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Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300

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Executive Summary

The U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) have prepared this Site-Wide Remediation Evaluation Summary report for LLNL Site 300 in accordance with the Site 300 Federal Facility Agreement Appendix A. LLNL Site 300 is a DOE high explosives experimental test facility operated by the University of California that supports the LLNL weapons program in research, development, and testing associated with weapon components.

This Site-Wide Remediation Evaluation Summary report assesses the protectiveness and effectiveness of the remedies that were specified in the Interim Site-Wide Record of Decision (ROD) for LLNL Site 300 (DOE, 2001). It was prepared to meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendment and Reauthorization Act of 1986. This document provides the basis for a subsequent Proposed Plan and the Final Site-Wide ROD for LLNL Site 300. The Site-Wide Proposed Plan for the Remediation of LLNL Site 300 will propose, describe, and justify the preferred remedy for each operable unit (OU). After public and regulatory review and comment on the Site-Wide Proposed Plan, DOE will present the selected remedies and ground water cleanup standards in the Final Site-Wide ROD, scheduled for 2008.

Purpose

The purposes of this Site-Wide Remediation Evaluation Summary report are to:

- Develop remedial action objectives based on potential Applicable or Relevant and Appropriate Requirements (ARARs).
- Evaluate the effectiveness and protectiveness of the interim remedial actions and their suitability as final remedial actions.
- Identify any deficiencies in the interim remedies in their effectiveness, protectiveness, and/or ability to meet remedial action objectives and ARARs.
- Recommend changes to the interim remedies, as needed, to address identified deficiencies.
- Propose the final cleanup remedies for OUs 2 through 8.
- Evaluate the ability of the remedies to meet Maximum Contaminant Levels (MCLs) and other Water Quality Numeric Limits (WQNLs) for ground water to support the selection of cleanup standards in the Final Site-Wide ROD.

The report covers the following operable units at LLNL Site 300 that were included in the Interim Site-Wide ROD:

- Building 834 (OU 2).
- Pit 6 Landfill (OU 3).
- High Explosives (HE) Process Area (OU 4) including Building 815, HE Lagoons, and the HE Burn Pit.
- Building 850 (OU 5) including the Building 850 Firing Table.

- Building 854 (OU 6).
- Building 832 Canyon (OU 7) including Buildings 830 and 832.
- The Site-Wide OU (OU 8) including Buildings 801, 833, 845, and 851 and the Pit 2, Pit 8, and Pit 9 Landfills.

This report does not apply to the General Services Area (GSA) (OU 1) because a final remedy and cleanup standards have already been selected for this OU in the Final Record of Decision for the GSA (U.S. DOE, 1997). The Pit 3, 5, and 7 Landfills, collectively designated as the Pit 7 Complex, are being evaluated through a separate, area-specific Feasibility Study and Proposed Plan. A remedy for the Pit 7 Complex area will be selected in an Amendment to the Interim Site-Wide ROD, and will be incorporated into the Final Site-Wide ROD. Buildings 812 and 865, and the Sandia Test Site areas are still undergoing characterization. If contaminant release sites that require remediation are identified, remedies to address contamination will be incorporated into the Final Site-Wide ROD through a ROD Amendment.

Methodology

The evaluation process used in this report generally follows the Five-Year Review process that is used to determine whether the remedy at a site is, or is expected to be, protective of human health and the environment (EPA, 2001). DOE/LLNL assessed the protectiveness of the interim remedies that were implemented in OUs 2 through 8 by determining if:

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

As part of this assessment, DOE/LLNL reviewed subsurface contaminant concentration data in ground water and soil vapor, and remediation system performance data through June 30, 2005 for OUs 2 through 8.

In addition, technical and logistical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered. The logistical factors considered in the evaluation included:

- Changes in land, surface water, and/or ground water use at Site 300 or the surrounding property that could affect the protectiveness of the remedy.
- Changes in the building or area use or access at Site 300 that could affect the risk assessment assumptions and/or institutional controls used to prevent exposure to contamination.
- Changes in ARARs.

In conjunction with the regulatory agencies, ARARs were previously identified for OUs 2 through 8 in the Site-Wide Feasibility Study for LLNL Site 300 (Ferry et. al., 1999) and the Interim Site-Wide ROD (DOE, 2001). The Interim Site-Wide ROD did not contain ground water cleanup standards. For this reason, any potential ARARs that applied to final ground water cleanup standards (i.e., the Basin Plan and State Water Resources Control Board

Resolutions 68-16 and 92-49) were not included in the Interim Site-Wide ROD, except as applied to the operational aspects of the treatment technologies. As part of this Site-Wide Remediation Evaluation report, potential ARARs related to ground water cleanup standards were evaluated in anticipation of selecting these standards in the Final Site-Wide ROD.

The technical factors considered in this evaluation included:

- Progress of the interim remedies in reducing risk, contaminant concentrations, plume size, and impacts to ground water.
- Identifying any new sources, releases, or contaminants.
- Identifying any new technologies capable of more rapidly or cost-effectively achieving remedial action objectives and ARARs.

The technical and logistical factors were considered for each OU to assess whether: (1) the interim remedies, as implemented, are sufficiently protective and effective to prevent exposure to contamination and meet remedial action objectives and ARARs in a reasonable timeframe, (2) the interim remedy or components of the interim remedy require modification to be protective and effective, or (3) a new remedy should be implemented. Any deficiencies that would affect the protectiveness of an interim remedy were identified. Depending on the nature and magnitude of the deficiency, recommendations for modifications to the existing interim remedy or implementation of new remedies were proposed. If no deficiencies were identified, the interim remedy was recommended as the final remedy, unless a new proven technology was identified that was capable of achieving site cleanup more quickly and/or cost-effectively.

Because of the differences in the contaminant sources, contaminants of concern (COCs), plume migration pathways, risks, and interim remedies, the interim remedies for OUs 2 through 8, are discussed separately. Each OU discussion includes:

- Background information including an OU description, chronology of important environmental activities, hydrogeologic setting, history of contamination, COCs, and initial response.
- Descriptions of the interim remedial actions.
- An evaluation of interim remedy performance and protectiveness.
- Identification of interim remedy deficiencies, if any, and any potential changes to the interim remedies to address the deficiencies.
- The proposed final remedial action for the OU.

As agreed in the Interim Site-Wide ROD, DOE/LLNL conducted an evaluation of various potential ground water cleanup standard scenarios. DOE, the U.S. EPA, DTSC, and the RWQCB subsequently agreed that the evaluation of potential ground water cleanup standards contained in Appendices B, C, and D of this report will not be used to support the selection of ground water cleanup standards in the Site-Wide ROD. However, the evaluation contained in these appendices is retained in this report to demonstrate and document DOE's compliance with the requirements of the Interim Site-Wide ROD.

Evaluation Results

Tables Summ-1 and Summ-2 summarize the results of the logistical and technical effectiveness reviews of the interim remedies. As seen on Table Summ-1, this evaluation found

that there have been no significant changes since the Interim Site-Wide ROD in ARARs or in land, building or ground water use at the site. The evaluation also showed that for the interim remedies in the Pit 6 Landfill, HE Process, Building 854, Building 801/Pit 8 Landfill, Building 845/Pit 9 Landfill, Building 851 and Building 833 areas:

- Progress has been made in remediating ground water, surface water, surficial soil, and the vadose zone (as applicable to each OU).
- Progress has been made in mitigating identified human health and/or ecological risks.
- No new sources, releases or contaminants have been identified.
- No new technologies that could accelerate cleanup have been identified.
- The interim remedies were found to be technically effective.
- No changes to the interim remedies are proposed.

In the Building 834 area, this evaluation found that remediation progress has been made in surficial soil, the vadose zone, and in mitigating identified risk. No new releases of contaminants were identified. However, remediation in the core area has not yet significantly reduced VOC concentrations in low permeability clay, and very long cleanup times are estimated. Enhanced bioremediation is currently being tested as a potential technology to shorten cleanup time. No changes are proposed in the interim remedy, pending results of the *in situ* enhanced bioremediation test.

In the Building 850 area, the cost of excavation and disposal of polychlorinated biphenyl (PCB)-, dioxin-, and furan-contaminated soil makes this remedy infeasible, and more cost-effective technologies have been identified to address these COCs in surface soil. Perchlorate has also been identified as a new COC in ground water in the Building 850 area. Changes to the interim remedy will be required to address the perchlorate in ground water and the contaminated surficial soil.

In the Building 832 area, vadose zone and surface/ground water remediation has progressed, and no new sources, releases or contaminants have been identified. Although the interim remedy is technically effective and no changes to it are proposed, vacuum-enhanced ground water extraction and expedited source area cleanup approaches are being evaluated to shorten cleanup time.

Monitoring will continue to evaluate a possible release of depleted uranium, composed almost entirely of uranium-238, from the Pit 2 Landfill. Since the mechanism for mobilizing any depleted uranium has been removed, no change to the interim remedy in this area is proposed at this time.

This evaluation also found that all of the interim remedies are protecting human health and the environment, and no significant deficiencies were identified for the interim remedies. However, the very long estimated cleanup time at Building 834 has prompted the *in situ* bioremediation test in the distal (T2) area; additional wells may be needed in the future in the HE Process Area to fully capture the distal portion of the VOC plume in that area; and the Building 850 remedy will need to be modified to address the recent discovery of perchlorate in ground water above the Public Health Goal, and PCB-, dioxin- and furan-contaminated soil.

Table Summ-3 summarizes the proposed final remedies for the OUs evaluated in this report. Except for continuing to evaluate bioremediation for the Building 834 area; assessing vacuum-enhanced ground water extraction and expedited source area cleanup approaches in the Building 832 area; and modifying the Building 850 remedy to address the contaminated surface soil and recently discovered perchlorate in ground water, the proposed final remedies are the same as the interim remedies.

Table Summ-1. Summary of logistical effectiveness review and institutional controls evaluation.

Area	Significant changes?			Is the interim remedy logistically effective?	Are institutional controls implemented and effective?	Are changes needed to improve the logistical effectiveness?
	ARARs	Land, building, and ground water land use	Exposure pathways toxicity, and other contaminant characteristics			
Building 834	No	No	No	Yes	Yes	No
Pit 6 Landfill	No	No	No	Yes	Yes	No
High Explosive Process Area	No	No	No	Yes	Yes	No
Building 850	No	No	No	Yes	Yes	No
Building 854	No	No	No	Yes	Yes	No
Building 832 Canyon	No	No	No	Yes	Yes	No
Building 801/ Pit 8 Landfill	No	No	No	Yes	Yes	No
Building 845/ Pit 9 Landfill	No	No	No	Yes	Yes	No
Building 851	No	No	No	Yes	Yes	No
Building 833	No	No	No	Yes	Yes	No
Pit 2 Landfill	No	No	No	Yes	Yes	No

Table Summ-2. Summary of technical effectiveness review.

Area	Is remediation progressing?				Have new sources, releases, or contaminants been identified?	Have new technologies been identified?	Is the interim remedy technically effective?	Are changes to the remedy needed?
	Surface soil	Vadose zone	Surface and ground water	Mitigating risk				
Building 834	NA	Yes	Yes. However, remediation in the core area has not significantly reduced VOC concentrations in ground water in the low-permeability sediments of the Tps clay HSU perching horizon.	Yes	No	*In situ* enhanced bioremediation technology is currently being tested in the T2 area.	The length of time necessary to achieve ground water cleanup standards using pump and treat technologies may be long due to: (1) low well yields resulting from the recharge-limited nature of the Tpsg HSU, (2) VOCs that will likely continue to diffuse from the low permeability Tps clay into ground water in the overlying Tpsg HSU, and (3) the limited ability of pump and treat technology to remove VOCs from low-permeability sediments in the Tps HSU.	No
Pit 6 Landfill	NA	NA	Yes	Yes	No	No	Yes	No
High Explosive Process Area	NA	NA	Yes. Additional extraction wells may be needed in the future to fully capture the distal VOC plume.	Yes	No	No	Yes	No
Building 850	The treatment of PCB-, dioxin-, and furan-contaminated surface soil has been delayed.	NA	Yes	The only risk is associated with surface soil.	Perchlorate is a new contaminant of concern.	More cost-effective technologies have been identified that are capable of addressing PCBs, dioxins, and furans in surface soil.	The cost of excavation and disposal of the PCB-, dioxin-, and furan-contaminated surface soil is economically infeasible.	Changes to the remedy will be required to address PCBs, dioxins, and furans in surface soil. DOE/LLNL will also discuss possible changes to the remedy to address perchlorate in ground water.
Building 854	Yes	Yes	Yes	Yes	No	No	Yes	No
Building 832	NA	Yes	Yes	Yes	No	Vacuum-enhanced ground water extraction and expedited source area cleanup approaches are being evaluated.	Yes	No
Building 801/Pit 8 Landfill	NA	NA	Yes	NA	No	No	Yes	No
Building 845/Pit 9 Landfill	NA	NA	NA	NA	No	No	Yes	No
Building 851	NA	NA	Yes	NA	No	No	Yes	No
Building 833	NA	NA	Yes	No	No	No	Yes	No
Pit 2 Landfill	NA	NA	NA	NA	Possible release of depleted uranium.	No	Yes	No. The mobilization mechanism for depleted uranium has been eliminated.

Notes:

HSU = Hydrostratigraphic unit.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
VOC = Volatile organic compound.

Table Summ-3. Summary of proposed final remedies for the LLNL Site 300 OUs 2 through 8.

Building 834 (OU 2)	Pit 6 (OU 3)	HE Process Area (OU 4)	Building 850 Firing Table (OU 5)	Building 854 (OU 6)	Building 832 Canyon (OU 7)
Monitoring Risk and hazard management Extraction and treatment of ground water and soil vapor to mitigate risk and hazards posed by VOCs in the subsurface soil and protect and restore beneficial uses of ground water Continue to evaluate innovative technologies	Monitoring Risk and hazard management Monitored natural attenuation of VOCs and tritium in ground water	No further action for VOCs and HE compounds in soil and bedrock Monitoring Risk and hazard management Ground water extraction and treatment of VOCs at the leading edge of the Building 815 TCE plume; VOCs, HE compounds, and perchlorate from Building 815 and HE rinsewater lagoons; and VOCs, nitrate, and perchlorate from the HE Burn Pit Monitored natural attenuation of nitrate in ground water	Monitoring Risk and hazard management Monitored natural attenuation of tritium in ground water and surface water Source control through the removal and disposal of the contaminated sand pile Mitigate risk to onsite workers from exposure to PCB-, dioxin, and furan-contaminated surface soil in the vicinity of the Building 850. Exposure control measures may be implemented, if necessary, to prevent exposure to PCBs, dioxins, and furans in surface soil until soil is remediated Note: DOE/LLNL will discuss possible measures needed to address perchlorate in ground water with the regulatory agencies.	No further action for metals, high explosives, PCBs, and tritium in surface soil Monitoring Risk and hazard management Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate	No further action for high explosive compounds in surface soil and nitrate in subsurface soil/bedrock at Building 830, and high explosive compounds in subsurface soil/rock at Building 832 Monitoring Risk and hazard management Controlling plume migration by extracting and treating ground water and soil vapor, both in the source area and at the leading edge of the Building 832 VOC, perchlorate, and nitrate plumes Controlling plume migration by extracting and treating ground water and soil vapor to remove VOCs, nitrate, and perchlorate at Building 830 Downgradient plume control by ground water extraction using an *ex situ* treatment of VOCs for the Building 830 area

Building 801, Landfill Pit 8 (OU 8)	B845 Firing Table, Pit 9 (OU 8)	Building 851 Firing Table (OU 8)	Building 833 (OU 8)	Pit 2 Landfill	
No further action for VOCs in subsurface soil at the Building 801 dry well Monitoring Inspecting the Pit 8 Landfill surface for damage that could compromise its integrity, and repairing any damage found	No further action for HMX and uranium in soil and bedrock Monitoring Inspecting the Pit 9 Landfill surface for damage that could compromise its integrity, and repair damage found	No further action for VOCs and uranium in subsurface soil and bedrock and for RDX, metals, and uranium in surface soil Monitoring	Monitoring Risk and hazard management	Monitoring Inspecting the Pit 2 Landfill surface for damage that could compromise its integrity, and repair damage found	

Notes:

HE = High explosive.
HSU = Hydrostratigraphic unit.
OU = Operable unit.
PCB = Polychlorinated biphenyl.
RDX = Research department explosive.
VOC = Volatile organic compound.

1. Introduction

The U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) have prepared this Site-Wide Remediation Evaluation Summary report for LLNL Site 300 in accordance with the Site 300 Federal Facility Agreement (FFA). The Site 300 FFA was negotiated between the DOE, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB). The FFA provides the framework for the conduct of site cleanup and preparation of the necessary regulatory documents. As agreed with the regulatory agencies, the Site-Wide Remediation Evaluation Summary report was prepared to meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA). It provides the basis for a Proposed Plan and the Final Site-Wide Record of Decision (ROD) for LLNL Site 300.

This Site-Wide Remediation Evaluation Summary report covers the following Operable Units (OUs) at LLNL Site 300 that were included in the Interim Site-Wide ROD (U.S. DOE, 2001):

- 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/Pits 3&5 (OU 5) including the Building 850 Firing Table, and the Pit 2 Landfill.
- Building 854 (OU 6).
- Building 832 Canyon (OU 7) including Buildings 830 and 832.
- Site-Wide (OU 8) including Buildings 801, 833, 845, and 851 and the Pit 2, 8, 9 Landfills.

This Site-Wide Remediation Evaluation Summary report does not apply to the General Services Area (GSA) (OU 1) because a final remedy and cleanup standards have already been selected for this OU in the Final ROD for the GSA (U.S. DOE, 1997). The Pit 3, 5, and 7 Landfills, collectively designated as the Pit 7 Complex, are being evaluated through a separate, area-specific Feasibility Study and Proposed Plan. A remedy for the Pit 7 Complex area will be selected in an Amendment to the Interim Site-Wide ROD, and will be incorporated into the Final Site-Wide ROD. The Building 812 and 865, and Sandia Test Site areas are still undergoing characterization. If these areas are identified as contaminant release sites requiring remediation, remedies to address contamination will be incorporated into the Final Site-Wide ROD through a ROD Amendment.

2. Purpose of Report

The purpose of this Site-Wide Remediation Evaluation Summary report is to:

- Develop remedial action objectives based on potential Applicable or Relevant and Appropriate Requirements (ARARs).
- Evaluate the effectiveness and protectiveness of the interim remedial actions and their suitability as final remedial actions.
- Identify any deficiencies in the interim remedies in their effectiveness, protectiveness, and/or ability to meet remedial action objectives and ARARs.
- Propose changes to the remedies, as needed to address identified deficiencies.
- Propose final cleanup remedies for OUs 2 through 8 at Site 300.

A Site-Wide Proposed Plan for the Remediation of LLNL Site 300 that follows the Site-Wide Remediation Evaluation Summary report will propose, describe, and justify the preferred remedy for each OU. After public and regulatory review and comment on the Site-Wide Proposed Plan, DOE will present the selected remedies and cleanup standards in a Final Site-Wide ROD, scheduled for 2008.

This Site-Wide Remediation Evaluation Summary report is based on the remedial investigations conducted from 1982 to 2000, as well as an evaluation of the performance of the interim remedies that were implemented under the Interim Site-Wide ROD and operated from 2001 to 2005. Chapter 3 summarizes background information for Site 300. Chapter 4 discusses the processes that were used to: (1) identify ARARs, and (2) assess the protectiveness of the selected interim remedies for OUs 2 through 8. Chapter 5 presents the remedial action objectives and potential ARARs for the site cleanup. The results of the protectiveness assessment are presented for each OU in Chapters 6 through 12.

Appendix A contains data for samples collected from ground water extraction and monitor wells at Site 300 during 2005. Appendices B, C, and D contain the evaluation of potential ground water standard scenarios and supporting modeling and costing documentation, as requested by the RWQCB and required in Appendix C of the Interim Site-Wide ROD. DOE, the U.S. EPA, DTSC, and the RWQCB subsequently agreed that the evaluation of potential ground water cleanup standards contained in Appendices B, C, and D of this report will not be used to support the selection of ground water cleanup standards in the Site-Wide ROD. Instead, the technical and economic feasibility analysis will be conducted when contaminant concentrations have been reduced to MCLs and more field data are available with which to conduct this analysis. However, the evaluation of potential ground water cleanup standards contained in these appendices is retained in this report to demonstrate and document DOE's compliance with the requirements of the Interim Site-Wide ROD.

3. Site Background

LLNL Site 300 is a DOE experimental test facility operated by the University of California. Site 300 is primarily a high-explosives test facility supporting the LLNL weapons program in research, development, and testing associated with weapon components. Operations at Site 300

include four defense program activities: (1) hydrodynamic testing, (2) charged particle beam research, (3) physical, environmental, and dynamic testing, and (4) HE formulation and fabrication.

This chapter describes the physical characteristics of Site 300 (Section 3.1), the hydrogeologic setting (Section 3.2), land, ground water, and surface water use (Section 3.3), and the nature and extent of contamination, risk characterization activities, and contaminants of concern (COCs) identified at the site (Section 3.4).

3.1. Site Description

Site 300 is located in the southeastern Altamont Hills of the Diablo range, about 13 miles southeast of Livermore and 8.5 miles southwest of Tracy (Figure 3-1). The site covers 11 square miles, most of which is in San Joaquin County. The western one-sixth of the site is located in Alameda County.

The topography of Site 300 consists of a series of steep hills and canyons generally oriented northwest to southeast. Elevation ranges from about 500 feet (ft) in the southeast corner to about 1,750 ft in the northwestern area. The climate of Site 300 is semiarid and windy. The average annual rainfall for the 39-year period from 1965 through 2004 was 10.2 inches (in.).

The seven major plant habitats occurring at Site 300, four upland habitats and three less extensive wetland habitats, consist of 14 plant communities containing 343 plant taxa. The upland habitats are introduced grassland, native grassland, coastal sage scrub, and oak woodland. The rare wetland habitats consist of northern riparian woodland, vernal pool, and herbaceous wetlands. Fauna observed at Site 300 include 20 species of reptiles and amphibians, 70 species of birds, and 25 species of mammals. Mammal species include mice, hares, squirrels, skunks, foxes, and black-tailed deer. Site 300 is the habitat for several rare, threatened, or endangered species of flora and fauna.

Site 300 is located in an area of historical seismicity and Quaternary folding. Bedrock strata exposed within Site 300 have been correlated with five mappable geologic units (Webster-Scholten, 1994). From oldest to youngest, the units are the late Cretaceous Great Valley sequence (Kgv), the late Paleocene to mid-Eocene Tesla Formation (Tts), the mid-Miocene Cierbo Formation (Tmss), the late Miocene Neroly Formation (Tn), and a Pliocene nonmarine unit (Tps). The bedrock units are locally overlain by mid- to late-Pleistocene terrace deposits and late Pleistocene to Holocene floodplain, ravine fill, landslide, and colluvial deposits.

3.2. Hydrogeologic Setting

This section describes the hydrogeologic setting of Site 300 including the occurrence of surface and ground water.

3.2.1. Surface Water

There are no perennial streams at Site 300. Surface water at the site consists of intermittent runoff, springs, vernal pools, and two man-made ponds. There are 25 springs at Site 300; most of which exhibit very low flow rates and are recognized mainly by small marshy areas, pools of water, or vegetation. There are ten springs located within the designated OUs; six of which contain current or past anthropogenic contamination. There are two onsite man-made surface

water bodies: (1) a constructed pond/wetland created as habitat for red-legged frogs south of Building 812, and (2) a sewage treatment pond located in the GSA OU. An offsite man-made pond is located at the Carnegie State Vehicular Recreation Area Park (hereafter referred to as Carnegie State Park) east of the Pit 6 Landfill.

3.2.2. Ground Water

Site 300 is a large and hydrogeologically diverse site. Due to the steep topography, and structural complexity, stratigraphic units and ground water contained within many of these units are discontinuous across the site. Consequently, site-specific hydrogeologic conditions govern the occurrence and flow of ground water and the fate and transport of contaminants beneath each OU. This section describes the primary water-bearing zones and their distribution at Site 300.

Hydrostratigraphic units (HSUs) have been defined consisting of one or more stratigraphic intervals that comprise a single hydraulic system within one or more OU. An HSU is a water-bearing zone that exhibits similar hydraulic and geochemical properties. In this document, ground water movement and contaminant migration in ground water are discussed in the context of HSUs.

Most ground water contamination at Site 300 occurs primarily in three types of water-bearing zones:

1. Quaternary deposits including the alluvium and weathered bedrock (Qal-WBR HSU), alluvial terrace deposits (Qt), and landslide deposits (Qls HSU).
2. Tertiary perched ground water in fluvial sands and gravels (Tpsg HSU) and semilithified silts and clay of the Tps HSU.
3. Tertiary Neroly Formation bedrock including the $Tnbs_2$, $Tnsc_{1b}$ $Tnbs_1$, and $Tnsc_0$ HSUs.

Composite stratigraphic columns showing saturated zones for the northern part and southeast corner of Site 300 is shown in Figure 3-2. The occurrence of HSUs at OU2 through 8 are shown in Table 3-1. The HSUs are discussed further in the following sections.

3.2.2.1. Quaternary Deposit HSUs

At Site 300, ground water is present in Quaternary deposits in the Qal-WBR HSU, Qt, and the Qls HSU. These HSUs generally exhibit moderate to high hydraulic conductivity (greater than 10^{-3} centimeters per second [cm/sec]) and characteristics of a porous medium.

The Qal-WBR HSU is comprised of silty clay, sand, and gravel deposited in ravines and surface water drainage courses throughout Site 300 and the weathered bedrock underlying these alluvial deposits. In many parts of Site 300, the Qal/WBR HSU is in hydraulic communication with underlying Neroly bedrock HSUs, where the dipping bedrock HSUs subcrop beneath the Qal/WBR HSU. Depending on the relative hydraulic head between the two zones, ground water and contaminants can flow from one zone into the other. The Qal-WBR HSU has been identified in the HE Process Area OU, the Building 850 area, and the Building 832 Canyon OU.

Qt deposits are comprised of variably saturated silty clay, sand, and gravel alluvial terrace deposits of moderate hydraulic conductivity that are present in the Pit 6 Landfill OU. Qt deposit ground water hydraulically communicates with ground water in the underlying $Tnbs_1$ to form the Qt-$Tnbs_1$ HSU in this area.

The Qls HSU is comprised of heterogeneous silty clay, sand, and gravel deposited as rock and sediment slides from the hillsides. While landslide deposits are present throughout Site 300, they contain contaminated ground water in the Building 854 OU, and therefore have been designated as an HSU in this OU. In the Building 854 OU, the Qls HSU contains variably saturated, ephemeral perched ground water.

3.2.2.2. Tertiary Perched HSUs

At Site 300, perched ground water occurs in Tertiary sands and gravels of the Tpsg and Tps HSUs. The characteristics and occurrence of these HSUs in Site 300 OUs are described below.

The Tpsg HSU is a shallow, perched water-bearing zone that is present in the Building 834 OU. This HSU exhibits variable but generally low hydraulic conductivity ranging from 10^{-4} to 10^{-6} cm/sec. It overlies 10 to 30 ft of silty clay in the Tps perching horizon that prevents downward migration of ground water into the underlying Lower $Tnbs_1$ HSU. Perched ground water is also present in the Tpsg-Tps HSU at the HE Process Area OU. The areal extent and saturated thickness of these perched water-bearing zones are variable depending on seasonal rainfall.

3.2.2.3. Tertiary Neroly Formation Bedrock HSUs

At Site 300, ground water is present in a number of HSUs within the Tertiary Neroly Formation bedrock. Tertiary Neroly (Tn) Formation bedrock includes the following stratigraphic units, listed from youngest to oldest:

- $Tnsc_2$ Upper siltstones and claystone.
- $Tnbs_2$ Upper blue sandstone.
- $Tnsc_1$ Middle siltstone and claystone.
- $Tnbs_1$ Lower blue sandstone.
- $Tnbs_0$ basal sandstone.
- $Tnsc_0$ basal siltstone/claystone.

The presence of ground water in these stratigraphic units, as well as ground water gradients and flow direction, are influenced by lithology and regional structure (i.e., bedrock dip, folding, and faulting) that control the recharge and discharge characteristics of ground water within the Neroly bedrock. The Neroly bedrock HSUs exhibit a broad range of hydraulic conductivities (10^{-3} to 10^{-5} cm/sec) and characteristics of both porous and fractured media. The occurrence of the Neroly bedrock HSUs in the Site 300 OUs is shown in Table 3-1.

Ground water in Neroly bedrock occurs under unconfined to confined conditions, and generally flows to the east-northeast in the northern part of the site and to the southeast in the southern part of Site 300. Ground water use at Site 300 and on neighboring properties is discussed in Section 3.3.2. The OU-specific hydrogeologic settings and HSUs are discussed in more detail in Chapters 6 through 12.

3.3. Land, Ground Water, and Surface Water Use

This section describes the land, ground water and surface water use at and in the vicinity of Site 300.

3.3.1. Land Use

Site 300 is a federal facility owned by the U.S. DOE that is used to conduct research, development, and testing associated with high explosives materials. This work includes explosives processing, preparation of new explosives, and pressing, machining, and assembly of explosives components. Site 300 activities also include hydrodynamic testing for verifying computer simulation results, obtaining equation-of-state data for explosives materials, evaluating material behavior at assembly joints and welds, evaluating the quality and uniformity of implosion, and evaluating the performance of experimental test design modifications. For this reason, the land use at Site 300 is designated as industrial/Federal materials and research testing.

Access to Site 300 is restricted and DOE control of the site is expected to continue for the foreseeable future. Provisions in the Site 300 FFA and in federal and state law assure that DOE will not transfer lands with unmitigated contamination that could cause potential harm. Because of DOE's current intentions and these assurances, non-DOE land uses for Site 300 have not been considered in any future land use assumptions.

Site 300 was selected as the LLNL test site because of the sparsely populated surrounding area. Many of the neighboring landowners do not live on their properties. On the basis of the residential population, the average density around the perimeter of Site 300 is less than one person per square mile. The surrounding land is used for cattle grazing, a State recreational vehicle park, a fireworks storage facility, and an ecological reserve. The properties adjacent to Site 300 and their land use are shown on Figure 3-3. Recently, a developer purchased land for a housing development to the north and east of Site 300. However, a Final Environmental Impact Report for this development that was prepared for the City of Tracy proposes to designate land along the northeast border of the Site 300 as open space. The open space would create a buffer of approximately one to one and a half miles between Site 300 and residential elements of the development. The buffer zone would be used for cattle or sheep grazing, and would have limited access points at existing trails for hikers, mountain bikers and equestrians. In the past, development in the immediate vicinity of Site 300 has been hindered by the limited availability of potable water, opposition by local residents and landowners, and the presence of endangered species habitat. If these issues are resolved in the future, it is possible that residential development of the land in the vicinity of Site 300 could occur.

3.3.2. Ground and Surface Water Use

At Site 300, ground water is used for a variety of needs including cooling towers, HE processing, and fire suppression. Bottled water is the primary source of onsite drinking water, however potable ground water from onsite water-supply Well 20, located in the southeast part of OU 4, is available as necessary for potable supply. This well is screened in the Lower $Tnbs_1$ bedrock HSU at a depth of 387 to 518 ft below ground surface (bgs). Although several nearby ground water monitor wells screened in the shallower $Tnbs_2$ HSU contain trichloroethylene (TCE), TCE has not been detected in Well 20 because it is sealed through the shallow aquifer. The use of Well 18, also located in the southeast part of OU 4, as a water-supply well was discontinued due to sporadic detections of TCE in samples from this well. Although Well 18 is inactive, it is considered a backup well to supply water for emergency fire suppression. There is no current onsite use of surface water by humans.

The California RWQCB-Central Valley Region's Water Quality Control Plan (Basin Plan) establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley region. State Water Resources Control Board (SWRCB) Resolution No. 88-63 specifies that all surface and ground waters of the State are considered suitable or potentially suitable, for municipal or domestic water-supply with the following exceptions: (1) those water bodies with yields below 200 gallons per day (gpd), (2) total dissolved solids exceeding 3,000 milligrams per liter (mg/L), or (3) contamination that cannot reasonably be treated for domestic use by either best management practices or best economically achievable treatment practices. Ground water wells at and in the vicinity of Site 300 yield approximately 100 to over 200,000 gpd and contain total dissolved solids at concentrations ranging from 300 to 2,000 mg/L. The ground water at Site 300 commonly contains naturally occurring selenium and arsenic above drinking water maximum contaminant levels (MCLs) (Webster-Scholten, 1994). However, in the absence of a Basin Plan Amendment excluding certain ground water bodies, all ground water below Site 300 and adjacent properties is presumed potentially suitable for municipal or domestic supply.

Offsite, ground water is currently used for dust and fire suppression, livestock watering, and irrigation. Some offsite water-supply wells are also used for domestic purposes and as a drinking water source. A description of the active and inactive private or state-owned water-supply wells located in the vicinity of Site 300, including well ownership, current water use, and well status are listed in Table 3-2. The locations of these wells are shown in Figure 3-5.

DOE/LLNL collect monthly samples from offsite water-supply wells for analyses of contaminants that could potentially impact these wells. Low concentrations (less than 4 micrograms per liter [μg/L]) of volatile organic compounds (VOCs) have been sporadically detected in privately-owned offsite wells Gallo-1 and CDF-1 and the owners of these wells are aware of these impacts. VOC contamination has not been detected in well CDF-1 for several years. While low concentrations of VOCs continue to be periodically detected in Gallo-1, this well is not used as a drinking water-supply. No other offsite wells are threatened by contamination from Site 300.

Surface water in the 24 springs located throughout Site 300 is not used for water-supply or other human uses at the site. Some of these springs provide wetland habitat for wildlife. Surface water from an offsite pond at the Carnegie State Vehicular Recreation Area Park is used for fire suppression. This pond is primarily replenished by ground water from well CARNRW-1.

3.4. Nature and Extent of Contamination

An extensive remedial investigation was conducted at Site 300 to: (1) identify contaminant release sites, (2) define the nature and extent of contamination, (3) estimate exposure risk to human and ecological receptors posed by site contamination, (4) evaluate the threat to ground water posed by contaminants in the vadose zone, and (5) identify COCs in environmental media. The results of these investigations are described in the Site-Wide Remedial Investigation (Webster-Scholten et al., 1994), the Building 854 Characterization Summary reports (Ziagos and Reber-Cox, 1998, and Ferry and Kearns, 2002), the Building 850 Site-Wide Remedial Investigation Addendum (Taffet et al., 1996), and the Building 832 Canyon Characterization Summary report (DOE, 1997), and are summarized in the Site-Wide Feasibility Study (Ferry et al., 1999).

A number of program activities in the past resulted in releases of chemicals to the environment including:

- Disposing waste fluids in sumps (dry wells).
- Surface spills from drum storage areas.
- Piping leaks from heat exchange systems.
- Burial of contaminated debris in unlined pits, trenches, and landfills.
- Debris and shrapnel scattered or released during HE detonations at firing tables.
- Open burning of HE compounds.
- Discharging contaminated rinse water to unlined lagoons and retention basins.

Forty-seven contaminant release sites have been confirmed at Site 300 (Figure 3-4). These release sites and any associated contamination have been assigned to eight OUs based on the specific location of the release and the extent of resulting contamination. An OU may contain more than one release site. The location of the OUs and ground water contamination within each OU are shown in Figure 3-5. These release sites and OUs have been the focus of environmental investigations at Site 300 since the mid-1980s. Historical information and analytic data were used to identify the nature and extent of anthropogenic contamination in environmental media at Site 300, risk to human and ecological receptors, and COCs within each OU.

The determination of the nature and extent of contamination at Site 300 was based on a detailed screening process performed in accordance with EPA guidelines. This screening process included record searches, interviews with operating personnel and retirees, examination of aerial photographs, site visits, and subsurface investigations. Subsurface investigations included soil vapor surveys, evaluation of rock cores and geophysical logging to define geologic units, and soil, rock, ground water and surface water analyses. Fate and transport modeling was conducted to assess the potential for: (1) contaminants to migrate in air, soil, or ground water where they might pose an exposure risk to human or ecological receptors, and/or (2) a contaminant in soil and rock to impact the underlying ground water.

A human health risk assessment was conducted to evaluate carcinogenic risks, noncarcinogenic health hazards, and additive risk for onsite workers and offsite residents that could potentially be exposed to contaminants at Site 300. An ecological assessment was conducted to determine the potential for ecological damage as a result of contaminant releases to the Site 300 environment. A detailed description of the human health and ecological risk assessments are presented in the Site-Wide Remedial Investigation (Webster-Scholten, 1994) and the Site-Wide Feasibility Study (Ferry et al., 1999).

COCs at Site 300 were identified based on the:

- Frequency with which each substance was detected.
- Concentrations of the compound relative to background concentrations.
- Risk or hazard presented by the compound.
- Potential for a compound present in soil and rock to affect ground water.

COCs identified at Site 300 include VOCs, tritium, depleted uranium, HE compounds, nitrate, perchlorate, metals, polychlorinated biphenyls (PCBs), tetrabutylorthosilicate (TBOS), dioxins, and furans in surface soil, subsurface soil/bedrock, ground water, and/or surface water

(Figure 3-4). The distribution of COCs in the vadose zone and HSU ground water in OUs 2 through 8 are shown on Table 3-1.

The nature and extent of contamination, results of the risk assessment, and COCs are discussed for each OU in Chapters 6 through 12.

4. Site-Wide Remediation Evaluation Summary Process

This chapter discusses the processes that were used to:

- Evaluate and identify ARARs for cleanup (Section 4.1).
- Assess the protectiveness of the selected interim remedies for OUs 2 through 8 (Section 4.2).

The results of the ARAR evaluation are presented in Chapter 5. The results of the assessment of the protectiveness of the interim remedies are presented for each OU in Chapters 6 through 12. Appendix A contains the chemical and radiological COC data for ground water samples collected in OUs 2 through 8 during 2005. Where COCs are present in surface soil and/or subsurface soil/rock that could potentially impact ground water, ground water data for these analytes are also presented.

4.1. Evaluation of ARARs

In conjunction with the regulatory agencies, ARARs were previously identified for OUs 2 through 8 in the Site-Wide Feasibility Study for LLNL Site 300 (Ferry et al., 1999) and the Interim Site-Wide ROD (DOE, 2001). The Interim Site-Wide ROD did not contain ground water cleanup standards. For this reason, any potential ARARs that applied to ground water cleanup standards (i.e., the Basin Plan or SWRCB Resolutions 68-16 and 92-49) were not included in the Interim Site-Wide ROD, except as applied to the operational aspects of the treatment technologies (e.g., standards for any treated water that is discharged to surface waters or land.) As part of this Site-Wide Remediation Evaluation Summary Report, potential ARARs related to ground water cleanup standards were evaluated in anticipation of the selection of these standards in the Final Site-Wide ROD. ARARs in the Interim Site-Wide ROD were reviewed to ensure the most recent version of the ARARs are presented. If any new remedies or remedy components were evaluated, potential ARARs that might apply were reviewed for inclusion in the ARARs presented in Table 5-1. The ARAR evaluation is discussed further in Chapter 5.

4.2. Interim Remedy Protectiveness Assessment Process

As part of the site-wide evaluation, DOE/LLNL assessed the protectiveness of the selected interim remedies that were implemented in OUs 2 through 8. The protectiveness of the interim remedies was assessed by determining if:

1. The interim remedies are functioning as intended at the time of the Interim Site-Wide ROD decision document.
2. The assumptions used in the decision-making process are still valid.

3. Any additional information has been identified that would call the protectiveness of the interim remedies into question.

As part of this assessment, DOE/LLNL reviewed contaminant concentration data in ground water and soil vapor, and remediation system performance data through the 1st Semester (June 30) of 2005 for OUs 2 through 8.

The evaluation process used in this report generally follows the Five-Year Review process that is used to determine whether the remedy(s) at a site is, or is expected to be, protective of human health and the environment (EPA, 2001). In addition, technical and logistical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered. The logistical factors considered in the evaluation included:

- Changes in land, surface water, and/or ground water use at Site 300 or the surrounding property that could affect the protectiveness of the remedy.
- Changes in the building or area use or access at Site 300 that could affect the risk assessment assumptions and/or institutional controls used to prevent exposure to contamination.
- Changes in ARARs.

The technical factors considered in this evaluation included:

- Progress of the interim remedies in reducing risk, contaminant concentrations, plume size, and impacts to ground water.
- Identifying any new sources, releases, or contaminants.
- Identifying any new technologies capable of more rapidly or cost-effectively achieving remedial action objectives and ARARs.

These technical and logistical factors were considered for each OU to assess whether: (1) the interim remedies, as implemented, are sufficiently protective and effective to prevent exposure to contamination and meet remedial action objectives and ARARs in a reasonable timeframe, (2) the interim remedy or components of the interim remedy require modification to be protective and effective, or (3) a new remedy should be implemented. As a result of this evaluation, any deficiencies that affect the protectiveness of an interim remedy were identified. Depending on the nature and magnitude of the deficiency, recommendations for modifications to the existing interim remedy or implementation of new remedies are proposed. If no deficiencies were identified, the interim remedy was recommended as the final remedy unless a new proven technology was identified that was capable of achieving site cleanup more quickly and/or cost-effectively.

Because of the differences in the contaminant sources, COCs, plume migration pathways, risks, and interim remedies for OUs 2 through 8, the evaluation and protectiveness assessment for each OU are reported separately in Chapters 6 through 12.

Chapters 6 through 12 present the following information for OUs 2 through 8:

- Background information including an OU description, OU site chronology, hydrogeologic setting, history of contamination, COCs, and initial response.
- Descriptions of the interim remedial actions.
- An evaluation of the performance of the interim remedies.

- A summary of the cleanup standard cost-benefit analysis.
- A protectiveness assessment.
- Identification of any deficiencies in the interim remedies.
- Recommended changes to the interim remedies to address these deficiencies.
- Proposed final remedy for the OU.

5. Applicable or Relevant and Appropriate Requirements and Remedial Action Objectives

This section describes the ARARs and remedial action objectives for Site 300. ARARs are federal, state and local requirements that CERCLA remedial actions must meet or consider. Remedial action objectives are specific goals for protecting human health and the environment. They are developed by identifying ARARs that protect human health and the environment and the results of remedial investigations, including human health and ecological risk assessments. Potential Site 300 ARARs are discussed below followed by the remedial action objectives.

5.1. Identification of Potential Applicable or Relevant and Appropriate Requirements

This section describes potential ARARs for Site 300, excluding the GSA, Buildings 812 and 865 (Advanced Test Accelerator [ATA]), and the Pit 7 Complex. The GSA is excluded because ARARs were identified in the Final ROD for that OU (DOE, 1997). Characterization is still in progress at Building 812, Building 865, and the Sandia Test Site; therefore, these areas are also excluded. ARARs for the Pit 7 Complex will be identified in an amendment to the Site 300 Final Site-Wide ROD, which is scheduled for completion in 2008.

In conjunction with the regulatory agencies, potential ARARs were previously identified for OUs 2 through 8 in the Site-Wide Feasibility Study for LLNL Site 300 (Ferry et al., 1999).

The Interim Site-Wide ROD (DOE, 2001) did not contain ground water cleanup standards. For this reason, any potential ARARs that applied to ground water cleanup standards (i.e., the Basin Plan and SWRCB Resolutions 68-16 and 92-49) were not included in the Interim Site-Wide ROD, except as they applied to the operational aspects of the treatment technologies, (e.g., standards for any treated water that is discharged to surface waters or land.) As part of this Site-Wide Remediation Evaluation Summary report, potential ARARs related to ground water cleanup standards were identified in anticipation of the selection of these standards in the Final Site-Wide ROD.

CERCLA Section 121 (d)(2)(A) requires that remedial actions meet any federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121 (d)(2)(A)(ii) requires that state ARARs are to be met if they are more stringent than federal requirements. In addition, the National Contingency Plan, published in 40 Code of Federal Regulations (CFR) Part 300, requires that local ordinances, unpromulgated criteria, advisories, or guidance that do not meet the definition of ARARs, but that may assist in the development of remedial objectives, be listed as “to be considered”.

According to CERCLA guidance there are three types of ARARs:

1. Chemical-specific requirements, which define acceptable exposure concentrations or water quality standards.
2. Location-specific requirements, which may restrict remediation activities at sensitive or hazard-prone locations such as active fault zones, wildlife habitat, and flood plains.
3. Action-specific requirements, which may control activities and/or technology.

Table 5-1 lists the potential ARARs for Site 300, excluding the areas noted previously. The three types of ARARs are described below.

5.2. Chemical-Specific ARARs

5.2.1. Risk-Based Requirements

40 CFR 300.430(e)(i)(A)(2) indicates that excess cancer risks greater than one in ten thousand (10^{-4}) are unacceptable, and excess cancer risk between 10^{-4} and one in one million (10^{-6}) may require risk management. The U.S. EPA states that "where the cumulative carcinogenic risk to an individual, based on a reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1.0, action generally is not warranted unless there are adverse environmental impacts," unless MCLs are exceeded. EPA uses the general 10^{-4} to 10^{-6} risk range as a "target range" within which risk management measures are taken as part of the Superfund cleanup (U.S. EPA, 1991). 40 CFR Part 300 also indicates that "the 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure." U.S. EPA (1999) indicates that a hazard index greater than 1.0 may be associated with a noncarcinogenic adverse health effect. Chemicals that were identified as presenting a risk greater than 10^{-6} and/or hazard index greater than 1.0 in any media for which a complete exposure pathway exists were considered as COCs and addressed in a remedial alternative.

5.2.2. Federal and State ARARs

Because ground water at Site 300 is used for drinking water and MCLs apply directly to public drinking water systems with 15 or more service connections, ground water at Site 300 is considered a potential public drinking water source under federal and California law. The U.S. EPA considers MCLs in setting cleanup standards for contaminated water that is, or may be used for drinking water.

Under CERCLA, the most stringent concentration limit is the ARAR for a particular COC. Under the Safe Drinking Water Act, a state may set more stringent standards for public drinking water systems. California has set more stringent MCLs for total trihalomethanes, 1,2-dichloroethane, 1,1-dichloroethylene (DCE), cis- and trans-1,2-DCE, benzene, toluene, total xylenes, and uranium-238. In addition, the State of California has established MCLs for tritium and Freon 113, whereas the U.S. EPA has not.

The California RWQCB-Central Valley Region's Water Quality Control Plan (Basin Plan) establishes beneficial uses and water quality objectives for ground water and surface waters in

the Central Valley region. The RWQCB considers the water quality objectives as a cleanup standard for contaminated water that is, or may be, used for drinking water.

SWRCB Resolution No. 68-16 reflects the State's policies for "maintaining high quality of waters in California." Commonly referred to as the anti-degradation policy, this Resolution applies to discharging waste that might affect the existing quality of the water into which it is discharged thereby affecting its beneficial use. The policy requires that waste discharges to existing high quality waters meet best practical treatment or control. Title 23, California Code of Regulations (CCR), Division 3, Chapter 15, also applies to discharges of waste. SWRCB Resolution No. 92-49 establishes policies and procedures for the oversight of investigations and cleanup activities resulting from discharges that affect or threaten water quality. This policy authorizes regional boards to oversee cleanup activities and to require complete cleanup of all waste discharges. These policies are ARARs for the discharge of waste to ground water.

SWRCB Resolution No. 88-63 specifies that all surface and ground waters of the State are considered suitable, or potentially suitable, for municipal or domestic water-supply with the following exceptions: (1) those water bodies with yields below 200 gpd, (2) total dissolved solids exceeding 3,000 mg/L, or (3) contamination that cannot reasonably be treated for domestic use by either best management practices or best economically achievable treatment practices.

5.2.3. Preliminary Remediation Levels

To comply with state and federal ARARs and CERCLA risk-based requirements, actions should be implemented that attempt to protect full beneficial use of ground water beneath Site 300. Because ground water near Site 300 is used for drinking water-supply, the preliminary remediation levels for the COCs are the MCLs, or WQNLs if applicable.

SWRCB Resolutions 68-16 and 92-49 indicates that background conditions should also be a remedial goal for ground water. At this time, available site and industry data are insufficient to evaluate whether remediation of ground water to background levels is technically or economically feasible. For example, there are currently no cost effective technologies available to treat tritiated ground water. Given its short half-life (12.3 years), natural decay of tritium should eventually reduce tritium activities to background levels. However, because this is an important policy issue with the State, DOE/LLNL will re-evaluate the achievability of this potential long-term goal in the future, as additional monitoring and remediation performance data, and/or new remediation technologies become available.

Since the completion of the Site-Wide Feasibility Study, DOE/LLNL have continued to gather information to assess the feasibility of attaining different ground water cleanup standards. This information will aid in setting final cleanup standards as part of a Final Site-Wide ROD.

5.3. Location-Specific ARARs

5.3.1. Faults

California location standards for permitted hazardous waste transfer, treatment, storage, and disposal facilities (22 CCR 66264.18[a]) prohibit location of new treatment, storage, and disposal facilities, or substantial modification of existing facilities, within 200 ft of a Holocene (active) fault. The northwest-trending, right-lateral strike-slip Corral Hollow-Carnegie Fault Zone, which traverses the Pit 6 Landfill OU at Site 300, is considered active and capable of generating an earthquake with a magnitude in the range of 6.3 to 7.1 (Carpenter et al., 1992.)

This fault zone is located in the southwest portion of Site 300, more than 3,500 ft from the nearest planned treatment facility infrastructure. Therefore, the probability of surface fault rupture damage to treatment facilities, pipelines, wells or other appurtenances is very low. Potential damage from ground shaking is considered in the design of all Site 300 treatment facility structures.

A potentially active extension of the northwest-trending Midway Fault has been mapped across the northeastern-most part of Site 300 (Dibblee, 1980). However, this extension was mapped as "questionable" and may not actually extend into the northeastern part of Site 300.

The northwest trending Elk Ravine Fault Zone also traverses the northwest portion of Site 300, southwest of the queried extension of the Midway fault. However, analysis of outcrops, trenches, and engineering studies (Woodward-Clyde, 1979; Hoffman, 1988) indicated no evidence for active or potentially active strands within the Elk Ravine Fault Zone as defined by the State of California.

No other known active or potentially active faults have been identified at Site 300. No Earth Quake Zones containing active or potentially active faults have been mapped through any part of Site 300 by the State of California.

5.3.2. Wilderness Areas, Wildlife Refuges, and Scenic Rivers

No area within or near Site 300 is designated as a federal wilderness area, wildlife refuge, or scenic river. The California Department of Fish and Game maintains an ecological preserve adjacent to the eastern Site 300 boundary. No remedial action activities will occur within this preserve.

5.3.3. Floodplains and Wetlands

22 CCR 66264.18(b)(1) states that treatment, storage, and disposal facilities within a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. The Site-Wide Environmental Impact Statement for LLNL (DOE, 2005) states that there are no 100-year floodplains at Site 300. Therefore, this requirement does not apply to the Site 300 remediation facilities.

Other areas that are consistent with California and federal definition of wetlands (DOE, 2005) have been identified at Site 300. Any future treatment-related activities will be carried out in accordance with 10 CFR 1022.

5.3.4. Historical Sites and Archaeological Findings

The Site-Wide Remedial Investigation (SWRI) (Webster-Scholten, 1994), the LLNL Final Site-Wide Environmental Impact Statement and Supplemental Programmatic Environmental Impact Statement (U.S. DOE, 2005), and inventories and assessments of historic and archeological sites performed in 2002 through 2003 discuss investigations of potential historical properties and archaeological sites performed at Site 300. Additional surveys may be conducted prior to remedial activity to ensure that no historical properties will be affected by the activity. Remedial construction personnel will be advised of the possibility of buried cultural artifacts and be alerted to likely indicators.

5.3.5. Rare, Threatened, or Endangered Species

The 1994 Site-Wide Remedial Investigation and the 2005 Site-Wide Environmental Impact Statement and Supplemental Programmatic Environmental Impact Statement indicate that portions of Site 300 are potential habitat for several species that have been designated by the federal and state governments as threatened or endangered. The California red-legged frog (Federal threatened), California tiger salamander (Federal threatened), Alameda whip snake (Federal and State threatened), large-flowered fiddleneck (Federal and State endangered), valley elderberry longhorn beetle (Federal threatened), and Swainson's Hawk (State threatened) have been observed at Site 300. Habitat for the federally- and state-listed San Joaquin kit fox (endangered) occurs at Site 300, but no individuals have been observed. Designated critical habitat for the large-flowered fiddleneck is located southeast of Building 854. Critical habitat for the Alameda whipsnake has been proposed and includes the southwestern portion of the Site 300. No critical habitat has been re-proposed for California red-legged frogs and California tiger salamanders at Site 300. A comprehensive list of special-status species that may occur at Site 300 is contained in Appendix E of the Site-Wide Environmental Impact Statement and Supplemental Programmatic Environmental Impact Statement.

In addition, the flora species commonly known as the large-flowered fiddleneck (endangered) grows onsite southeast of the Building 854 area. In an agreement with the U.S. Fish and Wildlife Service, DOE designated 160 acres in the southwest portion of Site 300 as an ecological reserve for the endangered large-flowered fiddle neck. In 2005, a wildfire burned through this ecological reserve. No remediation activities that could impact this reserve are planned.

DOE is committed to protecting all potential habitats for these species. Mandatory 60-day advance notification of all ground-breaking activities will initiate an ecological survey by an LLNL biologist to identify the presence of sensitive species and to mitigate any adverse impacts of the project.

5.4. Action-Specific ARARs

Most action-specific ARARs address treatment, transportation, and disposal of hazardous waste. They are usually technology-or activity-based limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the remedial activities that are selected to accomplish a remedy. Action-specific ARARs may influence how a remedial action is implemented. Table 5-1 includes descriptions of action-specific ARARs that may be associated with possible remedial actions.

While DOE is evaluating the consolidation of activities throughout the DOE complex that could result in changes to activities conducted at Site 300, DOE control of the site is expected to continue for the foreseeable future. There are no plans to release the land for recreational or residential uses. However, in the unlikely event that the Site 300 property is transferred to an owner other than DOE in the future, DOE will execute a land use covenant or other appropriate institutional control at the time of transfer in compliance with 22 CCR, Division 45, Chapter 39, Section 67391.1.

5.5. Remedial Action Objectives

The National Contingency Plan specifies that remedial action objectives be developed which address: (1) COCs, (2) media of concern, (3) potential exposure pathways, and (4) preliminary remediation levels. The development of these goals involves evaluating ARARs and the results of the baseline human and ecological risk assessment in the Site-Wide Remedial Investigation. Ground water cleanup standards for contaminant concentrations in the Final Site-Wide ROD will be between MCLs and background.

Preliminary remedial action objectives for Site 300 are:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards that will be set in the Final Site-Wide ROD.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above the State and federal MCLs and any more stringent WQNLs.
- Prevent human incidental ingestion and direct dermal contact with contaminants in surface soil that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human inhalation of VOCs and tritium volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human inhalation of VOCs and tritium volatilizing from surface water to air that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human inhalation of contaminants bound to resuspended surface soil particles that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative hazard index greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality, at a minimum, to WQNLs that are protective of beneficial uses within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with WQNLs. 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.

There is no remedial action objective for human health protection/ARAR compliance for ingestion of surface waters (i.e., water from Site 300 springs) 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 gpd). Since there is no complete exposure pathway for human ingestion of surface water at the site, a remedial action objective was not developed for this pathway.

The Site-Wide Compliance Monitoring Plan/Contingency Plan (Ferry et al., 2002a) addresses the contingent processes and actions to be taken if the cleanup remedies are unsuccessful in meeting any of the remedial action objectives. Contingent actions may include further evaluations and/or application of new remediation approaches. Chapters 6 through 12 of this document evaluate the effectiveness of the interim remedies that were implemented at Site 300 to meet these remedial action objectives.

6. Building 834 (OU 2)

6.1. Background

This section describes the Building 834 OU, the chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

6.1.1. OU Description

The Building 834 Complex is located on an isolated hilltop in the southeast portion of Site 300 (Figure 3-5). Facilities at the Building 834 Complex have been in use since the late 1950s for thermal-cycling experiments conducted on weapon components. These experiments were performed in four main buildings surrounded by a ring of eight smaller test cells (Figure 6-1). Aboveground pipes carried TCE-based heat-exchange fluid from storage tanks at the main buildings to the test cells. From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface with TCE and the silicone oils TBOS and tetra-kis-2-ethylbutyl silane (TKEBS) at eight release points. Nitrate associated with septic-system effluent is also present in ground water.

The Building 834 OU is informally divided into three areas: the core, (septic system) leachfield, and distal areas (Figure 6-1). The core area generally refers to the vicinity of the buildings and test cells in the center of the Building 834 Complex where the majority of contaminant releases occurred. The septic system leachfield area is located immediately southwest of the core area. The distal area refers to the area downgradient (south) of the core and leachfield areas. The T2 area, located near well W-834-T2 on Figure 6-1, is within the distal area.

6.1.2. Site Chronology

A chronology of important environmental restoration events at the Building 834 OU is summarized below.

Late 1950s

- Experiments involving the thermal-cycling (i.e., repeated heating and cooling) of weapon components started at the Building 834 Complex.

1962–1978

- During the course of these experiments, VOCs, primarily TCE, were released through spills and piping leaks. TCE was used as the primary heat-transfer fluid during these experiments and was sometimes mixed with TBOS and TKEBS to prevent degradation of pump seals and gaskets.

1982–1983

- DOE/LLNL excavated approximately 100 cubic yards of TCE-contaminated soil resulting from spills and piping leaks.
- Site investigations began at Building 834.

1986

- Ground water and soil vapor extraction began as treatability studies.

1989

- Ground water and soil vapor extraction treatability studies ended and construction of a full-scale facility began at Building 834.

1990

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

1991

- DOE/LLNL conducted a treatability test using an electron accelerator to treat VOCs in extracted vapor. This technology was later screened out in the Site-Wide Feasibility Study due to the production of undesirable byproducts, including phosgene.

1992

- An FFA for Site 300 was signed. The parties to the Agreement included DOE, EPA, the California DTSC, and RWQCB.
- DOE/LLNL conducted an evaluation of a technology to treat extracted soil vapor using ultraviolet light and hydrogen peroxide. This technology was later screened out in the Site-Wide Feasibility Study due to the high energy and operation costs.
- An electrical soil heating (Joule heating) pilot test was performed. This technology was later screened out in the Site-Wide Feasibility Study due to limited applicability at Building 834.

1993

- The heat-exchange system was dismantled in 1993–1994.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued.

- A Feasibility Study for the Building 834 OU was issued.

1995

- An Interim ROD for the Building 834 OU was signed. Ground water extraction began as an interim remedial action. DOE also agreed to test innovative cleanup technologies at Building 834.

1998

- Soil vapor extraction began as an interim remedial action.
- DOE/LLNL began treatability studies to evaluate the role of intrinsic *in situ* biodegradation in reducing TCE mass and concentration. This process was found to be important in removing TCE from the subsurface and measures to maximize biodegradation are being incorporated into the cleanup.
- A surfactant "push-pull" treatability test was performed. This technology was subsequently screened out in the Site-Wide Feasibility Study due to difficulty in ensuring complete capture of mobilized contaminants and resulting risk of enhanced migration.
- A laboratory-scale treatability test was performed using soil from Building 834 to test the capability of potassium permanganate injection to destroy VOCs *in situ*. These tests indicated potential problems with injection and distribution of the potassium permanganate. Therefore, this technology was subsequently screened out in the Site-Wide Feasibility Study.
- Surface water drainage was diverted to prevent infiltration of precipitation in the Building 834 contaminant source area.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 834 OU.

2000

- Additional extraction well configuration testing was conducted at Building 834 to optimize interim remedial action performance.

2001

- An Interim Site-Wide ROD for Site 300 was signed that superceded the 1995 Interim ROD for the Building 834 OU. The Interim Site-Wide ROD specified continued ground water and soil vapor extraction, administrative controls (e.g., risk and hazard management), and monitoring as the components of the selected interim remedy for the Building 834 OU. The Interim Site-Wide ROD did not contain ground water cleanup standards. These standards will be established in the Final Site-Wide ROD for Site 300.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.
- DOE/LLNL performed treatability studies at the Building 834 OU that indicated that the existing air-sparging ground water treatment system could be replaced by an aqueous-phase granular activated carbon (GAC) system.

2002

- The Interim Remedial Design document for the Building 834 OU was issued.

- Submitted the Compliance Monitoring Plan/Contingency Plan for the Interim Remedies (Ferry et al., 2002a).
- The first 5-Year Review for the Building 834 OU was submitted.

2004

- Building 834 buildout and upgrade of the ground water and soil vapor extraction and treatment systems were completed.

2005

- A ground water tracer test and microcosm study was conducted to evaluate the feasibility of accelerating ground water cleanup through *in situ* bioremediation. Preliminary results are discussed in Section 6.4.3.5.

6.1.3. Hydrogeologic Setting

The vadose zone and primary HSUs in the Building 834 area are described below, from shallowest to deepest. A conceptual hydrostratigraphic column for the southeast corner portion of Site 300 including the Building 834 area is shown on Figure 3-2.

6.1.3.1. Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated to highly cemented gravel, sand, silt, and clay sediments beneath the Building 834 Complex that are unsaturated to a depth of approximately 30 ft bgs.

6.1.3.2. Saturated Zone

The three HSUs have been identified in the Building 834 area:

Perched Water-Bearing Zone (Tpsg HSU) – This unit consists of variably saturated, discontinuous perched water-bearing zone in Tertiary sand and gravel lenses (defined as the Tpsg HSU) below the vadose zone. The saturated thickness of the perched zone is up to 8 ft. Ground water in the perched Tpsg HSU generally flows toward the south. Figure 6-2 shows potentiometric surface elevation contours and ground water flow direction in the Tpsg HSU. Perched ground water in this HSU is not laterally continuous except for short periods of time following heavy rainfall events. The lateral extent of the perched zone is limited by the steep slopes to the north, east, and west of the Complex.

Perching Horizon (Tps-Tnsc$_2$ HSU) – Downward ground water and contaminant movement from the perched zone is inhibited by the underlying low-permeability Tps-Tnsc$_1$ clay and claystone HSU perching horizon. The thickness of the perching horizon ranges from 10 to 40 ft.

Regional Aquifer (Tnbs$_1$ HSU) – Approximately 280 ft of unsaturated, interbedded claystone (Tnsc$_1$) and sandstone (Tnbs$_2$ and Upper Tnbs$_1$) lie below the Tps perching horizon. A laterally-extensive regional aquifer (Lower Tnbs$_1$ HSU) occurs at a depth of about 340 ft bgs.

6.1.4. History of Contamination

The Building 834 facilities have been used since the 1950s for experiments involving the thermal cycling of weapon components. From 1962 to 1978, intermittent spills and piping leaks at eight release points resulted in contamination of the subsurface with VOCs, primarily TCE and cis-1,2-DCE, and silicone oils (TBOS and TKEBS). DOE estimates that approximately

550 gallons of TCE were released, either directly to the ground surface and/or to floor drains leading to a nearby septic system leach field. It is likely that a significant fraction of the total amount of TCE released volatilized without infiltrating into the subsurface. Elevated nitrate concentrations in ground water results from a combination of septic system effluent and natural sources. The amount of silicone oil and nitrate released has not been determined. Diesel, benzene, toluene, and ethylbenzene have been detected sporadically in ground water in the core area. The source of these contaminants is an underground fuel storage tank that was excavated in 1994 and closed with the concurrence of the State of California regulatory agencies; no further action is required.

6.1.5. Contaminants of Concern

Three COCs have been identified in ground water in the Building 834 OU: (1) VOCs, (2) TBOS/TKEBs, and (3) nitrate. VOCs have also been identified as COCs in subsurface soil/rock. Historical and current concentrations of these COCs are discussed in Section 6.4.2. No COCs were identified in surface soil or surface water.

The predominant contaminant in the vadose zone and ground water is TCE, a suspected human carcinogen. Due to the high concentrations detected, TCE is suspected to be present as a discontinuous, diminishing dense non-aqueous phase liquid (DNAPL) residual source in the subsurface. The baseline human health risk assessment estimated a maximum excess cancer risk of 1×10^{-3} to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 834D over a 30-year period. The baseline risk assessment also identified a human cancer risk of 6×10^{-4} for onsite workers continuously inhaling VOC vapors volatilizing from the vadose zone into outdoor air in the vicinity of Building 834D over a 30-year period.

The baseline ecological risk assessment for the Building 834 OU identified a hazard index greater than one for inhalation of VOCs in burrow air and for cadmium in surface soil for ground squirrels and the San Joaquin kit fox.

Significant concentrations of cis-1,2-DCE and low concentrations of vinyl chloride and ethane have been detected in ground water. The presence of these breakdown products is primarily the result of the *in situ* biodegradation of TCE. Tetrachloroethylene has also been detected in ground water samples.

Silicone oils (TBOS and TKEBS) occur as a light non-aqueous phase liquid (LNAPL) floating on perched ground water. Silicone oils are relatively non-toxic, and no health risks have been identified for these compounds.

Elevated nitrate concentrations in ground water results from a combination of natural and anthropogenic sources including septic system effluent. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations.

The ground water COCs are present in two shallow HSUs: the Tpsg HSU perched water-bearing gravel zone and the underlying Tps-$Tnsc_2$ HSU clay perching horizon. The Tpsg perched HSU is highly contaminated with VOCs and TBOS/TKEBS beneath the core area. Discontinuous VOC plumes extend into distal areas in this HSU. Nitrate is present in the Tpsg HSU in the vicinity of the septic tank leach field. Some VOC contamination is also present in the Tps-$Tnsc_2$ HSU clay perching horizon. COCs have not been detected in the unsaturated portion of the $Tnbs_1$ sandstone or in ground water in the lower $Tnbs_1$ regional aquifer.

COC distribution is shown on Table 3-1 and discussed further in Section 6.4.3.

6.1.6. Initial Response

DOE/LLNL began environmental investigations in the Building 834 area in 1983. Since then, 117 boreholes have been drilled in the Building 834 OU; 82 of these boreholes were completed as ground water monitor or extraction wells (Figure 6-1). Eleven wells have since been abandoned due to long well screens that were placed across two HSUs. The geologic and chemical data from these wells and boreholes are used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization also included soil vapor surveys, test pits, hydraulic testing, and geophysical surveys.

As summarized in Section 6.1.2, remediation activities at the Building 834 OU conducted prior to the 2001 Interim Site-Wide ROD included soil excavation, numerous treatability studies, soil vapor and ground water extraction, and diverting surface water drainage from contaminant source areas.

6.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented at the Building 834 OU.

6.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the remedy for the Building 834 OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The selected interim remedy for the Building 834 OU consists of:

1. Monitoring soil vapor and ground water to evaluate the effectiveness of the remedial action in reaching remediation goals, plus post-remediation monitoring.
2. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors.
3. Extraction and treatment of ground water and soil vapor to mitigate risk and hazards posed by VOCs in the subsurface soil and protect and restore beneficial uses of ground water.

6.2.2. Interim Remedy Implementation

Ground water and soil vapor extraction and treatment systems have been operating in the Building 834 OU since 1986; first as treatability studies and later as interim remedial actions. The location of ground water and soil vapor extraction wells and treatment systems are shown in Figure 6-1. Full-scale ground water extraction and treatment began in the Building 834 core (source) area in 1995 to reduce VOC concentrations and mass in ground water. Full-scale soil vapor extraction and treatment began in 1998 to reduce VOC concentrations and mass in the vadose zone. In the source area, ground water extraction is used to dewater the Tpsg HSU, creating a larger volume of soil available to extract VOCs in soil vapor. Typically, soil vapor extraction is more effective in removing VOCs than ground water extraction. In addition, the

negative pressure (i.e., vacuum) created in the well casing during soil vapor extraction enhances the yield of ground water from this low permeability HSU.

Due to the very low ground water yield from individual extraction wells (less than 0.1 gallons per minute [gpm]), the ground water treatment system has been operated in batch mode. The original treatment process utilized an oil-water separator to remove the floating silicon oils (TBOS/TKEBS) followed by air sparging to remove VOCs from ground water. The VOC-laden vapors were removed using vapor-phase GAC. Treated ground water was then discharged via a misting system. The soil vapor extraction system utilizes vapor-phase GAC for VOC removal. Treated vapors are discharged to the atmosphere under an air permit from the San Joaquin Valley Unified Air Pollution Control District.

In 2004, modifications were made to improve the performance of both the ground water treatment system and the extraction wellfield at the Building 834 OU. In 2004, the following modifications were made to the ground water treatment system:

- Replacement of the oil-water separator with floating hydrocarbon adsorption devices (pigs) placed in the influent ground water storage tank to remove any floating product that is extracted.
- Conversion from air sparging with vapor-phase GAC treatment to the use of aqueous-phase GAC to remove VOCs from ground water.
- Installation of monitoring equipment to measure the volume of ground water and soil vapor extracted from each well.

The core area extraction wellfield was also modified, reducing the number of extraction wells from 16 to nine wells. This modification was based on individual well performance data collected during a series of zone-of-influence tests conducted on core area extraction wells. Test data indicated seven extraction wells were not contributing significantly to mass removal. These seven wells were converted to performance monitoring wells and the remaining nine core area extraction wells extract both ground water and soil vapor.

In 2004, the ground water and soil vapor extraction wellfield was expanded to the VOC plume in the leachfield area to accelerate ground water cleanup. The average ground water extraction rate for the expanded extraction wellfield is approximately 4,000 gallons per month. Three additional extraction wells are located in the T2 area. Pumping of the T2 area ground water and soil vapor extraction wells is being delayed to conduct studies to evaluate the potential of utilizing *in situ* bioremediation in this area.

6.3. System Operation and Maintenance

In general, the Building 834 OU ground water and soil vapor extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this evaluation. All required documentation is in place, and treatment system operations and maintenance (O&M) activities are consistent with established procedures and protocols.

O&M procedures are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the Building 834 Treatment Facilities, contained within the Interim Remedial Design document (Gregory et al., 2002).

- Building 834 Treatment Facility Operations and Maintenance Manual (LLNL, in progress).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #11344: Ground Water and Soil Vapor Extraction at Building 834.
- Building 834 Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB.
- Building 834 Permit to Operate issued by the San Joaquin Valley Unified Air Pollution Control District.
- Site-Wide Compliance Monitoring Plan for Interim Remedies at LLNL Site 300 (Ferry et al., 2002a).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Depue, 2003).

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprises a large portion of the O&M activities. Ground water treatment system effluent is monitored to ensure compliance with discharge requirements. Vapor effluent from the soil vapor treatment system is monitored to ensure compliance with air permit discharge limits. Treatment system parameters such as pressure and flow are recorded to anticipate potential mechanical problems and monitor system performance.

The major O&M activities for the Building 834 ground water and soil vapor treatment systems include:

- Maintaining the particulate filters, blower, and compressor.
- Maintaining the misting towers used to discharge treated ground water.
- Protecting the unit from freezing in cold weather.
- Replacing spent GAC.
- Routinely inspecting and maintaining extraction well pumps, pipelines, the soil vapor extraction blower, and temperature and air flow sensors.
- Ensuring the temperature within the vapor-phase GAC units remains within the optimal range.
- Collecting condensate from vapor extraction lines and vapor-phase GAC units to maximize GAC adsorption capacity.

The treatment systems have consistently operated in compliance with all permits and regulatory requirements.

The budgeted and actual environmental restoration costs for the Building 834 OU are tracked closely and are consistently within the allocated budget.

6.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 834 OU was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-

making process are still valid. Data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 6.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 6.4.2 evaluates the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the Building 834 OU. Section 6.4.3 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) assessing the progress of remediation in reducing contaminant concentrations and plume size, (2) hydraulically controlling the plume, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 6.4.3 also includes a discussion of any new or innovative technologies that were assessed to expedite cleanup of the Building 834 OU.

6.4.1. Assessment of Logistical Factors

6.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in location-, chemical-, or action-specific ARARs or other requirements that were presented in the Interim Site-Wide ROD in 2001. However, ARARs related to ground water cleanup standards were not included in the Interim Site-Wide ROD. Potential ARARs related to ground water cleanup standards have been included for evaluation in this Site-Wide Evaluation Remedy Summary report in preparation for the selection of cleanup standards in the Final Site-Wide ROD. Potential ARARs for the cleanup of Site 300 are discussed in Chapter 5.

6.4.1.2. Changes in Land, Building, or Ground Water Use

There have been no changes in land, building, or ground water use in the Building 834 OU since the Interim Site-Wide ROD. The Building 834 Complex is still used for thermal cycling experiments and is accessible only to DOE/LLNL workers. Building 834D, where an unacceptable risk for VOC inhalation was identified, is still used only for storage and building occupancy restrictions remain in place as discussed in Section 6.4.2. Ground water underlying the Building 834 Complex is present in a shallow, perched HSU and is not used for water-supply.

6.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Building 834 OU since the Interim Site-Wide ROD was signed in 2001.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously

considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

6.4.2. Institutional Control Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD to prevent the exposure of onsite workers to contaminants at Building 834 were evaluated for effectiveness under the current conditions at the Building 834 OU. They are:

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing water-supply wells in the Building 834 OU. LLNL environmental restoration staff periodically meets with site planning personnel and ensure that any new water-supply wells are located in uncontaminated areas. There is no offsite ground water contamination resulting from releases at the Building 834 OU, and no offsite water-supply wells are in use near the OU.
- **Briefing personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in contaminated areas except under the supervision of hazards control staff. LLNL environmental restoration staff coordinates with Site 300 management to ensure that no excavation occurs in the Building 834 area without the proper controls in place.
- **Maintaining building occupancy and land use restrictions in the vicinity of Building 834D –** Building occupancy and land use restrictions have been implemented by the Facility Coordinator for Building 834 and the LLNL Space and Site Planning Department.
- **Installing warning signs in the vicinity of Building 834D –** Warning signs have been installed stating that full-time occupancy of Building 834D is prohibited.
- **Conducting annual risk evaluation for VOCs within and adjacent to Building 834D until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** An annual risk evaluation program was implemented and the indoor and outdoor risks were re-evaluated in 2003 and 2004. The results of the risk re-evaluation monitoring program are summarized in Section 6.4.3.3.
- **Conducting annual wildlife surveys to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program was implemented and completed in 2004. The results indicated that burrow air did not contain VOCs at concentrations that would result in a hazard quotient greater than 1. Since there is no potential for ecological harm, VOCs in burrow air has been deleted from the list of ecological COCs and are no longer evaluated and reported. In addition,

surveys for sensitive species at Building 834 have been discontinued because there are no surface soil COCs and no inhalation hazard associated with burrow air.

- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling and survey data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operation Safety Procedures are in place, and new procedures are created as needed.

6.4.3. Assessment of Technical Factors

6.4.3.1. Vadose Zone Remediation Progress

The effectiveness of the selected interim remedy to remediate VOCs in the vadose zone sources was evaluated by:

1. Reviewing VOC concentrations trends in soil vapor over time and mass removal data.
2. Reviewing dissolved-phase ground water VOC mass removal data.
3. Assessing VOC concentration rebound in ground water following the 2002 to 2004 rebound test.

Prior to the startup of the Building 834 soil vapor extraction (SVE) system in 1998, the highest, pre-remediation TCE concentrations measured in soil vapor in the core area ranged from 2,000 to 3,000 parts per million on a volume per volume basis ($ppm_{v/v}$). Since full-scale soil vapor extraction began in 1998, TCE concentrations in soil vapor in the core area decreased to a maximum of 11 $ppm_{v/v}$ in the 1st Semester of 2005. In 2004, SVE was initiated from three new dual-phase extraction wells located in the leachfield area. Prior to SVE startup, TCE concentrations in soil vapor from these wells ranged from 250 to 750 $ppm_{v/v}$. By August 2005, TCE concentrations in soil vapor samples from the leachfield wells had decreased to 20 to 200 $ppm_{v/v}$.

The original mass of VOCs estimated to have been present in the vadose zone was 602 to 1,118 kilograms (kg) (Ferry et al., 2002b). In 1982 and 1983, DOE/LLNL excavated approximately 100 cubic yards of TCE-contaminated soil at five locations within the Building 834 core area where heat-exchange fluid had been spilled or released from leaking pipes. The excavated soil contained approximately 96 kg of VOCs, representing 9 to 16% of the estimated pre-remediation mass of VOCs in the vadose zone. DOE/LLNL have not identified any other areas at the Building 834 Complex where excavation would be a cost-effective remedial technology.

Approximately 208 kg of VOCs have been removed by SVE since the remedial action began in 1998. An estimated additional 201 kg of VOCs were removed during earlier treatability testing. The total mass of VOC removed through soil vapor extraction represents 37 to 68% of the original mass. Although the SVE wells in the leachfield area have only operated for a limited

period of time, analytical data indicate significant VOC mass is being removed; accounting for approximately 90% (50 kg) of the VOC mass removed using SVE in 2004.

Measuring the rebound of VOC concentrations in soil vapor following a shutdown period is one of the best indicators of remediation progress. The extent of concentration rebound is indicative of the magnitude of the remaining VOC source in the vadose zone. VOC concentrations were measured in soil vapor samples from core area wells while the treatment system was shutdown for modifications in 2002 to 2003. Prior SVE system shutdown, the maximum VOC soil vapor concentration detected in SVE wells in the core area was 38 $ppm_{v/v}$. The maximum rebound VOC concentration detected in soil vapor in the year following SVE system shutdown was 75 $ppm_{v/v}$. Significant rebound of VOC concentrations in soil vapor was not detected during this time period, indicating that remediation efforts have been successful in reducing the VOC source in the vadose zone.

In summary, vadose zone remediation efforts are progressing as expected. VOC soil vapor concentrations in individual extraction wells in the core and leachfield areas and in treatment facility influent are decreasing. Rebound testing indicates that the VOC vadose zone source strength within the influence of the core area extraction well field has significantly decreased. The expansion of the dual-phase extraction wellfield to the leachfield area has significantly increased vapor-phase VOC mass removal at this OU. COC data do not indicate any new or increased impacts to ground water as a result of leaching of contaminants from the vadose zone to ground water.

6.4.3.2. Ground Water Remediation Progress

Ground water data were evaluated to assess the effectiveness of extraction and treatment to remediate VOCs, TBOS/TKEBS, and nitrate in ground water in the Building 834 OU. Remediation progress was evaluated by:

1. Comparing pre-remediation dissolved-phase COC concentrations and spatial distribution in ground water to 1st Semester 2005 data.
2. Reviewing COC concentration trends in ground water over time.
3. Assessing VOC concentration rebound in ground water following the 2002 to 2004 rebound test.
4. Reviewing dissolved-phase ground water VOC mass removal data.
5. Evaluating extraction well field capture zones.

The results of this evaluation for VOCs, TBOS/TKEBs, and nitrate in ground water are discussed below.

Volatile organic compounds in ground water – A comparison of the distribution of total VOCs in perched ground water in the Tpsg HSU before full-scale ground water extraction and treatment began in 1995 and in the 1st Semester of 2005 is shown in Figure 6-3. While the overall extent of VOCs detected in ground water has not changed significantly, the highest concentrations have decreased by several orders of magnitude during the last 10 years in the vicinity of the core area extraction wellfield. In addition, the 2005 VOC plume map shows that the extent of VOCs with concentrations greater than 10,000 μg/L has decreased significantly compared to the pre-remediation extent, especially in the core area. In the leachfield and distal areas, the extent of VOCs in ground water has not changed significantly because ground water

remediation in these areas did not begin until late 2004. The extent of VOCs in ground water in the leachfield and distal areas is expected to decrease in the next few years as a result of ground water extraction from the expanded wellfield. A hydrogeologic cross-section showing the vertical distribution of total VOCs in the Building 834 OU HSUs is shown in Figure 6-4.

VOC concentration trends in ground water over time are another important indicator of ground water remediation progress. As shown in Figures 6-5 and 6-6, VOC concentrations in ground water in the core and leachfield areas have decreased significantly from their maximum historical levels. The maximum historical VOC concentration in the perched Tpsg HSU in the core area has declined from 1,060,000 μg/L in 1993 (pre-remediation) to 32,000 μg/L in the 1st Semester of 2005. This concentration decrease is due primarily to dual-phase extraction and treatment, and to a much lesser extent to intrinsic bioremediation. Remediation efforts in the core area have not significantly reduced VOC concentrations in ground water in the low-permeability sediments of the Tps-$Tnsc_2$ HSU clay perching horizon. VOCs in the Tps- $Tnsc_2$ clay will likely act as a long-term source for diffusive flux into the overlying Tpsg HSU, significantly extending ground water cleanup time. As shown in Figure 6-7, VOC concentrations in ground water in the distal (T2) area have remained relatively stable because no active remediation has yet taken place in this area. While the extraction wellfield was expanded to the distal area in 2004, pumping from these wells has not yet been initiated while the *in situ* enhanced bioremediation study conducted. VOC concentrations remain below method detection limits (0.5 μg/L) in the $Tnbs_1$ regional aquifer.

Measuring the rebound of VOC concentrations in ground water following a shutdown period is one of the best indicators of remediation progress. The extent of concentration rebound is indicative of the magnitude of the remaining VOC source. VOC concentrations were measured in ground water samples from core area wells while the treatment system was shutdown for modifications in 2002 to 2003. Significant rebound of VOC concentrations was not detected during this time period, indicating that remediation efforts have been successful in reducing the VOC source.

Ground water remediation progress was also evaluated by estimating the reduction in VOC mass achieved through remediation. Estimates of dissolved phase VOC mass prior to the start of ground water remediation in 1995 ranged from 65 to 120 kg. As shown in Figure 6-8, approximately 34 kg of VOCs have been removed from the ground water. An estimated additional 6 kg of VOCs were removed during pre-1995 short-term treatability testing. The total mass of ground water VOCs removed ranges from 30 to 60% of the original mass. Future dissolved phase mass removal rates depend on several factors including: (1) variations in seasonal recharge and saturated thickness, (2) extraction well field configuration, (3) dissolution from residual DNAPL sources, and (4) the rate of VOC diffusive flux from low permeability Tps clay.

Conservative estimates of ground water capture by the core, leachfield, and distal (T2) area extraction well fields are presented in Figure 6-9. As shown in Figure 6-9, the core area extraction wellfield capture zones extend to the saturated limits of the perched zone to the north, west, and east of the core area. The significant decreases in VOC concentrations observed in leachfield well W-834-S1 since the mid-1980s, is likely due in part to the effective hydraulic capture by the upgradient core area wellfield. The recently added leachfield and distal area extraction wells are designed to achieve complete capture of the VOC plumes in those areas.

The capture plots shown in Figure 6-9 show the estimated extent of capture after 5 years of pumping and for steady-state conditions.

The capture zones presented in Figure 6-9 were generated using the WinFlow analytical element model discussed in Section B-3.3 of Appendix B to predict long-term capture zones based on current and planned extraction flow rates. The capture zones predicted by the WinFlow model are conservative because: (1) the basic model parameters used for each model are selected conservatively (i.e., maximum aquifer thickness, hydraulic conductivity, and hydraulic gradient values), and (2) the WinFlow model assumes an infinite extent of saturation, while the extent of saturation in the Tpsg and Tps-$Tnsc_2$ HSUs is limited.

Once the extraction wellfield in the Building 834 distal plume area has operated long enough for capture zones to fully develop, DOE/LLNL will evaluate the extent of capture and the ability of the extraction wellfield to achieve ground water RAOs. This evaluation will be based on ground water elevation contours and concentration trends in extraction and performance monitoring wells. DOE/LLNL expects that the capture zones at Building 834 OU will extend to the entire extent of saturation, including the area south of the distal area and the area between W-834-S1 and W-834-S13. For example, capture in the core area has already influenced the entire extent of saturation due to higher flow rates enhanced by soil vapor extraction and the limited extent of saturation.

If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield will be implemented. Modifications may include changes to the extraction well pumping strategy and/or installing additional extraction wells.

TBOS/TKEBs in ground water – Although TBOS/TKEBS concentrations have significantly decreased, these compounds continue to be detected at high concentrations in some wells in the core area. The highest historical concentration of these compounds dissolved in ground water was 7,300,000 μg/L (1995). The maximum concentration detected in 1st quarter 2005 was 22,000 μg/L. Time-series plots of TBOS concentrations in ground water in well W-834-D3 and treatment facility influent are shown in Figure 6-10. The wells with the historical concentrations of TBOS vary from one sampling event to the next, likely due to varying amounts of free-phase TBOS in the sample. The silicone oil contamination in the subsurface is contained within the lateral and vertical distribution of the VOC plume. Therefore, the extraction wellfield for VOC cleanup will be used to remediate TBOS/TKEBS in ground water. Since 1995, approximately 10 kg of silicone oils have been extracted.

Nitrate in ground water – Elevated levels of nitrate occur in the ground water throughout the Building 834 OU with concentrations ranging from less than 0.44 milligrams per liter (mg/L) to 329 mg/L during the 1st Semester of 2005. The highest historical concentration of nitrate in ground water (750 mg/L) was detected near the septic system leachfield in 2000. Generally lower concentrations of nitrate occur in the core area. The low nitrate levels in this area are related to denitrification associated with intrinsic *in situ* biodegradation. Although both natural (soil) and anthropogenic (septic) sources contribute to the nitrate in the perched ground water, the septic source is likely to be the most significant. Nitrate concentrations remain below detection limits in ground water from the deep $Tnbs_1$ HSU guard wells. Since 1995, approximately 67 kg of nitrate has been extracted from ground water.

Toluene and xylenes in ground water – Although not identified as COCs in the Interim Site-Wide ROD, benzene, toluene, ethylbenzene, and xylene (BTEX) compounds and diesel continue to be monitored at the request of the regulatory agencies. Samples from only two wells contained BTEX compounds and diesel in the 1st Semester of 2005. Toluene and xylene compounds were detected at concentrations well below their State and Federal MCLs. Benzene concentrations (1.2 μg/L) were below the Federal MCL (5 μg/L) but slightly above the State MCL (1 μg/L).

6.4.3.3. Risk Mitigation Remediation Progress

This section summarizes the results the annual risk re-evaluations conducted for the Building 834 OU to assess the progress of the remediation effort in mitigating VOC inhalation risk to onsite workers in indoor and outdoor air at Building 834D. The risks from Building 834 COCs were summarized in Section 6.1.5 and described in more detail in the Interim ROD.

The risks associated with VOCs in subsurface soil at Building 834D were re-evaluated in 2003 and 2004 as part of the Risk and Hazard Management Program. Soil vapor extraction at Building 834 has contributed to reducing the human health risk due to inhalation of VOC vapors outside Building 834D to a level that is no longer of concern (less than 10^{-6}). Although Building 834D indoor air continues to present an unacceptable risk (greater than 10^{-6}) to onsite workers, the risk evaluations conducted in 2003 and 2004 indicate both risk and hazard are being reduced. Building 834D continues to be used only for storage and institutional controls are in place to prevent human exposure.

The results of the ecological survey program conducted in 2004 indicated that burrow air did not contain VOCs at concentrations that would result in a hazard index or quotient greater than 1. In addition, surface soil sampling and analysis for cadmium conducted in 2003 indicated there was no ecological hazard associated with cadmium in surface soil at Building 834. Therefore cadmium has been deleted from the list of ecological COCs and will no longer be evaluated and reported.

6.4.3.4. New Sources, Releases, or Contaminants

Ground water and soil vapor data indicate there are no new sources, releases, or contaminants in the Building 834 OU.

In 1999 through 2001, ground water samples were collected for perchlorate analysis to determine if this constituent was present in Building 834 ground water. Perchlorate was detected in ground water samples collected from two wells in the Building 834 OU at concentrations just above the method detection limit of 4 μg/L. In 2005, perchlorate was detected in ground water samples collected from four newly installed wells at concentrations ranging from 4.7 to 28 μg/L. However, perchlorate was not detected in a verification sample that was immediately collected from one of these wells. All monitor wells in the Building 834 OU are scheduled for resampling and perchlorate analysis in 2007. Results will be reported in the 2007 Annual Site-Wide Compliance Monitoring Report for Site 300. If these results indicate it is warranted, specific wells may continue to be monitored for perchlorate in ground water. This decision will be made in consultation with the regulatory agencies.

In 2004, n-butyl-benzenesulfonamide was identified in Building 834 ground water monitor wells. Following an evaluation of possible sources of the n-butyl-benzenesulfonamide, it was

determined that the compound was leaching from the nylon tubing used with the ground water extraction pumps. The tubing was replaced to correct the problem.

6.4.3.5. New Technology Assessment

As discussed in Section 6.1.2, several innovative technologies have been tested in the Building 834 OU to determine if they were more effective in VOC cleanup than the pump-and-treat technology. The technologies included electron acceleration, ultraviolet light/peroxidation, electrical soil heating, surfactant "push-pull", and potassium-permanganate injection. These innovative technologies were screened out in the Interim Site-Wide Feasibility Study based on cost, effectiveness, and/or the creation of additional problems such as toxic byproducts.

The feasibility of implementing an *in situ* enhanced bioremediation technology is currently being tested in the T2 area. The first phase of the enhanced bioremediation study that consisted of a tracer test and microcosm study, has been completed. The tracer test was performed to determine: (1) the reagent injection rate, (2) the transit time for the injected reagent, and (3) to identify the presence of any preferential flow paths. The tracer test results will be used to determine whether injection of a fluid reagent, such as lactate or ethanol, is feasible. The microcosm study was conducted to evaluate if indigenous bacteria are capable of completely degrading TCE or if the natural bacterial population needs to be augmented with non-indigenous bacteria that have this capability. Preliminary microcosm test results indicate that indigenous bacteria readily degrade TCE to cis-1,2-DCE but are limited in their ability to complete the reaction to the non-toxic end product ethane. However, the preliminary microcosm test results indicate that with bioaugmentation and introduction of a carbon source, the degradation reaction is completed. If the final results of the tracer test and microcosm study indicate that injection of a reactive material will accelerate ground water cleanup, a field test will be considered. The results of this study will be used to determine whether to implement enhanced bioremediation to provide more efficient, cost effective cleanup of the Building 834 OU, and possibly at other Site 300 OUs.

Other innovative technologies that enhance the permeability of low-yield formations and therefore potentially increase contaminant mass removal are also being considered for future application. The ability to control the fracturing and breaching of the integrity of the perching horizon is a major concern in applying these types of technologies.

6.5. Protectiveness Assessment

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

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

This evaluation determined that the interim remedy for the Building 834 OU is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements since the Interim Site-Wide ROD for Site 300 (2001) was

signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.

- There have been no changes in land, building, or water use in the Building 834 OU since the Interim Site-Wide ROD for Site 300 was signed.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Ground water and soil vapor extraction are reducing contaminant concentrations in the subsurface. The maximum VOC concentrations in ground water in the perched Tpsg HSU have decreased by approximately two orders of magnitude, although high concentrations remain in the upper part of the underlying low-permeability Tps clay perching horizon. The ground water and soil vapor extraction wellfield has been expanded to remove contaminant mass and decrease COC concentrations in the distal plumes. DOE/LLNL have removed approximately 545 kg of VOCs from the subsurface, representing 44 to 81% of the mass of total VOCs that were present prior to remediation. Of the total mass removed from the subsurface, 75% has been through soil vapor extraction, 18% through excavation, and 7% through ground water extraction. These data indicate that soil vapor extraction is much more effective than ground water extraction in removing contaminants from the subsurface. Mass removal rates are declining for both ground water and soil vapor in the core area as significant amounts of VOC mass have already been removed from the more permeable Tpsg sediments. However, VOCs continue to diffuse slowly from lower permeability Tps clay perching horizon.
- The treatment systems are performing as designed and will continue to be operated and optimized.
- System operation procedures are consistent with requirements.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No new sources, releases, or contaminants have been identified in the Building 834 OU.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

6.6. Deficiencies

No deficiencies in the overall approach specified in the interim remedy for the Building 834 OU were identified during the evaluation. However, the length of time necessary to achieve ground water cleanup standards using pump and treat technologies may be long due to: (1) low well yields resulting from the recharge-limited nature of the Tpsg HSU, (2) VOCs that will likely continue to diffuse from the low permeability Tps clay into perched ground water in the

overlying Tpsg HSU, and (3) the limited ability of pump and treat technology to remove VOCs from low-permeability sediments in the Tps HSU.

Experimental treatment technologies, such as bioremediation or hydraulic fracturing, are being evaluated to determine if these technologies can improve the long-term performance of the selected remedy.

6.7. Recommended Changes

Ground water and soil vapor extraction and treatment continue to make progress toward reducing contaminant concentrations and mass in the vadose zone and ground water. DOE/LLNL have implemented all the actions required in the Interim Site-Wide ROD, the Remedial Design Work Plan for the Interim Remedies (Ferry et al., 2001), and the Interim Remedial Design document for the Building 834 OU (Gregory et al., 2002).

In addition, DOE/LLNL will continue to evaluate other remedial technologies, such as *in situ* bioremediation, that could shorten cleanup time, especially those that will facilitate remediation of the low-permeability sediments. However, even if these technologies are implemented, it may not be possible to fully remediate VOCs in the low-permeability sediments.

As a result, it may not be technically or economically feasible to achieve even the 5 μg/L TCE MCL in ground water at the Building 834 OU. Because the perched Tpsg HSU at Building 834: (1) is not used as a source of water due to poor water quality and low well yield, (2) is isolated from the underlying regional water-supply aquifer (lower $Tnbs_1$ HSU), and (3) water in this HSU cannot migrate laterally outside the Building 834 area, DOE may submit a Technical/Economic Impracticability/Containment Zone Waiver for ground water in the Building 834 OU in the future.

No other follow-up actions were identified related to this evaluation.

6.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy. The proposed final remedy for the Building 834 OU consists of:

1. Monitoring soil vapor and ground water to evaluate the effectiveness of the remedial action in reaching remediation goals, plus post-remediation monitoring.
2. Risk and hazard management, including institutional/land use controls, to prevent contaminant exposure to humans and impacts to ecological receptors. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.
3. Extraction and treatment of ground water and soil vapor to mitigate risk and hazards posed by VOCs in the subsurface soil and protect and restore beneficial uses of ground water.
4. Continuing to evaluate innovative technologies, such as enhanced biodegradation and hydraulic fracturing, to improve remediation of VOCs residing in low permeability sediments.

6.9. Protectiveness Statement

The proposed final remedy for the Building 834 OU is expected to be sufficiently protective of human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, sufficient to control risks, and properly implemented, (2) ground water and soil vapor extraction and treatment are reducing contaminant concentrations in the subsurface, and (3) institutional controls to minimize heath risks and prevent use of contaminated ground water are in place. Therefore, it is proposed that the interim remedy is sufficiently protective of human health and the environment to serve as the final remedy for the Building 834 OU.

7. Pit 6 Landfill (OU 3)

7.1. Background

This section describes the Pit 6 Landfill OU, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

7.1.1. OU Description

The Pit 6 Landfill OU is located in the southwest corner of Site 300 (Figure 3-5). Most of the OU is undeveloped, and the only LLNL buildings located there are used to support firearms training operations by the LLNL Protective Forces Department. From 1964 to 1973, waste from the LLNL Livermore Site and Lawrence Berkeley Laboratory was buried in nine unlined debris trenches and animal pits at the Pit 6 Landfill. The waste included laboratory equipment, craft shop debris, and biomedical waste. DOE/LLNL excavated the portion of waste containing depleted uranium in 1971. VOCs, tritium, and perchlorate are present in ground water immediately downgradient from the landfill. Nitrate has also been detected in ground water about 500 ft downgradient of the landfill. The landfill was capped in 1997 under CERCLA to prevent infiltrating rainwater from further leaching contaminants from the buried waste and to mitigate potential inhalation risks.

Two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east of the Pit 6 landfill (Figure 7-1). They provide water for the nearby Carnegie State Park and are monitored on a monthly basis.

7.1.2. Site Chronology

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

1960s to 1970s

- Waste was buried at the Pit 6 Landfill.

1971

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

1982

Site investigations began at the Pit 6 Landfill.

1987

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

1990

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

1992

- An FFA for Site 300 was signed.

1994

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

1997

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

1998

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

1999

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

2001

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

2002

- Submitted the Compliance Monitoring Plan/Contingency Plan for the Interim Remedies (Ferry et al., 2002a).

7.1.3. Hydrogeologic Setting

This section describes the general hydrogeologic setting for the Pit 6 Landfill OU including the unsaturated zone and the two HSUs underlying the landfill, and surface water located in the vicinity of Pit 6. A conceptual hydrostratigraphic column for the Pit 6 Landfill area is shown on the southeast corner portion of Figure 3-2.

The Pit 6 Landfill is located in the Corral Hollow-Carnegie fault zone, a series of subparallel, northwest-southeast trending strike-slip faults (Figure 7-1). Because this fault zone has a significant effect on the hydrogeology of the Pit 6 Landfill area, it is briefly described below.

The northern limit of the Corral Hollow-Carnegie fault zone (hereafter referred to as the fault zone) is located beneath the Pit 6 Landfill (Figure 7-1). It represents a structural discontinuity and hydraulic barrier that creates two ground water flow regimes in the bedrock North of the fault zone, the Neroly $Tnbs_1$ bedrock dips 10 to 20 degrees to the south-southwest. Within the fault zone, bedrock units are steep to vertically-dipping.

The $Tnbs_1$ bedrock within and north of the fault zone is unconformably overlain by Quaternary terrace (Qt) deposits. The fault does not extend into or offset these deposits. Figure 7-2 presents a potentiometric surface map for the $Tnsbs_1$ bedrock HSUs north and within the fault zone.

7.1.3.1. Vadose (Unsaturated) Zone

Unconsolidated Quaternary alluvial terrace deposits (Qt) composed of silty and clayey sand and gravel beneath the Pit 6 Landfill are unsaturated to a depth of approximately 25 ft bgs north of the fault zone and variably saturated within the fault zone.

7.1.3.2. Saturated Zone

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

Qt-$Tnbs_1$ North HSU – Ground water north of the fault zone occurs in Qt deposits and fractured Neroly $Tnbs_1$ bedrock. Depth to ground water in this HSU ranges from 25 to over 60 ft bgs; approximately 10 to 15 ft below the base of the buried waste in Pit 6. As shown in Figure 7-2, ground water in this HSU exhibits a relatively flat gradient and flows to the east-southeast. Saturation in the Qt is laterally discontinuous and consists of, at most, a few feet of saturated silty gravel overlying the bedrock contact. Recharge for this unit occurs in the hills to the north and known discharge occurs locally as Springs 7, 8, and 15.

A deeper water-bearing zone has been identified in a separate fracture zone at depth in the $Tnbs_1$ stratigraphic unit. Data indicate that this deeper $Tnbs_1$ water-bearing zone is not in hydraulic communication with the Qt and shallow $Tnbs_1$ fractured bedrock. Ground water levels in the deeper $Tnbs_1$ water-bearing zone do not respond to pumping of wells completed in the Qt-shallow $Tnbs_1$ HSU. Therefore, the deeper $Tnbs_1$ water-bearing zone is considered as a separate HSU. However, since this deeper $Tnbs_1$ HSU is monitored regularly and it has not been impacted by contamination, it is not discussed further in this chapter.

Qt-$Tnsb_1$ South HSU – The Qt-$Tnbs_1$ South HSU consists of semiconsolidated Qt deposits that unconformably overlie vertically-dipping, folded Neroly $Tnbs_1$ and Cierbo Formation (Tmss) bedrock. As shown in Figure 7-2, ground water elevations in this HSU are typically 5 to 8 ft higher than water levels in the Qt-$Tnbs_1$ North HSU. The saturated thickness within the Qt-$Tnbs_1$ South HSU is spatially and temporally variable, depending on the magnitude of seasonal rainfall. Ground water in this HSU generally flows to the east.

Qal-Tts HSU – The Qal-Tts HSU is restricted to the area south of Corral Hollow Road and consists of Quaternary alluvial deposits (Qal) associated with Corral Hollow Creek and the underlying Tesla Formations (Tts). Tts deposits are vertical and locally overturned in the area. Ground water elevations in the Qal-Tts HSU are typically 25 to 30 ft lower than in the Qt-$Tnbs_1$

HSUs. Shallow ground water is ephemeral and present in the Qal only following heavy precipitation. Ground water in the Qal flows eastward in the same direction as surface flow in Corral Hollow Creek.

7.1.3.3. Surface Water

Three springs, Springs 7, 8, and 15, are located in the immediate vicinity of the Pit 6 Landfill and occur in along traces of the fault zone (Figure 7-1). When present, water in these springs is derived from the Qt-$Tnbs_1$ South HSU. Spring 8 is a perennial spring located about 550 ft southwest and hydraulically crossgradient of Pit 6. Ground water flows into Spring 8 at approximately 1 gpm.

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

A small man-made pond is located in the Carnegie State Park Residence Area, situated approximately 1,500 ft east-southeast of the Pit 6 Landfill. The CARNRW-1 well supplies ground water for filling the residence pond.

7.1.4. History of Contamination

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

7.1.5. Contaminants of Concern

Four COCs have been identified in ground water in the Pit 6 Landfill OU: (1) VOCs, (2) tritium, (3) perchlorate, and (4) nitrate. The ground water COCs are present in ground water in the Qt and shallow $Tnbs_1$ bedrock HSUs. No COCs have been detected in Qal-Tts HSU ground water. VOCs have also been identified as a COC in surface water at Spring 7 when water is present. Historical and current concentrations of these contaminants are discussed in Section 7.4.3. No COCs were identified in surface soil or subsurface soil/rock in the vadose zone.

VOCs, primarily TCE, a suspected human carcinogen, are present in the Pit 6 waste, ground water, and surface water when present in Spring 7. The baseline human health risk assessment estimated a maximum excess cancer risk of 5×10^{-6} to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 30-year period. An excess cancer risk of 4×10^{-5} was also identified for onsite workers inhaling

VOC vapors from surface water at Spring 7. Since this spring has been dry for several years, there is currently no potential for VOC inhalation. The baseline risk assessment also identified a future cancer risk for offsite residents inhaling TCE volatilizing from the State Vehicular Recreation Area residence pond located east of the landfill. The baseline ecological risk assessment for the Pit 6 Landfill identified a hazard index greater than one for inhalation of VOCs in burrow air for ground squirrels and the San Joaquin kit fox.

While tritium, a potential human carcinogen, occurs naturally at low activities in the environment, it is present in ground water in the Pit 6 Landfill OU above background levels (but below its MCL) as a result of releases from the landfill prior to capping of the pits. There was no unacceptable human health risk or hazard identified associated with tritium in ground water.

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (EPA, 2005). There was no unacceptable human health risk or hazard identified associated with perchlorate in ground water in the Pit 6 Landfill area.

Nitrate in ground water likely results from septic system effluent but may also have natural sources. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. There was no human health risk or hazard identified associated with nitrate in ground water.

At the Pit 6 Landfill OU, COCs are present in ground water in the Qt-$Tnbs_1$ North and Qt-$Tnbs_1$ South HSUs. VOCs and tritium are detected in ground water in the Qt-$Tnbs_1$ North HSU. VOCs, tritium, perchlorate, and nitrate are all detected in ground water in the Qt-$Tnbs_1$ South HSU. However, tritium in Qt-$Tnbs_1$ South HSU ground water is more limited in extent than in the Qt-$Tnbs_1$ North HSU. No contamination has been detected in the Qal-Tts HSU or the deeper $Tnbs_1$ HSU.

7.1.6. Initial Response

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

Remediation activities at the Pit 6 Landfill OU conducted prior to the Interim Site-Wide ROD included excavation of landfill waste containing depleted uranium in 1971. CERCLA closure of the Pit 6 Landfill was completed in 1997 with the construction of an impermeable cap over the landfill and a surface water drainage system designed to prevent rainwater from contacting the buried waste. The impermeable cap also prevents VOCs in the buried waste from degassing to the atmosphere. EPA, DTSC, and the RWQCB approved the post-closure monitoring plan in May 1998.

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

7.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented at the Pit 6 Landfill OU.

7.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the interim remedy for the Pit 6 Landfill OU was selected based on its ability to: (1) contain contaminant sources, (2) reduce the toxicity, mobility, and volume of contaminants through irreversible chemical degradation and radioactive decay (natural attenuation), and (3) provide a mechanism for establishing achievement of these goals in a timeframe comparable to active remediation. The engineered cap that was installed as a removal action in 1997 to contain contaminant sources in the landfill is considered part of the interim remedial action. The radioactive decay of tritium and degradation of TCE are irreversible and hence effective in the long term and permanent. The toxicity and volume of VOCs and tritium are reduced by natural degradation and decay and there would be no impacts on the community, onsite workers, or ecological receptors from these processes.

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

1. Monitoring ground water and surface water.
2. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors.
3. Monitored natural attenuation of VOCs and tritium in ground water.

7.2.2. Interim Remedy Implementation

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

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

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

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

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

As part of the corrective action monitoring program, ground water samples are collected from downgradient wells and analyzed for ground water COCs including:

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

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

In addition, institutional controls such as activity and construction restrictions have been implemented to prevent damage to the landfill cap. Fencing and a full-time security force prevent access to the landfill by unauthorized personnel.

7.3. System Operation and Maintenance

The interim remedy for the Pit 6 Landfill OU is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cap maintenance and monitoring procedures are consistent with established procedures and protocols.

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

- Post-Closure Plan for the Pit 6 Landfill Operable Unit at LLNL Site 300 (Ferry et al., 1998).
- Site-Wide Compliance Monitoring Plan for Interim Remedies at LLNL Site 300 (Ferry et al., 2002a).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Depue, 2003).

The major O&M activities for the Pit 6 Landfill interim remedy include:

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

The budgeted and actual environmental restoration costs for the Pit 6 Landfill OU are tracked closely and are consistently within the allocated budget.

7.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Pit 6 Landfill was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that will call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 7.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 7.4.2 evaluates the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the Pit 6 Landfill OU. Section 7.4.3 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) containing the contaminant source in the Pit 6 Landfill, (2) assessing the progress of natural attenuation in reducing contaminant concentrations and plume size, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 7.4.3 also includes a discussion of any new or innovative technologies that were assessed to expedite cleanup of the Pit 6 Landfill OU.

7.4.1. Assessment of Logistical Factors

7.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed in 2001. The State of California Office of Environmental Health Hazard Assessment has identified a new Public Health Goal of 400 picocuries per liter (pCi/L) for tritium, which is a To-Be-Considered Requirement, but not an ARAR.

7.4.1.2. Changes in Land, Building, or Ground Water Use

There have been no changes in land, building, or ground water use in the Pit 6 Landfill OU since the Interim Site-Wide ROD. Most of the Pit 6 Landfill OU area remains undeveloped. The buildings and firing ranges are still used to support firearms training operations for the LLNL Protective Forces Department. The property south and east of the Pit 6 Landfill OU remains under the ownership of the State of California Department of Parks and Recreation. The Carnegie State Park located to the south continues to be used by recreational off-road motorcyclists. Approximately 3 acres of the Carnegie State Park to the east contains four mobile homes that are still used for housing park personnel.

There are two water-supply wells located on this 3-acre parcel that are still used to supply water for dust-suppression and fire-fighting at the Carnegie State Park. Water from one of the wells is also used to supply potable water to the park and ranger residences. There are no onsite water-supply wells in the Pit 6 Landfill OU.

7.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Pit 6 Landfill OU since the Interim Site-Wide ROD.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

7.4.2. Institutional Control Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD for Site 300 were evaluated for effectiveness under the current conditions at the Pit 6 Landfill OU, as discussed below.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing onsite water-supply wells in the Pit 6 Landfill OU. LLNL environmental restoration staff routinely meets with site planning personnel and ensure that any new water-supply wells would be located in uncontaminated areas. DOE/LLNL collect monthly ground water samples from the Carnegie State Park water-supply wells CARNRW-1 and -2 to detect any new contaminants in these wells. In addition, quarterly ground water samples are analyzed from upgradient guard wells, located between onsite contamination and the Carnegie water-supply wells to provide an early indication of contaminant migration toward these wells.
- **Briefing personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination or the Pit 6 Landfill except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in contaminated area except under the supervision of Hazards Control staff.
- **Maintaining the Pit 6 Landfill cap –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that the Pit 6 Landfill cap is maintained and to prohibit activities that could impact the integrity of the cap.
- **Maintaining land use restrictions in the vicinity of Spring 7 and Pit 6 Landfill –** Land use restrictions have been implemented by the Site 300 Manager and the LLNL Space and Site Planning Department.

- **Inspecting Spring 7 in conjunction with quarterly ground water monitoring of Landfill Pit 6 to determine if the spring is flowing –** Inspections are made as specified and ambient air sampling is only conducted if water is flowing.
- **Sampling outdoor air annually for VOCs at Spring 7 until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** The results of the risk re-evaluation monitoring program are summarized in Section 7.4.3.2.
- **Conducting annual wildlife surveys to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program was implemented and completed in 2004. The results indicated that burrow air did not contain VOCs at concentrations that would result in a hazard index or quotient greater than 1. Since there is no potential for ecological harm, VOCs in burrow air has been deleted from the list of ecological COCs and will no longer be evaluated and reported. In addition, surveys for sensitive species at the Pit 6 Landfill has been discontinued.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling and survey data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operation Safety Procedures are in place, and new procedures are created as needed.

7.4.3. Assessment of Technical Factors

7.4.3.1. Ground Water Remediation Progress

Ground and surface water data were evaluated to assess the effectiveness of source containment (capping) and the natural attenuation of COCs at the Pit 6 Landfill OU. Remediation progress was evaluated by:

- Comparing the distribution of COCs in ground water prior to installation of the landfill cap and in the 1st Semester of 2005, where possible.
- Assessing COC concentrations trends in ground and surface water over time.
- Assessing ground water data in downgradient offsite water-supply wells.

The results of the evaluation for VOCs, tritium, perchlorate, and nitrate in ground water, and VOCs in surface water (Spring 7) are discussed below.

Volatile organic compounds in ground water – A comparison of the distribution of total VOCs in ground water in 1990 before the landfill cap was installed and in the 1st Semester of 2005 is shown in Figure 7-3. In 1997, VOCs were detected 475 ft downgradient from the landfill in the Qt-$Tnbs_1$ South HSU within the Corral Hollow Creek-Carnegie fault zone. In the 1st Semester of 2005, this distance has been reduced to 400 ft. A hydrogeologic cross-section showing the vertical distribution of total VOCs in the Pit 6 Landfill OU HSU within the Corral

Hollow Creek-Carnegie fault zone is shown in Figure 7-4. In addition, from 1997 to 2005, the extent of the VOC plume north of the fault zone has been significantly reduced.

Time-series plots of TCE concentrations in ground water samples from selected wells in the Pit 6 Landfill OU are shown in Figures 7-5 and 7-6. As shown in Figure 7-5, TCE concentrations in Qt-Tnbs$_1$ North ground water north of the fault zone remain near or at the 0.5 μg/L TCE detection limit. As shown in Figure 7-6(a), TCE concentrations in ground water within the fault zone have decreased significantly from an historical maximum of 250 μg/L in 1987 to a maximum concentration of 6 µg/L in 2005. During the 1st Semester of 2005, TCE was detected at concentration just exceeding the 5 μg/L MCL (6 μg/L) in a ground water sample from only one well (Figure 7-6b). PCE and cis-1,2-DCE concentrations in ground water remain well below their MCLs of 5 μg/L and 6 μg/L, respectively, and continue to decline. The cis-1,2-DCE detected in ground water is likely a product of the natural degradation of TCE. This indicates that VOCs in ground water in the Pit 6 Landfill OU continue to naturally attenuate.

To date, VOCs have not been detected above detection limits in downgradient CARNRW1 and CARNRW2 water-supply wells.

These data indicate that VOCs in ground water at the Pit 6 Landfill continue to meet EPA's criteria that monitored natural attenuation is capable of achieving the site's remedial objectives within a reasonable time frame compared to other remedial technologies. The data also support the continued presence of the elements that are important to establishing an MNA remedy: (1) the contamination is not currently posing an unacceptable risk, (2) source control measures have been implemented, and (3) static or retreating VOC plume contours. The natural attenuation of VOCs in the Pit 6 Landfill OU is demonstrated through multiple lines of evidence, including static or retreating plume concentration contours and the presence of contaminant breakdown products.

Tritium in ground water – The distribution of tritium in ground water in 1997 before the landfill cap was installed is compared with its distribution in 2005 is shown in Figure 7-7. In 1997, the tritium plume extended a maximum of 900 ft downgradient from the landfill. As of the 1st Semester of 2005, this distance has been reduced to 700 ft. A hydrogeologic cross-section showing the vertical distribution of tritium in the Pit 6 Landfill OU HSU north of the Corral Hollow Creek-Carnegie fault zone is shown in Figure 7-8.

While tritium in ground water continues to be detected above background activities of 100 pCi/L, tritium activities measured during 2005 remained far below the 20,000 pCi/L MCL. The maximum tritium activities measured in ground water in the Pit 6 OU have always been at least an order of magnitude below the tritium MCL. Time-series plots of tritium activities in ground water samples from selected wells in the Pit 6 Landfill OU are shown in Figures 7-9 and 7-10. North of the fault zone, the ground water tritium activity continues to decline from the historical maximum activity of 3,420 pCi/L in 2003 to a 2005 maximum activity of 1,490 pCi/L (Figure 7-9). Within the fault zone, maximum tritium activities in ground water declined from 2,520 pCi/L in October 1999 to 427 pCi/L in May 2005 (Figure 7-10). The observed decreasing temporal trends in tritium activity and reduction in spatial extent indicate that tritium is naturally attenuating through radioactive decay and dispersion.

To date, tritium has not been detected above the 100 pCi/L background level in the downgradient offsite water-supply wells CARNRW1 and CARNRW2.

These data indicate that tritium in ground water at the Pit 6 Landfill continue to meet EPA's criteria that monitored natural attenuation is capable of achieving the site's remedial objectives within a reasonable time frame compared to other remedial technologies. The data also support the continued presence of the elements that are important to establishing an MNA remedy: (1) the contamination is not currently posing an unacceptable risk, (2) source control measures have been implemented, and (3) static or retreating tritium plume contours.

Perchlorate in ground water – Time-series plots of perchlorate concentrations in ground water samples from selected wells in the Pit 6 Landfill OU are shown in Figures 7-11 and 7-12. Perchlorate concentrations in ground water have been steadily decreasing from their historical maximum concentration of 65 μg/L in 1998. During the 1st Semester of 2005, perchlorate was detected in ground water in only one well in the Pit 6 landfill OU above the method reporting limit of 4 μg/L. The perchlorate concentration detected in the sample from this well (4.6 μg/L) was below the 6 μg/L Public Health Goal. Figure 7-12 shows perchlorate concentrations from one well north of the fault zone. Perchlorate concentrations in this well decreased from a maximum of 8 μg/L in October 2002 to below the 4 μg/L detection limit in October 2004. Within the fault zone, perchlorate concentrations decreased from 65 μg/L in November 1998 to 4 μg/L in May 2005 (Figure 7-11). The declining concentration trends indicate that perchlorate continues to naturally attenuate.

Perchlorate has not been detected above 4 μg/L detection limits in the downgradient offsite water-supply wells CARNRW1 and CARNRW2.

Nitrate in ground water – Nitrate concentrations in ground water have been variable over time with a maximum historical concentration of 228 mg/L detected in 1998. However, the distribution of nitrate in ground water continues to be very limited in extent. For example, nitrate was detected in ground water at concentrations above the 45 mg/L MCL in only one well in the Pit 6 landfill OU in the 1st Semester of 2005. This localized elevated nitrate is likely due to septic system discharges from the Small Firearms Training Facility buildings rather than from the Pit 6 Landfill.

Nitrate has not been detected above background levels in the downgradient offsite water-supply wells CARNRW1 and CARNRW2.

7.4.3.2. Surface Water Remediation Progress

VOCs are the only contaminants that have been detected in surface water only at Spring 7. The maximum historical TCE concentration in Spring 7 was 110 μg/L in 1988. Other VOCs, including 1,2-DCE were also detected at concentrations up to 45 μg/L. However, the spring has been dry since the summer of 1992. Although DOE/LLNL have not been able to collect recent surface water samples from Spring 7, this spring is fed by ground water and VOC concentrations in ground water in the Pit 6 Landfill area have decreased significantly and are currently near or below MCLs. No contamination has been detected in surface water samples collected from other springs in the area or the Carnegie State Park Residence Pond.

7.4.3.3. Risk Mitigation Progress

This section summarizes the results of the annual risk re-evaluations conducted for the Pit 6 Landfill OU to assess the progress of the remedy in mitigating risk associated with VOCs in the pit waste, at Spring 7, and in ground water that could migrate to the Carnegie State Park wells

and pond. The risks from COCs at the Pit 6 OU Landfill were summarized in Section 7.4.3 and are discussed in more detail in the Interim Site-Wide ROD.

The risks associated with COCs in the Pit 6 Landfill OU were re-evaluated in 2003 and 2004. The landfill cap, installed as part of a CERCLA removal action in 1997, mitigated the inhalation risk associated with VOCs in the landfill waste.

Although an unacceptable risk was identified for onsite workers inhaling VOC vapors from surface water at Spring 7, this spring has been dry since 1992. Therefore, there is currently no potential for VOC inhalation from this spring. In addition, Spring 7 is fed by ground water and VOC concentrations in ground water in the Pit 6 Landfill area have decreased significantly. Therefore DOE/LLNL assume that if surface water were present in this spring, the risk associated with the inhalation of VOCs has likely been reduced. The spring is and will continue to be monitored for the presence of surface water or green hydrophilic vegetation, and if either is observed, ambient air in the vicinity of the spring will be sampled to evaluate risk.

The baseline risk assessment also identified a future cancer risk for offsite residents inhaling TCE volatilizing from the surface of the Carnegie State Park residence pond located east of the landfill. This risk scenario assumed no cleanup actions would be taken and that VOCs would migrate to the water-supply wells CARNRW-1 and CARNRW-2 used to fill the pond. However, VOCs have not migrated to the water-supply wells, the landfill cap was installed to prevent further releases of VOCs, and ground water TCE concentrations upgradient have substantially decreased.

The baseline ecological risk assessment identified a hazard index greater than one for inhalation of VOCs in burrow air for ground squirrels and the San Joaquin kit fox. The results of the ecological survey program conducted in 2004 indicated that burrow air did not contain VOCs at concentrations that would result in a hazard index or quotient greater than 1. For this reason, surveys for sensitive species at the Pit 6 Landfill OU have been discontinued.

7.4.3.4. New Sources, Releases, or Contaminants

Ground water monitoring data collected as part of the Leak Detection Monitoring Program indicate that the engineered cap has been effective in preventing new releases of contaminants from the Pit 6 Landfill. Individual well time-series plots indicate that contaminant releases occurred prior to the installation of the engineered cap in 1997. Ground water elevations beneath the Pit 6 landfill remain below the buried waste even at their highest seasonal levels. No new sources or contaminants have been identified in the Pit 6 Landfill OU.

7.4.3.5. New Technology Assessment

No new innovative technologies have been identified that would expedite cleanup in the Pit 6 Landfill OU. The addition of ground water extraction is unlikely to significantly accelerate the attainment of cleanup standards and would provide no significant health risk benefit.

7.5. Protectiveness Assessment

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

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.

3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

This evaluation determined that the interim remedy for the Pit 6 Landfill OU is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD for Site 300 was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Pit 6 Landfill OU since the Interim Site-Wide ROD was signed.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Natural attenuation is effectively reducing VOC concentrations and tritium activities in ground water. VOCs (TCE) are detected in ground water in only one well at concentrations slightly above MCLs. Tritium activities in ground water remain well below MCLs and continue to decrease. Perchlorate is detected above the method reporting limit in ground water in only one well and perchlorate concentrations are below the 6 μg/L Public Health Goal in all wells. Nitrate is detected in ground water at concentrations above the 45 mg/L MCL in only one well and concentrations are decreasing.
- The cap is performing as designed and will continue to be maintained.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No new sources, releases, or contaminants have been identified in the Pit 6 Landfill OU.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

7.6. Deficiencies

No deficiencies in the interim remedy were identified during this evaluation of the cleanup approach for the Pit 6 Landfill OU.

7.7. Recommended Changes

This evaluation does not identify a need for changing the overall approach to cleanup. DOE/LLNL have implemented all the actions required by the Interim Site-Wide ROD and the Remedial Design Work Plan for the Interim Remedy for the Pit 6 Landfill OU.

No other follow-actions were identified related to this evaluation.

7.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for the Pit 6 Landfill OU consists of:

1. Monitoring ground water and surface water.
2. Risk and hazard management, including institutional/land use controls, to prevent contaminant exposure to humans and impacts to ecological receptors. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.
3. Monitored natural attenuation of VOCs and tritium in ground water.

Ground water monitoring will be conducted in six detection monitoring wells located downgradient of the landfill at the point of compliance and at four upgradient wells, to detect future releases of contaminants to ground water from the buried waste at the Pit 6 Landfill. This Detection Monitoring Program is discussed in detail in the "Post-Closure Plan for the Pit 6 Landfill Operable Unit at LLNL Site 300" (Ferry et al., 1998). Detection monitoring of the landfill will be conducted during the post-closure maintenance period, the time after closure during which the waste could have an adverse effect on the quality of the waters of the state. The monitoring of ground water in all wells and springs that is conducted to assess the effectiveness of the natural attenuation of contaminants already present in ground water and surface water will continue until contaminant concentrations reach cleanup standards, to be determined in the Final Site-Wide ROD. The monitoring of ground water in guard well W-PIT6-1819 will continue until no COCs in ground water threaten to impact the well above the lowest water quality goal for each COC.

7.9. Protectiveness Statement

The proposed final remedy for the Pit 6 Landfill OU is expected to be protective of human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, sufficient to control risks, and properly implemented, (2) natural attenuation is reducing contaminant concentrations in the subsurface, and (3) institutional controls to minimize heath risks and prevent use of contaminated ground water are in place.

8. High Explosives Process Area (OU 4)

8.1. Background

This section describes the HE Process Area OU, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media, and the remedial investigations and actions conducted prior to selecting the interim remedy in the Interim Site-Wide ROD.

8.1.1. OU Description

The HE Process Area OU is located in the southeastern part of Site 300 (Figure 3-5). Facilities in the HE Process Area have been in use since the late 1950s for the chemical formulation, mechanical pressing and machining of HE compounds into shaped detonation devices. Solid HE waste remaining after machining operations was incinerated at the HE Open Burn Facility located near Building 829 in the northern part of the HE Process Area OU. Liquid waste generated during machining operations was discharged to former unlined disposal lagoons.

In 1982, TCE was detected in ground water from former onsite water-supply Well 6 located in the southern part of the HE Process Area OU near the Site 300 boundary (Figure 8-1). By 1986, TCE concentrations in Well 6 increased above the 5 μg/L TCE MCL, at which time, it was taken out of service and destroyed. It was replaced in 1989 with Well 20, located approximately 600 ft west of the former location of Well 6 (Figure 8-1). Well 20 is the main water-supply well for Site 300 and is screened in the deeper $Tnbs_1$ aquifer.

In 1984, two double-lined HE surface impoundments were installed south of Building 817 to receive all HE process waste water and replace the unlined disposal lagoons. The surface impoundments allow dissolved explosives chemicals in the wastewater to degrade from exposure to ultraviolet rays in sunlight. These surface impoundments were closed in 2005 under the oversight of the RWQCB.

In 1997, the Final Closure Plan for the HE Open Burn Facility at Building 829 was submitted to the regulatory agencies (Lamarre et al., 1997). This facility consisted of three unlined pits and an open-air burn unit to incinerate HE waste. As specified in the Final Closure Plan, this Burn Facility was dismantled, capped, and three deep ground water wells were installed in the regional $Tnbs_1$ aquifer for post-closure monitoring.

Twelve confirmed chemical release sites (source areas) have been identified in the HE Process OU. A former drum rack that was used to store and dispense TCE near Building 815 is considered to be the primary source of VOCs. The former unlined HE rinse-water disposal lagoons at Buildings 806, 807, and 817 and the dry well at Building 810 are considered the primary source areas of HE compounds and perchlorate. There are multiple natural and anthropogenic sources of nitrate in the ground water. Studies suggest that natural soil and septic discharges are probably a greater source of nitrate than discharge of HE-bearing waste fluids to the former lagoons and dry wells (Madrid et al., 2006).

8.1.2. Site Chronology

The chronology of important environmental restoration events at the HE Process Area OU is summarized below.

<u>1958–1989</u>

- Surface spills at the drum storage and dispensing area for the former Building 815 steam plant resulted in TCE release to the ground surface from1958 to 1986.
- Waste fluids were discharged to dry well 810A resulting in release of VOCs to the subsurface from 1959 to 1985.
- Wastewater containing HE compounds, nitrate, and perchlorate was discharged to former unlined rinsewater lagoons from the mid-to-late 1950s to 1985. Unlined HE rinsewater

lagoons were capped and closed between 1985 and 1989. Two double-lined surface impoundments were installed in 1984.

- TCE was detected in ground water from former water-supply Well 6 in 1982. Well 6 was destroyed in 1986 and replaced with Well 20 in 1989.

1990

- LLNL Site 300 was placed on the National Priorities List in 1990.

1992

- An FFA for Site 300 was signed.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued.

1998

- The Building 815 Operable Unit Engineering Evaluation/Cost Analysis (Madrid and Jakub, 1998) proposed a Removal Action involving installation of offsite ground water compliance monitoring wells and ground water extraction and treatment from onsite wells to prevent offsite migration of TCE.
- An Action Memorandum for the Building 815 Removal Action (Jakub, 1998) authorized an early phase of ground water cleanup as a Non Time-Critical Removal Action.
- Capping and closure of the HE Burn Pits was completed in 1998. These pits, located in the vicinity of Building 829, had been used to burn HE particulates and cuttings, explosive chemicals, and explosives-contaminated debris from the late 1950s until 1998.
- The Site-Wide Feasibility Study for Site 300 was issued.

2000

- Ground water extraction and treatment was initiated in the Building 815 source area.

2001

- Ground water extraction and treatment was initiated in the distal portion of the Building 815 VOC plume near the site boundary to prevent offsite plume migration.
- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified continued ground water and soil vapor extraction, administrative controls (e.g., risk and hazard management), monitoring, and no further action for: (1) VOCs in soil and bedrock at the HE rinsewater lagoons, and (2) VOCs and high melting explosive/research department explosive (HMX/RDX) in soil and bedrock at the HE Burn Pits, as the components of the selected interim remedy for the HE Process Area OU. The Interim Site-Wide ROD did not contain ground water cleanup standards. These standards will be established in the Final Site-Wide ROD for Site 300.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The Interim Remedial Design Report for the HE Process Area OU was issued.
- Submitted the Compliance Monitoring Plan/Contingency Plan for Interim Remedies (Ferry et al., 2002a).

- Ground water extraction and treatment was initiated in the proximal portion of Building 815 plume.

2003

- Ground water extraction and treatment was initiated in the Building 817 source area.

2005

- Ground water extraction and treatment was initiated in the Building 829 source area.
- Ground water extraction and treatment was initiated in Building 817 proximal area.
- The HE surface impoundments south of Building 817 were closed.

8.1.3. Hydrogeologic Setting

This section describes the general hydrogeologic setting for the HE Process Area OU including the unsaturated zone and the six water-bearing zones (HSUs) underlying the area. A conceptual hydrostratigraphic column for the southeast corner portion of Site 300 including the HE Process Area is shown on Figure 3-2.

8.1.3.1. Vadose (Unsaturated) Zone

The thickness of the vadose zone in the HE Process Area varies from less than 20 ft in the Quaternary alluvial sand and gravel of the Corral Hollow Creek floodplain to over 350 ft at the higher topographic elevations in the northwestern part of the OU. In some parts of the HE Process Area, limited amounts of perched ground water occur in the Tps and $Tnsc_2$ units within the vadose zone.

8.1.3.2. Saturated Zone

The six HSUs in the HE Process Area are described below.

Qal/WBR HSU – The Qal/WBR HSU consists of alluvial sands and gravels with minor silts and clays located along the southern Site 300 border within the floodplain of Corral Hollow Creek. It ranges up to 35 ft in total thickness, but saturated thickness is spatially and temporally variable depending on seasonal rainfall. Ground water in this HSU flows generally to the east. The Qal/WBR HSU is recharged by surface runoff from nearby canyons, direct infiltration during seasonal rainfall events, and from below by confined ground water in bedrock aquifers that subcrop beneath the Qal. Corral Hollow Creek discharges to the east into the San Joaquin Valley.

Tpsg-Tps HSU – The Tpsg-Tps HSU consists of variably saturated, perched ground water present in Tertiary sand and gravel (Tpgs) and the underlying Tps claystones. Perched ground water is present at depths ranging from ground surface where it discharges at Spring 3 to 45 ft bgs in the vicinity of Building 815. Ground water in this HSU flows to the southeast.

$Tnbs_2$ HSU – The $Tnbs_2$ HSU is saturated beneath the southern part of the HE Process Area OU from Building 815 to the site boundary. Ground water in the $Tnbs_2$ HSU occurs under phreatic to confined and artesian flow conditions. Under unstressed, natural conditions, $Tnbs_2$ ground water levels in the southern part of the HE Process Area are higher than water levels in the overlying Qal HSU, indicating an upward hydraulic gradient. However, under stressed (pumping) conditions, this upward hydraulic gradient can be reversed if water levels in the $Tnbs_2$ HSU fall below water levels in the Qal HSU. Under these conditions, ground water from the Qal

HSU flows downward into the $Tnbs_2$ HSU. The saturated thickness is variable in the $Tnbs_2$ HSU, ranging from 0 to 60 ft. Depth to ground water in the $Tnbs_2$ HSU ranges from 40 to 165 ft bgs. Ground water in this HSU flows to the southeast (Figure 8-2).

$Tnsc_{1b}$ HSU – Ground water occurs under unconfined to confined conditions in the $Tnsc_{1b}$ HSU beneath the HE Process Area OU. The $Tnsc_{1b}$ HSU is saturated beneath the southern part of the HE Process Area with a saturated thickness of approximately 25 ft. Depth to ground water in this HSU ranges from 145 to 250 ft bgs. Ground water flow is to the southeast.

$Tnbs_1$ HSUs – The $Tnbs_1$ HSU consists of Neroly Formation sandstone and conglomerate interbedded with siltstone and claystone and are present throughout the HE Process Area OU. There are two water-bearing zones in the $Tnbs_1$ stratigraphic unit, separated by a 10-ft thick claystone (claystone marker bed) that exists throughout the southeast corner of Site 300. Ground water occurs under unconfined to confined and flowing artesian conditions in the upper and lower $Tnbs_1$ HSUs. The saturated thickness of the upper $Tnbs_1$ HSU ranges from 75 to 125 ft with depths to ground water ranging from 300 to 400 ft bgs. The saturated thickness of the lower $Tnbs_1$ HSU is greater than 150 ft with depths to ground water ranging from 400 to 500 ft bgs. Ground water flow is to the southeast.

The lower $Tnbs_1$ HSU is the main water-supply aquifer for Site 300. Site 300's water needs are supplied from Well 20 that is located in the southern part of the HE Process Area OU and is screened in the lower $Tnbs_1$ HSU.

8.1.4. History of Contamination

Surface spills at the drum storage and dispensing area for the former Building 815 steam plant, where TCE was used to clean pipelines, resulted in release of TCE to the ground surface. This release site is the main source of TCE in ground water in the HE Process Area OU. Another minor source of TCE in ground water resulted from leaking contaminated waste stored at the former Building 829 Waste Accumulation Area. In addition, from 1959 to 1985, waste fluids were discharged to dry well 810A resulting in the release of VOCs to the subsurface. From the mid-to-late 1950s to 1985, rinsewater containing HE compounds was discharged to nine former unlined rinsewater lagoons. The largest volumes of HE-bearing rinsewater were discharged at Buildings 806, 807, and 817 (Henry, 1981; Crow et al., 1986). The rinsewater lagoons are believed to be the primary source of HE compounds (mainly RDX) and perchlorate in ground water. Three Resource Conservation and Recovery Act (RCRA)-regulated burn pits were located in the vicinity of Building 829 in which HE particulates and cuttings, explosive chemicals, and explosives-contaminated debris were burned. Reportedly nearly 150 kg/month of explosives, reactive chemicals, and explosives-contaminated combustible waste were destroyed in these burn pits. The facility operated from the late 1950s until 1998 when the burn pits were capped and closed under RCRA. No significant contamination associated with the HE burn pits have been detected in environmental media.

8.1.5. Contaminants of Concern

Four COCs have been identified in HE Process Area OU ground water: (1) VOCs, (2) the HE compounds HMX and RDX, (3) perchlorate, and (4) nitrate. The HE compounds HMX and RDX were identified as COCs in surface soil. VOCs, HMX, and RDX are COCs in subsurface soil/rock. VOCs are COCs in surface water at Spring 5. Historical and current concentrations of these COCs are discussed in Section 8.4.3.

VOCs, primarily TCE, a suspected human carcinogen, are present in subsurface soil and rock, in surface water at Spring 5, and in ground water. The baseline human health risk assessment estimated an excess cancer risk of 5×10^{-6} to onsite workers inhaling VOCs evaporating from subsurface soil into outdoor ambient air in the vicinity of Building 815. An excess cancer risk of 1×10^{-5} was also estimated for onsite workers inhaling TCE and 1,1-DCE volatilizing from surface water at Spring 5. An excess cancer risk of 3×10^{-6} was estimated for TCE, assuming human ingestion of contaminated ground water from a hypothetical well located at the Site 300 boundary.

The HE compounds HMX and RDX are human carcinogens present in surface soil, subsurface soil and rock, and ground water in the HE Process Area OU. The baseline human health risk assessment calculated an excess cancer risk of 2×10^{-6} for RDX assuming human ingestion of contaminated ground water from a hypothetical well located at the Site 300 boundary.

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (EPA, 2005). There was no human health risk or hazard identified associated with perchlorate in ground water.

Elevated nitrate is present in ground water as a result of releases from a combination of natural and anthropogenic sources in the HE Process Area OU. In addition to natural soil nitrate and septic system discharges, HE- and nitrate-bearing wastewater was discharged to the former lagoons and dry wells in the HE Process Area. DOE/LLNL are conducting an ongoing study to evaluate potential natural and anthropogenic sources and their relative contribution to nitrate ground water loading in this OU and other parts of Site 300. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. There is no human health risk or hazard identified associated with nitrate in ground water.

Most ground water contamination at the HE Process Area OU is present in the $Tnbs_2$ HSU. It contains VOCs, RDX, perchlorate, and elevated nitrate and is the main focus of ground water remediation at this OU. The $Tnbs_2$ HSU was the main water-supply aquifer for Site 300 before contaminants were discovered in it during the mid-1980s. Local ranchers, such as the Gallo family), pump water from wells completed in the $Tnbs_2$ HSU for domestic use and livestock watering.

Contamination has not been detected in the $Tnsc_{1b}$ HSU throughout most of the HE Process Area OU. However, this HSU contains contaminants from sources in the Building 832 Canyon OU upgradient (northeast) of the HE Process Area OU. Limited amounts of perched ground water in the $Tnsc_{1b}$ HSU that is contaminated with TCE, perchlorate and elevated nitrate occur beneath the former Building 829 HE Burn Pit and Waste Accumulation Area, located in the northwest part of the HE Process Area.

TCE, RDX, and perchlorate have been detected in the Tpsg sands and gravels of the Tpsg-Tps HSU in the vicinity of Building 815, although wells in this area have recently been dry. No contamination has been detected in the Qal/WBR HSU, the Tps portion of the Tpsg-Tps HSU, or the upper and lower $Tnbs_1$ HSUs in the HE Process Area OU.

A hydrogeologic cross-section showing the vertical distribution of total VOCs in the HE Process Area OU HSUs is shown in Figure 8-3.

8.1.6. Initial Response

DOE/LLNL began environmental investigations in the HE Process Area OU in the early 1980s to evaluate sources of contamination detected in former water-supply Well 6 and to determine if wastewater discharges into the unlined disposal lagoons had contaminated ground water. Since then, 194 boreholes have been drilled in the HE Process Area OU; 102 of these boreholes have been completed as ground water monitor or extraction wells (Figure 8-1). The geologic and chemical data from these wells and boreholes were used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included analyses of water samples from springs, and passive and active vacuum induced soil vapor surveys.

As summarized in Section 8.1.2, remediation activities at the HE Process Area OU conducted prior to the 2001 Interim Site-Wide ROD included sealing and abandoning of former water-supply Well 6, decommissioning of the former rinsewater lagoons and dry wells, closure and capping of the former HE Burn Pit, and extraction and treatment of contaminated ground water.

8.2. Interim Remedial Actions

This section describes the interim remedial action selected for the HE Process Area OU.

8.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the remedy for the HE Process Area OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The selected interim remedy for the HE Process Area OU consists of:

1. No Further Action for VOCs and HE compounds in soil and bedrock.
2. Ground water monitoring to evaluate the effectiveness of the remedial action in reaching remediation goals.
3. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation.
4. Controlling offsite contaminant migration by extracting and treating ground water at the leading edge of the Building 815 TCE ground water plume.
5. Mitigating risk and controlling contaminant source area and ground water plume migration by extracting and treating ground water to remove VOCs, HE compounds, nitrate, and perchlorate released from Building 815, the former rinsewater lagoons, and the HE Burn Pits.

Since the Interim Site-Wide ROD, DOE/LLNL evaluated and successfully demonstrated the effectiveness of natural attenuation processes in decreasing nitrate concentrations in ground water to meet cleanup standards in the HE Process Area OU. As a result, DOE/LLNL have proposed that the interim remedy of extraction and treatment of nitrate in ground water be replaced by a monitored natural attenuation remedy in the HE Process Area. Nitrate natural attenuation processes in ground water are discussed in Section 8.4.3.1. The proposed final remedy for nitrate in ground water is discussed in Section 8.9.

8.2.2. Interim Remedy Implementation

Ground water extraction and treatment systems have been operating in the HE Process Area OU since 1999. Six ground water extraction and treatment systems currently operate in the HE Process Area: Building 815-Source (B815-SRC), Building 815-Proximal (B815-PRX), Building 815-Distal Site Boundary (B815-DSB), Building 817- Source (B817-SRC), Building 829-Source (B829-SRC), and Building 817-Proximal (B817-PRX). The location of ground water extraction wells and treatment systems are shown in Figure 8-1.

These treatment systems all utilize aqueous-phase GAC to remove VOCs and HE compounds (mainly RDX) from extracted ground water. Where perchlorate is present, ion-exchange resin is used to remove it from the ground water. Initially, an anaerobic bioreactor and misting were used for nitrate treatment. In 2005, DOE/LLNL presented the results of a study that demonstrated that naturally-occurring *in situ* denitrification processes in $Tnbs_2$ HSU ground water are attenuating nitrate; converting it to non-toxic nitrogen (N_2) gas. As a result, EPA, DTSC, and the RWQCB approved reinjection of nitrate-bearing effluent from HE Process Area facilities into the $Tnbs_2$ HSU as a treatability test. The nitrate study results are discussed in more detail in Section 8.4.3.1.

The B815-SRC facility removes TCE, RDX, perchlorate, and nitrate from extracted ground water. This facility has been operating since September 2000. Initially, the facility consisted of aqueous-phase GAC, an ion-exchange system, and an anaerobic bioreactor for nitrate destruction, and the treated effluent was discharged to a misting system. The anaerobic bioreactor has been decommissioned and the treated effluent is now injected into well W-815-1918 for *in situ* denitrification in the $Tnbs_2$ HSU.

The B815-PRX facility removes TCE and perchlorate from extracted ground water. This facility has been operating since October 2002. Originally, the facility consisted of aqueous-phase GAC, an ion-exchange system, and the treated effluent was discharged to a misting system for nitrate treatment. The treated effluent is now injected into well W-814-2134 for *in situ* denitrification in the $Tnbs_2$ HSU.

The B815-DSB facility treats low concentrations (less than 10 μg/L) of TCE in ground water extracted near the Site 300 boundary. B815-DSB has been operating since September 1999. The facility originally consisted of a solar-powered aqueous-phase GAC treatment unit. In April 2005, it was connected to site power for continuous operation. The treated effluent is discharged to an infiltration trench.

The B817-SRC facility removes RDX and perchlorate from extracted ground water. This facility has been operating since September 2003 and consists of a solar-powered aqueous-phase GAC treatment unit with an ion-exchange system. Treated effluent is injected into well W-817-06A for *in situ* denitrification in the $Tnbs_2$ HSU.

The Building 817-PRX facility removes TCE, perchlorate, and RDX from extracted ground water. This facility began operating in September 2005 and consists of aqueous-phase GAC and ion-exchange units. Treated effluent is injected into well W-817-2109 for *in situ* denitrification in the $Tnbs_2$ HSU.

The Building 829-SRC facility removes TCE, nitrate, and perchlorate from the ground water and treats nitrate. This facility began operating in August 2005 and consists of aqueous-phase

GAC, ion-exchange, and a containerized wetland for nitrate treatment. Treated effluent is injected into upgradient well W-829-08 for *in situ* denitrification in the $Tnbs_2$ HSU.

8.3. System Operation and Maintenance

In general, the HE Process Area OU extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this review. All required documentation is in place (or is scheduled to be produced), and treatment system O&M activities are consistent with established procedures and protocols. O&M procedures are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the HE Process Area Treatment Facilities, contained within the Interim Remedial Design report (Madrid et al., 2002).
- Operations and Maintenance Manual for Miniature Treatment Units, Ground Water Treatment Units, and Solar Treatment Units, Volume 13 (LLNL, in progress).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #1265.02: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- HE Process Area Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Depue, 2004).

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprises a large portion of the HE Process Area O&M activities. Extracted ground water is sampled throughout the treatment process to ensure compliance with discharge requirements. Treatment system parameters such as pressure and flow are recorded to anticipate potential mechanical problems and monitor system performance.

The major O&M activities for the HE Process Area ground water extraction and treatment systems include:

- Maintaining the particulate filters.
- Maintaining the injection wells and infiltration trenches used to discharge treated ground water.
- Protecting the units from freezing in cold weather.
- Replacing spent GAC and resin.
- Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.

The budgeted and actual environmental restoration costs for the HE Process Area OU are tracked closely and are consistently within the allocated budget.

8.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the HE Process Area OU was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-

making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 8.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 8.4.2 evaluates the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the HE Process Area OU. Section 8.4.3 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) assessing the progress of remediation in reducing contaminant concentrations and plume size, (2) hydraulically controlling the plumes, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 8.4.3 also discusses any new or innovative technologies that were assessed to expedite cleanup of the HE Process Area OU.

8.4.1. Assessment of Logistical Factors

8.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in the location-, chemical-, or action-specific ARARs or other requirements that were presented in the Interim Site-Wide ROD in 2001.

8.4.1.2. Changes in Land, Building, or Ground Water Use

There have been no changes in land, building, or ground water use in the HE Process Area OU since the Interim Site-Wide ROD. The OU is still used for the formulation, mechanical pressing and machining of HE compounds and is accessible only to DOE/LLNL workers. Shallow contaminated ground water in the $Tnbs_2$ and $Tnsc_{1b}$ HSUs underlying the OU is not used for onsite water-supply. Ground water from the $Tnbs_2$ HSU is pumped from offsite water-supply Gallo-1 for domestic and livestock watering use at the Gallo ranch south of the HE Process Area. Monthly ground water samples are collected from this well and analyzed for COCs that may be present in upgradient ground water at Site 300. The B815-DSB ground water treatment system was installed upgradient of the Gallo well to prevent offsite migration of contaminant plumes toward this well. Ground water from Well 20, screened in the lower $Tnbs_1$ HSU, is used for Site 300 water-supply.

8.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics since the Interim Site-Wide ROD.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

8.4.2. Institutional Control Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD for Site 300 (DOE, 2001) were evaluated for effectiveness under the current conditions at the HE Process Area OU as described below.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** Ground water from onsite water-supply Well 20 remains free of COCs and is monitored regularly for COCs. LLNL environmental restoration staff routinely meet with site planning personnel and ensure that any new water-supply wells would be located in uncontaminated areas. Upgradient ground water extraction and treatment at the B815-DSB facility is designed to prevent migration of contaminant plumes to the offsite Gallo-1 well. Ground water from this well is monitored monthly to detect COCs that could impact the well.
- **Briefing personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in contaminated areas except under the supervision of the LLNL Hazards Control staff. LLNL environmental restoration staff also coordinates with Site 300 management to ensure that no excavation occurs in the HE Process Area without the proper controls in place.
- **Maintaining building occupancy and land use restrictions in the vicinity of Building 815 and Spring 5 –** Building occupancy and land use restrictions have been implemented by the Facility Coordinator for Building 815.
- **Conducting annual risk evaluations for VOCs adjacent to Building 815 and sample outdoor air annually at Spring 5 if water is flowing until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** An annual risk evaluation program was implemented and the outdoor risks at Building 815 were re-evaluated in 2003 and 2004. The results of the risk re-evaluation monitoring program are summarized in Section 8.4.3.2.
- **Conducting wildlife surveys every five years to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program will be conducted by 2007.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling and survey data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine any changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.

- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operation Safety Procedures are in place, and new procedures are created as needed.

8.4.3. Assessment of Technical Factors

8.4.3.1. Ground Water Remediation Progress

Although the first ground water extraction and treatment system was installed at the HE Process Area OU in late 1999, ground water remediation is still in its early stages. Most treatment facilities were installed in the last two to three years and extraction wellfield buildout specified in the Remedial Design is not yet completed. As a result, significant reductions in contaminant concentrations and mass in ground water have not yet been realized through the OU. For example, remediation has not yet resulted in significant changes to the extent of VOC contamination in ground water (Figure 8-4). However, some progress in ground water remediation has been accomplished as shown in Figure 8-4 by the reduction in the highest VOC concentrations (greater than 50 μg/L). This progress was evaluated by:

- Reviewing COC concentration trends in ground water over time.
- Reviewing dissolved-phase ground water COC mass removal data.
- Evaluating extraction wellfield capture zones.

Because the remediation efforts in HE Process Area OU are relatively recent and progress is not yet evident on an OU-wide scale, this evaluation focuses primarily on areas where ground water remediation has been underway long enough to measure progress. For this reason, the discussion of remediation progress is presented by treatment facility areas in the chronological order that they were installed.

VOC remediation at the B815-DSB treatment facility – The B815-DSB facility was installed in 1999 to hydraulically control and prevent offsite migration of the VOC plume originating from the Building 815 source area. Because the primary objective of this facility is to prevent offsite VOC plume migration, the most indicative measure of progress is concentrations trends in downgradient guard wells, used to detect plume migration. During the first few years of operation, VOCs were sporadically detected at a maximum concentration of 1.5 μg/L. As a result, extraction well flow rate was increased and an additional extraction well was added to the wellfield to increase hydraulic capture. In addition, the facility was converted from solar power to site power to ensure continuous operation. Since these modifications, VOCs have not been detected in any of the guard wells. The B815-DSB facility is located at the leading edge of the VOC plume, and therefore draws in upgradient contaminated ground water. This phenomenon is shown by time-series plot of VOC concentrations in the B815-DSB extraction well indicating increasing concentrations over time (Figure 8-5). Therefore, concentrations trends in extraction wells and treatment facility influent are not good indicators of remediation progress. Treatment facility B815-PRX was installed to minimize accelerating upgradient plume migration toward the site boundary by pumping at the B815-DSB facility.

As of the 1st Semester of 2005, the B815-DSB facility has removed 0.11 kg of VOCs from ground water. Figure 8-6 shows the cumulative mass of VOCs removed from ground water by treatment facilities in the HE Process Area including the B815-DSB facility. Because only very low VOC concentrations are present in ground water at the leading edge of the plume and the

facility's main objective is to prevent offsite plume migration, high mass removal rates are not expected.

Conservative estimates of ground water capture by the B815-DSB extraction wellfield are presented in Figure 8-7. The capture plots shown in Figure 8-7 show the estimated extent capture at 10-year pumping intervals from 10 years to 60 years. Because the capture zones presented in Figure 8-7 are the most conservative representation of the predicted capture zones, the actual capture in the field is expected to be larger. The extent of capture and the ability of the extraction wellfield to achieve ground water RAOs will be evaluated on an ongoing basis. If this evaluation indicates that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield will be implemented. However, the pumping strategy for the ground water extraction wells at the site boundary must be conducted to achieve a balance between preventing offsite plume migration and preventing accelerated migration of contaminants in the upgradient part of the plume toward the site boundary. Over-pumping of ground water from wells at the site boundary could result in more rapid migration of upgradient contamination toward the site boundary and lengthen cleanup times for this area.

VOCs, RDX, and perchlorate remediation at the B815-SRC treatment facility – The B815-SRC facility was installed in late 2000 to: (1) initiate cleanup of the Building 815 source area, and (2) partially offset the impact of pumping at the site boundary by reducing the VOC concentrations at the source.

Building 815 is the primary source of VOC ground water contamination in the HE Process Area OU. Although the B815-SRC facility is located in the Building 815 source area, the highest VOC concentrations are located more than 500 ft downgradient. Because there are no confirmed VOC release sites in this downgradient area, the VOC plume appears to be detached from its source, suggesting that the VOC source at Building 815 is likely depleted. As presented in Figure 8-8, VOC concentrations in B815-SRC extraction wells show a slightly decreasing trend from an historical maximum concentration of 14 μg/L to a maximum of 7 µg/L in the 1st Semester of 2005.

The B815-SRC facility also treats RDX in ground water that has migrated to this area from the rinsewater lagoon sources at Buildings 806 and 807. As shown in Figure 8-8, RDX concentrations in the B815-SRC extraction wells increased from 30 μg/L to 100 µg/L between 1987 and 2000, prior to the start of pumping. RDX concentrations in ground water decreased following the start of ground water extraction and treatment in 2000. The B815-SRC facility was shut down for extensive maintenance for a few months in 2003, during which time RDX concentrations rebounded to 130 μg/L. This concentration rebound is likely the result of the re-establishment of the equilibrium between the sorbed and dissolved phases of RDX when pumping stopped in 2003. RDX concentrations again decreased when pumping was reinitiated. However, these data indicate that the remediation of RDX in ground water may be significantly limited by sorption kinetics.

As shown in Figure 8-8, perchlorate concentrations in both the B815-SRC extraction well (W-815-02) and treatment facility influent have increased slightly since ground water extraction and treatment started. This slightly increasing trend is the result of this well capturing higher perchlorate concentrations from upgradient ground water.

The B815-SRC facility has removed 0.05 kg of VOCs, 0.5 kg of RDX, and 0.11 kg of perchlorate from ground water. Figures 8-6, 8-9, and 8-10 show the cumulative mass of VOCs,

RDX, and perchlorate respectively, removed from ground water by treatment facilities in the HE Process Area including the B815-SRC facility. Because contaminant mass removal in this area is limited by very low extraction well yield, DOE/LLNL recently began reinjecting treated effluent upgradient to increase the hydraulic gradient and flush contaminants toward the extraction well. Another extraction well was also installed to increase mass removal.

Conservative estimates of ground water capture by the B815-SRC extraction wellfield is presented in Figure 8-7. The capture plots shown in Figure 8-7 show the estimated extent of capture at 10-year pumping intervals from 10 years to 60 years. The capture zones presented in Figure 8-7 are the most conservative representation of the predicted capture zones. The actual capture in the field is expected to be larger, primarily because of the fractured nature of the $Tnbs_2$ HSU. Because the FEFLOW model conservatively simulated the $Tnbs_2$ HSU as a porous medium equivalent, the estimated capture zones are conservatively smaller.

Once the extraction wellfields in the HE Process Area OU have operated long enough for capture zones to fully develop, DOE/LLNL will evaluate the extent of capture and the ability of the extraction wellfield to achieve ground water RAOs. This evaluation will be based on ground water elevation contours and concentration trends in extraction, performance monitoring, and guard wells. If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield will be implemented. Modifications may include changes to the extraction well pumping strategy and/or installing additional extraction wells.

VOCs and perchlorate remediation at the B815-PRX treatment facility – The B815-PRX facility was installed in late 2002 to: (1) remove COC mass in the plume downgradient of the Building 815 source area, and (2) minimize the impact of pumping at the site boundary by reducing the VOC concentrations in upgradient ground water.

As shown in Figure 8-11, VOC concentrations in extraction well W-818-08 have decreased slightly from a pre-remediation concentration average of 62 μg/L to an average of 52 μg/L following the start of remediation. Concentrations in downgradient monitor wells indicate progress is being made toward slowing migration of the plume toward the site boundary.

As shown in Figure 8-11, perchlorate concentrations in B815-PRX extraction wells have been relatively stable with concentrations of 6 to 10 μg/L. However, perchlorate has not been detected in downgradient monitor wells, indicating that the B815-PRX extraction wells are adequately capturing the perchlorate plume in this area and preventing migration toward the site boundary.

The B815-PRX facility has removed 0.32 kg of VOCs and 0.06 kg of perchlorate from ground water. Because contaminant mass removal in this area is limited by very low extraction well yield, DOE/LLNL began reinjecting treated effluent upgradient in late 2005 to increase the hydraulic gradient and flush contaminants toward the extraction well. Another extraction well was added to increase mass removal.

RDX and perchlorate remediation at the B817-SRC treatment facility – The B817-SRC facility was installed in late 2003 to remove COC mass in the former rinsewater lagoon source areas. As shown in Figure 8-12, RDX concentrations in extraction well W-817-01 have significantly decreased from an historical maximum of 204 μg/L in 1992 to less than 50 μg/L in the 1st Semester of 2005. While perchlorate concentrations indicate a decreasing trend over time, concentrations have been relatively constant since remediation began in 2003 (Figure 8-12).

Conservative estimates of ground water capture by the B817-SRC extraction wellfield at 10-year pumping intervals from 10 years to 60 years are presented in Figure 8-7. Because the capture zones presented in Figure 8-7 are the most conservative representation of the predicted capture zones, the actual capture in the field is expected to be larger. The extent of capture and the ability of the extraction wellfield to achieve ground water RAOs will be evaluated on an ongoing basis. If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield will be implemented. Because this facility was installed relatively recently, it is too early to assess its performance.

RDX and perchlorate remediation at the B817-PRX treatment facility – The B817-PRX facility was installed in late 2005 to remove COC mass downgradient of the former rinsewater lagoon source areas. Conservative estimates of ground water capture by the B817-PRX extraction wellfield at 10-year pumping intervals from 10 years to 60 years are presented in Figure 8-7. Because the capture zones presented in Figure 8-7 are the most conservative representation of the predicted capture zones, the actual capture in the field is expected to be larger. The extent of capture and the ability of the extraction wellfield to achieve ground water RAOs will be evaluated on an ongoing basis. If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield will be implemented. Because this facility was installed very recently, it is too early to assess its performance.

TCE, perchlorate, and nitrate remediation in the B829-SRC facility – The B829-SRC facility was installed in late 2005 to remove COC mass in the vicinity of the former Building 829 Waste Accumulation Area. Because this facility was installed very recently, it is too early to assess its performance.

Natural Attenuation of Nitrate in Ground Water – DOE/LLNL conducted a study to determine if denitrification processes are naturally attenuating nitrate in $Tnbs_2$ HSU ground water at Site 300. Data obtained as part of this study indicate that denitrification processes are naturally attenuating nitrate in the confined, oxygen-depleted region of the $Tnbs_2$ HSU in the HE Process Area and the Building 832 Canyon OUs as discussed below:

- Both nitrate and dissolved oxygen concentrations in ground water decrease significantly as ground water flows from unconfined to confined conditions in the $Tnbs_2$ HSU.
- Low dissolved oxygen concentrations in the downgradient, confined region of the $Tnbs_2$ HSU are conducive for anaerobic bacteria to metabolize nitrate, converting it to harmless nitrogen (N_2) gas.
- Stable isotope signatures (i.e., $\delta^{15}N$ and $\delta^{18}O$) of nitrate in ground water indicate a trend of isotopic enrichment that is characteristic of denitrification.
- Dissolved nitrogen gas concentrations, the product of denitrification, are highly elevated in nitrate-depleted ground water in the confined region of the $Tnbs_2$ HSU (Beller et al., 2004).

Nitrate (as NO_3^-) concentrations have been relatively high and constant over time in recharge-area monitoring wells screened in the unconfined $Tnbs_2$ HSU, with concentrations typically ranging from 70 to 100 mg/L. Nitrate concentrations have been relatively low and constant over time in the downgradient, confined $Tnbs_2$ HSU region, typically ranging from in concentration from less than 0.1 to 3 mg/L. This suggests a balance between the rates of nitrate loading in the upgradient, unconfined region of the HSU and removal by denitrification in the

downgradient, confined HSU area. Anaerobic bacteria present in the oxygen-depleted, confined region of the $Tnbs_2$ HSU provide the main mechanism for denitrification. Based on the results of this study, monitored natural attenuation would be a health-protective, cost-effective final remedy for nitrate in ground water in the $Tnbs_2$ HSU.

These data indicate that nitrate in HE Process Area ground water support the presence of the elements that are important to establishing an MNA remedy: (1) the contamination is not currently posing an unacceptable risk, and (2) static nitrate plume contours. Natural attenuation is demonstrated through multiple lines of evidence, including static plume concentration contours, and the formation of geochemical indicators of dentrification (e.g., isotopic enrichment in nitrogen -15 and excess nitrogen gas).

8.4.3.2. Risk Mitigation Progress

This section summarizes the results of the annual risk re-evaluation conducted for the HE Process Area OU to assess the progress of the remediation effort in mitigating risk to onsite workers and at a hypothetical well located at the Site 300 boundary. Risks from HE Process Area OU COCs were summarized in Section 8.1.5 and in the Interim Site-Wide ROD.

The risks associated with VOCs in the HE Process Area OU were re-evaluated in 2003 and 2004 as part of the Risk and Hazard Management Program. Ground water extraction at Building 815 has contributed to reducing the human health risk due to inhalation of VOC vapors outside Building 815 to a level that is no longer of concern (less than 10^{-6}).

DOE/LLNL were unable to re-evaluate VOC inhalation risk to onsite workers at Spring 5 during 2003 or 2004 due to lack of water in this spring. However, the baseline risk was calculated from VOC concentrations in well W-817-03A located adjacent to Spring 5, since the actual flow in the spring is generally too low to measure and the spring consists primarily of moist soil with wetland vegetation. No one regularly works in the vicinity of Spring 5 and VOC concentrations in ground water that feeds the spring have decreased from 150 μg/L in 1987 to 50 μg/L in 2005. Therefore the cancer risk estimated in the baseline risk assessment has decreased correspondingly over time. In addition, more than half of the estimated risk resulted from the presence of 1,1-DCE which has not been detected in ground water in the area since 1987.

The baseline risk assessment estimated unacceptable cancer risks in ground water in the HE Process Area OU, assuming human ingestion of contaminated ground water that migrated offsite to a hypothetical well located at the Site 300 boundary. These risks were based on modeling of offsite migration of contaminated ground water in the absence of ground water remediation. Ground water extraction and treatment began in 1999 immediately upgradient of the site boundary to prevent offsite contaminant migration. As a result of onsite ground water remediation efforts, contaminant concentrations in upgradient ground water have substantially decreased since the baseline risk assessment was performed.

8.4.3.3. New Sources, Releases or Contaminants

Ground water data indicate that there are no new sources, releases, or contaminants in the HE Process Area OU since the selection of the interim remedy in 2001.

8.4.3.4. New Technology Assessment

No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the HEPA OU.

8.5. Protectiveness Assessment

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

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

This review determined that the interim remedy for the HE Process Area OU was protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements since the Interim Site-Wide ROD for Site 300 was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the HE Process Area OU since the Interim Site-Wide ROD for Site 300 was signed.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Ground water extraction and treatment is reducing contaminant concentrations in the subsurface. DOE has removed approximately 0.5 kg of VOCs from the subsurface.
- The treatment systems are performing as designed and will continue to be operated and optimized.
- System operation procedures are consistent with requirements.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that would call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

8.6. Deficiencies

No deficiencies in the interim remedy were identified during this evaluation. However, continued management and optimization of the extraction wellfield upgradient of the private offsite water-supply Gallo-1 will be necessary to prevent migration of VOCs in ground water

toward this well. In the future, additional extraction wells may be needed in the distal portions of the plume to fully capture contaminants migrating toward the site boundary.

8.7. Recommended Changes

This evaluation does not identify a need for changing the overall approach to cleanup for VOCs, HE compounds, or perchlorate in ground water in the HE Process Area OU. DOE/LLNL have implemented or is in the process of implementing all the actions required in the Interim Site-Wide ROD, the Remedial Design Work Plan for the Interim Remedies, and the Interim Remedial Design document for the HE Process Area OU (Madrid et al., 2002). No other follow-up actions were identified for VOCs, HE compounds, or perchlorate in ground water related to this evaluation.

Based on the results of the nitrate study discussed in Section 8.4.3.1, DOE/LLNL recommend implementing monitored natural attenuation as a health-protective, cost effective final remedy for nitrate in ground water.

8.8. Proposed Final Remedial Action

The proposed final remedial strategy for the HE Process Area OU consists of:

1. No Further Action for VOCs and HE compounds in soil and bedrock.
2. Ground water monitoring to evaluate the effectiveness of the remedial action and to determine when cleanup standards are met.
3. Exposure control through risk and hazard management, including institutional/land use controls. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.
4. Ground water extraction and treatment of VOCs at the leading edge of the Building 815 TCE plume, VOCs, HE compounds, and perchlorate from Building 815 and HE rinsewater lagoons, and VOCs, nitrate, and perchlorate from the HE Burn Pit.
5. Monitored natural attenuation of nitrate in ground water.

8.9. Protectiveness Statement

The proposed final remedy for the HE Process Area OU is expected to protect human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, sufficient to control risks, and properly implemented, (2) modeling indicates that HMX and RDX in surface soil and subsurface soil/rock do not pose a continued threat to ground water and there is no risk associated with these contaminants, (3) ground water extraction and treatment of VOCs and perchlorate and the natural attenuation of nitrate are reducing contaminant concentrations in the ground water, and (4) institutional controls are in place and effective in minimizing heath risks and preventing the use of contaminated ground water are in place.

9. Building 850 Firing Table (OU 5)

9.1. Background

This section describes the Building 850 firing table portion of OU 5, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

9.1.1. OU Description

OU 5 includes the Building 850 firing table and sand pile, the Pit 7 Landfill Complex, and ground water plumes originating at these release sites. An interim cleanup remedy was selected for the Building 850 area in the Interim Site-Wide ROD. The Pit 7 Complex Landfills required more investigation, therefore interim remediation measures for that part of the OU were not selected in the Interim Site-Wide ROD. Remedial alternatives for the Pit 7 Complex will be selected an Amendment to the Interim Site-Wide ROD in 2008. For this reason, the Pit 7 Complex portion of OU 5 is not included in this document.

The Building 850 firing table is located in the northwest part of Site 300 (Figure 3-5). The facility was completed in 1960 and has since been used to conduct hydrodynamic experiments. These experiments were conducted on the firing table, located adjacent to the Building 850 bunker. Figure 9-1 shows the locations of buildings, landfills, and monitoring wells in the vicinity of Building 850.

Tritium was used in firing table experimental test assemblies primarily between 1963 and 1978, although trace amounts were used until 1990. In addition, the test assemblies sometimes contained depleted uranium and metals. Leaching of contaminants from the firing table gravel resulted in tritium and depleted uranium contamination in ground water and subsurface soil/rock. As a result of the dispersal of contaminated shrapnel during explosives testing, surface soil was contaminated with various metals, HMX, depleted uranium, PCBs, and dioxin and furan compounds.

From 1962 to 1972, a large volume of sand was stockpiled near the Building 850 firing table and was periodically used and reused during large experiments, gradually becoming contaminated with tritium. Leaching from this sand pile resulted in release of tritium to the vadose zone and ground water.

9.1.2. Site Chronology

The chronology of important environmental events in the Building 850 area is summarized below.

1960

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

1988–1994

- Firing table gravel containing tritium and depleted uranium was disposed in the Pit 7 Landfill and replaced with clean gravel in 1988 (Lamarre and Taffet, 1989).

- From 1988 to 1994, five former water-supply wells were sealed and abandoned in the Building 850 area. The wells were sealed to prevent contaminants from migrating into deeper aquifers through the well sandpacks.
- In 1989, a pilot test of a 20-ft atomizing tower successfully evaporated tritium-bearing ground water from Well 8 Spring (Taffet and Oberdorfer, 1991). The U.S. EPA and San Joaquin Valley Unified Air Pollution Control District issued a permit for operation; however, the system was never operated at full scale.
- In 1990, soil contaminated with fuel hydrocarbons from a leaking underground storage tank at Building 850 was excavated and treated onsite using enhanced bioremediation. The tank site was closed in accordance with all environmental regulations (Copland and Lamarre, 1990).
- In 1990, visible fragments of metallic debris were removed from the slopes above the firing table area that might contain PCBs and depleted uranium.
- LLNL Site 300 was placed on the National Priorities List in 1990.
- An FFA for Site 300 was signed in 1992.
- The Site-Wide Remedial Investigation report for Site 300 was issued in 1994.

1996

- An Addendum to the Site-Wide Remedial Investigation Report for the Building 850/Pit 7 Complex OU was issued.

1999

- The Site-Wide Feasibility Study for Site 300 was issued.

2001

- The Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified monitoring, risk and hazard management, monitored natural attenuation of tritium, and removal of the contaminated soil and sand pile for the Building 850 area. Final surface soil cleanup standards were selected in the Interim Site-Wide ROD for PCBs, dioxins, and furans in surface soil and the tritium sand pile in the vicinity of the Building 850 firing table. These cleanup standards, discussed in Section 9.4.2.1, were based on risk and hazard to human and ecological receptors associated with the PCBs and the threat to beneficial uses of ground water posed by the tritium sandpile. The Interim Site-Wide ROD did not contain ground water cleanup standards. These standards will be established in a future Final Site-Wide ROD for Site 300.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- Submitted the Compliance Monitoring Plan/Contingency Plan for the Interim Remedies (Ferry et al., 2002a).

2004

- The Interim Remedial Design document for the Building 850 area was issued.

9.1.3. Hydrogeologic Setting

This section describes the primary HSUs and surface water in the Building 850 area. Previously, ground water underlying the Building 850 area was described as a single HSU (Qal-Tmss HSU). Additional evaluation has resulted in the differentiation of three HSUs as discussed in Section 9.1.3.2. This updated delineation of HSUs aids in defining the extent of contamination and progress of remediation in the Building 850 area, as discussed in Section 9.4.2.2. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 850 area is shown on Figure 3-2.

9.1.3.1. Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam on the slopes above Building 850 and in the Doall Ravine and Elk Ravine drainage channels. These deposits are unsaturated to a depth of approximately 5 to 50 ft bgs in the Building 850 area.

9.1.3.2. Saturated Zone

The three newly defined HSUs in the Building 850 are described below.

Qal/WBR HSU – The Qal/WBR HSU is unconfined and consists of saturated alluvial channel fill (Qal) and immediately underlying weathered and fractured bedrock. Saturation within the Qal/WBR HSU extends northward from Building 850 into the Pit 7 Complex area, but is limited south of Doall Ravine. This HSU is generally unsaturated in Elk Ravine except for short periods following winter storms. Depth to water in the Qal/WBR HSU varies from 0 to 25 ft bgs. Recharge for this unit occurs on the hillslopes above Building 850 and within the alluvial channels of Doall and Elk Ravines. Ground water flow follows topography/ground elevation contours and is parallel to stream channel axes (Figure 9-2).

$Tnbs_1/Tnbs_0$ HSU – The $Tnbs_1/Tnbs_0$ HSU consists of the Lower Blue Sandstone member of the Neroly Formation ($Tnbs_1$) and the Basal Blue Sandstone member of the Neroly Formation ($Tnbs_0$). Ground water is present in the $Tnbs_1/Tnbs_0$ HSU under unconfined to confined conditions. The HSU is saturated beneath the entire OU, except where rocks comprising the HSU are eroded away south of Doall Ravine, and Building 850. Depth to water varies from less than 35 ft bgs below Building 850 to over 50 ft bgs in Elk Ravine. The saturated thickness of the HSU varies from less than 10 ft in the western portion of the OU to over 100 ft beneath Elk Ravine in the east. As shown in Figure 9-3, ground water in the $Tnbs_1/Tnbs_0$ HSU generally flows to the east beneath Building 850 and Doall Ravine. East of the Elk Ravine Fault, ground water flows to the east-northeast in this HSU. This change in flow direction across the fault indicates that the fault influences ground water flow in the $Tnbs_1/Tnbs_0$ HSU. The Elk Ravine Fault may locally act as either a conduit or a barrier to ground water flow this HSU depending on several factors including: (1) the juxtaposition of lithologic units across the fault, (2) the presence of low-permeability fault gouge along the fault, and (3) the magnitude of the hydraulic gradient across the fault.

Recharge of the $Tnbs_1/Tnbs_0$ HSU occurs in the valley west of Building 850 and in Doall and Elk Ravines. Discharge occurs locally at Well 8 Spring and Spring 24.

The Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs are hydraulically connected in Doall Ravine east of Building 850. Elsewhere, they appear to be hydraulically separated by low-permeability strata.

Tmss HSU – This HSU is comprised of sandstone strata of the Cierbo Formation (Tmss). The Tmss HSU is saturated beneath Building 850 and Doall and Elk Ravines, but the extent of saturation in other portions of the Building 850 area is unknown. Depth to water varies from about 100 ft below Elk Ravine to over 150 ft below western Doall Ravine. Ground water is confined throughout the HSU and nearly flows as artesian in one Tmss well located in western Doall Ravine. The saturated thickness of the HSU varies from less than 10 ft in western Doall Ravine to over 40 ft beneath Elk Ravine in the east. Recharge for this unit likely occurs in the deep valley west of Building 850. The Tmss and overlying $Tnbs_1/Tnbs_0$ HSUs are hydraulically isolated in western Doall Ravine, as evidenced by differing potentiometric surface elevations and may be hydraulically connected east of the Elk Ravine Fault.

9.1.3.3. Surface Water

Natural surface water in the Building 850 area is the result of either surface runoff from precipitation or from spring discharge. As a result of the semiarid nature of Site 300, natural surface runoff is rarely observed, and only occurs briefly during severe (greater than 0.3 in./hour) or prolonged (greater than 2 hours) storm intervals. During severe storms, surface water may flow within Doall Ravine or Elk Ravine for short distances before infiltrating into the ground, except for perennial, artificially maintained surface water south of Building 865.

Two perennial springs, Well 8 Spring and Spring 24, are located in the Building 850 area (Figure 9-1). Well 8 Spring is an area where alluvial channel fill occupies an erosional surface and $Tnsbs_1/Tnbs_0$ HSU ground water discharges into the Qal/WBR HSU. Well 8 Spring is an area of saturation in the shallow alluvial fill where ground water from bedrock discharges at the bedrock/alluvial sediment contact. There is no actual surface water present at Well 8 Spring. Rather, it is an area of moist soil that supports hydrophilic vegetation. Data for "surface water" at Well 8 Spring are actually derived from ground water samples collected from a pipe driven horizontally into the side of the ravine. Spring 24 is a perennial spring where $Tnsbs_1/Tnbs_0$ HSU ground water discharges at the ground surface as a result of a shear zone of the Elk Ravine Fault.

9.1.4. History of Contamination

Leaching from the Building 850 firing table gravel has resulted in tritium and depleted uranium contamination in ground water and subsurface soil. As a result of the dispersal of contaminated shrapnel during explosives testing, surface soil was contaminated with various metals, HMX, depleted uranium, PCBs, and dioxin and furan compounds. As described above, from 1962 to 1972, a large volume of sand was stockpiled and used near the Building 850 firing table, gradually becoming contaminated with tritium. Leaching from this sand pile resulted in release of tritium to the vadose zone and ground water.

9.1.5. Contaminants of Concern

Three COCs have been identified in ground water in the Building 850 area: (1) tritium, (2) depleted uranium, and (3) nitrate. Perchlorate has also recently been detected in ground water in the OU. The occurrence of perchlorate in ground water is discussed in Section 9.4.2.3. Historical and current concentrations of these contaminants are discussed in Section 9.4.2.2. Tritium and depleted uranium have been identified as COCs in subsurface soil/rock. Beryllium, cadmium, copper, depleted uranium, HMX, PCBs, and dioxin and furan compounds are COCs in surface soil. Tritium is a COC is surface water at Well 8 Spring. Tritium has also been detected

in surface water at Spring 24 at activities that exceed the California 400 pCi/L Public Health Goal.

The predominant contaminant in the vadose zone and ground water at Building 850 is tritium, a potential human carcinogen. Although ground water in the Building 850 area contains tritium activities above the 20,000 pCi/L MCL, there is no current exposure pathway or unacceptable risk to human health and the environment associated with tritium in the vadose zone ground water.

Depleted uranium in ground water is limited to the immediate vicinity of the Building 850 firing table area. Depleted uranium activities are below the 20 pCi/L MCL for total uranium, and there is no current exposure pathway or unacceptable risk to human health and the environment associated with uranium in ground water.

Nitrate in ground water likely results from septic system effluent but may also have natural sources. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. Although nitrate is present at concentrations exceeding the 45 mg/L MCL, there was no human health risk or hazard identified associated with nitrate in ground water.

While tritium and nitrate are present in ground water in both the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs, depleted uranium is primarily limited to the Qal/WBR HSU. There are significant geologic and hydrogeologic constraints inhibiting the offsite migration of tritium in Building 850 ground water. Because the $Tnbs_1$ and $Tnbs_0$ bedrock units are eroded away in the northeastern portion of Site 300, the extent of saturation of this HSU is limited to Site 300. Additionally, there is significant faulting in the area that inhibits northeastward ground water flow. No COCs have been detected in Tmss HSU ground water. Elevated tritium activities have also been detected in surface water at Well 8 Spring and Spring 24.

The baseline risk assessment (Ferry et al., 1999) estimated an excess cancer risk of 5×10^{-4} to onsite workers resulting from the potential inhalation or ingestion of resuspended particulates and direct dermal exposure to surface soil contaminated with PCBs at the Building 850 firing table. In addition, a risk of 1×10^{-4} was calculated for potential inhalation/ingestion of resuspended particulates and direct dermal exposure to surface soil contaminated with dioxins and furans. An ecological risk assessment of PCBs, dioxins, and furans at Building 850 was conducted in 2004. The results of this evaluation showed burrowing owls were at risk from exposure to PCBs in surface soil at Building 850.

No unacceptable risk or threat to ground water was identified for depleted uranium, tritium, HMX, or metals in surface soil. No unacceptable risk or threat to ground water associated with tritium and uranium in subsurface soil/rock in the Building 850 area has been identified. However, tritium in the sand pile could pose a potential threat to ground water.

9.1.6. Initial Response

DOE/LLNL began environmental investigations in the Building 850 area in 1983. Since then, 150 boreholes have been drilled in the Building 850 area; 100 of these boreholes were completed as ground water monitor wells. Five former water-supply wells in the Building 850 area were sealed and abandoned to prevent downward migration of contaminants through long well screens and sand packs. The geologic and chemical data from these wells and boreholes were used to characterize the site contaminant hydrogeology and to monitor temporal and spatial

changes in saturation and dissolved contaminants. Site characterization also included trenching to evaluate for indications of recent fault movement, hydraulic testing, and geophysical surveys.

In 1988, firing table gravel containing tritium and depleted uranium were removed and replaced with clean gravel (Lamarre and Taffet, 1989). In 1990, soil contaminated with fuel hydrocarbons from a leaking underground storage tank at Building 850 was excavated and treated using enhanced soil bioremediation. The tank site was closed in accordance with all environmental regulations (Copland and Lamarre, 1990). The same year, workers removed and disposed of visible fragments of metallic debris from the slopes above the firing table area that might contain PCBs and depleted uranium.

9.2. Interim Remedial Actions

This section describes the interim remedy selected and implemented for the Building 850 portion of OU 5.

9.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the interim remedy for the Building 850 area was selected based on its ability to reduce the toxicity, mobility, and volume of contaminants through radioactive decay (natural attenuation), mitigate risk associated with PCBs, dioxin, and furans in surface soil, and protect human health and the environment.

The selected interim remedy for the Building 850 area consists of:

1. Monitoring ground water and surface water.
2. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors.
3. Monitored natural attenuation of tritium in ground water and surface water.
4. Source control through removal and disposal of the contaminated sand pile and surface soil in the vicinity of the Building 850 firing table.

9.2.2. Interim Remedy Implementation

Monitoring of ground water and surface water conducted at the Building 850 area includes:

- Monitoring ground water to detect any potential new releases of contaminants to ground water from sources at the Building 850 firing table.
- Monitoring of COCs in ground water and surface water (springs) to evaluate the effectiveness of natural attenuation in reducing contaminant concentrations.

Excavation and disposal of PCB-, dioxin-, and furan-contaminated soil around the Building 850 firing table and the tritium-contaminated sand pile was scheduled for 2006. Due to very large increases in the cost for the planned soil excavation and offsite disposal interim remedy, DOE is evaluating other technologies that would provide a more cost-effective final remedy for the PCB-, dioxin-, and furan-contaminated soil. This evaluation is discussed in more detail in Section 9.4.2.6.

Depleted uranium, HMX, metals, and tritium in surface soil around the firing table pose no unacceptable risks to health or ground water quality but will be removed incidentally during PCB-driven soil remediation.

In addition, institutional controls, such as activity and construction restrictions, have been implemented to reduce worker exposure to contaminants in surface soil. Fencing and a full-time security force prevent access to Site 300 and the Building 850 area by unauthorized personnel.

9.3. System Operations and Maintenance

The interim remedy for tritium, uranium, and nitrate in ground water in the Building 850 area is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. Monitoring is conducted in accordance with the Site-Wide Compliance Monitoring Plan for Interim Remedies at LLNL Site 300 (Ferry et al., 2002a).

All required documentation is in place and monitoring procedures are consistent with established procedures and protocols. However, recent monitoring data indicates the presence of perchlorate in ground water at concentrations exceeding the 6 μg/L Public Health Goal. The perchlorate plume is described in Section 9.4.2.5 as a new contaminant. Proposed measures to be taken to address this COC are discussed in Section 9.7.

The budgeted and actual environmental restoration costs for Building 850 ground water are tracked closely and are consistently within the allocated budget.

9.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 850 area was evaluated to determine if the currently implemented portions of the remedy are functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question were identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 9.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 9.4.1.4 contains an evaluation of the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the Building 850 area. Section 9.4.2 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) containing the contaminant sources, (2) assessing the progress of remediation in reducing contaminant concentrations and plume size, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 9.4.2 also discusses any new or innovative technologies that were assessed to expedite cleanup of the Building 850 area.

9.4.1. Assessment of Logistical Factors

9.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed. The State of California Office of Environmental Health Hazard Assessment has identified a new Public Health Goal of 400 pCi/L for tritium, which is a To-Be-Considered Requirement, but not an ARAR.

9.4.1.2. Changes in Land, Building, or Ground Water Use

There have been no changes in land, building, or ground water use in the Building 850 area since the Interim Site-Wide ROD. The Building 850 firing table is still used intermittently for explosives testing. The Pit 7 Complex landfills remain closed and activities in the area are institutionally controlled. Onsite property west and north of Building 850 is largely undeveloped and contains buildings and landfills that are no longer in use. Private ranch land is located to the west and north of Building 850 outside the Site 300 property boundaries.

There are no onsite water-supply wells in the Building 850 area.

9.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Building 850 area since the Interim Site-Wide ROD was signed in 2001.

9.4.1.4. Institutional Control Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD for Site 300 were evaluated for effectiveness under the current conditions at the Building 850 area as discussed below.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing water-supply wells in the Building 850 area. LLNL environmental restoration staff periodically meets with site planning personnel and ensure that any potential new water-supply wells would be sited in uncontaminated areas. There is no offsite ground water contamination resulting from releases at the Building 850 area, and no offsite water-supply wells are in use near the area.
- **Preventing installation of water-supply wells where ground water is contaminated above concentrations protective of human health –** DOE has no plans to install onsite water-supply wells near Building 850 and is not aware of any proposed offsite wells near the area.
- **Briefing all personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in contaminated areas except under the supervision of Hazards Control staff.
- **Sample surface soil for PCBs, dioxin and furans near the Building 850 firing table –** Surface soil sampling was conducted and the analytical results were reported in the Building 850 Remedial Design Report (Taffet et al., 2004).

- **Conducting wildlife surveys every five years to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program was implemented and completed in 2004. The results of this evaluation showed burrowing owls at Building 850 to be potentially at risk from the presence of PCBs in surface soil.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling and survey data are evaluated and reported annually in the Compliance Monitoring Report for Site 300 to determine changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operation Safety Procedures are in place, and new procedures are created as needed.

While surface soil containing PCBs, dioxins, and furans will be remediated to meet EPA Region IX's industrial PRGs, some soil may remain at the Building 850 firing table area that contains contaminant concentrations that exceed the residential PRGs for these constituents. As part of the site restoration, clean soil will be placed over some excavation areas that would prevent exposure to PCBs, dioxins, and furans above residential PRGs. However, in the event that Site 300 was to be released for residential land use, institutional controls may be needed to prevent exposure to surface soil at the Building 850 firing table area containing PCBs, dioxins, and furans above residential PRGs.

9.4.2. Assessment of Technical Factors

9.4.2.1. Surface Soil Remediation Progress

The excavation and disposal of PCB-, dioxin-, and furan-contaminated soil around the Building 850 firing table and the tritium-contaminated sand pile were scheduled for 2006. However, the cost to implement this selected interim remedy increased significantly (more than $4 million) from the cost estimates on which the remedy selection in the Interim Site-Wide ROD was based. Because of these cost increases, excavation and offsite disposal of contaminated soil from the Building 850 firing table is no longer economically practicable. Due to the economic impracticability, DOE/LLNL has been evaluating more cost-effective technologies to address PCBs, dioxins, and furans in the soil, such as onsite soil stabilization/solidification that are capable of achieving soil remediation goals. These alternate technologies will be assessed against the EPA evaluation criteria in an Engineering Evaluation/Cost Analysis and a remedy will be selected in an Action Memorandum, in consultation with the regulatory agencies. Removal of the tritium sandpile to mitigate the threat to underlying ground water will be incorporated into the remedy for this area.

Final surface soil cleanup standards were selected in the Interim Site-Wide ROD for PCBs, dioxins, and furans in surface soil and the tritium sand pile in the vicinity of the Building 850 firing table. The cleanup standards were based on risk and hazard to human and ecological receptors associated with the PCBs, dioxins, and furans, and the threat to beneficial uses of

ground water posed by the tritium sandpile. The cleanup standards for surface soil in the Building 850 firing table area are:

1. PCBs: 0.74 milligrams per kilogram (mg/kg), the U.S. EPA Region IX industrial Preliminary Remediation Goal (PRG).
2. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD): 2.7×10^{-5} mg/kg, the U.S. EPA Region IX industrial PRG. All related dioxin and furan compounds were converted to an equivalent concentration of 2,3,7,8-TCDD using the Dioxin Toxicity Equivalence Factors and compared to the PRG for 2,3,7,8-TCDD.
3. Tritium: 5,000,000 pCi/L as soil moisture in the Building 850 sand pile and any contiguous surface soil to protect ground water. This concentration can also be expressed as 277 pCi/g, assuming a soil moisture content of 10% and a bulk density of 1.8 grams per cubic centimeter.

9.4.2.2. Ground Water Remediation Progress

Ground water analytical data were evaluated to assess the effectiveness of the natural attenuation of tritium and the reduction of depleted uranium and nitrate in the Building 850 area. Remediation progress was evaluated by comparing the distribution and concentrations of these COCs in ground water over time. The results of this evaluation for tritium, depleted uranium and nitrate in ground water are discussed below.

Tritium in ground water – In 1991, the extent of the 20,000 pCi/L tritium MCL contour in ground water for the combined Qal-Tmss HSU extended 3,750 ft from the tritium source at the Building 850 firing table (Webster-Scholten, 1994). The distribution of tritium in Qal/WBR HSU ground water in 1998 and the 1st Semester of 2005 are shown in Figure 9-4. As shown in this figure, the length of the Building 850 tritium plume in the Qal/WBR HSU with activities greater than the 20,000 pCi/L MCL decreased from 1,700 ft in 1998 to 1,000 ft in the 1st Semester of 2005.

The distribution of tritium in $Tnbs_1/Tnbs_0$ HSU ground water in 1998 and the 1st Semester of 2005 are shown in Figure 9-5. As shown in this figure, the length of the Building 850 tritium plume in the $Tnbs_1/Tnbs_0$ HSU with activities above the MCL decreased from 3,600 ft in 1998 to 1,200 ft in the 1st Semester of 2005. The extent of the tritium plume in $Tnbs_1/Tnbs_0$ HSU ground water with activities above 100 pCi/L increased between 1998 and 2005. However, there is no ground water pathway from this HSU to a receptor point such as the City of Tracy water-supply wells located several miles to the northeast. Saturation of the $Tnbs_1/Tnbs_0$ HSU is limited to the northeast where these strata have been uplifted and eroded. The equivalent Neroly strata exist in the subsurface of the Central Valley, but at depths of about 2,000 ft below the Tracy water-supply wells. Additionally, there are significant faults in the area that inhibit northeastward ground water flow. Fate and transport modeling results indicate that tritium activity in a hypothetical water-supply well at the southeastern Site 300 boundary would be below background levels once the plume reached that point (Taffet et al., 1996). Therefore, tritium in $Tnbs_1/Tnbs_0$ HSU ground water will continue to attenuate through radioactive decay without impacting human health. Hydrogeologic cross-sections showing the vertical distribution of tritium in the Building 850 area are shown in Figures 9-6, 9-7, and 9-8.

At the request of the RWQCB, the effect of tritium migrating from the Pit 7 Complex on the downgradient Building 850 tritium plume was evaluated. For this reason, the tritium plumes in

the Qal/WBR and $Tnbs_1/Tnbs_0$ HSU emanating from sources in both the Building 850 area and the Pit 7 Complex landfills to the north are shown on Figures 9-4 through 9-5. As shown in these figures, the Pit 7 Complex tritium plume within the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs is slowly migrating into and commingling with the tritium plumes emanating from Building 850. The contribution of the Pit 7 plumes to the Building 850 plumes appears to be negligible as there is no obvious increase in tritium activity where the two plumes merge.

Time-series plots of tritium activities in ground water from selected Qal/WBR and $Tnbs_1/Tnbs_0$ HSU wells throughout the Building 850 area are shown in Figures 9-9 and 9-10. These data indicate that tritium continues to decline both in the Building 850 source area and throughout the length of the plumes in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs over time. For example, tritium activities in the source area have decreased from an historical maximum of 566,00 pCi/L in 1985 to 91,000 pCi/L in 2005 (Figure 9-9a).

The significant decreases in activities and extent of the tritium plume with activities exceeding the MCL indicate that natural attenuation (radioactive decay) continues to be effective in reducing tritium activities in ground water and protective of human health. These data indicate that tritium in Building 850 ground water continues to meet EPA's criteria that monitored natural attenuation is capable of achieving the site's remedial objectives within a reasonable time frame compared to other remedial technologies. The data also support the continued presence of the elements that are important to establishing an MNA remedy: (1) the contamination is not currently posing an unacceptable risk, (2) the data show that the source is no longer releasing significant tritium to the environment, and (3) static or retreating tritium plume contours.

Uranium in ground water – Uranium has not been detected ground or surface water at activities above the 20 pCi/L MCL in the Building 850 OU. Figure 9-11 shows the distribution of total uranium and uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratios in the combined Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs in 2004. Uranium data from 2004 was used to create this map because a complete uranium data set was not available by the June 2005 data cutoff for this report. Atom ratios indicative of depleted uranium ($^{235}U/^{238}U$ less than 0.0072) were identified in ground water samples collected from several wells in the vicinity of and immediately downgradient of the firing table, as well as in Well 8 Spring. The maximum total uranium activity detected in samples from these wells during 2004 was 9.1 pCi/L in well NC7-28. This sample contained depleted uranium. The distribution of uranium in Building 850 ground water has not changed significantly over time.

Figure 9-12 presents time-series plots of total uranium in ground water and $^{235}U/^{238}U$ ratios for samples collected from wells adjacent to the Building 850 firing table source area. The figure shows that the samples with the highest total uranium activity are the most depleted (lowest $^{235}U/^{238}U$ atom ratios). As shown in this figure, uranium was detected in well NC7-28 in June 2005 at an activity of 18 pCi/L. This represents a significant increase over the historical and the 2004 uranium activity (9.1 pCi/L) in this well but it is a single data point. Additional uranium data are needed to determine whether the uranium in the ground water in this area is truly increasing or this is a single anomalous result. Uranium in ground water samples from other wells in the firing table area remains fairly stable at activities well below its MCL.

Human health continues to be protected because: (1) total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL, (2) the areal extent of depleted uranium has not

changed during the period of monitoring, and (3) the temporal trends in $^{235}U/^{238}U$ atom ratios remain stable.

Nitrate in ground water – The extent of nitrate in the ground water above its 45 mg/L MCL is localized in the area downgradient of the Building 850 septic system leachfield. Nitrate concentrations in this area range from 45 to 65 mg/L (as NO_3). The majority of the wells located downgradient from Building 850 in Doall Ravine have nitrate concentrations that range from 15 to 38 mg/L (as NO_3). Overall, the distribution and concentrations of nitrate in ground water are similar to those observed in previous years.

Nitrate has also been detected in ground water at concentrations exceeding the 45 mg/L MCL in samples collected from wells located upgradient and cross-gradient of the firing table. For example, the highest nitrate concentrations detected in ground water in the Building 850 area in 2005 were in samples collected from well NC7-29 (140 mg/L), which is located cross-gradient from the firing table, and well NC7-44 (65 mg/L) located upgradient of the firing table. These data indicate that a significant natural source of nitrate in ground water is present in the Building 850 firing table area.

A comprehensive site-wide study is in progress to evaluate natural and anthropogenic sources of nitrate in ground water at Site 300. Although this study to-date has focused mainly on the HE Process Area and Building 832 Canyon, the study is being expanded to include other areas of Site 300 including the Building 850 firing table area. The study objectives are to develop a better understanding of the spatial and temporal distribution of nitrate in ground water at Site 300 and to more accurately determine the relative contribution of natural versus anthropogenic sources of nitrate at Site 300 ground water wherever the nitrate concentrations in ground water exceed the MCL.

Active measures to address nitrate in ground water, such as ground water extraction and treatment, do not appear to be warranted in the Building 850 firing table area at this time because:

- The maximum nitrate concentrations in ground water are detected in crossgradient and upgradient wells indicating the presence of a significant natural source of nitrate in ground water in the Building 850 firing table area.
- The extent of nitrate with concentrations exceeding the MCL is limited and does not pose a threat to human health or the environment.
- There is not yet sufficient data to determine if the nitrate detected in ground water in the Building 850 firing table area originates entirely from natural sources, or if some nitrate was released from the firing table.

DOE/LLNL will continue to monitor ground water to detect any changes in nitrate concentrations and extent that could impact human health. Data from the nitrate study will be used to attempt to determine the source of the elevated nitrate detected in the Building 850 firing table area. If it is determined that the Building 850 firing table is the cause of the elevated nitrate, DOE/LLNL will discuss possible measures to address nitrate in ground water with the regulatory agencies.

9.4.2.3. Surface Water Remediation Progress

Tritium activities in Well 8 Spring water have decreased over an order of magnitude from an historical maximum of 770,000 pCi/L in 1972 to 26,600 pCi/L in the 1st Semester of 2005. The time-series plot of water samples from Well 8 Spring (Figure 9-10) shows a steady decrease in tritium activities over time, indicating that monitored natural attenuation has been effective in reducing tritium activities. Samples from this spring represent activity decreases in both ground water and surface water, because this spring is a discharge point for $Tnbs_1/Tnbs_0$ HSU ground water. No other ground water COCs were detected in Well 8 Spring.

9.4.2.4. Risk Mitigation Progress

This section summarizes progress of remediation efforts in the Building 850 OU in mitigating risk.

As discussed in Section 9.1.5, the only risk to human or ecological receptors in the Building 850 area was associated with PCBs, dioxins, and furans in the vicinity of the Building 850 firing table. DOE/LLNL and the regulatory agencies are currently discussing remedial measures to mitigate this risk.

9.4.2.5. New Sources, Releases, or Contaminants

Ground water data do not indicate any new sources or releases in the Building 850 OU. Tritium activities in ground water immediately downgradient of the Building 850 firing table source area continue to decline from an historical maximum of 566,000 pCi/L in 1985 to 91,900 pCi/L in the 1st Semester of 2005. In addition, ground water data shows that the extent of tritium in ground water that exceeds the 20,000 pCi/L MCL continues to decrease in size. These data indicate that the tritium source in the vadose zone beneath Building 850 continues to diminish.

As discussed in Section 9.4.2.2, a sample from one well located immediately downgradient of the Building 850 firing table contained 18 pCi/L of uranium in 2005, which is a significant increase over the historical uranium activity in water at this well. However, this was a single measurement and uranium in other wells in the firing table area remain relatively constant at activities well below the 20 pCi/L MCL. Ground water in the firing table area will be monitored to determine whether uranium in the ground water is truly increasing, representing a new release, or if this is a single anomalous result.

Recent monitoring data indicates the presence of perchlorate in ground water in the Building 850 OU at concentrations exceeding the 6 μg/L Public Health Goal. Perchlorate was first detected in ground water at Building 850 in 2003 at a maximum concentration of 53 μg/L. Monitoring for perchlorate in ground water was subsequently expanded in this area. During the 1st Semester of 2005, perchlorate was detected at concentrations equal to or exceeding the 6 mg/L Public Health Goal in 22 of 24 wells sampled. The maximum perchlorate concentration detected in 2005 was 46 μg/L in ground water from a $Tnbs_1/Tnbs_0$ well immediately downgradient of Building 850. Ammonium perchlorate is a known constituent of past explosive assemblies tested at Site 300 firing tables.

The distribution of perchlorate in excess of the 6 mg/L State Public Health Goal in ground water in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs during the 1st Semester of 2005 is shown in

Figures 9-13 and 9-14, respectively. The perchlorate plume extends 3,900 ft downgradient from Building 850 in the Qal/WBR HSU, and 3,500 ft downgradient in the $Tnbs_1/Tnbs_0$ HSU.

Based on the recent definition of perchlorate in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water, DOE/LLNL will discuss possible measures needed to address perchlorate in ground water at Building 850 with the regulatory agencies. DOE/LLNL plan to conduct a treatability test of *in situ* bioremediation of perchlorate in the Building 850 area as discussed in Section 9.4.2.6.

9.4.2.6. New Technology Assessment

No new innovative technologies have been identified that would expedite the cleanup of tritium, uranium, and nitrate in Building 850 area ground water. The addition of ground water extraction for depleted uranium and nitrate in ground water is unlikely to significantly accelerate the attainment of cleanup standards and would provide no significant health risk benefit.

There are no cost-effective remedies available to treat tritium in ground water. DOE/LLNL evaluated the feasibility of using hydraulic recirculation technology to prevent further migration of the tritium plume in the Building 850 OU. Hydraulic re-circulation consists of extracting tritiated ground water in the downgradient portion of the plume, and reinjecting it upgradient. The applicability of hydraulic recirculation of the tritiated ground water to prevent migration of the plume with activities above background is limited by site conditions including the permeability and storage capacity of the $Tnbs_1/Tnbs_0$ HSU. This HSU consists of a low permeability, consolidated sandstone in which the rate of ground water movement is 0.01 to 0.03 foot per day and wells typically produce less than 1 gallon per minute. These characteristics limit the volume of water that can be reinjected, stored in, and moved through the aquifer. For this reason, continuous reinjection of ground water into the upgradient portion of the plume near the
Building 850 firing table would increase the hydraulic gradient and increase the tritium plume migration rate. To achieve even partial hydraulic capture and recirculation of the tritium plume would upset the local water balance and exceed the volume of water the aquifer could hold, also resulting in increased plume migration rates. Attempting partial hydraulic capture and recirculation of the tritium plume by reinjecting ground water downgradient of the Building 850 firing table would also have negative impacts, causing the lateral expansion of the plume into uncontaminated ground water.

Although the Qal/WBR HSU consists of more permeable material than the bedrock aquifer, tritium plume migration is currently limited due to extended dry periods at Site 300. The Qal/WBR HSU is not saturated for significant periods during the year; therefore, significant downgradient plume migration does not occur. Hydraulic recirculation would create a continuously saturated pathway year-round in the higher conductivity Qal/WBR HSU, resulting in faster migration of the tritium plume.

Therefore, both partial and complete hydraulic capture and recirculation of the tritium plume is not a technically feasible technology for controlling tritium plume migration at the Building 850 firing table because it would result in exceedence of the HSU storage capacitiy, increase the hydraulic gradient, and accelerate plume migration.

As a result of the recent definition of perchlorate in ground water at concentrations above the Public Health Goal, DOE/LLNL plan to conduct a treatability test of *in situ* bioremediation of perchlorate in the Building 850 area. Bioremediation of perchlorate utilizes the microorganisms

that are already present in the subsurface to completely mineralize perchlorate to oxygen and chloride, and has been used successfully to remediate other perchlorate-contaminated sites. At Building 850, *in situ* bioremediation could be applied by injecting environmentally acceptable substrates, such as vinegar or ethanol, into wells near the Building 850 firing table, in order to cut off the source of the perchlorate from the distal plume (Figure 9-13). The performance of this test would be assessed by measuring perchlorate concentrations in existing monitoring wells at intermediate distances downgradient. The presence of tritium in Building 850 ground water makes *in situ* bioremediation of perchlorate attractive, because the treatment occurs in the subsurface, and should not require the pumping and handling of tritium contaminated water at the surface.

As discussed in Section 9.4.2.1, the interim remedy selected in the 2001 Interim Site-Wide ROD included the excavation and disposal of soil containing PCBs, dioxins, and furans in excess of PRGs from the area surrounding Building 850. However, due to very large cost increases for transportation and offsite waste disposal, an evaluation is underway to identify more cost-effective technologies, to attain the same overall goals. Several technologies that have been proven capable of remediating PCBs, dioxins, and furans in soil, have been identified. These alternative technologies will be assessed against EPA evaluation criteria in an Engineering Evaluation/Cost Analysis and a remedy will be selected in an Action Memorandum. A schedule for this process is being developed with the regulatory agencies.

9.5. Protectiveness Assessment

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

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

This review determined that the interim remedy for tritium, uranium, and nitrate in ground water in the Building 850 area is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD for Site 300 was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 850 area since the Interim Site-Wide ROD for Site 300 was signed.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Monitored natural attenuation continues to be effective in reducing tritium activities in ground water at Building 850. The highest tritium activities in ground water in the OU continue to be located immediately downgradient of the tritium sources at the Building 850 firing table and continue to decline. The extent of the 20,000 pCi/L tritium activity contour also continues to diminish. In general, ground water tritium activities continue to decline or are below historic highs. Total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL, and the extent of depleted uranium in ground water has not changed,

- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No new sources or releases have been identified in the Building 850 area. However, perchlorate has recently been identified in ground water. An *in situ* bioremediation treatability test for perchlorate is planned.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

9.6. Deficiencies

No deficiencies in the interim remedy for tritium, uranium, and nitrate were identified during this review. However, recent monitoring data indicates the presence of perchlorate in ground water in the Building 850 OU at concentrations exceeding the 6 μg/L Public Health Goal. An *in situ* bioremediation treatability test for perchlorate in ground water is planned.

9.7. Recommended Changes

This review does not identify a need for changing the overall approach to cleanup for tritium, uranium, and nitrate in ground water. DOE has implemented all the actions to address these ground water contaminants that were recommended in the Remedial Design Work Plan for the Interim Remedies (Ferry et al., 2001) and the Interim Remedial Design document for the Building 850 area (Taffet et al., 2004).

Based on the recent definition of perchlorate in Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSU ground water, DOE/LLNL will discuss possible measures needed to address perchlorate in ground water at Building 850 with the regulatory agencies, including an *in situ* bioremediation treatability test.

DOE/LLNL, together with the regulatory agencies, will also evaluate, identify, and implement a more cost-effective remedy for PCB-, dioxin-, and furan-contaminated soil in the Building 850 firing table area. Public input will be solicited on the preferred soil alternative prior to selection of the final remedy.

9.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD for tritium, uranium, and nitrate in ground water in the Building 850 OU. The proposed final remedy for tritium, uranium, and nitrate in ground water at Building 850 consists of:

1. Risk and hazard management, including institutional/land use controls, to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

2. Monitoring contaminants in ground water to track changes in plume concentrations/activities to evaluate the effectiveness of source control measures and natural attenuation of contaminants in ground water and surface water to health- and environmentally-protective levels, as well as to ensure there is no impact to downgradient receptors.
3. Monitored natural attenuation of tritium in ground water and surface water.
4. Source control through removal and disposal of the contaminated sand pile.
5. Mitigate exposure risk to onsite workers through remediation of PCB-, dioxin-, and furan-contaminated surface soil in the vicinity of the Building 850. Remediation technologies will be evaluated in an Engineering Evaluation/Cost Analysis and a technology selected in an Action Memorandum in consultation with the regulatory agencies.
6. Exposure control measures may be implemented, if necessary, to prevent exposure to PCBs, dioxins, and furans in surface soil until soil remediation occurs.

Additional actions may be needed to address perchlorate in ground water and to reduce costs associated surface soil remediation at the Building 850 firing table as recommended in Section 9.6. These actions will be discussed with the regulatory agencies and addressed separately and outside the scope of this document.

9.9. Protectiveness Statement

The proposed final remedy for tritium, uranium, and nitrate in ground water in the Building 850 area is expected to continue to protect human health and the environment upon completion, and in the interim: (1) the Health and Safety Plan is in place, sufficient to control risks, and properly implemented, (2) natural attenuation continues to be effective in reducing tritium activities in ground water, (3) total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL and the extent of depleted uranium in ground water has not changed, and (4) institutional controls to minimize heath risks and prevent use of contaminated ground water are in place.

10. Building 854 (OU 6)

10.1. Background

This section describes the Building 854 OU, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selecting the interim remedy in the Interim Site-Wide ROD.

10.1.1. OU Description

The Building 854 OU is located in the southwestern portion of Site 300 (Figure 3-5). It contains thirteen buildings built between 1959 and 1970 including the Building 854 Complex (Buildings 854A, B, C, D, E, F, G, H, J, and V), the Building 855 Complex (Buildings 855A, B, and C), Building 856, and Building 857 (Figure 10-1). The Building 854 Complex was used to

test the stability of weapon components under various environmental conditions and mechanical and thermal stresses. In 1967, two TCE brine systems were installed in the Building 854 Complex. The primary loop connected Buildings 854B and 854G and the secondary loop connected Buildings 854 C, 854D, 854E, and 854F. Both loops were used extensively until 1986, infrequently used after 1986, and removed in 1989.

10.1.2. Site Chronology

The chronology of important environmental restoration events at the Building 854 OU is summarized below.

1959

- Former water-supply Well 13 was drilled.

1967–1986

- Two TCE brine systems were installed and extensively used at the Building 854 Complex.

1983

- TCE-contaminated soil was excavated from the northeast corner of Building 854F and near the drain outfall near Building 854H.

1989

- TCE brine systems were removed from the Building 854 Complex.

1990

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

1992

- An FFA for Site 300 was signed.

1996

- Water-supply Well 13 was sealed and abandoned due to the detection of TCE in water samples from the well, and because it was a potential vertical conduit for contaminant migration.

1998

- The Building 854 Operable Unit Characterization Summary was submitted (Ziagos and Reber-Cox, 1998).

1999

- The Site-Wide Feasibility Study (Ferry et al., 1999) for Site 300 was issued.
- The Building 854-Source (B854-SRC) ground water extraction and treatment facility began operating.

2000

- The Building 854-Proximal (B854-PRX) ground water extraction and treatment facility began operating.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified ground water and soil vapor extraction and treatment, ground water monitoring, and administrative controls (i.e., risk and hazard management) as components of the remedy for the Building 854 OU.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- Submitted the Compliance Monitoring Plan/Contingency Plan for the Interim Remedies (Ferry et al., 2002a).
- Additional characterization data for the Building 854 OU was submitted (Ferry and Kearns, 2002).

2003

- Submitted the Building 854 Interim Remedial Design Report (Daily et al., 2003).

2005

- Excavated and disposed PCB-contaminated soil from the former Building 855 lagoon (Holtzapple, 2005).

10.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 854 OU, including the unsaturated zone and the three HSUs underlying the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 854 area is shown on Figure 3-2.

10.1.3.1. Vadose (Unsaturated Zone)

The vadose zone is approximately 100 ft thick and consists of up to 70 ft of poorly consolidated Quaternary landslide deposits (Qls) and the unsaturated portion of the lower Neroly $Tnbs_1$ sandstone. While trace amounts of moisture have been encountered in the vadose zone during drilling, the upper 100 ft of the subsurface is generally unsaturated.

10.1.3.2. Saturated Zone

The three HSUs underlying the Building 854 OU are described below.

Qls HSU – The Qls HSU is an unconfined, ephemeral water-bearing zone that occurs in sand, silt, and angular, weathered bedrock fragments within landslide deposits. It ranges up to 100 ft in total thickness, and the saturated thickness is spatially and temporally variable depending on seasonal rainfall. The Qls HSU is recharged by surface water runoff and direct infiltration of rainfall. Discharge occurs at Springs 10 and 11, located at the toe of the landslide deposit in a canyon in the southern part of the OU (Figure 10-1). The landslide is underlain by up to 200 ft of sandstone, siltstone, and claystone of the lower Neroly Formation.

$Tnbs_1/Tnsc_0$ HSU – The $Tnbs_1/Tnsc_0$ HSU is comprised of the lower $Tnbs_1$ sandstone and underlying $Tnsc_0$ siltstone/claystone fractured bedrock, and is present throughout the Building 854 OU. The saturated thickness of the HSU varies from tens of feet near the

upgradient recharge area to over a hundred feet in downgradient areas. The depth to ground water ranges from 90 to 180 ft bgs. Ground water in this HSU is unconfined.

Hydrologic, chemical, and optical televiewer data indicate that fractures are important flow-controlling features in the $Tnbs_1/Tnsc_0$ HSU. The magnitude and speed of water level response observed during pumping tests suggests preferential flow along fractures. Fracture orientation also appears to influence the $Tnbs_1/Tnsc_0$ ground water flow direction. In the northern portion of the OU, ground water generally flows east-southeast. In the central and southern portions of the site, ground water generally flows to the south (Figure 10-2).

Tmss HSU – The Tmss HSU is comprised of sandstone, claystone, and pebble conglomerate bedrock of the Cierbo Formation, and is present throughout the Building 854 OU. The potentiometric surface for this HSU is separate and distinct from the overlying Neroly water-bearing zone, and the upper part of the Cierbo Formation is unsaturated beneath the Building 854 source area. The saturated thickness of the Tmss HSU in the Building 854 area is not known because this unit has never been fully penetrated during drilling. The depth to ground water is approximately 300 ft bgs. Ground water in this HSU is confined.

10.1.3.3. Surface Water

Two springs, Springs 10 and 11, are located in the Building 854 OU, approximately 2,400 ft southeast of Building 855 (Figure 10-1). Springs 10 and 11 are perennial springs with flow rates of 0.5 and 0.1 gpm. Water in these springs is thought to be derived from ground water discharging at the toe of the Qls deposits.

10.1.4. History of Contamination

TCE was released to subsurface soil in the Building 854 OU through leaks and discharges of TCE-based heat exchange fluid from the TCE brine system. These leaks occurred primarily from outdoor valve stations and piping between buildings, or from waste fluid discharge practices that are no longer permitted at Site 300. Most spills are believed to have occurred between 1967 and 1984 (Stupfel, 1992). Nitrate and perchlorate are also detected in ground water. Although the distribution of these contaminants does not suggest a specific source, the presence of HE compounds in soil may indicate an anthropogenic contribution. Septic systems serving the Building 854 and 855 Complexes are also possible sources of anthropogenic nitrate.

Historical records indicated that wastewater containing PCB oils was discharged from Building 855A to a former lagoon, south of the building. The HE compound HMX, metals, and low tritium activities have been detected in soil in the Building 854 OU.

10.1.5. Contaminants of Concern

COCs in surface soil in the Building 854 OU include lead, zinc, HMX, PCBs and tritium. No unacceptable risk or hazard to human health or ecological receptors has been identified for lead, zinc, HMX or tritium in the Building 854 area. A baseline human health risk of 7×10^{-5} was calculated for incidental ingestion and direct dermal contact with PCB-contaminated soil.

VOCs were identified as COCs in subsurface soil/rock in the Building 854 Complex area. Baseline cancer risks of 1.0×10^{-6} and 9.3×10^{-6} were calculated for the inhalation of VOCs in indoor air at Buildings 854A and 854F, respectively. A baseline cancer risk of 1×10^{-5} was calculated for the inhalation of VOCs in outdoor air at Building 854F.

Three COCs have been identified in ground water at the Building 854 OU: (1) VOCs (primarily TCE), (2) perchlorate, and (3) nitrate.

VOCs, primarily TCE, a suspected human carcinogen, are present in ground water and in water at Springs 10 and 11. There was no human health or ecological risk or hazard identified associated with TCE in ground or surface water.

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (EPA, 2005). There was no human health risk or hazard identified associated with perchlorate in ground water.

Elevated nitrate in ground water may be attributable to a combination of natural and anthropogenic sources in the Building 854 OU. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. There was no human health risk or hazard identified associated with nitrate in ground water.

At the Building 854 OU, VOCs, perchlorate, and nitrate are present in ground water in the Qls and $Tnbs_1$/$Tnsc_0$ HSUs. To date, COCs have not been detected in ground water in the Tmss HSU with the exception of TCE at a concentration of 0.6 μg/L in one sample collected from a Tmss HSU well in 1996.

10.1.6. Initial Response

DOE/LLNL began environmental investigations in the Building 854 area in 1983. Since then, 43 boreholes have been drilled in the OU, 32 of which were completed as ground water monitor wells (Figure 10-1). The geologic and chemical data from these wells and boreholes have been used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization also included surface soil sampling, soil vapor flux chamber measurements, soil vapor surveys, hydraulic testing, and soil vapor extraction testing.

As summarized in Section 10.1.2, remediation activities at the Building 854 OU conducted prior to the Interim Site-Wide ROD (2001) included sealing and abandoning water-supply Well 13, and the excavation of TCE-contaminated soil near Buildings 854F and H. In addition, the B854-SRC and B854-PRX ground water extraction and treatment systems were installed in 1999 and 2000, respectively.

10.2. Interim Remedial Actions

This section describes the interim remedial actions selected for the Building 854 OU.

10.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the remedy for the Building 854 OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The selected interim remedy for the Building 854 OU consists of:

1. No further action for metals, high explosives, PCBs, and tritium in surface soil.
2. Ground water monitoring to evaluate the effectiveness of the remedial action and to determine when cleanup standards are met.

3. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation.
4. Mitigating risk and controlling contaminant source area and ground water plume migration by extracting and treating ground water and soil vapor to remove VOCs, and extracting and treating ground water to remove nitrate, and perchlorate released from past operations at Building 854.

Subsequent to the Interim Site-Wide ROD, additional characterization identified PCBs in surface soil in the former Building 855A lagoon at concentrations that posed an unacceptable risk to onsite workers. DOE/LLNL agreed to remove the PCB-contaminated soil from the lagoon to mitigate this risk as part of the interim remedy.

10.2.2. Interim Remedy Implementation

Ground water extraction and treatment systems have been operating in the Building 854 OU since 1999. Two ground water extraction and treatment systems currently operate in the Building 854 OU: B854-SRC and B854-PRX. The location of ground water extraction wells and treatment systems are shown in Figure 10-1.

The B854-SRC ground water extraction and treatment system began operating in December 1999 and treats ground water for VOCs, nitrate and perchlorate. Ground water is extracted at approximately 1 gpm from well W-854-02 (Figure 10-1). The facility consists of a particulate filtration system, two ion-exchange columns connected in series to remove perchlorate, and aqueous-phase GAC connected in series for VOC removal. The treated ground water is discharged through nearby misting towers to indigenous grasses to remove nitrate.

The B854-PRX ground water extraction and treatment system began operating in November 2000 and treats ground water for VOCs, nitrate and perchlorate. Ground water is extracted at about 1 gpm from well W-854-03 located southeast of the Building 854 complex (Figure 10-1). The facility consists of aqueous-phase GAC connected in series for VOC removal, an above-ground containerized wetland biotreatment unit for perchlorate and nitrate removal, and an ion-exchange resin treatment to sorb any perchlorate that is not treated in the biotreatment unit. The treated water is discharged to a nearby infiltration trench.

In 2005, a soil vapor extraction and treatment system was installed and began operating in the Building 854 source area as a long-term treatability test. The objective of this test is to determine if soil vapor extraction is a viable technology for long-term VOC source mass removal. This facility consists of vapor-phase GAC to remove VOCs from extracted soil vapor. Treated vapors are discharged to ambient air.

In 2005, approximately 100 cubic yards of PCB-, dioxin-, and furan-contaminated surface and shallow subsurface soil from the former Building 855 lagoon was excavated and disposed.

The installation of an additional ground water extraction and treatment system (Building 854-Distal [B854-DIS]) to address contaminants in the downgradient contaminant plume is planned for fiscal year 2006. Expansions of the Building 854-Source and -Proximal extraction wellfields to increase contaminant mass removal are planned for fiscal year 2007.

10.3. System Operations/Operation and Maintenance

In general, the Building 854 OU extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this review. All required documentation is in place (or is scheduled to be produced), and treatment system O&M activities are consistent with established procedures and protocols.

O&M procedures for the Building 854 treatment systems are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the Building 854 Treatment Facilities, contained within the Interim Remedial Design report (Daily et al., 2003).
- Operations and Maintenance Manual for Miniature Treatment Units Ground Water Treatment Units, and Solar Treatment Units, Volume 13 (LLNL, in progress).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #1265.02: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- Building 832 Canyon and Building 854 OU Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Depue, 2004).

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprises a large portion of the O&M activities. Extracted ground water is sampled throughout the treatment process to ensure compliance with discharge requirements. Treatment system parameters such as pressure and flow are recorded to anticipate potential mechanical problems and monitor system performance.

The major O&M activities for the Building 854 ground water extraction and treatment systems include:

- Maintaining the particulate filters.
- Maintaining the misting tower and infiltration trench used to discharge treated ground water.
- Maintaining the wetland biotreatment unit.
- Protecting the units from freezing in cold weather.
- Replacing spent GAC and resin.
- Replenishing vinegar used as carbon source for the wetland biotreatment unit.
- Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.

The budgeted and actual environmental restoration costs for the Building 854 OU are tracked closely and are consistently within the allocated budget.

10.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 854 OU was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 10.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 10.4.2 evaluates the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the Building OU. Section 10.4.3 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) assessing the progress of remediation in reducing contaminant concentrations and plume size, (2) hydraulically controlling the plume, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 10.4.3 also discusses any new or innovative technologies that were assessed to expedite cleanup of the Building OU.

10.4.1. Assessment of Logistical Factors

10.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in the location-, chemical-, or action-specific ARARs or other requirements that were presented in the Interim Site-Wide ROD in 2001.

10.4.1.2. Changes in Land, Building, or Ground Water Use

There have been no changes in land, building, or ground water use in the Building 854 OU since the Interim Site-Wide ROD that would affect the approach to cleanup. Facilities in this OU are no longer used for weapons components testing. In 2005, Buildings 854B, C, D, E, F, G, and J were decontaminated and demolished. There are plans to decontaminate and demolish Building 854A in the future. Building 854V is still used as a HE magazine and there are plans to convert Building 854H to an HE magazine. In 2005, HE processing and machining operations started at Building 855, which had been unoccupied for a number of years. The OU area is accessible only to DOE/LLNL workers. Ground water beneath the OU is not used for water-supply.

10.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics since the Interim Site-Wide ROD was signed.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously

considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

10.4.2. Institutional Control Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD for Site 300 (DOE, 2001) were evaluated for effectiveness under the current conditions at the Building 854 OU.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing water-supply wells in the Building 854 OU. LLNL environmental restoration staff periodically meet with site planning personnel and ensure that any potential new water-supply wells would be located in uncontaminated areas. There is no offsite ground water contamination resulting from releases at the Building 854 OU, and no offsite water-supply wells are in use near the OU.
- **Preventing installation of water-supply wells where ground water is contaminated above concentrations protective of human health –** DOE has no plans to install onsite water-supply wells near the Building 854 OU and is not aware of any proposed offsite wells near the OU.
- **Briefing all personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that excavation does not occur in contaminated areas except under the supervision of Hazards Control staff. LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in the Building 854 area without the proper controls in place.
- **Maintaining building occupancy and land use restrictions in the vicinity of Buildings 854F and 854A –** Building occupancy and land use restrictions have been implemented by the LLNL Facility Coordinators.
- **Installing warning signs in the vicinity of Buildings 854F and 854A –** Warning signs have been installed stating that full-time occupancy of Building 854A is prohibited. Building 854F was demolished in 2005.
- **Conducting annual risk evaluations for VOCs within and adjacent to Building 854F and indoor air within Building 854A until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** An annual risk evaluation program was implemented and the indoor and outdoor risks were re-evaluated in 2003 and 2004. The results of the risk re-evaluation monitoring program are summarized in Section 10.4.3.4.

- **Conducting wildlife surveys every five years to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program will be conducted by 2007.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine any changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operational Safety Procedures are in place, and new procedures are created as needed.

10.4.3. Assessment of Technical Factors

10.4.3.1. Surface Soil Remediation Progress

In 2005, approximately 100 cubic yards of PCB-, dioxin-, and furan-contaminated surface and shallow subsurface soil from the former Building 855 lagoon was excavated and disposed. The soil excavation was conducted to mitigate unacceptable exposure risk (greater than 10^{-6}) for onsite workers. Following soil excavation, sampling of the excavation was conducted to verify that surface soil cleanup standards for PCBs, dioxins, and furans had been met. The cleanup standards for these contaminants in surface soil at the former Building 855 lagoon are that same as those for the PCB-, dioxin-, and furan-contaminated soil at Building 850 discussed in Section 9.4.2.1.

In January 2006, the regulatory agencies concurred that the PCB soil cleanup was complete.

10.4.3.2. Vadose Zone Remediation Progress

Two soil vapor extraction treatability tests have been conducted in the Building 854 source area to determine its applicability as a remedial technology for VOC mass removal. The results of the initial short-term treatability test indicated that: (1) significant VOC mass removal at Building 854F could possibly be achieved using soil vapor extraction, and (2) the pneumatic conductivity of the vadose zone beneath the Building 854 Complex appeared to be very high.

A long-term treatability test was started in the Building 854F area in late 2005. The purpose of the long-term test is to determine whether soil vapor mass removal rates achieved during the short-term test are sustainable over longer periods. Initial results from this long-term test show a constant, high flow rate with VOC soil vapor concentrations of 4 $ppm_{v/v}$. The system will continue to be operated until VOC vapor concentrations decrease below the 0.4 $ppm_{v/v}$ detection limits. At that point, the soil vapor extraction system will be shut down for a three to six month period to monitor any rebound in soil vapor VOC concentrations. If rebound occurs, the SVE system will be restarted and operated until VOC concentrations decline again. The system will be operated in a cyclic fashion, until no further rebound in VOC concentrations is observed. VOC concentrations in the vadose zone may be the result of vadose zone and/or ground water sources.

10.4.3.3. Ground Water Remediation Progress

Although ground water remediation at this OU began in 1999, it is still in its early stages. The construction of all treatment facilities and extraction wellfields specified in the Building 854 Remedial Design has not yet been completed. However, some ground water remediation progress has been accomplished. This progress was evaluated by:

- Reviewing COC concentration trends in ground water over time.
- Comparing pre-remediation and the 1st Semester 2005 ground water COC concentrations and spatial distribution.
- Reviewing ground water COC mass removal data.
- Evaluating extraction wellfield capture zones.

The results of this evaluation for VOCs, perchlorate, and nitrate in ground water are discussed below.

Overall, VOC concentrations in Building 854 ground water have decreased from an historical, pre-remediation maximum of 2,900 μg/L in 1997 to a maximum concentration of 180 μg/L in the 1st Semester of 2005. Perchlorate concentrations have decreased from an historical maximum of 27 μg/L in 2003 to 15 μg/L in the 1st Semester of 2005. Nitrate concentrations have decreased from an historical maximum of 180 mg/L in 1996 to 62 mg/L in the 1st Semester of 2005. While nitrate concentrations in ground water have not changed significantly during the period of remediation in this OU, this could be the result of the ongoing contribution of nitrate to ground water from natural sources in the Neroly bedrock.

Figure 10-3 presents a comparison of the pre-remediation extent of the VOC plume in 1999 to the extent of the VOC plume in the 1st Semester of 2005. The figure shows that since remediation has started: (1) the portion of the northern VOC plume with concentrations greater than 50 μg/L has disappeared, (2) the extent of the northern VOC plume with concentrations greater than 10 μg/L and 25 μg/L has decreased, and (3) the extent of the southern VOC plume with concentrations greater than 5 μg/L has decreased significantly in size. A hydrogeologic cross-section showing the vertical distribution of total VOCs in the Building 854 OU HSUs is shown in Figure 10-4. To date, approximately 4.4 kg of VOCs, 0.14 kg of perchlorate, and 975 kg of nitrate have been removed from ground water by the B854-SRC and B854-PRX extraction and treatment facilities. Time-series plots of cumulative VOC and perchlorate mass removed by these treatment facilities are shown in Figures 10-5 and 10-6, respectively.

Figure 10-7 presents the hydraulic capture zones for the fully implemented ground water extraction and treatment remedy for the Building 854 OU. The capture plots in Figure 10-7 show the extent of capture at 5-year pumping intervals from 5 to 15 years. The capture zones presented in this figure are the most conservative representation of the predicted capture zones. The capture zones are conservative due to the recharge-limited nature of the $Tnbs_1/Tsnc_0$ HSU and the assumption of continuous recharge in the capture zone analysis. Actual capture zones area expected to be larger. Once the extraction wellfields in the Building 854 OU are fully implemented and have operated long enough for capture zones to fully develop, DOE/LLNL will evaluate the extent of capture and the ability of the extraction wellfield to achieve ground water RAOs. This evaluation will be based on ground water elevation data and concentration trends in extraction, performance monitoring, and guard wells. If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the

wellfield will be implemented. Modifications may include changes to the extraction well pumping strategy and/or installing additional extraction wells**.** The perchlorate plume is co-located with the northern VOC plume, and therefore perchlorate should also be captured by the extraction wellfield.

Data collected to date and capture modeling indicate that the primary objectives of interim remedy in the Building 854 OU will be met including: (1) removal of contaminant mass from the Building 854 source area, (2) mitigation of the VOC inhalation risk to onsite workers at Buildings 854A and F, (3) preventing further migration of ground water contaminants in the $Tnbs_1$ regional water-supply aquifer, and (4) preventing contaminant migration into the Ecological Preserve.

Remediation progress by treatment facility area is discussed below in the chronological order that they were installed.

VOC, perchlorate, and nitrate remediation at the B854-SRC treatment facility – The B854-SRC treatment facility began operation in late 1999 to (1) initiate cleanup of the Building 854 source area, (2) prevent further ground water plume migration, and (3) mitigate the VOC inhalation risk to onsite workers at Buildings 854A and F.

As shown in Figure 10-8a, VOC concentrations in the B854-SRC extraction well (W-854-02) decreased from a pre-remediation maximum concentration of 650 μg/L to 180 μg/L in the 1st Semester of 2005. VOC concentrations in treatment facility influent (STU08-I) have decreased from a maximum historical concentration of 630 μg/L to 210 μg/L in 2005. As shown in Figure 10-8b, perchlorate concentrations in the extraction well and treatment facility influent have remained relatively constant at concentrations between 4 and 10 μg/L. Nitrate concentrations in ground water have been relatively constant over time with concentrations ranging from 35 to 60 mg/L. The most likely sources of nitrate in ground water in the Building 854 source area are discharges from the septic system leachfield and natural soil. This could account for the lack of response of nitrate in ground water to remediation in the area.

VOC and perchlorate mass removed from ground water by the B854-SRC treatment facility is presented in Figures 10-5 and 10-6, respectively. To date, the facility has removed 4.04 kg of VOCs and 0.09 kg of perchlorate from ground water. The treated effluent from B854-SRC is discharged through misting towers to remove nitrate. The extraction wellfield for this facility will be expanded in fiscal year 2007 to increase contaminant mass removal.

VOC, perchlorate, and nitrate remediation at the B854-PRX treatment facility – The B854-SRC facility began operation in late 2000 to (1) capture the proximal and distal portions of the ground water plume emanating from the Building 854 source, (2) prevent further migration of ground water contaminants in the $Tnbs_1$ regional water-supply aquifer, and (3) prevent contaminant migration into the Ecological Preserve in the southern part of the Building 854 OU.

As shown in Figure 10-9a, VOC concentrations in the B854-PRX extraction well (W-854-03) decreased from a pre-remediation maximum concentration of 270 μg/L to 51 μg/L in the 1st Semester of 2005. VOC concentrations in treatment facility influent (STU02-I) have decreased from a maximum historical concentration of 130 μg/L to 59 μg/L in 2005. As shown in Figure 10-9b, perchlorate concentrations in the extraction well and treatment facility influent have remained relatively constant at concentrations between 6 and 14 μg/L. Nitrate concentrations have also remained relatively constant in ground water in the vicinity of the B854-PRX facility, possibly due to continued contributions from the $Tnbs_1/Tnsc_0$ bedrock.

VOC and perchlorate mass removed from ground water by the B854-PRX treatment facility is presented in Figures 10-5 and 10-6, respectively. To date, the facility has removed 0.35 kg of VOCs and 0.04 kg of perchlorate. The performance of the B854-PRX facility is currently constrained by the limited capacity of the constructed wetland biotreatment unit. An expansion of the biotreatment unit to increase the performance at this facility is scheduled for fiscal year 2007.

VOC, perchlorate, and nitrate remediation at the B854-DIS treatment facility – In fiscal year 2006, the B854-DIS treatment facility will be constructed to (1) capture the small-scale contaminant plume in the vicinity of former well 13, and (2) prevent further migration of ground water contaminants in the $Tnbs_1$ regional water-supply aquifer, (3) prevent contaminant migration into the Ecological Preserve, and (4) prevent contamination of Springs 10 and 11.

The B854-DIS treatment facility will be located in the vicinity of former well 13 and will consist of aqueous-phase GAC to treat VOCs and a biotreatment unit to remove perchlorate and nitrate from extracted ground water. Options for discharging the treated effluent currently being considered include an infiltration trench, misting towers, and an injection well.

10.4.3.4. Risk Mitigation Progress

This section summarizes the results of the annual risk re-evaluation conducted for the Building 854 OU to assess the progress of the remediation in mitigating risk to onsite workers. Potential risks from Building 854 area COCs are summarized in Section 10.1.5 and described in the Interim Site-Wide ROD.

Remediation at the Building 854 source area has reduced the human health risk due to inhalation of VOC vapors in outdoor air in the vicinity of Building 854F to a level that is no longer of concern (less than 10^{-6}). Building 854F was demolished in 2005, and therefore no longer presents an indoor air VOC inhalation risk. Building 854A indoor air continues to present an unacceptable risk to onsite workers. However, institutional controls are in place to prevent exposure and the building is not occupied full-time.

In 2005, PCB-, dioxin-, and furan-contaminated surface and shallow subsurface soil from the former Building 855 lagoon was excavated and disposed, mitigating the unacceptable cancer risk (greater than 10^{-6}) for onsite workers.

10.4.3.5. New Sources, Releases or Contaminants

Ground water and soil vapor data indicate that there are no new sources, releases or contaminants in the Building 854 OU. However, data collected to support preparation of the Building 854 OU Remedial Design report indicates that VOCs in ground water in the vicinity of former Well 13 may be the result of a separate, localized release and not the distal portion of the TCE plume extending from Building 854F. In 2002, three wells were installed downgradient of the Building 854 Complex, but upgradient of former Well 13. VOCs were not detected in ground water samples from these wells, indicating two separate VOC plumes with two different sources. These wells are now used to define the current downgradient extent of the TCE plume emanating from Building 854 source area.

10.4.3.6. New Technologies Assessment

No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 854 OU. However, as discussed in Section 10.2.2, a long-term soil vapor extraction treatability test began in the Building 854 source area to determine if soil vapor extraction is a viable technology to accelerate VOC source mass removal.

10.5. Protectiveness Assessment

The protectiveness of the Building 854 interim remedy was assessed by determining if:

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

This review determined that the interim remedy for the Building 854 OU is protective, as summarized below.

- There have been no changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements since the Interim Site-Wide ROD for Site 300 was signed (2001), nor have there been any changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 854 OU that create new exposure risk since the Interim Site-Wide ROD was signed.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Ground water extraction is reducing contaminant concentrations in the subsurface. DOE has removed approximately 4.4 kg of VOCs, 0.13 kg of perchlorate, and 975 kg of nitrate from the ground water.
- The treatment systems are performing as designed and will continue to be operated and optimized.
- System operation procedures are consistent with requirements.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

10.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

10.7. Recommended Changes

This evaluation did not identify a need for changing the overall approach to cleanup in the Building 854 OU. DOE/LLNL have implemented all the actions recommended in the Remedial Design Work Plan for the Interim Remedies (Ferry et al., 2001). The actions proposed in the Interim Remedial Design document for the Building 854 OU (Dibley et al., 2003) are scheduled for completion by 2008.

10.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected for the Building 854 OU in the Interim Site-Wide ROD. The proposed final remedy for the OU consists of:

1. No further action for metals, HMX, and tritium in surface soil.
2. Ground water monitoring to evaluate the effectiveness of the remedial action and to determine when cleanup standards are met.
3. Risk and hazard management, including institutional/land use controls, to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.
4. Mitigating risk and controlling contaminant source areas and ground water plume migration by extracting and treating ground water to remove VOCs, nitrate, and perchlorate released from past Building 854 operations.

Based on the results of the long-term soil vapor extraction treatability test at the Building 854 source area, DOE/LLNL will make a decision on whether to continue soil vapor extraction as part of the final cleanup remedy. This decision will be based on the long-term sustainability of VOC concentrations in soil vapor.

10.9. Protectiveness Statement

The proposed final remedy for the Building 854 OU is expected to protect human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, sufficient to control risks, and properly implemented, (2) monitoring data indicates that ground water has not been impacted metals, HMX, and tritium in surface soil and there is no risk associated with these contaminants, (3) ground water extraction and treatment are reducing contaminant concentrations in the subsurface, and (4) institutional controls to minimize heath risks and prevent use of contaminated ground water are in place.

11. Building 832 Canyon (OU 7)

11.1. Background

This section describes the Building 832 Canyon OU, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this OU. It also describes the history of contamination, COCs identified in environmental media and the remedial

investigations and actions conducted prior to selecting the interim remedy in the Interim Site-Wide ROD.

11.1.1. OU Description

The Building 832 Canyon OU is located in a two mile-long, southeast-oriented, canyon in the southeastern part of Site 300 (Figure 3-5). This 400-acre canyon is an ephemeral drainage that conveys surface runoff and shallow ground water into Corral Hollow Creek during heavy rainfall events. Starting in the late 1950s and early 1960s, facilities in the Building 830 and 832 areas were used to test the stability of weapon components under various environmental conditions. The use of the Building 830 and 832 facilities for testing was discontinued in the late 1970s and 1985, respectively.

The Building 830 Complex is a single building containing three test cells where experiments involving explosives chemicals and weapon components were conducted (Figure 11-1). Since experiments ceased in 1970, the Building 830 Complex has been used mainly for electrical equipment storage. The Building 830 Complex is scheduled for decontamination and demolition.

The Building 832 Complex consists of eight buildings (Buildings 832 A-F and Buildings 831 and 838) where experiments were conducted (Figure 11-1). Since testing ceased in 1985, the Building 832 Complex has been used mainly for records storage and office space. Building 832F was decontaminated and demolished in 2005.

11.1.2. Site Chronology

A chronology of important environmental restoration events at the Building 832 Canyon OU is summarized below.

1950s–1960s

- The Building 830 and 832 Complexes were used to test the stability of weapon components under various environmental conditions.

1970s–1980s

- Testing at Buildings 830 and 832 was discontinued in 1985.

1990

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

1992

- An FFA for Site 300 was signed.

1996

- The Building 832 Canyon Study Area Fact Sheet (Ziagos and Sutherland, 1996) was issued, which summarized the historical operations, use, and chemical releases in the OU, as well as plans for additional investigations.

1997

- The Building 832 Canyon Operable Unit Characterization Summary letter report was issued (Ziagos and Ko, 1997).

1999

- The Site-Wide Feasibility Study (Ferry et al., 1999) for Site 300 was issued that included the Building 832 Canyon OU.
- The Building 832-Source (B832-SRC) ground water and soil vapor extraction and treatment facility began operating.

2000

- The Building 830-Proximal North (B832-PRXN) ground water extraction and treatment facility began operating.
- The Building 830-Distal South (B830-DISS) ground water extraction and treatment facility began operating.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for: (1) HMX in surface soil and nitrate in subsurface soil and bedrock at Building 830, and (2) HMX and nitrate in soil and bedrock at Building 832. Soil vapor and ground water extraction and treatment, ground water monitoring, and administrative controls (i.e., risk and hazard management) were also selected as components of the remedy for the Building 832 Canyon OU.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD (Ferry et al., 2001).

2002

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

2003

- The Building 830-Source (B830-SRC) ground water and soil vapor extraction and treatment facility began operating.

2005

- The Building 832-Source ground water extraction wellfield was expanded into the downgradient portion of the contaminant plumes.

11.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 832 Canyon OU, including the unsaturated zone, the four HSUs underlying the area, and surface water in the OU. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 832 Canyon area is shown on Figure 3-2.

11.1.3.1. Vadose (Unsaturated) Zone

A seasonally variable unsaturated zone exists in the Building 832 Canyon OU. Quaternary alluvial sand and gravel and the underlying weathered bedrock within the canyon and tributary surface water drainages are generally dry in the summer months and become completely unsaturated during periods of drought. A 20- to 30-ft thick sandstone ($Tnsc_{1b}$) within the $Tnsc_1$ claystone/siltstone is variably saturated in beneath the Building 832 and 830 source areas.

11.1.3.2. Saturated Zone

The four HSUs in the Building 832 Canyon OU are described below.

Qal/WBR HSU – The Qal/WBR HSU is comprised of alluvial sands and gravels and the underlying weathered bedrock within the canyon and tributary surface water drainages. In addition to the natural alluvial material, the Building 832 and Building 830 tributary canyons contain several feet of artificial fill underneath building foundations. This artificial fill is a heterogeneous mixture of sand, gravel, and native soil. It is generally of low permeability and difficult to distinguish from the underlying natural alluvium. The Qal/WBR HSU typically contains water only after significant rainfall events and is highly responsive to seasonal rainfall. This response is typical of shallow alluvial water-bearing zones at Site 300 that transmit ground water following intense rainfall events but are generally dry during summer months and become completely unsaturated during drought periods. When saturated conditions exist, ground water flows in the down-canyon direction (generally southeast) and ultimately discharges into Corral Hollow Creek. A ground water elevation map for the Qal/WBR HSU is presented in Figure 11-2.

$Tnsc_{1b}$ HSU – The $Tnsc_{1b}$ HSU is a 20- to 30-foot thick, medium-grained sandstone that occurs within the $Tnsc_1$ siltstone/claystone. The $Tnsc_{1b}$ HSU is laterally continuous over the southeast part of Site 300. Although this zone is widespread over a large area, its hydraulic properties are spatially variable. For example, $Tnsc_{1b}$ extraction wells in the Buildings 830 and 832 source areas exhibit such low yield that they cannot sustain continuous flow, while other wells sustain long-term flow under natural artesian pressure at a rate of a few gpm. The low yield wells are generally located near the limit of saturation for this HSU and are limited by the available recharge from tributary canyons. The $Tnsc_{1b}$ beneath these tributary canyons is difficult to distinguish from the weathered bedrock and artificial fill that exist beneath the buildings in these areas. The saturated thickness of the $Tnsc_{1b}$ HSU ranges from 0 to 30 ft. Depth to ground water in this HSU ranges from 15 to over 100 ft bgs. Ground water flows to the south-southeast. A potentiometric surface map for the $Tnsc_{1b}$ HSU is presented in Figure 11-3.

$Tnbs_1$ HSUs – The $Tnbs_1$ HSUs consist of Neroly Formation sandstones interbedded with siltstones and claystones and are present throughout the Building 832 Canyon OU. There are two water-bearing zones within the $Tnbs_1$ stratigraphic unit, separated by a 10-ft thick claystone (claystone marker bed). Ground water occurs under unconfined to confined, and flowing artesian conditions in the upper and lower $Tnbs_1$ HSUs. In some wells, the artesian head is as much as 10 to 15 ft above the ground surface. The saturated thickness of the upper $Tnbs_1$ HSU ranges from 0 to 60 ft. Depth to ground water in the upper $Tnbs_1$ HSU ranges from 60 to 280 ft bgs. The saturated thickness of the lower $Tnbs_1$ HSU is not known because this unit has never been fully penetrated. The depth to ground water in lower $Tnbs_1$ ranges from approximately 100 to 350 ft bgs. Ground water flows generally to the south-southeast (Figure 11-4). The upper and lower $Tnbs_1$ HSUs are recharged in the upper reaches for Building 832 Canyon northwest of the Building 832 source area. Some of the ground water from the $Tnbs_1$ HSUs ultimately discharges into the Corral Hollow Creek alluvium in the Central GSA where these bedrock zones subcrop beneath the alluvium. The $Tnbs_1$ HSUs exhibit lower magnitude, delayed responses to rainfall events compared to the Qal/WBR.

11.1.3.3. Surface Water

Short-term flows of surface water in the Building 832 Canyon OU drainages occur during or after significant rainfall events. Minor amounts of surface water are present in Spring 3 near the southern end of the canyon (Figure 11-2). Discharge rates from this ephemeral spring are too low to measure and standing surface water is rarely observed. However, flow can be sufficient to moisten the soil and support vegetation in the vicinity of the spring. A vertical standpipe has been installed within the spring area from which samples can generally be collected. Surface water at Spring 3 likely originates primarily from the saturated $Tnsc_{1b}$ bedrock where it intersects the Building 832 Canyon bottom, and discharges into the Qal/WBR HSU. Spring 4 is located on the west wall of Building 832 Canyon south of Building 832. Ground water from the Tps stratigraphic unit likely feeds the spring. Due to the location of the spring on the canyon wall, surface water does not collect in this spring. However, flow can be sufficient to moisten the soil and support vegetation in the vicinity of the spring.

11.1.4. History of Contamination

TCE was used as a heat exchange fluid as part of testing activities at Buildings 830 and 832. TCE and other VOCs were released to soil, rock, and ground water as a result of piping leaks and surface spills. Rinsewater containing HE compounds was disposed via floor drains in Building 832 leading to a surface discharge outside the building. As a result, HMX has been detected in soil and bedrock. However, no HE compounds have been detected in ground water. Nitrate in ground water in the OU is believed to be the result of a combination of HE-related testing, some septic system releases, and natural sources. Although rinsewater containing HE compounds was likely discharged to one or more small disposal lagoons or dry wells near Building 830, no HE compounds have been detected in any media in this area. However, the HE compounds released may have degraded and migrated downward as nitrogenous compounds. The source of perchlorate in Building 832 Canyon OU ground water is not known at this time, but it is suspected that perchlorate was a component of HE test assemblies.

11.1.5. Contaminants of Concern

Three COCs have been identified in Building 832 Canyon OU ground water: (1) VOCs, (2) nitrate, and (3) perchlorate, HMX has been identified as a COC in surface soil at Building 832. VOCs, HMX, and nitrate are COCs in subsurface soil and bedrock. VOCs are the only COCs in surface water at Spring 3.

VOCs, primarily TCE a suspected human carcinogen, are present in subsurface soil and rock, in surface water at Spring 3, and in ground water. An unacceptable baseline cancer risk (greater than 10^{-6}) was calculated for VOCs in the following environmental media in the Building 832 Canyon OU:

- Inhalation risk of 3×10^{-6} for onsite workers inside Building 830.
- Inhalation risk of 1×10^{-5} for onsite workers outside of Building 830.
- Inhalation risk of 3×10^{-6} for onsite workers inside Building 832.
- Inhalation risk of 7×10^{-5} for onsite workers in ambient air in the vicinity of Spring 3.

The HE compound HMX is a human carcinogen present in surface soil and subsurface soil and rock in the Building 832 Canyon. No risk or hazard associated with HMX in surface soil or subsurface soil/rock in the Building 832 Canyon OU has been identified.

Elevated nitrate is present in ground water as a result of a combination of natural and anthropogenic sources in the Building 832 Canyon OU. In addition to natural soil nitrate and septic system discharges, discharge of rinsewater containing nitrogenous HE-compounds to the ground surface occurred at Building 832 and possibly at small disposal lagoons or dry wells near Building 830. DOE/LLNL are conducting an ongoing study to evaluate potential natural and anthropogenic sources, and their relative contribution of nitrate to ground water in this OU and other parts of Site 300. Nitrate can cause non-carcinogenic health effects if ingested at elevated levels. There was no human health risk identified associated with nitrate in subsurface soil/rock or ground water.

There was no hazard identified for ecological receptors associated with COCs in any environmental media in the Building 832 Canyon OU.

Ground water contamination is present in the Qal/WBR and $Tnsc_{1b}$ HSUs throughout most of the Building 832 Canyon OU. The highest concentrations of VOCs, perchlorate, and nitrate in ground water in these HSUs are generally detected in or immediately downgradient of the Buildings 830 and 832 source areas. Total VOC concentrations in Qal/WBR, $Tnsc_{1b}$, and the upper $Tnbs_1$ HSU ground water are shown in Figures 11-5, 11-6, and 11-7, respectively. As shown in these figures, the highest VOC concentrations in both HSUs are located in the Building 830 source area. The leading edge of the $Tnsc_{1b}$ VOC plume is located near the southern site boundary (Figure 11-6). A hydrogeologic cross-section showing the vertical distribution of total VOCs in the Building 832 Canyon OU HSUs is shown in Figure 11-8. The distribution of perchlorate and nitrate in Qal/WBR and $Tnsc_{1b}$ HSU ground water does not extent beyond the limits of the VOC plume.

VOCs are the only COC detected in upper $Tnbs_1$ HSU ground water with maximum concentrations occurring in the vicinity of Building 830 (Figure 11-7). No COCs have been detected in ground water in the lower $Tnbs_1$ HSU.

11.1.6. Initial Response

DOE/LLNL began environmental investigations in the Building 832 Canyon OU in the early 1980s to identify contaminant source areas and the distribution of contaminants in the soil, bedrock, and ground water. Since then, 168 boreholes have been drilled in the Building 832 Canyon OU; 79 of these boreholes have been completed as ground water monitor or extraction wells (Figure 11-1). The geologic and chemical data from these wells and boreholes were used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included analysis of water samples from springs, and passive and active vacuum induced soil vapor surveys.

As summarized in Section 11.1.2, remediation activities at the Building 832 Canyon OU conducted prior to the Interim Site-Wide ROD included extraction and treatment of contaminated ground water at the Building 832 source area, immediately downgradient of the Building 830 source area, and near the site boundary.

11.2. Interim Remedial Actions

This section describes the interim remedial actions implemented in the Building 832 Canyon OU.

11.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the remedy for the Building 832 Canyon OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The selected interim remedy for the Building 832 Canyon OU consists of:

1. No Further Action for HE compounds in surface soil and nitrate in subsurface soil/bedrock at Building 830, and for HE compounds in subsurface soil/rock at Building 832.
2. Ground water monitoring to evaluate the effectiveness of the remedial action and to determine when cleanup standards are met.
3. Risk and hazard management to prevent contaminant exposure to humans until cleanup standards are achieved through active remediation.
4. Controlling plume migration by extracting and treating ground water and soil vapor, both in the source area and at the leading edge of the Building 832 VOC, perchlorate, and nitrate plumes.
5. Controlling plume migration by extracting and treating ground water and soil vapor to remove VOCs, nitrate, and perchlorate at Building 830.
6. Preventing offsite plume migration by extracting ground water to remove VOCs at the distal portion of the plume.

11.2.2. Interim Remedy Implementation

Ground water extraction and treatment systems have been operating in the Building 832 Canyon OU since 1999. Four ground water extraction and treatment systems currently operate in the Building 832 Canyon OU: B832-SRC, B830-SRC, B830-PRXN, and B830-DISS. The B832-SRC and B830-SRC facilities extract and treat both ground water and soil vapor, and the B830-PRXN and B830-DISS facilities extract and treat ground water only. The location of the ground water and soil vapor extraction wells and treatment system are shown in Figure 11-1.

The B832-SRC facility treats ground water for VOCs, perchlorate, and nitrate and has been operating since October 1999. Initially, ground water was extracted from nine wells at a combined total flow rate that initially ranged from 30 to 300 gpd. The total flow eventually dropped to 5 to 50 gpd due to lowering of the water table by pumping. In early 2005, the source area extraction wellfield was reduced to two wells operating with vacuum enhancement and a combined flow rate ranging from 60 to 220 gpd. In late 2005, the extraction wellfield was expanded to include three additional downgradient wells. As a result, the combined flow rate has increased to about 1,300 gpd, and VOC concentrations in facility influent have increased four-fold. Ground water is treated using a filter to remove particulates, aqueous-phase GAC to remove VOCs, and ion-exchange to remove perchlorate. Treated ground water is discharged through a misting system to indigenous grasses to remove nitrate. Soil vapor is extracted from the same wells used for ground water extraction. The contaminated vapors are treated using vapor-phase GAC.

The B830-SRC facility treats ground water for VOCs, perchlorate, and nitrate and has been operating since June 2005. Ground water is extracted from four wells at a total flow rate ranging from 5 to 100 gpd. The extraction wells exhibit very low sustainable yield and are operated by

timers that pump the wells at low flow rates until dry and then shut off while the water levels recover. The extraction wellfield will be expanded in 2006 to include four additional downgradient wells. Ground water is treated using aqueous-phase GAC to remove VOCs followed by ion-exchange to remove perchlorate. Treated water is then discharged through a misting tower to indigenous grasses to remove nitrate. The Building 830-Source soil vapor extraction and treatment system is being tested to evaluate whether it is a viable remediation technology for this low permeability source area. Extracted soil vapor is treated using vapor-phase GAC.

Since October 2000, the B830-PRXN facility has been treating ground water for VOCs and nitrate. Ground water is extracted from one well at a flow rate ranging from 500 to 1,500 gpd. The ground water is treated using aqueous-phase GAC to remove VOCs, and the effluent is discharged into an infiltration trench.

The B830-DISS facility treats ground water for VOCs, perchlorate, and nitrate and has been operating since July 2000. Ground water is extracted using natural artesian pressure from three wells located approximately 650 ft north of the treatment facility, at a total flow rate ranging from 600 to 3,000 gpd. Extracted ground water will be treated to remove perchlorate using ion exchange resins at the current B830-DISS location. The water will then be piped to the Central GSA ground water treatment facility for the treatment of VOCs. The treated water will be discharged to the Central GSA treatment facility misting towers.

In 2006, the B830-SRC extraction wellfield will be expanded to include additional downgradient wells to increase contaminant mass removal and plume capture. In addition, the extraction well for the Building 832-PRXN facility will be connected to the B830-SRC facility to increase operational efficiency and cost-effectiveness. In 2007, the B832-SRC extraction wellfield will be expanded to include additional downgradient wells to increase contaminant mass removal and plume capture. The capacity of the B830-DISS bioreactor will be increased to allow for increased pumping from the facility's extraction wells.

11.3. System Operations/Operation and Maintenance

In general, the Building 832 Canyon OU extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this review. All required documentation is in place (or is scheduled to be produced), and treatment system O&M activities are consistent with established procedures and protocols.

O&M procedures for the Building 832 Canyon treatment systems are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the Building 832 Canyon Treatment Facilities, contained within the Interim Remedial Design document (Madrid et al., 2006).
- Operations and Maintenance Manual for Miniature Treatment Units, Ground Water Treatment Units, and Solar Treatment Units, Volume 13 (LLNL, in progress).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #1265.02: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.

- Building 832 Canyon and Building 854 OU Substantive Requirements and the Monitoring and Reporting Program issued by the RWQCB.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Depue, 2003).

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprise a large portion of the O&M activities. Extracted ground water is sampled throughout the treatment process to ensure compliance with discharge requirements.

The major O&M activities for the Building 832 Canyon ground water and soil vapor extraction and treatment systems include:

- Maintaining the particulate filters.
- Maintaining the misting towers and infiltration trenches used to discharge treated ground water.
- Maintaining the bioreactor and replenishing vinegar used as a carbon source for this unit.
- Protecting the treatment units and pipelines from freezing in cold weather.
- Replacing spent GAC and ion-exchange resin.
- Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.

The budgeted and actual environmental restoration costs for the Building 832 Canyon OU are tracked closely and are consistently within the allocated budget.

11.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 832 Canyon OU was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 that could affect the protectiveness and effectiveness of the interim remedies were also considered.

Section 11.4.1 presents the results of the evaluation that was conducted to determine if there have been any changes to logistical factors such as ARARs; land, building, or ground water use; or exposure pathways, toxicity or other contaminant characteristics that could affect the protectiveness of the interim remedy. Section 11.4.2 evaluates the effectiveness of institutional controls specified in the Interim Site-Wide ROD under current conditions at the Building 832 Canyon OU. Section 11.4.3 presents the results of the technical evaluation of the protectiveness of the interim remedy including: (1) assessing the progress of remediation in reducing contaminant concentrations and plume size, (2) hydraulically controlling the plume, (3) mitigating risk, and (4) assessing data for indications of new sources, releases, or contaminants. Section 11.4.3 also discusses any new or innovative technologies that were assessed to expedite cleanup of the Building 832 Canyon OU.

11.4.1. Assessment of Logistical Factors

11.4.1.1. Changes in ARARs and To-Be-Considered Requirements

There have been no changes in the location-, chemical-, or action-specific ARARs or other requirements that were presented in the Interim Site-Wide ROD in 2001.

11. 4.1.2. Changes in Land, Building or Ground Water Use

There have been no changes in land, building, or ground water use in the Building 832 Canyon OU since the Interim Site-Wide ROD. Buildings in the Building 832 Complex are still used mainly for records storage and office space, and the OU is accessible only to DOE/LLNL workers. Building 832F was decontaminated and demolished in 2005. Building 830 is still used mainly for electrical equipment storage but is scheduled for decontamination and demolition in 2006. Ground water underlying the OU is not used for water-supply.

11.4.1.3. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics since the Interim Site-Wide ROD was signed in 2001.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

11.4.2. Institutional Controls Evaluation

The institutional controls that were specified in the Interim Site-Wide ROD for Site 300 were evaluated for effectiveness under the current conditions at the Building 832 Canyon OU and are summarized below.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing water-supply wells in the Building 832 Canyon OU. LLNL environmental restoration staff periodically meet with site planning personnel and ensure that any potential new water-supply wells would be sited in uncontaminated areas. There is no offsite ground water contamination resulting from releases at the Building 832 Canyon OU, and no offsite water-supply wells are in use near the OU.
- **Preventing installation of water-supply wells where ground water is contaminated above concentrations protective of human health –** DOE has no plans to install onsite water-supply wells near the Building 832 Canyon OU and is not aware of any proposed offsite wells near the OU.
- **Briefing all personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to

ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.

- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in contaminated areas except under the supervision of Hazards Control staff. LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in the Building 832 Canyon area without the proper controls in place.
- **Maintaining building occupancy and land use restrictions in the vicinity of Buildings 830 and 832 –** Building occupancy and land use restrictions have been implemented by the Facility Coordinators.
- **Installing warning signs in the vicinity of Buildings 830 and 832 –** Warning signs have been installed stating that full-time occupancy of Building 830 is prohibited.
- **Conducting annual risk evaluations for VOCs within and adjacent to Building 830 and indoor air for Building 832F until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** An annual risk revaluation was implemented and the indoor and outdoor risks were re-evaluated in 2003 and 2004. The results of the risk re-evaluation monitoring program are summarized in Section 11.4.3.3.
- **Conducting wildlife surveys every five years to evaluate the presence of the San Joaquin kit fox and other burrowing species of special concern –** An ecological survey program will be conducted by 2007.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operational Safety Procedures are in place, and new procedures are created as needed.

11.4.3. Assessment of Technical Factors

11.4.3.1. Vadose Zone Remediation Progress

Long-term soil vapor extraction treatability tests have been ongoing at the Buildings 832 and 830 source areas since 1999 and 2003, respectively. The initial strategy was to implement simultaneous ground water and soil vapor extraction to lower the water table in these source areas, thereby effectively increasing the volume of VOC-contaminated soil and bedrock available for soil vapor extraction. Generally, vapor-phase extraction is a more effective mass removal method than ground water extraction. However, the source area must exhibit a minimal pneumatic permeability for soil vapor extraction to be effective. The bedrock underlying the Building 832 and 830 source areas exhibits such low pneumatic permeability that soil vapor extraction has proven to be of limited effectiveness under current operating parameters.

However, continued operation of extraction wells at the B832-SRC and B830-SRC while maintaining a vacuum in the well casing has proven to be an effective method of increasing ground water yield.

The B832-SRC soil vapor extraction system operated from 1999 to 2003 using nine dual-phase extraction wells. During this period, TCE soil vapor concentrations in the facility influent decreased from 5.4 $ppm_{v/v}$ to levels below the 0.2 $ppm_{v/v}$ method reporting limit. A rebound test was initiated in October 2003 to determine if significant VOC mass remained in the source area vadose zone. After one and half years of rebound testing, VOC concentrations in soil vapor remain below the method reporting limit. Therefore, DOE/LLNL are evaluating data for the system against the soil vapor extraction shutoff criteria in the Building 832 Canyon Remedial Design report (Madrid et al., 2006).

The B830-SRC soil vapor extraction system has been operating since May 2003. This treatability test has demonstrated that the pneumatic permeability in the formation in which the extraction well is screened may be so low that the system cannot sustain measurable flow (less than 0.2 standard cubic ft per minute), even under high vacuum. However, total VOC concentrations of 24 to 35 $ppm_{v/v}$ were measured in vapor samples from the wells, indicating some minimal pneumatic permeability in the formation. Continued wellfield optimization tests are being conducted to evaluate if soil vapor extraction can effectively remove VOC mass at the Building 830 source area.

As of the 1st Semester of 2005, 1.6 kg of VOCs have been removed from the vadose zone by the Building 832 and 830 soil vapor extraction systems.

11.4.3.2. Ground Water Remediation Progress

Although the first ground water and soil vapor extraction and treatment system was installed in the Building 832 Canyon in 1999, remediation is still in the early stages. While all planned treatment facilities are now in place, construction of the extraction wellfield specified in the Remedial Design has not yet been completed. However, some progress in ground water remediation system has been accomplished. This progress was evaluated by:

- Comparing pre-remediation and 1st Semester 2005 ground water COC concentrations.
- Reviewing ground water COC mass removal data.
- Evaluating extraction wellfield capture zones.

Overall, maximum contaminant concentrations in Building 832 Canyon OU ground water have decreased significantly over time. VOC concentrations have decreased from an historical, pre-remediation maximum of over 30,000 μg/L in 1997 to 9,500 μg/L in the 1st Semester of 2005. Perchlorate concentrations have decreased from an historical, pre-remediation maximum of over 51 μg/L in 1998 to 15 μg/L in the 1st Semester of 2005. Nitrate concentrations have decreased from an historical, pre-remediation maximum of over 501 μg/L in 1998 to 150 μg/L in the 1st Semester of 2005. As of the 1st Semester of 2005, approximately 1.4 kg of VOCs, 0.02 kg of perchlorate, and 539 kg of nitrate have been removed from ground water by the B832-SRC, B830-SRC, B830-PRXN, and B830-DISS treatment facilities. Time-series plots of cumulative VOC and perchlorate mass removed by these treatment facilities are shown in Figures 11-9 and 11-10, respectively.

Figures 11-11 and 11-12 presents the predicted hydraulic capture zones for the fully implemented ground water extraction and treatment remedy in the $Tnsc_{1b}$ and $Tnbs_1$ HSUs. The capture zones predicted by the WinFlow models for the Building 832 Canyon OU are conservative because: (1) the basic model parameters used for each model are selected conservatively (i.e., maximum aquifer thickness, hydraulic conductivity, and hydraulic gradient values), (2) the WinFlow models assume an infinite extent of saturation, while the extent of saturation in the $Tnsc_{1b}$ and $Tnbs_1$ HSUs are limited, and (3) the $Tnsc_{1b}$ and $Tnbs_1$ HSUs are recharge-limited and the capture zone analysis model assumes continuous recharge. The actual capture zones are expected to be larger. The capture plots shown in Figures 11-11 and 11-12 show the long-term extent of capture after pumping until the capture streamlines extend to the extent of saturation.

Once the extraction wellfields in the Building 832 Canyon OU are fully implemented and have operated long enough for capture zones to fully develop, DOE/LLNL will evaluate the extent of capture and the ability of the extraction wellfields to achieve ground water RAOs. This evaluation will be based on ground water elevation data and concentration trends in extraction, performance monitoring, and guard wells. If data from this evaluation indicate that the existing extraction wellfields will not achieve ground water RAOs, modifications to the wellfields will be implemented. Modifications may include changes to the extraction well pumping strategy and/or installing additional extraction wells. Because the perchlorate plume is commingled with the VOC plume, perchlorate should also be captured by the extraction wellfield.

However, there are limitations on DOE/LLNL's ability to further expand the extraction wellfields as follows:

- Steep topography within Building 832 Canyon limits the availability of accessible drilling locations.
- Pumping from downgradient locations where there are existing wells that do not currently contain contamination is not desired because it will likely accelerate plume migration into uncontaminated ground water and toward the boundary. However, if the plume migrates into these downgradient areas, DOE/LLNL will evaluate adding additional extraction wells in this area to prevent further migration.

Remediation progress by treatment facility area is discussed below in the chronological order that they were installed.

VOCs, perchlorate and nitrate remediation at the B832-SRC treatment facility – The B832-SRC ground water and soil vapor extraction and treatment facility began operating in late 1999 to: (1) initiate cleanup of the Building 832 source area, (2) prevent further contaminant plume migration, and (3) mitigate the VOC inhalation risk to onsite workers at Building 832F.

Time-series plots of VOC and perchlorate concentrations in ground water in the Building 832 source area are shown in Figure 11-13. VOC concentrations in ground water in the Building 832 source area have been reduced from a pre-remediation historical maximum of 5,600 μg/L in 1999 to 2,200 μg/L in the 1st Semester of 2005. While decreases in perchlorate concentrations have been detected in Building 832 source area wells, the maximum concentration of perchlorate detected in ground water in this area remain relatively constant at around 14 to 15 μg/L. Nitrate levels remain relatively constant with a maximum concentration of 120 mg/L detected in ground water in the 1st Semester of 2005. The stability of nitrate concentrations in the Building 832 source area over time are likely attributable to continued contributions from the septic system

leachfield and natural sources in bedrock. As of the 1st Semester of 2005, this facility has removed 0.038 kg of VOCs, 0.005 kg of perchlorate, and 78.3 kg of nitrate from ground water.

Downgradient extraction wells were added to the B832-SRC wellfield in 2005 to remove contaminant mass downgradient of the source area. An additional expansion of the B832-SRC extraction wellfield into the downgradient portion of the plume is scheduled for 2007.

VOCs, perchlorate and nitrate remediation at the B830-DISS treatment facility – The B830-DISS ground water treatment facility began operating in July 2000 to: (1) reduce contaminant concentrations in the distal portion of the VOC plume originating from the Building 830 source area, and (2) prevent offsite plume migration.

TCE concentrations in the distal portion of the Building 830 plume have stabilized at concentrations of about 80 to 90 μg/L. As of the 1st Semester of 2005, this facility has removed 0.65 kg of VOCs, 0.016 kg of perchlorate, and 441 kg of nitrate from ground water. The capture zone created by the B830-DISS extraction wellfield adequately captures the TCE and perchlorate plume in this area. The planned expansion of the bioreactor capacity will allow for increased flow from the extraction wells for this facility, increasing capture and contaminant mass removal.

VOCs and perchlorate remediation at the B830-PRXN treatment facility – The B830-PRXN ground water treatment facility began operating in early 2003 to: (1) reduce contaminant concentrations in ground water immediately downgradient of Building 830 source area, and (2) prevent migration of the VOC plume emanating from the Building 832 source area. As of the 1st Semester of 2005, this facility has removed 0.213 kg of VOCs from ground water.

VOCs, perchlorate and nitrate remediation at the B830-SRC treatment facility – The B830-SRC ground water and soil vapor extraction treatment facility began operating in May 2003 to: (1) initiate cleanup of the Building 830 source area, (2) prevent further ground water plume migration, and (3) mitigate the VOC inhalation risk to onsite workers at Building 830.

VOC concentrations in ground water in the Building 830 source area have been reduced from a pre-remediation historical maximum of 13,000 μg/L in 2003 to 9,500 μg/L in the 1st Semester of 2005. While decreases in perchlorate concentrations have been detected in Building 830 source area wells, the maximum concentration of perchlorate detected in ground water in this area remain relatively constant at around 10 to 11 μg/L. Nitrate levels have decreased from an historical maximum concentration of 200 mg/L in 1999 to a maximum concentration of 150 mg/L in the 1st Semester of 2005. As of the 1st Semester of 2005, this facility has removed 0.51 kg of VOCs, 0.001 kg of perchlorate, and 20.2 kg of nitrate from ground water.

The Building 830-SRC extraction wellfield is scheduled for expansion in 2006 to increase contaminant mass removal.

11.4.3.3. Risk Mitigation Progress

The risks associated with COCs in the Building 832 Canyon were summarized in Section 11.1.5 and the baseline risk assessment. This section summarizes the results of annual risk re-evaluations conducted in the Building 832 Canyon OU to assess the progress of remediation in mitigating risk to onsite workers.

The risks associated with COCs in the Building 832 Canyon OU were re-evaluated in 2003 and 2004. The re-evaluation indicates that ground water and soil vapor extraction at Building 830 has contributed to reducing the human health risk due to inhalation of VOC vapors outside Building 830 to a level that is no longer of concern (less than 10^{-6}). Remediation at the Building 832 source area has also contributed to reducing VOC inhalation risk inside Building 832F to acceptable levels (less than10^{-6}). VOCs that could volatilize into air inside Building 830 continue to present an unacceptable risk to onsite workers. However, institutional controls are in place and the building is not occupied full-time. This building is scheduled for decontamination and demolition in 2006.

The VOC inhalation risk for Spring 3 was also re-evaluated. VOCs are still present in the spring at concentrations that could pose a risk to onsite workers. No surface water or hydrophilic vegetation was present at Spring 3 in 2004, and therefore DOE/LLNL was not able to reassess risk. There are no site employees that regularly work in the vicinity of Spring 3. Therefore, the assumption that a worker would be inhaling VOCs volatilizing from the spring for 8 hours a day, 5 days a week for 30 years on which the risk calculation was based does not currently apply.

11.4.3.4. New Sources, Releases, or Contaminants

Ground water and soil vapor data indicate that there are no new sources, releases, or contaminants in the Building 832 Canyon OU since the Interim Site-Wide ROD was signed.

11.4.3.5. New Technology Assessment

Vacuum-enhanced ground water extraction and expedited source area cleanup approaches are being evaluated to determine if contaminant cleanup in the Building 832 Canyon OU can be expedited, as discussed below.

Vacuum-enhanced Ground Water Extraction – A treatability test to evaluate whether ground water yield can be increased in low yield extraction wells by inducing a vacuum in the extraction well casing began in early 2005 at the B832-SRC facility. This method has been successfully applied at the Building 834 ground water and soil vapor extraction and treatment facility where ground water yield was increased up to three times in extraction wells placed under a vacuum.

Four extraction wells were tested under different operating parameters, including vacuum enhancement. These wells were selected based on their long-term yield during the last four years. The system was first operated without vacuum enhancement for two weeks, and then with vacuum enhancement for two weeks, while monitoring ground water yield from the four extraction wells. A minor increase in ground water yield was observed in two wells. Additionally it was observed that nearly all the ground water yield was attributable to these two extraction wells, regardless of whether the system was operated with or without vacuum enhancement. Based on these findings, the extraction wellfield was reduced to these two extraction wells that are now operated with vacuum enhancement. Ground water yield from these two extraction wells was higher in 2005 than during the previous four years.

Expedited Source Area Cleanup – Conventional soil vapor and ground water extraction methods may have limited success in achieving long-term source area cleanup in the fine-grained, low-permeability bedrock in the Building 832 and 830 source areas. A more aggressive approach to source area remediation, including evaluation and implementation of innovative remediation technologies, may be necessary to cleanup rock and ground water in these source

areas in a reasonable timeframe. Technologies that may expedite source area cleanup, such as source area flushing and hydraulic fracturing to increase the permeability of fine-grained materials in source areas, may be evaluated.

The Building 832 and 830 source areas are recharge-limited and significant contamination is present in low-permeability sediments. For these reasons, the time necessary to achieve cleanup in the source areas will be impacted by low well yield, and therefore mass removal rates. The injection of treated effluent from the B832-SRC and B830-SRC treatment facilities back into the $Tnsc_{1b}$ HSU will increase the long-term sustainable yield from individual extraction wells, improve overall contaminant mass removal rates, and facilitate operation of these facilities at their peak capacity. In addition, reinjection of treated water will flush contaminants in the source areas and increase the hydraulic gradient toward extraction wells. Reinjection of treated effluent will be evaluated to determine if this technique will significantly reduce source area cleanup time.

Hydraulic fracturing is a technique originally developed in the oil industry to improve oil production from low permeability reservoirs. A similar technique has been successfully applied to ground water cleanup projects (Sutherson, 1999). The advantages of applying this technique at the Building 832 and 830 source areas are that it may:

1. Effectively increase the hydraulic influence of the extraction wells, thereby decreasing the transit time from the aquifer to the pumping well.
2. Reduce the number of extraction wells necessary for site cleanup.
3. Provide a conduit for delivery of fluids for remedial enhancement purposes.
4. Potentially reduce source area cleanup cost.

Any plans to hydraulically fracture bedrock within the VOC source areas at Building 830 and 832 would be subject to review by the regulatory agencies. Any source area considered for hydraulic fracturing would be analyzed in detail to ensure that the subsurface conditions are optimal and that the technique would not result in the spread of contamination.

11.5. Protectiveness Assessment

The protectiveness of the Building 832 Canyon interim remedy was assessed by determining if:

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

This review determined that the interim remedy for the Building 832 Canyon OU is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD for Site 300 was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 832 Canyon OU that affect the protectiveness of the remedy since the Interim Site-Wide ROD for Site 300 was signed.

- All required institutional controls are in place and no current or planned changes in land use in the OU suggest that they are not or would not be effective.
- The interim remedy is functioning as intended. Ground water and soil vapor extraction are making progress to: (1) reduce contaminant concentrations in the subsurface, (2) remove contaminant mass removal from the Building 830 and 832 source areas, (3) mitigate VOC inhalation risk to onsite workers, and (4) prevent contaminant plume migration. Approximately 3 kg of VOCs, 0.02 kg of perchlorate, and 539 kg of nitrate have been removed from the subsurface.
- The treatment systems are performing as designed and will continue to be operated and optimized.
- System operation procedures are consistent with requirements.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that would call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

11.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

11.7. Recommended Changes

This review does not identify a need for reassessing the overall approach to cleanup. DOE has implemented all the actions recommended in the Remedial Design Work Plan for the Interim Remedies (Ferry et al., 2001) and the Interim Remedial Design document for the Building 832 Canyon OU (Madrid et al., 2006).

However, innovative source area cleanup approaches, such as vacuum-enhanced ground water extraction and hydraulic fracturing, are being evaluated to determine if alternative technologies can expedite contaminant cleanup source in the Building 832 Canyon OU. These technologies are discussed in Section 11.4.3.4.

11.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for the Building 832 Canyon OU consists of:

1. No Further Action for HE compounds in surface soil and nitrate in subsurface soil/bedrock at Building 830 and for HE compounds in subsurface soil/rock at Building 832.
2. Ground water monitoring to evaluate the effectiveness of the remedial actions and to determine when cleanup standards are met.

3. Risk and hazard management, including institutional/land use controls, to prevent contaminant exposure to humans and impacts to ecological receptors. The institutional/land use controls include prohibiting the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.
4. Controlling plume migration by extracting and treating ground water and soil vapor, both in the source area and at the leading edge of the Building 832 VOC, perchlorate, and nitrate plumes.
5. Controlling plume migration by extracting and treating ground water and soil vapor to remove VOCs, nitrate, and perchlorate at Building 830.
6. Controlling offsite plume migration by extracting and treating ground water to remove VOCs at the distal portion of the Building 830 plume.

DOE/LLNL will continue to evaluate innovative source area cleanup approaches to determine if alternative technologies can expedite contaminant source cleanup in the Building 832 Canyon OU.

11.9. Protectiveness Statement

The proposed final remedy for the Building 832 Canyon OU is expected to protect human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, sufficient to control risks, and is properly implemented, (2) ground water and soil vapor extraction and treatment are reducing contaminant concentrations in the subsurface, and (3) institutional controls to minimize heath risks and prevent use of contaminated ground water are in place.

12. Site-Wide (OU 8)

The Site 300 Site-Wide OU is comprised of release sites at which no significant contamination that can impact human health or the environment. For this reason, monitoring-only interim remedies were selected for the release sites in the Interim Site-Wide ROD (DOE, 2001). OU 8 consists of the Building 801 Dry Well and Pit 8 Landfill, the Building 845 and the Pit 9 Landfill, the Building 851 Firing Table, Building 833, and the Pit 2 Landfill (Figures 3-4 and 3-5).

The OU8 release sites are discussed in this chapter as follows:

- Building 801 and Pit 8 Landfill (Section 12.1).
- Building 845 and Pit 9 Landfill (Section 12.2).
- Building 851 firing table area (Section 12.3).
- Building 833 (Section 12.4).
- Pit 2 Landfill (Section 12.5).

12.1. Building 801 Firing Table and Pit 8 Landfill

12.1.1. Background

This section describes the facilities in the Building 801 and Pit 8 Landfill release site in OU 8, a chronology of important events related to environmental restoration, and the hydrogeologic setting for these areas. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

12.1.1.1. Facility Description

The Building 801 facilities are located at the base of a wide and shallow valley and the Pit 8 Landfill is located northeast of these facilities (Figure 12-1). Since 1955, the Building 801 firing table has been used for explosives testing. A dry well, located under Building 801D, was used to dispose of rinsewater from a sink in the machine shop at Building 801D from the late 1950s to about 1984 (Lamarre et al., 1989). The dry well was decommissioned and filled with concrete in 1984 (Lamarre et al., 1989). Use of the firing table was suspended briefly in 1988, and the firing table gravel and some underlying soil were removed and disposed in the Pit 1 Landfill in 1988 under oversight of the RWQCB (Lamarre and Taffet, 1989). Outdoor firing experiments resumed and continued until 2001, when an indoor test chamber, the Contained Firing Facility was built on the site of the former firing table.

Pit 8 is an unlined landfill that was constructed in 1958 immediately northeast of the Building 801 Complex (Taffet, 1989). Debris from the Building 801 firing table was disposed in Pit 8 until 1974 when an earthen cover was installed. The total estimated volume of material disposed in the Pit 8 Landfill is about 24,700 yd^3.

12.1.1.2. Chronology

A chronology of important environmental restoration events at the Building 801 and the Pit 8 Landfill is summarized below.

<u>1955–1999</u>

- Building 801 firing table was used for explosives testing (1955-1999).
- Gravel was removed from the Building 801 firing table under oversight of the CVRWQCB in 1988.
- The Building 801D dry well was active from the late 1950s to about 1984 when it was decommissioned and filled with concrete.
- The Pit 8 Landfill was constructed in 1958.
- Debris from the Building 801 firing table was disposed in Pit 8 until 1974 when an earthen native soil cover was installed.

<u>1990</u>

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

<u>1992</u>

- An FFA for Site 300 was signed.

1999

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

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs in subsurface soil at the Building 801 dry well and ground water monitoring as components of the remedy for Building 801 and the Pit 8 Landfill.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The Compliance Monitoring Plan/Contingency Plan for Interim Remedies (Ferry et al., 2002a) was issued.
- The Contained Firing Facility began operating.

12.1.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 801 and Pit 8 Landfill area, including the unsaturated zone, the underlying HSU, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 801 and Pit 8 Landfill area is shown on Figure 3-2.

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

Saturated Zone – The Building 801/Pit 8 Landfill area is underlain by a single HSU, the $Tnbs_1/Tnbs_0$ HSU. This HSU consists of the Tertiary Neroly Formation lower blue sandstone ($Tnbs_1$) and the basal blue sandstone ($Tnbs_0$). Ground water is present in the $Tnbs_1/Tnbs_0$ HSU under unconfined to confined conditions. Depth to water averages about 130 to 150 ft bgs. Recharge for this HSU occurs within alluvial channels. Ground water generally flows northeast beneath Building 801 and the Pit 8 Landfill (Figure 12-1). The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft. A ground water elevation map for the area is presented in Figure 12-1.

Surface Water – Natural surface water in the Building 801 and Pit 8 Landfill area is the result of runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant (greater than 0.3 in./hour) or prolonged (greater than 2 hours) storms.

12.1.1.4. History of Contamination

Although explosive test debris was routinely dispersed during experiments at the Building 801 firing table, no environmental contamination has been identified associated with firing table activities. Waste fluid discharges to the Building 801 dry well resulted in low concentrations of VOCs in the surrounding surface and subsurface soil and ground water. Contaminants have not been detected in the vicinity of or beneath the Pit 8 Landfill.

12.1.1.5. Contaminants of Concern

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

12.1.1.6. Initial Response

Investigation began in 1982 at the Building 801 and Pit 8 Landfill area to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then 14 boreholes have been drilled; five of these boreholes have been completed as ground water monitor wells (Figure 12-1). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Firing table gravel samples were also collected from five of the boreholes. Ground water monitoring has been conducted to evaluate VOCs released from the Building 801 dry well and to detect any potential future releases from the Pit 8 Landfill.

12.1.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented in the Building 801 and Pit 8 Landfill area.

12.1.2.1. Interim Remedy Selection

The interim remedy for the Building 801 and Pit 8 Landfill area was selected based on the low concentrations of VOCs in soil and ground water and the limited extent of VOCs, perchlorate, and nitrate in ground water. The selected interim remedy for the Building 801 and Pit 8 Landfill consists of:

1. No Further Action for VOCs in subsurface soil at the Building 801 dry well.
2. Ground water monitoring to detect any changes in COC concentrations in ground water or future releases from the Pit 8 Landfill that could impact human health or the environment.
3. Inspecting the Pit 8 Landfill cover and monitoring network for damage that could compromise their integrity and repairing any damage found.

12.1.2.2. Interim Remedy Implementation

Ground water compliance and landfill leak detection monitoring and inspections have been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. Ground water samples are collected semi-annually from wells in the Building 801/Pit 8 Landfill area and are analyzed for VOCs, perchlorate, and nitrate. The landfill is inspected semi-annually for evidence of burrows, cracks, subsidence, and surface erosion and to evaluate whether the

monitoring wellfield is functioning properly. Repairs are made as necessary to correct any deficiencies that could compromise landfill cover integrity or monitoring.

12.1.3. Remedy Operation

The Pit 8 Landfill has been inspected for surface damage that could compromise its integrity. Any damage was repaired as necessary. The landfill is also inspected annually for subsidence. The results of these inspections are reported in the semi-annual Compliance Monitoring Reports. Ground water in the Building 801/Pit 8 Landfill area is monitored as specified in the Compliance Monitoring Plan. Results are reported in the semi-annual Compliance Monitoring Reports. The interim remedy is operating as intended and no significant operations, performance, or cost issues were identified during this evaluation.

12.1.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 801 and Pit 8 Landfill area was evaluated to determine if it is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

12.1.4.1. Assessment of Logistical Factors

Changes in ARARs and To-Be-Considered Requirements – There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed.

Changes in Land, Building, or Ground Water Use – There have been no changes in land, building, or ground water use in the Building 801/Pit 8 Landfill area since the Interim Site-Wide ROD, except for conversion of Building 801 from an outdoor firing table facility to an indoor explosives testing facility (Contained Firing Facility) in 2001.

Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics – There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Building 801/Pit 8 Landfill area since the Interim Site-Wide ROD was signed.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

Institutional Control Evaluation – There were no institutional controls specified in the Interim Site-Wide ROD for Building 801 and the Pit 8 Landfill. However, access restrictions to Site 300, Building 801, and the Pit 8 Landfill area are maintained by the LLNL Safeguards and Security Organization. In addition, LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs within the Pit 8 Landfill.

Because the landfill waste would remain in place under the interim and proposed final remedies, institutional controls may be needed to prevent exposure to the waste in the Pit 8 Landfill in the event that Site 300 was to be released for residential land use. While DOE is evaluating consolidation of activities throughout the DOE complex that could result in changes to activities conducted at Site 300, DOE control of the site is expected to continue for the foreseeable future. There are no plans to release the land for recreational or residential (unrestricted) uses.

12.1.4.2. Assessment of Technical Factors

Surface Soil Remediation Progress – Surface soil remediation is not a component of the interim remedy for this area.

Vadose Zone Remediation Progress – Vadose zone remediation is not a component of the interim remedy for this area.

Ground Water Remediation Progress – Ground water data were evaluated to assess the effectiveness of the monitoring remedy for COCs in the Building 801 and in detecting releases to ground water from the Pit 8 Landfill. The progress of ground water remediation in the Building 801 area was evaluated by evaluating changes in COC concentrations over time. Figure 12-2 shows time-series plot of VOC concentrations for ground water collected from the four wells in the Building 801/Pit 8 Landfill area. Total VOC concentrations detected in ground water samples collected from wells downgradient of Building 801 have decreased from an historical maximum of 10 μg/L of VOCs in May 1990 to a maximum of 5.9 μg/L in the 1st Semester of 2005. TCE concentrations in ground water have been below the Federal and State MCL of 5 μg/L since 1992. Cis-1,2-DCE has never been detected in ground water at concentrations above the Federal or State MCLs of 70 μg/L and 6 μg/L, respectively.

In the 1st Semester of 2005, VOCs were detected ground water from the wells immediately downgradient of the Pit 8 Landfill at concentrations up to 1.6 μg/L, suggesting that the VOC plume originating at Building 801D is migrating beneath the Pit 8 Landfill.

Perchlorate was not detected in ground water samples from any of the Building 801/Pit 8 monitor wells above its 4 μg/L detection limit in the 1st Semester of 2005. Although perchlorate was reported in one historical ground water sample collected from the Building 801/Pit 8 Landfill area in 2004, perchlorate has not been detected in any wells in this area above the analytical reporting limit in any other samples/wells since that time.

Nitrate concentrations in ground water in this area have been fairly stable over time. During the 1st Semester of 2005, nitrate concentrations in ground water samples from wells in the Building 801/Pit 8 Landfill area ranged from 13 mg/L to 53 mg/L.

No contaminant releases have been identified from the Pit 8 Landfill. Depth to ground water remains approximately 130 to 150 ft beneath the Pit 8 Landfill.

Risk Mitigation Progress – In the baseline risk assessment, no unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 801 dry well or Pit 8 Landfill. There is no evidence of new releases or contamination that warrants re-evaluation of risk.

New Sources, Releases or Contaminants – Ground water data do not indicate any new sources, releases, or contaminants in the Building 801/Pit 8 Landfill area.

New Technology Assessment – No new innovative technologies have been identified that would apply to the cleanup in the Building 801 portion of this OU.

12.1.5. Protectiveness Assessment

The protectiveness of the Building 801/Pit 8 Landfill area interim remedy was assessed by determining if:

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

This review determined that the interim remedy for the Building 801 and Pit 8 Landfill is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD for Site 300 (2001) was signed, and there have been no changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 801/Pit 8 Landfill area that would affect the protectiveness of the remedy since the Interim Site-Wide ROD for Site 300 was signed.
- The interim remedy is functioning as intended.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Site-Wide Contingency Plan is in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

12.1.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

12.1.7. Recommended Changes

This review does not identify a need for changing the overall approach to cleanup.

12.1.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for Building 801 and Pit 8 Landfill consists of:

1. No Further Action for VOCs in subsurface soil at the Building 801 dry well.
2. Ground water monitoring to detect any changes in COC concentrations in ground water or future releases from the Pit 8 Landfill that could impact human health or the environment.

3. Inspecting the Pit 8 Landfill surface for damage that could compromise its integrity, and repairing any damage found.
4. Prohibit the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

12.1.9. Protectiveness Statement

The proposed final remedy for Building 801 and the Pit 8 Landfill is expected to protect human health and the environment.

12.2. Building 845 Firing Table and Pit 9 Landfill

12.2.1. Background

This section describes the facilities in the Building 845 and Pit 9 Landfill release site in OU 8, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this area. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

12.2.1.1. Facility Description

Pit 9 is located within the upper portions of a U-shaped valley that opens to the north. Building 845 is located about 150 ft northeast of the landfill (Figure 12-3). High explosives experiments were conducted at the Building 845 firing table from 1958 to 1963. The Pit 9 Landfill was used until 1968 to dispose of approximately 4.400 yd^3 of debris generated at the Building 845 firing table (Taffet, 1989). In 1988, firing table gravel and soil from a berm at the firing table were removed and disposed at the Nevada Test Site.

12.2.1.2. Chronology

A chronology of important environmental restoration events at the Building 845 firing table and Pit 9 Landfill is summarized below.

1958–1968

- Explosives experiments were conducted at the Building 845 firing table from 1958 until 1963.
- Debris from the Building 845 firing table was deposited in the Pit 9 Landfill prior to 1968.

1988

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

1990

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

1992

- An FFA for Site 300 was signed.

1999

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

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for HMX and uranium in subsurface soil and bedrock and monitoring as components of the remedy for Building 845 and the Pit 9 Landfill.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

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

12.2.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 845 and Pit 9 Landfill area, including the unsaturated zone and the HSU underlying the area, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 845 and Pit 9 Landfill area is shown on Figure 3-2.

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

Saturated Zone – The Building 845/Pit 9 Landfill area is underlain by a single water-bearing zone: the $Tnsc_0$ HSU. This HSU consists of the Tertiary Neroly Formation $Tnsc_0$ basal claystone unit. Ground water is generally confined, and depth to water averages about 110 ft beneath Building 845. Recharge for this HSU occurs on hilltops and within alluvial channels. Ground water generally flows east-northeast beneath Building 845 and Pit 9 (Figure 12-3). The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft.

Surface Water – Natural surface water in the Building 845 and Pit 9 Landfill area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms.

12.2.1.4. History of Contamination

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

12.2.1.5. Contaminants of Concern

There are no COCs in $Tnsc_0$ HSU ground water or surface soil in the Building 845 firing table area. Uranium-238 and the HE compound HMX have been identified as COCs in the vadose zone underlying the Building 845 firing table. No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 9 Landfill. No

unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 845 firing table or Pit 9 Landfill in the baseline risk assessment. Modeling conducted in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that the uranium and HMX in the vadose zone do not represent a significant threat to ground water.

12.2.1.6. Initial Response

Investigations began at Building 845 and the Pit 9 Landfill in 1982 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then nine boreholes have been drilled; four of these boreholes have been completed as ground water monitor wells (Figure 12-3). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Firing table gravel samples were also collected from the pilot boreholes for five wells located in this area. In 1988, firing table gravel and the soil berm at the Pit 9 Landfill was removed and disposed at the Nevada Test Site. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 9 Landfill.

12.2.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented in the Building 845 and Pit 9 Landfill area.

12.2.2.1. Interim Remedy Selection

The interim remedy for Building 845 and the Pit 9 Landfill was selected based on its ability to confirm that no releases of contaminants to ground water occurred from waste within the Pit 9 Landfill.

The selected remedial strategy for the Building 845 and Pit 9 Landfill area consists of:

1. No Further Action for HMX and uranium in soil and bedrock.
2. Ground water monitoring to detect any future releases of contamination from the firing table or the Pit 9 Landfill that could impact human health or the environment.
3. Inspecting the Pit 9 landfill cover for damage that could compromise its integrity, and repairing any damage found.

12.2.2.2. Interim Remedy Implementation

Ground water and landfill leak detection monitoring and inspections have been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. Ground water samples are collected semi-annually from wells at the Building 845 and Pit 9 Landfill area and are analyzed for uranium isotopes, tritium, HE compounds, metals, nitrate, and perchlorate. The landfill is inspected semi-annually for evidence of burrows, cracks, and surface erosion and to determine that the monitoring system is functioning properly. Repairs are made to correct any deficiencies that could compromise landfill cover integrity or monitoring.

12.2.3. Remedy Operation

The Pit 9 Landfill is inspected for surface damage that could compromise its integrity, and any damage is repaired as necessary. The landfill is inspected annually for subsidence, and the results of these inspections are reported in the semi-annual Compliance Monitoring Reports. Ground water in the Building 845/Pit 9 Landfill area is monitored as specified in the Compliance Monitoring Plan. Results are reported in the semi-annual Compliance Monitoring Reports. The interim remedy is operating as intended and no significant operations, performance, or cost issues were identified during this evaluation.

12.2.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 845 and Pit 9 Landfill area was evaluated to determine if the remedy is functioning as intended and to ensure that the assumptions used in the decision-making process are still valid. Any data or information that would call into question the protectiveness of the interim remedy was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

12.2.4.1. Assessment of Logistical Factors

Changes in ARARs and To-Be-Considered Requirements – There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed.

Changes in Land, Building, or Ground Water Use – There have been no changes in land, building, or ground water use in the Building 845 and Pit 9 Landfill area since the Interim Site-Wide ROD.

Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics – There have been no changes in exposure pathways, toxicity, or other contaminant characteristics in the Building 845 and Pit 9 Landfill area since the Interim Site-Wide ROD was signed.

Institutional Control Evaluation - There were no specific institutional controls specified in the Interim Site-Wide ROD for Site 300 for Building 845 and the Pit 9 Landfill. However, access restrictions to Site 300 and the Building 845 firing table and Pit 9 Landfill area are maintained by the LLNL Safeguards and Security Organization. In addition, LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs within the Pit 9 Landfill.

Because the landfill waste would remain in place under the interim and proposed final remedies, institutional controls may be needed to prevent exposure to the waste in the Pit 9 Landfill in the event that Site 300 was to be released for residential land use. While DOE is evaluating consolidation of activities throughout the DOE complex that could result in changes to activities conducted at Site 300, DOE control of the site is expected to continue for the foreseeable future. There are no plans to release the land for recreational or residential (unrestricted) uses.

12.2.4.2. Assessment of Technical Factors

Vadose Zone Remediation Progress – Vadose zone remediation in not a component of the interim remedy in this area.

Ground Water Remediation Progress – No COCs have been detected in ground water in the Building 845 and Pit 9 Landfill area. Monitoring of the ground water beneath Pit 9 Landfill is conducted to detect any potential new releases. Ground water samples are collected semi-annually from Pit 9 monitoring wells and analyzed for VOCs, nitrate, perchlorate, HE compounds, and metals. Since the interim remedy was implemented, no constituents of concern have been detected in Building 845 and Pit 9 Landfill area ground (Dibley et al., 2004a, 2004b, 2005a, 2005b). There continues to be no contamination detected in ground water in the Building 845 and Pit 9 Landfill area.

Ground water elevation data collected from Building 845 and Pit 9 wells indicate that ground water levels remain over 100 ft below the landfill.

Risk Mitigation Progress – No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 845 firing table or the Pit 9 Landfill in the baseline risk assessment. There is no evidence of new releases or contamination that warrants re-evaluation of risk.

New Sources Releases or Contaminants – Ground water data indicate there are no new sources, releases, or contaminants in the Building 845/Pit 9 Landfill area.

New Technology Assessment – Because no significant contamination is present in environmental media in the Building 845/Pit 9 Landfill area, no new technologies were evaluated.

12.2.5. Protectiveness Assessment

The protectiveness of the Building 845/Pit 9 Landfill area interim remedy was assessed by determining if:

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

This review determined that the interim remedy for the Building 845 and Pit 9 Landfill is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed, and there have been no changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 845/Pit 9 Landfill area since the Interim Site-Wide ROD for Site 300.
- The interim remedy is functioning as intended.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Site-Wide Contingency Plan is in place and properly implemented.

- There have been no changes in risk assessment methodologies that would call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

12.2.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

12.2.7. Recommended Changes

This review does not identify a need for changing the overall approach to cleanup.

12.2.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for Building 845 and Pit 9 Landfill consists of:

1. No Further Action for HMX and uranium in soil and bedrock.
2. Ground water monitoring to detect any future releases from the Pit 9 Landfill that could impact human health or the environment.
3. Inspecting the Pit 9 Landfill surface for damage that could compromise its integrity, and repair any damage found.
4. Prohibit the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

12.2.9. Protectiveness Statement

The proposed final remedy for Building 845 and Pit 9 Landfill is expected to protect human health and the environment.

12.3. Building 851 Firing Table

12.3.1. Background

This section describes the facilities in the Building 851 firing table release site in OU 8, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this area. It also describes the history of contamination, COCs identified in environmental media, and remedial investigations and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

12.3.1.1. Facility Description

The Building 851 firing table has been used since 1962 to conduct experimental high explosives research. Although the firing table is still used for explosives testing, firing table gravels were removed in 1988 and are still replaced periodically to prevent the accumulation of contaminants in firing table gravels that could be released to the environment. Gravels from Building 851 firing table were formerly disposed in the Pit 3 Landfill (open 1958 to 1967), Pit 4 Landfill (open 1968 to 1974), Pit 5 Landfill (open 1968 to 1978), and the Pit 7 Landfill (open 1978 to 1988). Since the Pit 7 Landfill was closed in 1988, gravel removed from the Building 851 firing table has been transported to the Nevada Test Site for disposal.

12.3.1.2. Chronology

A chronology of important environmental restoration events at the Building 851 firing table is summarized below.

1962–Present

- Building 851 firing table began operating in 1962 and is still used to conduct experimental high explosives research.

1988

- Building 851 firing table gravels were removed in 1988.

1990

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

1992

- An FFA for Site 300 was signed.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 851 firing table.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs and uranium in soil and bedrock and for RDX and metals in surface soil as well as monitoring as components of the remedy for the Building 851 area.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

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

12.3.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 851 area, including the unsaturated zone, one HSU underlying the area, and surface water in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 851 firing table area is shown on Figure 3-2.

Vadose (Unsaturated) Zone – The vadose zone consists of approximately 100 to 150 ft of unconsolidated Quaternary alluvial and colluvial deposits (Qal), Quaternary landslide deposits (Qls), and underlying unsaturated Neroly Formation $Tnbs_1$lower blue sandstone and $Tnsc_0$ siltone/claystone bedrock.

Saturated Zone – The Tmss HSU consists of one stratigraphic unit: the Cierbo Formation (Tmss) that is comprised of sandstone, claystone, pebble conglomerate, and shale. Tmss strata beneath Building 851 are saturated with ground water under confined conditions. Depth to water varies from 100 to 150 ft below ground surface, and the saturated thickness varies from 5 to 10 ft. Ground water within Tmss strata flows to the southwest (Figure 12-4).

Surface Water – Natural surface water in the Building 851 firing table area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms.

12.3.1.4. History of Contamination

High explosives testing have been conducted at the Building 851 firing table since 1962. Although the firing table is still used for explosives testing, the firing table gravels were removed in 1988 and are still replaced periodically to prevent accumulation of contaminants in gravels that could be released to the environment. Former explosives experiments resulted in the release of uranium-238, the HE compound HMX, and metals to the surrounding surface soil; VOCs and uranium-238 to subsurface soil; and uranium-238 to ground water.

12.3.1.5. Contaminants of Concern

Uranium-238 has been identified as a COC in Tmss HSU ground water in the Building 851 area. However, the maximum total uranium activities in ground water continue to be a fraction of the 20 pCi/L MCL. VOCs and uranium-238 are COCs in subsurface soil and rock. The HE compound RDX, uranium-238, and the metals cadmium, copper, and zinc were identified as COCs in surface soil.

As agreed with the regulatory agencies and consistent with site use, risk associated with contaminants at Site 300 was calculated using an industrial exposure scenario. No risk or hazard associated with surface soil, subsurface soil/bedrock, or ground water was identified for the Building 851 area in the baseline risk assessment (Ferry et al., 1999).

As shown in Table 12-1, the maximum concentrations of all COCs detected in surface soil at Building 851 are below residential PRGs with the exception of uranium-238. While these uranium-238 activities in soil indicate the potential for some risk under a residential exposure scenario, determination of the specific risk under site-specific conditions would require re-calculating the baseline risks for a residential land use scenario. In the event that the Site 300 property was to be considered for release for unrestricted, residential land use, DOE would re-evaluate the site risks under a residential exposure scenario.

Modeling conducted in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that COCs in surface soil and subsurface soil/rock do not pose a significant threat to ground water. The water-bearing zone (Tmss HSU) affected by contamination is not used for drinking water.

12.3.1.6. Initial Response

Investigations at Building 851 began in 1988 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then 12 boreholes have been drilled at Building 851; four of these boreholes have been completed as ground water monitor wells (Figure 12-4). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Five of the boreholes were drilled within the firing table to characterize the extent of any contamination in firing table gravels and underlying vadose zone. Firing table gravels and some contaminated soil were removed in 1988 and disposed in Pit 7. Ground water monitoring has been conducted to evaluate uranium activities in ground water.

12.3.2. Interim Remedial Actions

This section describes the interim remedial actions selected and implemented at the Building 851 firing table.

12.3.2.1. Interim Remedy Selection

In the Interim Site-Wide ROD, the interim remedy for the Building 851 area was selected based on its ability to define any changes in ground water chemistry that would indicate a new release to ground water.

The selected remedial strategy for the Building 851 area consists of:

1. No further action for VOCs and uranium in subsurface soil and bedrock and for RDX, uranium, and metals in surface soil.
2. Ground water monitoring to detect any changes in COC concentrations in ground water that could impact human health or the environment.

12.3.2.2. Interim Remedy Implementation

Ground water monitoring has been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. The four monitor wells at Building 851 are sampled semi-annually and ground water is analyzed for uranium isotopes, tritium, HE compounds, VOCs, metals, nitrate, and perchlorate. Water elevations are also measured quarterly.

12.3.3. Remedy Operations

The only operations conducted for the interim remedial action for the Building 851 area are semi-annual well sampling and ground water analysis and any necessary well maintenance. The interim remedy is operating as intended and no significant operations, performance, or cost issues were identified during this evaluation.

12.3.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 851 area was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call into question the protectiveness of the interim remedy was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

12.3.4.1. Assessment of Logistical Factors

Changes in ARARs and To Be Considered Requirements – There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed.

Changes in Land, Building or Ground Water Use – There have been no changes in land, building, or ground water use in the Building 851 area since the Interim Site-Wide ROD.

Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics – There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Building 851 area since the Interim Site-Wide ROD was signed.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

Institutional Control Evaluation – There were no institutional controls specified in the Interim Site-Wide ROD for Building 851. However, access restrictions to Site 300 and the Building 851 firing table area are maintained by the LLNL Safeguards and Security Organization.

12.3.4.2. Assessment of Technical Factors

Surface Soil Remediation Progress – Surface soil remediation is not a component of the interim remedy because the COCs in this medium did not pose a risk to human or ecological receptors or a threat to ground water.

Vadose Zone Remediation Progress – Vadose zone remediation is not a component of the interim remedy because the COCs in unsaturated soil and bedrock did not pose a risk to human or ecological receptors. Modeling conducted in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that residual COCs in the vadose zone did not pose a threat to ground water.

Ground Water Remediation Progress – Ground water data were evaluated to assess the effectiveness of the monitoring remedy for uranium in the Building 851 firing table area. Ground water remediation progress was assessed by evaluating changes in uranium activities over time**.**

Figure 12-5 shows time-series plots of total uranium activity and $^{235}U/^{238}U$ atom ratio for ground water in the Building 851 area. Recent total uranium activities in all ground water samples are below the maximum historical activity of 1.3 pCi/L in 1991. During the 1st Semester of 2005, total uranium activities ranged from 0.071 to 0.36 pCi/L, well below the 20 pCi/L MCL. The atom ratio of $^{235}U/^{238}U$ in the samples collected from three wells in the 1st Semester of 2005 indicated the presence of some depleted uranium, though the sample from a deeper well contained only natural uranium. These data indicate that uranium activities in ground water are continuing to decrease over time and remain well below the MCL for total uranium.

Ground water monitoring data do not indicate release of any new chemicals (VOCs, HE compounds, metals, nitrate, or perchlorate) to ground water or increases in COC concentrations that could indicate new releases.

Risk Mitigation Progress – No risk or hazard associated with contaminants in surface soil, subsurface soil/bedrock, or ground water was identified for the Building 851 area in the baseline risk assessment (Ferry et al. 1999). Total uranium activities in ground water have always been well below the 20 pCi/L MCL and at similar levels to those at which uranium naturally occurs in ground water in this area. The water-bearing zone in the Building 851 firing table area that is affected by the contamination is not used for drinking water. No unacceptable risk or hazard to human health was identified for VOCs, uranium, RDX, cadmium, copper, and zinc in surface or subsurface soil/rock. Ground water data do not indicate any new sources, releases, or contaminants in the Building 851 area.

New Technology Assessment – No new innovative technologies have been identified that would apply to the cleanup in the Building 851 area.

12.3.5. Protectiveness Assessment

The protectiveness of the interim remedy for the Building 851 area was assessed by determining if:

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

This review determined that the interim remedy for the Building 851 is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD for Site 300 (2001) were signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 851 firing table area since the Interim Site-Wide ROD was signed. The interim remedy is functioning as intended. Uranium activities in ground water continue to decrease over time and remain well below the MCL. There are no indications of releases of any new chemicals or increases in COC concentrations that could indicate new releases
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Site-Wide Contingency Plan is in place and properly implemented.
- No additional information has been identified that would call into question the protectiveness of the interim remedy.

12.3.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

12.3.7. Recommended Changes

This review has not identified a need for changing the overall approach to cleanup.

12.3.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for Building 851 consists of:

1. No further action for VOCs and uranium in subsurface soil and bedrock and for RDX, metals, and uranium in surface soil.
2. Ground water monitoring to detect any new releases of COCs from surface soil or the vadose zone and changes in COC concentrations in ground water that could impact human health or the environment.
3. Prohibit the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

12.3.9. Protectiveness Statement

The proposed remedy for Building 851 is expected to protect human health and the environment upon completion.

12.4. Building 833 Release Site

12.4.1. Background

12.4.1.1. Facility Description

Building 833 is located on a hilltop in southeastern Site 300 and was used from 1959 to 1982 to conduct thermal and mechanical tests on various mixtures of HE compounds (Figure 12-6). TCE served exclusively as the heat-transfer fluid for these tests. Surface discharge of waste fluids occurred through spills, building washdown, and release of rinsewater from the test cell and settling basin to an adjacent lagoon.

12.4.1.2. Chronology

A chronology of important environmental restoration events at Building 833 is summarized below.

1959–1982

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

1985–1990

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

1992

- An FFA for Site 300 was signed.

1999

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

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified exposure control through risk and hazard management; and ground water monitoring as components of the remedy for the Building 833.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

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

12.4.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 833 area, including the unsaturated zone, the two HSUs underlying the area and surface water present in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 833 area is shown on Figure 3-2.

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

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

The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone within unconsolidated sand and gravel. During heavy rainfall events, this HSU may become saturated. However, ground water monitoring from 1993 to 2005 has shown little evidence of saturation. Since 2003, all wells screened in the Tpsg HSU at Building 833 were dry or only contained water within a sump below the screen. When present, depth to water is about 20 to 25 ft bgs, and the saturated thickness varies from 0 to 5 ft. Due to the lack of saturation in wells screened in the HSU, a ground water gradient and flow direction cannot be accurately determined (Figure 12-6). Recharge for this HSU occurs on hilltops via rainwater percolation.

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

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

Surface Water – Natural surface water in the Building 833 area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms.

12.4.1.4. History of Contamination

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

No TCE or other VOCs were detected in surface soil samples collected in the vicinity of the former lagoon. TCE concentrations in shallow subsurface soil (less than 10 ft) ranged from 0.0031 mg/kg to 0.0085 mg/kg. The results of both active and passive soil vapor surveys in the vicinity of the lagoon also indicated that a significant VOC source was not present in surface or

shallow subsurface soil. Because soil in the vicinity of the lagoon did not pose a risk to human or ecological receptors, or further threat to ground water, no cleanup was required.

12.4.1.5. Contaminants of Concern

TCE, a human carcinogen, has been identified as a COC in ground water in the Tpsg HSU and in the vadose zone in the Building 833 area. The baseline risk assessment indicated that TCE in indoor air at Building 833 presented a 1×10^{-6} risk to onsite workers.

TCE is present only in perched ground water in the Tpsg HSU. Because this HSU is limited to the Building 833 area, there is not migration pathway for TCE from the Building 833 area to onsite or offsite water-supply wells. In addition, exposure, use, or ingestion of the contaminated ground water is highly unlikely because the perched water-bearing zone is naturally unsuitable for drinking water due to high dissolved solid concentrations and low sustainable yields.

12.4.1.6. Initial Response

Environmental studies began in 1981 when LLNL initiated a survey of potential TCE spills to the ground at Site 300 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then 63 boreholes have been drilled at Building 833; nine of these boreholes have been completed as ground water monitor wells (Figure 12-6). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included active and passive soil vapor surveys.

12.4.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented at Building 833.

12.4.2.1. Interim Remedy Selection

The interim remedy for the Building 833 area was selected to prevent exposure of onsite workers to any harmful concentrations of VOCs in indoor air, to monitor VOC concentration trends in ground water, and to detect any new releases of contaminants from Building 833.

The selected remedial strategy for the Building 833 consists of:

1. Exposure control through risk and hazard management including engineered controls (enhanced indoor ventilation) at Building 833.
2. Ground water monitoring to detect any changes in TCE concentrations in ground water that could impact human health or the environment.

12.4.2.2. Interim Remedy Implementation

Ground water monitoring has been implemented and the results are reported in the semi-annual Compliance Monitoring Report. Samples of ground water are collected semi-annually for VOC analysis. The VOC inhalation risk at Building 833 is re-evaluated annually.

12.4.3. Remedy Operations

Ground water monitoring is the only activity conducted for the Building 833 interim remedy. Maintenance is performed on monitoring wells as necessary. The interim remedy is operating as

intended and no significant operations, performance or cost issues were identified during this evaluation.

12.4.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Building 833 area was evaluated to determine if the remedy is functioning as intended and the assumptions used in the decision-making process are still valid. Any data or information that would call the protectiveness of the interim remedy into question was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

12.4.4.1. Assessment of Logistical Factors

Changes in ARARs and To-Be-Considered Requirements – There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed.

Changes in Land, Building or Ground Water Use – There have been no changes in land, building, or ground water use in the Building 833 area since the Interim Site-Wide ROD.

Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics – There have been no changes in exposure pathways, toxicity, and other contaminant characteristics since the Interim Site-Wide ROD was signed.

In August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review. This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

Institutional Control Evaluation – The institutional controls that were specified in the Interim Site-Wide ROD were evaluated for effectiveness under the current conditions at Building 833, as summarized below.

- **Maintaining access restrictions to Site 300 –** Access restrictions continue to be maintained by the LLNL Safeguards and Security organization.
- **Preventing ingestion of ground water where contaminated above concentrations protective of human health –** There are no existing water-supply wells in the Building 833 area. LLNL environmental restoration staff routinely meet with site planning personnel to ensure that any potential new water-supply wells would be sited in uncontaminated areas. There is no offsite ground water contamination resulting from releases at Building 833, and no offsite water-supply wells are in use near the building.
- **Preventing installation of water-supply wells where ground water is contaminated above concentrations protective of human health –** DOE has no plans to install onsite water-supply wells near Building 833 and is not aware of any proposed offsite wells near the OU.

- **Briefing all personnel working onsite on areas of contamination and possible hazards –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that all facility managers and site workers are aware of potential hazards that may be encountered in contaminated areas.
- **Preventing excavation within areas of contamination except for approved remedial actions –** LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs in the Building 833 area without the proper controls in place.
- **Maintaining building occupancy and land use restrictions in the vicinity of Building 833 –** Engineered controls consisting of enhanced ventilation/positive pressure have been implemented at Building 833 to prevent infiltration and buildup of VOC vapors inside the building. As a result, building occupancy restrictions are not needed.
- **Conducting annual risk evaluation for VOCs within Building 833 until risk is less than 10^{-6} and the hazard index is less than 1 for two years –** An annual risk evaluation program was implemented and the indoor and outdoor risks were re-evaluated in 2003 and 2004. The results of the risk re-evaluation monitoring program are summarized in Section 12.4.4.2.
- **Integrating the sampling and survey data and risk assessment calculations to determine any changes in risks and hazards –** Sampling and survey data are evaluated annually as part of the Compliance Monitoring Report for Site 300 to determine any changes in risks and hazards.
- **Reviewing human health and ecological data to evaluate compliance with the remedial action objectives –** Provisions for reviewing these data are included in the Compliance Monitoring Plan for Site 300.
- **Developing and implementing Operational Safety Procedures for all remedial actions where risks can be foreseen –** All required Operational Safety Procedures are in place, and new procedures are created as needed.

12.4.4.2. Assessment of Technical Factors

Surface Soil Remediation Progress – Surface soil remediation is not a component of the interim remedy for Building 833.

Vadose Zone Remediation Progress – Vadose zone remediation was not a component of the interim remedy. Because risk due to VOCs in indoor air at Building 833 continues to exceed 1×10^{-6}, engineered controls are maintained to prevent infiltration and buildup of VOC vapors inside the building. The annual risk re-evaluation conducted in 2004 indicated a risk of 2×10^{-6} (Dibley et al., 2005a). The annual risk re-evaluation will continue until risk is below 1×10^{-6}.

Ground Water Remediation Progress – Ground water data were evaluated to assess the effectiveness of the monitoring remedy for VOCs at Building 833 by evaluating changes in COC concentrations with time. Monitoring conducted from 1993 to 2005 has shown a decline in VOC concentrations in Tpsg HSU ground water from an historical maximum concentration of 2,100 μg/L in 1992 to maximum of 7.5 μg/L in the 1st Semester of 2005. In 2005, ground water was present in only one Tpsg HSU well in the Building 833 area. Figure 12-7 shows a time-series plot of total VOC concentrations for the well with the longest history in the Tpsg HSU.

The graph shows that the maximum total VOC concentration in ground water at Building 833 was 2,100 μg/L in August 1992. The total VOC concentration in ground water at this well, and beneath Building 833, declined to 20 μg/L before the well went dry after June 2000.

Monitoring of Building 833 wells from 1993 to 2005 has shown little evidence of saturation. From 2001–2004, all the wells screened in the Tpsg HSU at Building 833 were dry or had insufficient water to collect a valid sample, so no VOC data were obtained during this time.

Only one well screened in the deep regional aquifer within the $Tnbs_1$ HSU perennially contains sufficient water to collect regular samples. VOCs have never been detected in this well, indicating that VOCs continue to be confined to the shallow, Tpsg HSU perched water-bearing zone.

Building 833 ground water data continue to indicate that there are no new releases of VOCs to ground water, and that VOC concentration in the Tpsg HSU continue to decrease.

Risk Evaluation Mitigation Progress – The risks associated with VOCs in Building 833 subsurface soil/rock and ground water were summarized in Section 12.4.1.3 and in the baseline risk assessment. These risks were re-evaluated in 2003 and 2004. The results of this re-evaluation indicate that Building 833 indoor air continues to present an unacceptable risk to onsite workers of 2×10^{-6} (Dibley et al., 2005a). However, engineering controls consisting of enhanced ventilation/positive pressure are in place to prevent infiltration and buildup of VOC vapors inside Building 833 that could result in an unacceptable exposure risk to workers in this building.

The apparent increase in exposure risk from 1×10^{-6} presented in the baseline risk assessment, and 2×10^{-6} calculated in 2004, is due to the difference in risk calculation methodology. The baseline risk assessment calculation was based on concentrations in soil samples obtained from boreholes drilled in the Building 833 area. Because it is not practical to collect additional subsurface soil samples, the risk was re-evaluated using the EPA-approved Johnson-Ettinger Model (Environmental Quality Management, 2003). This model simulates the transport of VOC vapors from ground water to the building foundations and then into indoor ambient air.

New Sources, Releases or Contaminants – Ground water data do not indicate any new sources, releases, or contaminants in the Building 833 area.

New Technology Assessment – No new innovative technologies have been identified that would apply to the cleanup in the Building 833 area.

12.4.5. Protectiveness Assessment

The protectiveness of the Building 833 interim remedy was assessed by determining if:

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

This review determined that the interim remedy for the Building 833 is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 833 area since the Interim Site-Wide ROD.
- The interim remedy is functioning as intended.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- All required institutional and engineering controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that would call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call into question the protectiveness of the interim remedy.

12.4.6. Deficiencies

No deficiencies in the interim remedy were identified during this review.

12.4.7. Recommended Changes

This review did not identify a need for changing the overall approach to cleanup.

12.4.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy for the Building 833 area selected in the Interim Site-Wide ROD. The proposed final remedy for Building 833 consists of:

1. Exposure control through risk and hazard management including engineered controls (enhanced indoor ventilation) at Building 833.
2. Ground water monitoring to detect any changes in TCE concentrations in ground water that could impact human health or the environment.
3. Prohibit the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

12.4.9. Protectiveness Statement

The proposed final remedy for Building 833 is expected to protect human health and the environment upon completion, and in the interim because: (1) the Health and Safety Plan is in place, is sufficient to control risks, and has been properly implemented, and (2) institutional and engineered controls to minimize heath risks and prevent use of contaminated ground water are in place.

12.5. Pit 2 Landfill

12.5.1. Background

This section describes the Pit 2 Landfill area, a chronology of important events related to environmental restoration, and the hydrogeologic setting for this area. It also describes the history of contamination, any COCs identified in environmental media, and remedial investigation and actions conducted prior to selection of the interim remedy in the Interim Site-Wide ROD.

12.5.1.1. Facility Description

The Pit 2 Landfill is an unlined landfill that was constructed south of Building 865 in 1956 (Figure 9-1). The Pit 2 Landfill was used until 1960 to dispose of firing table debris from Buildings 801 and 802. An earthen cover was installed in 1960.

12.5.1.2. Chronology

A chronology of important environmental restoration events at the Pit 2 Landfill is summarized below.

1956–1960

- Debris from the Buildings 801 and 802 firing tables was deposited in the Pit 2 Landfill.
- In 1960, an earthen cover was installed on the landfill.

1990

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

1992

- An FFA for Site 300 was signed.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Pit 2 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified ground water monitoring to detect any potential future contaminant releases as the remedy for the Pit 2 Landfill.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

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

12.5.1.3. Hydrogeologic Setting

This section describes the hydrogeologic setting for the Pit 2 Landfill area, including the unsaturated zone, three HSUs, and surface water present in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Pit 2 Landfill area is shown on Figure 3-2.

Vadose (Unsaturated) Zone – The vadose zone in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam that are unsaturated to a depth of approximately 5 to 50 ft bgs.

Saturated Zone – The Qal/WBR HSU in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and underlying weathered bedrock in the Elk Ravine drainage channels. This HSU is generally unconfined and unsaturated in Elk Ravine except for short periods following winter storms. Until 2005, potable water from Building 865 was discharged to Elk Ravine to maintain a wetland habitat for red-legged frogs, a Federally-listed endangered species. While this discharge occurred, the Qal/WBR was likely perennially saturated in Elk Ravine in the area south of Building 865 and around the northern and eastern boundaries of the Pit 2 Landfill. In 2005, the frogs were relocated to a constructed wetland habitat, and the discharge of water from Building 865 ceased. Depth to water in the Qal/WBR HSU varies from 0 to 25 ft bgs. Ground water flow follows the topography/ground elevation contours and is parallel to stream channel axes (Figure 9-2).

The $Tnbs_1/Tnbs_0$ HSU in the Pit 2 Landfill area is comprised of the Neroly Formation Lower Blue Sandstone ($Tnbs_1$) and the Basal Blue Sandstone ($Tnbs_0$). Ground water in this HSU is unconfined to confined. The HSU is saturated beneath Elk Ravine, where depth to water is about 50 to 65 ft bgs. The saturated thickness of the HSU may be from 25 to 100 ft. As suggested by the potentiometric surface contours shown on Figure 9-3, the southwestern branch of the Elk Ravine Fault may locally be a conduit or barrier to ground water flow in this HSU.

Figures 9-2 and 9-3 present potentiometric surface maps for the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs beneath the Pit 2 Landfill.

The Tmss HSU is comprised of sandstone of the Cierbo Formation (Tmss). The saturated thickness of this HSU may be over 40 ft beneath Elk Ravine.

Surface Water – Surface water in the vicinity of the Pit 2 Landfill is the result of either surface runoff from precipitation or from spring discharge. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms. During severe storms, surface water may flow within Doall Ravine or Elk Ravine for short distances before infiltrating into the ground. As discussed previously, perennial surface water was present south of Building 865 around the northern and eastern boundaries of the Pit 2 Landfill until the discharge from Building 865 was discontinued in 2005.

12.5.1.4. History of Contamination

Debris from the Buildings 801 and 802 firing tables, contaminated during experiments at these facilities, were disposed in the Pit 2 Landfill. Soil, rock, and ground water monitoring data indicated that contaminants have not been released from the Pit 2 Landfill at the time the interim remedy was selected for this area.

12.5.1.5. Contaminants of Concern

No COCs were identified in surface soil, subsurface soil and rock, or ground water at the Pit 2 Landfill. No unacceptable risk or hazard to human or ecological receptors was identified for the Pit 2 Landfill in the baseline risk assessment.

12.5.1.6. Initial Response

Investigations began at the Pit 2 Landfill in 1982 to identify contaminant sources and the distribution of contaminants in soil, bedrock, and ground water. Since then, ten boreholes have been drilled; all of these boreholes have been completed as ground water monitor wells (Figure 12-7). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 2 Landfill.

12.5.2. Interim Remedial Actions

This section describes the interim remedial action selected and implemented in the Pit 2 Landfill area.

12.5.2.1. Interim Remedy Selection

The interim remedy for the Pit 2 Landfill was selected because no COC were identified in any environmental media and no unacceptable risk or hazard to human health or the environment was identified in the baseline risk assessment. However, because the Pit 2 Landfill is unlined and could potentially contain constituents of concern in the pit waste that could result in future releases, a monitoring remedy was selected. This remedy was implemented to comply with the requirements of 23 CCR, Division 3, Chapter 3, Article 5 and 22CCR Division 4.5, Chapter 14, Article 6 to ensure detection of any future release of contaminants from the landfill.

The selected remedial strategy for the Pit 2 Landfill area consists of:

1. Ground water monitoring to detect any potential future releases of contamination from the Pit 2 Landfill that could impact human health or the environment.
2. Inspecting the Pit 2 landfill cover for damage that could compromise its integrity, and repairing any damage found.

12.5.2.2. Interim Remedy Implementation

Ground water and landfill leak detection monitoring and inspections have been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. Ground water samples are collected semi-annually from wells in the Pit 2 Landfill area and are analyzed for uranium isotopes, tritium, HE compounds, metals, nitrate, and perchlorate. The landfill is inspected semi-annually for evidence of burrows, cracks, and surface erosion and to determine that the monitoring system is functioning properly. Repairs are made to correct any deficiencies that could compromise landfill cover integrity or monitoring.

12.5.3. Remedy Operation

The Pit 2 Landfill is inspected for surface damage that could compromise its integrity, and any damage is repaired as necessary. The landfill is inspected annually for subsidence, and the results of these inspections are reported in the semi-annual Compliance Monitoring Reports. Ground water in the Pit 2 Landfill area is monitored as specified in the Compliance Monitoring Plan. Results are reported in the semi-annual Compliance Monitoring Reports. The interim remedy is operating as intended and no significant operations or cost issues were identified during this evaluation.

12.5.4. Interim Remedial Action Evaluation Summary

The protectiveness of the interim remedy for the Pit 2 Landfill area was evaluated to determine if the remedy is functioning as intended and to ensure that the assumptions used in the decision-making process are still valid. Any data or information that would call into question the protectiveness of the interim remedy was identified. As described in Section 4.2, both logistical and technical factors from the Contingency Plan for the Interim Remedies at Site 300 (Ferry et al., 2002a) that could affect the protectiveness and effectiveness of the interim remedies were also considered.

12.5.4.1. Assessment of Logistical Factors

Changes in ARARs and To-Be-Considered Requirements – There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed.

Changes in Land, Building, or Ground Water Use – There have been no changes in land, building, or ground water use in the Pit 2 Landfill area since the Interim Site-Wide ROD.

Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics – There have been no changes in exposure pathways, toxicity, or other contaminant characteristics in the Pit 2 Landfill area since the Interim Site-Wide ROD was signed.

Institutional Control Evaluation – There were no specific institutional controls specified in the Interim Site-Wide ROD for Site 300 for the Pit 2 Landfill. However, access restrictions to Site 300 and the Pit 2 Landfill area are maintained by the LLNL Safeguards and Security Organization. In addition, LLNL environmental restoration staff coordinate with Site 300 management to ensure that no excavation occurs within the Pit 2 Landfill.

Because the landfill waste would remain in place under the interim and proposed final remedies, institutional controls may be needed to prevent exposure to the waste in the Pit 2 Landfill in the event that Site 300 was to be released for residential land use. While DOE is evaluating the consolidation of activities throughout the DOE complex that could result in changes to activities conducted at Site 300, DOE control of the site is expected to continue for the foreseeable future. There are no plans to release the land for recreational or residential (unrestricted) uses.

12.5.4.2. Assessment of Technical Factors

Vadose Zone Remediation Progress – Vadose zone remediation in not a component of the interim remedy in this area.

Ground Water Remediation Progress – Ground water monitoring is routinely conducted in the Pit 2 Landfill area to detect any potential future releases of contaminants from the landfill. Uranium activities detected in ground water samples from the Pit 2 Landfill monitor wells are all historically below the 20 pCi/L MCL. In May 2004, depleted uranium was detected in ground water samples from three wells completed within the $Tnbs_1/Tnbs_0$ HSU along the north and east sides of the landfill with total uranium activities of 17.4, 6.97, and 5.58 pCi/L. In the 1st Semester of 2005, depleted uranium was detected in ground water samples from the three wells at total uranium activities of 17, 9.9, and 1.9 pCi/L (Figure 12-8).

Figure 12-9 shows time-series plots of total uranium activity and $^{235}U/^{238}U$ atom ratio for ground water samples collected from the Pit 2 Landfill area. As shown in this figure, total

uranium activities in well K2-01C have decreased from the historical high of 23.1 pCi/L observed in 1995. Wells W-Pit 2-1934 and -1935 were installed in 2004, therefore uranium activities trends show no clear pattern due to the limited data available for the wells. Total uranium activities in ground water in the Pit 2 Landfill area in the 1st Semester of 2005 are below the 20 pCi/L MCL. As shown in Figure 12-9, $^{235}U/^{238}U$ atom ratios are fairly consistent, although the well with the longest record shows a gradual increase in the depleted uranium component ($^{235}U/^{238}U$ atom ratio is declining).

The detection of depleted uranium in the ground water samples from the Pit 2 wells suggests that low activities of depleted uranium have been added to the naturally-occurring uranium in the $Tnbs_1/Tnbs_0$ HSU ground water underlying the Pit 2 Landfill. This may be the result of the infiltration of potable water used to maintain the red-legged frog wetland habitat adjacent to the landfill, into the pit waste. This discharge was discontinued in 2005, removing the mobilization mechanism for leaching of depleted uranium from Pit 2 Landfill waste.

Figure 12-8 shows tritium activities in ground water in the vicinity of the Pit 2 Landfill in the 1st Semester of 2005. As shown in this figure, tritium activities are higher in wells upgradient of the Pit 2 Landfill than in downgradient wells. This data indicate that the tritium detected in ground water in the Pit 2 Landfill area are largely the result of transport of the Building 850 tritium plume into the Pit 2 Landfill area. Figure 12-10 shows time-series plots of tritium activity in ground water from wells near the Pit 2 Landfill. The data shown in this figure indicates that tritium activities are generally stable or decreasing in ground water.

Perchlorate was detected at a concentration at the 6 μg/L Public Health Goal in two samples collected from one well located downgradient of the Pit 2 Landfill in 2003 and 2004. Perchlorate was also detected in two samples from a second downgradient well at concentrations ranging from 4.9 to 5.9 μg/L in 2004. However, perchlorate has not been detected in subsequent samples from this well or in any other wells downgradient of the Pit 2 Landfill.

No other constituents of concern (i.e., HE compounds or metals) were detected in ground water above background levels.

Risk Mitigation Progress – No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Pit 2 Landfill in the baseline risk assessment. Although there is evidence of a possible a new release of depleted uranium from the landfill, re-evaluation of risk does not appear to be warranted at this time. Total uranium activities are below its MCL, and there is not threat of impacts to water-supply wells.

New Sources Releases or Contaminants – As discussed previously, ground water data suggests that low activities of depleted uranium have been added to the naturally-occurring uranium in the $Tnbs_1/Tnbs_0$ HSU ground water underlying the Pit 2 Landfill. This may be the result of the infiltration of potable water used to maintain the red-legged frog wetland habitat adjacent to the landfill, into the pit waste. This discharge of potable water from Building 865 was discontinued in 2005 when the red-legged frogs were moved to a new habitat constructed south of Building 812. As a result, the mobilization mechanism for leaching of depleted uranium from Pit 2 Landfill waste has been removed.

New Technology Assessment – Because no significant contamination is present in environmental media in the Pit 2 Landfill area, no new technologies were evaluated.

12.5.5. Protectiveness Assessment

The protectiveness of the interim remedy for the Pit 2 Landfill was assessed by determining if:

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

This review determined that the interim remedy for Pit 2 Landfill is protective, based on the following:

- There have been no changes in location-, chemical-, or action-specific requirements since the Interim Site-Wide ROD was signed, and there have been no changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Pit 2 Landfill area since the Interim Site-Wide ROD for Site 300.
- The interim remedy is functioning as intended. The mobilization mechanism (discharge of water from Building 865) for leaching of depleted uranium from Pit 2 Landfill waste has been removed, Ground water monitoring will continue to determine whether depleted uranium continues to be released from the Pit 2 Landfill.
- Costs have been consistently within budget.
- No early indicators of potential interim remedy failure were identified.
- The Site-Wide Contingency Plan is in place and properly implemented.
- There have been no changes in risk assessment methodologies that would call the protectiveness of the interim remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

12.5.6. Deficiencies

Although data indicate a possible release of depleted uranium from the Pit 2 Landfill to ground water, the mobilization mechanism (discharge of water from Building 865) for leaching of depleted uranium from landfill waste has been removed. Ground water monitoring will continue to determine whether depleted uranium continues to be released from the Pit 2 Landfill.

The tritium detected in ground water in the Pit 2 Landfill area is largely the result of transport of the Building 850 tritium plume into the Pit 2 Landfill area. Although perchlorate was detected in ground water from two wells in 2003 and 2004, it was not detected in ground water in the 1st Semester of 2005. No other constituents of concern (i.e., HE compounds or metals) were detected in ground water above background levels or detection limits.

12.5.7. Recommended Changes

This review does not identify a need for changing the overall approach to cleanup.

12.5.8. Proposed Final Remedial Action

No changes are proposed to the interim remedy selected in the Interim Site-Wide ROD. The proposed final remedy for the Pit 2 Landfill consists of:

1. Ground water monitoring to detect any future releases from the Pit 2 Landfill that could impact human health or the environment.
2. Inspecting the Pit 2 Landfill surface for damage that could compromise its integrity, and repair any damage found.
3. Prohibit the transfer of Site 300 lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

12.5.9. Protectiveness Statement

The proposed final remedy for Pit 2 Landfill is expected to protect human health and the environment.

13. Evaluation of Innovative Technologies

Throughout the remediation process at both LLNL Site 300 and the Livermore Site, DOE has conducted evaluations of new, alternate, and/or innovative technologies that have the potential to more effectively address site contamination, and reduce the costs and time to achieve cleanup. These evaluations have included *ex situ* zero valent iron filings treatment, dynamic stripping, electro-osmosis, electron acceleration, ultraviolet/oxidation, electrical soil heating, surfactant "push-pull", potassium-permanganate injection, and an ongoing bioremediation test. This is consistent with DOE's objective of conducting environmental remediation projects to allow for the continued testing and implementation of better, faster, and more cost-effective treatment options. DOE will continue to review the development of and evaluate treatment technologies, i.e., zero-valent iron injection, hydrofracturing, and bioremediation, for application at Site 300 as appropriate. However, because the sufficient data is not yet available with which to determine the efficacy of these technologies as a long-term remedial solution, and the existing interim remedial technologies are effective and continue to make progress toward site cleanup, these potential remedial technologies are not included as part of the proposed final remedies.

Innovative and/or alternate technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost will continue to be considered and evaluated for application at Site 300 throughout the remediation process. In particular, technologies would be evaluated that could shorten cleanup times at source areas and in low permeability sediments at the Building 834, HE Process Area, Building 854, and Building 832 Canyon OUs. These technologies may be employed if site conditions change or technology development, evaluation, and testing indicate a potential for cost-effective and expedited remediation. Innovative and/or alternate cleanup technologies will be employed with regulatory concurrence and would be documented through the appropriate post-ROD change mechanism (i.e., an Explanation of Significant Difference or ROD Amendment).

14. References

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15. Acronyms and Abbreviations

ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, xylenes
B815-DSB	Building 815 Distal South Boundary
B815-PRX	Building 815 Proximal
B815-SRC	Building 815 Source
B817-PRX	Building 817 Proximal
B817-SRC	Building 817 Source

B829-SRC	Building 829 Source
B830-SRC	Building 830-Source
B830-PRXN	Building 830-Proximal North
B830-DISS	Building 830-Distal South
B832-PRXN	Building 832 Proximal North
B832-SRC	Building 832-Source
B854-DIS	Building 854-Distal
B854-PRX	Building 854 Proximal
B854-SRC	Building 854 Source
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm/sec	Centimeters per second
COC	Contaminant of concern
DCE	Dichloroethylene
DNAPL	Dense non-aqueous phase liquid
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
FFA	Federal Facility Agreement
ft	Feet
GAC	Granular activated carbon
gpd	Gallons per day
gpm	Gallons per minute
GSA	General Services Area
HE	High explosives
HMX	High Melting Explosive
HSU	Hydrostratigraphic unit
in	Inches
kg	Kilogram
Kgv	Cretaceous Great Valley Sequence
LLNL	Lawrence Livermore National Laboratory
LNAPL	Light non-aqueous phase liquid
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mi^2	Square miles
MNA	Monitored natural attenuation
N^2	Nitrogen gas
OEHHA	(California) Office of Environmental Health and Hazard Assessment

O&M	Operation and maintenance
OU	Operable unit
PCBs	Polychlorinated biphenyls
pCi/L	Picocuries per liter
$ppm_{v/v}$	Parts per million on a volume per volume basis
Qal/WBR	Quaternary alluvium/weathered bedrock
Qls	Quaternary landslide deposits
Qt	Quaternary terrace deposits
RCRA	Resource Conservation and Recovery Act
RDX	Research Department Explosive
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SVE	Soil vapor extraction
SWRCB	State Water Resources Control Board
SWRI	Site Wide Remedial Investigation
TBOS	Tetrabutylorthosilicate
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	Trichloroethylene
TKEBS	Tetra-kis-2-ethylbutyl silane
Tmss	Tertiary Cierbo Formation
Tn	Tertiary Neroly Formation
$Tnbs_0$	Tertiary Neroly Basal Sandstone
$Tnbs_1$	Tertiary Neroly Lower Blue Sandstone
$Tnbs_2$	Tertiary Neroly Upper Blue Sandstone
$Tnsc_0$	Tertiary Neroly Lower Siltstone/Claystone Basal Unit
$Tnsc_1$	Tertiary Neroly Lower Siltstone/Claystone
$Tnsc_{1a}$	Tertiary Neroly Lower Siltstone/Claystone Unit 1a
$Tnsc_{1b}$	Tertiary Neroly Lower Siltstone/Claystone Unit 1b
$Tnsc_2$	Tertiary Neroly Upper Siltstone/Claystone
Tps	Tertiary Pliocene nonmarine sediments
Tpsg	Tertiary Pliocene sand and gravel
Tts	Tertiary Tesla Formation
$^{235}U/^{238}U$	Uranium-235/uranium-238 atom ratio
VOCs	Volatile organic compounds
WQNLs	Water Quality Numeric Limits
yd^3	Cubic yards
μg/L	Micrograms per liter

Figures

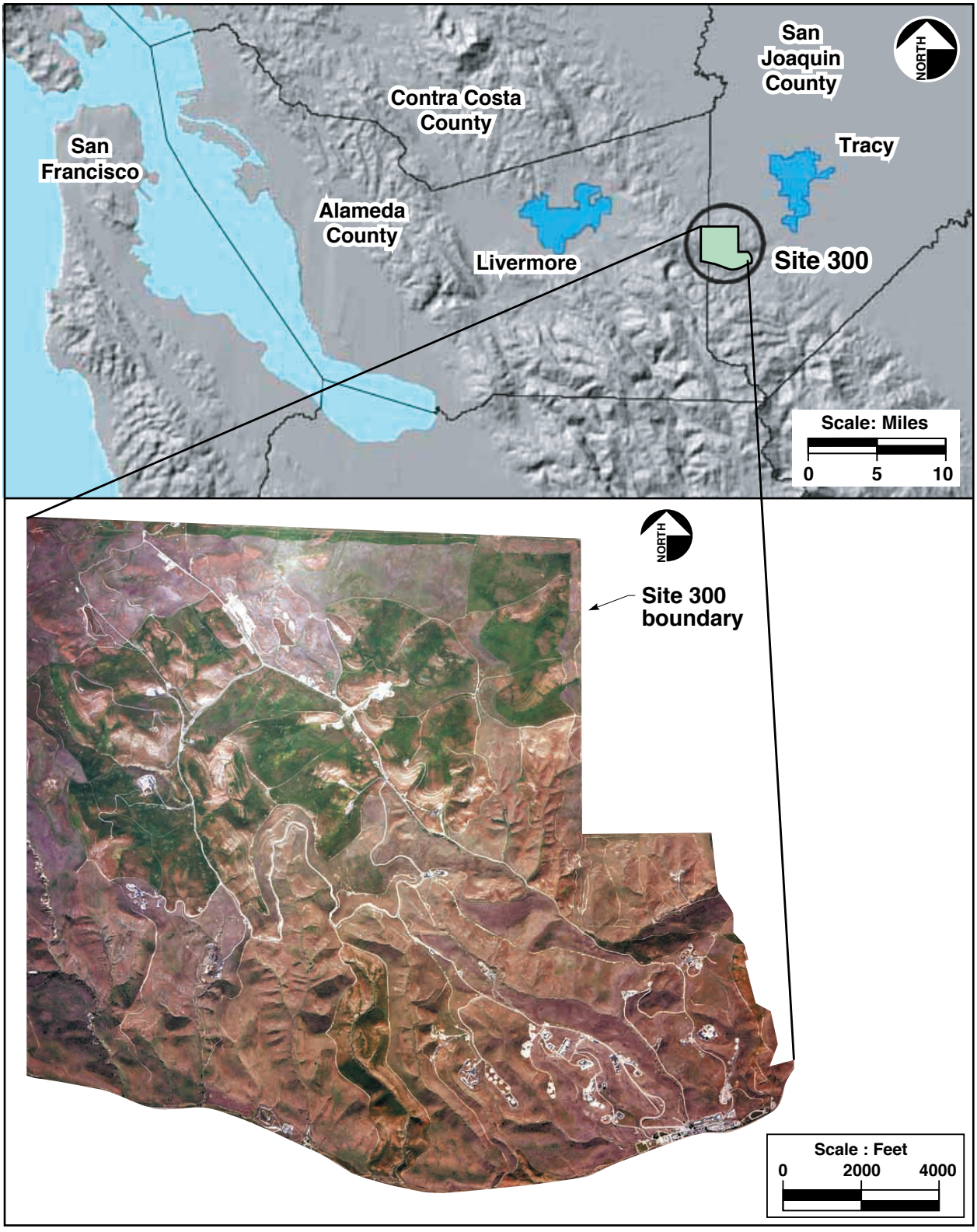

Figure 3-1. Location of LLNL Site 300.

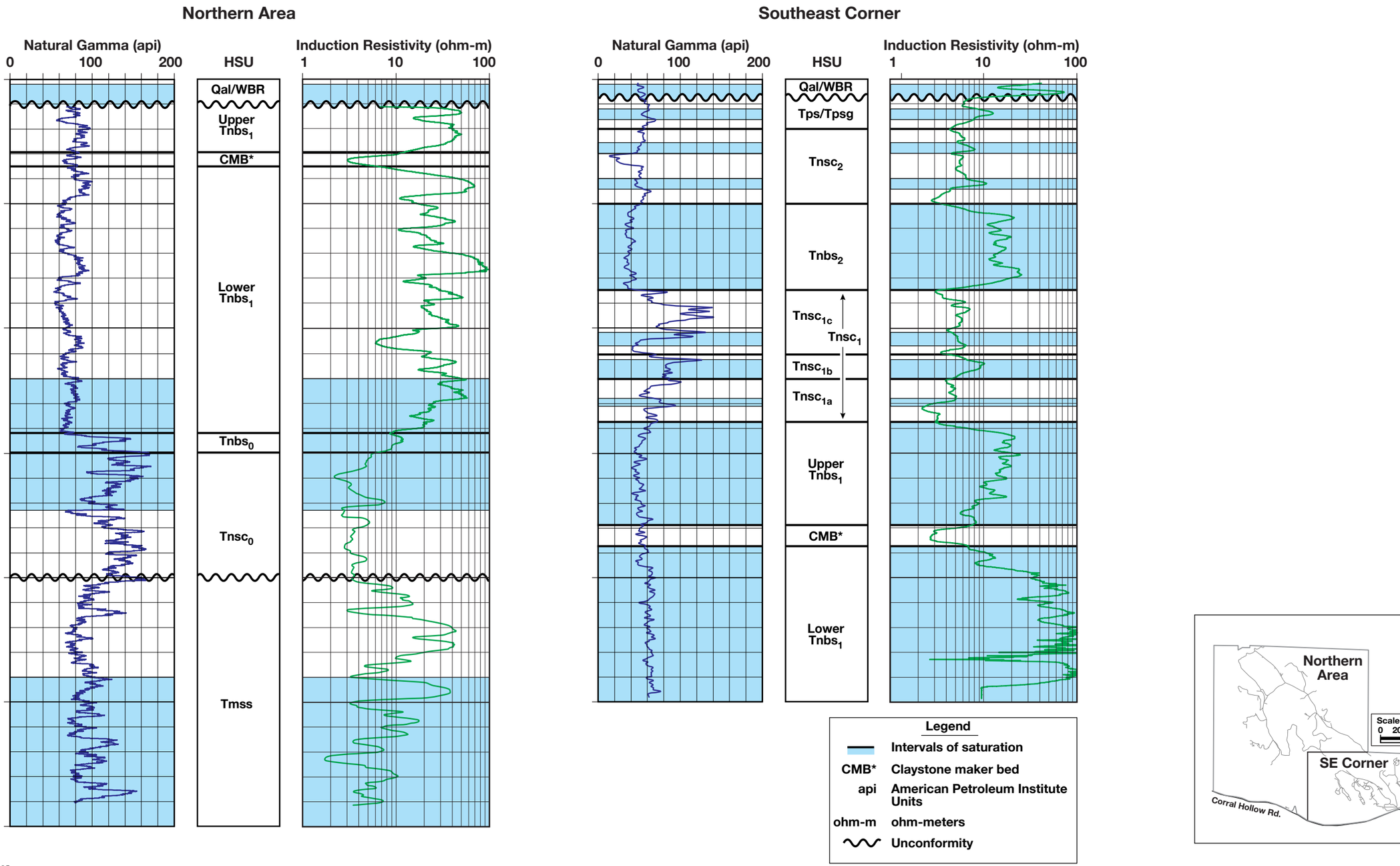

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Figure 3-2. Composite hydrostratigraphic columns for Site 300 showing saturated HSUs.

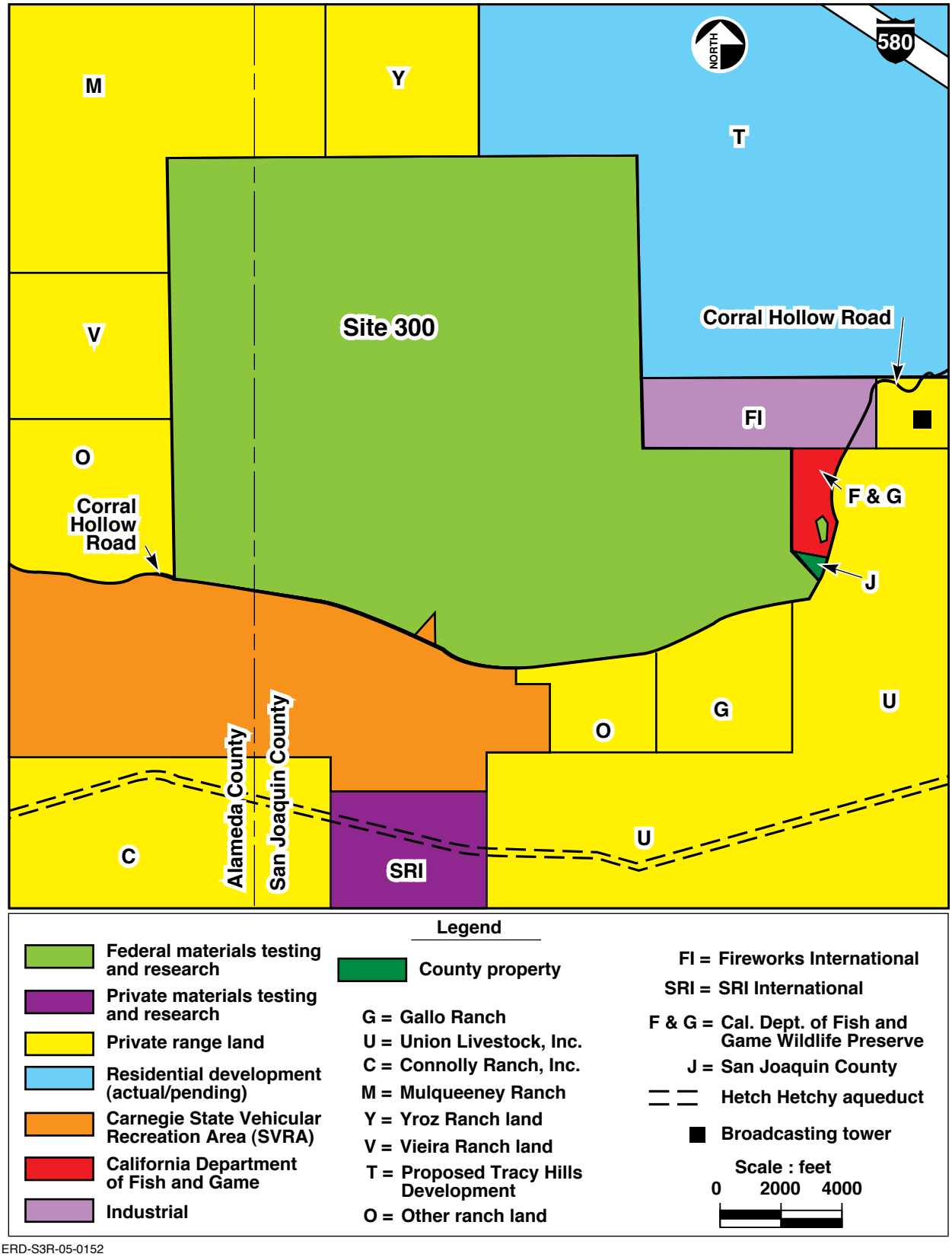

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Figure 3-3. Land use in the vicinity of Site 300.

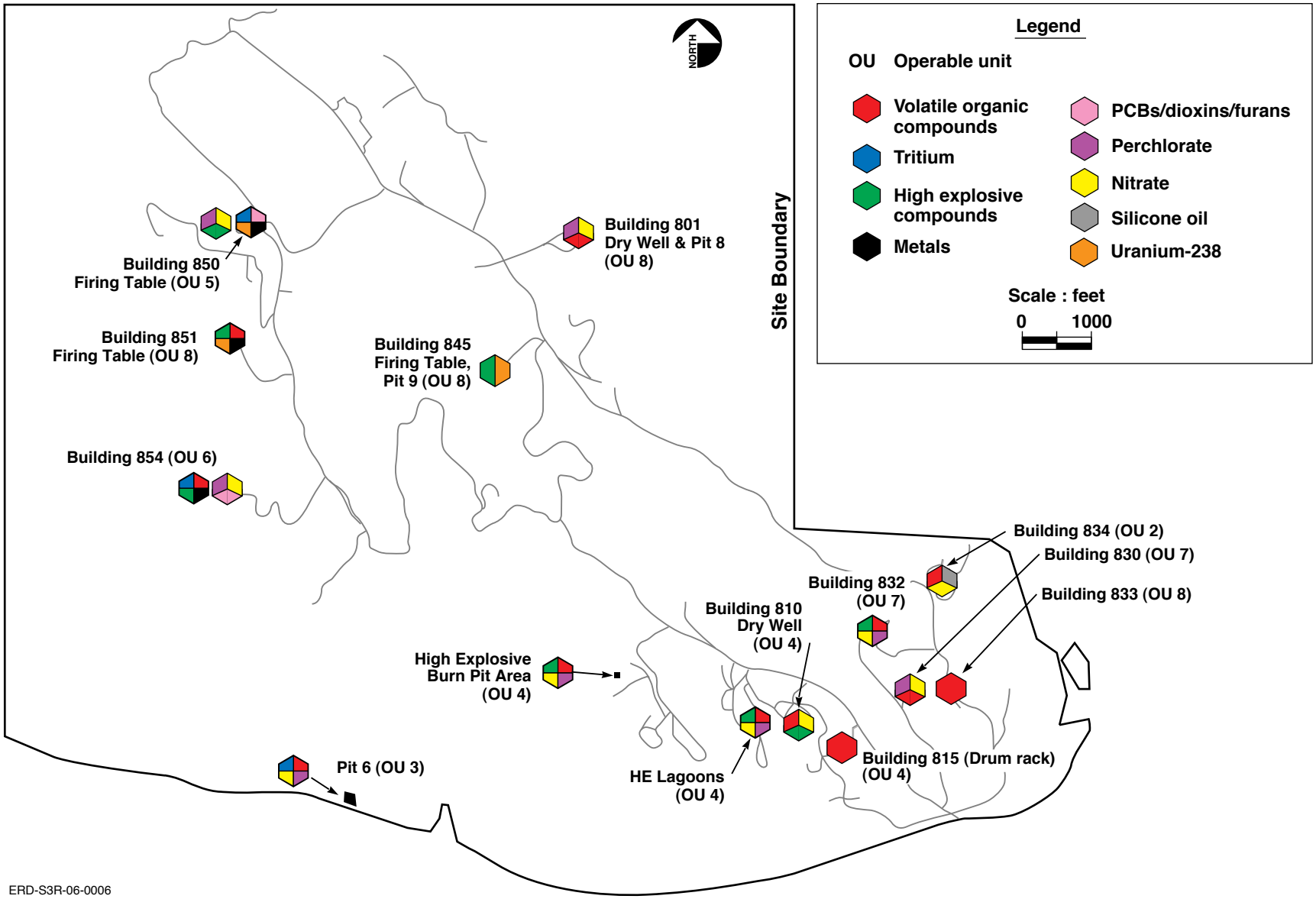

Figure 3-4. Release sites and contaminants of concern at Site 300 for surface soil, subsurface soil/rock, surface water, and ground water.

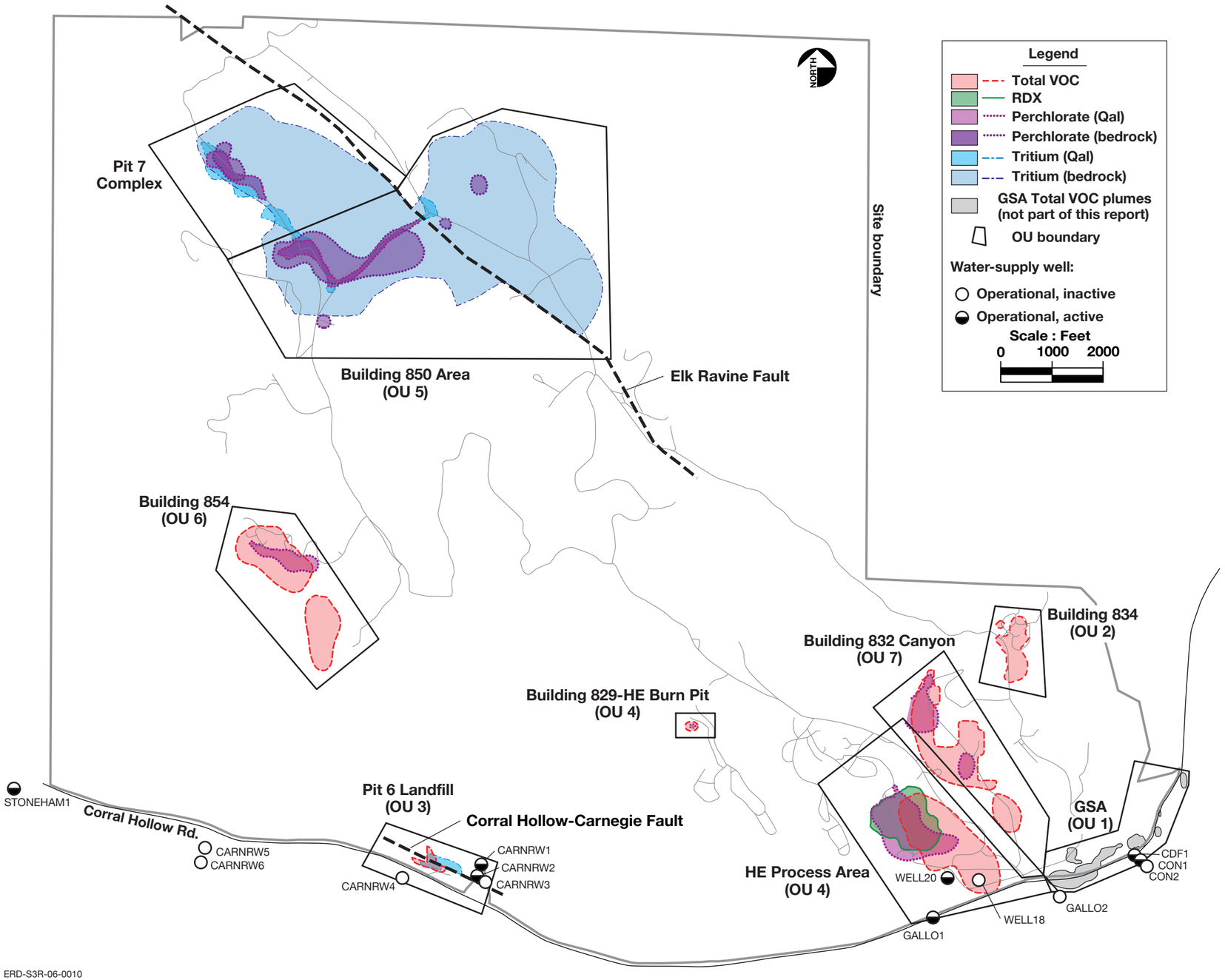

Figure 3-5. Map of Site 300 showing operable units with plume outlines and operational water-supply wells.

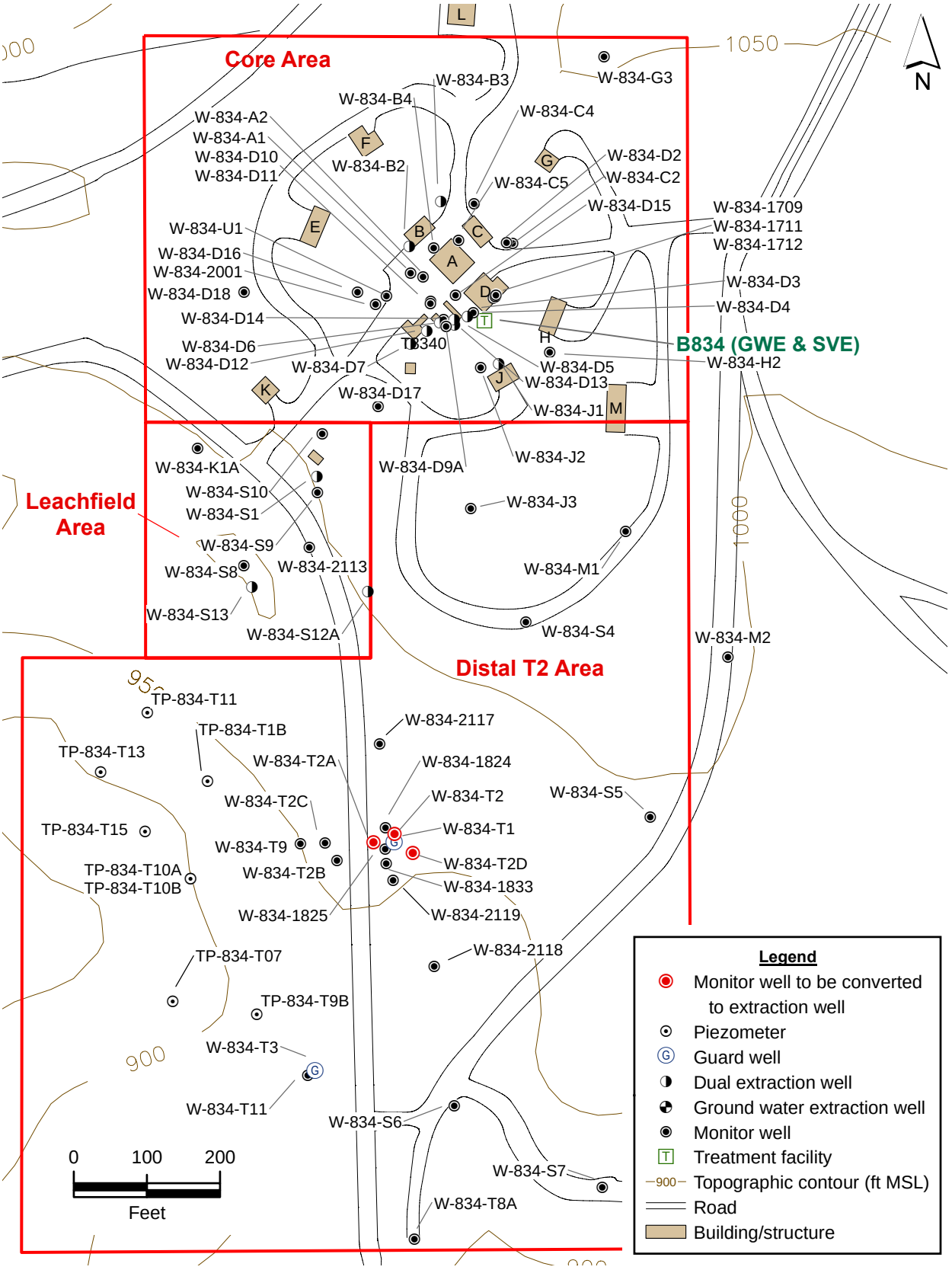

Figure 6-1. Building 834 OU site map showing piezometers and monitoring, extraction, and guard wells and the treatment facilities.

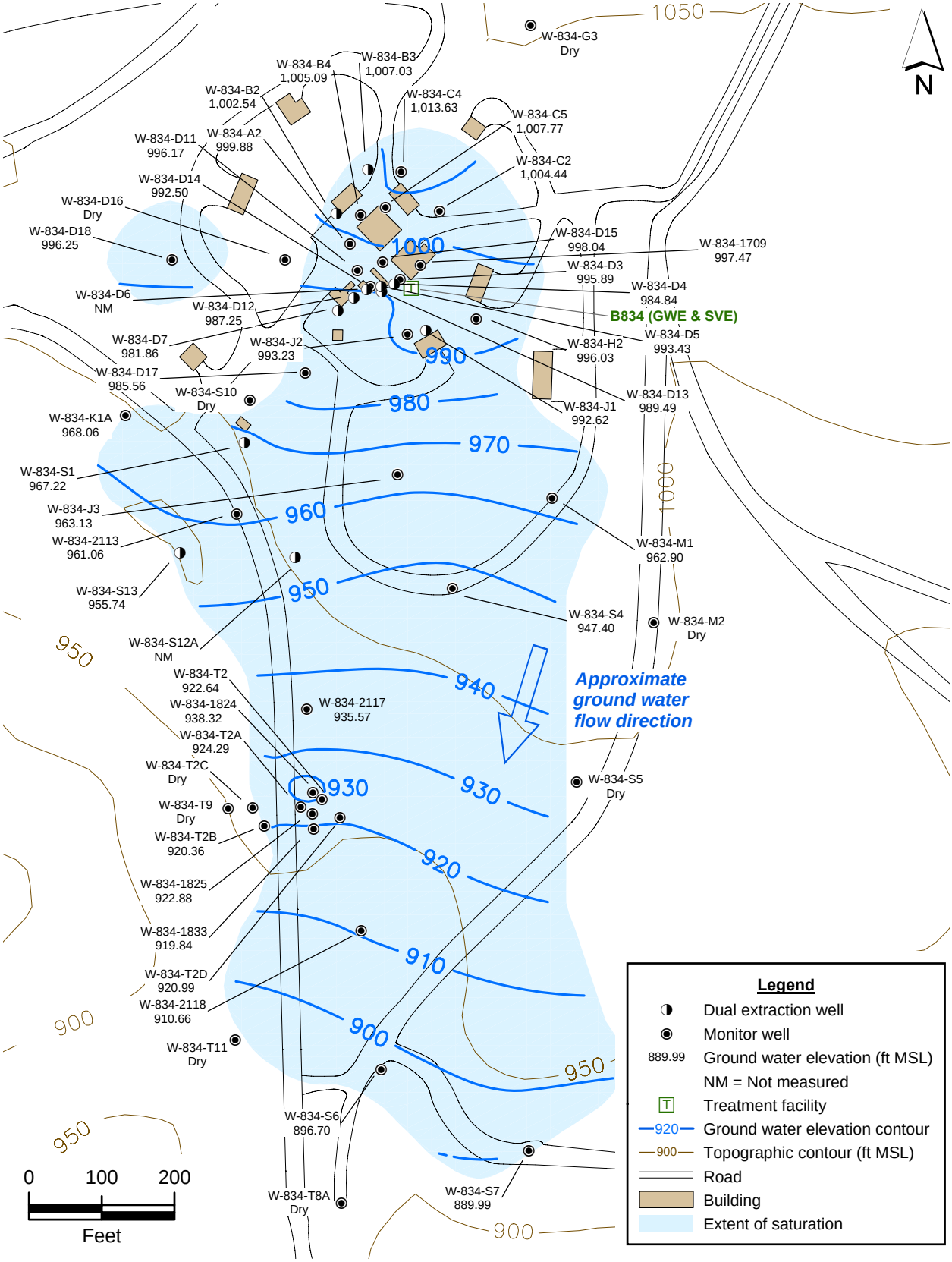

Figure 6-2. Building 834 OU potentiometric surface and ground water flow direction in the Tpsg perched water-bearing zone (1st Semester 2005).

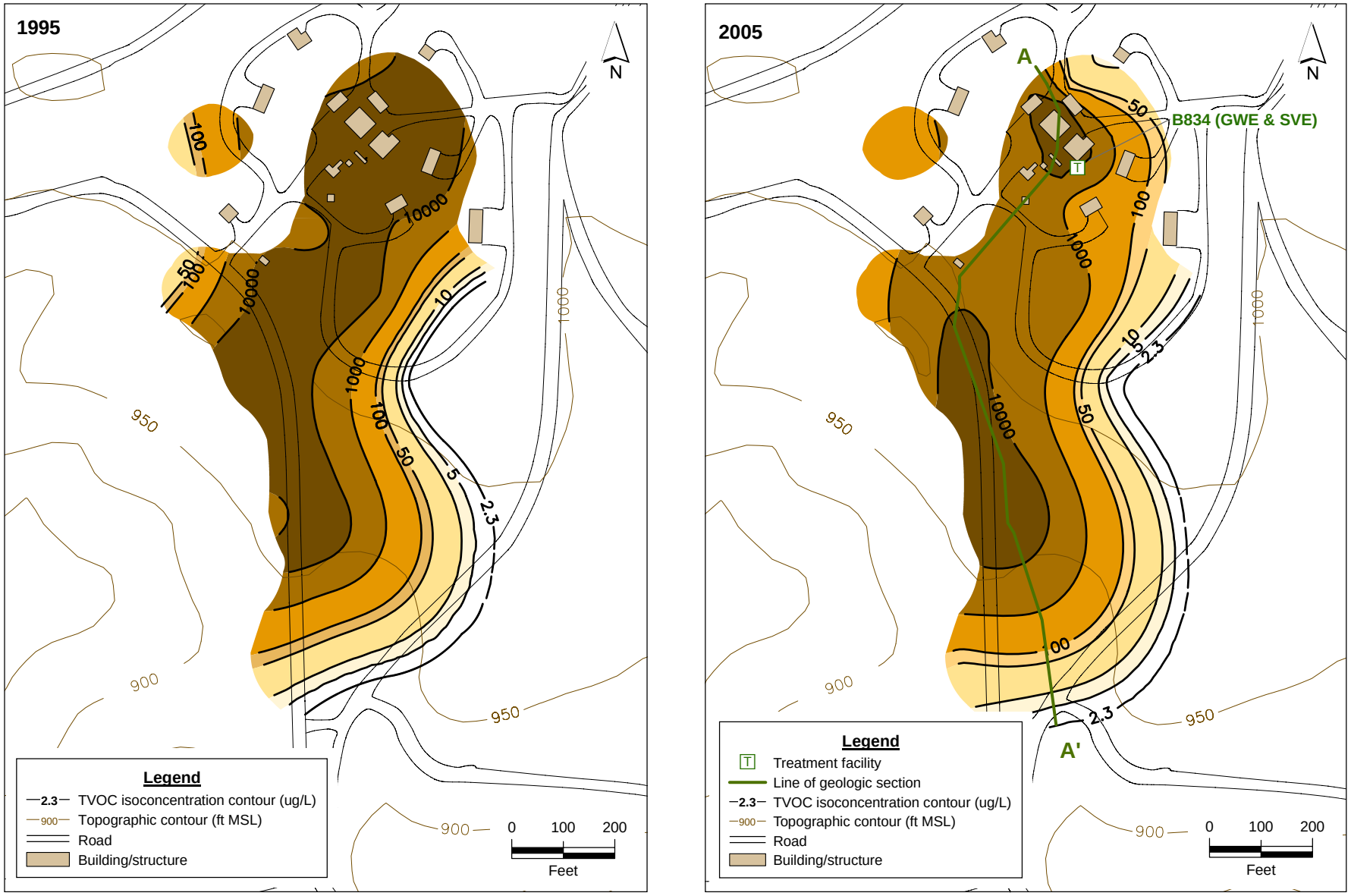

Figure 6-3. Comparison of the distribution of total VOCs in the Building 834 Tpsg perched water-bearing zone in 1995 and 1st Semester 2005.

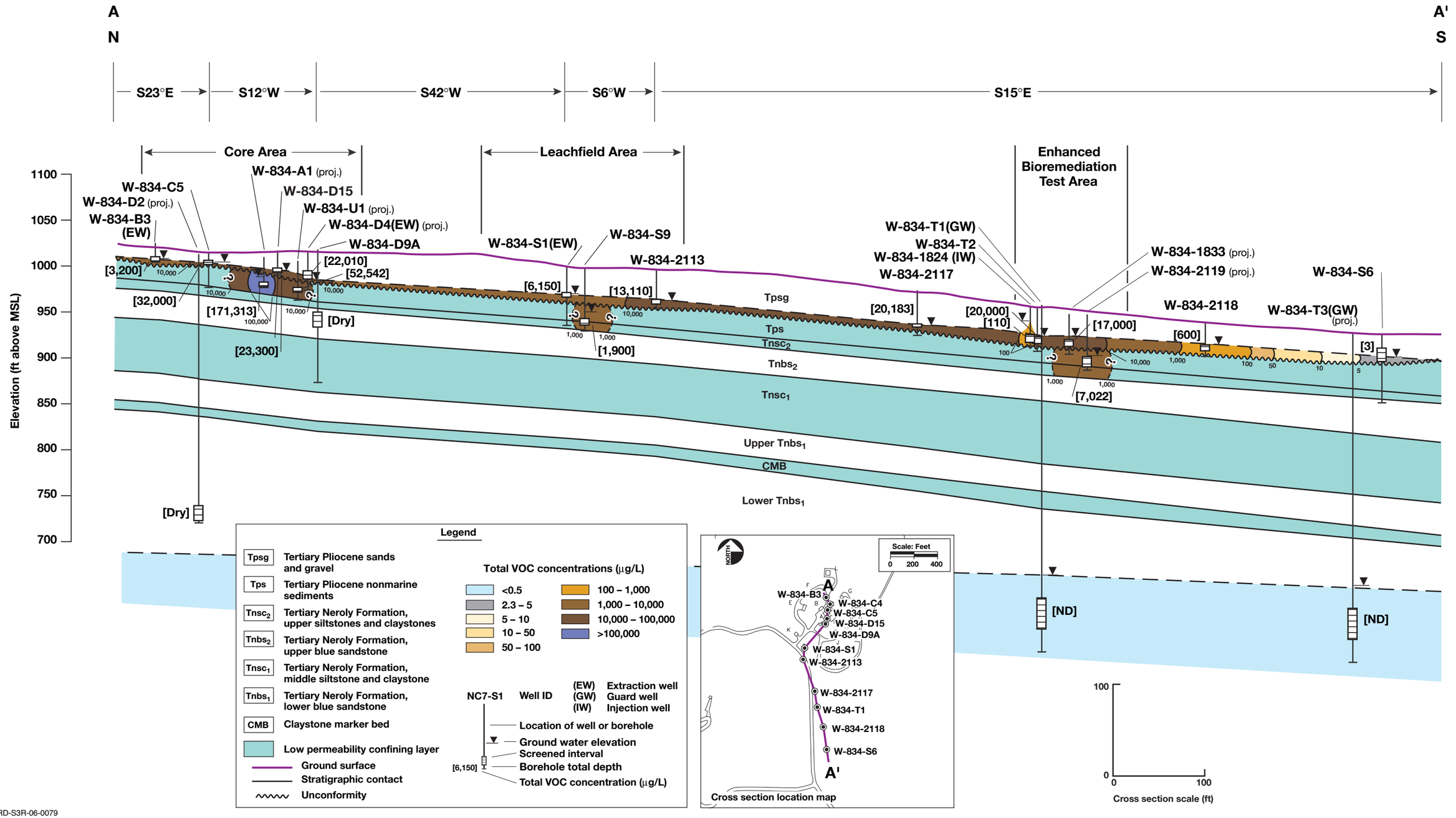

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Figure 6-4. Building 834 Hydrogeologic Cross-section A-A'.

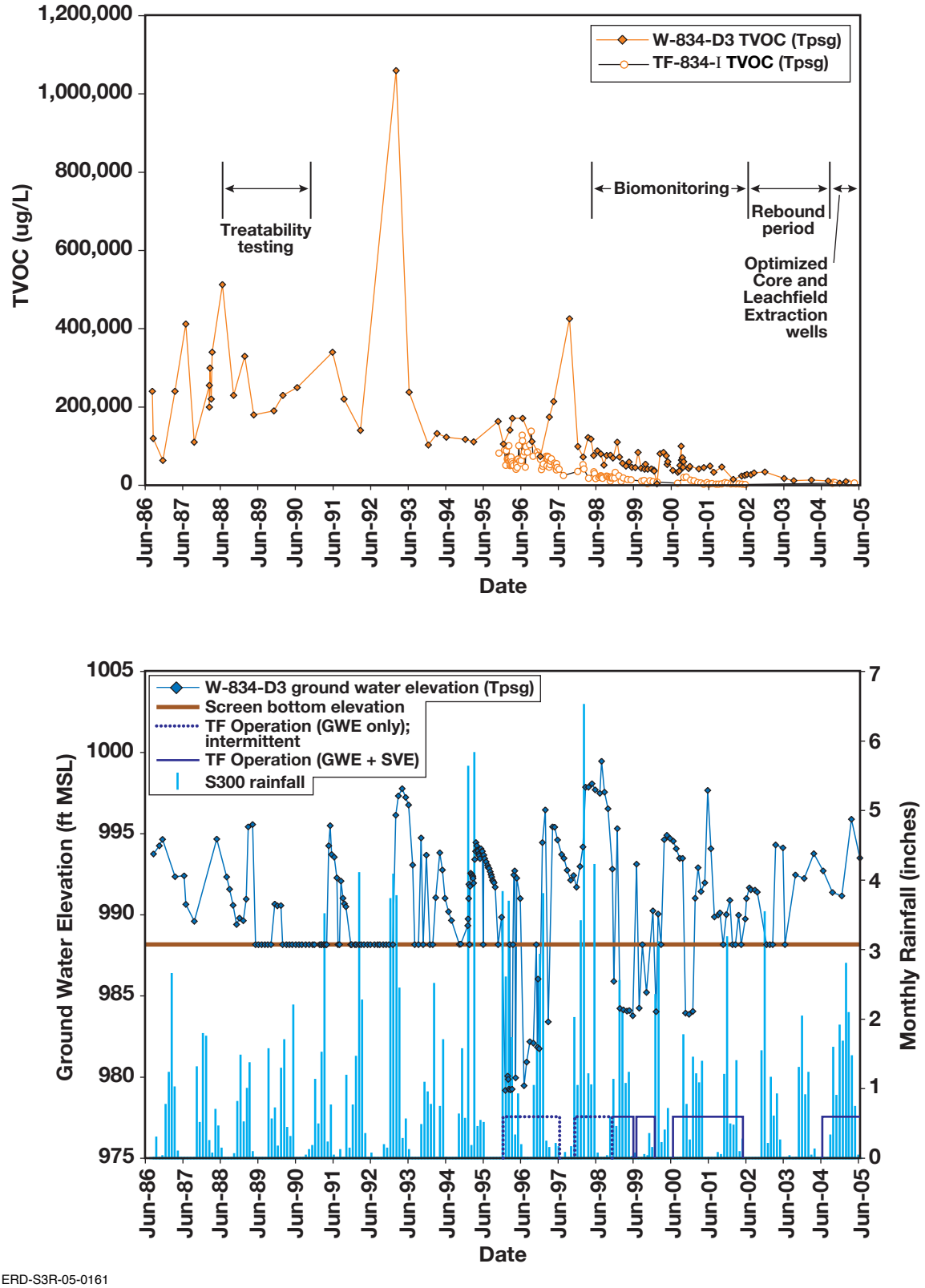

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Figure 6-5. Time-series plots of total VOCs in ground water and hydrograph at the Building 834 Core Area.

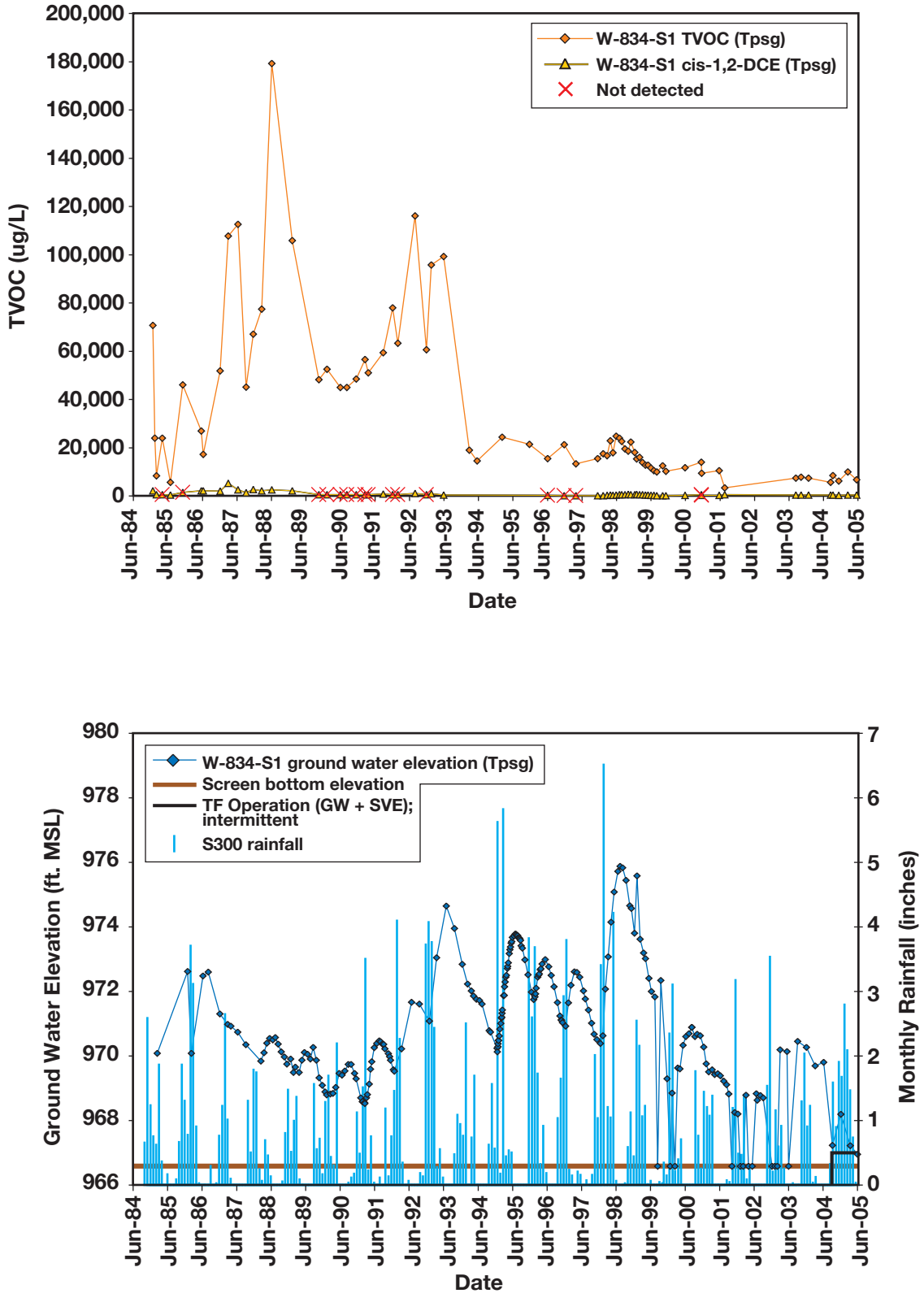

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Figure 6-6. Time-series plots of total VOCs and cis-1,2-DCE in ground water and hydrograph at the Building 834 Leachfield Area.

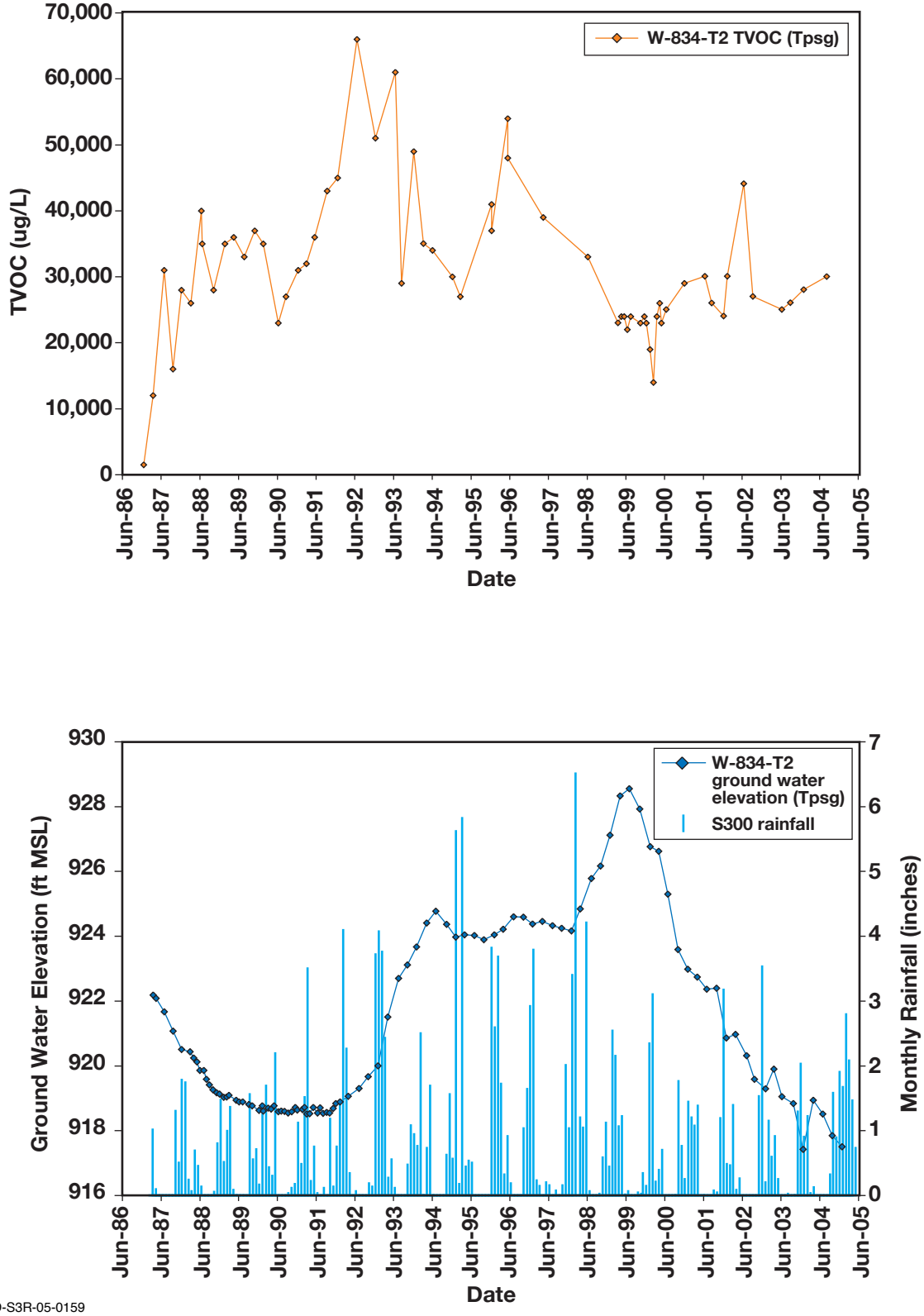

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Figure 6-7. Time-series plots of total VOCs in ground water and hydrograph at the Building 834 Distal (T2) Area.

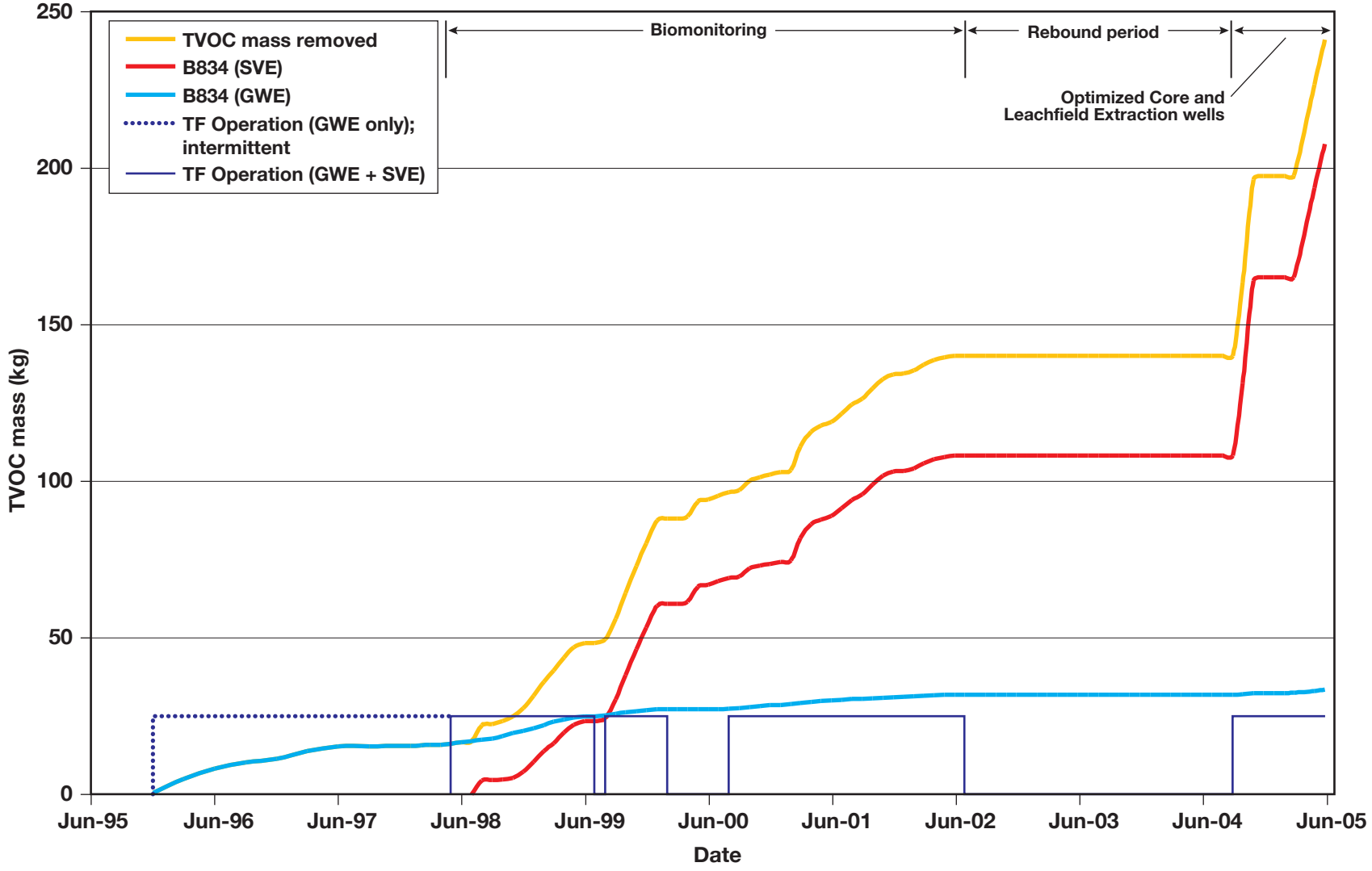

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Figure 6-8. Time-series plots of cumulative mass of total VOCs removed by ground water extraction (GWE) and SVE from the Building 834 OU.

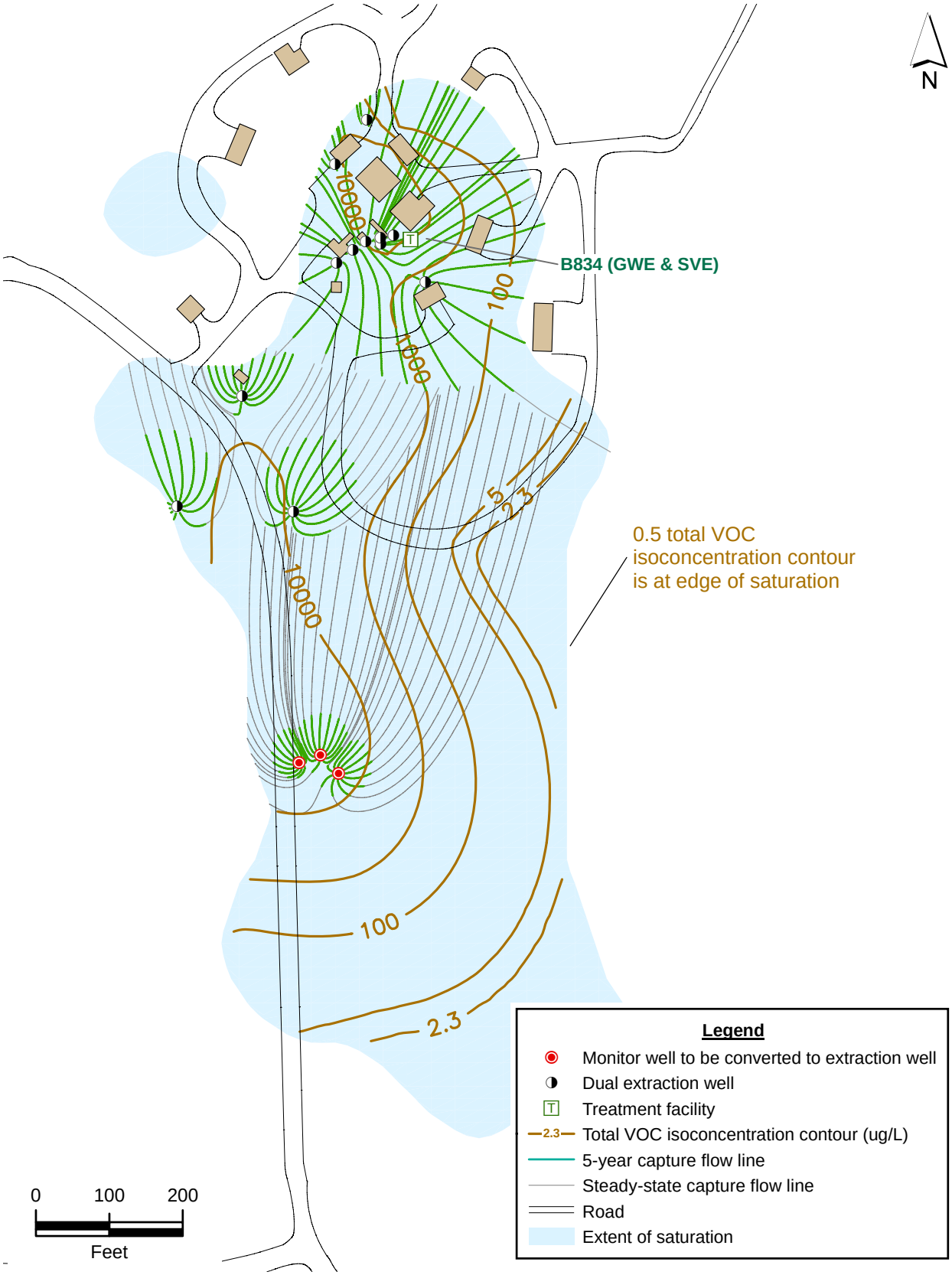


Figure 6-9. Capture zone analysis results for the designed remedial extraction wellfield at the Building 834 OU.

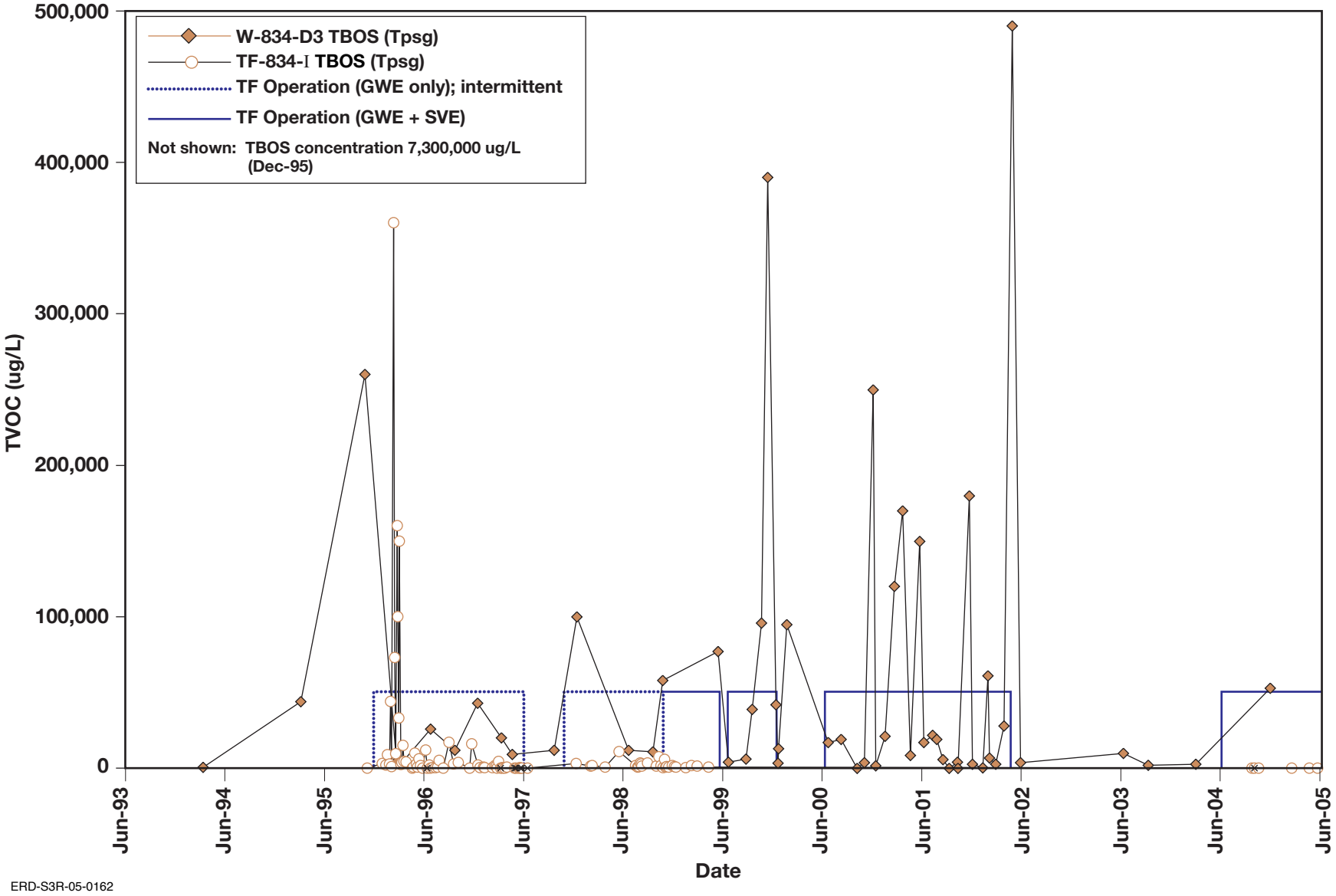


Figure 6-10. Time-series plots of TBOS in ground water at the Building 834 Core Area.

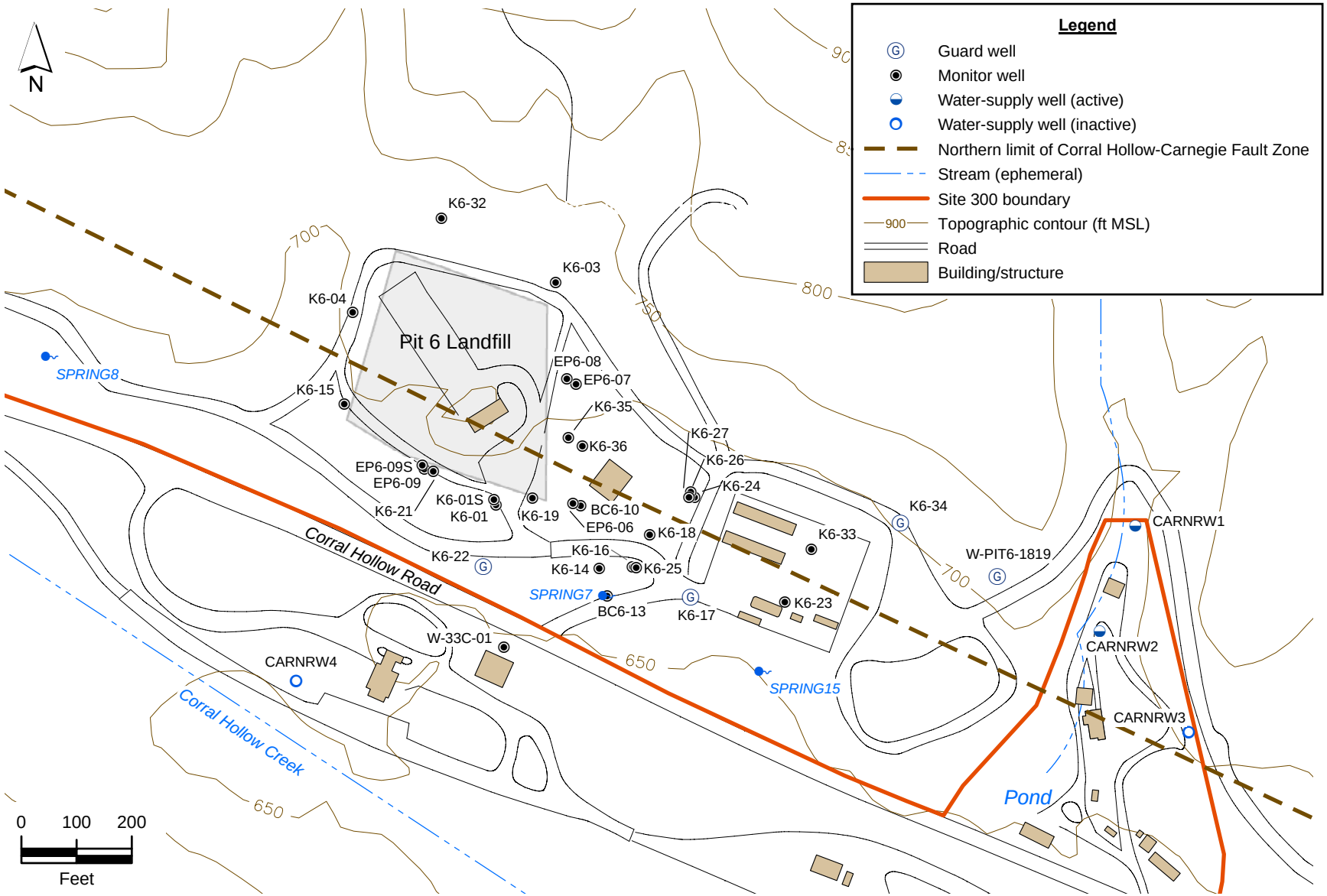


Figure 7-1. Pit 6 Landfill OU site map showing monitor and water-supply wells, springs, and the northern limit of the Corral-Hollow-Carnegie Fault Zone.

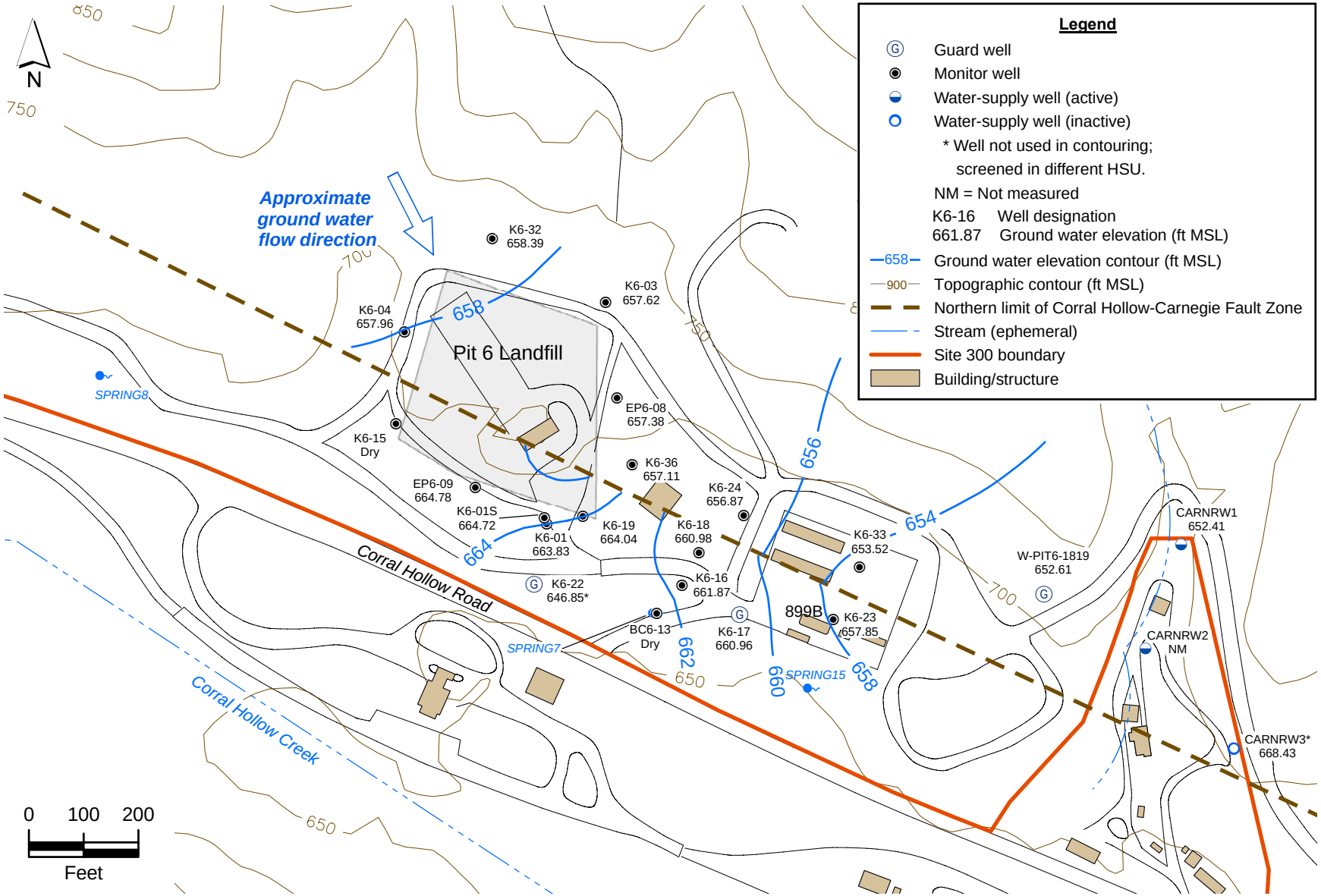


Figure 7-2. Pit 6 Landfill OU potentiometric surface and ground water flow direction in the Qt-Tnbs$_1$ North and South HSUs (1st Semester 2005).

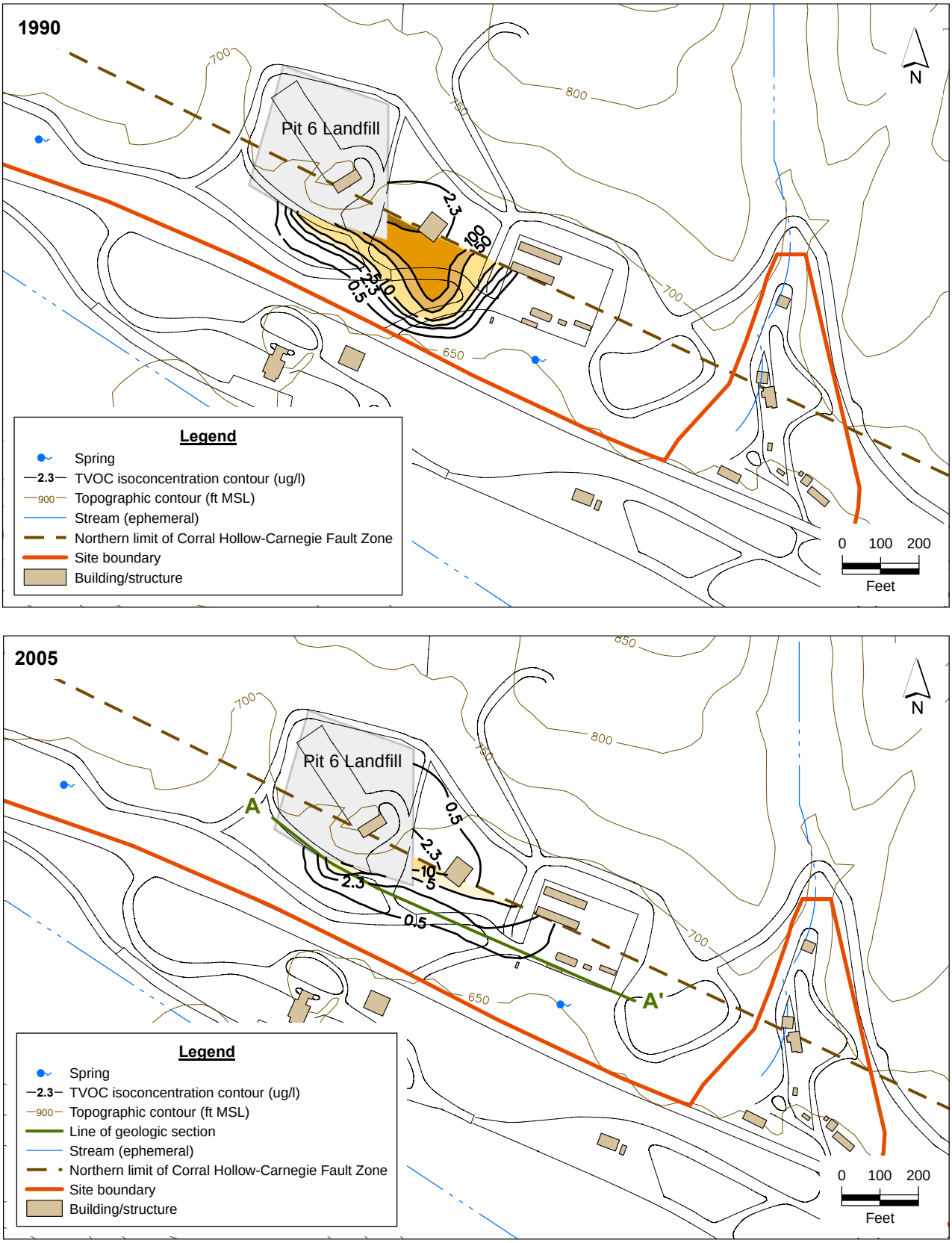
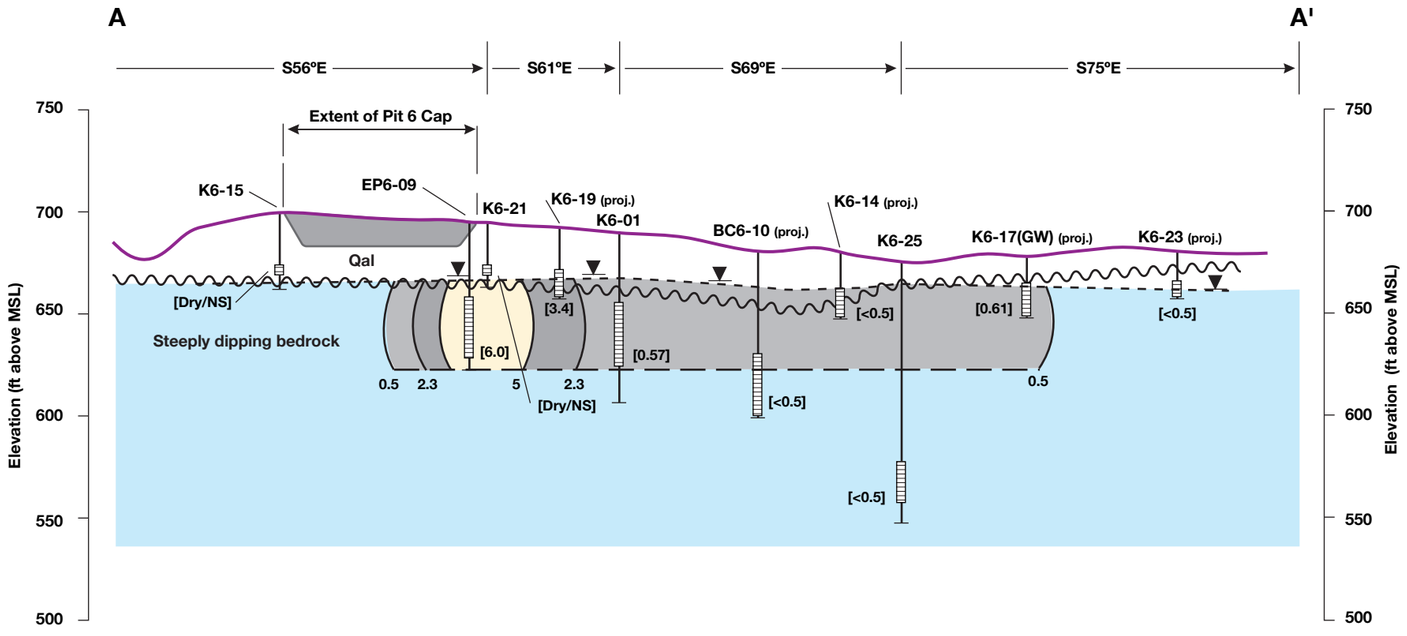
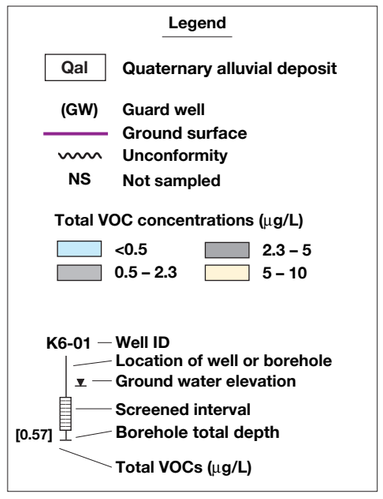
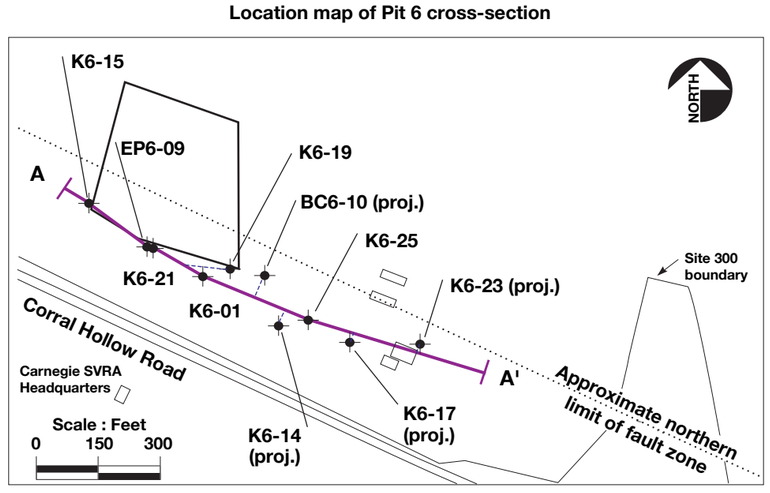


Figure 7-3. Comparison of the distribution of total VOCs in Pit 6 Landfill ground water in the Qt-Tnbs$_1$ North and South HSUs in 1990 and 1st Semester 2005.







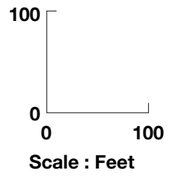


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Figure 7-4. Pit 6 Hydrogeologic Cross-section A-A'.

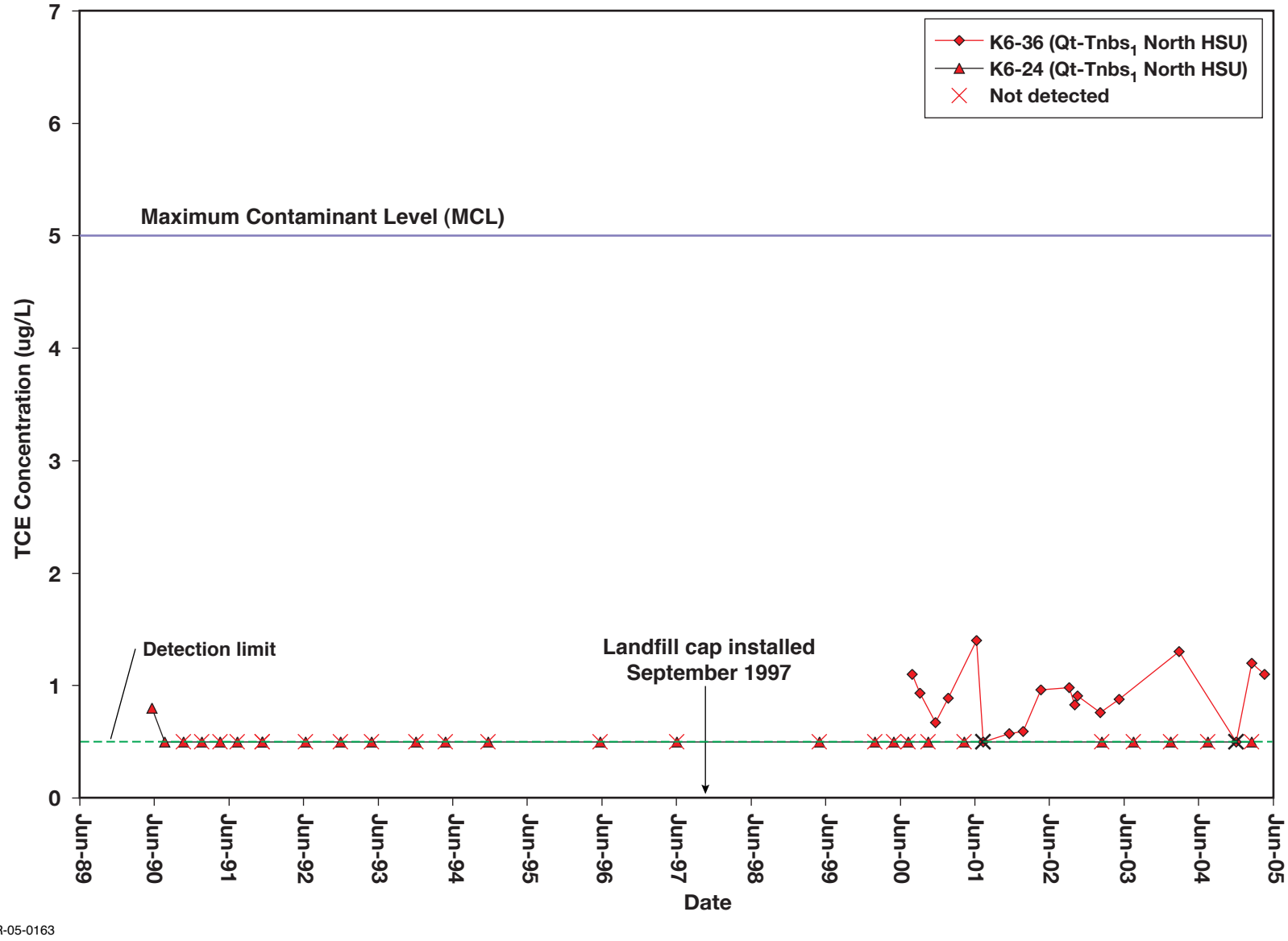

Figure 7-5. Time-series plot of TCE in ground water at Pit 6, north of Corral Hollow-Carnegie Fault Zone.

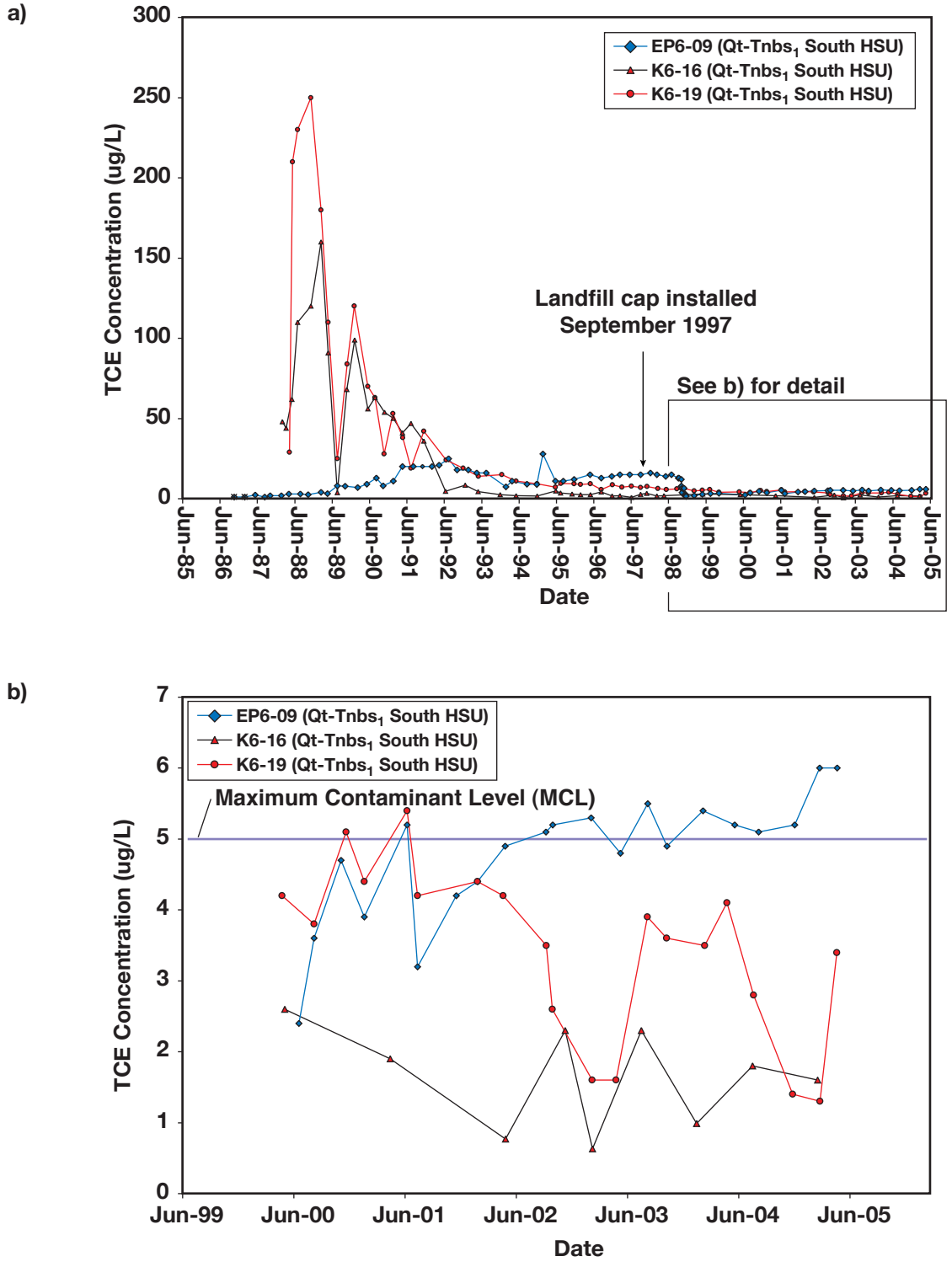

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Figure 7-6. Time-series plot of a) TCE concentrations in ground water within the Corral Hollow-Carnegie Fault Zone from 1988 to 2005, and b) TCE concentrations in ground water within the fault zone from 2000 to 2005.

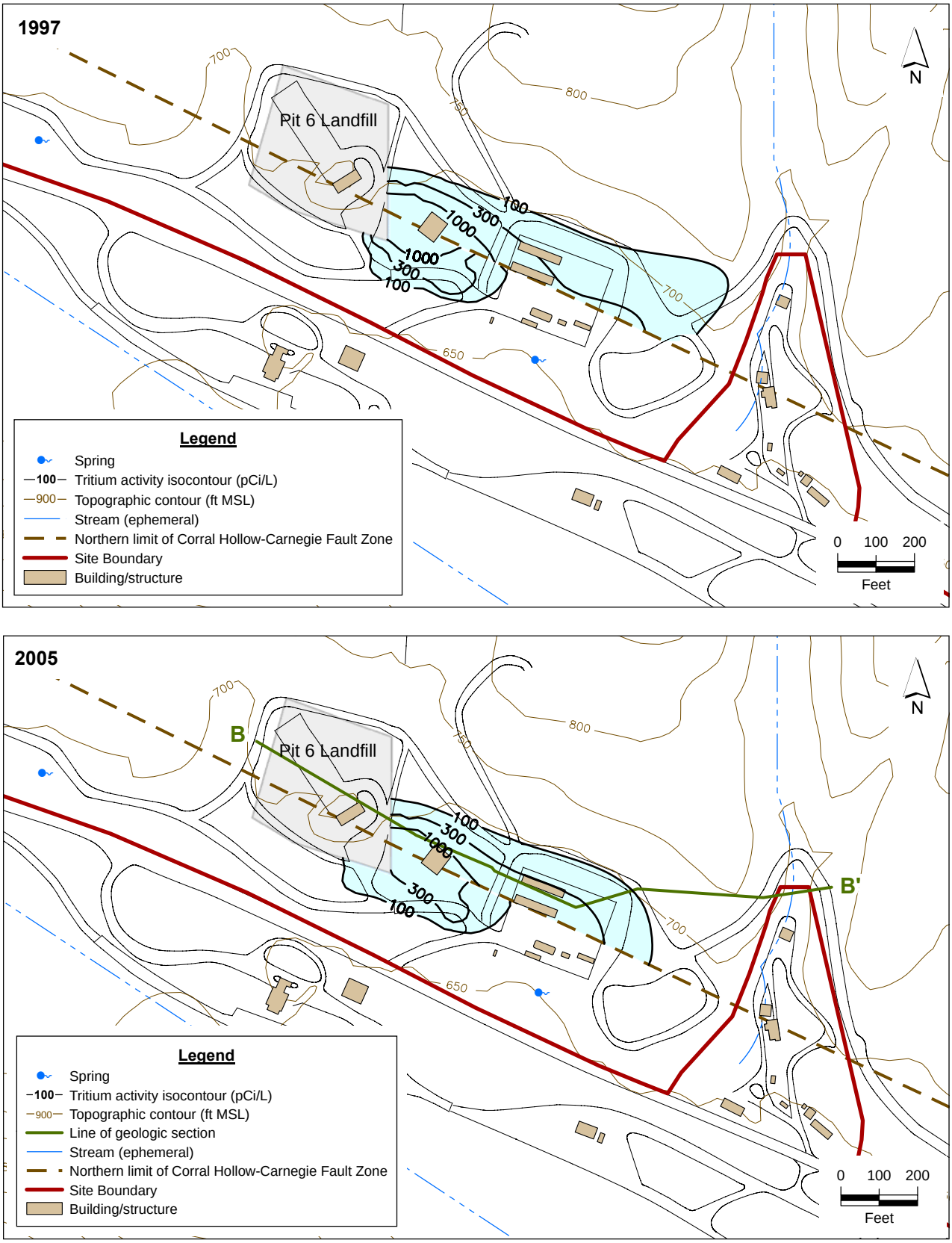

Figure 7-7. Comparison of the distribution of tritium in Pit 6 Landfill ground water in the Qt-Tnbs$_1$ North and South HSUs in 1997 and 1st Semester 2005.

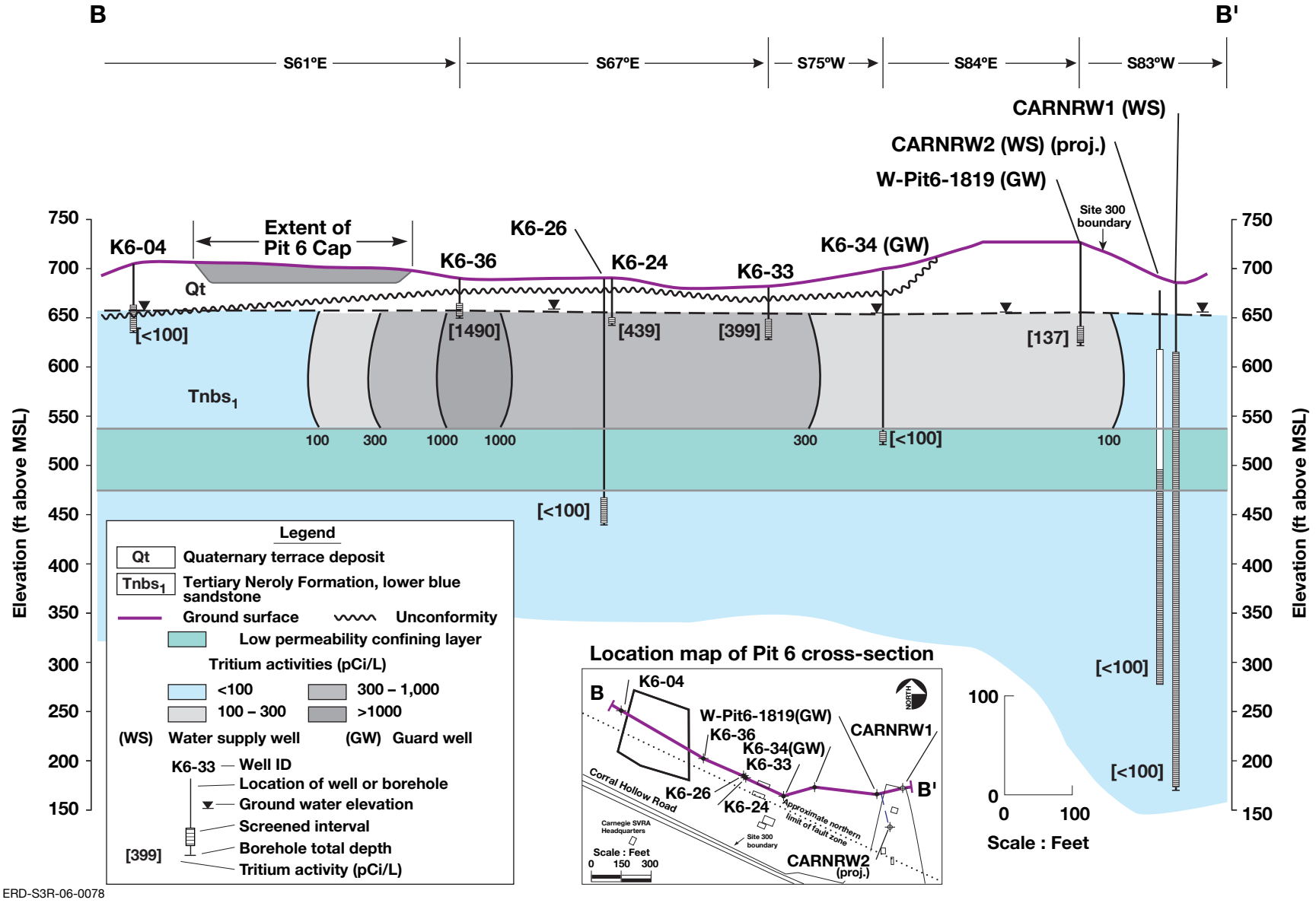

Figure 7-8. Pit 6 Hydrogeologic Cross-section B-B'.

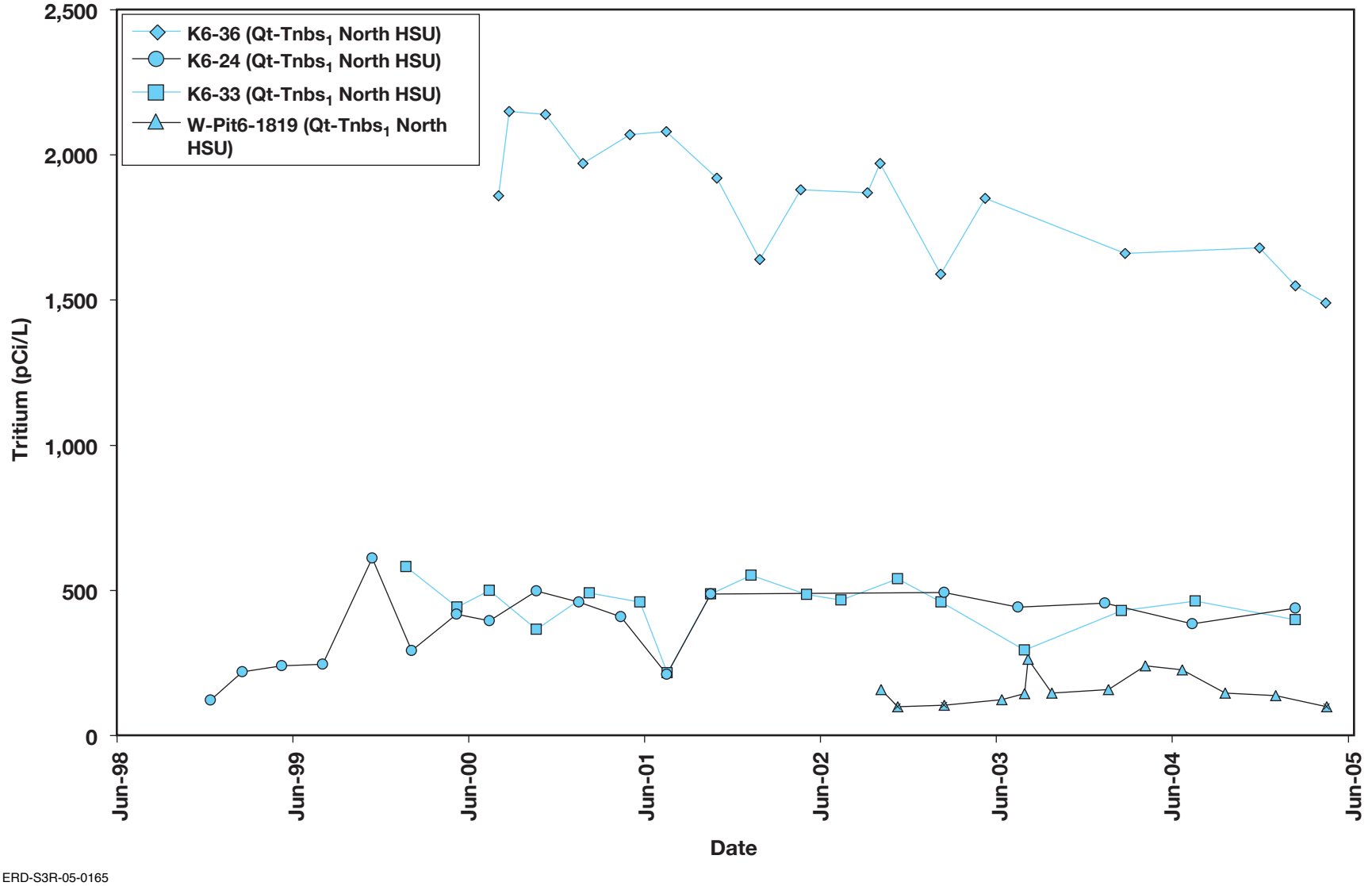

Figure 7-9. Time-series plot of tritium in ground water at Pit 6, north of Corral Hollow-Carnegie Fault Zone.

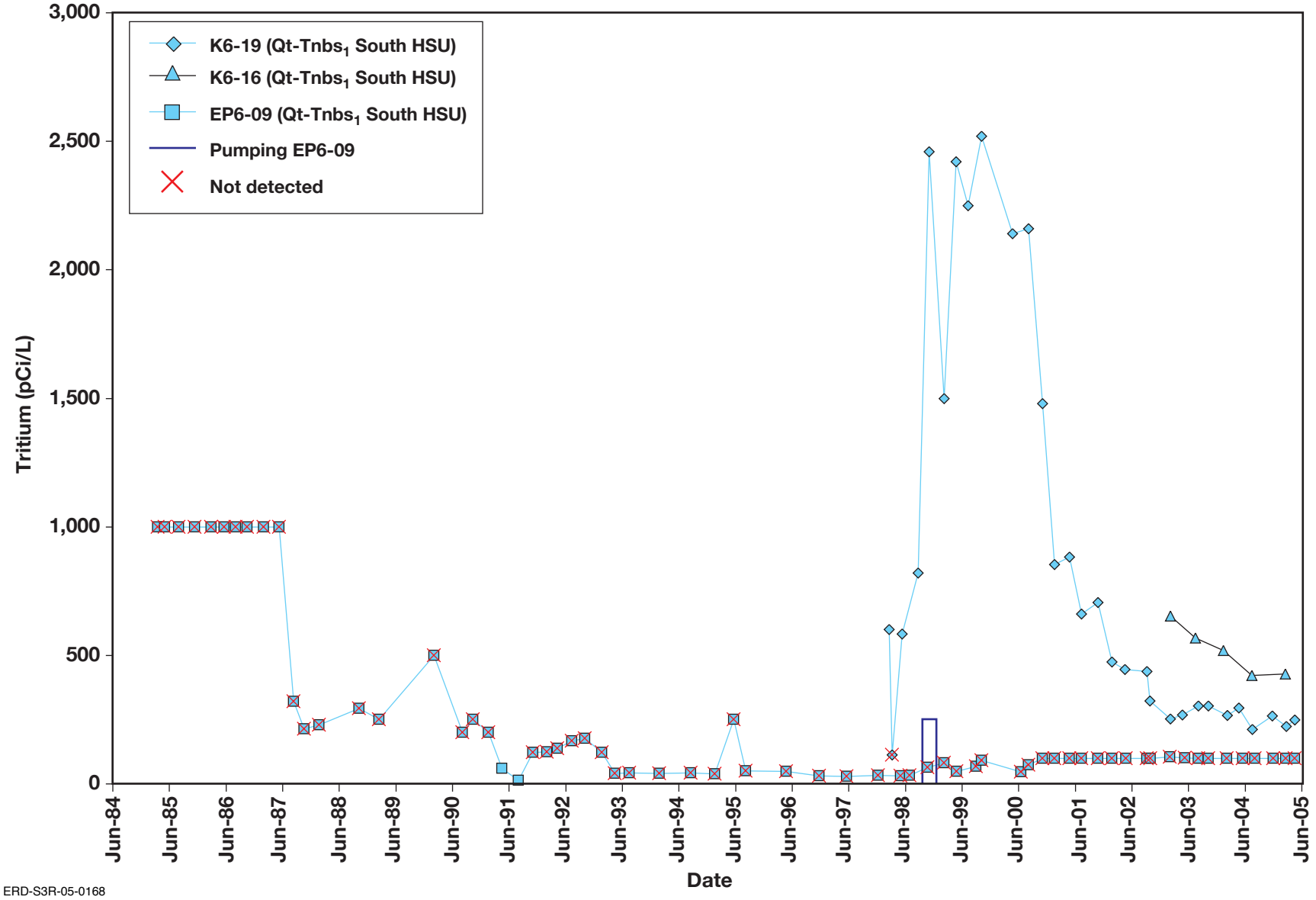

Figure 7-10. Time-series plot of tritium in ground water at Pit 6, within the Corral Hollow-Carnegie Fault Zone.

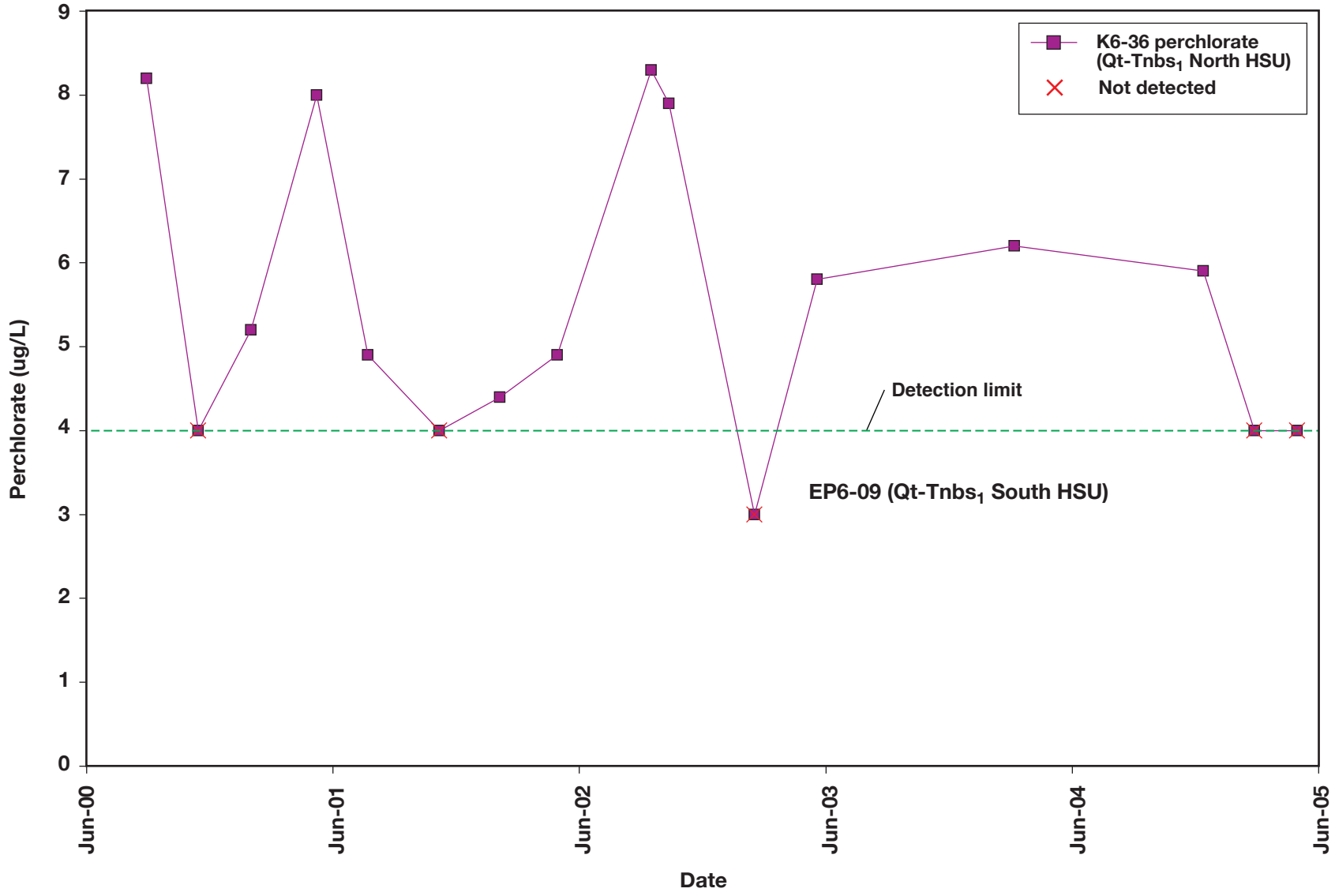

Figure 7-11. Time-series plot of perchlorate in ground water at Pit 6, north of Corral Hollow-Carnegie Fault Zone.

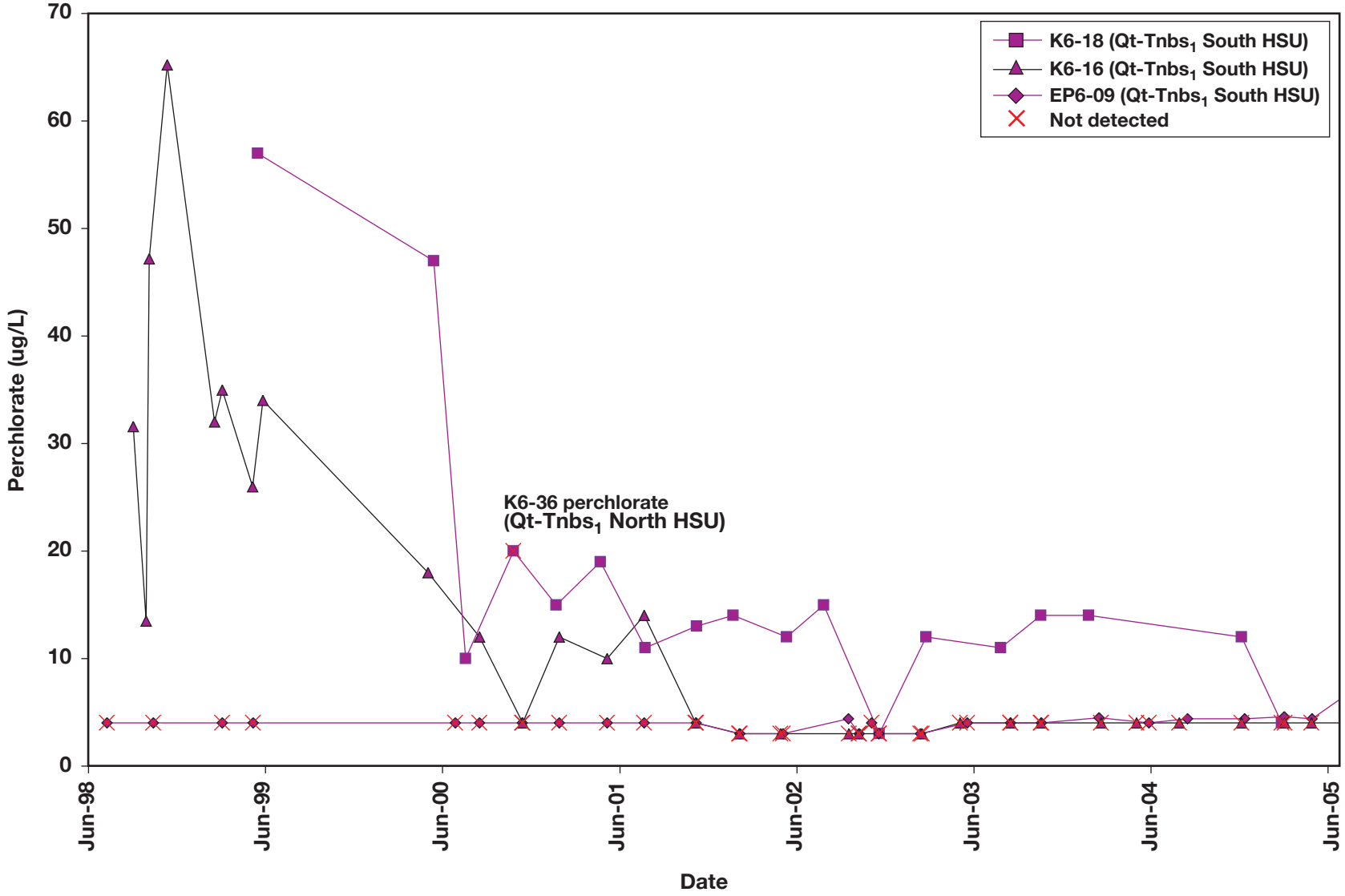

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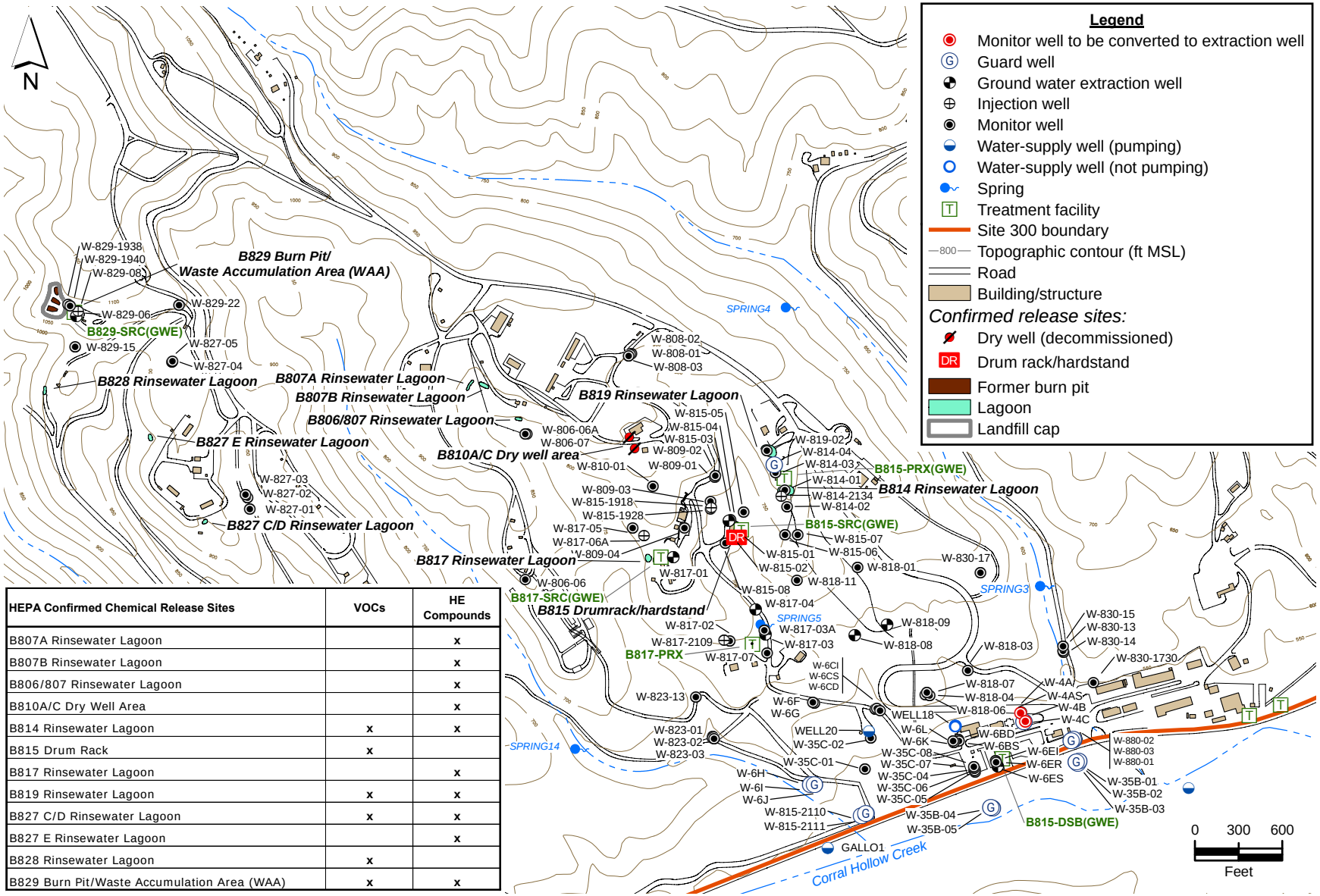
Figure 7-12. Time-series plot of perchlorate concentration in ground water at Pit 6, within the Corral Hollow-Carnegie Fault Zone.



HEPA Confirmed Chemical Release Sites	VOCs	HE Compounds
B807A Rinsewater Lagoon		x
B807B Rinsewater Lagoon		x
B806/807 Rinsewater Lagoon		x
B810A/C Dry Well Area		x
B814 Rinsewater Lagoon	x	x
B815 Drum Rack	x	
B817 Rinsewater Lagoon		x
B819 Rinsewater Lagoon	x	x
B827 C/D Rinsewater Lagoon	x	x
B827 E Rinsewater Lagoon		x
B828 Rinsewater Lagoon	x	
B829 Burn Pit/Waste Accumulation Area (WAA)	x	x

Figure 8-1. High Explosive Process Area OU site map showing monitor, extraction and water-supply wells, and treatment facilities.

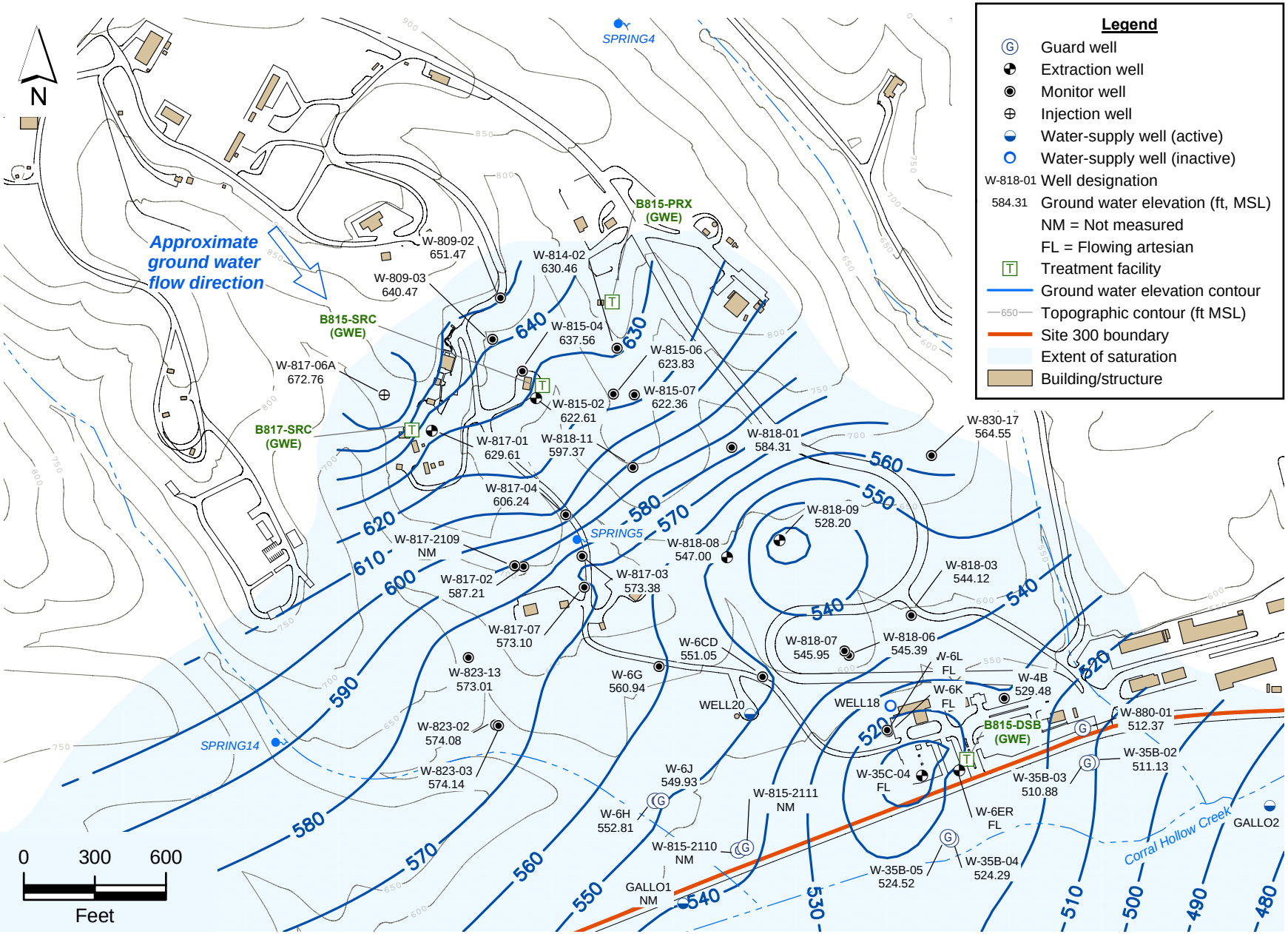
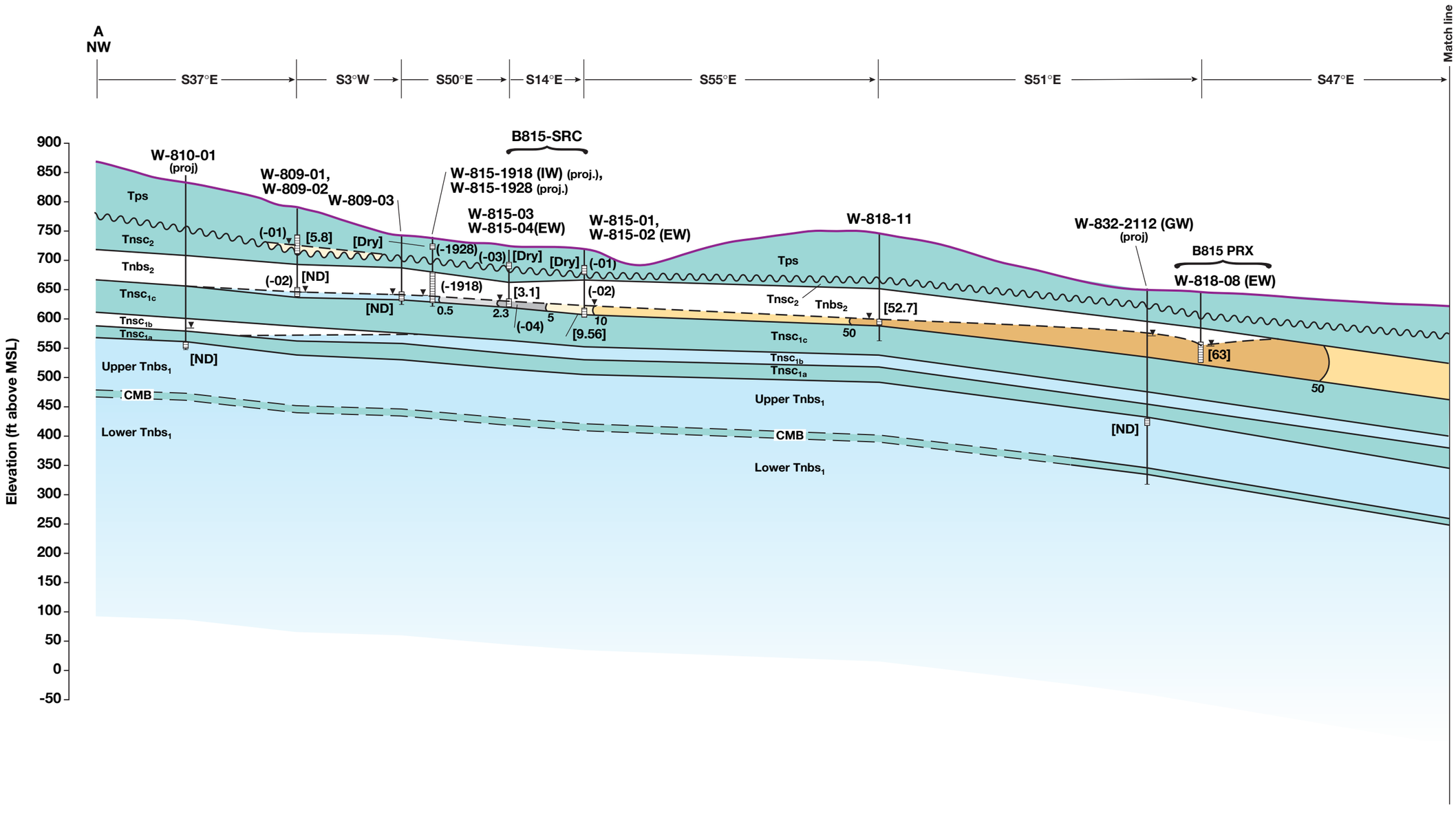
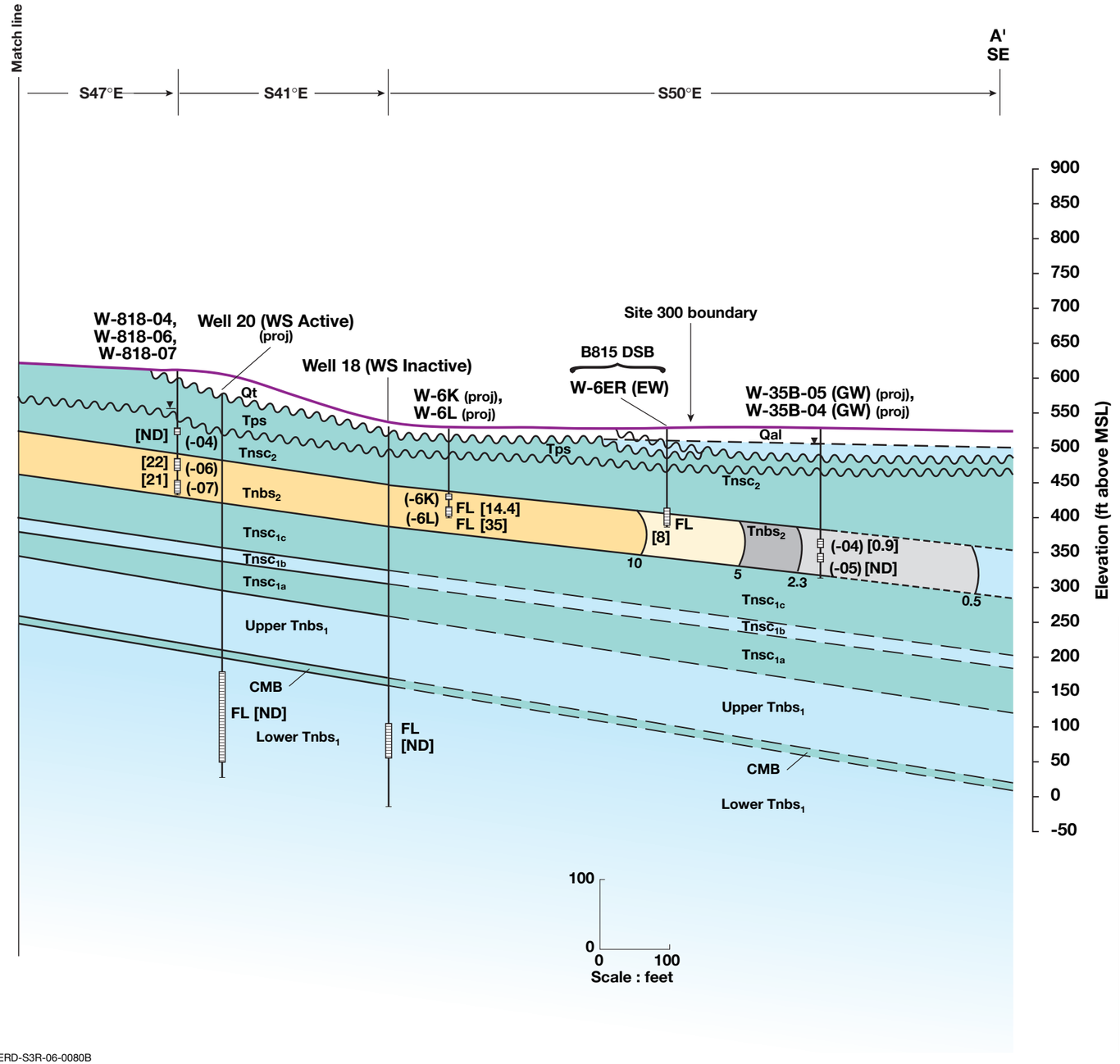


Figure 8-2. High Explosive Process Area OU potentiometric surface and ground water flow direction in the $Tnbs_2$ HSU (1st Semester 2005).

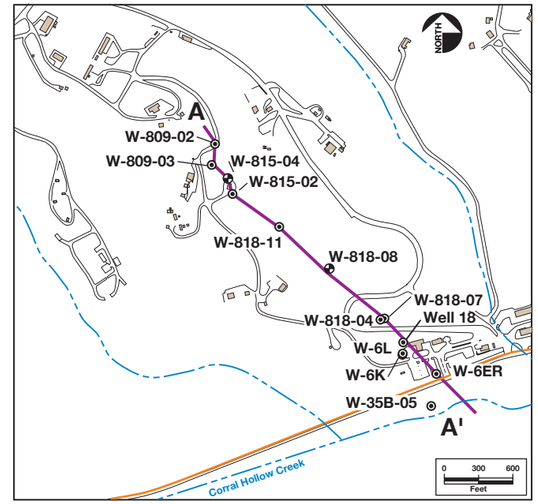


ERD-S3R-06-0080A

Figure 8-3. High Explosives Process Area Hydrogeologic Cross-section A-A'.



ERD-S3R-06-0080B



Legend

Qal	Quaternary alluvial deposit
Qt	Quaternary terrace deposit
Tps	Tertiary Plioscene nonmarine sediments
$Tnsc_2$	Tertiary Neroly Formation, upper siltstones and claystones
$Tnbs_2$	Tertiary Neroly Formation, upper blue sandstone
$Tnsc_1$	Tertiary Neroly Formation, middle siltstone and claystone [$Tnsc_{1c}$ (Upper), $Tnsc_{1b}$ (Middle), $Tnsc_{1a}$ (Lower)]
$Tnbs_1$	Tertiary Neroly Formation, lower blue sandstone
CMB	Claystone marker bed
	Low permeability confining layer
	Ground surface
	Unconformity
	Stratigraphic contact
	Potentiometric surface

Total VOC concentrations (µg/L)

<0.5	5 – 10
0.5 – 2.3	10 – 50
2.3 – 5	>50

(EW)	Extraction well
(GW)	Guard well
(IW)	Injection well
(WS)	Water supply well

W-809-01 Well ID
Location of well or borehole
Ground water elevation
[100] Screened interval
Borehole total depth
TVOC concentration, µg/L
[ND] Non-detected

Figure 8-3. High Explosives Process Area Hydrogeologic Cross-section A-A' (continued).

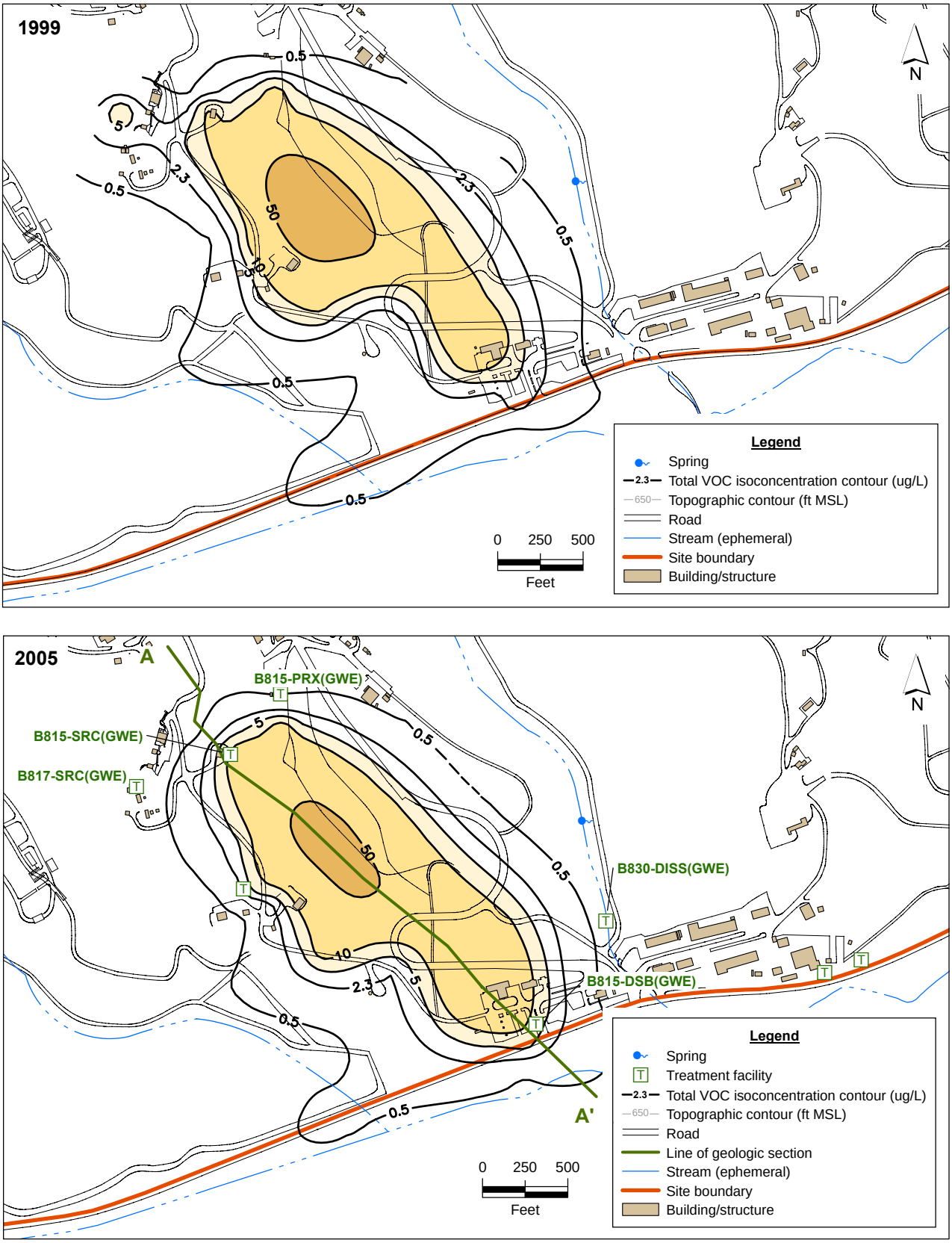


Figure 8-4. Comparison of the distribution of total VOCs in HE Process Area $Tnbs_2$ HSU in 1999 and 1st Semester 2005.

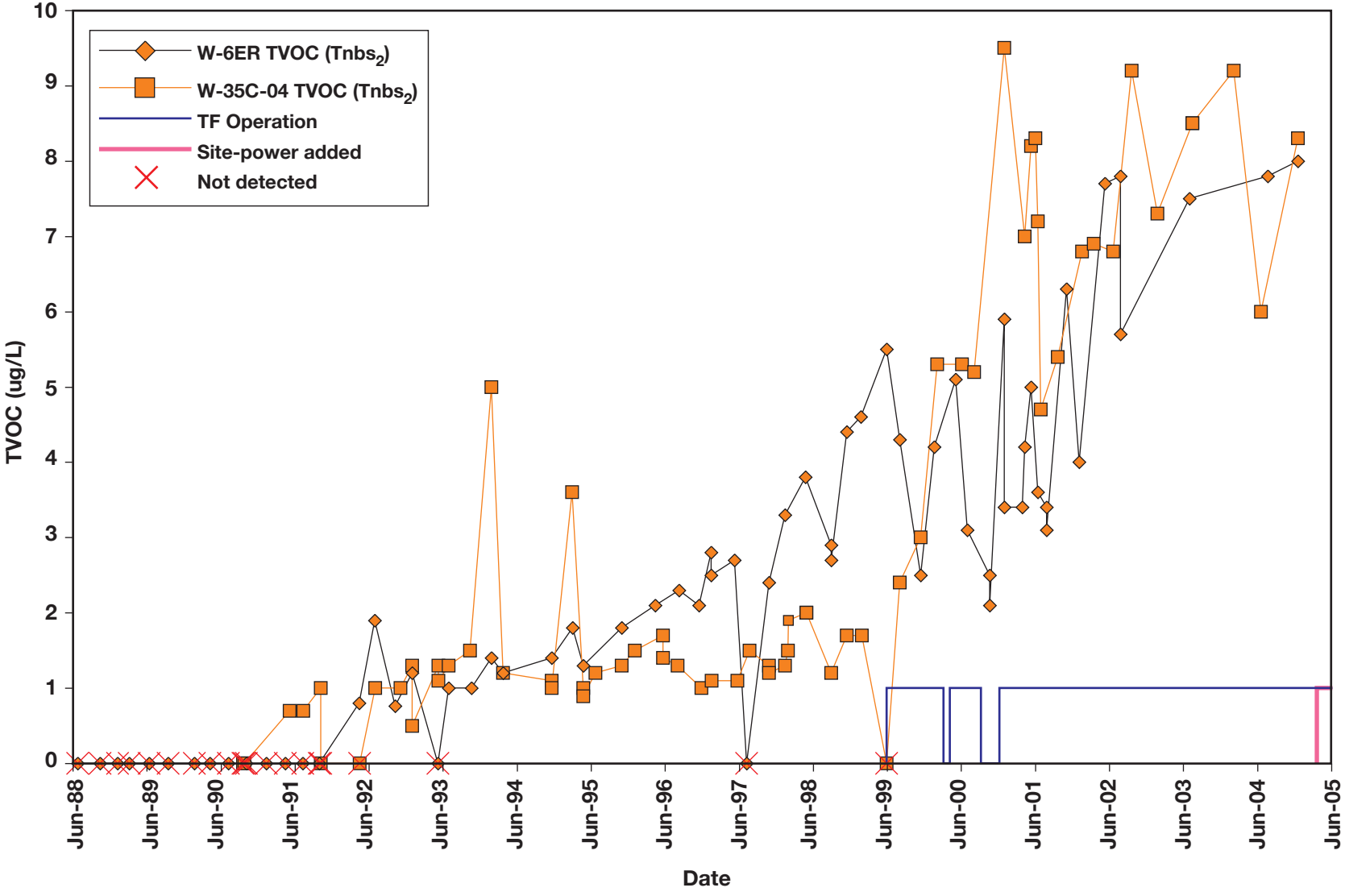
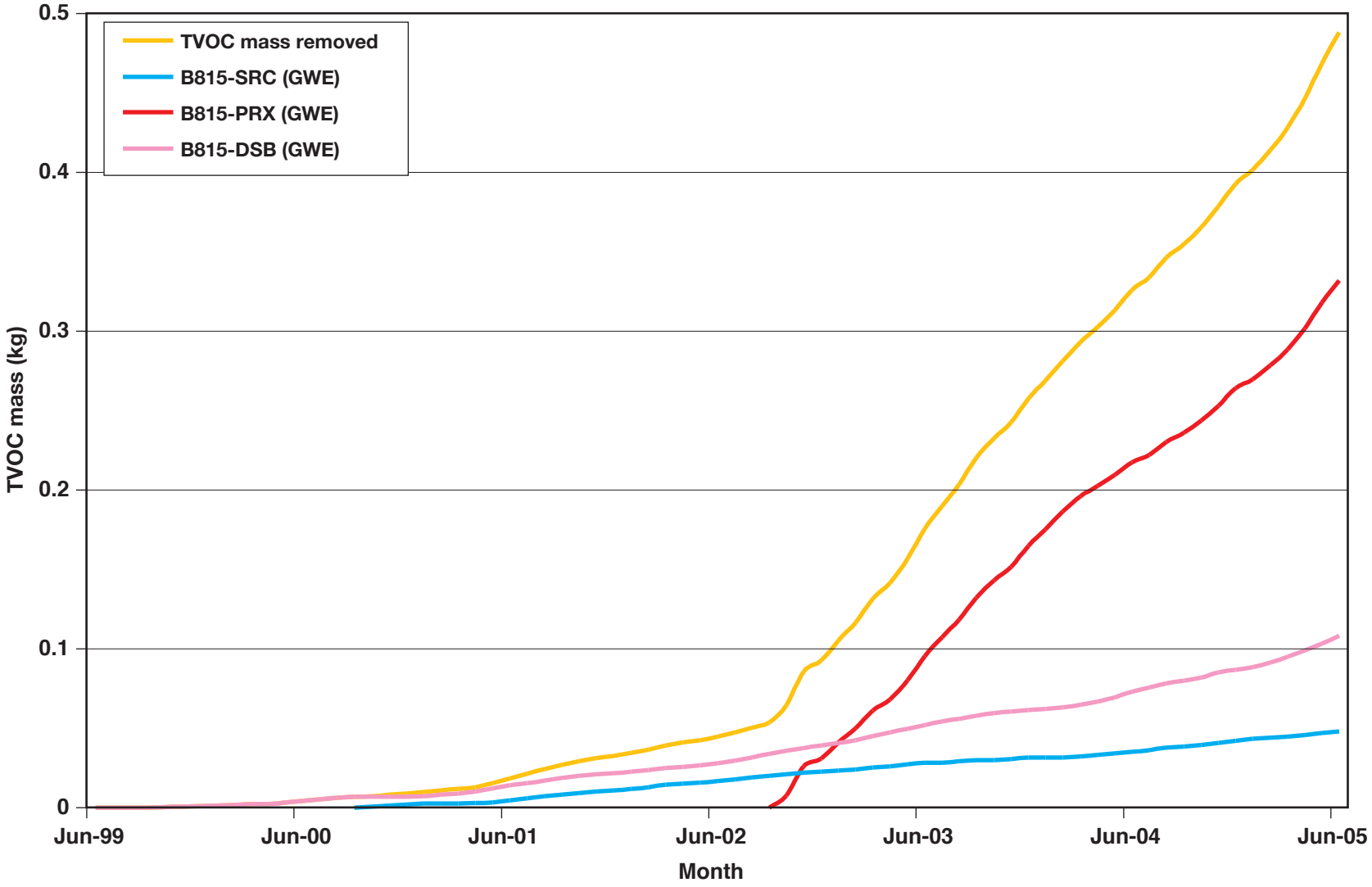


Figure 8-5. Time-series plots of total VOCs in ground water at the Building 815-DSB Area.



ERD-S3R-05-0172

Figure 8-6. Time-series plots of cumulative mass of total VOCs removed by ground water extraction (GWE) from the HE Process Area ground water.

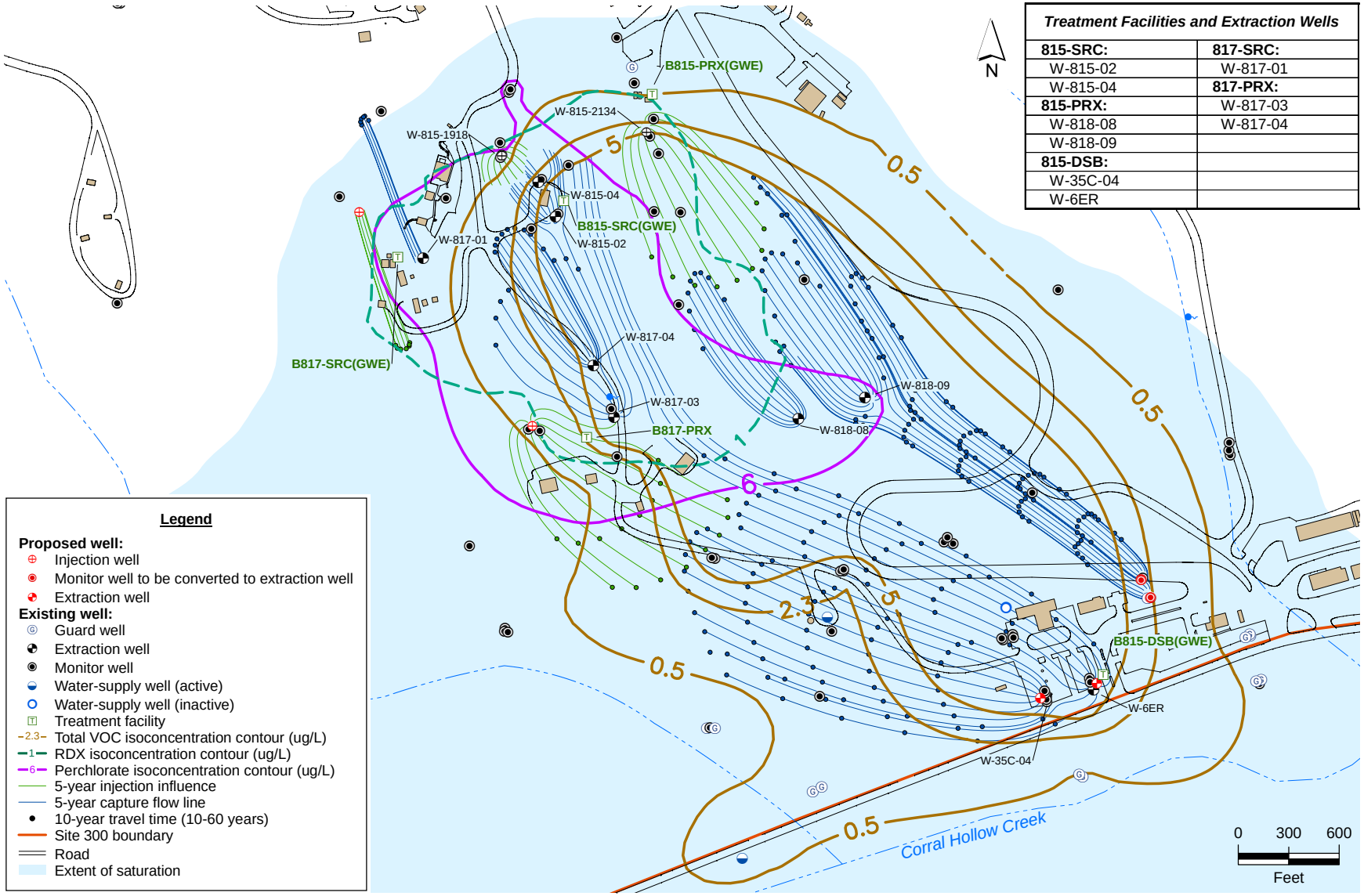
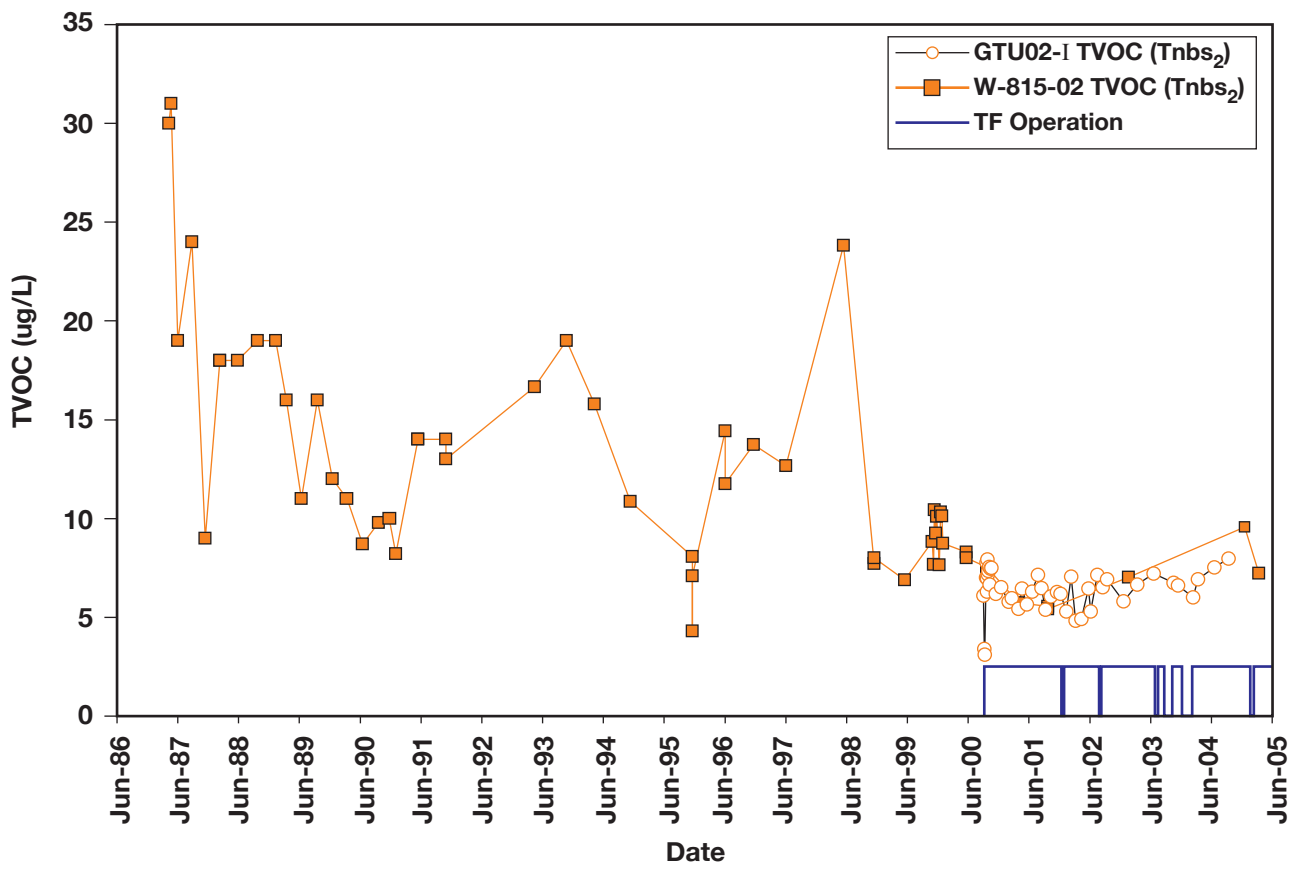
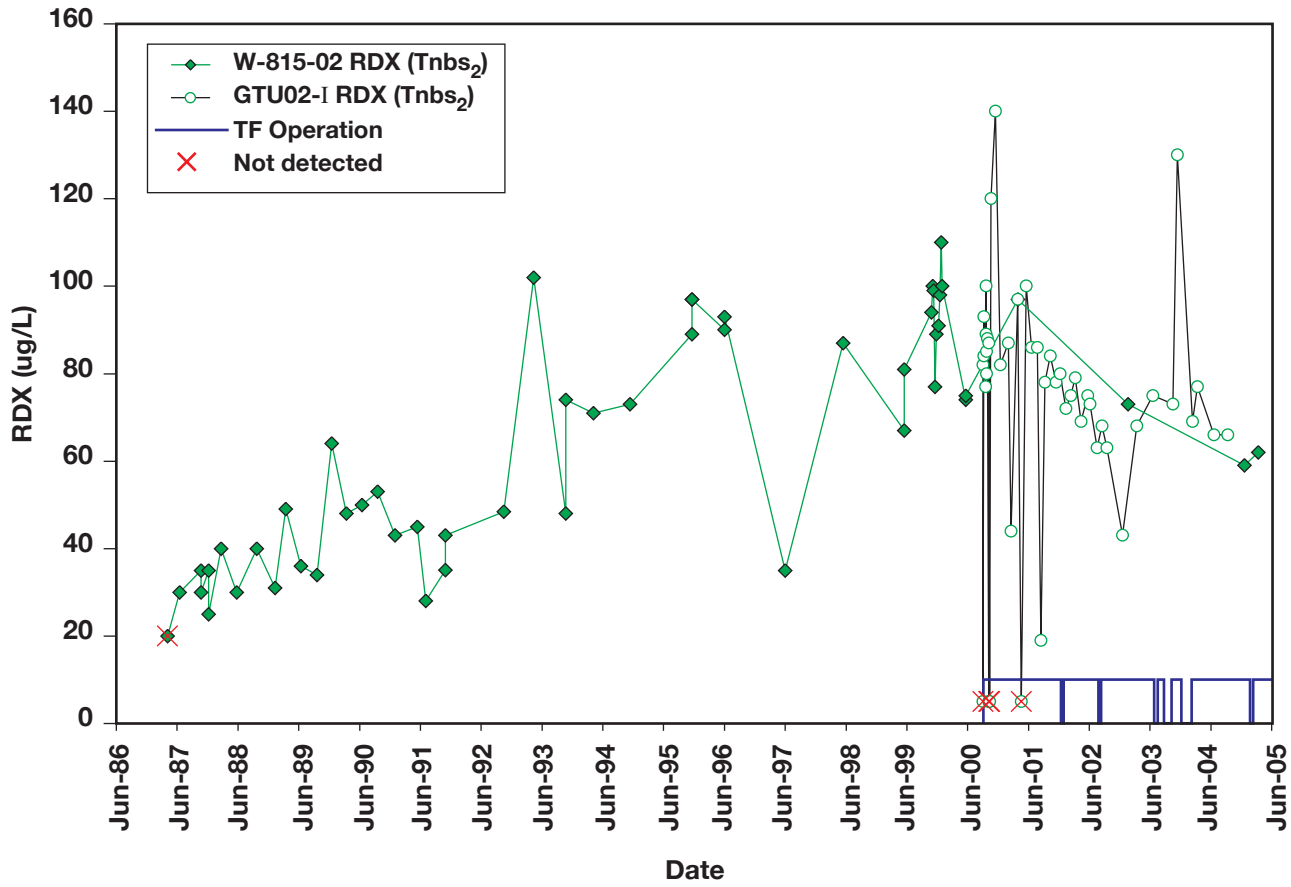


Figure 8-7. Capture zone analysis results for the design remedial extraction wellfield at the HE Process Area OU.

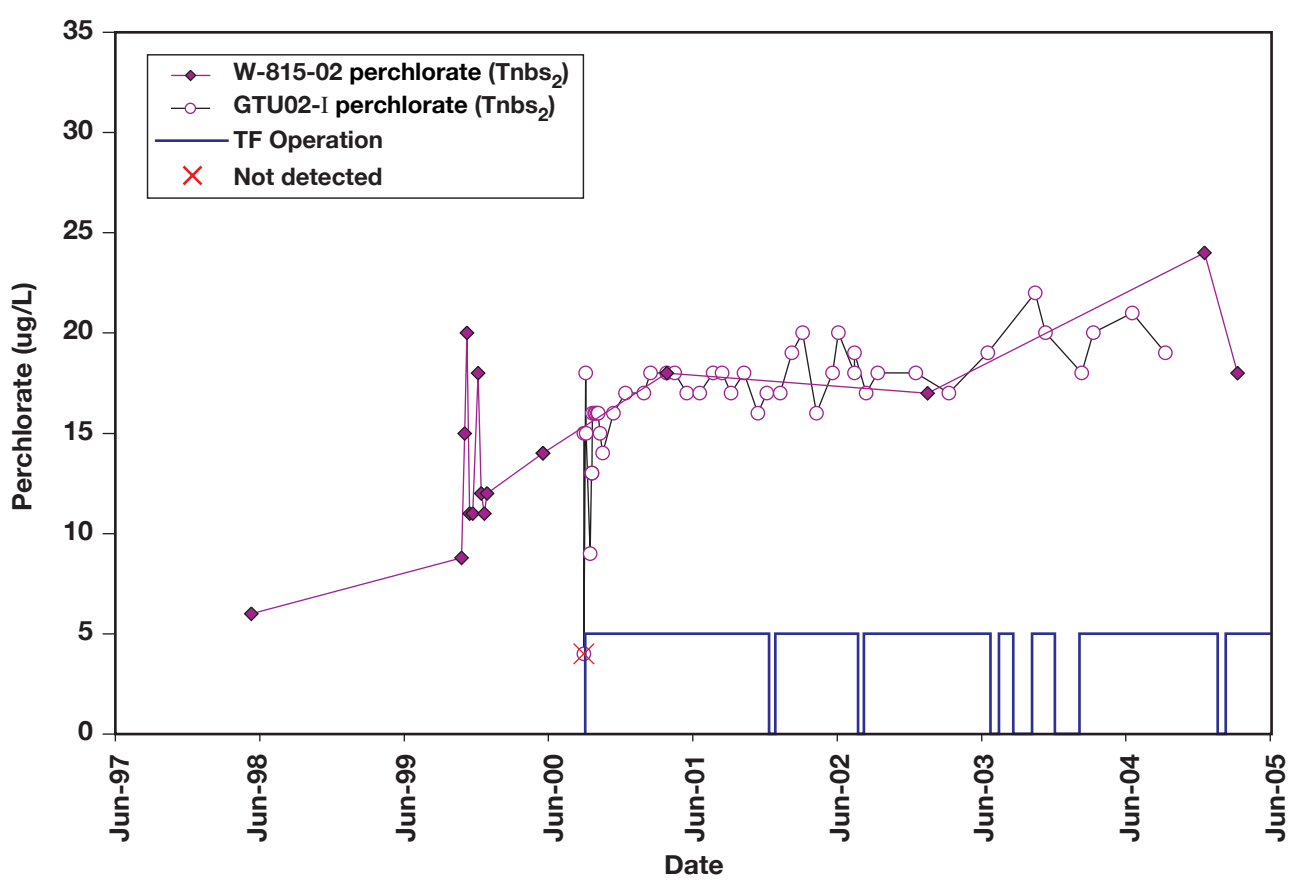
a)



b)

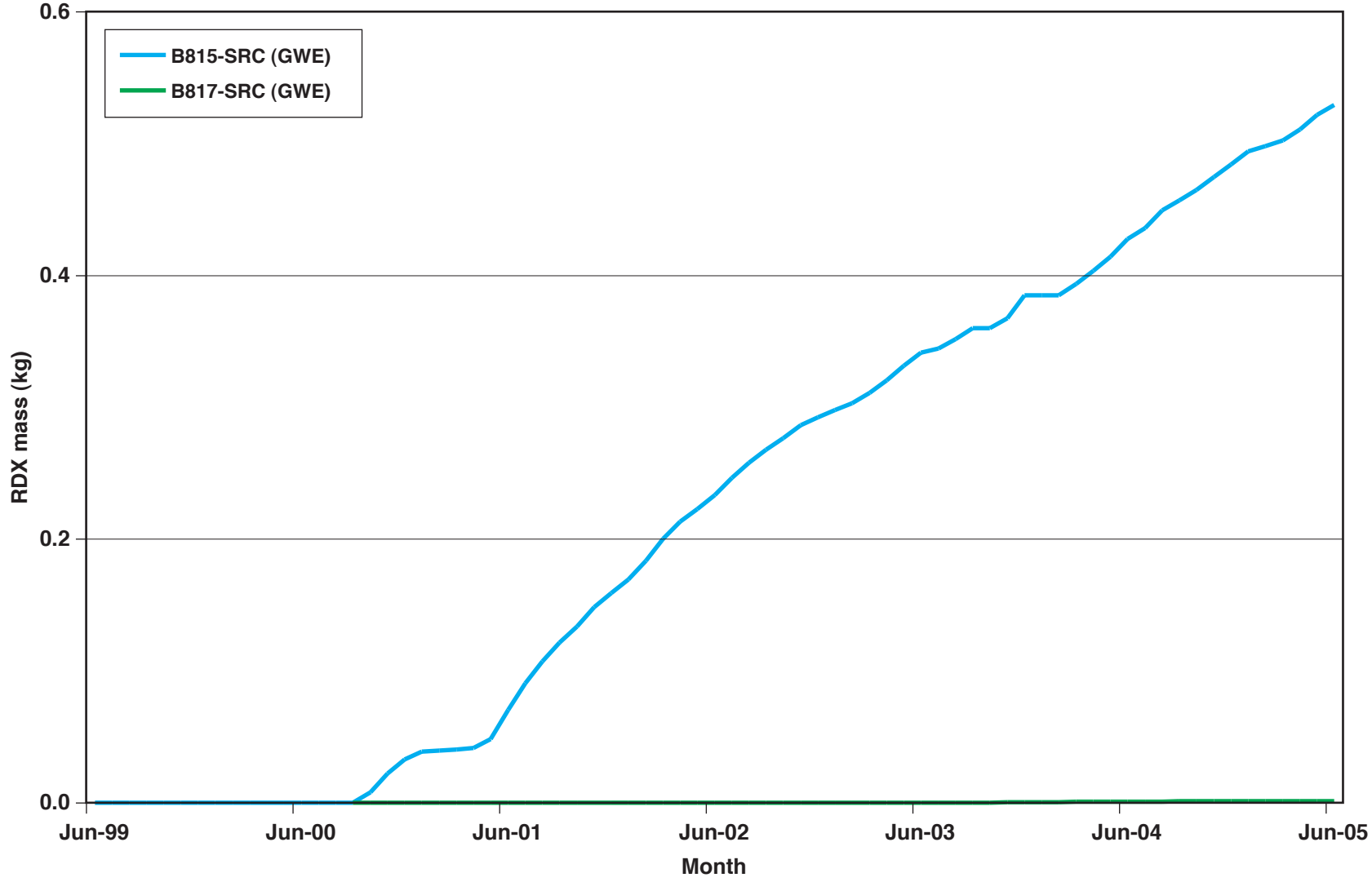


c)



ERD-S3R-05-0144

Figure 8-8. Time-series plots of a) total VOCs, b) RDX, and c) perchlorate in ground water at the Building 815-SRC Area.



ERD-S3R-05-0173

Figure 8-9. Time-series plots of cumulative mass of RDX removed by ground water extraction (GWE) from the HE Process Area ground water.

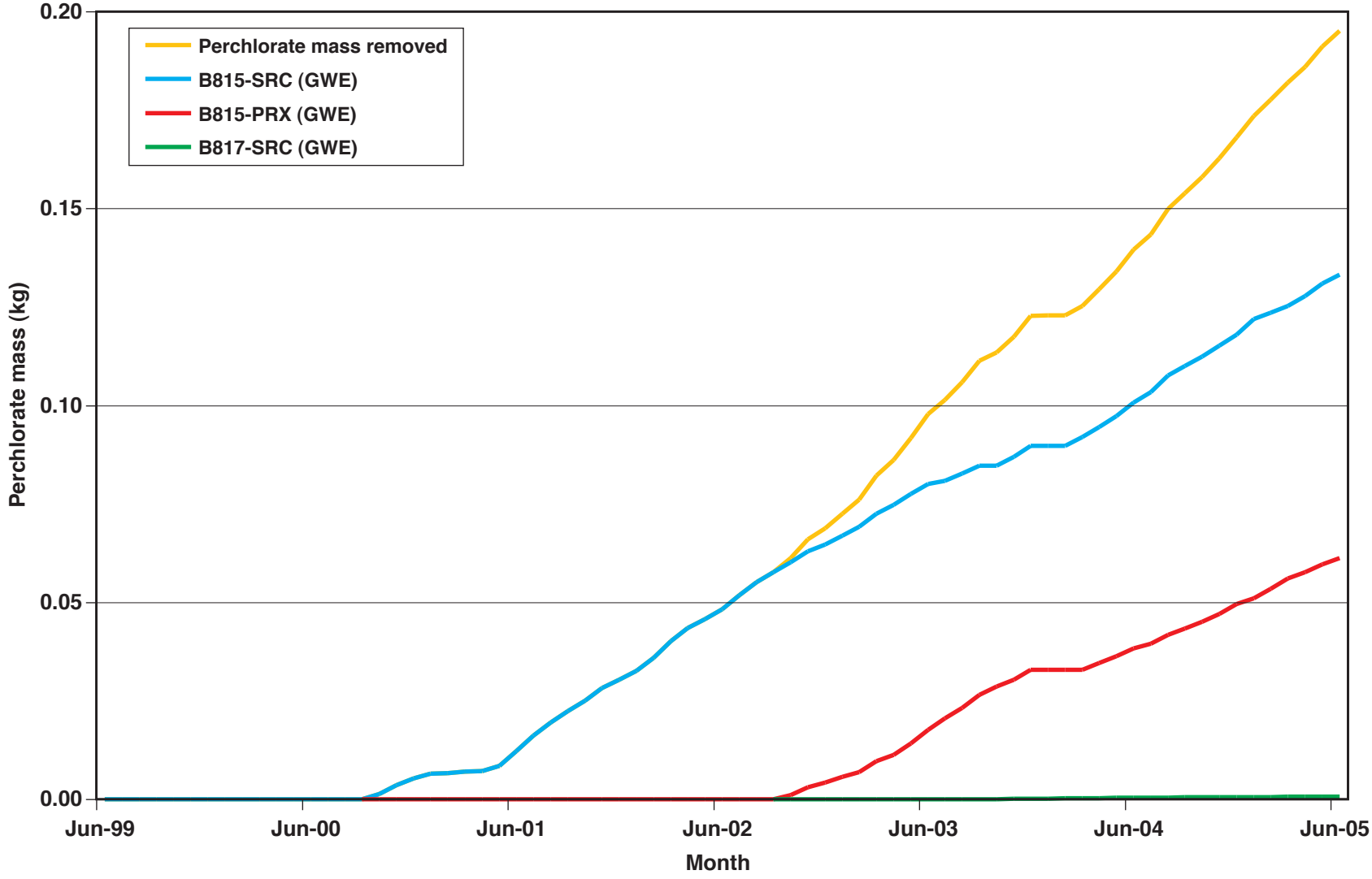
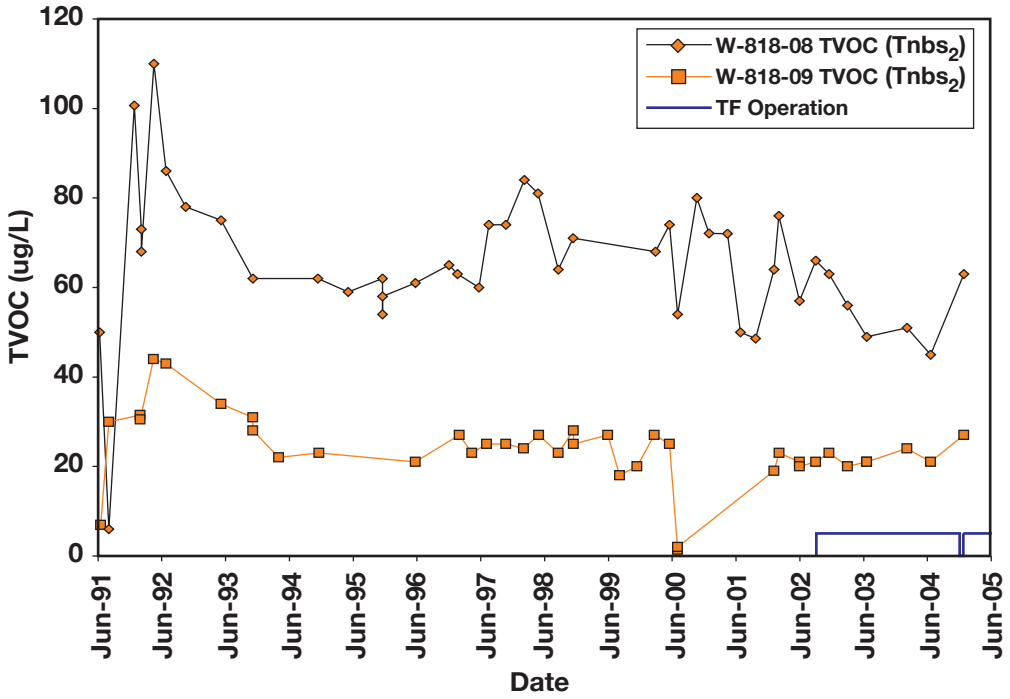
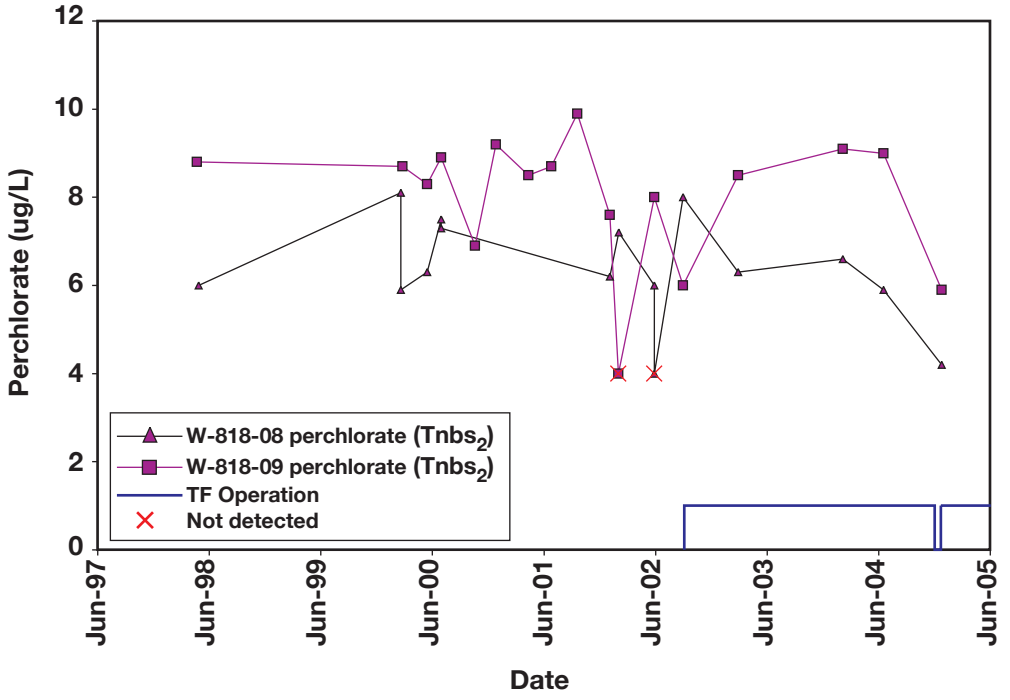


Figure 8-10. Time-series plots of cumulative mass of perchlorate removed by ground water extraction (GWE) from the HE Process Area ground water.

a)



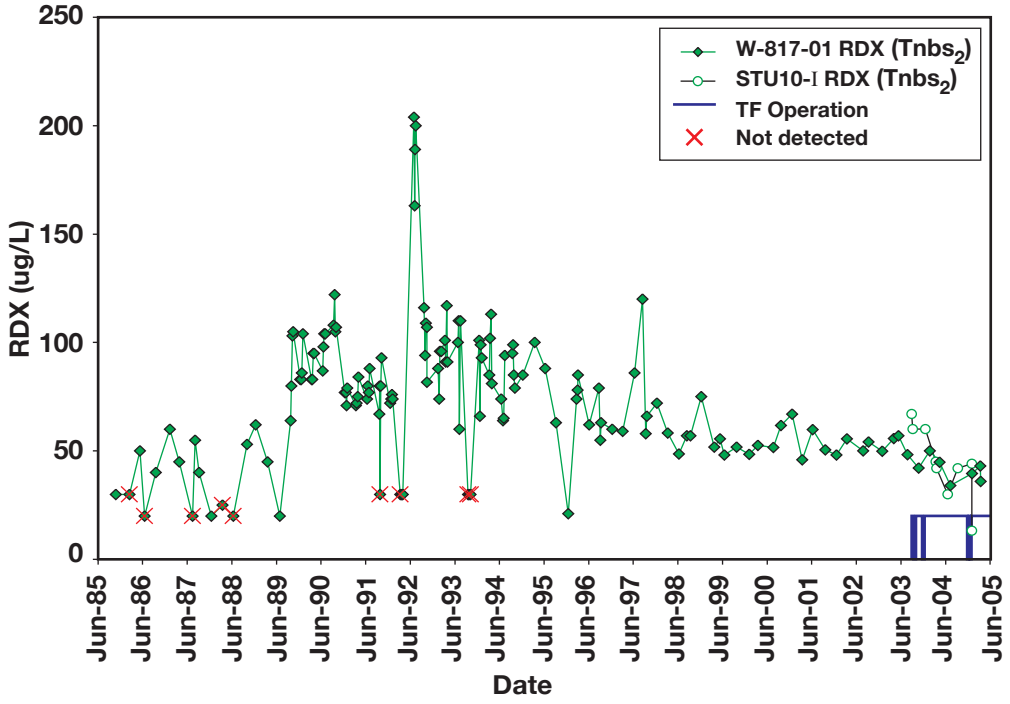
b)



ERD-S3R-05-0147

Figure 8-11. Time-series plots of a) total VOCs, and b) perchlorate in ground water at the Building 815-PRX Area.

a)



b)

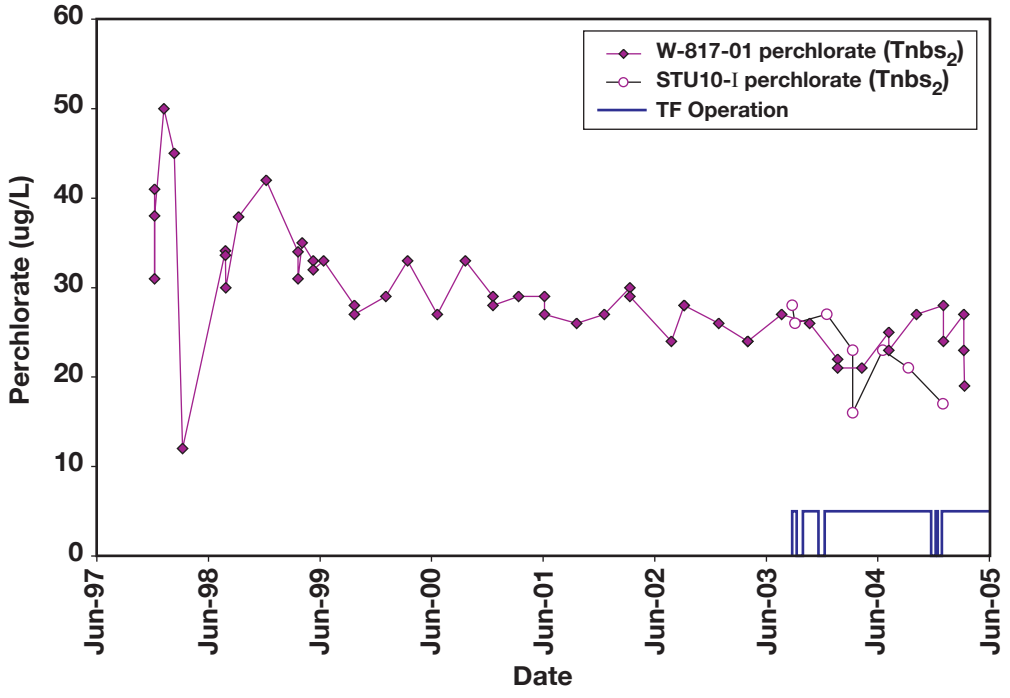


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Figure 8-12. Time-series plots of a) RDX, and b) perchlorate in ground water at the Building 817-SRC Area.

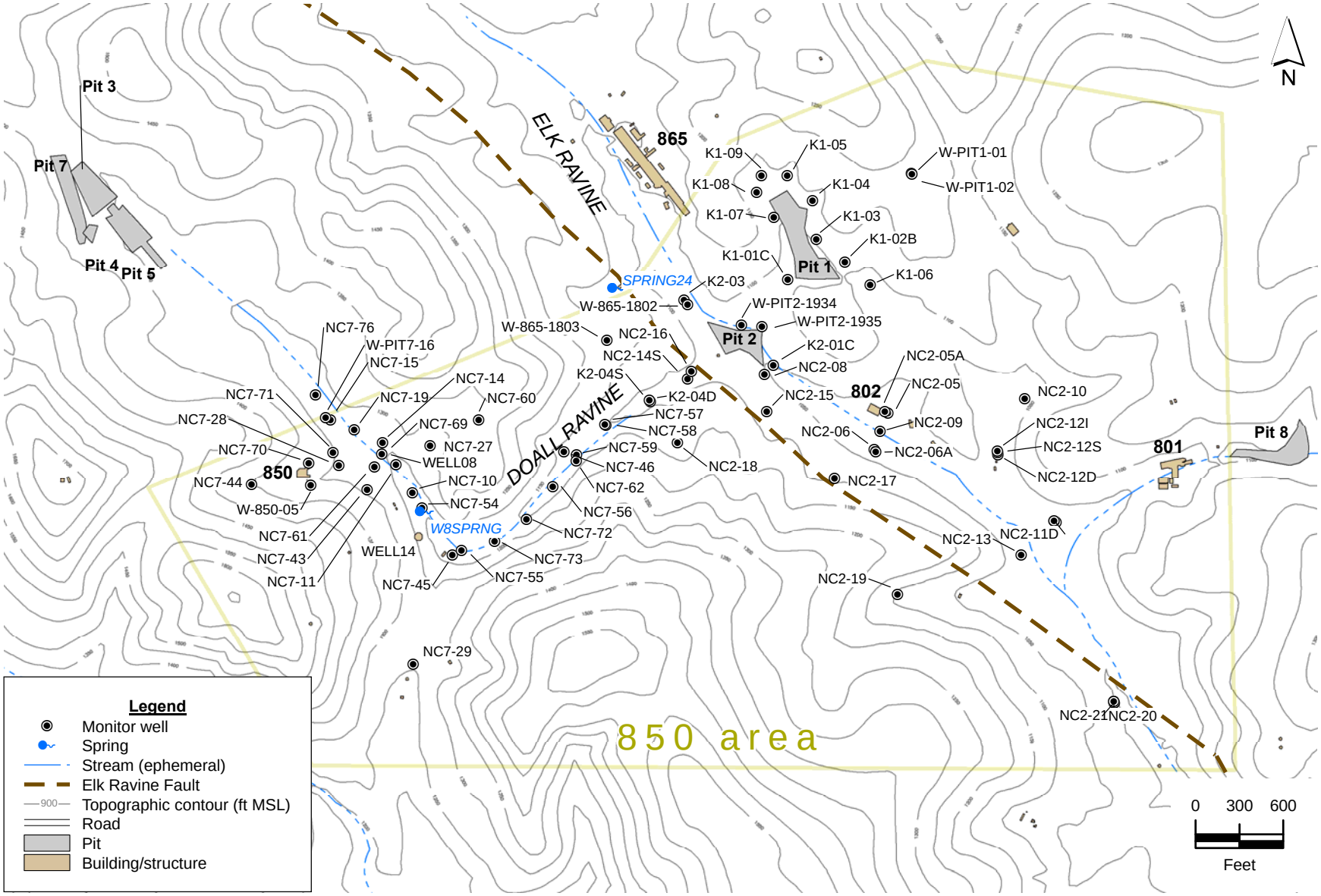


Figure 9-1. Building 850 area site map showing buildings, monitor wells and springs.

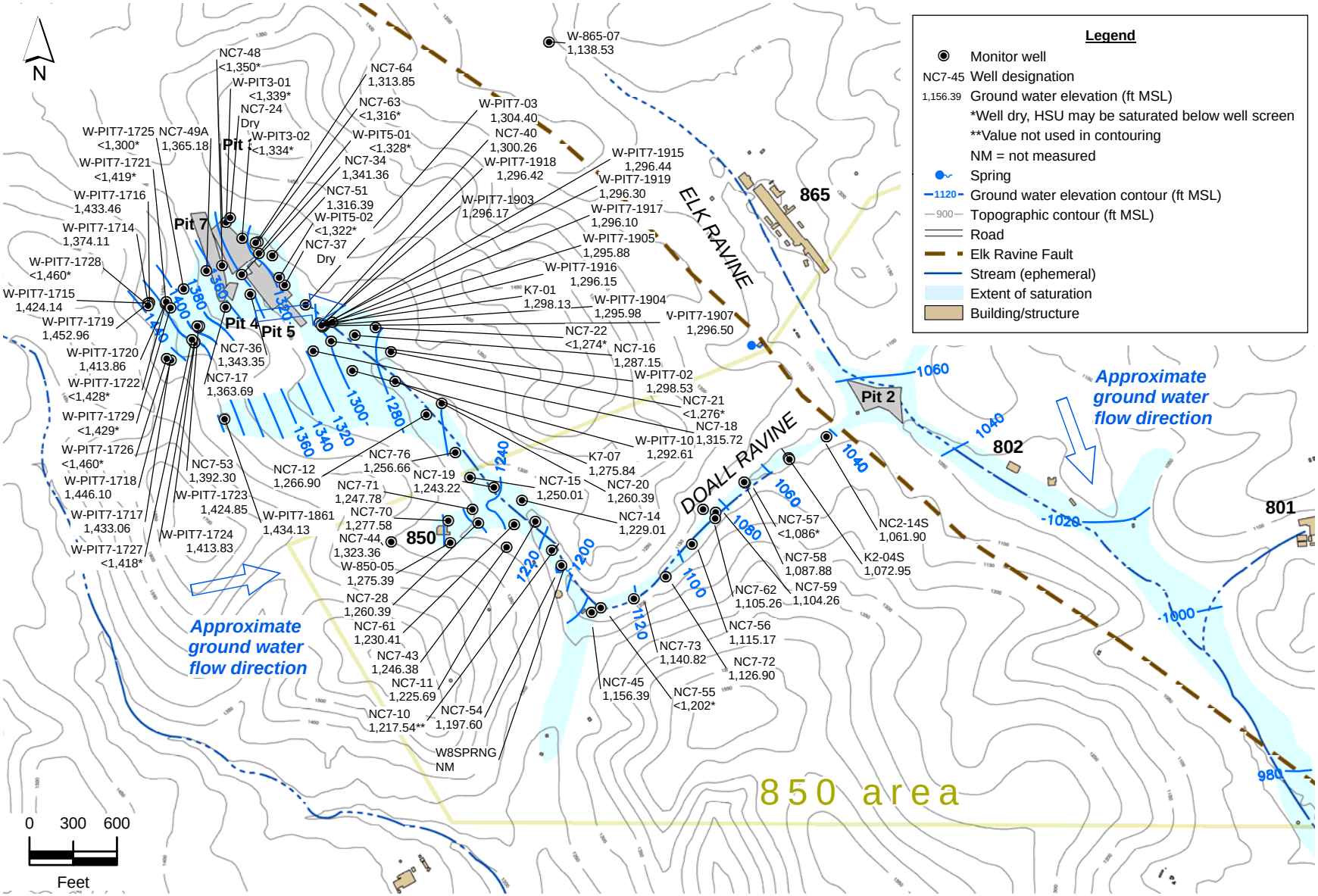


Figure 9-2. Building 850 area potentiometric surface and ground water flow direction in the Qal/WBR HSU (1st Semester 2005).

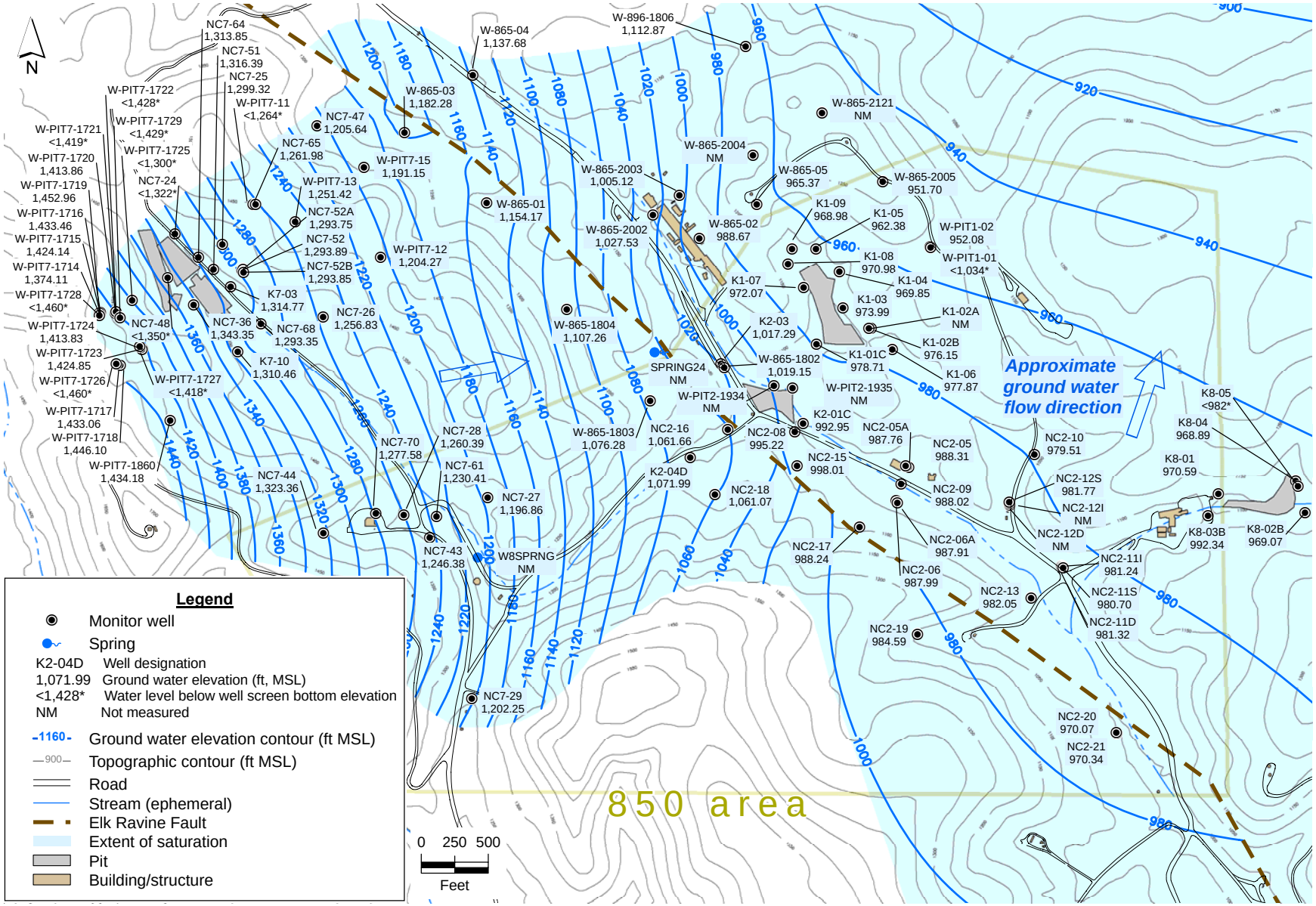


Figure 9-3. Building 850 area potentiometric surface and ground water flow direction in the $Tnbs_1/Tnbs_0$ HSU (1st Semester 2005).

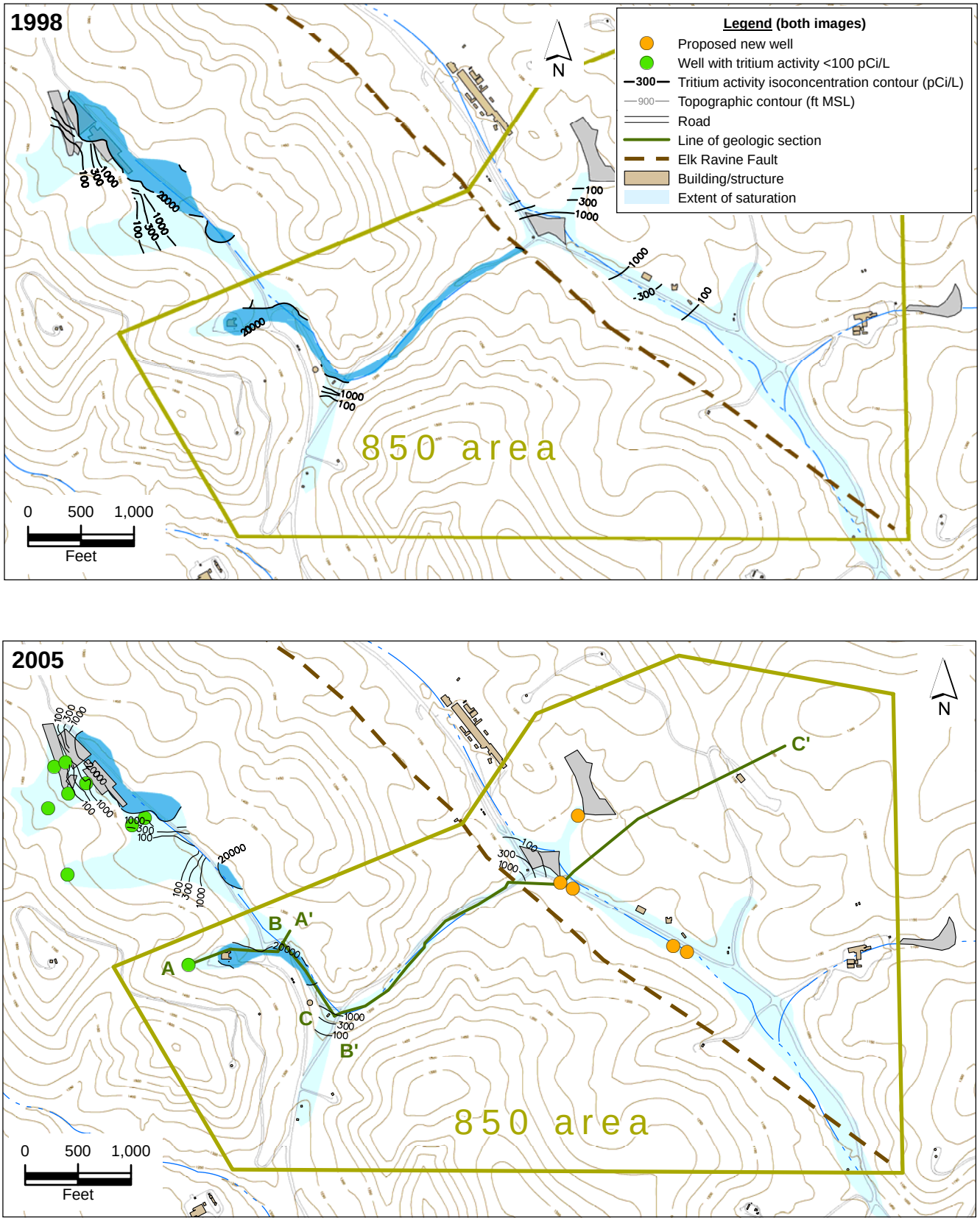


Figure 9-4. Comparison of the distribution of tritium in Building 850 area ground water in the Qal/WBR HSU in 1998 and 1st Semester 2005.

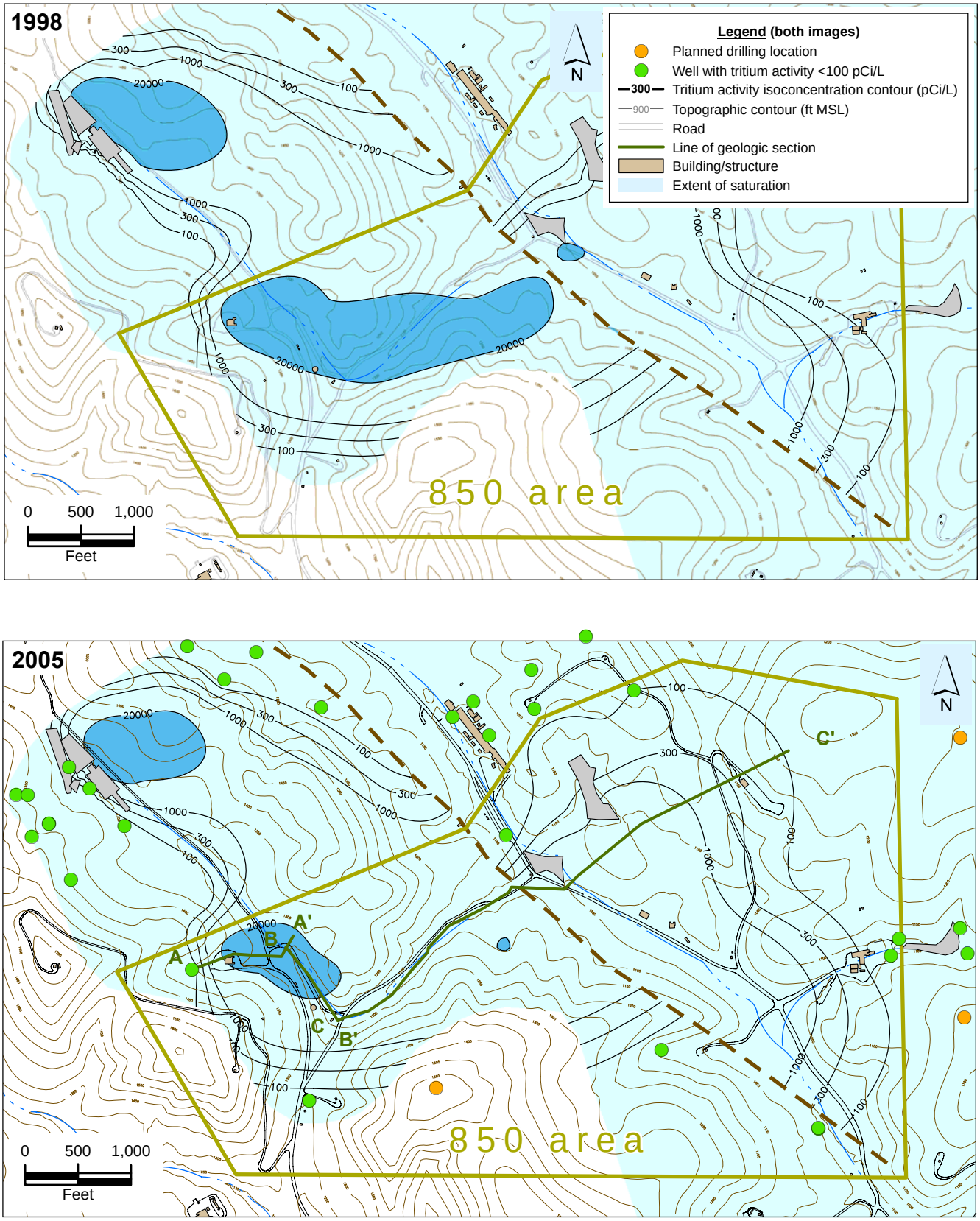
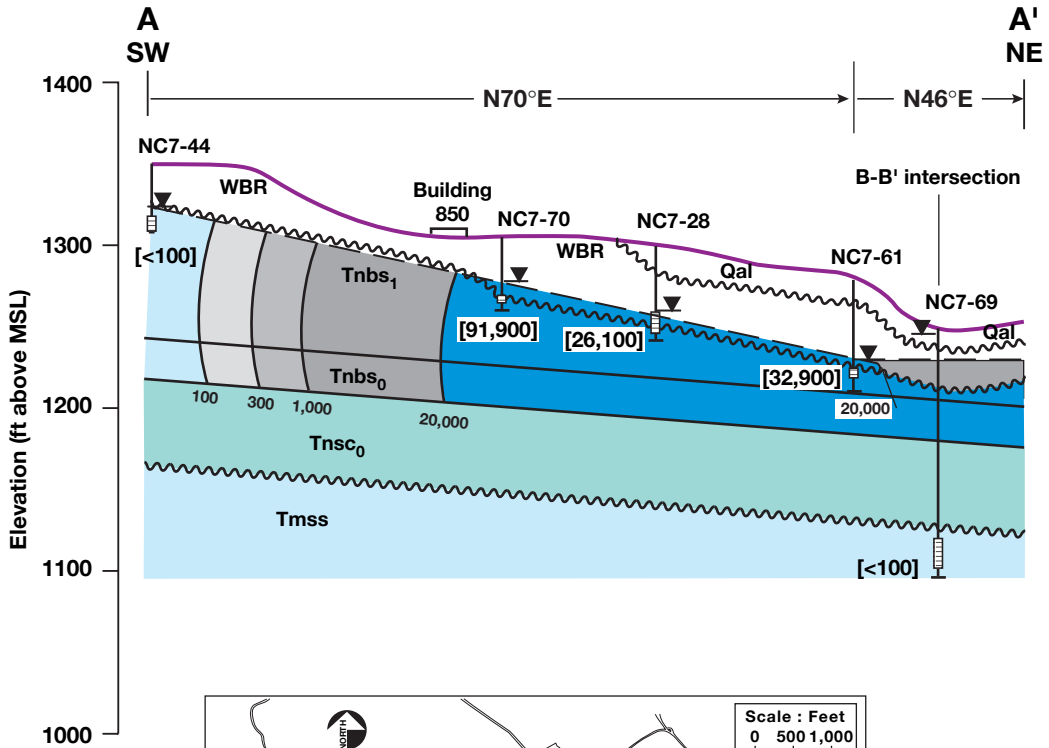
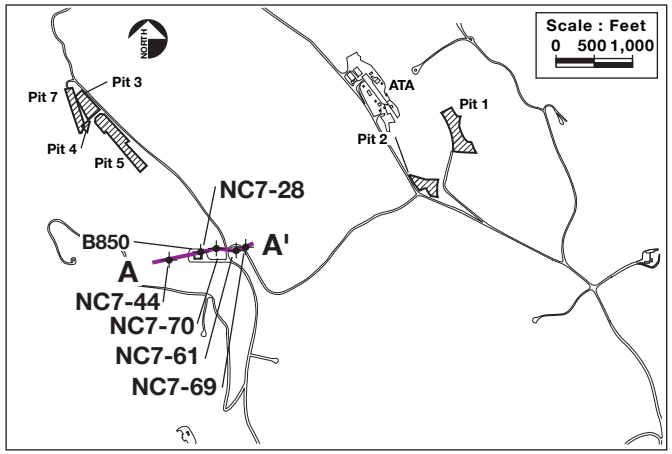
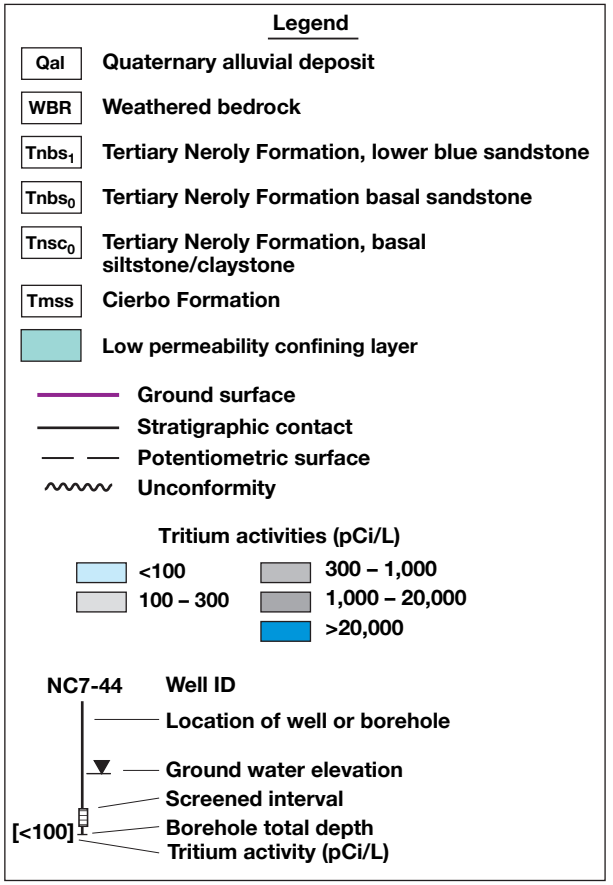
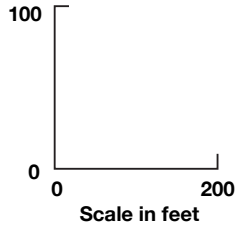


Figure 9-5. Comparison of the distribution of tritium in Building 850 area ground water in the $Tnbs_1/Tnbs_0$ HSU in 1998 and 1st Semester 2005.



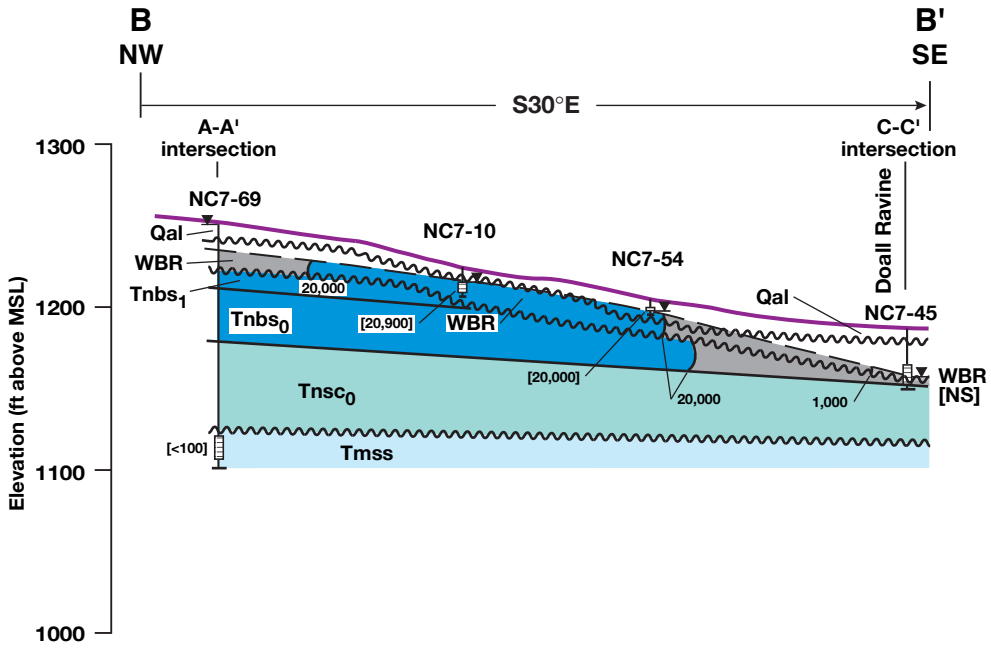


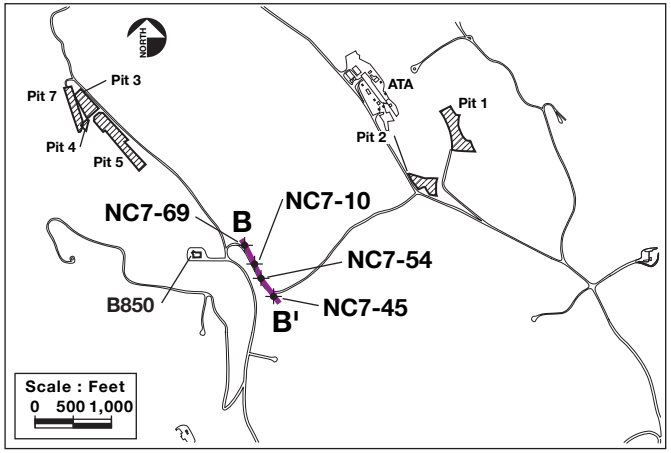


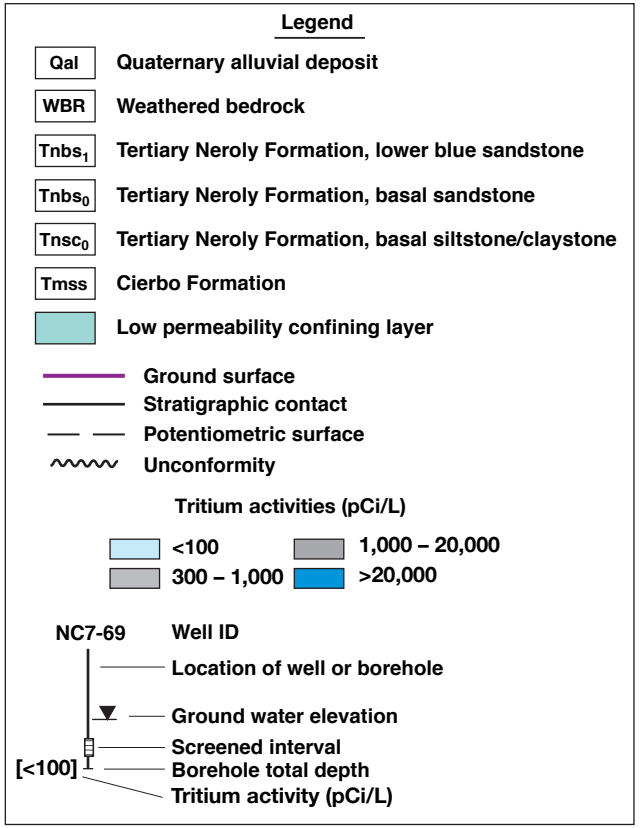


ERD-S3R-06-0081

Figure 9-6. Building 850 Firing Table Hydrogeologic Cross-section A-A'.







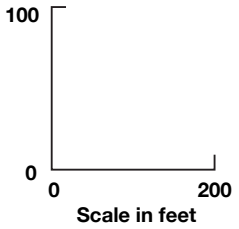


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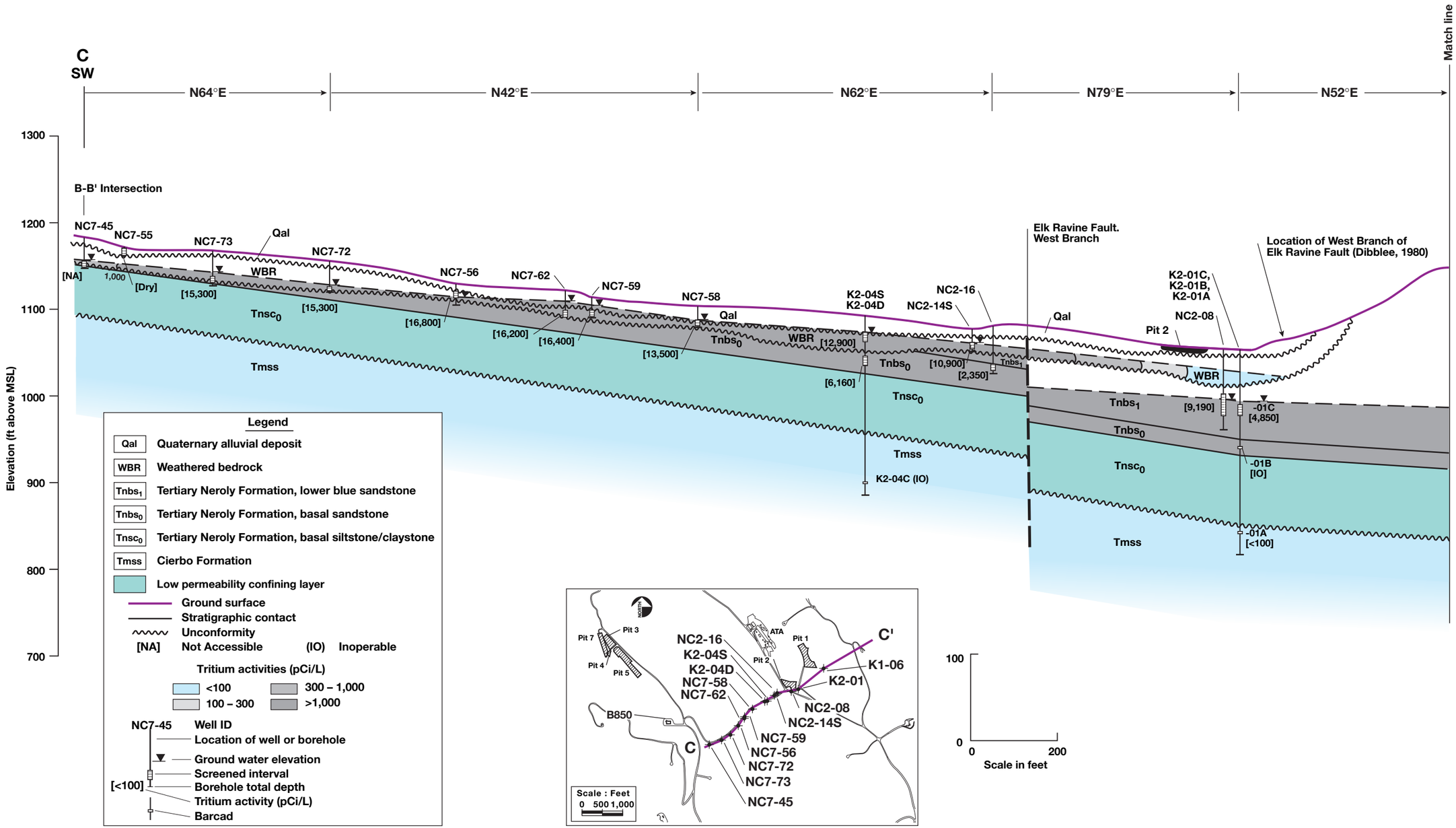
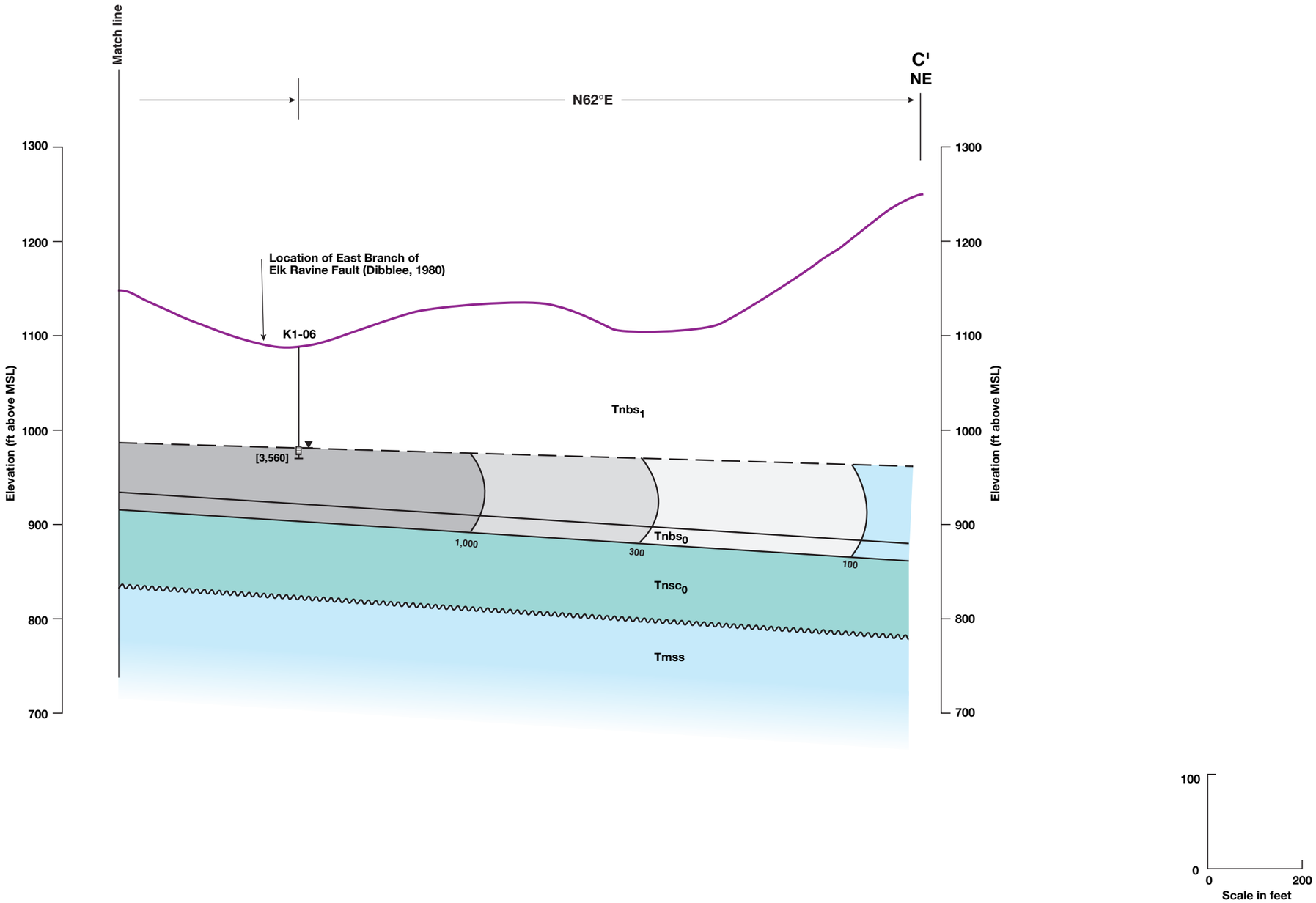
Figure 9-7. Building 850 Firing Table Hydrogeologic Cross-section B-B'.



ERD-S3R-06-0083A

Figure 9-8. Building 850 Firing Table Hydrogeologic Cross-section C-C'.



ERD-S3R-06-0083B

Figure 9-8. Building 850 Firing Table Hydrogeologic Cross-section C-C' (continued).

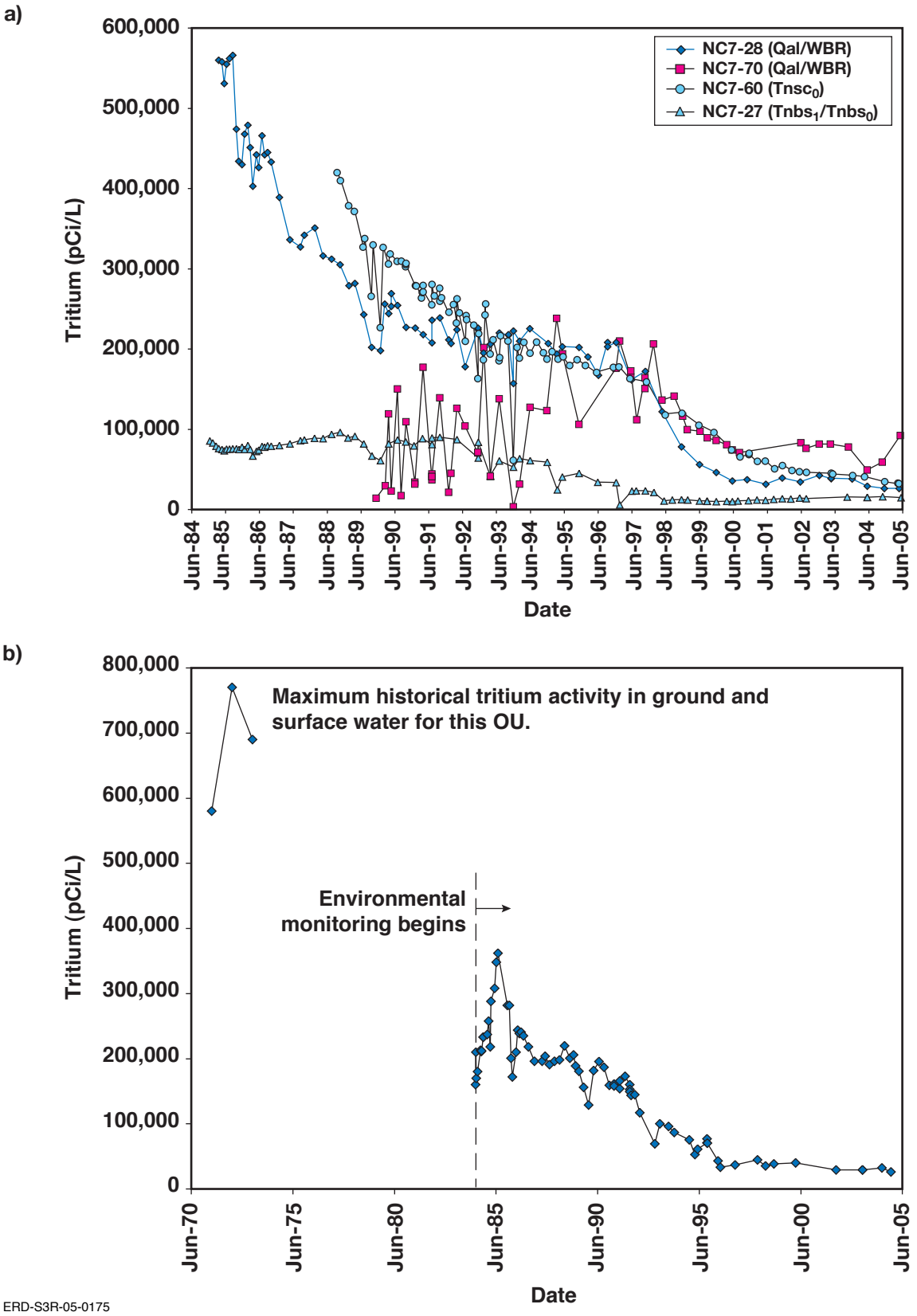
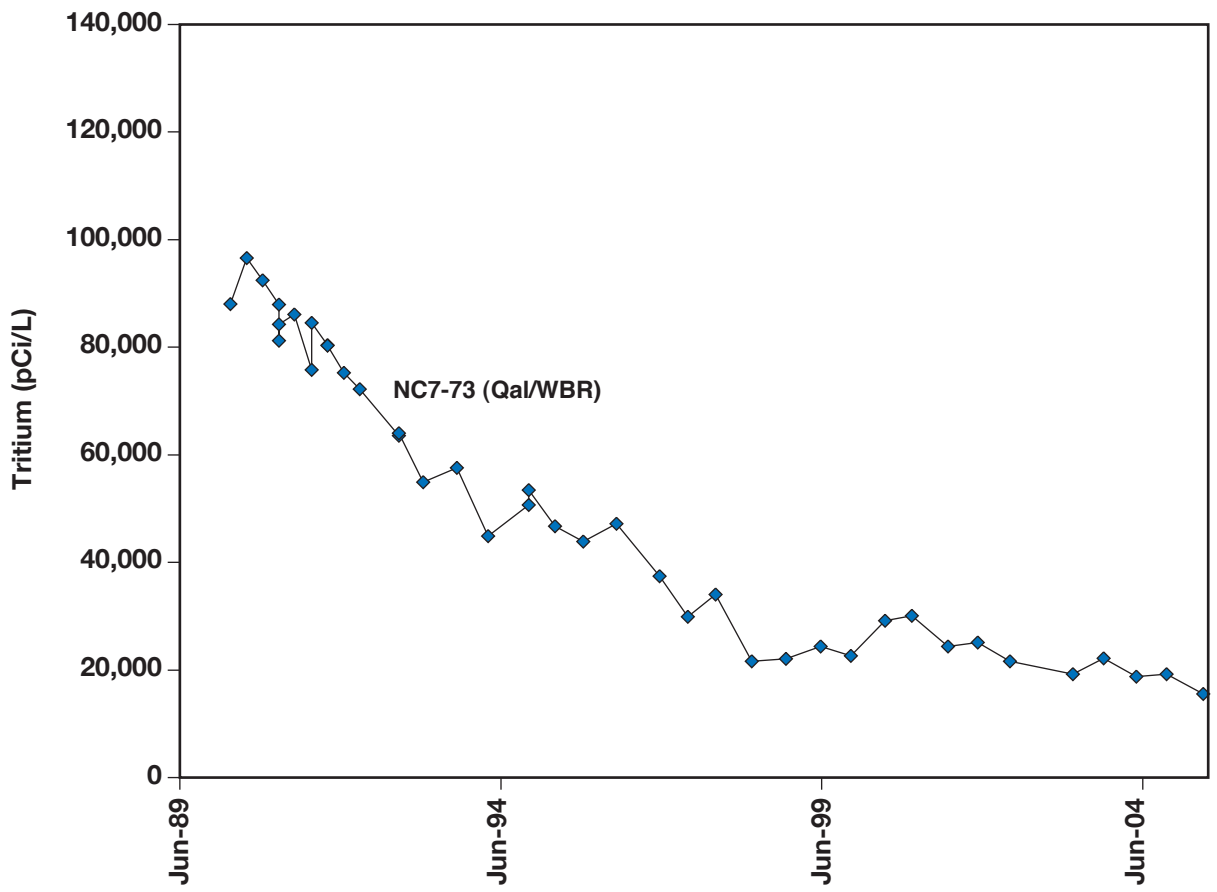
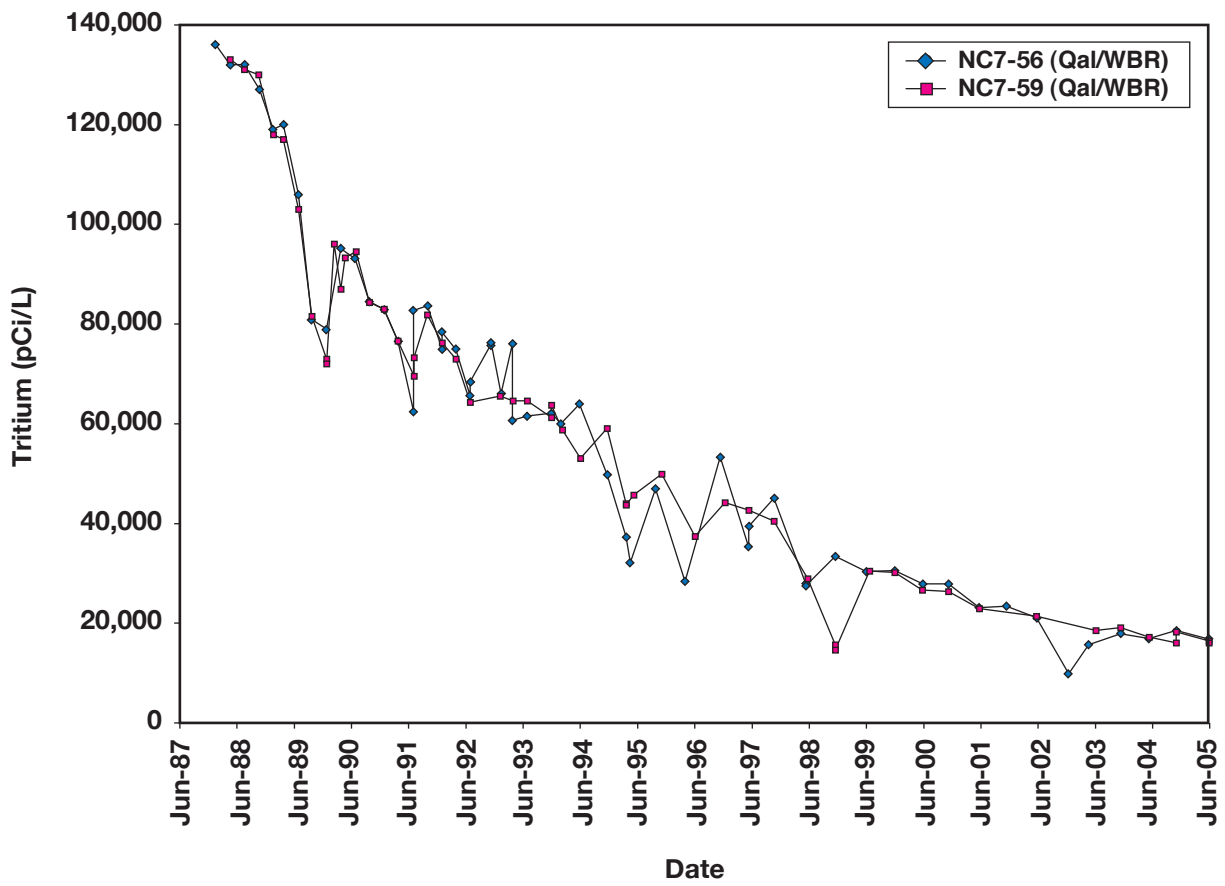


Figure 9-9. Time-series plots of tritium activity in a) ground water at the Building 850 Source Area, and b) ground and surface water at the Upper Doall Ravine Area (Well 8 Spring).

a)



b)



c)

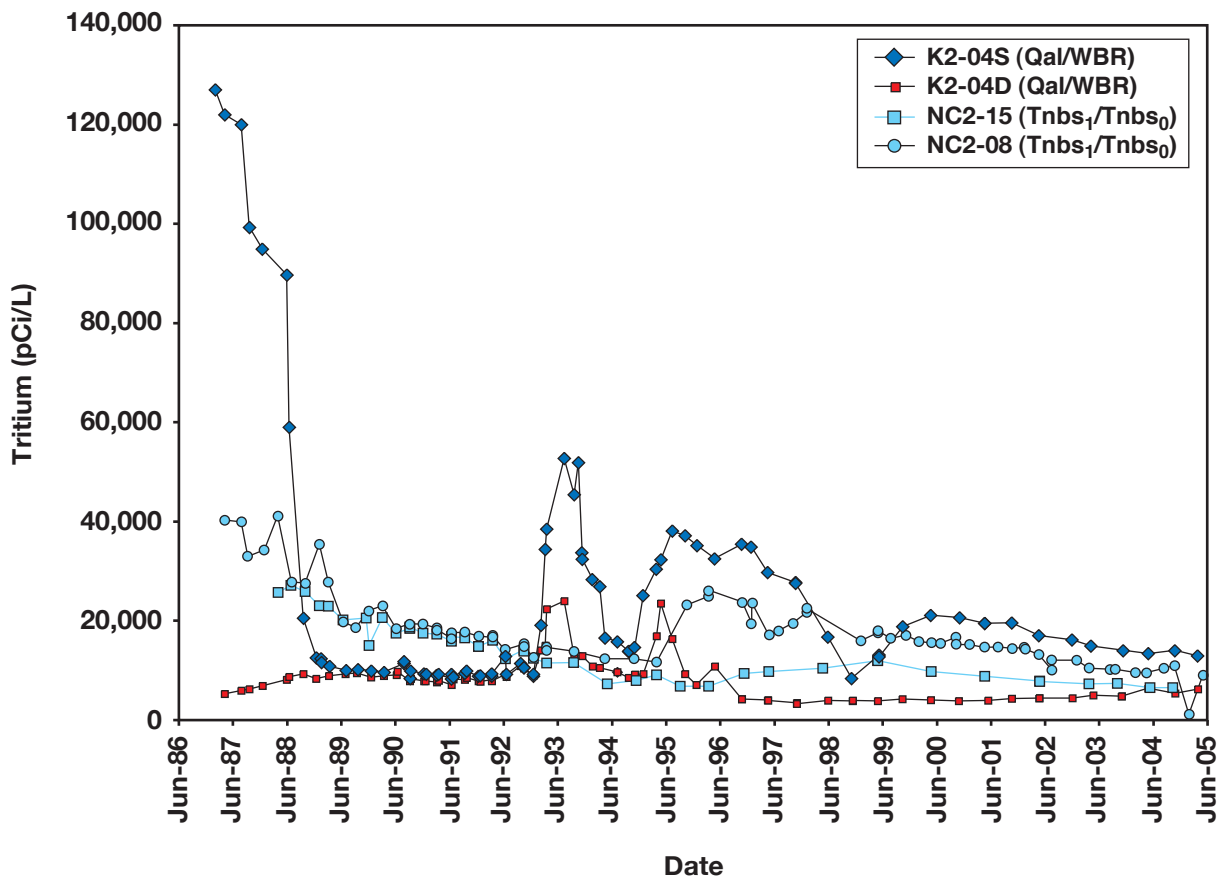


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Figure 9-10. Time-series plots of tritium activity in ground water for the Building 850 a) Upper-, b) Mid-, and c) Lower-Doall Ravine Area.

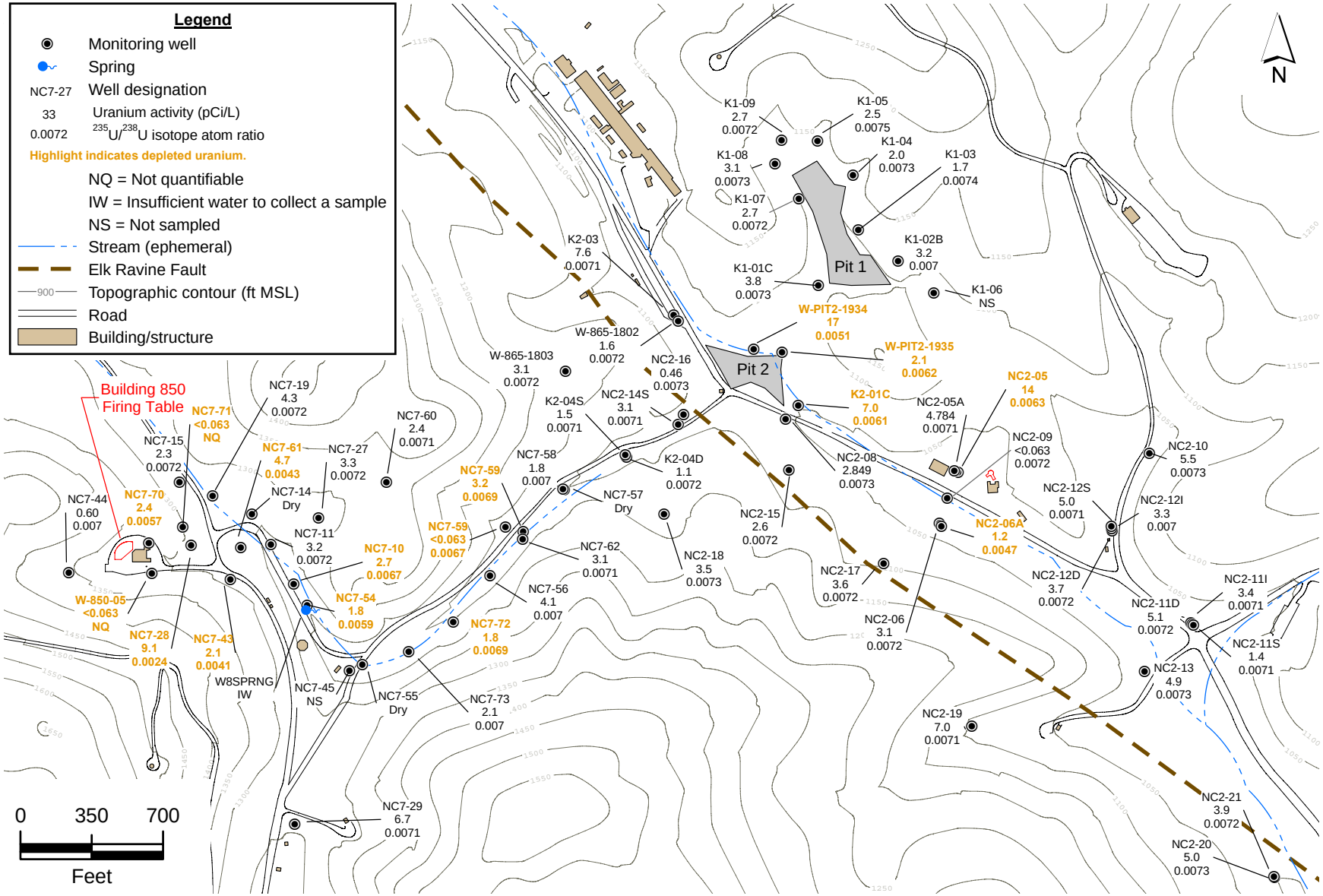


Figure 9-11. Building 850 area map showing total uranium activity and $^{235}U/^{238}U$ atom ratios for the combined Qal/WBR and $Tnbs_1$ HSUs (2004).

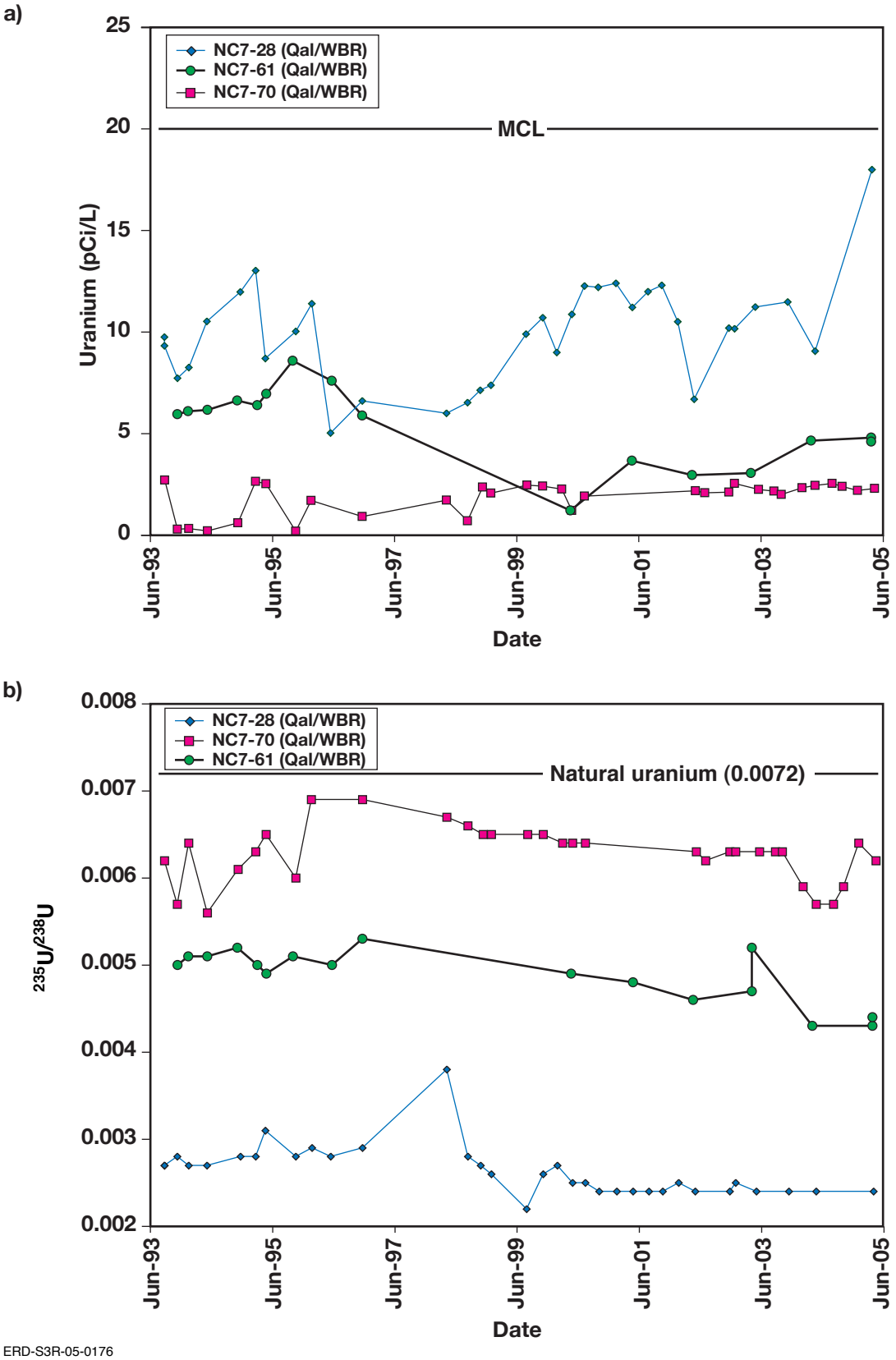


Figure 9-12. Time-series plots of a) total uranium activity and b) $^{235}U/^{238}U$ atom ratio in ground water at the Building 850 Source Area.

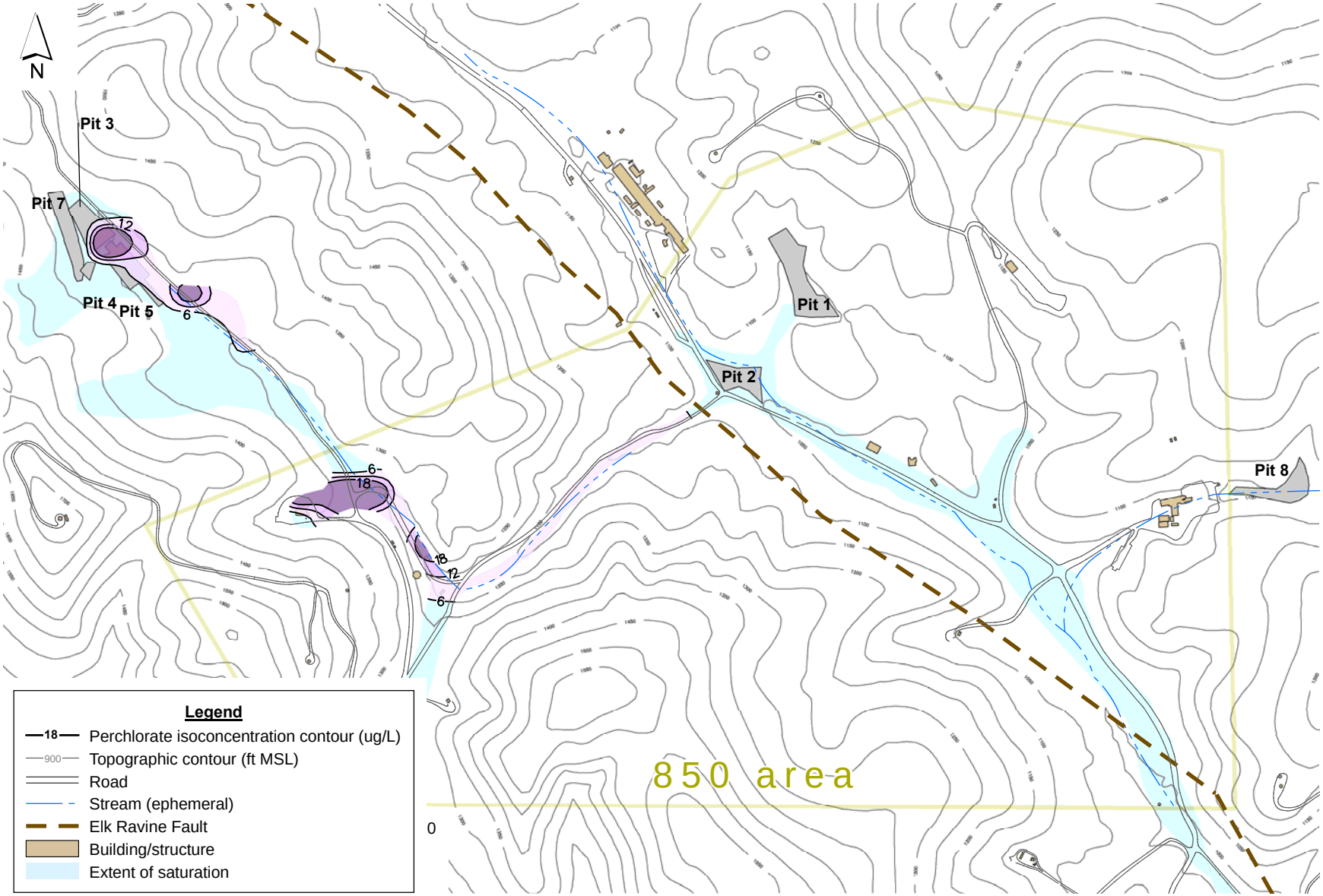


Figure 9-13. Building 850 area perchlorate isoconcentration contour map for the Qal/WBR HSU (1st Semester 2005).

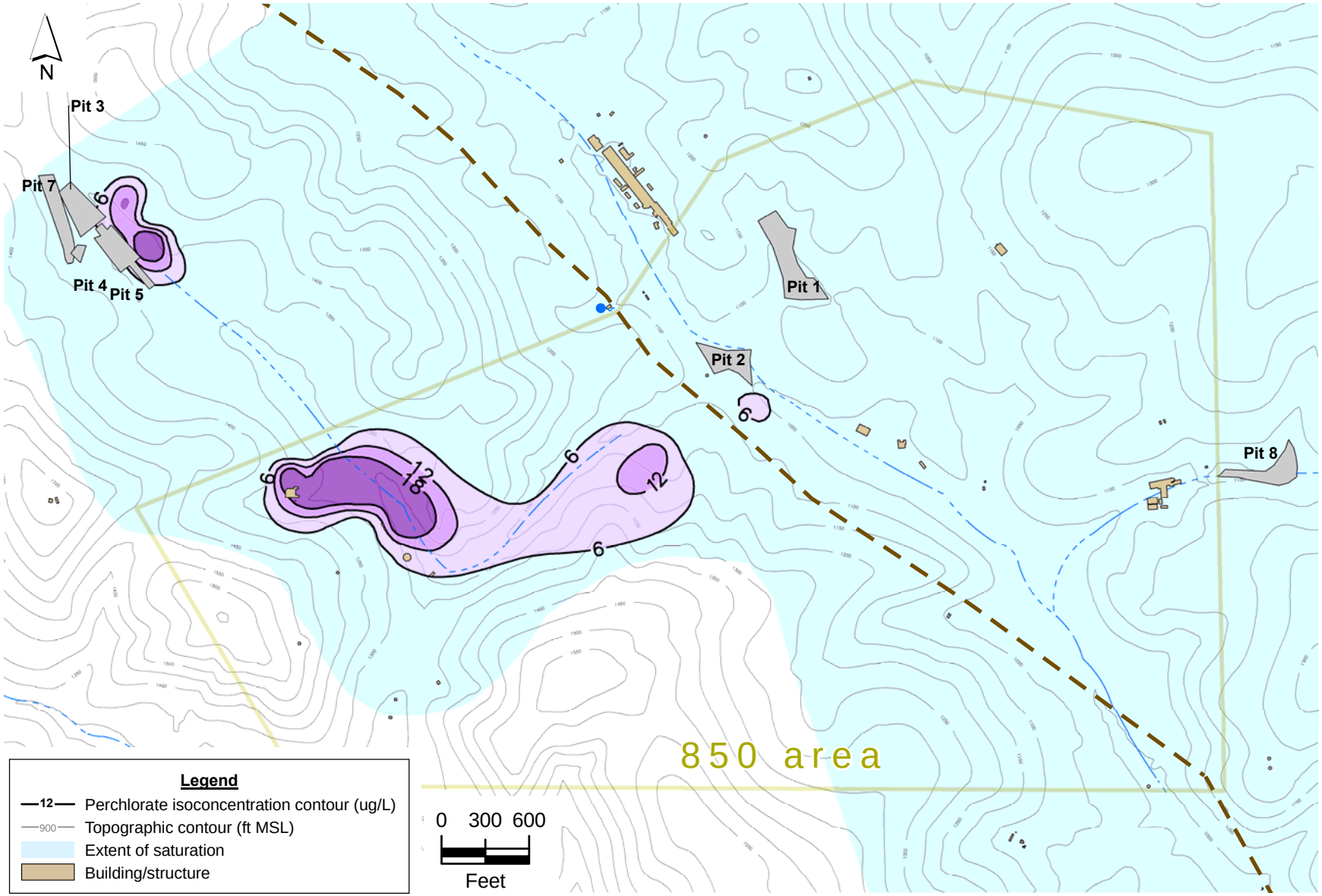


Figure 9-14. Building 850 area perchlorate isoconcentration contour map for the $Tnbs_1/Tnbs_0$ HSU (1st Semester 2005).

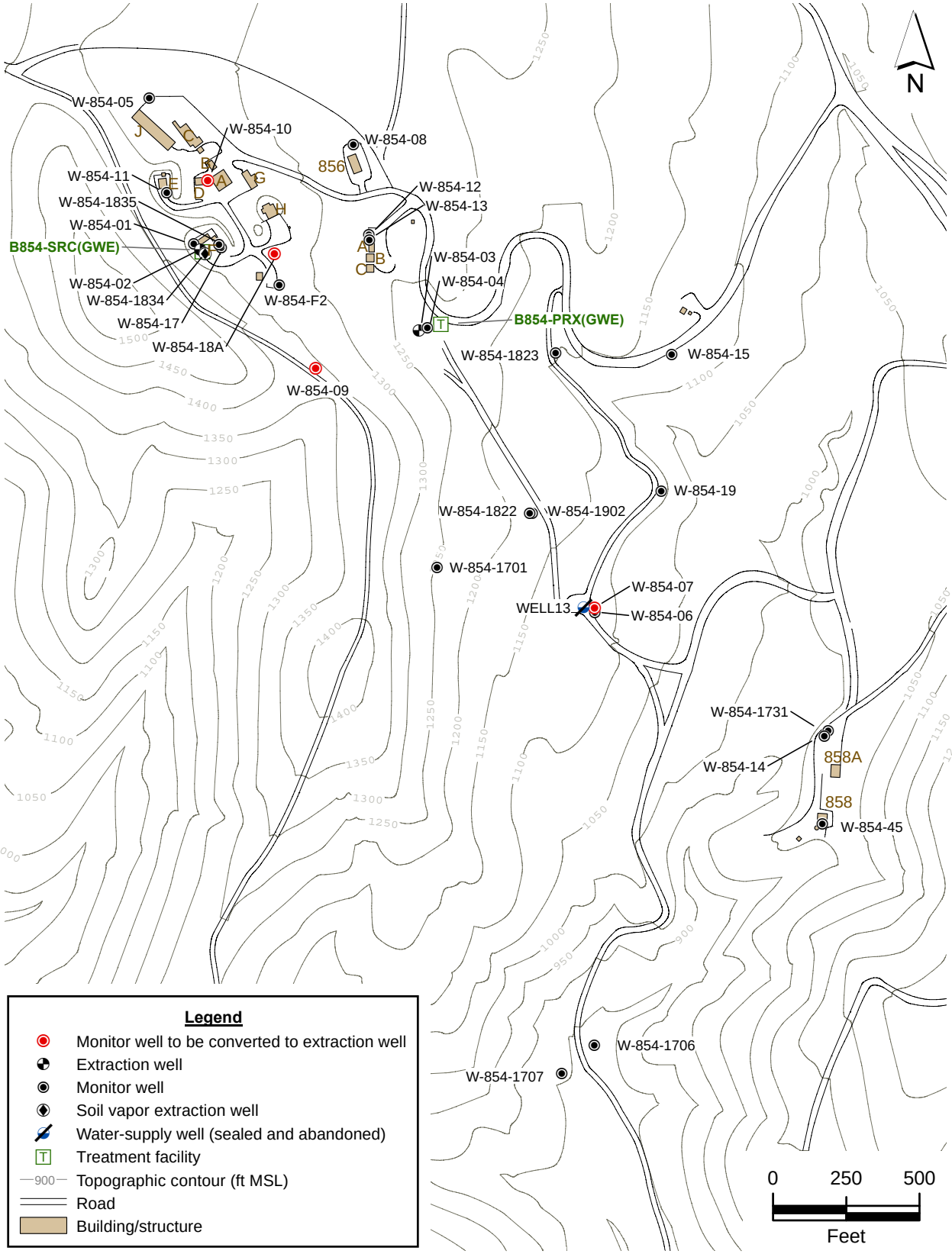


Figure 10-1. Building 854 OU site map showing monitor and extraction wells and treatment facilities.

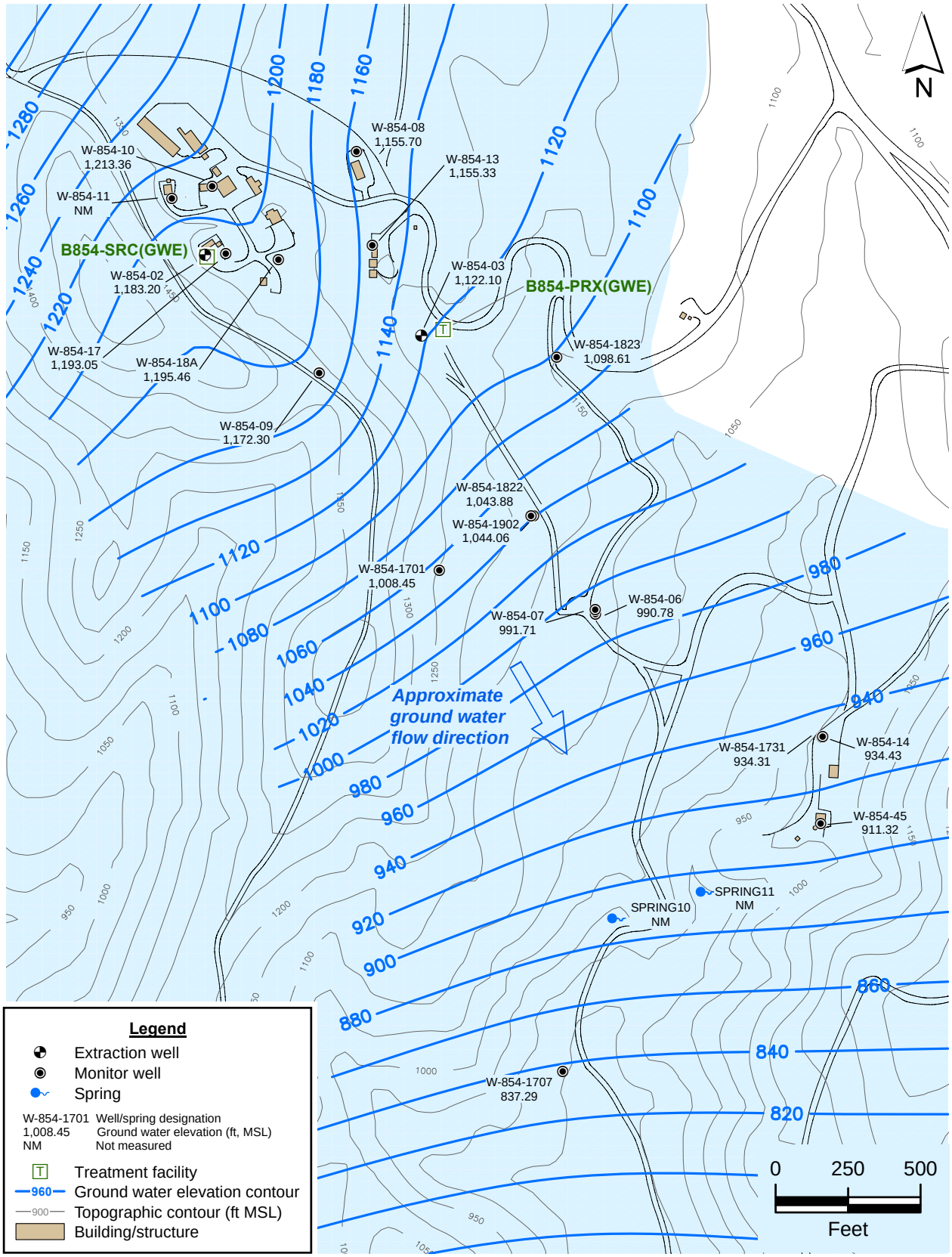


Figure 10-2. Building 854 OU potentiometric surface and ground water flow direction in the $Tnbs_1/Tnsc_0$ HSU (1st Semester 2005).

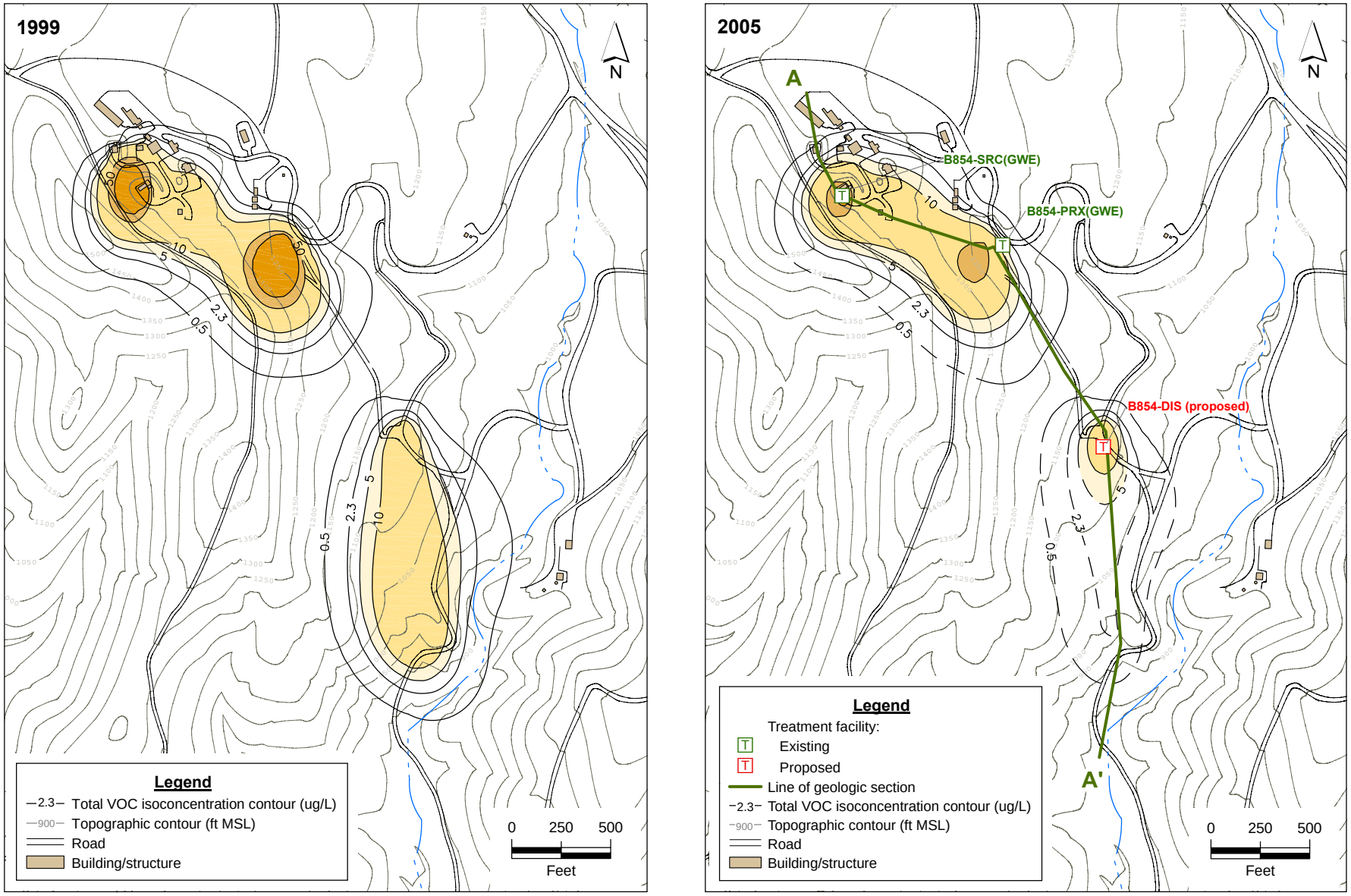
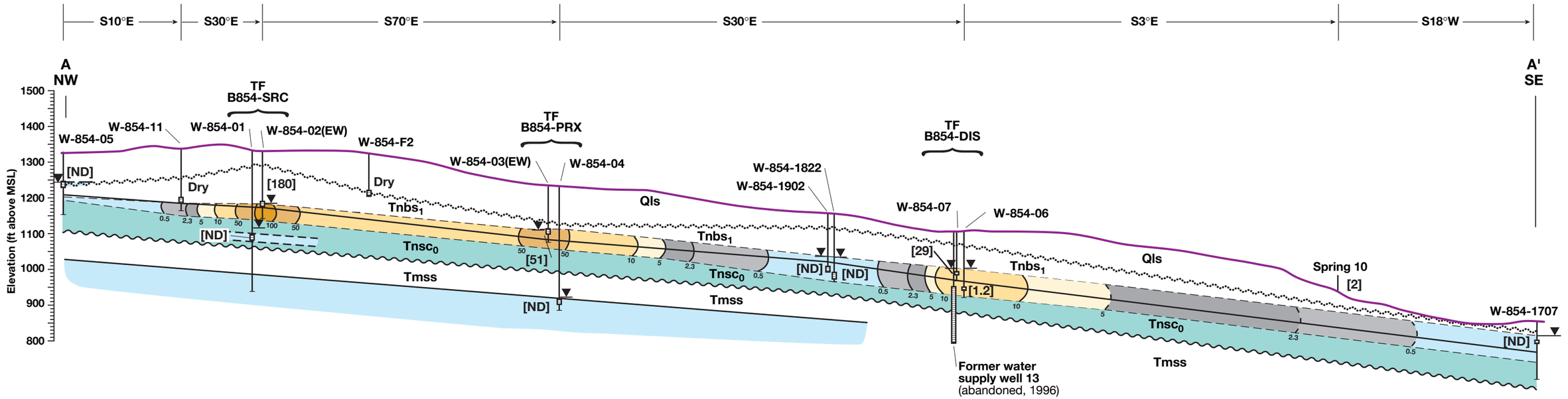
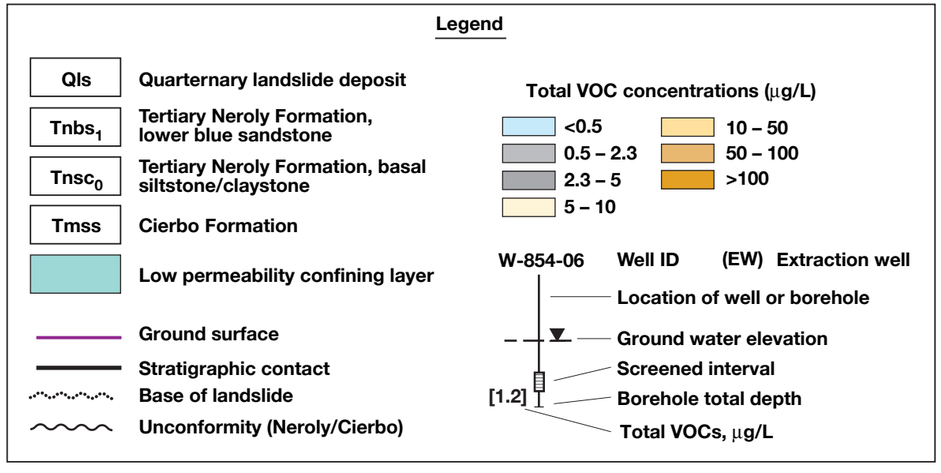
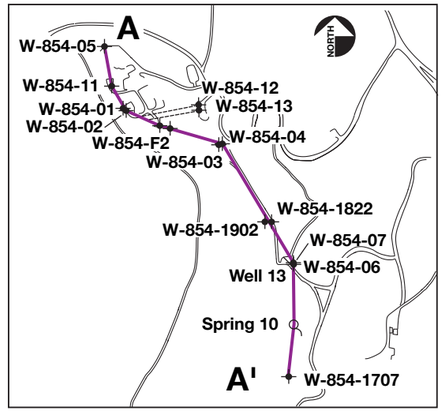


Figure 10-3. Comparison of the distribution of total VOCs in the $Tnbs_1/Tnsc_0$ HSU at the Building 854 OU in 1999 and 1st Semester 2005.







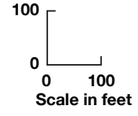


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Figure 10-4. Building 854 Hydrogeologic Cross-section A-A'.

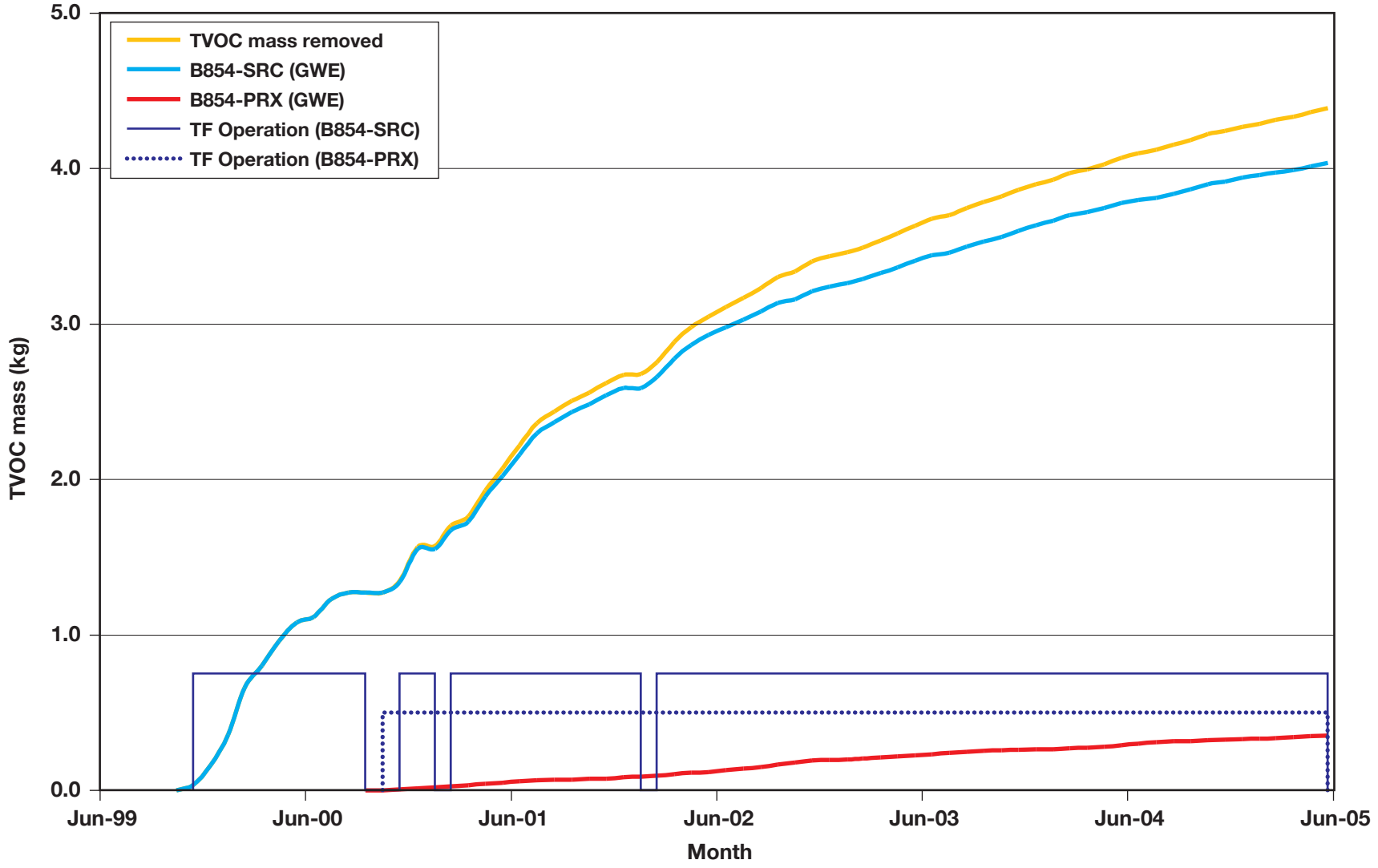

Figure 10-5. Time-series plots of cumulative mass of total VOCs removed by ground water extraction (GWE) from the Building 854 OU.

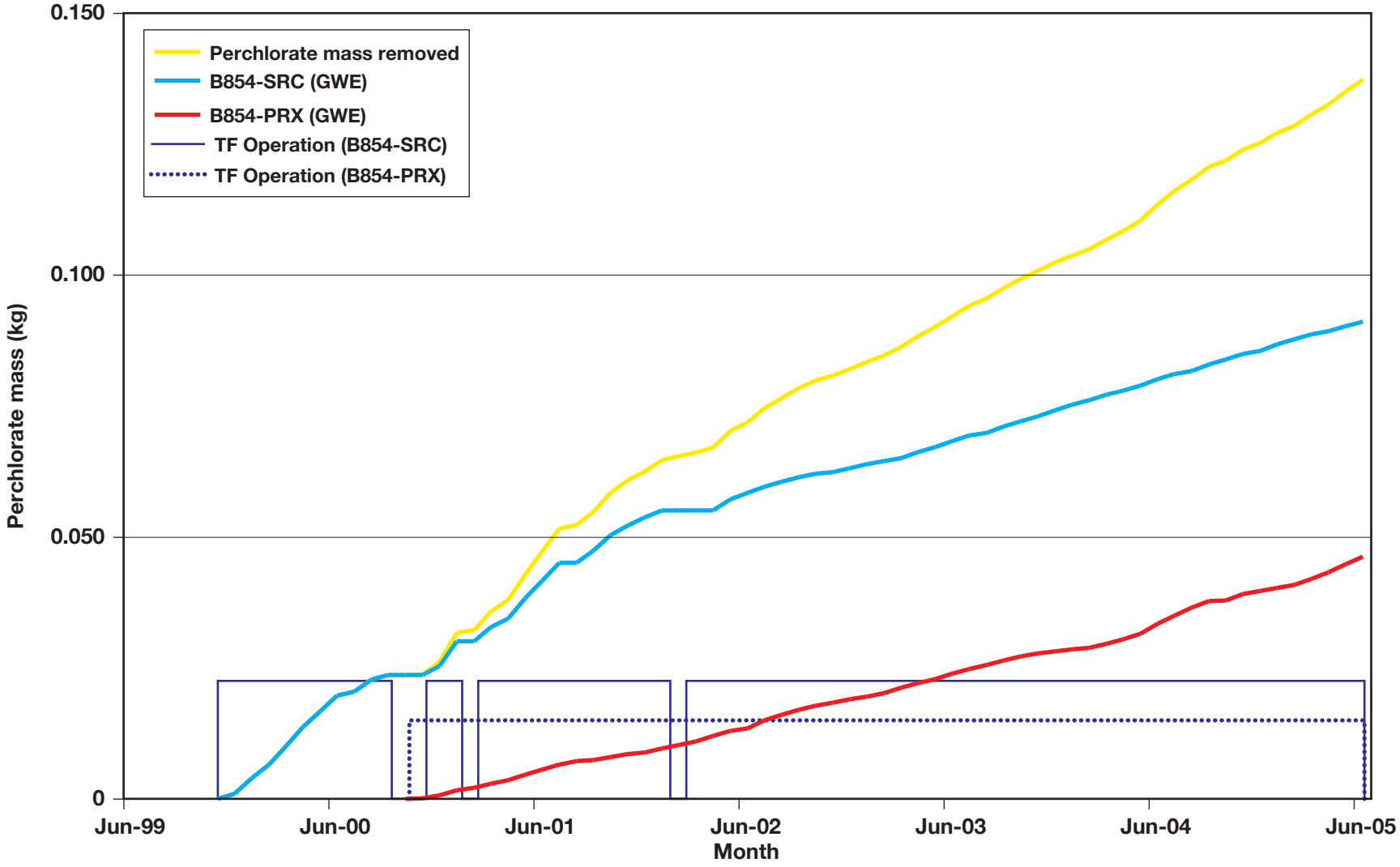

Figure 10-6. Time-series plots of cumulative mass of perchlorate removed by ground water extraction (GWE) from the Building 854 OU.

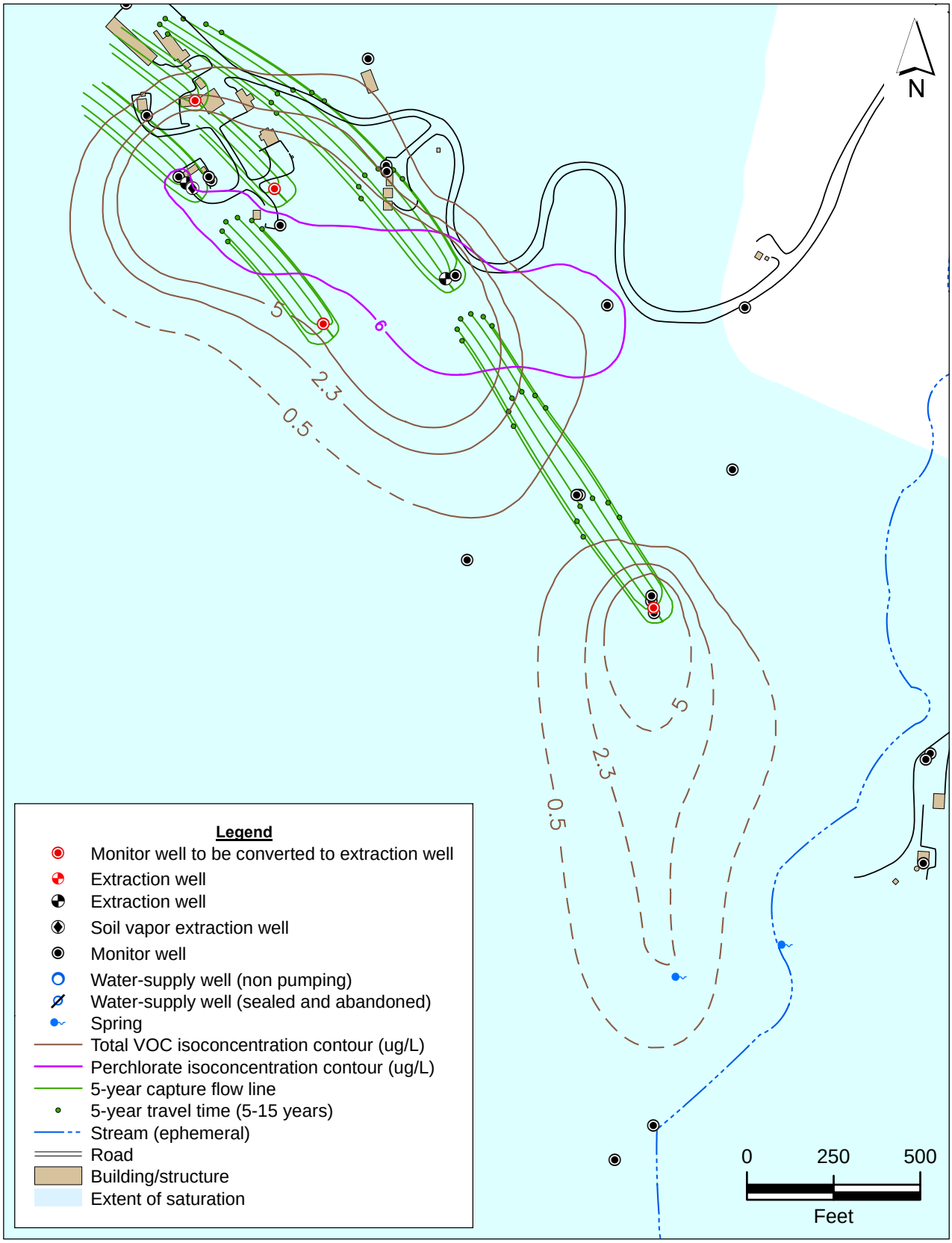

Figure 10-7. Capture zone results for the designed remedial extraction wellfield at the Building 854 OU.

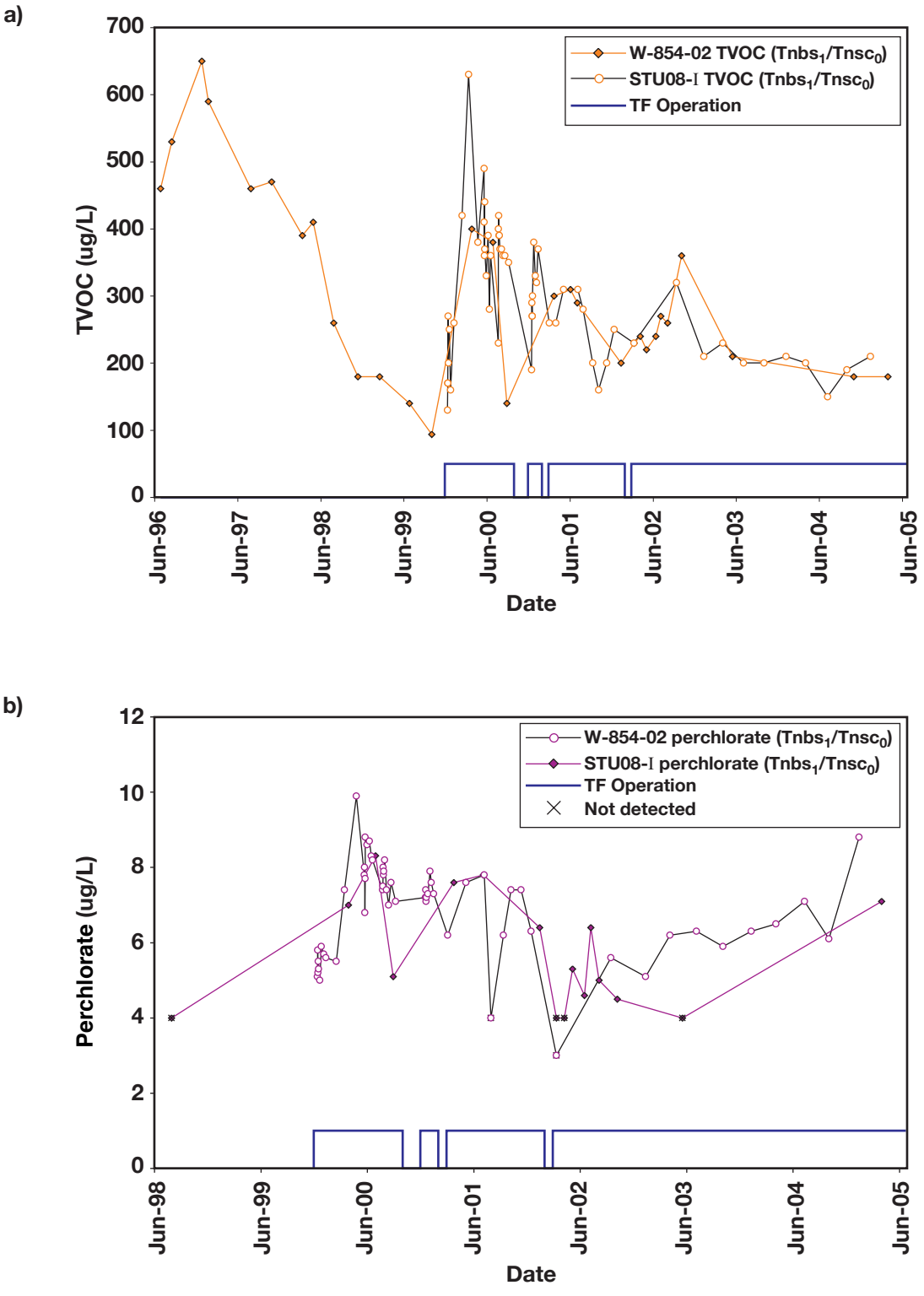

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Figure 10-8. Time-series plots of a) total VOCs, and b) perchlorate in ground water at the Building 854 Source Area.

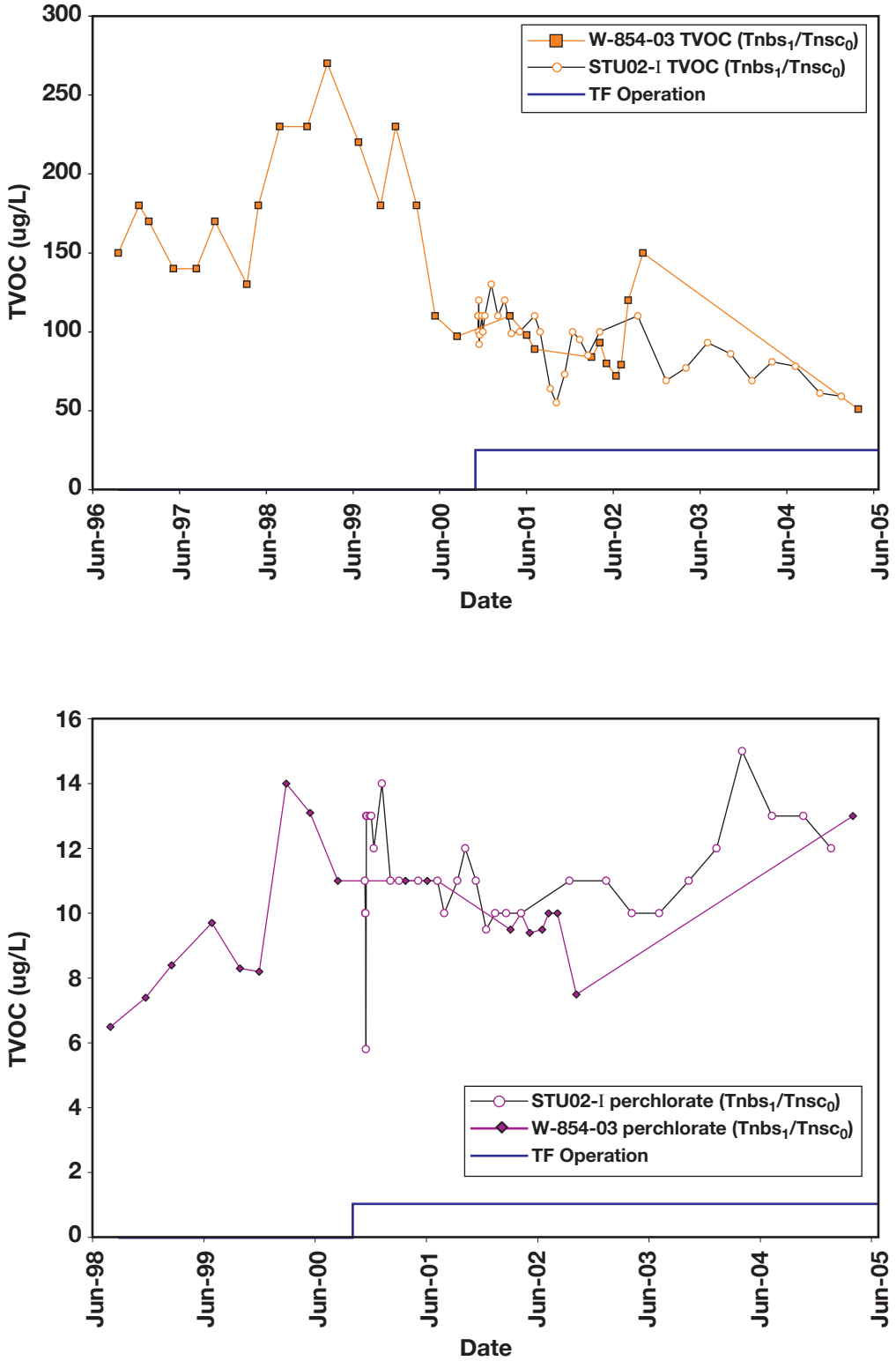


Figure 10-9. Time-series plots of a) total VOCs and b) perchlorate in ground water at the Building 854 Proximal Area.

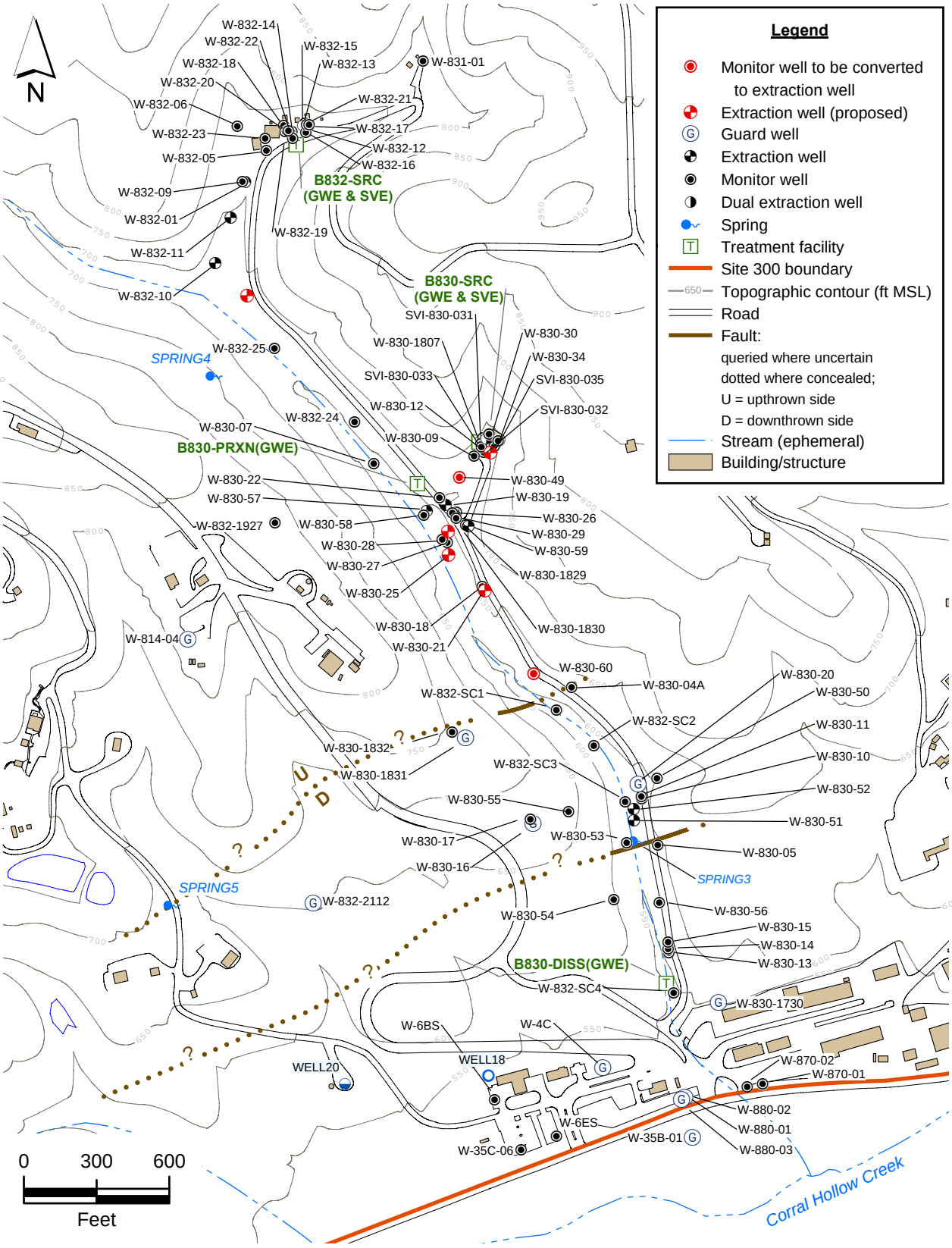


Figure 11-1. Building 832 Canyon OU site map showing monitor, extraction and water-supply wells, and treatment facilities.

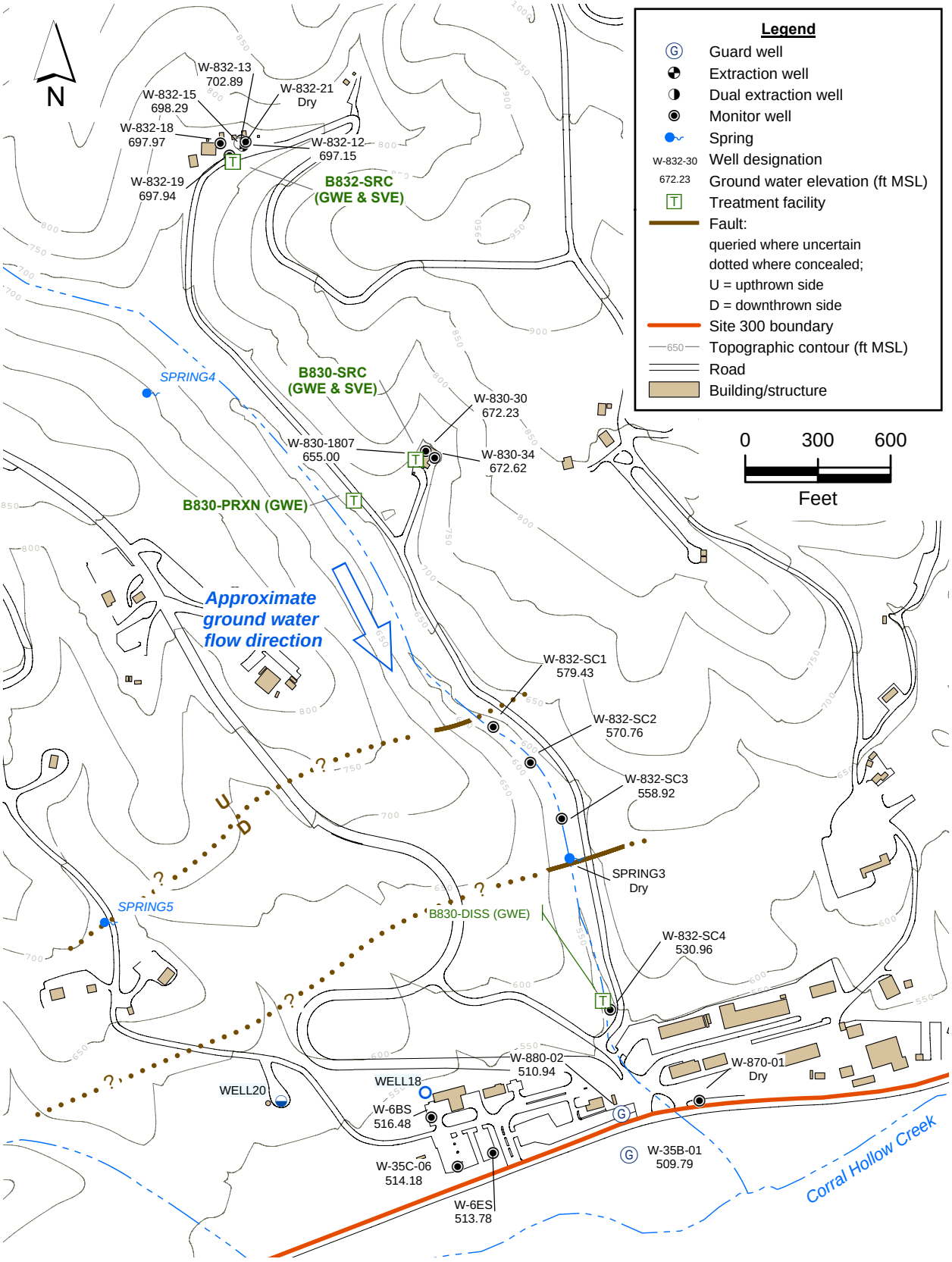


Figure 11-2. Building 832 Canyon OU map showing ground water elevations and flow direction in the Qal/WBR HSU (1st Semester 2005).

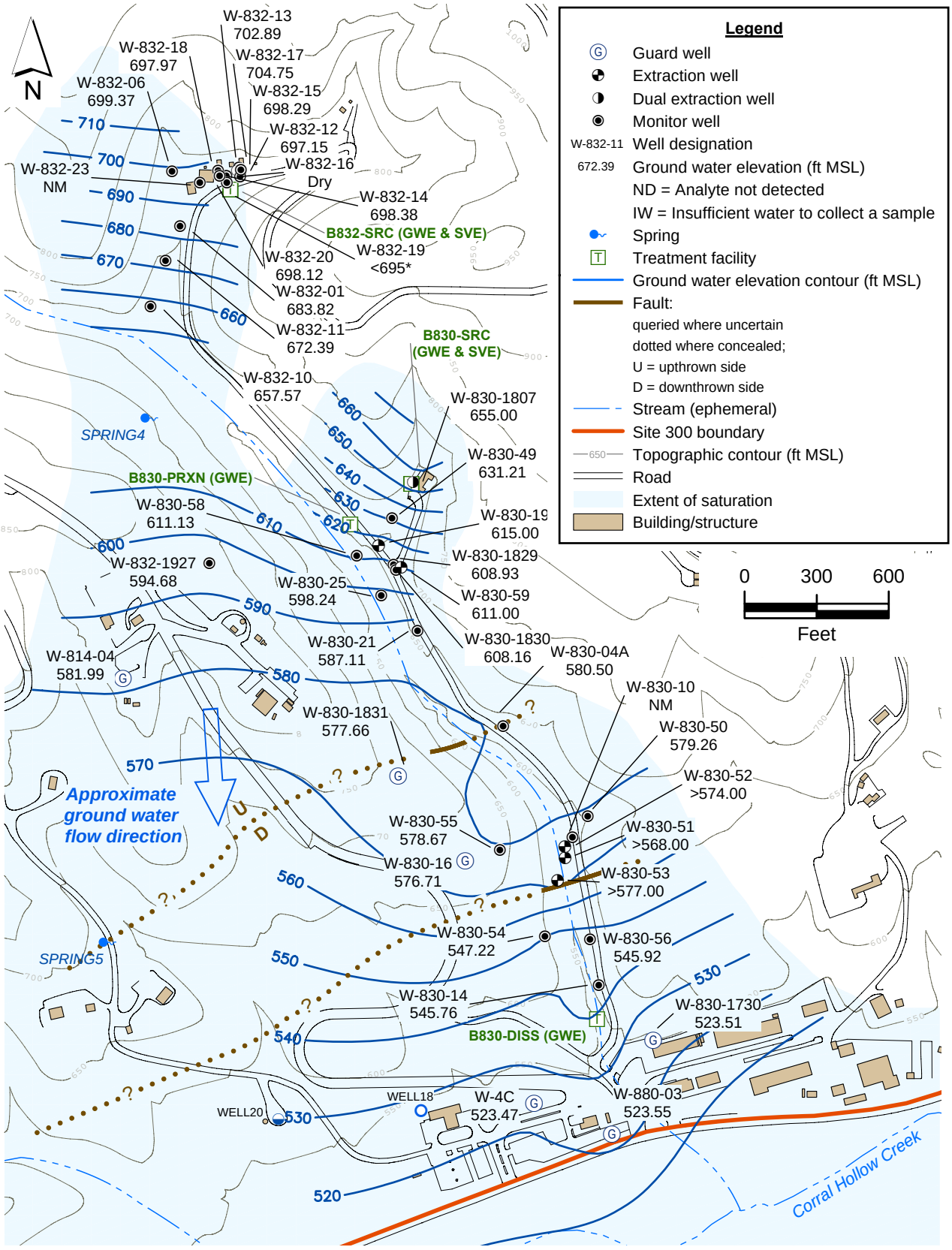


Figure 11-3. Building 832 Canyon OU potentiometric surface contours and ground water flow direction in the $Tnsc_{1b}$ HSU (1st Semester 2005).

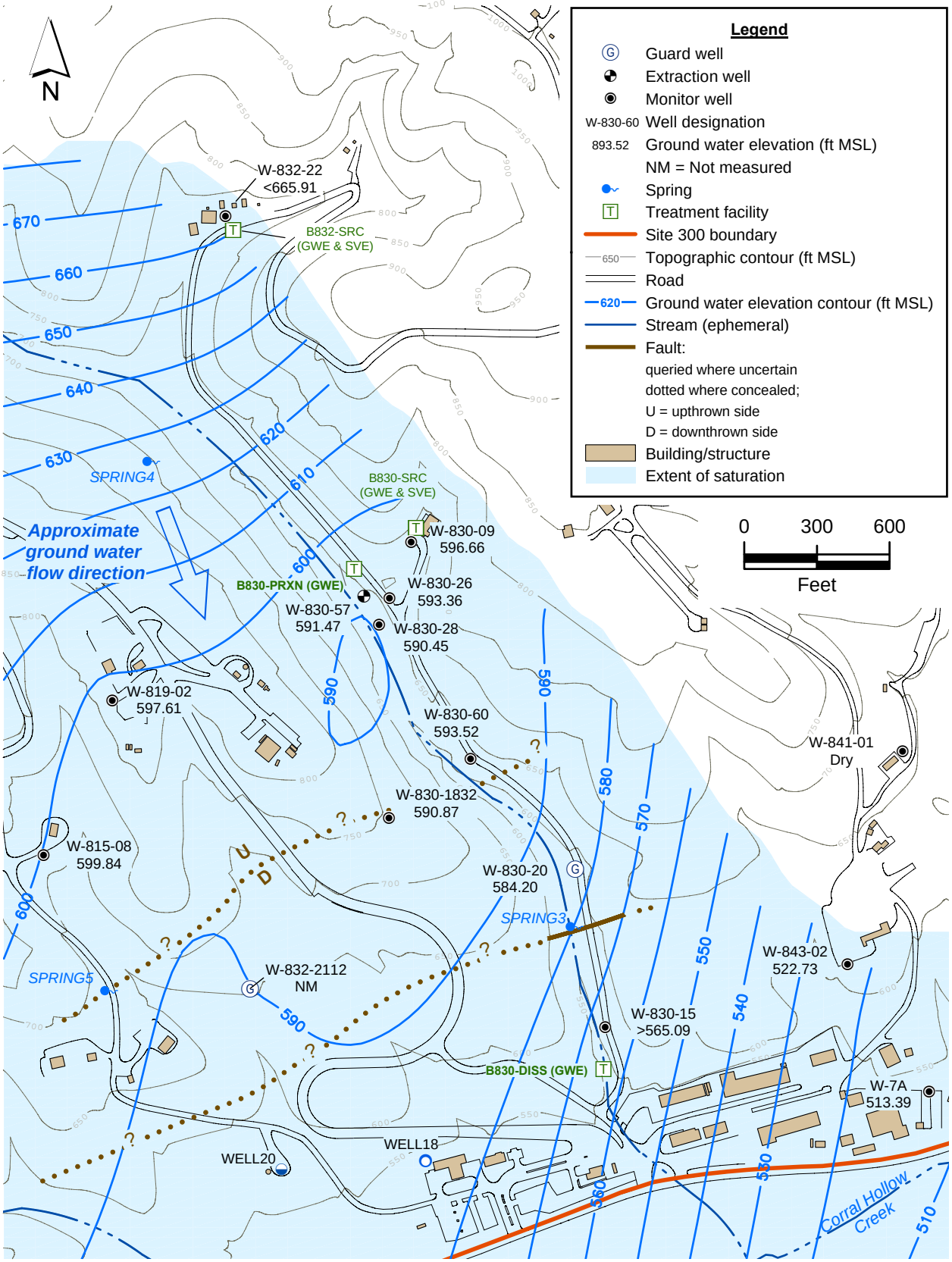


Figure 11-4. Building 832 Canyon OU potentiomentric surface and ground water flow direction in the Upper Tnbs$_1$ HSU (1st Semester 2005).

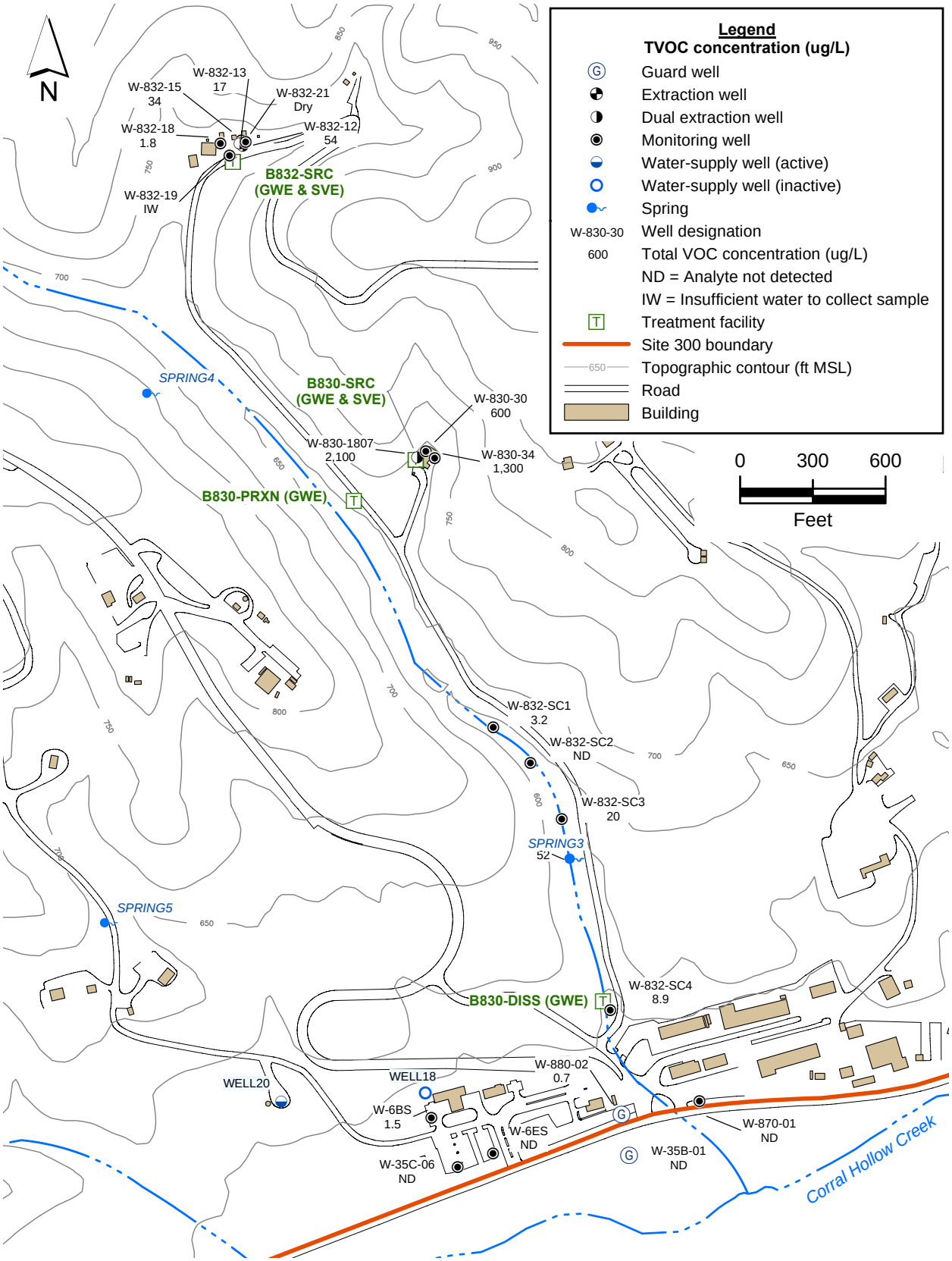


Figure 11-5. Building 832 Canyon OU map showing total VOC concentrations for the Qal/WBR HSU (1st Semester 2005).

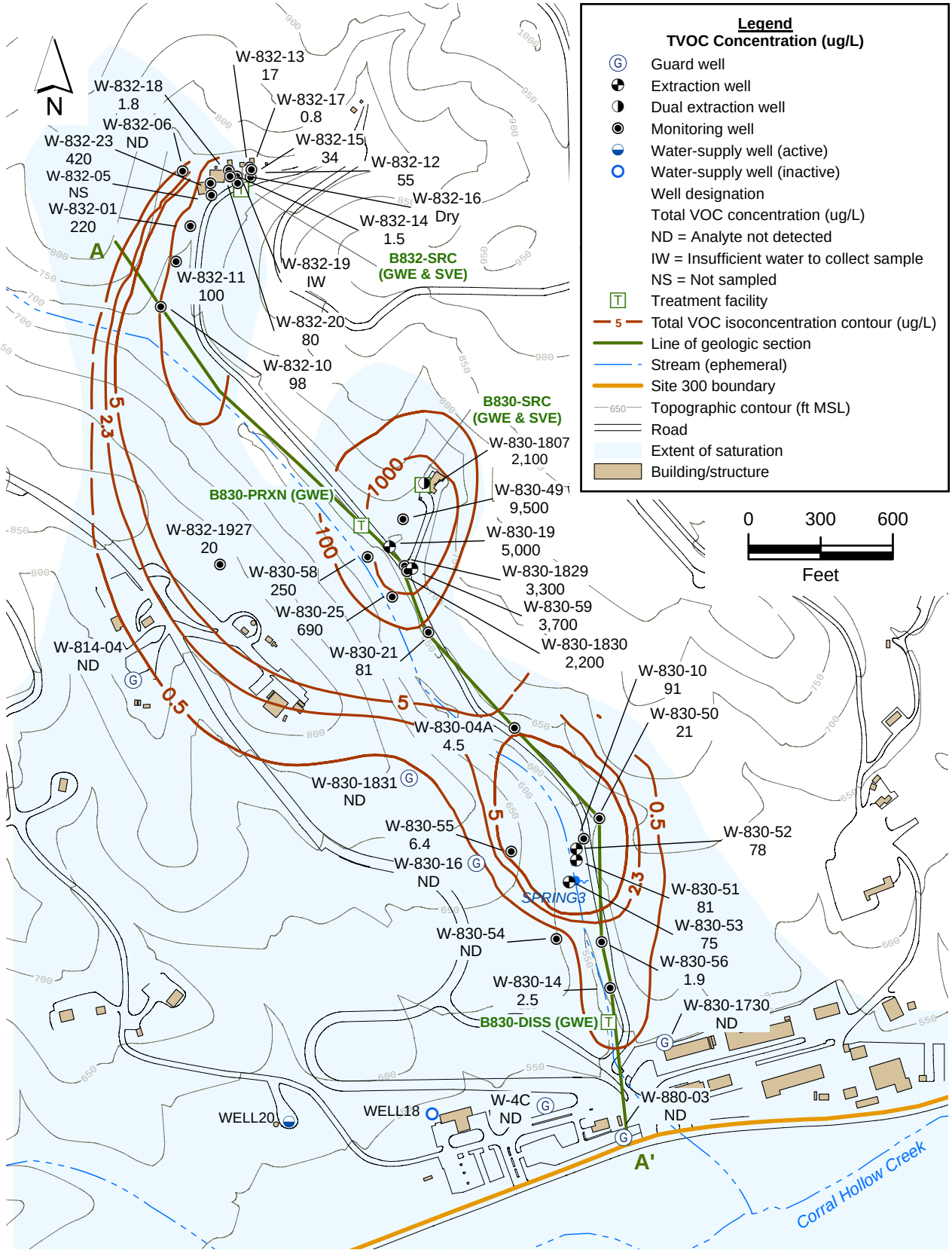


Figure 11-6. Building 832 Canyon OU total VOC isoconcentration contour map for the $Tnsc_{1b}$ HSU (1st Semester 2005).

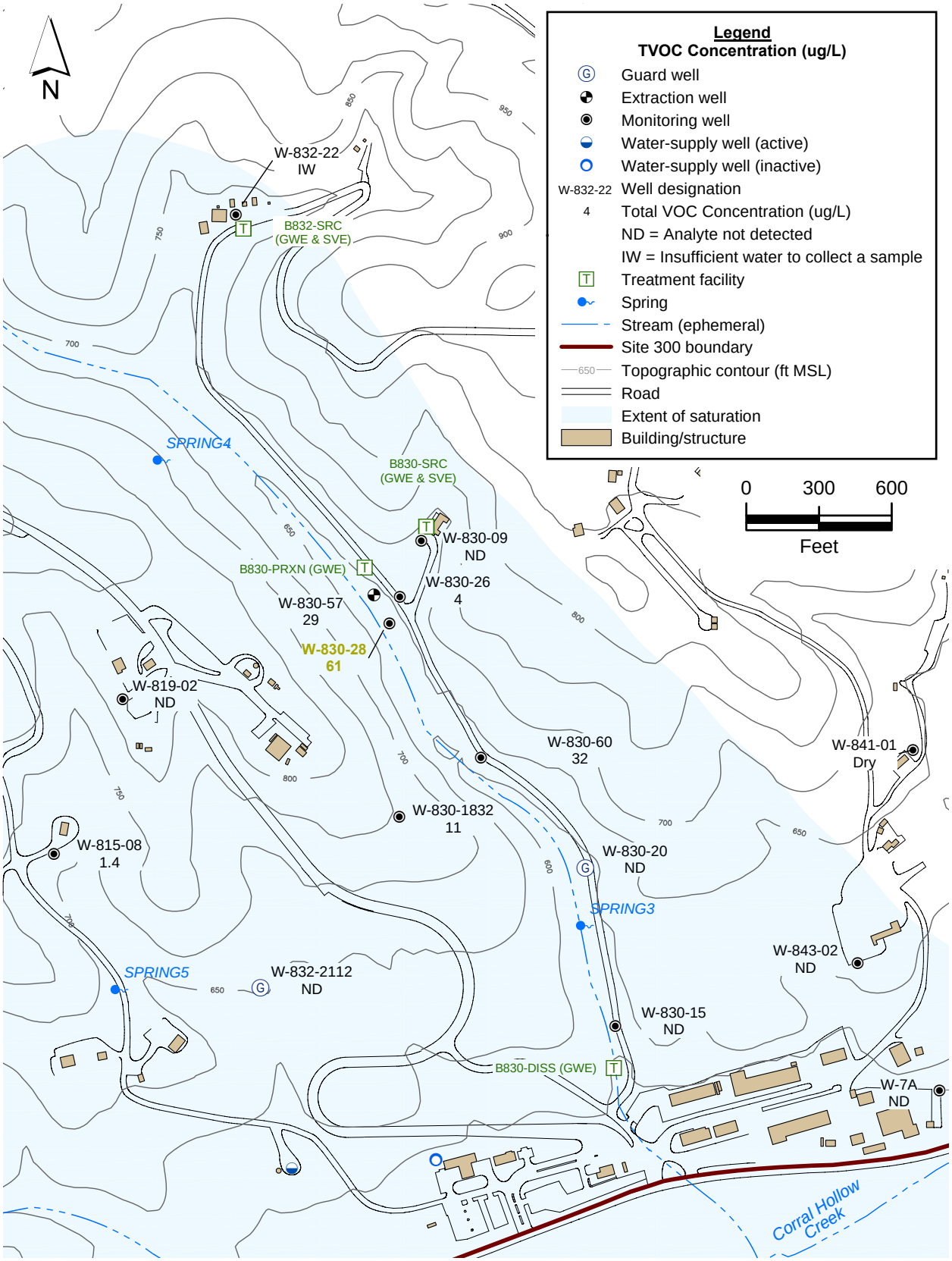
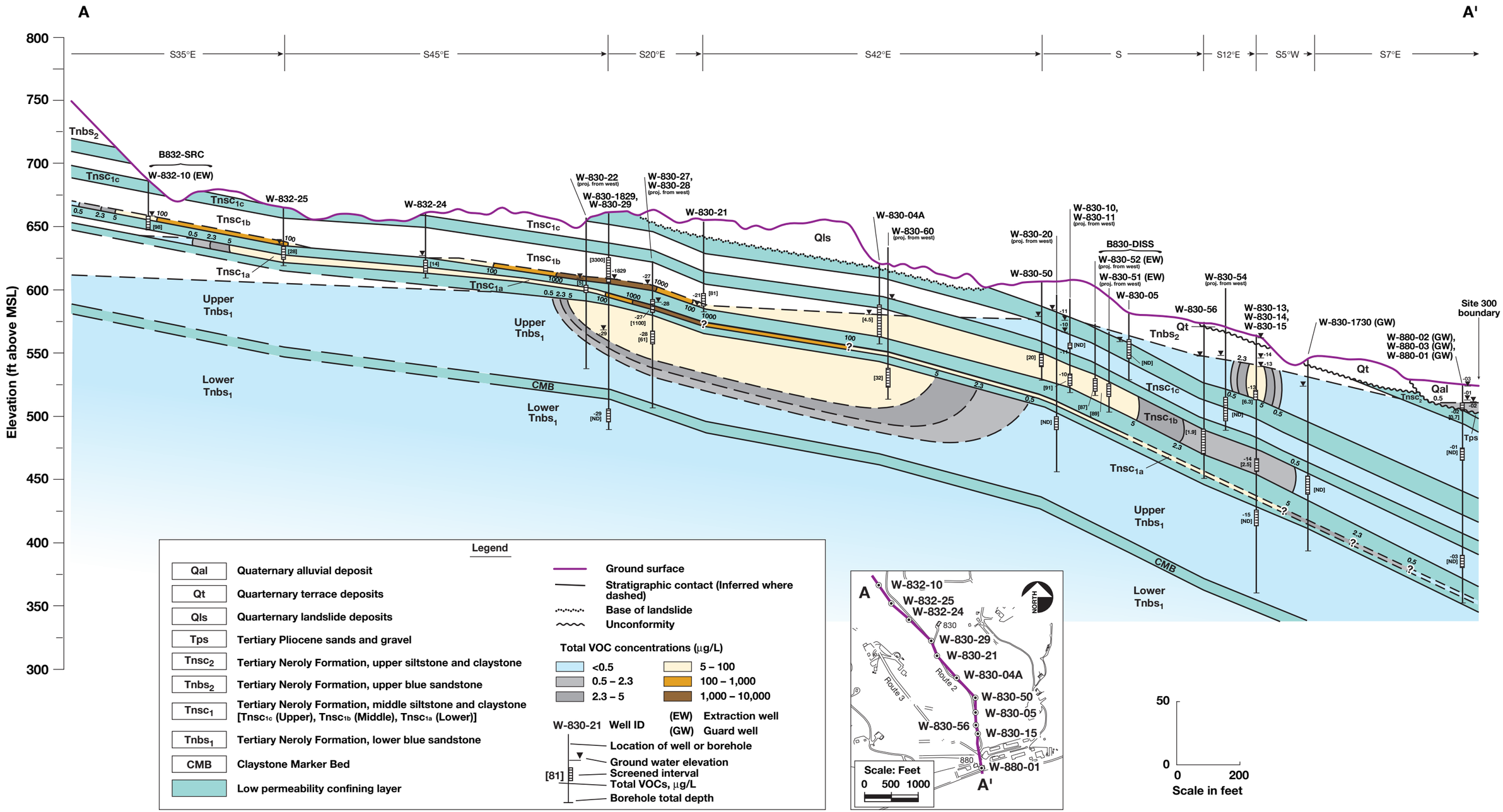


Figure 11-7. Building 832 Canyon OU site map showing total VOC concentrations for the Upper $Tnbs_1$ HSU (1st Semester 2005).



Legend

Qal	Quaternary alluvial deposit
Qt	Quaternary terrace deposits
Qls	Quaternary landslide deposits
Tps	Tertiary Pliocene sands and gravel
$Tnsc_2$	Tertiary Neroly Formation, upper siltstone and claystone
$Tnbs_2$	Tertiary Neroly Formation, upper blue sandstone
$Tnsc_1$	Tertiary Neroly Formation, middle siltstone and claystone [$Tnsc_{1c}$ (Upper), $Tnsc_{1b}$ (Middle), $Tnsc_{1a}$ (Lower)]
$Tnbs_1$	Tertiary Neroly Formation, lower blue sandstone
CMB	Claystone Marker Bed
	Low permeability confining layer

Ground surface
Stratigraphic contact (Inferred where dashed)
Base of landslide
Unconformity

Total VOC concentrations (µg/L)

<0.5	5 – 100
0.5 – 2.3	100 – 1,000
2.3 – 5	1,000 – 10,000

W-830-21 Well ID
(EW) Extraction well
(GW) Guard well
Location of well or borehole
Ground water elevation
[81] Screened interval
Total VOCs, µg/L
Borehole total depth

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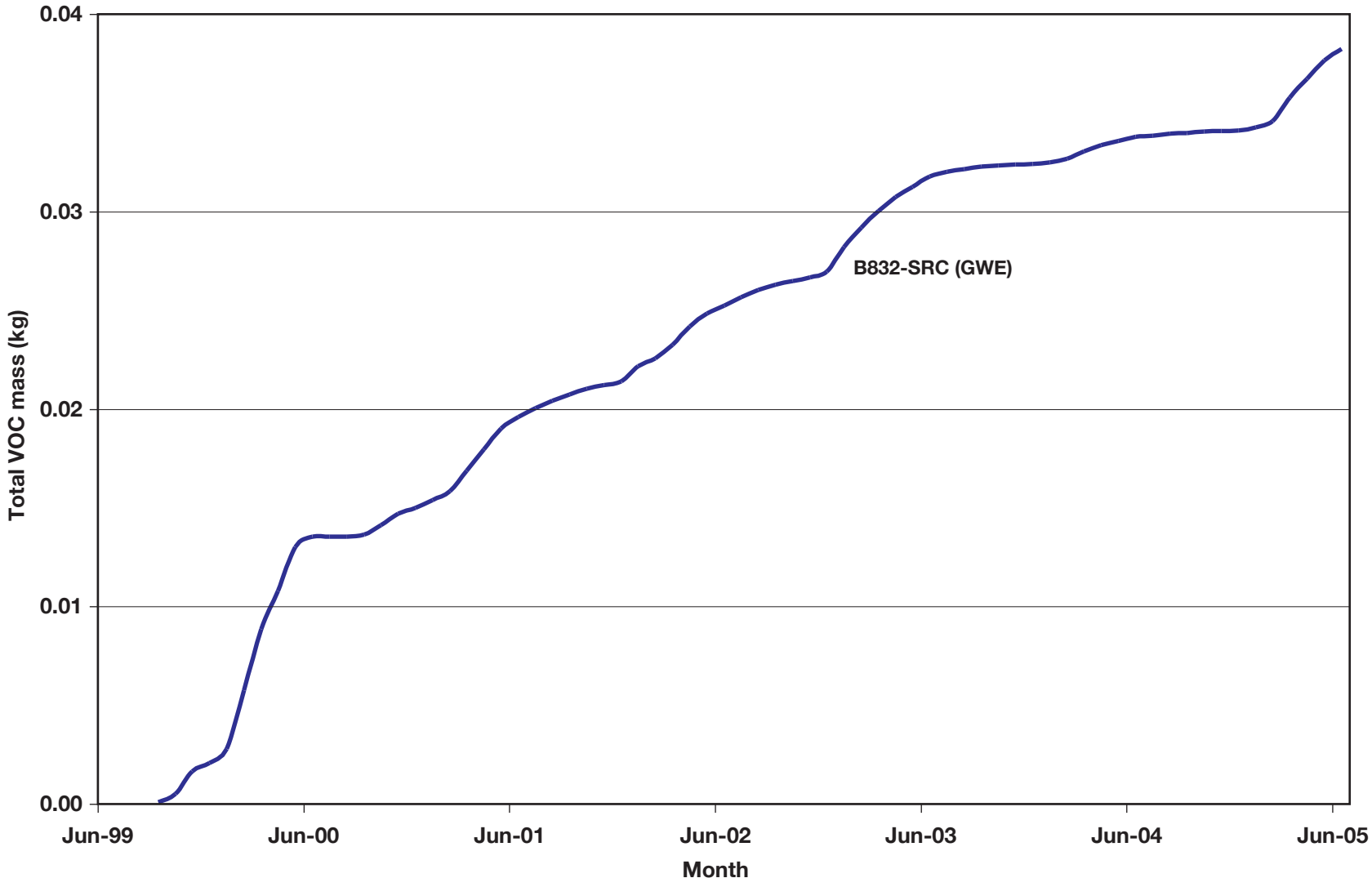
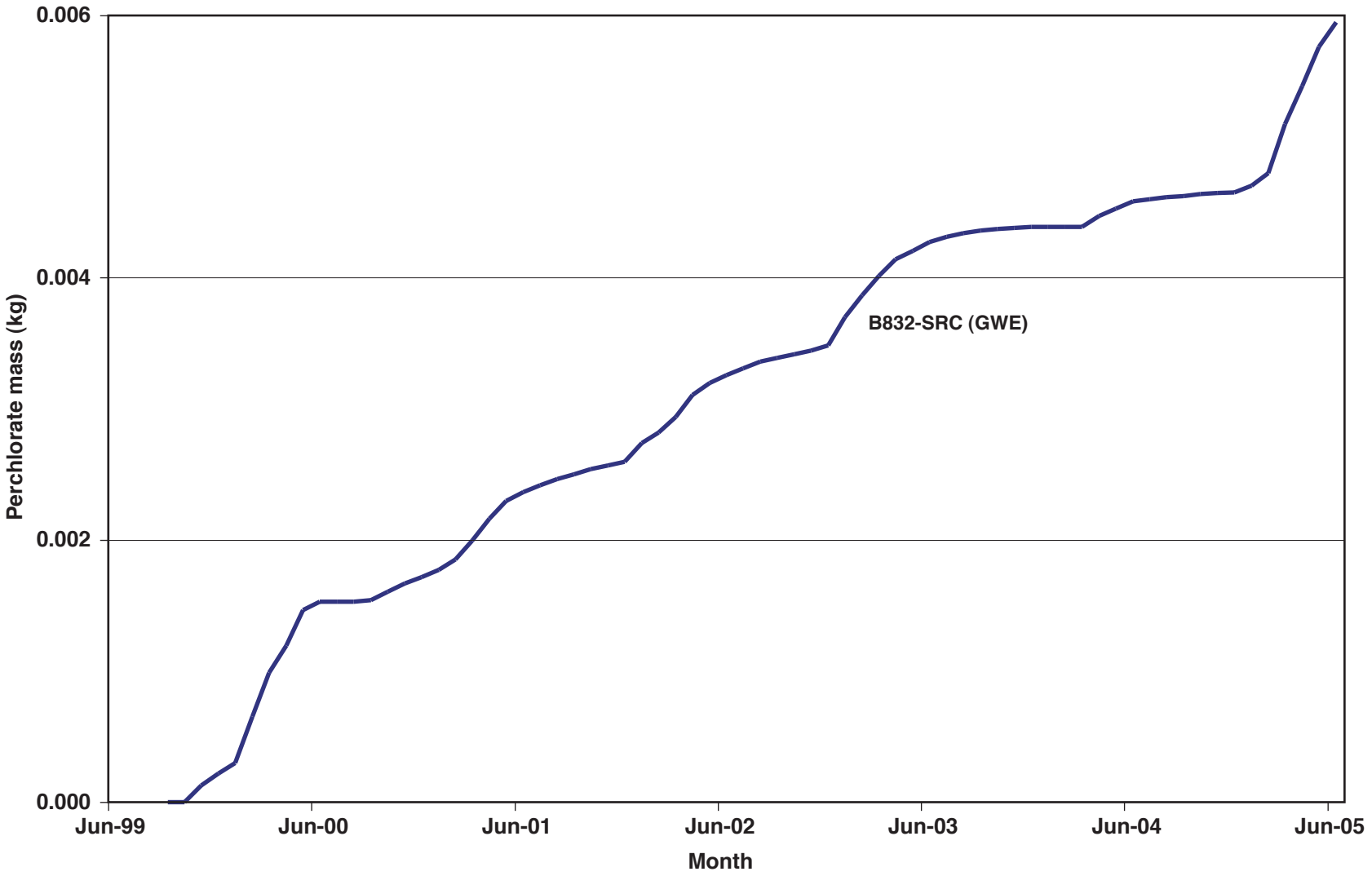
Figure 11-8. Building 832 Canyon Hydrogeologic Cross-section A-A'.



ERD-S3R-06-0011

Figure 11-9. Time-series plot of cumulative mass of total VOCs removed by ground water extraction (GWE) from the Building 832-Source Area.



ERD-S3R-06-0012

Figure 11-10. Time-series plot of cumulative mass of perchlorate removed by ground water extraction (GWE) from the Building 832-Source Area.

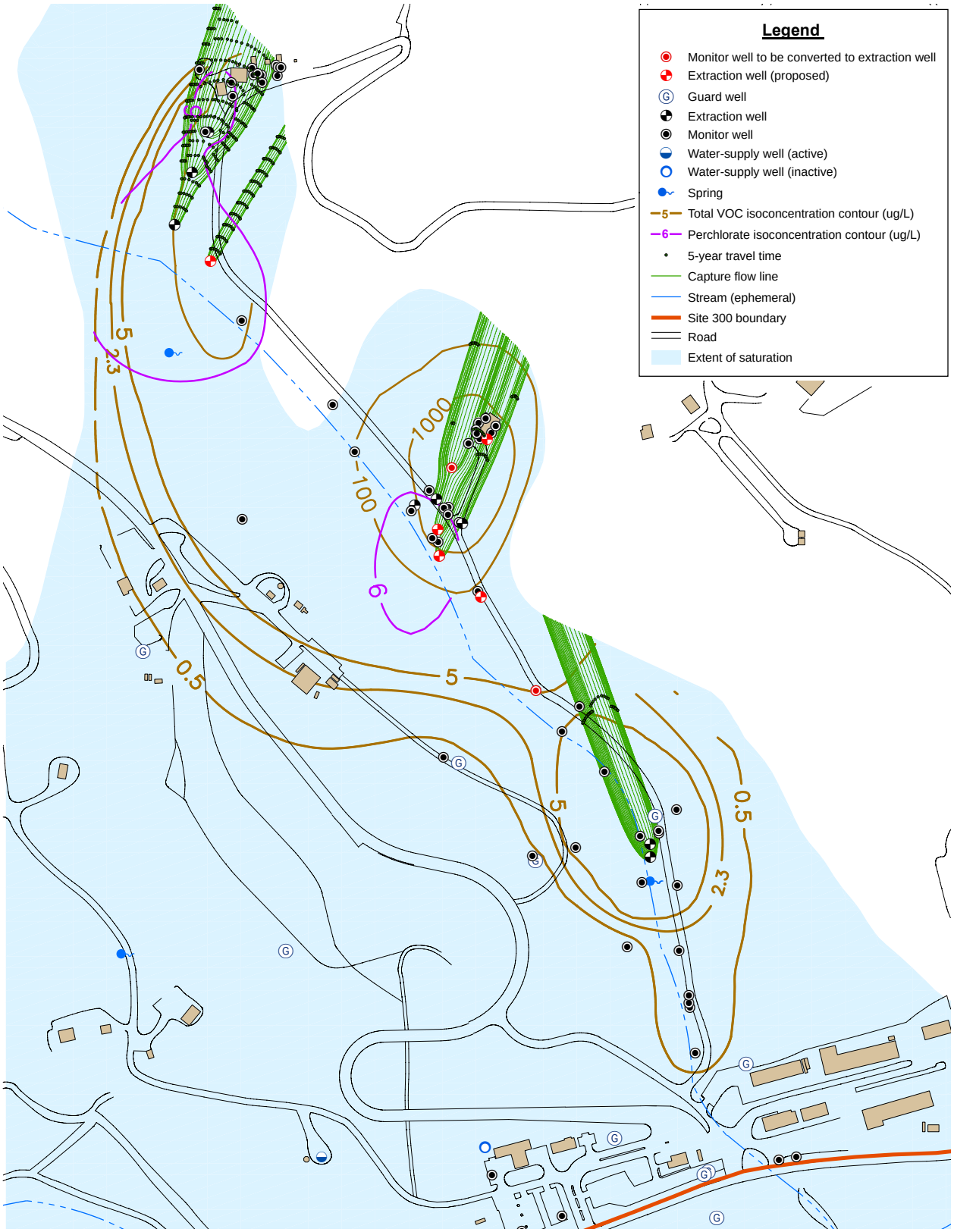


Figure 11-11. Capture zone analysis results for the designed remedial extraction wellfield in the $Tnsc_{1b}$ HSU at the Building 832 Canyon OU.

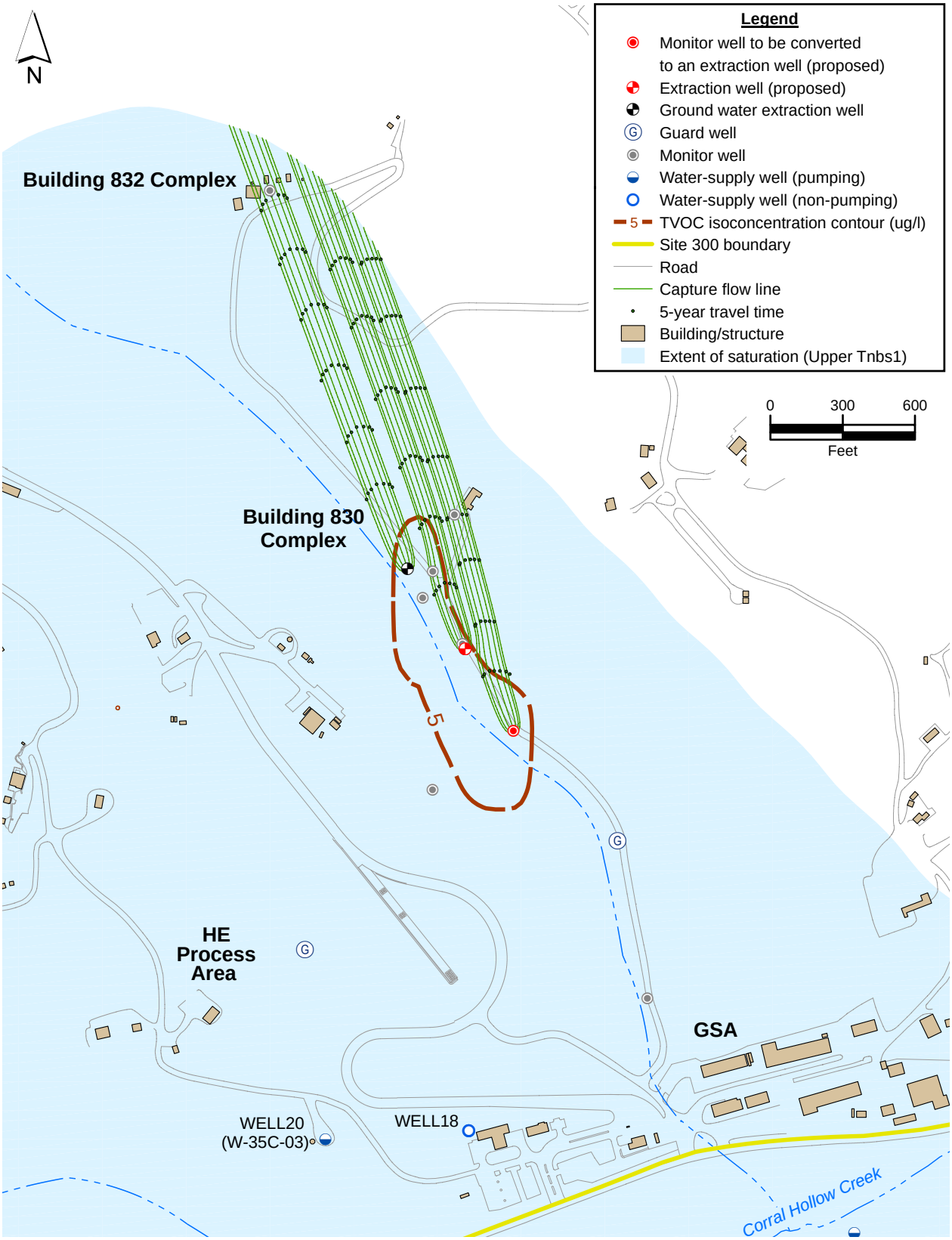


Figure 11-12. Capture zone analysis results for the designed remedial extraction wellfield in the Upper $Tnbs_1$ HSU at the Building 832 Canyon OU.

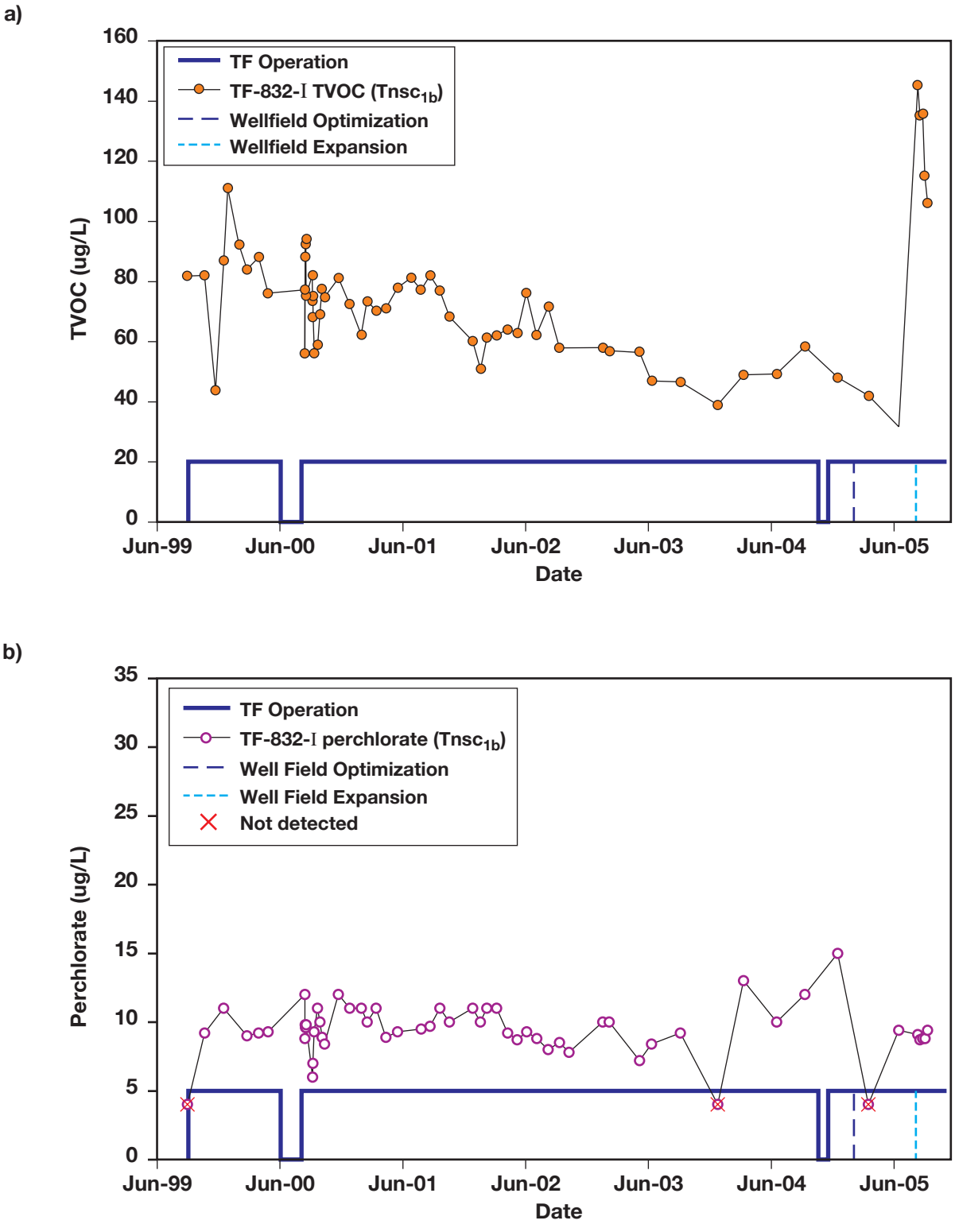


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Figure 11-13. Time-series plots of a) total VOCs, and b) perchlorate in ground water at the Building 832 Source Area.

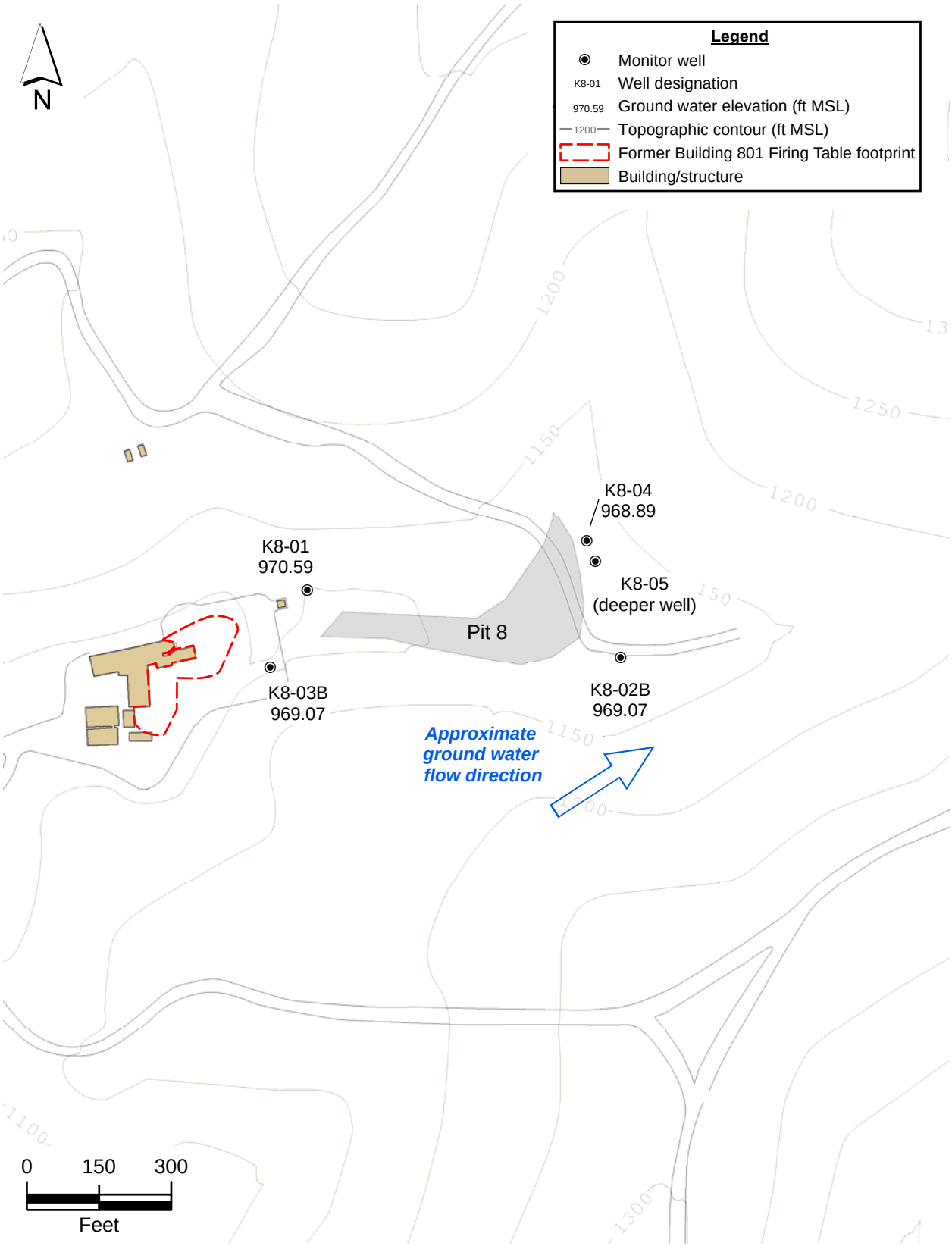
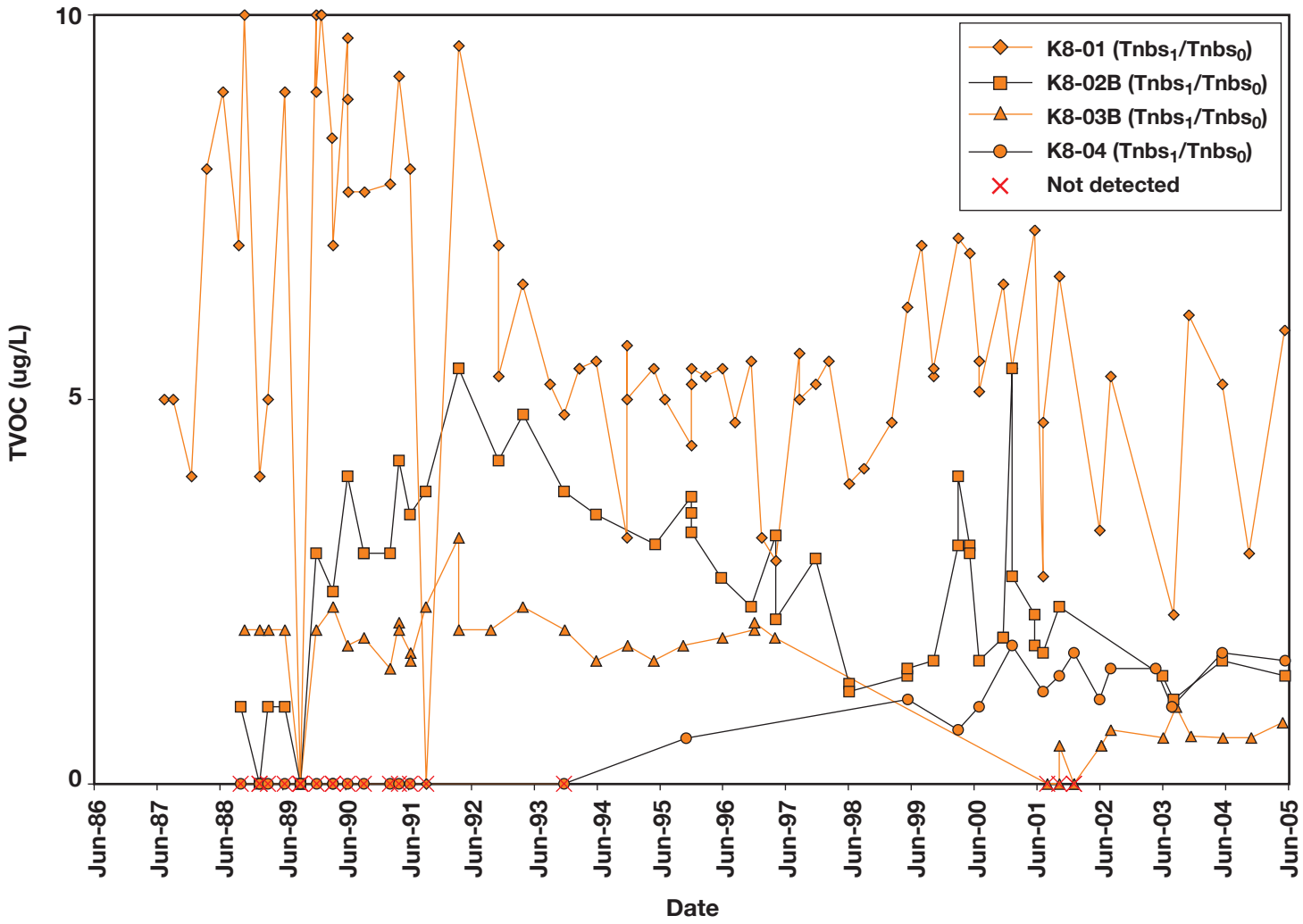


Figure 12-1. Building 801 Firing Table and Pit 8 Landfill ground water elevations and ground water flow direction in the $Tnbs_1/Tnbs_0$ HSU (1st Semester 2005).



ERD-S3R-05-0181

Figure 12-2. Time-series plots of total VOCs in ground water at the Building 801 Firing Table and Pit 8 Landfill.

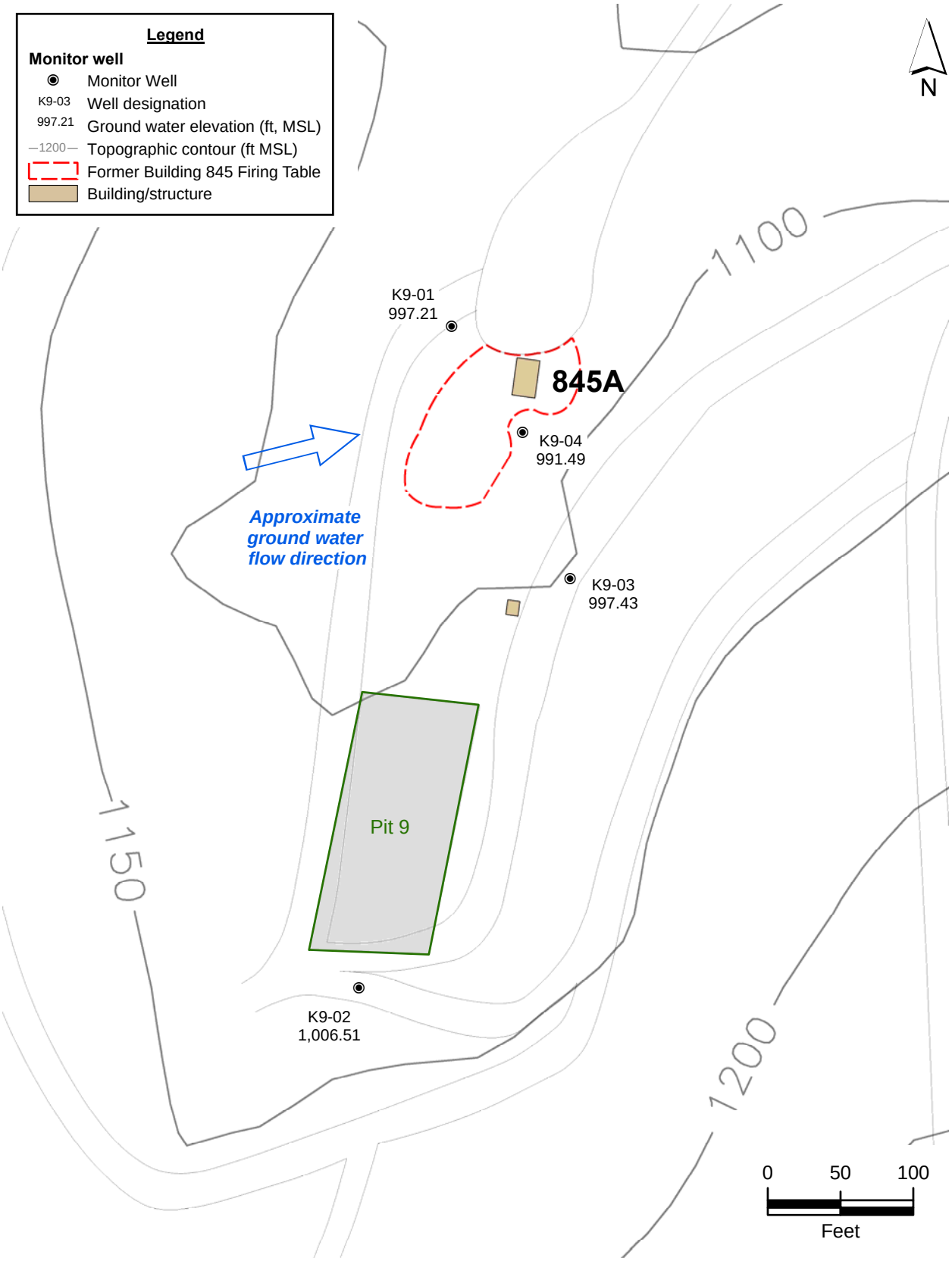


Figure 12-3. Building 845 Firing Table and Pit 9 Landfill ground water elevations and flow direction in the $Tnsc_0$ HSU (1st Semester 2005).

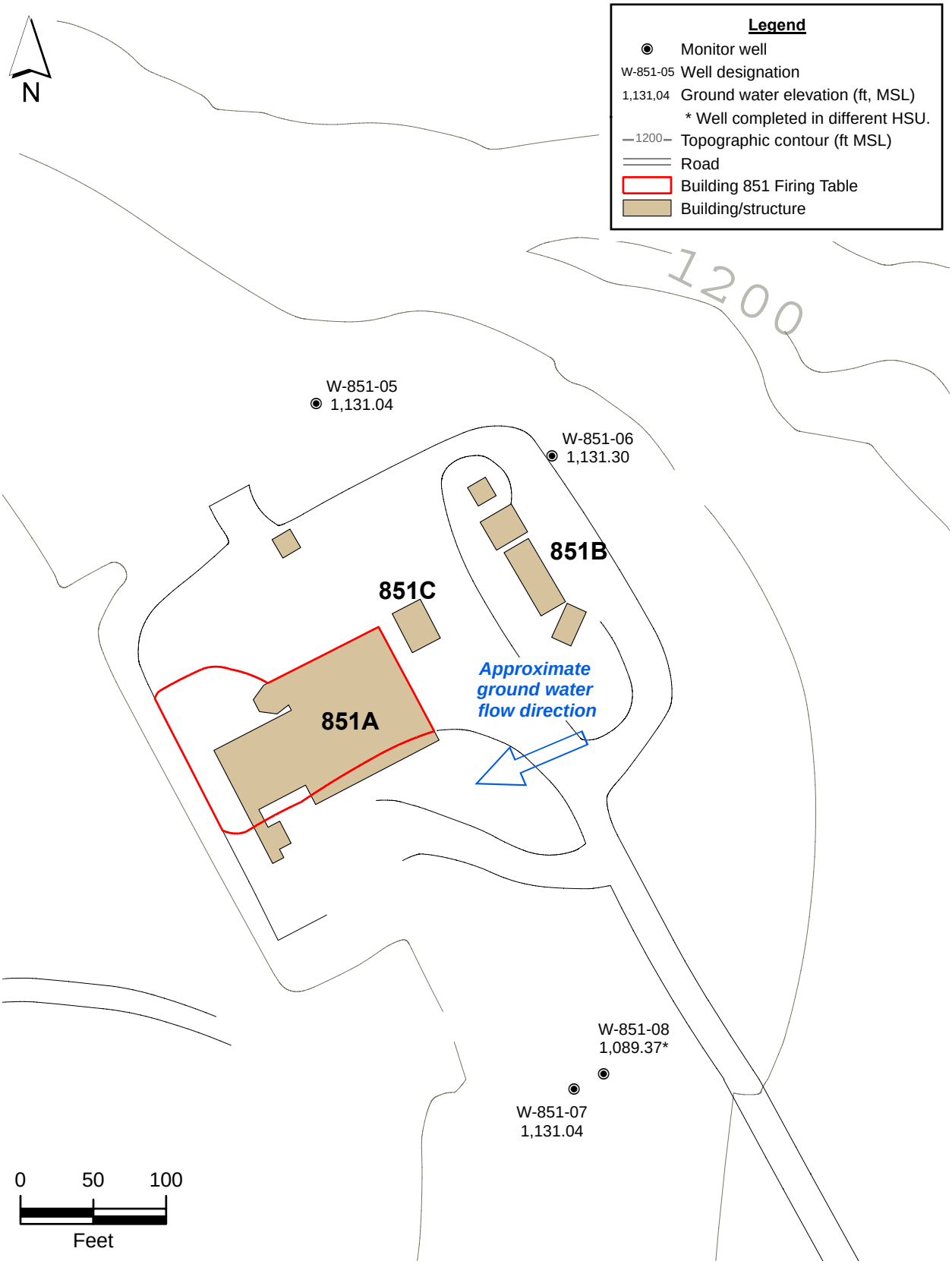
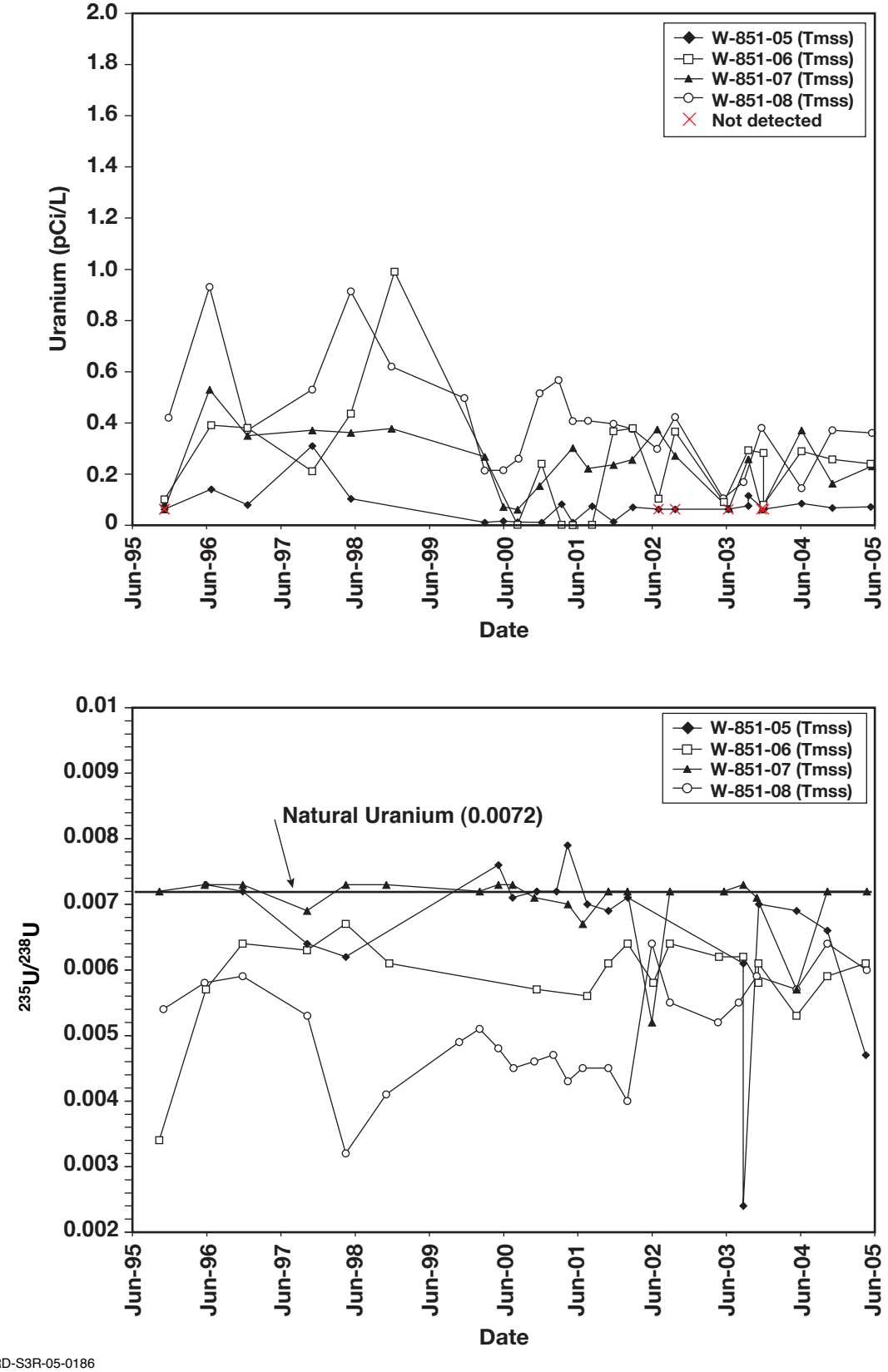


Figure 12-4. Building 851 Firing Table ground water elevations and flow direction in the Tmss HSU (1st Semester 2005).



ERD-S3R-05-0186

Figure 12-5. Time-series plots of uranium activity and $^{235}U/^{238}U$ atom ratio in Tmss HSU ground water at the Building 851 Firing Table.

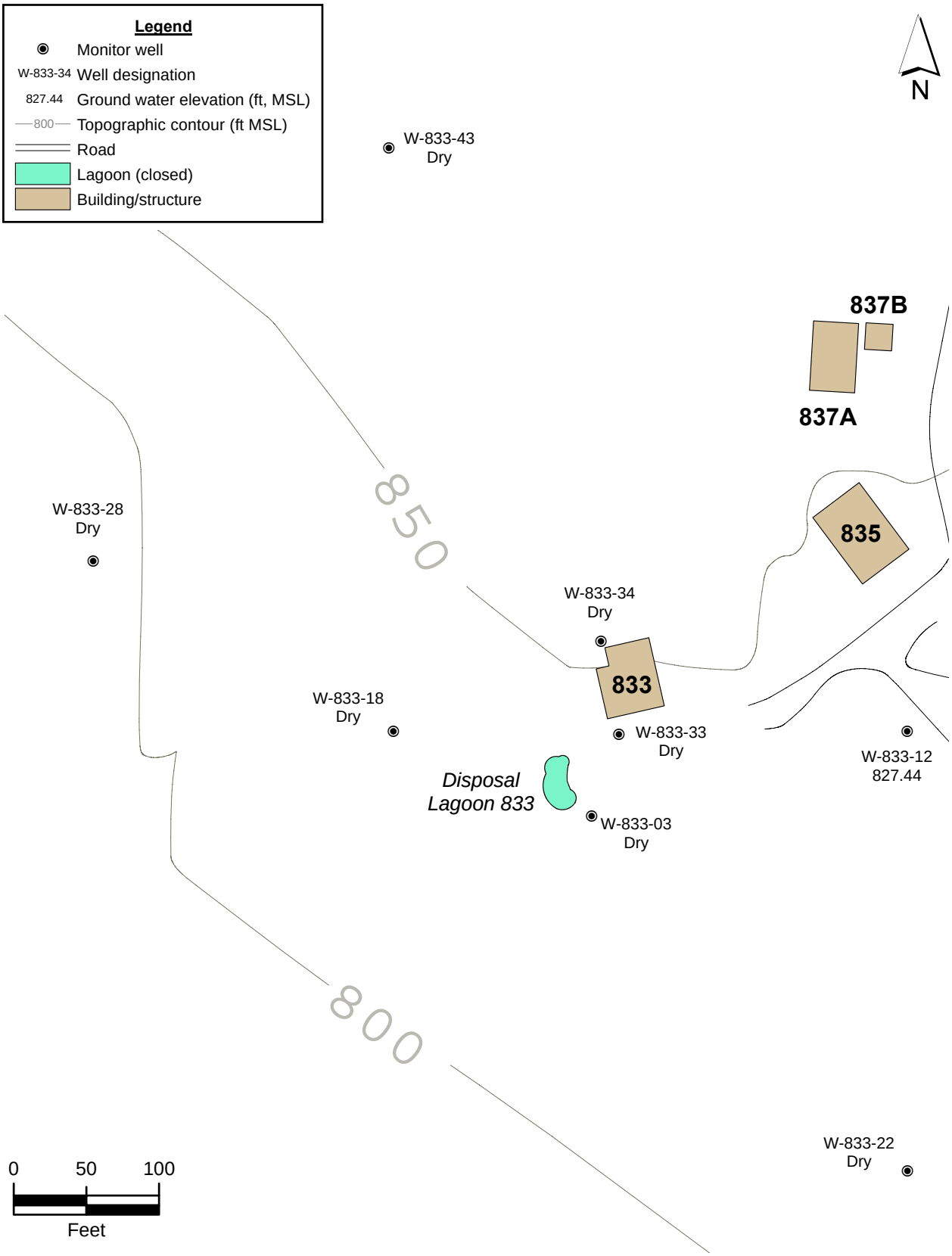


Figure 12-6. Building 833 site map showing ground water elevations in the Tpsg HSU (1st Semester 2005).

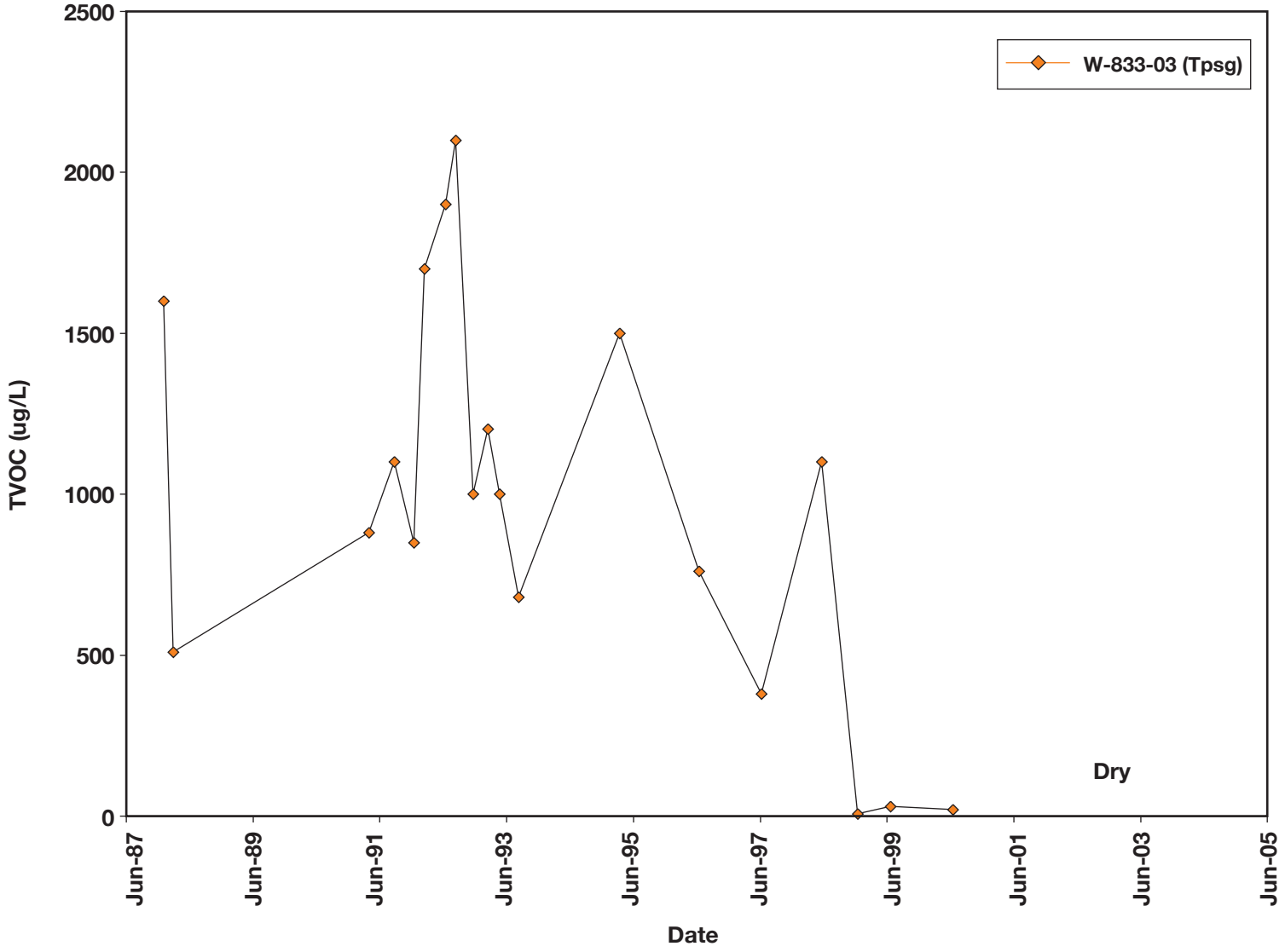


Figure 12-7. Time-series plot of total VOCs in ground water in the Tpsg HSU at the Building 833 Area.

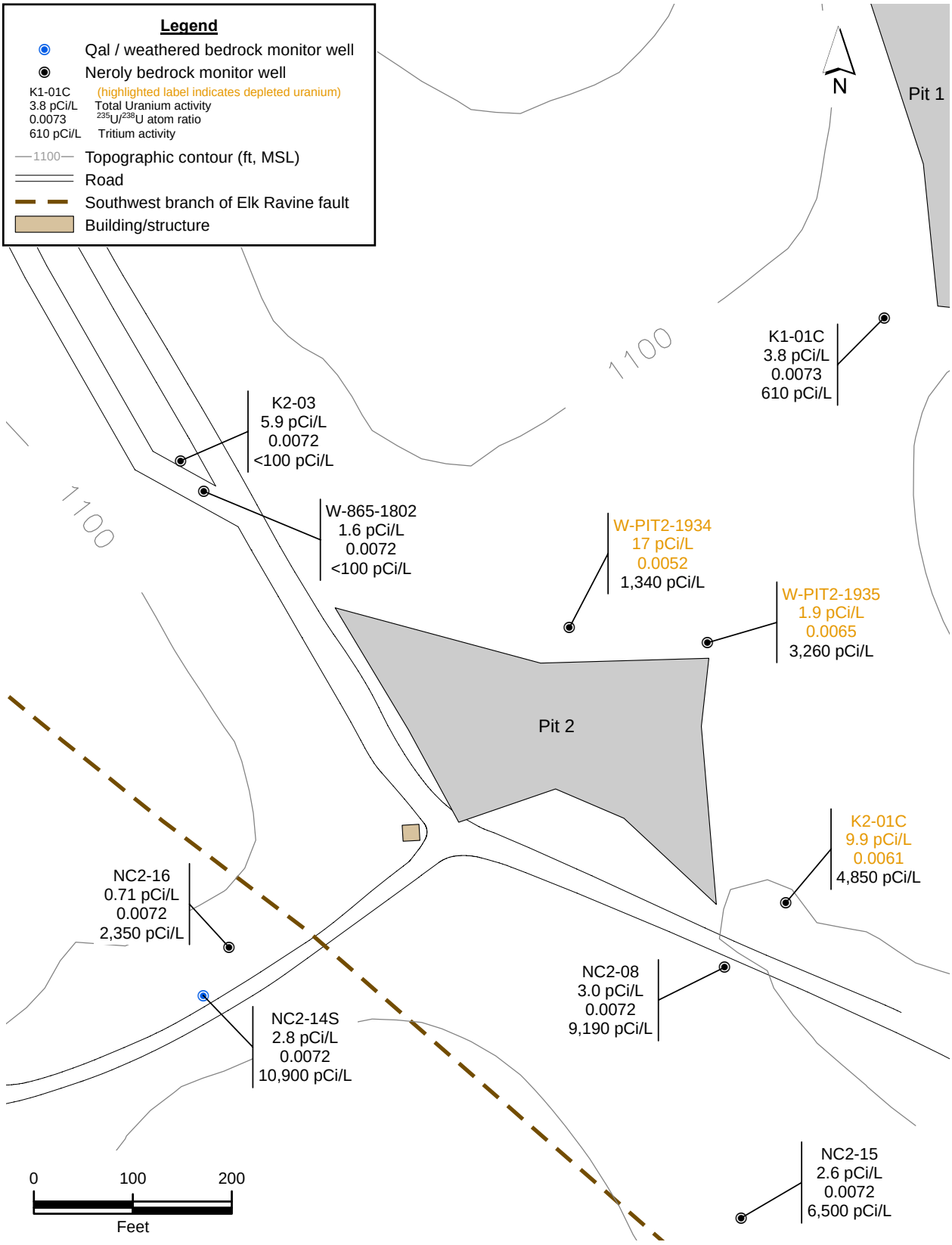
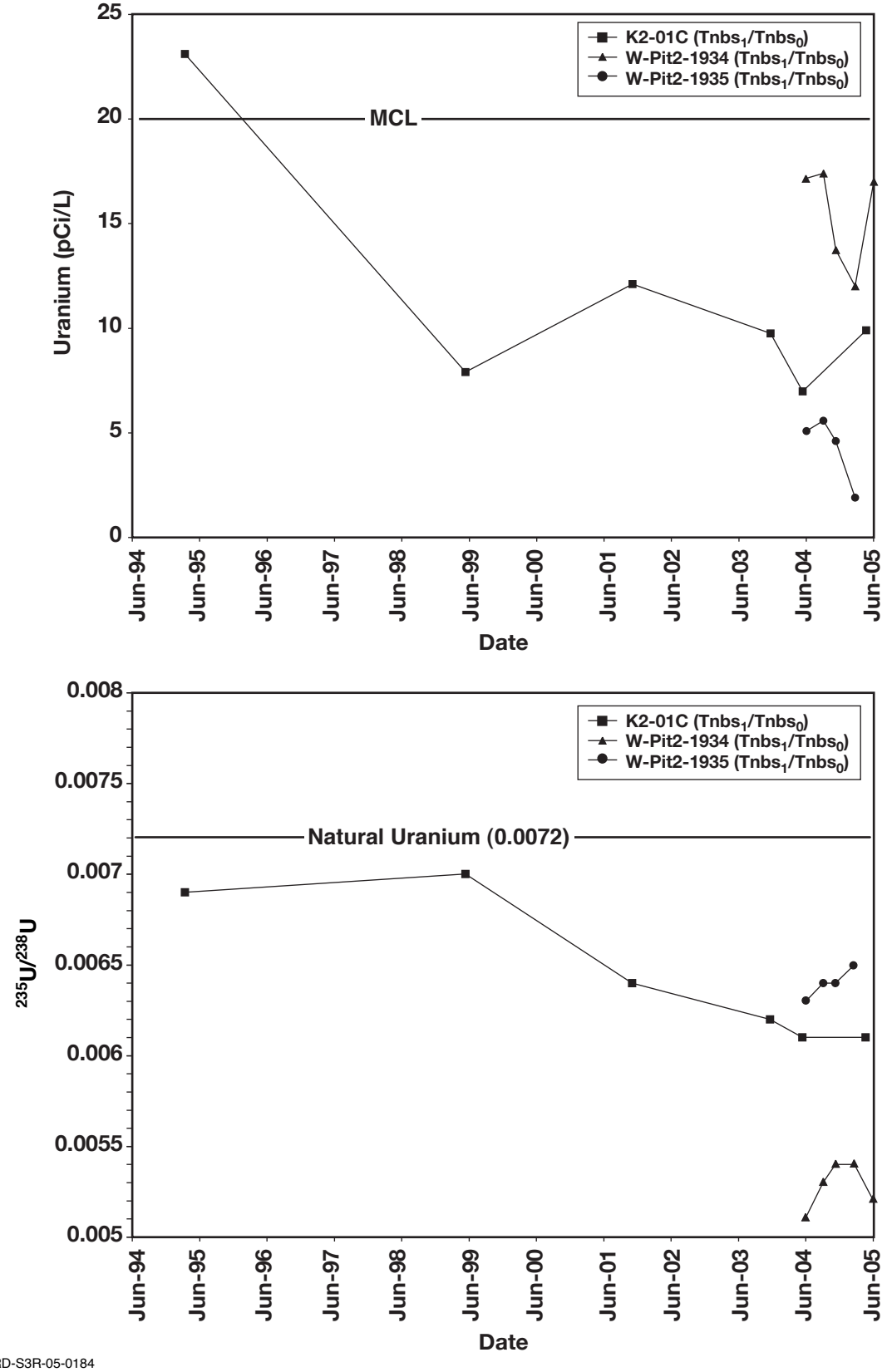
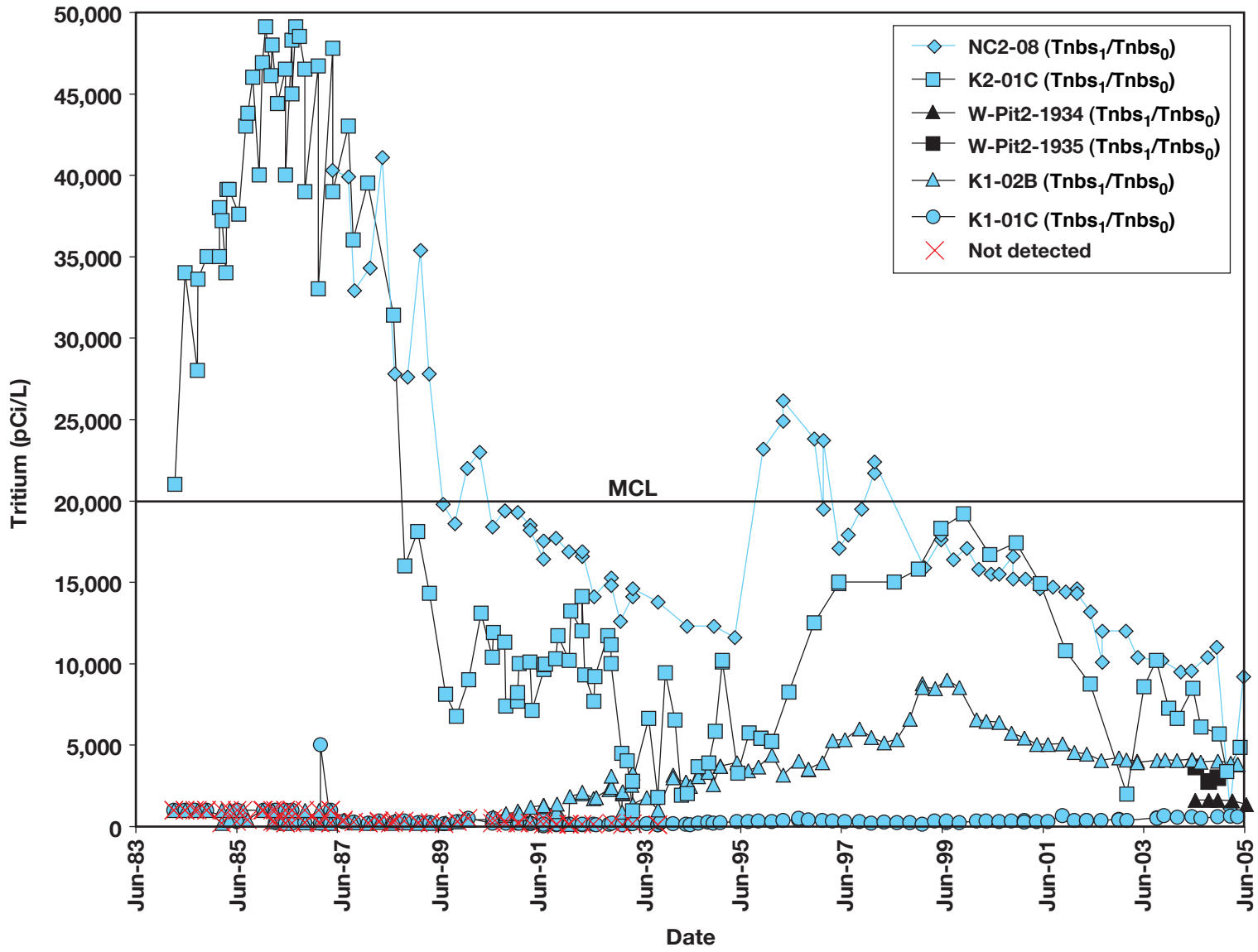


Figure 12-8. Activities of total uranium, $^{235}U/^{238}U$ atom ratio, and tritium in $Tnbs_1/Tnbs_0$ HSU ground water at the Pit 2 Landfill.



ERD-S3R-05-0184

Figure 12-9. Time series plots of uranium activity and $^{235}U/^{238}U$ atom ratio in $Tnbs_1/Tnbs_0$ HSU ground water at the Pit 2 Landfill.



ERD-S3R-05-0183

Figure 12-10. Time-series plots of tritium activity in $Tnbs_1/Tnbs_0$ HSU ground water at the Pit 2 Landfill.

Tables

Table 3-1. Contaminants of concern in the vadose zone and hydrostratigraphic units (HSUs) in Site 300 operable units (OUs).

OU	Hydrostratigraphic Unit	COCs in ground water
Building 834 (OU 2)		
	Tpsg (Vadose zone: VZ)	VOCs
	Tpsg HSU	VOCs TBOS/TKEBS, nitrate
	Tps-$Tnsc_2$ HSU	VOCs
	$Tnbs_2$ (VZ)	None
	$Tnsc_1$ (VZ)	None
	Upper $Tnbs_1$ (VZ)	None
	Lower $Tnbs_1$ HSU	None
Pit 6 Landfill (OU 3)		
North of Corral Hollow Rd	Qt (VZ)	None
	Qt- $Tnbs_1$ North HSU	VOCs, tritium
	Qt- $Tnbs_1$ South HSU	VOCs, tritium, perchlorate, nitrate
	Lower $Tnbs_1$ HSU	None
South of Corral Hollow Rd:	Qal (VZ)	None
	Qal-Tts HSU	None
HE Process Area (OU 4)		
Building 815/HE Lagoons	Qal (VZ)[a]	None
	Qal/WBR HSU[b]	None
	Tpsg (VZ)	VOCs, HMX, RDX
	Tpsg-Tps HSU	VOCs, RDX, perchlorate
	$Tnbs_2$ HSU	VOCs, RDX, perchlorate, nitrate
	$Tnsc_{1b}$ HSU	VOCs, perchlorate, nitrate
	Upper $Tnbs_1$ HSU	None
	Lower $Tnbs_1$ HSU	None
HE Burn Pit	Tpsg (VZ)	None
	Tpsg-Tps HSU	None
	$Tnbs_2$ (VZ)	None
	$Tnsc_{1b}$ HSU	VOCs, perchlorate, nitrate
	Upper $Tnbs_1$ (VZ)	None
	Lower $Tnbs_1$ HSU	None

Table 3-1. Contaminants of concern in the vadose zone and hydrostratigraphic units (HSUs) in Site 300 operable units (OUs). (Cont. Page 2 of 3)

OU	Hydrostratigraphic Unit	COCs in ground water
Building 850 (OU 5)		
	Qal (VZ)[a]	None
	Qal/WBR HSU[b]	Tritium, uranium, nitrate, and perchlorate[c]
	$Tnbs_1$ (VZ)	Tritium, uranium
	$Tnbs_1/Tnbs_0$ HSU	Tritium, nitrate, perchlorate[c]
	Tmss HSU	None
Building 854 (OU 6)		
	Qls (VZ)	None
	Qls HSU	VOCs, perchlorate, nitrate
	$Tnbs_1/Tnsc_0$ HSU	VOCs, perchlorate, nitrate
	Tmss HSU	None
Building 832 Canyon (OU 7)		
Building 832	Qal (VZ)[a]	None
	Qal/WBR HSU[b]	VOCs, perchlorate, nitrate
	$Tnsc_{1b}$ (VZ)	VOCs
	$Tnsc_{1b}$ HSU	VOCs, perchlorate, nitrate
	Upper $Tnbs_1$ HSU	None
	Lower $Tnbs_1$ HSU	None
Building 830		
	Qal (VZ)	None
	Qal/WBR HSU	VOCs, perchlorate, nitrate
	$Tnbs_2$ (VZ)	VOCs
	$Tnsc_{1b}$ HSU	VOCs, perchlorate, nitrate
	Upper $Tnbs_1$ HSU	VOCs
	Lower $Tnbs_1$ HSU	None
OU 8		
Building 801/Pit 8 Landfill	$Tnbs_1$ (VZ)	VOCs
	$Tnbs_1/Tnbs_0$ HSU	VOCs, perchlorate, nitrate
Building 845/Pit 9 Landfill	Lower $Tnbs_1$ (VZ)	HMX, uranium
	$Tnsc_0$ HSU	None
Building 851	$Tnbs_1$ (VZ)	VOCs, uranium
	$Tnsc_0$ (VZ)	Uranium
	Tmss HSU	Uranium
Building 833	Tpsg (VZ)	VOCs

Table 3-1. Contaminants of concern in the vadose zone and hydrostratigraphic units (HSUs) in Site 300 operable units (OUs). (Cont. Page 3 of 3)

OU	Hydrostratigraphic Unit	COCs in ground water
OU 8 (cont.)		
Building 833 (cont.)	Tpsg HSU	VOCs
	Tps (VZ)	None
	$Tnbs_2$ (VZ)	None
	Upper $Tnbs_1$ (VZ)	None
	Lower $Tnbs_1$ HSU	None
Pit 2 Landfill	Qal (Unsaturated)[a]	None
	Qal/WBR HSU[b]	None
	Lower $Tnbs_1$ (VZ)	None
	$Tnbs_1/Tnbs_0$ HSU	Tritium[c], uranium[c], perchlorate[c]
	Tmss HSU	None

Notes:

Yellow shading in Stratigraphic Unit column indicates vadose (unsaturated) zone.

Blue shading Stratigraphic Unit column indicates saturated zone.

COC = Contaminant of concern.

HE = High explosives.

HSU = Hydrostratigraphic unit.

HMX = High melting explosive.

OU = Operable unit.

RDX = Research department explosive.

TBOS/TKEBS = Tetrabutylorthosilicate/tetra-kis-2-ethylbutyl silane.

VOCs = Volatile organic compound.

VZ = Vadose zone.

WBR = Weathered bedrock.

[a] Qal present only in surface water drainage courses in ravines in OU.

[b] Qal/WBR present only in surface water drainage courses in ravines in OU. Variably saturated with seasonal rainfall.

[c] Not identified as a ground water COC in the Interim Site-Wide ROD.

Table 3-2. Offsite water-supply wells in the vicinity of Site 300.

Water-supply well	Well ownership	Current water use	Well status
CDF-1	Union Livestock, Inc.	Domestic, irrigation, livestock watering	Active
CON-1	Union Livestock, Inc.	Domestic, irrigation, livestock watering	Active
CON-2	Union Livestock, Inc.	NA	Inactive
Gallo-1	Gallo Ranch	Livestock watering	Active
Gallo-2	Gallo Ranch	NA	Inactive
STONEHAM1	California Department of Parks and Recreation	Domestic use for SVRA park ranger residence	Active
CARNRW1	California Department of Parks and Recreation	Water-supply for visitors and employees of the Carnegie State SVRA park	Active
CARNRW2	California Department of Parks and Recreation	Dust and fire suppression at the Carnegie State SVRA park	Active
CARNRW3	California Department of Parks and Recreation	NA	Inactive
CARNRW4	California Department of Parks and Recreation	NA	Inactive
CARNRW5	California Department of Parks and Recreation	NA	Inactive
CARNRW6	California Department of Parks and Recreation	NA	Inactive

Notes:

NA = Not applicable; well inactive.

SVRA = State Vehicular Recreation Area.

Table 5-1. Potential ARARs for Site 300 cleanup.

Action(s)	Source	Description	Application
Monitored natural attenuation, ground water extraction and treatment, *in situ* treatment, containment and hydraulic control	*Federal:* Safe Drinking Water Act [42 USCA 300 and 40 CFR 141.11-141.16, 141.50-141.51] (Relevant and appropriate, chemical-specific)	Establishes treatment standards for current potential drinking water sources by setting Maximum Contaminant Levels (MCLs) and non-zero Maximum Contaminant Level Goals (MCLGs).	Contaminants will be reduced to concentrations no higher than MCLs in all Site 300 ground water.
	State: State Water Resources Control Board (SWRCB) Resolution 92-49, Paragraph IIIG (Applicable, chemical-specific)	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must cleanup and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4, requirements to cleanup.	Final cleanup standards for ground water in the final Record of Decision will be equal to background concentrations unless such levels are technically and economically infeasible to achieve. In such cases, cleanup standards will not exceed applicable MCLs, or any more stringent Water Quality Objectives (WQOs).
	Cal. Safe Drinking Water Act [California Health and Safety Code Section 4010.1 et. seq., Title 22, CCR, Div. 4, Chapter 15] (Relevant and appropriate, chemical-specific)	Establishes treatment standards for current potential drinking water sources by setting MCLs which are used as cleanup standards. Those standards for Site 300 are listed in Table 2-2.	Contaminants will be reduced to concentrations no higher than MCLs in all Site 300 ground water.
	Chapter 15, California Code of Regulations (CCR), Title 23, Sections 2550.7, 2550.10 (Applicable, chemical-specific)	Requires monitoring of the effectiveness of the remedial actions.	Contaminant concentrations in *in situ* ground water will be measured during and after implementation of the selected remedies.
	Water Quality Control Plan (Basin Plan) for the Central	Establishes beneficial uses and water quality objectives for	Specific applicable portions of the Basin Plan include beneficial

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 2 of 7)

Action(s)	Source	Description	Application
Monitored natural attenuation, ground water extraction and treatment, *in situ* treatment, containment and hydraulic control *(cont.)*	Valley Regional Water Quality Control Board (CVRWQCB) (Applicable, chemical-specific)	ground water and surface waters in the Central Valley Region as well as implementation plans to meet water quality objectives and protect beneficial uses.	uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated soils or waters or *in-situ* treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding WQOs.
	SWRCB Resolution 88-63 (Applicable, chemical-specific)	Designates all ground and surface waters in the State as drinking water sources with specific exceptions.	Contaminant concentrations in ground water will be reduced to levels protective of beneficial uses.
	SWRCB Resolution 68-16 (Applicable, action-specific)	Requires that high quality surface and ground water be maintained to the maximum extent possible.	This applies to enhanced *in situ* bioremediation of ground water. The levels of residual injected materials or by-products will be below WQOs.
Soil vapor extraction	*State:* Water Quality Control Plan (Basin Plan) for CVRWQCB (Applicable, chemical-specific)	Establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley Region, as well as implementation plans to meet water quality objectives and protect beneficial uses.	As part of the selected remedies, VOC concentrations in soil vapor will be remediated to levels that protect ground water (MCLs, WQOs, or lower).
	Chapter 15, CCR, Title 23, Sections 2550.7, 2550.10 (Applicable, chemical-specific)	Requires monitoring of the effectiveness of the remedial actions.	Contaminant concentration in *in situ* soil vapor will be measured during and after remediation.
	22CCR 66264.601, Article 16, Miscellaneous Units (Relevant and Appropriate, action-specific)	Provides performance standards for operation of SVE units.	Operation of all SVE units must comply with the substantive requirements of this provision.

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 3 of 7)

Action(s)	Source	Description	Application
Surface discharge of treated ground water	*Federal:* **40 CFR 122 (The National Pollutant Discharge Elimination System (NPDES): 40 CFR 122.41(d), (e), (j)(1), (j)(3), (j)(4), and (l)(6); 40 CFR 122.44(d) and (i) ; 40 CFR 122.45, (d), (e), and (f). (Applicable, action-specific)**	**These sections are the substantive requirements of NPDES permits. Off site discharges where the receiving water body is within the area of contamination or in very close proximity to the site, and that are necessary for the remediation are also exempt from permitting.**	**Will be applied to point source discharges of treated ground water to surface water drainages.**
	State: **SWRCB Resolution 68-16 (Anti-degradation policy) (Applicable, chemical-specific)**	**Requires that high quality surface and ground water be maintained to the maximum extent possible.**	**Applies to the discharge of treated ground water. Ground water treatment system effluent will be monitored to ensure that surface and ground water quality will be maintained to the maximum extent possible.**
	Water Quality Control Plan (Basin Plan) for CVRWCB (Applicable, chemical-specific)	**Establishes beneficial uses and WQOs for ground water and surface waters in the Central Valley Region as well as implementation plans to meet water quality objectives and protect beneficial uses.**	**Specific applicable portions of the Basin Plan include beneficial uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated waters must not result in actual water quality exceeding water quality objectives.** **Any new discharge to surface water shall be subject to either an NPDES permit adopted by the CVRWQCB or substantive requirements concurred by the CVRWQCB. Any NPDES permit or substantive requirement must include applicable State requirements under the Water**

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 4 of 7)

Action(s)	Source	Description	Application
Surface discharge of treated ground water *(cont.)*			**Code, including the antidegradation policy.**
Treated ground water reinjection	*Federal:* **Safe Drinking Water Act Underground Injection Control Program (40 CFR 144.12(a)) (Applicable, action-specific)**	**Prohibits any injection activity that would cause the movement of contaminants into underground sources of drinking water that would violate the primary drinking water regulations or adversely affect human health.**	**Treated ground water will be analyzed to verify removal of contaminants to regulatory treatment standards, prior to reinjection. Hydrogeologic analysis will be conducted to ensure contaminants above MCLs would not be introduced into drinking water sources.**
	State: **SWRCB Resolution 68-16 (Anti-degradation policy) (Applicable, action-specific)**	**Requires that high quality ground water be maintained to the maximum extent possible.**	**During implementation of the selected remedies, treated ground water will be analyzed to verify complete removal of contaminants to regulatory treatment standards, prior to re-injection.**
	State: **Water Quality Control Plan (Basin Plan) for CVRWCB (Applicable, chemical-specific)**	**Establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley Region as well as implementation plans to meet water quality objectives and protect beneficial uses.**	**During implementation of the selected remedies, monitoring will be conducted to preclude any activity, including but not limited to, discharge of contaminated waters, from resulting in actual water quality exceeding WQOs.**
Treated soil vapor discharge	*Local:* **San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rules and Regulations, Rules 4651 and 2201 (Applicable, chemical-specific)**	**Regulates stationary sources of air contaminants and limits VOC emissions from the excavation and treatment of contaminated soil.**	**Soil vapor will be treated before discharge to the atmosphere. The compliance standards for treated soil vapor are contained in the Authority to Construct and subsequent Permit to Operate issued by the SJVUAPCD.**

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 5 of 7)

Action(s)	Source	Description	Application
Landfill cap inspection, monitoring, and maintenance	*State:* **Title 22, CCR, 66264.91 - .100; 66264.310 (b) (1), (b) (3) and (b) (4); and 23 CCR 2550.1 - .10, and 27 CCR 20950 (c) (3), (C) (4) and (e) (Relevant and appropriate, action-specific)**	**Provide requirements for inspecting, maintaining, and monitoring landfill caps.**	**Applies to landfill pits 1, 4, 6, and 7 as inspection, monitoring, and maintenance activities are currently being conducted at these landfills.**
	CCR, Title 27, Section 21090 (c) (1) (Applicable, action-specific)	**Requires maintenance of a final cover constructed in accordance with specific prescriptive standards as long as wastes pose a threat to ground water.**	**Applies to wastes contained or left in place at the end of remedial actions that could affect water quality. Includes closure of landfills and other areas where waste has been disposed to land.**
Disposition of hazardous waste	*State:* **Title 22, CCR, Section 66260.1 (Applicable, action-specific)**	**Established criteria for determining waste classification for the purposes of transportation and disposal of wastes.**	**Applies to the spent treatment media (GAC and resin), and to excavated contaminated soil.**
	Title 22, CCR, Section 66262.1 (Applicable-action specific)	**Establishes standards applicable to generators of hazardous waste.**	
	Title 22, CCR, Chapter 18 (Applicable, action-specific)	**Identifies hazardous waste restricted from land disposal unless specific treatment standards are met.**	
	Title 22, CCR, Chapter 13 (Applicable, action-specific)	**Governs transportation of hazardous materials.**	
	Health and Safety Code, Chapter 6.5, Section 253000-25395.15 (Applicable, action-specific)	**Establishes hazardous waste control measures.**	

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 6 of 7)

Action(s)	Source	Description	Application
Disposition of hazardous waste *(cont.)*	***State:*** **Water Quality Control Plan (Basin Plan) for CVRWCB (Applicable, chemical-specific)**	**Establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley Region as well as implementation plans to meet water quality objectives and protect beneficial uses.**	**Specific applicable portions of the Basin Plan include beneficial uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated soils or waters or *in situ* treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.**
Closure	***State:*** **22 CCR 66264.110-120 (Applicable, action-specific)**	**Requires that a facility be closed in a manner that minimizes the need for further maintenance and protects human health and the environment, and provides for post-closure care.**	**Any facility closures must meet this State equivalent of RCRA.**
Storm water controls	***Federal:*** **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by California Storm Water Permit for Industrial Activities, State Water Resources Control Board Order #97-03-DWQ. (Applicable, action-specific)**	**Regulates pollutants in discharges of storm water associated with hazardous waste treatment, storage, and disposal facilities, wastewater treatment plants, landfills, land application sites, and open dumps. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**Applies to storm water discharges from industrial areas. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate compliance.**
	Federal: **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by State Water Resources Control Board Order No. 99-08 DWQ**	**Regulates pollutants in discharges of storm water associated with construction activity (clearing, grading, or excavation) involving the disturbance of 5 acres or more.**	**Applies to construction areas over one acre or more in size. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate**

Table 5-1. Potential ARARs for Site 300 cleanup. (Cont. Page 7 of 7)

Action(s)	Source	Description	Application
Storm water controls *(cont.)*	**(Applicable, action-specific)**	**Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**compliance. Projects meeting the disturbance threshold will a develop project- specific construction Storm Water Pollution Prevention Plan.**
Protection of endangered species	***Federal:*** **Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2] (Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. NEPA implementation requirements may apply.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**
	State: **California Endangered Species Act, California Department of Fish and Game Sections 2050-2068 (Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**
Land use controls	**Hazardous Waste Property (22 CCR 67391.1) (Applicable, action-specific)**	**Prohibits the federal government from transferring land where hazardous substances remain at levels that do not allow unrestricted use of the land, unless a land use covenant or other institutional control is used to ensure that future land use will be compatible with the levels of remaining hazardous materials.**	**Would apply in the event that DOE transfers property at Site 300 to another owner.**

Table 12-1. Comparison of maximum contaminants of concern (COC) concentration detected in surface soil at Building 851 to residential surface soil preliminary remediation goals (PRGs).

COC in surface soil	Maximum detected concentrations	Residential surface soil PRG
RDX	0.131 mg/kg	4.4 mg/kg
Cadmium	9 mg/kg	37 mg/kg
Copper	79 mg/kg	3,100 mg/kg
Zinc	360 mg/kg	23,000 mg/kg
Uranium-238	14.1 pCi/g	4.46 pCi/g

Notes:

COC = Contaminants of concern.

mg/kg = Milligram per kilogram.

pCi/g = Picocuries per liter.

PRG = U.S. EPA Region 9 preliminary remediation goal.

RDX = Research department explosive

Appendix A
2005 Ground Water Data on CD

List of Analytical Data Tables

A-1. Building 834 OU VOCs in ground water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-834-1709	1/20/05	E624	16,000 D	100 D	260 D	0.86	<0.5	2.9	<0.5	<0.5	1.8	<0.5	4	<0.5	<0.5	<0.5
W-834-1709	8/9/05	E601	9,200 D	64 D	910 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D
W-834-1711	1/20/05	E624	1,100 D	7.2	0.79	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-1711	8/9/05	E601	860 D	3.8	0.57	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-2001	2/1/05	E624	710 D	17 D	20 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D
W-834-2001	8/10/05	E624	6,000 D	<50 D	370 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-2113	6/28/05	E624	13,000 D	<50 D	110 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-2113	9/27/05	E624	20,000 DHL	42 H	150 H	4.4 H	2.1 H	7.1 H	<1 H	<1 H	<1 H	<1 H	5.5 H	6.1 H	<1 H	<1 H
W-834-2113	10/17/05	E624	20,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH
W-834-2113	10/17/05 DUP	E624	17,000 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH
W-834-2117	6/28/05	E624	20,000 D	99 D	84 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-2117	9/27/05	E624	22,000 DHL	80 H	130 H	1.7 H	4 H	8.1 H	<1 H	<1 H	<1 H	<1 H	4.2 H	6.1 H	<1 H	<1 H
W-834-2117	10/4/05	E624	10,000 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<1,000 DH	<500 DH
W-834-2117	10/04/05 DUP	E624	14,000 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<1,000 DH	<500 DH
W-834-2118	6/29/05	E624	600 BD	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-834-2118	9/27/05	E624	310 DHL	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H	<1 H
W-834-2118	10/17/05	E624	320 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH
W-834-2119	5/23/05	E601	7,000 D	8.5	6.1	0.5	1.1	2.4	<0.5	<0.5	<0.5	<0.5	1.3	2.1	<0.5	<0.5
W-834-2119	8/22/05	E624	10,000 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-2119	10/4/05	E624	6,300 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<1,000 DH	<500 DH
W-834-A1	1/20/05	E624	170,000 D	890 D	270 D	14	<0.5	30	<0.5	2.2	62	<0.5	16	29	<0.5	0.63
W-834-A1	8/4/05	E624	190,000 BD	1,000 D	410 D	<50 D	<50 D	<50 D	<50 D	<50 D	69 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-A2	1/20/05	E624	7,500 D	12 D	960 D	1.2	<0.5	2	<0.5	<0.5	2.2	<0.5	2.9	<0.5	<0.5	<0.5
W-834-B2	3/14/05	E624	1,500 D	48 D	160 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-834-B2	6/14/05	E601	4,200 D	190 D	1,800 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-B2	8/2/05	E601	3,500 D	76 D	850 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-B2	10/11/05	E601	5,600 BD	120 D	990 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-B3	3/10/05	E624	120 D	<5 D	2,900 D	<5 DE	<5 D	<5 D	<5 D	<5 D	10 D	<5 D	<5 D	<5 D	<5 D	5.8 D
W-834-B3	6/14/05	E601	380 D	<5 D	2,800 D	<5 D	<5 D	<5 D	<5 D	<5 D	12 D	<5 D	<5 D	<5 D	<5 D	8.1 D
W-834-B3	8/2/05	E601	1,900 D	<25 D	8,000 D	<25 D	<25 D	<25 D	<25 D	<25 D	54 D	<25 D	<25 D	<25 D	<25 D	36 D
W-834-B3	10/11/05	E601	690 BD	<5 D	3,700 D	<5 D	<5 D	<5 D	<5 D	<5 D	11 D	<5 D	<5 D	<5 D	<5 D	6 D
W-834-B4	2/7/05	E624	18,000 D	<30 D	7,600 D	<30 D	<30 D	<30 D	<30 D	<30 D	32 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-B4	8/4/05	E601	27,000 BD	42 D	14,000 D	<25 D	<25 D	<25 D	<25 D	<25 D	52 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-C2	2/1/05	E624	500 D	1.8 D	7.4 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D
W-834-C4	1/31/05	E624	32	<0.5	29	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-C4	8/4/05	E601	140 BD	<0.5	130 D	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-C5	1/31/05	E624	25,000 D	68 D	6,900 D	<30 D	<30 D	<30 D	<30 D	<30 D	32 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-C5	01/31/05 DUP	E624	28,000 DHL	<500 DH	8,500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<1,000 DH	<500 DH
W-834-C5	8/4/05	E601	39,000 BD	140 D	19,000 D	<25 D	<25 D	<25 D	<25 D	<25 D	70 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D3	2/7/05	E624	<20 D	<20 D	9,300 D	<20 D	<20 D	<20 D	<20 D	<20 D	<20 D	<20 D	<20 D	<20 D	<20 D	130 D
W-834-D3	8/10/05	E601	8.2 D	<5 D	2,000 D	5.9 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	74 D
W-834-D4	3/10/05	E624	2,100 D	<25 DE	15,000 D	<25 DE	<25 D	<25 D	<25 D	<25 D	26 D	<25 D	<25 D	<25 D	<25 D	<25 DE
W-834-D4	6/14/05	E601	20,000 D	110 D	1,900 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D4	8/2/05	E601	20,000 D	130 D	4,200 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D4	10/11/05	E601	18,000 BD	110 D	7,500 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D5	3/10/05	E624	1,300 D	4.6 D	460 D	<2.5 D	<2.5 D	<2.5 DE	<2.5 D	<2.5 D	<2.5 DE	<2.5 D	<2.5 DE	<2.5 D	<2.5 D	<2.5 DE
W-834-D5	8/9/05	E601	88	0.94	170 D	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.75
W-834-D6	3/10/05	E624	13,000 D	42 D	640 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D6	6/14/05	E601	6,400 D	<25 D	660 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D6	8/2/05	E601	2,300 D	8 D	220 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	6 D	<5 D
W-834-D6	10/11/05	E601	3,500 BD	9 D	550 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	5.3 D	<5 D
W-834-D7	3/10/05	E624	1,600 D	36 D	86 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-834-D7	6/14/05	E601	3,900 D	29 D	450 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-D7	8/2/05	E624	230 D	3	24	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-834-D7	10/11/05	E601	3,300 BD	13 D	240 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-D10	2/7/05	E624	2,200 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-D10	8/15/05	E624	6,800 BD	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-D10	08/15/05 DUP	E624	8,800 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH
W-834-D11	2/7/05	E624	6,300 D	<30 D	350 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-D11	02/07/05 DUP	E624	6,200 D	<30 D	360 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-D11	8/9/05	E601	620 D	0.93	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-D12	3/10/05	E624	3,700 D	11 D	300 D	<5 D	<5 D	<5 DE	<5 D	<5 D	<5 DE	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-D12	6/14/05	E601	870 D	2.4 D	170 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	1.3 D	<1 D	<1 D	<1 D
W-834-D12	8/2/05	E624	47	<1	3.7	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-834-D12	10/12/05	E601	460 BD	2.6	38	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.77	<0.5	<0.5	<0.5
W-834-D13	3/10/05	E624	20,000 D	160 D	190 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 DE	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D13	6/14/05	E601	16,000 D	130 D	140 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D13	8/2/05	E601	1,200 D	12	8.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-D13	10/12/05	E601	27,000 BD	180 D	290 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D14	2/7/05	E624	13,000 D	38 D	590 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-D14	02/07/05 DUP	E624	25,000 D	38 D	560 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-D14	8/9/05	E601	3,900 D	7.6 D	400 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-D15	2/7/05	E624	23,000 D	<30 D	300 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-D15	8/4/05	E601	31,000 BD	50 D	280 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-D18	2/8/05	E624	290 D	0.51	130 D	0.51	<0.5	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-D18	8/15/05	E601	54 B	<0.5	25	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-D18	08/15/05 DUP	E601	40	<0.5	17	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-1. Building 834 OU VOCs in ground water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-834-H2	8/10/05	E601	190 D	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-J1	3/14/05	E624	520 D	0.66	<0.5 E	<0.5	<0.5	0.91	<0.5	<0.5	<0.5	<0.5	0.98	<0.5 E	<0.5	<0.5
W-834-J1	6/16/05	E601	94	0.75	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.7	<0.5	<0.5	<0.5
W-834-J1	8/2/05	E601	100 D	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.7	<0.5	<0.5	<0.5
W-834-J1	10/12/05	E601	450 BD	<0.5	<0.5	<0.5	<0.5	0.52	<0.5	<0.5	<0.5	<0.5	1.9	<0.5	<0.5	<0.5
W-834-J2	2/1/05	E624	630 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D
W-834-J2	8/8/05	E601	310 BD	0.63	0.52	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-K1A	8/4/05	E624	4.3 B	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-834-M1	2/8/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	3.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-M1	02/08/05 DUP	E624	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	4.3 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
W-834-M1	8/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	3.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S1	3/14/05	E624	9,100 D	480 D	400 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D
W-834-S1	6/16/05	E601	5,400 D	330 D	420 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-S1	06/16/05 DUP	E601	6,000 D	330 D	430 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-S1	8/2/05	E624	840 D	28 D	34 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-834-S1	08/02/05 DUP	E624	880 DH	33 DH	39 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH
W-834-S1	10/12/05	E624	7,200 BD	240 D	340 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-S12A	6/16/05	E601	7,800 D	<25 D	28 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-834-S12A	8/2/05	E624	8,100 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-S12A	10/12/05	E624	8,400 BD	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-834-S13	6/16/05	E601	1,700 D	6.4 D	59 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-834-S13	06/16/05 DUP	E601	1,600 D	8.4	62	<0.5	<0.5	1.2	<0.5	<0.5	<0.5	<0.5	1.8	<0.5	<0.5	<0.5
W-834-S13	8/2/05	E601	610 D	2.3	11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S13	10/12/05	E601	1,300 BD	5.3 D	52 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-834-S4	2/1/05	E624	5.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S4	8/8/05	E601	5.2 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S6	2/3/05	E624	3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S6	8/11/05	E601	3.4 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S7	2/3/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S7	8/11/05	E601	<0.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-S8	2/1/05	E624	2,400 D	31 D	48 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-S8	8/8/05	E624	1,500 BD	27 D	44 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-S9	2/1/05	E624	1,900 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-S9	8/8/05	E624	2,000 BD	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-834-T1	1/18/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T1	4/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T1	8/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T1	10/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T3	1/18/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T3	4/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T3	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T3	10/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T5	2/9/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T5	8/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T7A	2/9/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-T7A	8/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-U1	1/31/05	E624	49,000 D	300 D	3,200 D	<30 D	<30 D	<30 D	<30 D	<30 D	42 D	<30 D	<30 D	<30 D	<30 D	<30 D
W-834-U1	01/31/05 DUP	E624	37,000 DHL	<500 DH	2,500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<500 DH	<1,000 DH	<500 DH
W-834-U1	8/9/05	E624	45,000 D	230 D	1,900 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D	<200 D

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	1,3-Dichlorobenzene (µg/L)	Benzene (µg/L)	Bromodichloromethane (µg/L)	Dibromochloromethane (µg/L)	Methylene chloride (µg/L)	Toluene (µg/L)	Total Trihalomethanes (µg/L)	Total xylene isomers (µg/L)
W-834-1709	1/20/05	E624	1 of 31	260 D	-	-	-	-	-	-	-	-
W-834-1709	8/9/05	E601	1 of 19	910 D	-	-	-	-	-	-	-	-
W-834-1711	1/20/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-1711	8/9/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-2001	2/1/05	E624	2 of 31	20 D	-	-	-	-	-	-	-	2.3 D
W-834-2001	8/10/05	E624	1 of 30	370 D	-	-	-	-	-	-	-	-
W-834-2113	6/28/05	E624	1 of 30	120 D	-	-	-	-	-	-	-	-
W-834-2113	9/27/05	E624	1 of 30	150 H	-	-	-	-	-	-	-	-
W-834-2113	10/17/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2113	10/17/05 DUP	E624	1 of 29	-	-	-	-	-	160 BDHL	-	-	-
W-834-2117	6/28/05	E624	1 of 30	84 D	-	-	-	-	-	-	-	-
W-834-2117	9/27/05	E624	1 of 30	130 H	-	-	-	-	-	-	-	-
W-834-2117	10/4/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2117	10/04/05 DUP	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2118	6/29/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2118	9/27/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2118	10/17/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2119	5/23/05	E601	1 of 18	6.6	-	-	-	-	-	-	-	-
W-834-2119	8/22/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-2119	10/4/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-A1	1/20/05	E624	4 of 31	270 D	-	1.2	-	-	2	1.4	-	-
W-834-A1	8/4/05	E624	1 of 30	430 D	-	-	-	-	-	-	-	-
W-834-A2	1/20/05	E624	1 of 31	960 D	-	-	-	-	-	-	-	-
W-834-B2	3/14/05	E624	1 of 29	160 D	-	-	-	-	-	-	-	-
W-834-B2	6/14/05	E601	1 of 19	1,800 D	-	-	-	-	-	-	-	-
W-834-B2	8/2/05	E601	1 of 19	850 D	-	-	-	-	-	-	-	-
W-834-B2	10/11/05	E601	1 of 19	990 D	-	-	-	-	-	-	-	-
W-834-B3	3/10/05	E624	1 of 29	2,900 D	-	-	-	-	-	-	-	-
W-834-B3	6/14/05	E601	1 of 19	2,800 D	-	-	-	-	-	-	-	-
W-834-B3	8/2/05	E601	1 of 19	8,000 D	-	-	-	-	-	-	-	-
W-834-B3	10/11/05	E601	1 of 19	3,700 D	-	-	-	-	-	-	-	-
W-834-B4	2/7/05	E624	1 of 31	7,600 D	-	-	-	-	-	-	-	-
W-834-B4	8/4/05	E601	1 of 19	14,000 D	-	-	-	-	-	-	-	-
W-834-C2	2/1/05	E624	1 of 31	7.4 D	-	-	-	-	-	-	-	-
W-834-C4	1/31/05	E624	1 of 31	29	-	-	-	-	-	-	-	-
W-834-C4	8/4/05	E601	1 of 19	130 D	-	-	-	-	-	-	-	-
W-834-C5	1/31/05	E624	1 of 31	6,900 D	-	-	-	-	-	-	-	-
W-834-C5	01/31/05 DUP	E624	0 of 25	-	-	-	-	-	-	-	-	-
W-834-C5	8/4/05	E601	1 of 19	19,000 D	-	-	-	-	-	-	-	-
W-834-D3	2/7/05	E624	1 of 31	9,300 D	-	-	-	-	-	-	-	-
W-834-D3	8/10/05	E601	1 of 19	2,000 D	-	-	-	-	-	-	-	-
W-834-D4	3/10/05	E624	1 of 29	15,000 D	-	-	-	-	-	-	-	-
W-834-D4	6/14/05	E601	1 of 19	1,900 D	-	-	-	-	-	-	-	-
W-834-D4	8/2/05	E601	1 of 19	4,200 D	-	-	-	-	-	-	-	-
W-834-D4	10/11/05	E601	1 of 19	7,500 D	-	-	-	-	-	-	-	-
W-834-D5	3/10/05	E624	1 of 29	460 D	-	-	-	-	-	-	-	-
W-834-D5	8/9/05	E601	1 of 19	170 D	-	-	-	-	-	-	-	-
W-834-D6	3/10/05	E624	1 of 29	640 D	-	-	-	-	-	-	-	-
W-834-D6	6/14/05	E601	1 of 19	660 D	-	-	-	-	-	-	-	-
W-834-D6	8/2/05	E601	1 of 19	220 D	-	-	-	-	-	-	-	-
W-834-D6	10/11/05	E601	1 of 19	550 D	-	-	-	-	-	-	-	-
W-834-D7	3/10/05	E624	1 of 29	86 D	-	-	-	-	-	-	-	-
W-834-D7	6/14/05	E601	1 of 19	450 D	-	-	-	-	-	-	-	-
W-834-D7	8/2/05	E624	1 of 30	24	-	-	-	-	-	-	-	-
W-834-D7	10/11/05	E601	1 of 19	240 D	-	-	-	-	-	-	-	-
W-834-D10	2/7/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-D10	8/15/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-D10	08/15/05 DUP	E624	0 of 27	-	-	-	-	-	-	-	-	-
W-834-D11	2/7/05	E624	1 of 31	350 D	-	-	-	-	-	-	-	-
W-834-D11	02/07/05 DUP	E624	1 of 31	360 D	-	-	-	-	-	-	-	-
W-834-D11	8/9/05	E601	1 of 19	1.3	-	-	-	-	-	-	-	-
W-834-D12	3/10/05	E624	1 of 29	300 D	-	-	-	-	-	-	-	-
W-834-D12	6/14/05	E601	1 of 19	170 D	-	-	-	-	-	-	-	-
W-834-D12	8/2/05	E624	1 of 30	3.7	-	-	-	-	-	-	-	-
W-834-D12	10/12/05	E601	1 of 19	38	-	-	-	-	-	-	-	-
W-834-D13	3/10/05	E624	1 of 29	190 D	-	-	-	-	-	-	-	-
W-834-D13	6/14/05	E601	1 of 19	140 D	-	-	-	-	-	-	-	-
W-834-D13	8/2/05	E601	1 of 19	8.6	-	-	-	-	-	-	-	-
W-834-D13	10/12/05	E601	1 of 19	290 D	-	-	-	-	-	-	-	-
W-834-D14	2/7/05	E624	1 of 31	590 D	-	-	-	-	-	-	-	-
W-834-D14	02/07/05 DUP	E624	1 of 31	560 D	-	-	-	-	-	-	-	-
W-834-D14	8/9/05	E601	1 of 19	400 D	-	-	-	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	1,3-Dichlorobenzene (µg/L)	Benzene (µg/L)	Bromodichloromethane (µg/L)	Dibromochloromethane (µg/L)	Methylene chloride (µg/L)	Toluene (µg/L)	Total Trihalomethanes (µg/L)	Total xylene isomers (µg/L)
W-834-D15	2/7/05	E624	1 of 31	300 D	-	-	-	-	-	-	-	-
W-834-D15	8/4/05	E601	1 of 19	280 D	-	-	-	-	-	-	-	-
W-834-D18	2/8/05	E624	1 of 31	130 D	-	-	-	-	-	-	-	-
W-834-D18	8/15/05	E601	1 of 19	25	-	-	-	-	-	-	-	-
W-834-D18	08/15/05 DUP	E601	1 of 16	17	-	-	-	-	-	-	-	-
W-834-H2	8/10/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-J1	3/14/05	E624	0 of 29	-	-	-	-	-	-	-	-	-
W-834-J1	6/16/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-J1	8/2/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-J1	10/12/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-J2	2/1/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-J2	8/8/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-K1A	8/4/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-M1	2/8/05	E624	2 of 31	-	1.2	-	0.56	-	-	-	-	-
W-834-M1	02/08/05 DUP	E624	3 of 25	-	1.5 H	-	0.7 H	0.5 H	-	-	-	-
W-834-M1	8/8/05	E601	2 of 19	-	0.92	-	-	-	-	-	4.1	-
W-834-S1	3/14/05	E624	1 of 29	400 D	-	-	-	-	-	-	-	-
W-834-S1	6/16/05	E601	1 of 19	420 D	-	-	-	-	-	-	-	-
W-834-S1	06/16/05 DUP	E601	1 of 19	430 D	-	-	-	-	-	-	-	-
W-834-S1	8/2/05	E624	1 of 30	34 D	-	-	-	-	-	-	-	-
W-834-S1	08/02/05 DUP	E624	1 of 29	39 DH	-	-	-	-	-	-	-	-
W-834-S1	10/12/05	E624	1 of 30	340 D	-	-	-	-	-	-	-	-
W-834-S12A	6/16/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-S12A	8/2/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-S12A	10/12/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-S13	6/16/05	E601	1 of 19	59 D	-	-	-	-	-	-	-	-
W-834-S13	06/16/05 DUP	E601	1 of 18	56 D	-	-	-	-	-	-	-	-
W-834-S13	8/2/05	E601	1 of 19	11	-	-	-	-	-	-	-	-
W-834-S13	10/12/05	E601	1 of 19	52 D	-	-	-	-	-	-	-	-
W-834-S4	2/1/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-S4	8/8/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-S6	2/3/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-S6	8/11/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-S7	2/3/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-S7	8/11/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-S8	2/1/05	E624	1 of 31	48 D	-	-	-	-	-	-	-	-
W-834-S8	8/8/05	E624	1 of 30	44 D	-	-	-	-	-	-	-	-
W-834-S9	2/1/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-S9	8/8/05	E624	0 of 30	-	-	-	-	-	-	-	-	-
W-834-T1	1/18/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-T1	4/21/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T1	8/1/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T1	10/3/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T3	1/18/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-T3	4/21/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T3	7/19/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T3	10/3/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T5	2/9/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-T5	8/9/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-T7A	2/9/05	E624	0 of 31	-	-	-	-	-	-	-	-	-
W-834-T7A	8/10/05	E601	0 of 19	-	-	-	-	-	-	-	-	-
W-834-U1	1/31/05	E624	1 of 31	3,200 D	-	-	-	-	-	-	-	-
W-834-U1	01/31/05 DUP	E624	0 of 25	-	-	-	-	-	-	-	-	-
W-834-U1	8/9/05	E624	1 of 30	1,900 D	-	-	-	-	-	-	-	-

A-2. Building 834 OU TBOS in ground water.

Sample Location	Sample Date	TBOS (µg/L)
W-834-1709	1/20/05	2.9
W-834-1711	1/20/05	31
W-834-2001	2/1/05	<1
W-834-2113	8/11/05	<100
W-834-2117	8/11/05	<100
W-834-2118	8/11/05	<100
W-834-2119	5/23/05	<1
W-834-A1	1/20/05	<1
W-834-A2	1/20/05	1.5
W-834-B2	3/14/05	<1
W-834-B3	3/10/05	<1 DO
W-834-B4	2/7/05	<1
W-834-C2	2/1/05	<1
W-834-C4	1/31/05	<1
W-834-C5	1/31/05	<1
W-834-D3	8/10/05	4,500 DJ
W-834-D4	3/10/05	22,000 DO
W-834-D4	8/2/05	59,000 D
W-834-D5	3/10/05	220 DO
W-834-D5	8/9/05	130 DJ
W-834-D6	3/10/05	<1
W-834-D6	8/2/05	55 D
W-834-D7	3/10/05	4.1
W-834-D11	2/7/05	<1
W-834-D11	02/07/05 DUP	11
W-834-D12	3/10/05	<1 DE
W-834-D13	3/10/05	<1 O
W-834-D13	8/2/05	1.1 D
W-834-D14	2/7/05	6.2
W-834-D14	02/07/05 DUP	1.5
W-834-D15	2/7/05	<1
W-834-D18	2/8/05	<1
W-834-J1	3/14/05	<1
W-834-J2	2/1/05	<1
W-834-M1	2/8/05	<1
W-834-S1	3/14/05	<1
W-834-S1	8/2/05	<1
W-834-S4	2/1/05	<1
W-834-S6	2/3/05	<1
W-834-S7	2/3/05	<1
W-834-S8	2/1/05	<1
W-834-S9	2/1/05	<1
W-834-T1	1/18/05	<1
W-834-T3	1/18/05	<1
W-834-T3	7/19/05	<1
W-834-T5	2/9/05	<1
W-834-U1	1/31/05	<1

OU2-TBOS [ug/L] 2005 data (prepared 2006-03-08 07:58:08, Oracle)

A-3. Building 834 OU nitrate in ground water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)
W-834-1709	1/20/05	-	11.9
W-834-1709	8/9/05	-	-
W-834-1711	1/20/05	-	93 D
W-834-1711	8/9/05	-	-
W-834-2001	2/1/05	-	1.8
W-834-2001	8/10/05	-	-
W-834-2113	6/28/05	<0.1 L	<0.1 L
W-834-2117	6/28/05	<0.1 L	<0.1 L
W-834-2117	10/4/05	-	-
W-834-2117	10/04/05 DUP	-	-
W-834-2118	6/29/05	25 D	110 D
W-834-2118	10/17/05	-	-
W-834-2119	5/23/05	-	-
W-834-2119	8/22/05	-	-
W-834-A1	1/20/05	-	0.68
W-834-A2	1/20/05	-	14.5
W-834-B2	3/14/05	-	39
W-834-B3	3/10/05	-	9.4
W-834-B4	2/7/05	-	20.4
W-834-C2	2/1/05	-	85.5
W-834-C4	1/31/05	-	47.2
W-834-C5	1/31/05	-	75.6
W-834-C5	01/31/05 DUP	-	75 D
W-834-D3	2/7/05	-	<0.44
W-834-D4	3/10/05	-	5.9
W-834-D5	3/10/05	-	16
W-834-D6	3/10/05	-	48
W-834-D7	3/10/05	-	68
W-834-D11	2/7/05	-	86.9
W-834-D11	02/07/05 DUP	-	88.4
W-834-D12	3/10/05	-	69
W-834-D13	3/10/05	-	120 D
W-834-D14	2/7/05	-	37.6
W-834-D14	02/07/05 DUP	-	42.3
W-834-D15	2/7/05	-	118 D
W-834-D18	2/8/05	-	58.8
W-834-J1	3/14/05	-	72
W-834-J2	2/1/05	-	106 D
W-834-M1	2/8/05	61.1 D	270 D
W-834-M1	02/08/05 DUP	57 D	250 D
W-834-M1	02/08/05 DUP	65 D	290 D
W-834-M1	02/08/05 DUP	-	267 D
W-834-S1	3/14/05	-	54
W-834-S4	2/1/05	-	132 D
W-834-S6	2/3/05	-	164 D
W-834-S7	2/3/05	-	328 D
W-834-S8	2/1/05	-	116 D
W-834-S9	2/1/05	-	93.2 D
W-834-T1	1/18/05	-	<0.44
W-834-T1	8/1/05	-	<0.5

A-3. Building 834 OU nitrate in ground water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)
W-834-T3	1/18/05	-	21.7
W-834-T3	7/19/05	-	<0.5 H
W-834-T5	2/9/05	-	90.6 D
W-834-U1	1/31/05	-	<0.44
W-834-U1	01/31/05 DUP	-	<0.1

OU2-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-08 08:35:53, Oracle)

A-4. Building 834 OU BTEX compounds in ground water.

Sample Location	Sample Date	Benzene (µg/L)	1,3-Dichlorobenzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Total xylene isomers (µg/L)
W-834-1709	1/20/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-1709	8/9/05	-	<12 D	-	-	-
W-834-1711	1/20/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-1711	8/9/05	-	<0.5	-	-	-
W-834-2001	2/1/05	<1 D	<1 D	<1 D	<1 D	2.3 D
W-834-2001	8/10/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-2113	6/28/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-2113	9/27/05	<1 H	<1 H	<1 H	<1 H	<2 H
W-834-2113	10/17/05	<1,000 DH	<1,000 DH	<1,000 DH	<1,000 DH	<2,000 DH
W-834-2113	10/17/05 DUP	<100 DH	<100 DH	<100 DH	<100 DH	<100 DH
W-834-2117	6/28/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-2117	9/27/05	<1 H	<1 H	<1 H	<1 H	<2 H
W-834-2117	10/4/05	<1,000 DH	<500 DH	<1,000 DH	<1,000 DH	<2,000 DH
W-834-2117	10/04/05 DUP	<1,000 DH	<500 DH	<1,000 DH	<1,000 DH	<2,000 DH
W-834-2118	6/29/05	<1	<1	<1	<1	<2
W-834-2118	9/27/05	<1 H	<1 H	<1 H	<1 H	<2 H
W-834-2118	10/17/05	<10 DH	<10 DH	<10 DH	<10 DH	<20 DH
W-834-2119	5/23/05	-	<0.5	-	-	-
W-834-2119	8/22/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-2119	10/4/05	<1,000 DH	<500 DH	<1,000 DH	<1,000 DH	<2,000 DH
W-834-A1	1/20/05	1.2	<0.5	<0.5	1.4	<1
W-834-A1	8/4/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-A2	1/20/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-B2	3/14/05	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<5 D
W-834-B2	6/14/05	-	<5 D	-	-	-
W-834-B2	8/2/05	-	<5 D	-	-	-
W-834-B2	10/11/05	-	<25 D	-	-	-
W-834-B3	3/10/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-B3	6/14/05	-	<5 D	-	-	-
W-834-B3	8/2/05	-	<25 D	-	-	-
W-834-B3	10/11/05	-	<5 D	-	-	-
W-834-B4	2/7/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-B4	8/4/05	-	<25 D	-	-	-
W-834-C2	2/1/05	<1 D	<1 D	<1 D	<1 D	<2 D
W-834-C4	1/31/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-C4	8/4/05	-	<0.5	-	-	-
W-834-C5	1/31/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-C5	01/31/05 DUP	<1,000 DH	<500 DH	<1,000 DH	<1,000 DH	<2,000 DH

A-4. Building 834 OU BTEX compounds in ground water.

Sample Location	Sample Date	Benzene (µg/L)	1,3-Dichlorobenzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Total xylene isomers (µg/L)
W-834-C5	8/4/05	-	<25 D	-	-	-
W-834-D3	2/7/05	<20 D	<20 D	<20 D	<20 D	<30 D
W-834-D3	8/10/05	-	<5 D	-	-	-
W-834-D4	3/10/05	<25 D	<25 D	<25 D	<25 D	<50 D
W-834-D4	6/14/05	-	<25 D	-	-	-
W-834-D4	8/2/05	-	<25 D	-	-	-
W-834-D4	10/11/05	-	<25 D	-	-	-
W-834-D5	3/10/05	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<5 D
W-834-D5	8/9/05	-	<0.5	-	-	-
W-834-D6	3/10/05	<25 D	<25 D	<25 D	<25 D	<50 D
W-834-D6	6/14/05	-	<25 D	-	-	-
W-834-D6	8/2/05	-	<5 D	-	-	-
W-834-D6	10/11/05	-	<5 D	-	-	-
W-834-D7	3/10/05	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<5 D
W-834-D7	6/14/05	-	<5 D	-	-	-
W-834-D7	8/2/05	<1	<1	<1	<1	<2
W-834-D7	10/11/05	-	<5 D	-	-	-
W-834-D10	2/7/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-D10	8/15/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-D10	08/15/05 DUP	<100 DH	-	<100 DH	<100 DH	<100 DH
W-834-D11	2/7/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-D11	02/07/05 DUP	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-D11	8/9/05	-	<0.5	-	-	-
W-834-D12	3/10/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-D12	6/14/05	-	<1 D	-	-	-
W-834-D12	8/2/05	<1	<1	<1	<1	<2
W-834-D12	10/12/05	-	<0.5	-	-	-
W-834-D13	3/10/05	<25 D	<25 D	<25 D	<25 D	<50 D
W-834-D13	6/14/05	-	<25 D	-	-	-
W-834-D13	8/2/05	-	<0.5	-	-	-
W-834-D13	10/12/05	-	<25 D	-	-	-
W-834-D14	2/7/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-D14	02/07/05 DUP	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-D14	8/9/05	-	<5 D	-	-	-
W-834-D15	2/7/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-D15	8/4/05	-	<25 D	-	-	-
W-834-D18	2/8/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-D18	8/15/05	-	<0.5	-	-	-

A-4. Building 834 OU BTEX compounds in ground water.

Sample Location	Sample Date	Benzene (µg/L)	1,3-Dichlorobenzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Total xylene isomers (µg/L)
W-834-H2	8/10/05	-	<0.5	-	-	-
W-834-J1	3/14/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-J1	6/16/05	-	<0.5	-	-	-
W-834-J1	8/2/05	-	<0.5	-	-	-
W-834-J1	10/12/05	-	<0.5	-	-	-
W-834-J2	2/1/05	<1 D	<1 D	<1 D	<1 D	<2 D
W-834-J2	8/8/05	-	<0.5	-	-	-
W-834-K1A	8/4/05	<1	<1	<1	<1	<2
W-834-M1	2/8/05	<0.5	1.2	<0.5	<0.5	<1
W-834-M1	02/08/05 DUP	<1 H	1.5 H	<1 H	<1 H	<2 H
W-834-M1	8/8/05	-	0.92	-	-	-
W-834-S1	3/14/05	<12 DE	<12 D	<12 D	<12 D	<25 D
W-834-S1	6/16/05	-	<25 D	-	-	-
W-834-S1	06/16/05 DUP	-	<25 D	-	-	-
W-834-S1	8/2/05	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<5 D
W-834-S1	08/02/05 DUP	<10 DH	<10 DH	<10 DH	<10 DH	<10 DH
W-834-S1	10/12/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-S12A	6/16/05	-	<25 D	-	-	-
W-834-S12A	8/2/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-S12A	10/12/05	<50 D	<50 D	<50 D	<50 D	<100 D
W-834-S13	6/16/05	-	<2.5 D	-	-	-
W-834-S13	06/16/05 DUP	-	<0.5	-	-	-
W-834-S13	8/2/05	-	<0.5	-	-	-
W-834-S13	10/12/05	-	<2.5 D	-	-	-
W-834-S4	2/1/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-S4	8/8/05	-	<0.5	-	-	-
W-834-S6	2/3/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-S6	8/11/05	-	<0.5	-	-	-
W-834-S7	2/3/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-S7	8/11/05	-	<0.5	-	-	-
W-834-S8	2/1/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-S8	8/8/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-S9	2/1/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-S9	8/8/05	<5 D	<5 D	<5 D	<5 D	<10 D
W-834-T1	1/18/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-T1	4/21/05	-	<0.5	-	-	-
W-834-T1	8/1/05	-	<0.5	-	-	-
W-834-T1	10/3/05	-	<0.5	-	-	-

A-4. Building 834 OU BTEX compounds in ground water.

Sample Location	Sample Date	Benzene (µg/L)	1,3-Dichlorobenzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Total xylene isomers (µg/L)
W-834-T3	1/18/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-T3	4/21/05	-	<0.5	-	-	-
W-834-T3	7/19/05	-	<0.5	-	-	-
W-834-T3	10/3/05	-	<0.5	-	-	-
W-834-T5	2/9/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-T5	8/9/05	-	<0.5	-	-	-
W-834-T7A	2/9/05	<0.5	<0.5	<0.5	<0.5	<1
W-834-T7A	8/10/05	-	<0.5	-	-	-
W-834-U1	1/31/05	<30 D	<30 D	<30 D	<30 D	<50 D
W-834-U1	01/31/05 DUP	<1,000 DH	<500 DH	<1,000 DH	<1,000 DH	<2,000 DH
W-834-U1	8/9/05	<200 D	<200 D	<200 D	<200 D	<400 D

OU2-BTEX [ug/L] 2005 data (prepared 2006-03-08 12:19:00, Oracle)

A-5. Pit 6 Landfill OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
CARNRW1	1/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	1/13/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	2/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	3/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	03/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	4/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	4/13/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	04/13/05 DUP	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
CARNRW1	04/13/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	5/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	05/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	6/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	06/08/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	7/14/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CARNRW1	7/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	07/14/05 DUP	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CARNRW1	07/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	07/14/05 DUP	E624	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H
CARNRW1	07/14/05 DUP	E624	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H
CARNRW1	07/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	07/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	8/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	10/12/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CARNRW1	10/12/05 DUP	E624	<0.5 HL	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
CARNRW1	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	11/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	11/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	12/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW1	12/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	1/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.72	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	1/13/05	E502.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.44	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
CARNRW2	2/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.62	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	3/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.51	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	03/10/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	4/18/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	0.87	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	04/18/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	1 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
CARNRW2	04/18/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	1 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW2	5/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.82	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	05/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	6/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.64	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	06/08/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	7/19/05	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	1.6 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H
CARNRW2	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	07/19/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	07/19/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
CARNRW2	8/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.64	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	09/14/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	0.7 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW2	10/12/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	10/12/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	10/12/05 DUP	E502.2	<0.5 HL	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
CARNRW2	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	11/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	11/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	12/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.66	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW2	12/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	1/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	2/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	3/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	03/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	4/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	04/18/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW3	5/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	05/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	6/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	06/08/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	7/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-5. Pit 6 Landfill OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
CARNRW3	07/14/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	8/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	08/15/05 DUP	E601	2.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	9/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	09/13/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW3	10/12/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	11/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	11/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	12/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW3	12/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	1/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	2/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	3/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	03/10/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	4/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	04/18/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW4	5/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	05/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	6/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	06/08/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	7/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	07/14/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	8/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	9/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	09/13/05 DUP	E601	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L	<0.5 L
CARNRW4	10/12/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	11/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	11/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	12/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
CARNRW4	12/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BC6-10	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BC6-10	7/14/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-06	3/8/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-06	5/4/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-06	7/27/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
EP6-06	10/25/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
EP6-07	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-07	7/18/05	E601	<0.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-08	3/8/05	E624	<0.5 E	0.83	<0.5	<0.5	<0.5	<0.5 E	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5
EP6-08	4/28/05	E624	<0.5	0.97	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-08	7/21/05	E624	<0.5 BE	0.77	<0.5	<0.5	<1	<0.5 E	<1 E	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<1
EP6-08	10/19/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
EP6-09	3/7/05	E624	6	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-09	03/07/05 DUP	E624	5.8	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-09	5/4/05	E624	6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP6-09	7/21/05	E624	6.4 B	<0.5	<0.5	<0.5	<1	<0.5	<1	<0.5 E	<0.5	<0.5	<1	<0.5	<0.5	<1
EP6-09	10/25/05	E624	5.7	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-PIT6-1819	1/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-PIT6-1819	5/6/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-PIT6-1819	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-PIT6-1819	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-01	3/3/05	E601	<0.5	<0.5	0.57	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-01	7/27/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
K6-01S	3/3/05	E624	<0.5 E	<0.5	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-01S	5/4/05	E624	<0.5	<0.5	2.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-01S	7/7/05	E624	<0.5	<0.5	2.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
K6-01S	07/07/05 DUP	E624	<0.5	<0.5	2.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
K6-01S	10/6/05	E624	<0.5 H	<0.5 H	2 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
K6-03	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-03	7/18/05	E601	<0.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-04	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-04	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-14	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-14	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-16	3/1/05	E601	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-5. Pit 6 Landfill OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
K6-16	03/01/05 DUP	E601	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-16	7/13/05	E601	2.4 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	1/19/05	E601	0.58	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	01/19/05 DUP	E601	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	5/4/05	E601	0.61	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	05/04/05 DUP	E601	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	7/18/05	E601	0.53 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-17	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-18	3/2/05	E601	3.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-18	7/14/05	E601	1.6 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
K6-18	07/14/05 DUP	E601	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-19	3/8/05	E624	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-19	5/3/05	E624	3.4	<0.5 E	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-19	05/03/05 DUP	E624	3.4	<0.5 E	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-19	7/7/05	E624	3.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
K6-19	10/19/05	E624	3.1 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
K6-19	10/19/05 DUP	E624	3 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
K6-22	5/6/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-22	7/18/05	E601	<0.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-22	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-23	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-23	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-24	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-24	7/14/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
K6-25	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-25	7/13/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-26	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-26	7/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-27	3/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-27	7/14/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
K6-32	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-32	7/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-33	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-33	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-34	1/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-34	5/6/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-34	7/19/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-34	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-35	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-35	7/14/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
K6-36	3/2/05	E624	1.2	0.68	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5
K6-36	5/4/05	E624	1.1	0.64	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K6-36	7/28/05	E624	0.8	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
K6-36	10/27/05	E624	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
W-33C-01	3/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-33C-01	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-34-01	3/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5
W-34-02	3/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING8	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Bromodichloromethane (µg/L)	Bromoform (µg/L)	Dibromochloromethane (µg/L)	Total Trihalomethanes (µg/L)
CARNRW1	1/13/05	E624	0 of 32	-	-	-	-	-
CARNRW1	1/13/05	E624	0 of 18	-	-	-	-	-
CARNRW1	2/11/05	E601	0 of 19	-	-	-	-	-
CARNRW1	3/9/05	E601	0 of 19	-	-	-	-	-
CARNRW1	03/09/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	4/13/05	E624	0 of 30	-	-	-	-	-
CARNRW1	4/13/05	E624	0 of 18	-	-	-	-	-
CARNRW1	04/13/05 DUP	E624	0 of 30	-	-	-	-	-
CARNRW1	04/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	5/13/05	E601	0 of 19	-	-	-	-	-
CARNRW1	05/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	6/8/05	E601	0 of 19	-	-	-	-	-
CARNRW1	06/08/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	7/14/05	E624	0 of 31	-	-	-	-	-
CARNRW1	7/14/05	E601	0 of 18	-	-	-	-	-
CARNRW1	07/14/05 DUP	E624	0 of 31	-	-	-	-	-
CARNRW1	07/14/05 DUP	E624	0 of 30	-	-	-	-	-
CARNRW1	07/14/05 DUP	E624	0 of 30	-	-	-	-	-
CARNRW1	07/14/05 DUP	E624	0 of 18	-	-	-	-	-
CARNRW1	07/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	07/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	8/15/05	E601	0 of 19	-	-	-	-	-
CARNRW1	08/15/05 DUP	E601	0 of 19	-	-	-	-	-
CARNRW1	08/15/05 DUP	E601	0 of 17	-	-	-	-	-
CARNRW1	08/15/05 DUP	E601	0 of 17	-	-	-	-	-
CARNRW1	9/14/05	E601	0 of 19	-	-	-	-	-
CARNRW1	09/14/05 DUP	E601	0 of 19	-	-	-	-	-
CARNRW1	09/14/05 DUP	E601	0 of 17	-	-	-	-	-
CARNRW1	09/14/05 DUP	E601	0 of 17	-	-	-	-	-
CARNRW1	10/12/05	E624	0 of 30	-	-	-	-	-
CARNRW1	10/12/05 DUP	E624	0 of 30	-	-	-	-	-
CARNRW1	10/12/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW1	11/8/05	E601	0 of 19	-	-	-	-	-
CARNRW1	11/9/05	E601	0 of 18	-	-	-	-	-
CARNRW1	12/14/05	E601	0 of 19	-	-	-	-	-
CARNRW1	12/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW2	1/13/05	E502.2	4 of 46	-	-	-	-	-
CARNRW2	1/13/05	E601	-	-	2	17	7.8	27
CARNRW2	1/13/05	E502.2	3 of 17	-	1.4	14	5.7	-
CARNRW2	2/11/05	E601	4 of 19	-	1.7	11	6	20
CARNRW2	3/10/05	E601	4 of 19	-	1.5	14	5.8	22
CARNRW2	03/10/05 DUP	E601	3 of 18	-	2.1	21	9	-
CARNRW2	4/18/05	E601	4 of 19	-	2	23	7.2	33
CARNRW2	04/18/05 DUP	E502.2	3 of 46	-	2.2 H	32 H	9.3 H	-
CARNRW2	04/18/05 DUP	E601	3 of 17	-	2.2 L	30 L	9.2 L	-
CARNRW2	5/13/05	E601	4 of 19	-	1.9	14	7.1	24
CARNRW2	05/13/05 DUP	E601	3 of 18	-	2.3	20	9.3	-
CARNRW2	6/8/05	E601	4 of 19	-	1.7	13	6.2	22
CARNRW2	06/08/05 DUP	E601	3 of 18	-	1.7	21	7.3	-
CARNRW2	7/19/05	E502.2	3 of 46	-	1.9 H	14 H	6.4 H	-
CARNRW2	7/19/05	E601	3 of 17	-	1.6	17	5.9	-
CARNRW2	07/19/05 DUP	E502.2	3 of 46	-	-	-	-	-
CARNRW2	07/19/05 DUP	E601	-	-	2	17	7.5	-
CARNRW2	07/19/05 DUP	E502.2	3 of 17	-	1.7	17	7.1	-
CARNRW2	8/15/05	E601	4 of 19	-	0.88	16	3.8	21
CARNRW2	08/15/05 DUP	E601	3 of 18	-	1.1	25	4.9	-
CARNRW2	9/14/05	E601	3 of 17	-	0.88	7.1	2.2	-
CARNRW2	09/14/05 DUP	E601	3 of 18	-	0.9 L	8.1 L	2.6 L	-
CARNRW2	10/12/05	E502.2	4 of 48	-	0.95	18	3.3	-
CARNRW2	10/12/05	E601	-	-	-	-	-	27
CARNRW2	10/12/05	E601	3 of 17	-	0.95	22 O	3.4	-
CARNRW2	10/12/05 DUP	E502.2	3 of 46	-	0.7 H	19 H	3.1 H	-
CARNRW2	10/12/05 DUP	E601	3 of 17	-	0.9	20	3.4	-
CARNRW2	11/9/05	E601	0 of 19	-	-	-	-	-
CARNRW2	11/09/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW2	12/14/05	E601	4 of 19	-	0.79	5.4	2.2	9
CARNRW2	12/14/05 DUP	E601	3 of 18	-	0.8	4.7	2	-
CARNRW3	1/13/05	E601	0 of 19	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Bromodichloromethane (µg/L)	Bromoform (µg/L)	Dibromochloromethane (µg/L)	Total Trihalomethanes (µg/L)
CARNRW3	2/11/05	E601	0 of 19	-	-	-	-	-
CARNRW3	3/9/05	E601	0 of 18	-	-	-	-	-
CARNRW3	03/09/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	4/18/05	E601	0 of 19	-	-	-	-	-
CARNRW3	04/18/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	5/13/05	E601	0 of 19	-	-	-	-	-
CARNRW3	05/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	6/8/05	E601	0 of 19	-	-	-	-	-
CARNRW3	06/08/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	7/14/05	E601	0 of 19	-	-	-	-	-
CARNRW3	07/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	8/15/05	E601	0 of 19	-	-	-	-	-
CARNRW3	08/15/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	9/13/05	E601	0 of 19	-	-	-	-	-
CARNRW3	09/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	10/12/05	E601	0 of 19	-	-	-	-	-
CARNRW3	10/12/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW3	11/9/05	E601	4 of 19	-	2	15	7.2	25
CARNRW3	11/09/05 DUP	E601	3 of 18	-	2.6	15	8.9	-
CARNRW3	12/14/05	E601	0 of 19	-	-	-	-	-
CARNRW3	12/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	1/13/05	E601	0 of 19	-	-	-	-	-
CARNRW4	2/11/05	E601	0 of 19	-	-	-	-	-
CARNRW4	3/10/05	E601	0 of 19	-	-	-	-	-
CARNRW4	03/10/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	4/18/05	E601	0 of 19	-	-	-	-	-
CARNRW4	04/18/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	5/13/05	E601	0 of 19	-	-	-	-	-
CARNRW4	05/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	6/8/05	E601	0 of 19	-	-	-	-	-
CARNRW4	06/08/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	7/14/05	E601	0 of 19	-	-	-	-	-
CARNRW4	07/14/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	8/15/05	E601	0 of 19	-	-	-	-	-
CARNRW4	08/15/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	9/13/05	E601	0 of 19	-	-	-	-	-
CARNRW4	09/13/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	10/12/05	E601	0 of 19	-	-	-	-	-
CARNRW4	10/12/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	11/9/05	E601	0 of 19	-	-	-	-	-
CARNRW4	11/09/05 DUP	E601	0 of 18	-	-	-	-	-
CARNRW4	12/14/05	E601	0 of 19	-	-	-	-	-
CARNRW4	12/14/05 DUP	E601	0 of 18	-	-	-	-	-
BC6-10	3/1/05	E601	0 of 19	-	-	-	-	-
BC6-10	7/14/05	E601	0 of 18	-	-	-	-	-
EP6-06	3/8/05	E624	0 of 29	-	-	-	-	-
EP6-06	5/4/05	E624	0 of 29	-	-	-	-	-
EP6-06	7/27/05	E624	0 of 30	-	-	-	-	-
EP6-06	10/25/05	E624	0 of 30	-	-	-	-	-
EP6-07	3/1/05	E601	0 of 19	-	-	-	-	-
EP6-07	7/18/05	E601	0 of 19	-	-	-	-	-
EP6-08	3/8/05	E624	0 of 29	-	-	-	-	-
EP6-08	4/28/05	E624	0 of 29	-	-	-	-	-
EP6-08	7/21/05	E624	0 of 30	-	-	-	-	-
EP6-08	10/19/05	E624	0 of 30	-	-	-	-	-
EP6-09	3/7/05	E624	0 of 29	-	-	-	-	-
EP6-09	03/07/05 DUP	E624	0 of 29	-	-	-	-	-
EP6-09	5/4/05	E624	0 of 29	-	-	-	-	-
EP6-09	7/21/05	E624	0 of 30	-	-	-	-	-
EP6-09	10/25/05	E624	0 of 30	-	-	-	-	-
W-PIT6-1819	1/19/05	E601	0 of 19	-	-	-	-	-
W-PIT6-1819	5/6/05	E601	0 of 19	-	-	-	-	-
W-PIT6-1819	7/19/05	E601	0 of 19	-	-	-	-	-
W-PIT6-1819	10/12/05	E601	0 of 19	-	-	-	-	-
K6-01	3/3/05	E601	0 of 19	-	-	-	-	-
K6-01	7/27/05	E601	0 of 18	-	-	-	-	-
K6-01S	3/3/05	E624	1 of 29	2.6	-	-	-	-
K6-01S	5/4/05	E624	1 of 29	2.2	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Bromodichloromethane (µg/L)	Bromoform (µg/L)	Dibromochloromethane (µg/L)	Total Trihalomethanes (µg/L)
K6-01S	7/7/05	E624	1 of 30	2.4	-	-	-	-
K6-01S	07/07/05 DUP	E624	1 of 30	2.4	-	-	-	-
K6-01S	10/6/05	E624	1 of 30	2 H	-	-	-	-
K6-03	3/1/05	E601	0 of 19	-	-	-	-	-
K6-03	7/18/05	E601	0 of 19	-	-	-	-	-
K6-04	3/2/05	E601	0 of 19	-	-	-	-	-
K6-04	7/13/05	E601	0 of 19	-	-	-	-	-
K6-14	3/1/05	E601	0 of 19	-	-	-	-	-
K6-14	7/13/05	E601	0 of 19	-	-	-	-	-
K6-16	3/1/05	E601	0 of 19	-	-	-	-	-
K6-16	03/01/05 DUP	E601	0 of 19	-	-	-	-	-
K6-16	7/13/05	E601	0 of 18	-	-	-	-	-
K6-17	1/19/05	E601	0 of 19	-	-	-	-	-
K6-17	01/19/05 DUP	E601	0 of 18	-	-	-	-	-
K6-17	5/4/05	E601	0 of 19	-	-	-	-	-
K6-17	05/04/05 DUP	E601	0 of 18	-	-	-	-	-
K6-17	7/18/05	E601	0 of 19	-	-	-	-	-
K6-17	10/12/05	E601	0 of 19	-	-	-	-	-
K6-17	10/12/05 DUP	E601	0 of 18	-	-	-	-	-
K6-18	3/2/05	E601	0 of 19	-	-	-	-	-
K6-18	7/14/05	E601	0 of 18	-	-	-	-	-
K6-18	07/14/05 DUP	E601	0 of 18	-	-	-	-	-
K6-19	3/8/05	E624	0 of 29	-	-	-	-	-
K6-19	5/3/05	E624	0 of 29	-	-	-	-	-
K6-19	05/03/05 DUP	E624	0 of 29	-	-	-	-	-
K6-19	7/7/05	E624	0 of 30	-	-	-	-	-
K6-19	10/19/05	E624	0 of 30	-	-	-	-	-
K6-19	10/19/05 DUP	E624	0 of 30	-	-	-	-	-
K6-22	5/6/05	E601	0 of 19	-	-	-	-	-
K6-22	7/18/05	E601	0 of 19	-	-	-	-	-
K6-22	10/12/05	E601	0 of 19	-	-	-	-	-
K6-23	3/2/05	E601	0 of 19	-	-	-	-	-
K6-23	7/19/05	E601	0 of 19	-	-	-	-	-
K6-24	3/1/05	E601	0 of 19	-	-	-	-	-
K6-24	7/14/05	E601	0 of 18	-	-	-	-	-
K6-25	3/1/05	E601	0 of 19	-	-	-	-	-
K6-25	7/13/05	E601	0 of 18	-	-	-	-	-
K6-26	3/1/05	E601	0 of 19	-	-	-	-	-
K6-26	7/14/05	E601	0 of 19	-	-	-	-	-
K6-27	3/1/05	E601	0 of 19	-	-	-	-	-
K6-27	7/14/05	E601	0 of 18	-	-	-	-	-
K6-32	3/2/05	E601	0 of 19	-	-	-	-	-
K6-32	7/21/05	E601	0 of 19	-	-	-	-	-
K6-33	3/2/05	E601	0 of 19	-	-	-	-	-
K6-33	7/19/05	E601	0 of 18	-	-	-	-	-
K6-34	1/19/05	E601	0 of 19	-	-	-	-	-
K6-34	5/6/05	E601	0 of 19	-	-	-	-	-
K6-34	7/19/05	E601	0 of 19	-	-	-	-	-
K6-34	10/12/05	E601	0 of 19	-	-	-	-	-
K6-35	3/2/05	E601	0 of 19	-	-	-	-	-
K6-35	7/14/05	E601	0 of 18	-	-	-	-	-
K6-36	3/2/05	E624	0 of 29	-	-	-	-	-
K6-36	5/4/05	E624	0 of 29	-	-	-	-	-
K6-36	7/28/05	E624	0 of 30	-	-	-	-	-
K6-36	10/27/05	E624	0 of 30	-	-	-	-	-
W-33C-01	3/2/05	E601	0 of 19	-	-	-	-	-
W-33C-01	7/13/05	E601	0 of 19	-	-	-	-	-
W-34-01	3/8/05	E601	0 of 19	-	-	-	-	-
W-34-02	3/8/05	E601	0 of 19	-	-	-	-	-
SPRING8	10/12/05	E601	0 of 19	-	-	-	-	-

A-6. Pit 6 Landfill OU tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
CARNRW1	1/13/05	<100
CARNRW1	2/11/05	<100
CARNRW1	3/9/05	<100
CARNRW1	03/09/05 DUP	<200
CARNRW1	4/13/05	<100
CARNRW1	04/13/05 DUP	<200
CARNRW1	5/13/05	<100
CARNRW1	05/13/05 DUP	<200
CARNRW1	6/8/05	<100
CARNRW1	06/08/05 DUP	<200
CARNRW1	7/14/05	<100
CARNRW1	07/14/05 DUP	<200
CARNRW1	07/14/05 DUP	<200
CARNRW1	07/14/05 DUP	1,200 ± 140
CARNRW1	8/15/05	<100
CARNRW1	08/15/05 DUP	<200
CARNRW1	08/15/05 DUP	<200
CARNRW1	08/15/05 DUP	<100
CARNRW1	9/14/05	<100
CARNRW1	09/14/05 DUP	<200
CARNRW1	09/14/05 DUP	<200
CARNRW1	09/14/05 DUP	<100
CARNRW1	10/12/05	108 ± 58.0
CARNRW1	10/12/05 DUP	<200
CARNRW1	11/9/05	<100
CARNRW1	11/09/05 DUP	<200
CARNRW1	12/14/05	<100
CARNRW1	12/14/05 DUP	<200
CARNRW2	1/13/05	<100
CARNRW2	2/11/05	<100
CARNRW2	3/10/05	<100
CARNRW2	03/10/05 DUP	<200
CARNRW2	4/18/05	<100
CARNRW2	04/18/05 DUP	<200
CARNRW2	5/13/05	<100
CARNRW2	05/13/05 DUP	<200
CARNRW2	6/8/05	<100
CARNRW2	06/08/05 DUP	<200
CARNRW2	7/19/05	<100
CARNRW2	07/19/05 DUP	<200
CARNRW2	8/15/05	<100
CARNRW2	08/15/05 DUP	<200
CARNRW2	9/14/05	<100
CARNRW2	09/14/05 DUP	<200
CARNRW2	10/12/05	<100
CARNRW2	10/12/05 DUP	<200
CARNRW2	11/9/05	<100
CARNRW2	11/09/05 DUP	<200
CARNRW2	12/14/05	<100
CARNRW2	12/14/05 DUP	<200

A-6. Pit 6 Landfill OU tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
CARNRW3	1/13/05	<100
CARNRW3	2/11/05	<100
CARNRW3	3/9/05	<100
CARNRW3	03/09/05 DUP	<200
CARNRW3	4/18/05	<100
CARNRW3	04/18/05 DUP	<200
CARNRW3	5/13/05	<100
CARNRW3	05/13/05 DUP	<200
CARNRW3	6/8/05	<100
CARNRW3	06/08/05 DUP	<200
CARNRW3	7/14/05	<100
CARNRW3	07/14/05 DUP	<200
CARNRW3	8/15/05	<100
CARNRW3	08/15/05 DUP	<200
CARNRW3	9/13/05	<100
CARNRW3	09/13/05 DUP	<200
CARNRW3	10/12/05	<100
CARNRW3	10/12/05 DUP	<200
CARNRW3	11/9/05	<100
CARNRW3	11/09/05 DUP	<200
CARNRW3	12/14/05	<100
CARNRW3	12/14/05 DUP	<200
CARNRW4	1/13/05	<100
CARNRW4	2/11/05	<100
CARNRW4	3/10/05	<100
CARNRW4	03/10/05 DUP	<200
CARNRW4	4/18/05	<100
CARNRW4	04/18/05 DUP	<200
CARNRW4	5/13/05	<100
CARNRW4	05/13/05 DUP	<200
CARNRW4	6/8/05	<100
CARNRW4	06/08/05 DUP	<200
CARNRW4	7/14/05	109 ± 60.0
CARNRW4	07/14/05 DUP	<200
CARNRW4	8/15/05	<100
CARNRW4	08/15/05 DUP	<200
CARNRW4	9/13/05	<100
CARNRW4	09/13/05 DUP	<200
CARNRW4	10/12/05	192 ± 63.0
CARNRW4	10/12/05 DUP	<200
CARNRW4	11/9/05	<100
CARNRW4	11/09/05 DUP	<200
CARNRW4	12/14/05	<100
CARNRW4	12/14/05 DUP	<200
BC6-10	3/1/05	200 ± 62.0
BC6-10	6/23/05	<200
BC6-10	6/30/05	<100
BC6-10	7/14/05	<100
EP6-06	3/8/05	<100
EP6-06	5/4/05	<100

A-6. Pit 6 Landfill OU tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
EP6-06	7/27/05	<100
EP6-06	10/25/05	<100
EP6-07	3/1/05	134 ± 60.0
EP6-07	7/18/05	<100
EP6-08	3/8/05	<100
EP6-08	4/28/05	<100
EP6-08	7/21/05	<100
EP6-08	10/19/05	<100
EP6-09	3/7/05	<100
EP6-09	03/07/05 DUP	<100
EP6-09	5/4/05	<100
EP6-09	7/21/05	<100
EP6-09	10/25/05	<100
W-PIT6-1819	1/19/05	137 ± 56.0
W-PIT6-1819	5/6/05	<100
W-PIT6-1819	7/19/05	164 ± 61.0
W-PIT6-1819	10/12/05	156 ± 61.0
K6-01	3/3/05	238 ± 64.0
K6-01	7/27/05	211 ± 64.0
K6-01S	3/3/05	237 ± 63.0
K6-01S	5/4/05	138 ± 56.0
K6-01S	7/7/05	213 ± 57.0
K6-01S	07/07/05 DUP	216 ± 49.0
K6-01S	10/6/05	278 ± 67.0
K6-03	3/1/05	<100
K6-03	7/18/05	<100
K6-04	3/2/05	<100
K6-04	7/13/05	<100
K6-14	3/1/05	<100
K6-14	7/13/05	<100
K6-16	3/1/05	343 ± 71.0
K6-16	03/01/05 DUP	427 ± 78.0
K6-16	7/13/05	179 ± 62.0
K6-17	1/19/05	<100
K6-17	01/19/05 DUP	<205
K6-17	5/4/05	<100
K6-17	05/04/05 DUP	<200
K6-17	7/18/05	<100
K6-17	10/12/05	<100
K6-17	10/12/05 DUP	<200
K6-18	3/2/05	240 ± 66.0
K6-18	7/14/05	383 ± 73.0
K6-18	07/14/05 DUP	316 ± 72.1
K6-19	3/8/05	223 ± 63.0
K6-19	5/3/05	226 ± 60.0
K6-19	05/03/05 DUP	248 ± 61.0
K6-19	7/7/05	372 ± 55.0
K6-19	10/19/05	323 ± 68.0
K6-19	10/19/05 DUP	333 ± 70.0
K6-22	5/6/05	<100

A-6. Pit 6 Landfill OU tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
K6-22	7/18/05	<100
K6-22	10/12/05	<100
K6-23	3/2/05	<100
K6-23	7/19/05	<100
K6-24	3/1/05	439 ± 80.0
K6-24	7/14/05	512 ± 81.0
K6-25	3/1/05	215 ± 63.0
K6-25	6/23/05	<200
K6-25	6/30/05	<100
K6-25	7/13/05	<100
K6-26	3/1/05	<100
K6-26	7/14/05	<100
K6-27	3/1/05	274 ± 67.0
K6-27	7/14/05	<100
K6-32	3/2/05	<100
K6-32	7/21/05	<100
K6-33	3/2/05	399 ± 78.0
K6-33	7/19/05	294 ± 68.0
K6-34	1/19/05	<100
K6-34	5/6/05	<100
K6-34	7/19/05	<100
K6-34	10/12/05	<100
K6-35	3/2/05	116 ± 60.0
K6-35	7/14/05	<100
K6-36	3/2/05	1,550 ± 170
K6-36	5/4/05	1,490 ± 160
K6-36	7/28/05	1,590 ± 190
K6-36	10/27/05	1,560 ± 180
W-33C-01	3/2/05	<100
W-33C-01	7/13/05	<100
W-34-01	3/8/05	<100
W-34-02	3/8/05	<100
SPRING8	10/12/05	<100

OU3-RAD [pCi/L] 2005 data (prepared 2006-03-08 09:26:00, Oracle)

A-7. Pit 6 Landfill OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
CARNRW3	07/14/05 DUP	-	0.19	<4
CARNRW2	03/10/05 DUP	<0.1	0.27	<4
CARNRW3	08/15/05 DUP	-	0.37	<4
CARNRW2	04/18/05 DUP	-	0.38	<4
K6-36	7/28/05	-	0.45	<4
K6-32	3/2/05	-	0.58	<4
CARNRW1	10/12/05 DUP	-	0.63	<4
CARNRW1	10/12/05	-	0.81	<4
CARNRW1	08/15/05 DUP	-	0.86	<4
CARNRW4	7/14/05	-	0.86	<4
K6-36	3/2/05	-	0.87	<4 E
CARNRW1	08/15/05 DUP	-	0.95	<4
K6-24	3/1/05	-	0.98	<4
CARNRW1	8/15/05	-	1	<4
CARNRW1	08/15/05 DUP	-	1.1	<4
CARNRW4	1/13/05	-	1.1	<4
CARNRW4	07/14/05 DUP	-	1.1	<4
K6-33	3/2/05	-	1.7	<4
CARNRW4	05/13/05 DUP	-	1.8	<4
CARNRW4	5/13/05	-	1.9	<4
BC6-10	3/1/05	-	3	<4
EP6-09	03/07/05 DUP	-	3.1	4.5
EP6-09	7/21/05	-	3.1	6.9
EP6-09	3/7/05	-	3.2	4.6
EP6-09	10/25/05	-	3.2	4
EP6-09	5/4/05	-	3.3	4.4
CARNRW4	4/18/05	-	3.5	<4
CARNRW4	04/18/05 DUP	-	3.5	<4
K6-04	3/2/05	-	8.8	<4
CARNRW4	03/10/05 DUP	-	10	<4
CARNRW4	3/10/05	-	13	<4

A-7. Pit 6 Landfill OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
CARNRW2	07/19/05 DUP	-	-	<4
SPRING8	10/12/05	-	-	<4
CARNRW1	03/09/05 DUP	<0.1	<0.1	<4
CARNRW1	04/13/05 DUP	-	<0.1	<4
CARNRW1	05/13/05 DUP	-	<0.1	<4
CARNRW1	12/14/05 DUP	-	<0.1	<4
CARNRW2	05/13/05 DUP	-	<0.1	<4
CARNRW2	08/15/05 DUP	-	<0.1	<4
CARNRW2	09/14/05 DUP	-	<0.1	<4
CARNRW2	10/12/05 DUP	-	<0.1	<4
CARNRW2	12/14/05 DUP	-	<0.1	<4
CARNRW3	03/09/05 DUP	-	<0.1	<4
CARNRW3	04/18/05 DUP	-	<0.1	<4
CARNRW3	05/13/05 DUP	-	<0.1	<4
CARNRW3	09/13/05 DUP	<0.1	<0.1	<4
CARNRW3	10/12/05 DUP	-	<0.1	<4
CARNRW3	12/14/05 DUP	-	<0.1	<4
CARNRW4	08/15/05 DUP	-	<0.1	<4
CARNRW4	09/13/05 DUP	-	<0.1	<4
CARNRW4	10/12/05 DUP	-	<0.1	<4
CARNRW4	12/14/05 DUP	-	<0.1	<4
K6-01S	7/7/05	-	<0.1	<4
K6-01S	07/07/05 DUP	-	<0.1	<4
K6-01S	10/6/05	-	<0.1	<4 L
K6-19	7/7/05	-	<0.1	<4
K6-19	10/19/05	-	<0.1	<4
K6-19	10/19/05 DUP	-	<0.1	<4
K6-36	10/27/05	-	<0.1	<4
CARNRW1	06/08/05 DUP	-	<0.1 L	<4
CARNRW3	06/08/05 DUP	-	<0.1 L	<4
CARNRW1	1/13/05	-	<0.44	<4

A-7. Pit 6 Landfill OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
CARNRW1	2/11/05	-	<0.44	<4
CARNRW1	3/9/05	-	<0.44	<4
CARNRW1	4/13/05	-	<0.44	<4
CARNRW1	5/13/05	-	<0.44	<4
CARNRW1	6/8/05	-	<0.44	<4
CARNRW1	7/14/05	-	<0.44	<4
CARNRW1	07/14/05 DUP	-	<0.44	<4
CARNRW2	1/13/05	-	<0.44	<4
CARNRW2	2/11/05	-	<0.44	<4
CARNRW2	3/10/05	-	<0.44	<4
CARNRW2	5/13/05	-	<0.44	<4
CARNRW2	6/8/05	-	<0.44	<4
CARNRW3	1/13/05	-	<0.44	<4
CARNRW3	2/11/05	-	<0.44	<4
CARNRW3	3/9/05	-	<0.44	<4
CARNRW3	4/18/05	-	<0.44	<4 E
CARNRW3	5/13/05	-	<0.44	<4
CARNRW3	6/8/05	-	<0.44	<4
CARNRW3	7/14/05	-	<0.44	<4
EP6-07	3/1/05	-	<0.44	<4
EP6-08	3/8/05	-	<0.44	<4
W-PIT6-1819	1/19/05	-	<0.44	<4
K6-01	3/3/05	-	<0.44	<4
K6-03	3/1/05	-	<0.44	<4
K6-14	3/1/05	-	<0.44	<4
K6-17	1/19/05	-	<0.44	<4
K6-17	7/18/05	-	<0.44	<4
K6-19	3/8/05	-	<0.44	<4
K6-26	3/1/05	-	<0.44	<4
K6-27	3/1/05	-	<0.44	<4
K6-34	1/19/05	-	<0.44	<4

A-7. Pit 6 Landfill OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
K6-35	3/2/05	-	<0.44	<4
W-34-01	3/8/05	-	<0.44	<4
W-34-02	3/8/05	-	<0.44	<4
CARNRW2	4/18/05	-	<0.44 E	<4
W-PIT6-1819	7/19/05	-	<0.44 S	<4
K6-34	7/19/05	-	<0.44 S	<4
CARNRW1	9/14/05	-	<0.5	<4
CARNRW1	09/14/05 DUP	-	<0.5	<4
CARNRW1	09/14/05 DUP	-	<0.5	<4 L
CARNRW1	09/14/05 DUP	-	<0.5	<4 L
CARNRW1	11/8/05	-	<0.5	<4
CARNRW1	12/14/05	-	<0.5	<4
CARNRW2	8/15/05	-	<0.5	<4
CARNRW2	9/14/05	-	<0.5	<4 L
CARNRW2	10/12/05	-	<0.5	<4
CARNRW2	12/14/05	-	<0.5	<4
CARNRW3	8/15/05	-	<0.5	<4
CARNRW3	9/13/05	-	<0.5	<4
CARNRW3	10/12/05	-	<0.5	<4
CARNRW3	12/14/05	-	<0.5	<4
CARNRW4	10/12/05	-	<0.5	<4
CARNRW4	11/9/05	-	<0.5	<4
CARNRW4	12/14/05	-	<0.5	<4
EP6-06	3/8/05	-	<0.5	<4
EP6-06	5/4/05	-	<0.5	<4
EP6-06	7/27/05	-	<0.5	<4
EP6-06	10/25/05	-	<0.5	<4
EP6-08	4/28/05	-	<0.5	<4
EP6-08	7/21/05	-	<0.5	<4
EP6-08	10/19/05	-	<0.5	<4
K6-19	5/3/05	-	<0.5	<4

A-7. Pit 6 Landfill OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
K6-19	05/03/05 DUP	-	<0.5	<4 E
K6-36	5/4/05	-	<0.5	<4
CARNRW2	11/9/05	-	<0.5 E	<4
CARNRW3	11/9/05	-	<0.5 E	<4
K6-01S	3/3/05	-	<0.88 D	<4
K6-22	7/18/05	-	<0.88 D	<4
K6-25	3/1/05	-	<0.88 D	<4
CARNRW4	8/15/05	-	<1 D	<4
CARNRW4	9/13/05	-	<1 D	<4
CARNRW1	11/9/05	-	<2	<4
CARNRW2	11/09/05 DUP	-	<2	<4
CARNRW3	11/09/05 DUP	-	<2	<4
CARNRW4	11/09/05 DUP	-	<2	<4
K6-17	01/19/05 DUP	-	<2	<4
K6-01S	5/4/05	-	<2.5 D	<4
CARNRW1	07/14/05 DUP	-	<5 D	<4
CARNRW1	07/14/05 DUP	-	<5 D	<4
CARNRW2	06/08/05 DUP	-	0.44 L	<4
CARNRW4	6/8/05	-	1.5 D	<4
CARNRW4	06/08/05 DUP	-	1.8 L	<4
W-33C-01	3/2/05	-	2.5 D	<4
K6-23	3/2/05	-	200 D	<4
CARNRW2	7/19/05	-	5.2 D	<4
K6-16	03/01/05 DUP	-	7 D	<4
K6-16	3/1/05	-	7.1 D	<4
CARNRW4	2/11/05	-	9.24 D	<4
K6-18	3/2/05	-	9.9 D	<4

OU3-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-08 09:25:43, Oracle)

A-8. High Explosive Process Area OU VOCs in ground water and surface water.

Location	Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-815-2110	9/7/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
W-815-2111	9/14/05	E624	1.6 HL	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 HL	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
W-817-2109	9/15/05	E624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
GALLO1	1/12/05	E601	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	1/12/05	E502.2	0.59	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
GALLO1	2/9/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	3/9/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	03/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	4/20/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	4/20/05	E502.2	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	04/20/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
GALLO1	04/20/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	5/13/05	E601	0.59	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	05/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	6/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	06/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	7/13/05	E601	0.53	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	7/13/05	E502.2	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	07/13/05 DUP	E601	0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	07/13/05 DUP	E502.2	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
GALLO1	8/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	08/10/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	10/20/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	10/20/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	10/20/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	10/20/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
GALLO1	11/10/05	E601	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	11/10/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	12/15/05	E601	0.66 BL	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
GALLO1	12/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-01	1/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-01	4/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-01	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-01	10/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-02	1/14/05	E601	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-02	4/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-02	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-02	10/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-03	1/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-03	4/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-03	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-03	10/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-04	1/14/05	E601	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-04	4/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-04	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-04	10/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-05	1/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-05	4/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-05	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35B-05	10/18/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-01	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-01	9/20/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-02	2/4/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-02	7/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-04	1/12/05	E601	8.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-04	7/13/05	E601	8.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-04	8/9/05	E601	8.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-04	10/18/05	E601	8.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-05	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-05	8/17/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-06	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-06	7/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-07	3/4/05	E601	2.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-07	03/04/05 DUP	E601	2.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-07	7/21/05	E601	2.9 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-08	3/4/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-35C-08	8/17/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4A	2/24/05	E601	3.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4A	02/24/05 DUP	E601	3.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4A	9/7/05	E601	6.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4AS	2/24/05	E601	2.6 B	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4AS	02/24/05 DUP	E601	3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4AS	9/7/05	E601	2.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4B	1/27/05	E601	1.9	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4B	01/27/05 DUP	E601	2.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4B	8/1/05	E601	2.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4C	1/27/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4C	8/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-4C	10/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-8. High Explosive Process Area OU VOCs in ground water and surface water.

Location	Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-6BD	1/27/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6BD	8/16/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6BS	1/27/05	E601	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6BS	8/16/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6BS	08/16/05 DUP	E601	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CD	1/28/05	E601	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CD	7/21/05	E601	0.7 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CI	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CI	7/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CS	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6CS	7/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6EI	1/28/05	E601	7.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6EI	8/11/05	E601	6.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ER	1/12/05	E601	8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ER	7/13/05	E601	8.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ER	8/9/05	E601	8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ER	10/18/05	E601	8.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ES	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6ES	8/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6F	1/28/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6F	8/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6G	1/28/05	E601	8.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6G	8/11/05	E601	7.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6H	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-6H	4/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6H	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6H	10/5/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-6I	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-6I	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6J	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-6J	4/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6J	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6J	10/5/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-6K	1/26/05	E601	13	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.9
W-6K	8/15/05	E601	3.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6L	1/26/05	E601	35	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-6L	8/15/05	E601	28	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-806-06A	1/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-806-06A	5/20/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-808-01	1/27/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-808-01	8/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-808-03	1/27/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-808-03	8/22/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-01	1/21/05	E601	2.5 B	<0.5 E	<0.5	<0.5	<0.5	1.7	<0.5	<0.5	1.6	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-01	01/21/05 DUP	E601	2.8	<0.5	<0.5	<0.5	<0.5	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-01	8/24/05	E601	1.9 L	<0.5	<0.5	<0.5	<0.5	2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-01	08/24/05 DUP	E601	3.1	-	<0.5	<0.5	<0.5	2.1	<0.5	<0.5	1.9	<0.5	<0.5 L	-	<0.5	<0.5
W-809-02	1/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-02	8/22/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-03	1/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-03	8/22/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-04	1/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-809-04	8/22/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-810-01	1/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-810-01	8/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-01	2/4/05	E601	2.5 L	<0.5	1.5	<0.5	<0.5	0.9	<0.5	0.6	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-01	8/30/05	E601	2	<0.5	1.2	<0.5	0.6	0.8	<0.5	0.7	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-02	2/4/05	E601	11 L	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-02	8/30/05	E601	9.7	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-04	3/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-04	8/30/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-04	12/1/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-814-2134	9/19/05	E624	3.1 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
W-815-02	1/12/05	E601	8.9	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5 E	<0.5	0.66	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-02	4/6/05	E601	6.5 B	<0.5 E	<0.5	<0.5	<0.5	<0.5 E	<0.5 E	<0.5	0.73	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-02	7/13/05	E601	7.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.91	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-02	10/12/05	E601	7.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.95	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-04	1/21/05	E601	3.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-04	8/18/05	E601	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-04	12/8/05	E601	2.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.72	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-05	1/21/05	E601	17 B	<0.5 E	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-05	01/21/05 DUP	E601	23	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-05	8/18/05	E601	5.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-05	08/18/05 DUP	E601	4.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-06	2/4/05	E601	15 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-06	8/31/05	E601	13 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-07	2/4/05	E601	20 L	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-07	8/31/05	E601	17 L	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-08	1/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-08	4/5/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-08	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-815-08	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-8. High Explosive Process Area OU VOCs in ground water and surface water.

Location	Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-815-1918	8/24/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<1	<0.5
W-815-1918	12/6/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
W-815-1928	8/24/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-01	1/28/05	WDRE624	<0.5 EF	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-01	4/5/05	WDRE624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-01	04/05/05 DUP	WDRE624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-01	4/7/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-01	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-01	7/27/05	WDRE624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-01	10/5/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-01	10/12/05	WDRE624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-01	10/12/05 DUP	WDRE624	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-02	2/4/05	WDRE624	0.67	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-02	4/5/05	WDRE624	0.52	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-02	7/25/05	WDRE624	0.53	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-02	10/12/05	WDRE624	0.6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-03	1/28/05	WDRE624	12 F	<0.5 E	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-03	01/28/05 DUP	WDRE624	12 F	<0.5 E	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-03	4/4/05	WDRE624	13	<1 E	<1	<1	<1	<1 E	<1	<1	<1 E	<1	<1	<1	<1	<1
W-817-03	7/19/05	WDRE624	13	<1	<1	<1	<1	<1 E	<1	<1	<1 E	<1	<1	<1	<1	<1
W-817-03	10/11/05	WDRE624	7.4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-03	10/24/05	E601	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-03A	1/21/05	E601	12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-03A	8/18/05	E601	50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-04	2/4/05	WDRE624	6.8	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-04	4/4/05	WDRE624	6.6	<1	<1	<1	<1	<1 E	<1	<1	<1	<1	<1	<1	<1	<1
W-817-04	7/26/05	WDRE624	7.8	<1	<1	<1	<1	<1 E	<1	<1	<1	<1	<1	<1	<1	<1
W-817-04	07/26/05 DUP	WDRE624	8.5	<1	<1	<1	<1	<1 E	<1	<1	<1	<1	<1	<1	<1	<1
W-817-04	10/11/05	WDRE624	6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
W-817-04	10/24/05	E601	5.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-04	11/17/05	WDRE624	7.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
W-817-04	11/22/05	WDRE624	7.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
W-817-05	1/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-05	8/24/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-07	1/21/05	E601	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-07	8/18/05	E601	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-817-07	08/18/05 DUP	E601	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-01	2/4/05	E601	19 L	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-01	8/31/05	E601	15 L	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-03	3/15/05	E601	14	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-04	3/4/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-04	8/24/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-06	3/4/05	E601	18 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-06	03/04/05 DUP	E601	22	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-06	8/24/05	E601	16 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-07	3/15/05	E601	21	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-07	8/24/05	E601	16 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-08	1/20/05	E601	63	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-08	8/9/05	E601	40	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-08	10/18/05	E601	38	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-09	1/20/05	E601	27	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-09	8/9/05	E601	18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-09	10/18/05	E601	19	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-11	2/4/05	E601	52 DL	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-818-11	8/31/05	E601	50 L	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-819-02	3/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-819-02	9/7/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-01	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-01	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-02	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-02	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-03	1/21/05	E601	0.8 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-03	7/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-13	1/21/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-823-13	9/1/05	E601	0.9 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-02	3/14/05	E601	2.5	<0.5	<0.5	<0.5	<0.5	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-03	9/7/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-05	3/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-05	6/6/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-05	9/7/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-827-05	10/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	3/15/05	E601	95	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	7/19/05	E601	91	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	8/18/05	E601	61	<0.5	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	8/22/05	E601	57	<0.5	0.62	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	8/23/05	E601	65 B	<0.5	0.64	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	8/24/05	E601	63	<0.5	0.67	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06	10/20/05	E601	26	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-08	3/15/05	E601	19	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-08	7/19/05	E601	20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-15	2/17/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-15	4/7/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-8. High Explosive Process Area OU VOCs in ground water and surface water.

Location	Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-829-15	04/07/05 DUP	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-1938	2/23/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-1938	4/21/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-1938	7/21/05	E624	<0.5 BE	<0.5	<0.5	<0.5	<1	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1
W-829-1938	10/5/05	E624	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<1	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<1
W-829-1938	10/05/05 DUP	E624	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<1	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<1
W-829-1940	3/14/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-1940	8/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-22	2/10/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-22	02/10/05 DUP	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-22	5/2/05	E624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	1/12/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	01/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	2/9/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	02/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	3/9/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	03/09/05 DUP	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	03/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	4/13/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	4/13/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	04/13/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	04/13/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	5/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	5/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	05/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	05/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	6/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	6/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	06/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	06/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	07/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	07/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	8/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	8/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	08/10/05 DUP	E601	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D
WELL18	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	11/9/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	11/09/05 DUP	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	11/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	12/15/05	E601	<0.5 BL	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	12/15/05 DUP	E601	<0.5 BL	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL18	12/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	1/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	1/12/05	E502.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
WELL20	2/9/05	E502.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
WELL20	2/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	3/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	3/9/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	03/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	03/09/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
WELL20	4/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	04/13/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
WELL20	04/13/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	5/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	5/12/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	05/12/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
WELL20	05/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	6/9/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	6/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	06/09/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
WELL20	06/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	7/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	7/13/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	07/13/05 DUP	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	07/13/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
WELL20	8/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	8/10/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	08/10/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	08/10/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
WELL20	9/14/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	9/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	09/14/05 DUP	E502.2	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
WELL20	09/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	10/12/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	10/12/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-8. High Explosive Process Area OU VOCs in ground water and surface water.

Location	Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
WELL20	10/12/05 DUP	E502.2	<0.5 HL	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<0.5 H	<1 H	<0.5 H
WELL20	10/12/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	11/9/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	11/9/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	11/09/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	11/09/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
WELL20	12/15/05	E601	<0.5 BL	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	12/15/05	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WELL20	12/15/05 DUP	E502.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5
WELL20	12/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING14	3/30/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	2-Butanone (µg/L)	Acetone (µg/L)	Bromodichloromethane (µg/L)	Chloromethane (µg/L)	Methylene chloride (µg/L)
W-815-2110	9/7/05	E624	0 of 30	-	-	-	-	-	-
W-815-2111	9/14/05	E624	1 of 30	-	-	-	-	1.7 H	-
W-817-2109	9/15/05	E624	0 of 30	-	-	-	-	-	-
GALLO1	1/12/05	E502.2	0 of 46	-	-	-	-	-	-
GALLO1	1/12/05	E502.2	0 of 17	-	-	-	-	-	-
GALLO1	2/9/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	3/9/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	03/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	4/20/05	E502.2	0 of 48	-	-	-	-	-	-
GALLO1	4/20/05	E502.2	0 of 17	-	-	-	-	-	-
GALLO1	04/20/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
GALLO1	04/20/05 DUP	E601	0 of 17	-	-	-	-	-	-
GALLO1	5/13/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	05/13/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	6/9/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	06/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	7/13/05	E502.2	0 of 48	-	-	-	-	-	-
GALLO1	7/13/05	E502.2	0 of 17	-	-	-	-	-	-
GALLO1	07/13/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
GALLO1	07/13/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
GALLO1	8/10/05	E601	0 of 18	-	-	-	-	-	-
GALLO1	08/10/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	9/14/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	09/14/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	10/20/05	E502.2	0 of 48	-	-	-	-	-	-
GALLO1	10/20/05	E601	0 of 17	-	-	-	-	-	-
GALLO1	10/20/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
GALLO1	10/20/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
GALLO1	11/10/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	11/10/05 DUP	E601	0 of 18	-	-	-	-	-	-
GALLO1	12/15/05	E601	0 of 19	-	-	-	-	-	-
GALLO1	12/15/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-35B-01	1/14/05	E601	0 of 18	-	-	-	-	-	-
W-35B-01	4/20/05	E601	0 of 18	-	-	-	-	-	-
W-35B-01	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-35B-01	10/18/05	E601	0 of 18	-	-	-	-	-	-
W-35B-02	1/14/05	E601	0 of 18	-	-	-	-	-	-
W-35B-02	4/20/05	E601	0 of 18	-	-	-	-	-	-
W-35B-02	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-35B-02	10/18/05	E601	0 of 18	-	-	-	-	-	-
W-35B-03	1/14/05	E601	0 of 18	-	-	-	-	-	-
W-35B-03	4/20/05	E601	0 of 18	-	-	-	-	-	-
W-35B-03	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-35B-03	10/18/05	E601	0 of 18	-	-	-	-	-	-
W-35B-04	1/14/05	E601	0 of 18	-	-	-	-	-	-
W-35B-04	4/20/05	E601	0 of 18	-	-	-	-	-	-
W-35B-04	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-35B-04	10/18/05	E601	0 of 18	-	-	-	-	-	-
W-35B-05	1/14/05	E601	0 of 18	-	-	-	-	-	-
W-35B-05	4/20/05	E601	0 of 18	-	-	-	-	-	-
W-35B-05	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-35B-05	10/18/05	E601	0 of 18	-	-	-	-	-	-
W-35C-01	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-35C-01	9/20/05	E601	0 of 18	-	-	-	-	-	-
W-35C-02	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-35C-02	7/21/05	E601	0 of 18	-	-	-	-	-	-
W-35C-04	1/12/05	E601	0 of 18	-	-	-	-	-	-
W-35C-04	7/13/05	E601	0 of 19	-	-	-	-	-	-
W-35C-04	8/9/05	E601	0 of 19	-	-	-	-	-	-
W-35C-04	10/18/05	E601	0 of 19	-	-	-	-	-	-
W-35C-05	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-35C-05	8/17/05	E601	1 of 18	-	-	-	-	-	0.8
W-35C-06	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-35C-06	7/21/05	E601	0 of 18	-	-	-	-	-	-
W-35C-07	3/4/05	E601	1 of 18	-	-	-	-	-	2.6
W-35C-07	03/04/05 DUP	E601	1 of 18	-	-	-	-	-	2.6
W-35C-07	7/21/05	E601	1 of 18	-	-	-	-	-	2.2
W-35C-08	3/4/05	E601	0 of 18	-	-	-	-	-	-
W-35C-08	8/17/05	E601	0 of 18	-	-	-	-	-	-
W-4A	2/24/05	E601	0 of 18	-	-	-	-	-	-
W-4A	02/24/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-4A	9/7/05	E601	0 of 18	-	-	-	-	-	-
W-4AS	2/24/05	E601	0 of 19	-	-	-	-	-	-
W-4AS	02/24/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-4AS	9/7/05	E601	0 of 18	-	-	-	-	-	-
W-4B	1/27/05	E601	0 of 19	-	-	-	-	-	-
W-4B	01/27/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-4B	8/1/05	E601	0 of 18	-	-	-	-	-	-
W-4C	1/27/05	E601	0 of 18	-	-	-	-	-	-
W-4C	8/1/05	E601	0 of 18	-	-	-	-	-	-
W-4C	10/13/05	E601	0 of 18	-	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	2-Butanone (µg/L)	Acetone (µg/L)	Bromodichloromethane (µg/L)	Chloromethane (µg/L)	Methylene chloride (µg/L)
W-6BD	1/27/05	E601	0 of 18	-	-	-	-	-	-
W-6BD	8/16/05	E601	0 of 18	-	-	-	-	-	-
W-6BS	1/27/05	E601	0 of 18	-	-	-	-	-	-
W-6BS	8/16/05	E601	0 of 18	-	-	-	-	-	-
W-6BS	08/16/05 DUP	E601	0 of 16	-	-	-	-	-	-
W-6CD	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6CD	7/21/05	E601	0 of 18	-	-	-	-	-	-
W-6CI	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6CI	7/21/05	E601	0 of 18	-	-	-	-	-	-
W-6CS	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6CS	7/21/05	E601	0 of 18	-	-	-	-	-	-
W-6EI	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6EI	8/11/05	E601	0 of 18	-	-	-	-	-	-
W-6ER	1/12/05	E601	0 of 18	-	-	-	-	-	-
W-6ER	7/13/05	E601	0 of 19	-	-	-	-	-	-
W-6ER	8/9/05	E601	0 of 19	-	-	-	-	-	-
W-6ER	10/18/05	E601	0 of 19	-	-	-	-	-	-
W-6ES	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6ES	8/11/05	E601	0 of 18	-	-	-	-	-	-
W-6F	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6F	8/11/05	E601	0 of 18	-	-	-	-	-	-
W-6G	1/28/05	E601	0 of 18	-	-	-	-	-	-
W-6G	8/11/05	E601	0 of 18	-	-	-	-	-	-
W-6H	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-6H	4/25/05	E601	0 of 18	-	-	-	-	-	-
W-6H	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-6H	10/5/05	E601	0 of 18	-	-	-	-	-	-
W-6I	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-6I	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-6J	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-6J	4/25/05	E601	0 of 18	-	-	-	-	-	-
W-6J	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-6J	10/5/05	E601	0 of 18	-	-	-	-	-	-
W-6K	1/26/05	E601	1 of 18	0.5	-	-	-	-	-
W-6K	8/15/05	E601	0 of 18	-	-	-	-	-	-
W-6L	1/26/05	E601	0 of 18	-	-	-	-	-	-
W-6L	8/15/05	E601	0 of 18	-	-	-	-	-	-
W-806-06A	1/24/05	E601	0 of 18	-	-	-	-	-	-
W-806-06A	5/20/05	E601	0 of 18	-	-	-	-	-	-
W-808-01	1/27/05	E601	0 of 18	-	-	-	-	-	-
W-808-01	8/23/05	E601	0 of 18	-	-	-	-	-	-
W-808-03	1/27/05	E601	0 of 18	-	-	-	-	-	-
W-808-03	8/22/05	E601	0 of 18	-	-	-	-	-	-
W-809-01	1/21/05	E601	0 of 19	-	-	-	-	-	-
W-809-01	01/21/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-809-01	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-809-01	08/24/05 DUP	E601	0 of 16	-	-	-	-	-	-
W-809-02	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-809-02	8/22/05	E601	0 of 18	-	-	-	-	-	-
W-809-03	1/26/05	E601	0 of 18	-	-	-	-	-	-
W-809-03	8/22/05	E601	0 of 18	-	-	-	-	-	-
W-809-04	1/24/05	E601	0 of 18	-	-	-	-	-	-
W-809-04	8/22/05	E601	0 of 18	-	-	-	-	-	-
W-810-01	1/24/05	E601	0 of 18	-	-	-	-	-	-
W-810-01	8/23/05	E601	0 of 18	-	-	-	-	-	-
W-814-01	2/4/05	E601	1 of 18	1.5	-	-	-	-	-
W-814-01	8/30/05	E601	1 of 18	1.2	-	-	-	-	-
W-814-02	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-814-02	8/30/05	E601	0 of 18	-	-	-	-	-	-
W-814-04	3/15/05	E601	0 of 18	-	-	-	-	-	-
W-814-04	8/30/05	E601	0 of 18	-	-	-	-	-	-
W-814-04	12/1/05	E601	0 of 18	-	-	-	-	-	-
W-814-2134	9/19/05	E624	2 of 30	-	97 H	57 H	-	-	-
W-815-02	1/12/05	E601	0 of 19	-	-	-	-	-	-
W-815-02	4/6/05	E601	0 of 19	-	-	-	-	-	-
W-815-02	7/13/05	E601	0 of 19	-	-	-	-	-	-
W-815-02	10/12/05	E601	0 of 19	-	-	-	-	-	-
W-815-04	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-815-04	8/18/05	E601	0 of 18	-	-	-	-	-	-
W-815-04	12/8/05	E601	0 of 19	-	-	-	-	-	-
W-815-05	1/21/05	E601	0 of 19	-	-	-	-	-	-
W-815-05	01/21/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-815-05	8/18/05	E601	0 of 18	-	-	-	-	-	-
W-815-05	08/18/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-815-06	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-815-06	8/31/05	E601	0 of 18	-	-	-	-	-	-
W-815-07	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-815-07	8/31/05	E601	0 of 18	-	-	-	-	-	-
W-815-08	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-815-08	4/5/05	E601	0 of 18	-	-	-	-	-	-
W-815-08	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-815-08	10/12/05	E601	0 of 18	-	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	2-Butanone (µg/L)	Acetone (µg/L)	Bromodichloromethane (µg/L)	Chloromethane (µg/L)	Methylene chloride (µg/L)
W-815-1918	8/24/05	E624	0 of 30	-	-	-	-	-	-
W-815-1918	12/6/05	E624	0 of 30	-	-	-	-	-	-
W-815-1928	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-817-01	1/28/05	WDRE624	0 of 34	-	-	-	-	-	-
W-817-01	4/5/05	WDRE624	0 of 32	-	-	-	-	-	-
W-817-01	04/05/05 DUP	WDRE624	0 of 32	-	-	-	-	-	-
W-817-01	4/7/05	E601	0 of 19	-	-	-	-	-	-
W-817-01	7/13/05	E601	0 of 19	-	-	-	-	-	-
W-817-01	7/27/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-01	10/5/05	E601	0 of 19	-	-	-	-	-	-
W-817-01	10/12/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-01	10/12/05 DUP	WDRE624	0 of 31	-	-	-	-	-	-
W-817-02	2/4/05	WDRE624	0 of 34	-	-	-	-	-	-
W-817-02	4/5/05	WDRE624	0 of 32	-	-	-	-	-	-
W-817-02	7/25/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-02	10/12/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-03	1/28/05	WDRE624	0 of 34	-	-	-	-	-	-
W-817-03	01/28/05 DUP	WDRE624	0 of 34	-	-	-	-	-	-
W-817-03	4/4/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-03	7/19/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-03	10/11/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-03	10/24/05	E601	0 of 18	-	-	-	-	-	-
W-817-03A	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-817-03A	8/18/05	E601	0 of 18	-	-	-	-	-	-
W-817-04	2/4/05	WDRE624	0 of 34	-	-	-	-	-	-
W-817-04	4/4/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-04	7/26/05	WDRE624	0 of 31	-	-	-	-	-	-
W-817-04	07/26/05 DUP	WDRE624	0 of 31	-	-	-	-	-	-
W-817-04	10/11/05	WDRE624	2 of 31	-	810 D	18	-	-	-
W-817-04	10/24/05	E601	0 of 18	-	-	-	-	-	-
W-817-04	11/17/05	WDRE624	0 of 30	-	-	-	-	-	-
W-817-04	11/22/05	WDRE624	0 of 30	-	-	-	-	-	-
W-817-05	1/26/05	E601	0 of 18	-	-	-	-	-	-
W-817-05	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-817-07	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-817-07	8/18/05	E601	0 of 18	-	-	-	-	-	-
W-817-07	08/18/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-818-01	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-818-01	8/31/05	E601	0 of 18	-	-	-	-	-	-
W-818-03	3/15/05	E601	0 of 18	-	-	-	-	-	-
W-818-04	3/4/05	E601	0 of 18	-	-	-	-	-	-
W-818-04	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-818-06	3/4/05	E601	0 of 19	-	-	-	-	-	-
W-818-06	03/04/05 DUP	E601	0 of 18	-	-	-	-	-	-
W-818-06	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-818-07	3/15/05	E601	0 of 18	-	-	-	-	-	-
W-818-07	8/24/05	E601	0 of 18	-	-	-	-	-	-
W-818-08	1/20/05	E601	0 of 18	-	-	-	-	-	-
W-818-08	8/9/05	E601	0 of 19	-	-	-	-	-	-
W-818-08	10/18/05	E601	0 of 19	-	-	-	-	-	-
W-818-09	1/20/05	E601	0 of 18	-	-	-	-	-	-
W-818-09	8/9/05	E601	0 of 19	-	-	-	-	-	-
W-818-09	10/18/05	E601	0 of 19	-	-	-	-	-	-
W-818-11	2/4/05	E601	0 of 18	-	-	-	-	-	-
W-818-11	8/31/05	E601	0 of 18	-	-	-	-	-	-
W-819-02	3/15/05	E601	0 of 18	-	-	-	-	-	-
W-819-02	9/7/05	E601	0 of 18	-	-	-	-	-	-
W-823-01	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-823-01	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-823-02	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-823-02	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-823-03	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-823-03	7/25/05	E601	0 of 18	-	-	-	-	-	-
W-823-13	1/21/05	E601	0 of 18	-	-	-	-	-	-
W-823-13	9/1/05	E601	0 of 18	-	-	-	-	-	-
W-827-02	3/14/05	E601	1 of 18	-	-	-	0.8	-	-
W-827-03	9/7/05	E601	0 of 18	-	-	-	-	-	-
W-827-05	3/14/05	E601	0 of 19	-	-	-	-	-	-
W-827-05	6/6/05	E601	0 of 19	-	-	-	-	-	-
W-827-05	9/7/05	E601	0 of 19	-	-	-	-	-	-
W-827-05	10/13/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	3/15/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	7/19/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	8/18/05	E601	1 of 19	1.8	-	-	-	-	-
W-829-06	8/22/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	8/23/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	8/24/05	E601	0 of 19	-	-	-	-	-	-
W-829-06	10/20/05	E601	0 of 19	-	-	-	-	-	-
W-829-08	3/15/05	E601	0 of 19	-	-	-	-	-	-
W-829-08	7/19/05	E601	0 of 19	-	-	-	-	-	-
W-829-15	2/17/05	E624	0 of 31	-	-	-	-	-	-
W-829-15	4/7/05	E624	0 of 29	-	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	2-Butanone (µg/L)	Acetone (µg/L)	Bromodichloromethane (µg/L)	Chloromethane (µg/L)	Methylene chloride (µg/L)
W-829-15	04/07/05 DUP	E624	0 of 29	-	-	-	-	-	-
W-829-1938	2/23/05	E624	0 of 29	-	-	-	-	-	-
W-829-1938	4/21/05	E624	0 of 29	-	-	-	-	-	-
W-829-1938	7/21/05	E624	0 of 30	-	-	-	-	-	-
W-829-1938	10/5/05	E624	0 of 30	-	-	-	-	-	-
W-829-1938	10/05/05 DUP	E624	0 of 30	-	-	-	-	-	-
W-829-1940	3/14/05	E601	0 of 19	-	-	-	-	-	-
W-829-1940	8/11/05	E601	0 of 19	-	-	-	-	-	-
W-829-22	2/10/05	E624	0 of 31	-	-	-	-	-	-
W-829-22	02/10/05 DUP	E624	0 of 31	-	-	-	-	-	-
W-829-22	5/2/05	E624	0 of 29	-	-	-	-	-	-
WELL18	1/12/05	E601	0 of 19	-	-	-	-	-	-
WELL18	01/12/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	2/9/05	E601	0 of 19	-	-	-	-	-	-
WELL18	02/09/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	3/9/05	E601	0 of 19	-	-	-	-	-	-
WELL18	03/09/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	03/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	4/13/05	E601	0 of 19	-	-	-	-	-	-
WELL18	4/13/05	E601	0 of 19	-	-	-	-	-	-
WELL18	04/13/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	04/13/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	5/12/05	E601	0 of 19	-	-	-	-	-	-
WELL18	5/12/05	E601	0 of 19	-	-	-	-	-	-
WELL18	05/12/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	05/12/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	6/9/05	E601	0 of 19	-	-	-	-	-	-
WELL18	6/9/05	E601	0 of 19	-	-	-	-	-	-
WELL18	06/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	06/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	7/13/05	E601	0 of 19	-	-	-	-	-	-
WELL18	7/13/05	E601	0 of 19	-	-	-	-	-	-
WELL18	07/13/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	07/13/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	8/10/05	E601	0 of 18	-	-	-	-	-	-
WELL18	8/10/05	E601	0 of 18	-	-	-	-	-	-
WELL18	08/10/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	9/14/05	E601	0 of 19	-	-	-	-	-	-
WELL18	09/14/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	10/12/05	E601	0 of 19	-	-	-	-	-	-
WELL18	10/12/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	10/12/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	11/9/05	E601	0 of 19	-	-	-	-	-	-
WELL18	11/09/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	11/09/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL18	12/15/05	E601	0 of 19	-	-	-	-	-	-
WELL18	12/15/05 DUP	E601	0 of 19	-	-	-	-	-	-
WELL18	12/15/05 DUP	E601	0 of 18	-	-	-	-	-	-
WELL20	1/12/05	E502.2	0 of 46	-	-	-	-	-	-
WELL20	1/12/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	2/9/05	E502.2	0 of 46	-	-	-	-	-	-
WELL20	2/9/05	E601	0 of 17	-	-	-	-	-	-
WELL20	3/9/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	3/9/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	03/09/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	03/09/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
WELL20	4/13/05	E601	0 of 19	-	-	-	-	-	-
WELL20	04/13/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	04/13/05 DUP	E601	0 of 17	-	-	-	-	-	-
WELL20	5/12/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	5/12/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	05/12/05 DUP	E502.2	0 of 45	-	-	-	-	-	-
WELL20	05/12/05 DUP	E601	0 of 17	-	-	-	-	-	-
WELL20	6/9/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	6/9/05	E601	0 of 17	-	-	-	-	-	-
WELL20	06/09/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	06/09/05 DUP	E601	0 of 17	-	-	-	-	-	-
WELL20	7/13/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	7/13/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	07/13/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	07/13/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
WELL20	8/10/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	8/10/05	E502.2	0 of 16	-	-	-	-	-	-
WELL20	08/10/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	08/10/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
WELL20	9/14/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	9/14/05	E601	0 of 17	-	-	-	-	-	-
WELL20	09/14/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	09/14/05 DUP	E601	0 of 17	-	-	-	-	-	-
WELL20	10/12/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	10/12/05	E601	0 of 17	-	-	-	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	2-Butanone (µg/L)	Acetone (µg/L)	Bromodichloromethane (µg/L)	Chloromethane (µg/L)	Methylene chloride (µg/L)
WELL20	10/12/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	10/12/05 DUP	E601	0 of 17	-	-	-	-	-	-
WELL20	11/9/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	11/9/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	11/09/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	11/09/05 DUP	E502.2	0 of 17	-	-	-	-	-	-
WELL20	12/15/05	E502.2	0 of 48	-	-	-	-	-	-
WELL20	12/15/05	E502.2	0 of 17	-	-	-	-	-	-
WELL20	12/15/05 DUP	E502.2	0 of 46	-	-	-	-	-	-
WELL20	12/15/05 DUP	E601	0 of 17	-	-	-	-	-	-
SPRING14	3/30/05	E601	0 of 18	-	-	-	-	-	-

OU4-VOC [ug/L] 2005 data (prepared 2006-03-08 12:50:22, Oracle)

A-9. High Explosive Process Area OU high explosive compounds in ground water and surface water.

Sample Location	Sample Date	HMX (µg/L)	RDX (µg/L)
W-815-2110	9/7/05	<1	<1
W-815-2111	9/14/05	<1	<1
W-817-2109	9/15/05	<5	<5
GALLO1	1/12/05	<5	<5
GALLO1	2/9/05	<5	<5
GALLO1	3/9/05	<7 D	<7 D
GALLO1	03/09/05 DUP	<1	<1
GALLO1	4/20/05	<4.4	<4.4
GALLO1	04/20/05 DUP	<1	<1
GALLO1	5/13/05	<4.1	<4.1
GALLO1	05/13/05 DUP	<1	<1
GALLO1	6/9/05	<3.8	<3.8
GALLO1	06/09/05 DUP	<1	<1
GALLO1	7/13/05	<4.1	<4.1
GALLO1	07/13/05 DUP	<1	<1
GALLO1	8/10/05	<3.5	<3.5
GALLO1	08/10/05 DUP	<1	<1
GALLO1	9/14/05	<5	<5
GALLO1	09/14/05 DUP	<1	<1
GALLO1	10/20/05	<5	<5
GALLO1	10/20/05 DUP	<1	<1
GALLO1	11/10/05	<5	<5
GALLO1	11/10/05 DUP	<1	<1
GALLO1	12/15/05	<5	<5
GALLO1	12/15/05 DUP	<1	<1
W-35B-01	1/14/05	<1	<1
W-35B-01	7/25/05	<1	<1
W-35B-02	1/14/05	<1	<1
W-35B-02	7/25/05	<1	<1
W-35B-03	1/14/05	<1	<1
W-35B-03	7/25/05	<1	<1
W-35B-04	1/14/05	<1	<1
W-35B-04	7/25/05	<1	<1
W-35B-05	1/14/05	<1	<1
W-35B-05	7/25/05	<1	<1
W-35C-01	1/21/05	<1	<1
W-35C-02	2/4/05	<1 LO	<1 LO
W-35C-04	1/12/05	<1 L	<1
W-35C-05	1/28/05	<1	<1
W-35C-06	1/28/05	<1	<1
W-35C-07	3/4/05	<1	<1
W-35C-07	03/04/05 DUP	<1	<1
W-35C-08	3/4/05	<1	<1
W-4AS	2/24/05	<4	<4
W-4AS	02/24/05 DUP	<1	<1
W-4B	1/27/05	<5	<5
W-4B	01/27/05 DUP	<1	<1
W-4C	1/27/05	<1	<1
W-4C	8/1/05	<1	<1
W-6BD	1/27/05	<1	<1
W-6BS	1/27/05	<1	<1
W-6CD	1/28/05	<1	<1
W-6CI	1/28/05	<1	<1
W-6CS	1/28/05	<1	<1
W-6EI	1/28/05	<0.9	<0.9
W-6ER	1/12/05	<1 L	<1
W-6ES	1/28/05	<1	<1
W-6F	1/28/05	<0.9	<0.9
W-6G	1/28/05	<0.9	<0.9

A-9. High Explosive Process Area OU high explosive compounds in ground water and surface water.

Sample Location	Sample Date	HMX (µg/L)	RDX (µg/L)
W-6H	1/21/05	<1	<1
W-6H	7/25/05	<1	<1
W-6I	1/21/05	<1	<1
W-6J	1/21/05	<1	<1
W-6J	7/25/05	<1	<1
W-6K	1/26/05	<0.9	<0.9
W-6L	1/26/05	<1	<1
W-806-06A	1/24/05	<1	<1
W-806-06A	5/20/05	<1	<1
W-808-01	1/27/05	<0.9	<0.9
W-808-03	1/27/05	<1	<1
W-809-01	1/21/05	<5	<5
W-809-01	01/21/05 DUP	<1.1	<1.1
W-809-02	1/21/05	<1	<1
W-809-03	1/26/05	<1	<1
W-809-04	1/24/05	<1	<1
W-810-01	1/24/05	<1	<1
W-814-01	2/4/05	<1 LO	<1 LO
W-814-02	2/4/05	<1 LO	<1 LO
W-814-04	3/15/05	<1	<1
W-814-04	8/30/05	<1	<1
W-815-02	1/12/05	5.3	59
W-815-02	4/6/05	5.7 D	62 D
W-815-02	7/13/05	5.4	55
W-815-02	10/12/05	5.2	57
W-815-04	1/21/05	6.9	91
W-815-04	12/8/05	7.9	83
W-815-05	1/21/05	<5	<5
W-815-05	01/21/05 DUP	<1.1	<1.1
W-815-06	2/4/05	<1 LO	28 LO
W-815-08	1/21/05	<1	<1
W-815-08	7/25/05	<1	<1
W-817-01	1/28/05	12.3 D	39.6 DLO
W-817-01	4/5/05	12.1 D	32.1 D
W-817-01	04/05/05 DUP	16 D	43 D
W-817-01	4/7/05	11 D	36 D
W-817-01	7/13/05	12	32
W-817-01	7/27/05	14.4 D	41.1 D
W-817-01	10/5/05	14	35
W-817-01	10/12/05	14.5 D	37.6 D
W-817-01	10/12/05 DUP	14.5 D	36.1 D
W-817-02	2/4/05	<0.486 DLO	0.655 D
W-817-02	4/5/05	<0.649 D	<0.649 D
W-817-02	7/25/05	<0.649 D	<0.649 D
W-817-02	10/12/05	<0.649 D	0.665 D
W-817-03	1/28/05	<0.486 D	6.52 DLO
W-817-03	01/28/05 DUP	<0.486 D	7.28 DLO
W-817-03	4/4/05	<0.649 D	8.68 D
W-817-03	7/19/05	<0.649 D	14.4 D
W-817-03	9/21/05	<0.649 D	8.2 D
W-817-03	9/28/05	<0.649 D	8.01 D
W-817-03	10/11/05	<0.649 D	8.3 D
W-817-03A	1/21/05	<1.1	<1.1
W-817-04	2/4/05	<0.486 DLO	5.72 D
W-817-04	4/4/05	<0.649 D	4.6 D
W-817-04	7/26/05	<0.649 D	5.23 D
W-817-04	07/26/05 DUP	<0.649 D	4.53 D
W-817-04	10/11/05	<0.649 D	4.98 D
W-817-05	1/26/05	<1	<1

A-9. High Explosive Process Area OU high explosive compounds in ground water and surface water.

Sample Location	Sample Date	HMX (µg/L)	RDX (µg/L)
W-817-07	1/21/05	<1.1	<1.1
W-818-03	3/15/05	<1	<1
W-818-04	3/4/05	<1	<1
W-818-06	3/4/05	<40 D	<40 D
W-818-06	03/04/05 DUP	<1	<1
W-818-07	3/15/05	<1	<1
W-818-08	1/20/05	<1	<1
W-818-09	1/20/05	<1	<1
W-819-02	3/15/05	<1	<1
W-823-01	1/21/05	<1	<1
W-823-02	1/21/05	<1	<1
W-823-03	1/21/05	<1	<1
W-823-13	1/21/05	<1	<1
W-827-02	3/14/05	<1	<1
W-827-03	9/7/05	<1	<1
W-827-05	3/14/05	<5 D	<5 D
W-827-05	9/7/05	<5	<5
W-829-15	2/17/05	<5	<5
W-829-15	4/7/05	<5 D	<5 D
W-829-15	04/07/05 DUP	<7 D	<7 D
W-829-1938	2/23/05	<5	<5
W-829-1938	4/21/05	<5	<5
W-829-1938	7/21/05	<5	<5
W-829-1938	10/5/05	<5	<5
W-829-1938	10/05/05 DUP	<5	<5
W-829-1940	3/14/05	<5 D	<5 D
W-829-22	2/10/05	<5	<5
W-829-22	5/2/05	<5 D	<5 D
WELL18	1/12/05	<5	<5
WELL18	2/9/05	<5	<5
WELL18	3/9/05	<7 D	<7 D
WELL18	03/09/05 DUP	<1	<1
WELL18	4/13/05	<5	<5
WELL18	04/13/05 DUP	<1	<1
WELL18	5/12/05	<3.8	<3.8
WELL18	05/12/05 DUP	<1	<1
WELL18	6/9/05	<3	<3
WELL18	06/09/05 DUP	<1	<1
WELL18	7/13/05	<3.5	<3.5
WELL18	07/13/05 DUP	<1	<1
WELL18	8/10/05	<3.1	<3.1
WELL18	08/10/05 DUP	<1	<1
WELL18	9/14/05	<5	<5
WELL18	09/14/05 DUP	<1	<1
WELL18	10/12/05	<5	<5
WELL18	10/12/05 DUP	<1	<1
WELL18	11/9/05	<5	<5
WELL18	11/09/05 DUP	<1	<1
WELL18	12/15/05	<5	<5
WELL18	12/15/05 DUP	<1	<1
WELL20	1/12/05	<5	<5
WELL20	2/9/05	<5	<5
WELL20	3/9/05	<7.3 D	<7.3 D
WELL20	03/09/05 DUP	<1	<1
WELL20	4/13/05	<5	<5
WELL20	04/13/05 DUP	<1	<1
WELL20	5/12/05	<3.1	<3.1
WELL20	05/12/05 DUP	<1	<1
WELL20	6/9/05	<3.8	<3.8

A-9. High Explosive Process Area OU high explosive compounds in ground water and surface water.

Sample Location	Sample Date	HMX (µg/L)	RDX (µg/L)
WELL20	06/09/05 DUP	<1	<1
WELL20	7/13/05	<3.5	<3.5
WELL20	07/13/05 DUP	<1	<1
WELL20	8/10/05	<4.1	<4.1
WELL20	08/10/05 DUP	<1	<1
WELL20	9/14/05	<5	<5
WELL20	09/14/05 DUP	<1	<1
WELL20	10/12/05	<5	<5
WELL20	10/12/05 DUP	<1	<1
WELL20	11/9/05	<5 D	<5 D
WELL20	11/09/05 DUP	<1	<1
WELL20	12/15/05	<5	<5
WELL20	12/15/05 DUP	<1	<1
SPRING14	3/30/05	<1	<1

OU4-E8330 [ug/L] 2005 data (prepared 2006-03-03 08:36:52, Oracle)

A-10. High Explosive Process Area OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-815-2110	9/7/05	-	-	<4
W-815-2111	9/14/05	-	-	<4
W-817-2109	9/15/05	14	63 H	22
GALLO1	1/12/05	-	<0.44	<4
GALLO1	2/9/05	-	<0.44	<4
GALLO1	3/9/05	-	<0.44	<4
GALLO1	03/09/05 DUP	<0.1	<0.1	<4
GALLO1	4/20/05	-	<0.44	<4
GALLO1	04/20/05 DUP	-	<0.1	<4
GALLO1	5/13/05	-	<0.44	<4
GALLO1	05/13/05 DUP	-	<0.1	<4
GALLO1	6/9/05	-	<0.44	<4
GALLO1	06/09/05 DUP	-	0.62	<4
GALLO1	7/13/05	-	<0.44	<4
GALLO1	07/13/05 DUP	-	<0.1	<4
GALLO1	8/10/05	-	<0.5	<4
GALLO1	08/10/05 DUP	-	<0.1	<4
GALLO1	9/14/05	-	<0.5	24
GALLO1	09/14/05 DUP	-	<0.1	<4
GALLO1	10/20/05	-	<0.5	6.1
GALLO1	10/20/05 DUP	-	<2 LO	<4
GALLO1	11/10/05	-	<0.5	<4
GALLO1	11/10/05 DUP	-	<2	<4
GALLO1	12/15/05	-	<0.5	<4
GALLO1	12/15/05 DUP	-	<0.1	<4
W-35B-01	1/14/05	<0.1	-	<4
W-35B-01	7/25/05	-	0.45	<4
W-35B-02	1/14/05	2.8	-	<4
W-35B-02	7/25/05	-	12 D	<4
W-35B-03	1/14/05	0.23	-	<4
W-35B-03	7/25/05	-	1.5	<4
W-35B-04	1/14/05	0.12	-	<4
W-35B-04	7/25/05	-	1.8	<4
W-35B-05	1/14/05	0.25	-	<4
W-35B-05	7/25/05	-	1.5	<4
W-35C-01	1/21/05	-	<0.1	<4
W-35C-02	2/4/05	<0.1	<0.1	<4
W-35C-04	1/12/05	-	<0.1	<4
W-35C-05	1/28/05	0.34	1.5	<4
W-35C-06	1/28/05	-	7.4	<4
W-35C-07	3/4/05	<0.1	-	<4
W-35C-07	03/04/05 DUP	<0.1	-	<4
W-35C-08	3/4/05	<0.1	-	<4
W-4A	2/24/05	-	0.29	<4
W-4A	02/24/05 DUP	<0.1	0.22	<4
W-4AS	2/24/05	-	1	<4
W-4AS	02/24/05 DUP	-	1.3	<4
W-4B	1/27/05	-	<0.44	<4
W-4B	01/27/05 DUP	<0.1	<0.1	<4
W-4C	1/27/05	-	<0.1	<4
W-4C	8/1/05	-	<0.1	<4
W-6BD	1/27/05	-	0.7	<4
W-6BS	1/27/05	-	18 D	<4
W-6CD	1/28/05	-	<0.1	<4
W-6CI	1/28/05	-	<0.1	<4
W-6CS	1/28/05	-	720 D	<4
W-6EI	1/28/05	-	<0.1	<4
W-6ER	1/12/05	-	<0.1	<4
W-6ES	1/28/05	-	7.1	<4
W-6F	1/28/05	-	1.3	<4
W-6G	1/28/05	-	15	<4
W-6H	1/21/05	-	<0.1	<4
W-6H	7/25/05	-	<0.1	<4

A-10. High Explosive Process Area OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-6I	1/21/05	-	0.83	<4
W-6J	1/21/05	-	<0.1	<4
W-6J	7/25/05	-	<0.1	<4
W-6K	1/26/05	<0.1	<0.1	<4
W-6L	1/26/05	-	10 D	<4
W-806-06A	1/24/05	0.15	0.68	<4
W-806-06A	5/20/05	-	1.2	<4
W-808-01	1/27/05	-	91 D	<4
W-808-03	1/27/05	-	<0.1	<4
W-809-01	1/21/05	-	89.7 D	5.4
W-809-01	01/21/05 DUP	-	69 D	<4
W-809-02	1/21/05	-	87 D	9.2
W-809-03	1/26/05	-	90 D	5.7
W-809-04	1/24/05	-	1.2	<4
W-810-01	1/24/05	-	<0.1	<4
W-814-01	2/4/05	15 D	66 D	5.1
W-814-02	2/4/05	-	100 D	4.1
W-814-04	3/15/05	0.4	1.8	<4
W-814-04	8/30/05	-	4	<4
W-814-2134	9/19/05	-	-	<4 LO
W-815-02	1/12/05	-	94.1 D	24
W-815-02	4/6/05	-	100 D	18
W-815-02	7/13/05	-	100 D	19
W-815-02	10/12/05	-	95 D	20
W-815-04	1/21/05	-	74 D	9.2
W-815-04	12/8/05	-	100 D	11
W-815-05	1/21/05	-	91.4 D	11
W-815-05	01/21/05 DUP	-	68 D	6.9
W-815-06	2/4/05	-	110 D	6.5
W-815-08	1/21/05	<0.1	0.1	<4
W-815-08	7/25/05	-	<0.1	<4
W-815-1918	8/24/05	25 DL	-	13
W-815-1918	12/6/05	-	110 D	10
W-817-01	1/28/05	-	81.9	28
W-817-01	01/28/05 DUP	-	80	24
W-817-01	4/5/05	-	88	27
W-817-01	04/05/05 DUP	-	89	23
W-817-01	4/7/05	-	89	19
W-817-01	7/13/05	-	94 D	19
W-817-01	7/27/05	-	88 D	22
W-817-01	07/27/05 DUP	-	88	21
W-817-01	10/5/05	-	88	22
W-817-01	10/12/05	-	86	18
W-817-01	10/12/05 DUP	-	88	24
W-817-02	2/4/05	-	92.3 D	30
W-817-02	4/5/05	-	94 D	14
W-817-02	7/25/05	-	92 D	26
W-817-02	10/12/05	-	91 D	26
W-817-03	1/28/05	-	90 D	30
W-817-03	01/28/05 DUP	-	89.9 D	29
W-817-03	4/4/05	-	92 D	48
W-817-03	7/19/05	-	91 D	27
W-817-03	10/11/05	-	91 D	27
W-817-03	10/24/05	-	91 D	29
W-817-03A	1/21/05	-	100 D	17
W-817-04	2/4/05	-	86.7 D	29
W-817-04	4/4/05	-	88 D	<4
W-817-04	7/26/05	-	92 D	24
W-817-04	07/26/05 DUP	-	92 D	24
W-817-04	10/11/05	-	89 D	25
W-817-04	10/24/05	-	91 D	22
W-817-05	1/26/05	-	0.98	<4
W-817-07	1/21/05	-	63 D	14

A-10. High Explosive Process Area OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-818-01	2/4/05	-	97 D	4.4
W-818-03	3/15/05	11 D	48 D	<4
W-818-04	3/4/05	<0.1	-	<4
W-818-06	3/4/05	-	30	<4 E
W-818-06	03/04/05 DUP	5.5	-	<4
W-818-07	3/15/05	0.85	3.8	<4
W-818-08	1/20/05	13 D	58 D	5.9
W-818-09	1/20/05	-	60 D	4.2
W-818-11	2/4/05	-	93 D	5.8
W-819-02	3/15/05	<0.1	<0.1	<4
W-823-01	1/21/05	-	14 D	<4
W-823-02	1/21/05	-	<0.1	<4
W-823-03	1/21/05	-	32 D	<4
W-823-13	1/21/05	-	35 D	<4
W-827-02	3/14/05	3	13	<4
W-827-03	9/7/05	-	2	<4
W-827-05	3/14/05	-	<0.44	<4
W-827-05	9/7/05	-	<1 D	<4
W-829-06	7/19/05	-	120 DOS	7.7
W-829-06	8/18/05	-	95 D	6.2
W-829-06	8/22/05	-	100 D	5.8
W-829-06	8/23/05	-	50	4
W-829-06	8/24/05	-	110 D	9.3
W-829-06	10/20/05	-	98 D	5.4
W-829-08	7/19/05	-	66 DOS	15
W-829-15	2/17/05	-	-	<4
W-829-15	4/7/05	-	<0.5	<4
W-829-15	04/07/05 DUP	-	<0.5	<4
W-829-1938	2/23/05	-	<0.5 E	<4
W-829-1938	4/21/05	-	-	<4
W-829-1938	7/21/05	-	-	<4
W-829-1938	10/5/05	-	-	<4
W-829-1938	10/05/05 DUP	-	-	<4
W-829-1940	3/14/05	-	60	<4
W-829-22	2/10/05	-	-	<4
W-829-22	02/10/05 DUP	-	-	<4
W-829-22	5/2/05	-	-	<4
WELL18	1/12/05	-	<0.44	<4
WELL18	2/9/05	-	<0.44	<4
WELL18	3/9/05	-	<0.44	<4
WELL18	03/09/05 DUP	-	<0.1	<4
WELL18	4/13/05	-	<0.44	<4
WELL18	04/13/05 DUP	-	<0.1	<4
WELL18	5/12/05	-	<0.44	<4
WELL18	05/12/05 DUP	-	<0.1	<4
WELL18	6/9/05	-	<0.44	<4
WELL18	06/09/05 DUP	-	<0.1	<4
WELL18	7/13/05	-	<0.44	<4
WELL18	07/13/05 DUP	-	<0.1	<4
WELL18	8/10/05	-	<0.5	<4
WELL18	08/10/05 DUP	-	<0.1	<4
WELL18	9/14/05	-	<0.5	<4
WELL18	09/14/05 DUP	-	<0.1	<4
WELL18	10/12/05	-	<0.5	<4
WELL18	10/12/05 DUP	-	<0.1	<4
WELL18	11/9/05	-	<0.5	<4
WELL18	11/09/05 DUP	-	<2	<4
WELL18	12/15/05	-	<0.5	<4
WELL18	12/15/05 DUP	-	<0.1	<4
WELL20	1/12/05	-	<0.44	<4
WELL20	2/9/05	-	<0.44	<4
WELL20	3/9/05	-	<0.44	<4
WELL20	03/09/05 DUP	-	<0.1	<4

A-10. High Explosive Process Area OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
WELL20	4/13/05	-	<0.44	<4
WELL20	04/13/05 DUP	-	<0.1	<4
WELL20	5/12/05	-	<0.44	<4
WELL20	05/12/05 DUP	-	<0.1	<4
WELL20	6/9/05	-	<0.44	<4
WELL20	06/09/05 DUP	-	<0.1	<4
WELL20	7/13/05	-	<0.44	<4
WELL20	07/13/05 DUP	-	<0.1	<4
WELL20	8/10/05	-	<0.5	<4
WELL20	08/10/05 DUP	-	<0.1	<4
WELL20	9/14/05	-	<0.5	<4
WELL20	09/14/05 DUP	-	<0.1	<4
WELL20	10/12/05	-	<0.5	<4
WELL20	10/12/05 DUP	-	<0.1	<4
WELL20	11/9/05	-	<0.5	<4
WELL20	11/09/05 DUP	-	<2	<4
WELL20	12/15/05	-	<0.5	<4
WELL20	12/15/05 DUP	-	<0.1	<4
SPRING14	3/30/05	1	4.6	<4

OU4-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-03 08:36:06, Oracle)

A-11. Building 850 tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
K1-01C	2/22/05	625 ± 92.0
K1-01C	4/12/05	610 ± 89.0
K1-01C	7/5/05	655 ± 110
K1-01C	10/10/05	669 ± 97.0
K1-02B	2/23/05	3,880 ± 400
K1-02B	4/12/05	3,790 ± 390
K1-02B	04/12/05 DUP	3,820 ± 400
K1-02B	7/6/05	3,980 ± 430
K1-02B	10/4/05	3,980 ± 410
K1-02B	10/04/05 DUP	3,900 ± 410
K1-03	2/22/05	824 ± 110
K1-03	4/13/05	768 ± 100
K1-03	7/28/05	918 ± 120
K1-03	10/4/05	817 ± 110
K1-04	2/24/05	167 ± 61.0
K1-04	4/12/05	127 ± 57.0
K1-04	8/1/05	117 ± 57.0
K1-04	10/5/05	289 ± 69.0
K1-05	3/1/05	<100
K1-05	4/13/05	<100
K1-05	7/7/05	160 ± 53.0
K1-05	07/07/05 DUP	191 ± 55.0
K1-05	10/5/05	264 ± 68.0
K1-06	3/4/05	3,510 ± 540
K1-06	4/13/05	3,560 ± 370
K1-06	11/2/05	3,500 ± 380
K1-07	2/28/05	<100
K1-07	4/6/05	<100
K1-07	7/6/05	<100
K1-07	10/17/05	<100
K1-08	3/2/05	124 ± 56.0
K1-08	03/02/05 DUP	<100
K1-08	4/6/05	164 ± 60.0
K1-08	7/6/05	168 ± 55.0
K1-08	10/13/05	202 ± 62.0
K1-09	2/24/05	113 ± 60.0
K1-09	4/6/05	203 ± 63.0
K1-09	8/1/05	162 ± 59.0
K1-09	10/13/05	133 ± 60.0
K2-03	5/23/05	<100
K2-03	10/19/05	<100
K2-04D	4/20/05	6,160 ± 630
K2-04D	10/6/05	4,810 ± 500
K2-04S	4/20/05	12,900 ± 1,300
K2-04S	10/6/05	13,200 ± 1,300

A-11. Building 850 tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
NC2-05	5/9/05	<100
NC2-05	10/19/05	<100
NC2-05A	5/10/05	4,600 ± 510
NC2-05A	10/19/05	4,610 ± 470
NC2-06	5/25/05	4,290 ± 440
NC2-06	10/19/05	4,220 ± 430
NC2-06A	5/25/05	<100
NC2-06A	10/19/05	<100
NC2-09	5/25/05	<100
NC2-09	11/9/05	<100
NC2-10	6/2/05	350 ± 65.0
NC2-10	11/9/05	295 ± 63.0
NC2-11D	4/12/05	4,000 ± 410
NC2-11D	10/4/05	4,210 ± 440
NC2-11I	5/10/05	4,090 ± 460
NC2-11I	11/8/05	4,200 ± 430
NC2-11S	5/10/05	4,890 ± 540
NC2-11S	11/8/05	4,550 ± 470
NC2-12D	4/12/05	7,240 ± 740
NC2-12D	10/11/05	7,320 ± 780
NC2-12I	5/10/05	7,140 ± 790
NC2-12I	11/8/05	7,110 ± 720
NC2-12S	5/10/05	5,960 ± 660
NC2-12S	11/8/05	3,030 ± 320
NC2-13	6/2/05	5,390 ± 550
NC2-13	11/9/05	5,340 ± 550
NC2-14S	6/2/05	10,900 ± 1,100
NC2-14S	12/5/05	4,750 ± 530
NC2-15	9/15/05	6,020 ± 610
NC2-15	11/9/05	5,950 ± 610
NC2-16	6/2/05	2,350 ± 250
NC2-16	12/5/05	1,130 ± 140
NC2-17	9/15/05	12,500 ± 1,300
NC2-17	11/9/05	12,300 ± 1,200
NC2-18	8/30/05	18,900 ± 1,900
NC2-18	11/3/05	18,600 ± 1,900
NC2-19	6/8/05	<100
NC2-19	12/5/05	<100
NC2-20	6/6/05	<100
NC2-20	11/3/05	<100
NC2-21	6/6/05	<100
NC2-21	11/3/05	<100
NC7-10	4/25/05	20,900 ± 2,200
NC7-10	10/27/05	19,000 ± 2,000
NC7-11	4/25/05	18,300 ± 1,900

A-11. Building 850 tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
NC7-11	10/27/05	20,500 ± 2,200
NC7-14	4/26/05	2,460 ± 280
NC7-15	4/26/05	1,280 ± 160
NC7-15	04/26/05 DUP	1,480 ± 92.5
NC7-15	11/15/05	1,100 ± 140
NC7-19	4/26/05	8,330 ± 920
NC7-19	04/26/05 DUP	8,380 ± 920
NC7-19	12/5/05	6,600 ± 720
NC7-19	12/05/05 DUP	6,860 ± 760
NC7-27	5/20/05	14,600 ± 1,500
NC7-27	10/27/05	16,200 ± 1,700
NC7-28	4/26/05	26,100 ± 2,800
NC7-28	11/9/05	31,000 ± 3,100
NC7-29	6/6/05	<100
NC7-29	11/8/05	<100
NC7-43	4/26/05	26,000 ± 2,800
NC7-43	11/9/05	10,900 ± 1,100
NC7-44	6/7/05	<100
NC7-44	10/31/05	<100
NC7-46	5/20/05	<100
NC7-46	11/9/05	<100
NC7-54	4/25/05	20,000 ± 2,100
NC7-54	10/24/05	21,300 ± 2,200
NC7-56	6/1/05	16,800 ± 1,800
NC7-56	11/30/05	16,200 ± 1,700
NC7-58	5/19/05	13,500 ± 1,400
NC7-58	11/15/05	5,100 ± 590
NC7-59	6/2/05	16,000 ± 1,600
NC7-59	06/02/05 DUP	16,400 ± 243
NC7-59	11/30/05	15,800 ± 1,600
NC7-60	5/23/05	1,670 ± 200
NC7-60	10/27/05	1,500 ± 170
NC7-61	4/21/05	32,100 ± 3,400
NC7-61	04/21/05 DUP	32,900 ± 3,400
NC7-61	10/27/05	31,100 ± 3,300
NC7-61	10/27/05 DUP	30,600 ± 3,200
NC7-62	6/1/05	16,200 ± 1,800
NC7-62	11/15/05	6,070 ± 700
NC7-69	4/14/05	<100
NC7-69	10/25/05	<100
NC7-70	5/11/05	91,900 ± 9,900
NC7-70	11/8/05	79,400 ± 8,000
NC7-70	11/08/05 DUP	76,600 ± 847
NC7-71	5/11/05	428 ± 80.0
NC7-71	11/9/05	408 ± 71.0

A-11. Building 850 tritium in ground water and surface water.

Sample Location	Sample Date	Tritium (pCi/L)
NC7-72	6/1/05	15,300 ± 1,700
NC7-72	11/15/05	14,100 ± 1,500
NC7-73	6/1/05	15,500 ± 1,700
NC7-73	11/15/05	13,600 ± 1,400
NC7-76	8/25/05	4,870 ± 520
NC7-76	12/8/05	4,580 ± 490
W-850-05	5/11/05	21,900 ± 2,400
W-850-05	11/9/05	22,600 ± 2,300
W-PIT7-16	4/26/05	<100
W-PIT7-16	11/15/05	104 ± 59.0
W-865-1802	3/3/05	105 ± 58.0
W-865-1802	03/03/05 DUP	<200
W-865-1802	5/10/05	<100
W-865-1802	8/24/05	186 ± 59.0
W-865-1802	10/6/05	154 ± 61.0
W-865-1803	5/17/05	1,990 ± 210
W-865-1803	11/3/05	2,480 ± 260
SPRING24	6/8/05	1,960 ± 210
SPRING24	8/25/05	2,020 ± 230
SPRING24	10/5/05	2,070 ± 230
W8SPRNG	8/25/05	22,500 ± 2,400
W8SPRNG	10/24/05	21,300 ± 2,200
W8SPRNG	10/24/05 DUP	20,400 ± 318 L

OU5-RADABH3 [pCi/L] 2005 data (prepared 2006-03-06 15:48:21, Oracle)

A-12. Building 850 uranium isotopes by mass spectrometry in ground water and surface water.

Sample Location	Sample Date	Uranium (pCi/L)	Uranium 234 by mass (pCi/L)	Uranium 235 by mass (pCi/L)	Uranium 236 by mass (pCi/L)	Uranium 238 by mass (pCi/L)	Uranium 235/238
K1-06	4/13/05	8.20 ± 0.0970	5.60 ± 0.0940	0.120 ± 0.00180	<0.00047	2.50 ± 0.0250	0.00730 ± 0.0000870
K2-03	5/23/05	5.90 ± 0.0780	3.40 ± 0.0760	0.110 ± 0.00130	<0.00084	2.38 ± 0.0180	0.00720 ± 0.0000690
K2-04D	4/20/05	2.90 ± 0.0200	1.70 ± 0.0190	0.0500 ± 0.000450	<0.00025	1.08 ± 0.00640	0.00724 ± 0.0000480
K2-04D	10/6/05	2.70 ± 0.0460	1.60 ± 0.0460	0.0470 ± 0.000220	<0.0002	1.00 ± 0.000600	0.00715 ± 0.0000330
K2-04S	4/20/05	3.20 ± 0.0500	1.70 ± 0.0410	0.0640 ± 0.00170	<0.00027	1.40 ± 0.0290	0.00720 ± 0.000127
NC2-05	5/9/05	12.0 ± 0.160	6.50 ± 0.160	0.210 ± 0.00170	<0.007	5.14 ± 0.0310	0.00641 ± 0.0000330
NC2-05A	5/10/05	4.80 ± 0.0580	2.90 ± 0.0570	0.0810 ± 0.000540	<0.00052	1.79 ± 0.0100	0.00702 ± 0.0000260
NC2-06	5/25/05	1.50 ± 0.0240	0.890 ± 0.0220	0.0270 ± 0.000430	<0.00014	0.592 ± 0.00890	0.00720 ± 0.0000340
NC2-06A	5/25/05	1.00 ± 0.0150	0.510 ± 0.0150	0.0150 ± 0.000120	<0.007	0.485 ± 0.00190	0.00494 ± 0.0000340
NC2-06A	10/19/05	0.850 ± 0.0130	0.440 ± 0.0130	0.0130 ± 0.0000770	<0.007	0.400 ± 0.000780	0.00500 ± 0.0000290
NC2-09	5/25/05	<0.0627	<0.062	0.000920 ± 0.0000300	<0.000013	0.0197 ± 0.000440	0.00725 ± 0.000170
NC2-10	6/2/05	5.00 ± 0.0630	3.30 ± 0.0610	0.0790 ± 0.000890	<0.0004	1.69 ± 0.0170	0.00726 ± 0.0000380
NC2-11D	4/12/05	4.80 ± 0.0940	3.00 ± 0.0910	0.0840 ± 0.00170	<0.00034	1.80 ± 0.0240	0.00730 ± 0.000117
NC2-11D	10/4/05	4.70 ± 0.0830	2.80 ± 0.0830	0.0830 ± 0.000230	<0.00035	1.80 ± 0.00330	0.00711 ± 0.0000160
NC2-11I	5/10/05	4.20 ± 0.0520	2.60 ± 0.0510	0.0710 ± 0.000810	<0.00054	1.53 ± 0.0120	0.00720 ± 0.0000610
NC2-11S	5/10/05	3.90 ± 0.0560	2.50 ± 0.0530	0.0660 ± 0.00110	<0.0005	1.42 ± 0.0180	0.00721 ± 0.0000700
NC2-12D	4/12/05	3.70 ± 0.0260	2.20 ± 0.0250	0.0670 ± 0.000480	<0.00033	1.43 ± 0.00760	0.00729 ± 0.0000350
NC2-12D	10/11/05	2.90 ± 0.0510	1.70 ± 0.0510	0.0500 ± 0.000270	<0.00021	1.10 ± 0.00510	0.00715 ± 0.0000200
NC2-12I	5/10/05	3.70 ± 0.0470	2.30 ± 0.0450	0.0610 ± 0.000710	<0.00031	1.33 ± 0.0120	0.00720 ± 0.0000510
NC2-12S	5/10/05	4.30 ± 0.0750	2.80 ± 0.0740	0.0710 ± 0.000850	<0.00036	1.51 ± 0.0140	0.00727 ± 0.0000530
NC2-13	6/2/05	5.30 ± 0.0830	3.30 ± 0.0780	0.0920 ± 0.00190	<0.00037	1.90 ± 0.0300	0.00736 ± 0.0000980
NC2-14S	6/2/05	2.80 ± 0.0590	1.50 ± 0.0580	0.0560 ± 0.000720	<0.00024	1.20 ± 0.0130	0.00719 ± 0.0000500
NC2-15	9/15/05	2.40 ± 0.0420	1.50 ± 0.0410	0.0390 ± 0.000630	<0.00016	0.830 ± 0.00870	0.00720 ± 0.0000910
NC2-16	6/2/05	0.710 ± 0.00830	0.450 ± 0.00810	0.0120 ± 0.0000920	<0.000048	0.250 ± 0.00160	0.00724 ± 0.0000350
NC2-17	9/15/05	2.10 ± 0.0280	1.30 ± 0.0270	0.0380 ± 0.000420	<0.00016	0.820 ± 0.00650	0.00729 ± 0.0000550
NC2-18	8/30/05	2.90 ± 0.0270	1.60 ± 0.0240	0.0570 ± 0.000630	<0.00024	1.20 ± 0.0120	0.00727 ± 0.0000410
NC2-19	6/8/05	6.80 ± 0.150	3.90 ± 0.140	0.130 ± 0.00300	<0.00053	2.70 ± 0.0500	0.00733 ± 0.000106
NC2-20	6/6/05	2.20 ± 0.0220	1.30 ± 0.0210	0.0420 ± 0.000340	<0.00064	0.920 ± 0.00570	0.00715 ± 0.0000360
NC2-21	6/6/05	3.90 ± 0.0380	2.30 ± 0.0340	0.0740 ± 0.00110	<0.0003	1.60 ± 0.0170	0.00735 ± 0.0000730
NC7-10	4/25/05	3.10 ± 0.0440	1.80 ± 0.0420	0.0540 ± 0.000650	<0.007	1.25 ± 0.0130	0.00671 ± 0.0000450
NC7-11	4/25/05	3.40 ± 0.0470	1.90 ± 0.0460	0.0650 ± 0.000680	<0.00041	1.42 ± 0.0110	0.00708 ± 0.0000490
NC7-15	4/26/05	2.30 ± 0.0170	1.20 ± 0.0170	0.0490 ± 0.000280	<0.00037	1.05 ± 0.00410	0.00720 ± 0.0000300
NC7-19	4/26/05	4.20 ± 0.0350	2.20 ± 0.0320	0.0900 ± 0.000920	<0.00037	1.90 ± 0.0120	0.00730 ± 0.0000590
NC7-19	04/26/05 DUP	4.20 ± 0.0420	2.20 ± 0.0370	0.0890 ± 0.00160	<0.00036	1.90 ± 0.0190	0.00730 ± 0.000103
NC7-27	5/20/05	3.00 ± 0.0430	1.70 ± 0.0420	0.0610 ± 0.000670	<0.0003	1.30 ± 0.0110	0.00729 ± 0.0000520
NC7-28	4/26/05	18.0 ± 0.270	3.50 ± 0.210	0.210 ± 0.00320	0.0800 ± 0.0000710	13.8 ± 0.170	0.00238 ± 0.0000200
NC7-29	6/6/05	17.0 ± 0.300	9.10 ± 0.270	0.340 ± 0.00710	<0.0014	7.40 ± 0.120	0.00726 ± 0.0000870
NC7-43	4/26/05	2.60 ± 0.0170	1.10 ± 0.0100	0.0370 ± 0.000430	<0.007	1.42 ± 0.0130	0.00409 ± 0.0000260

A-12. Building 850 uranium isotopes by mass spectrometry in ground water and surface water.

Sample Location	Sample Date	Uranium (pCi/L)	Uranium 234 by mass (pCi/L)	Uranium 235 by mass (pCi/L)	Uranium 236 by mass (pCi/L)	Uranium 238 by mass (pCi/L)	Uranium 235/238
NC7-44	6/7/05	1.70 ± 0.0290	1.10 ± 0.0290	0.0280 ± 0.000380	<0.00011	0.590 ± 0.00510	0.00728 ± 0.0000780
NC7-46	5/20/05	0.0890 ± 0.00180	<0.062	0.00170 ± 0.0000310	<0.0000086	0.0367 ± 0.000360	0.00712 ± 0.000110
NC7-54	4/25/05	3.50 ± 0.0290	1.80 ± 0.0270	0.0620 ± 0.000620	<0.007	1.61 ± 0.0100	0.00597 ± 0.0000470
NC7-54	10/24/05	3.20 ± 0.280	2.00 ± 0.280	<0.063	<0.0046	1.20 ± 0.0160	<0.007921
NC7-56	6/1/05	4.20 ± 0.0440	2.20 ± 0.0380	0.0870 ± 0.00140	<0.00037	1.91 ± 0.0220	0.00710 ± 0.0000760
NC7-58	5/19/05	4.00 ± 0.0420	2.20 ± 0.0370	0.0810 ± 0.00100	<0.00051	1.80 ± 0.0200	0.00710 ± 0.0000360
NC7-59	6/2/05	4.20 ± 0.0860	2.30 ± 0.0850	0.0840 ± 0.00110	<0.00035	1.80 ± 0.0130	0.00716 ± 0.0000730
NC7-60	5/23/05	1.00 ± 0.0140	0.600 ± 0.0130	0.0190 ± 0.000230	<0.00012	0.410 ± 0.00310	0.00720 ± 0.0000690
NC7-61	4/21/05	4.80 ± 0.0840	2.20 ± 0.0800	0.0700 ± 0.000780	0.00890 ± 0.0000190	2.53 ± 0.0260	0.00433 ± 0.0000190
NC7-61	04/21/05 DUP	4.60 ± 0.0500	2.10 ± 0.0430	0.0680 ± 0.000850	0.00920 ± 0.0000190	2.40 ± 0.0260	0.00444 ± 0.0000270
NC7-61	10/27/05	4.80 ± 0.0410	2.10 ± 0.0400	0.0690 ± 0.000450	0.00810 ± 0.0000200	2.50 ± 0.0110	0.00426 ± 0.0000210
NC7-61	10/27/05 DUP	4.80 ± 0.0400	2.20 ± 0.0390	0.0690 ± 0.000470	0.00850 ± 0.0000190	2.50 ± 0.00480	0.00425 ± 0.0000280
NC7-62	6/1/05	3.80 ± 0.0570	2.00 ± 0.0550	0.0790 ± 0.000980	<0.0004	1.71 ± 0.0160	0.00717 ± 0.0000600
NC7-69	4/14/05	<0.0627	<0.16	0.00260 ± 0.0000510	<0.00003	0.0570 ± 0.000810	0.00711 ± 0.0000960
NC7-69	10/25/05	<0.0627	<0.2	0.00200 ± 0.0000500	<0.00052	0.0440 ± 0.000690	0.00715 ± 0.000138
NC7-70	1/29/05	2.20 ± 0.0110	1.40 ± 0.0100	0.0310 ± 0.000140	<0.007	0.760 ± 0.00230	0.00640 ± 0.0000210
NC7-70	5/11/05	2.30 ± 0.0290	1.40 ± 0.0280	0.0330 ± 0.000370	<0.007	0.823 ± 0.00760	0.00619 ± 0.0000390
NC7-70	8/10/05	2.20 ± 0.0420	1.40 ± 0.0400	0.0310 ± 0.000610	<0.0015	0.770 ± 0.0110	0.00632 ± 0.0000790
NC7-70	11/8/05	2.00 ± 0.0330	1.30 ± 0.0330	0.0290 ± 0.000160	<0.007	0.710 ± 0.00280	0.00634 ± 0.0000240
NC7-71	5/11/05	<0.0627	<0.025	<0.000022	<0.00012	0.00620 ± 0.000100	0.00895 ± 0.000157
NC7-72	6/1/05	3.70 ± 0.0570	2.00 ± 0.0540	0.0770 ± 0.00100	<0.00032	1.69 ± 0.0150	0.00703 ± 0.0000700
NC7-73	6/1/05	4.60 ± 0.0410	2.50 ± 0.0370	0.0950 ± 0.000940	<0.00075	2.00 ± 0.0170	0.00718 ± 0.0000410
NC7-76	8/25/05	3.50 ± 0.0750	1.80 ± 0.0740	0.0730 ± 0.000590	<0.00031	1.60 ± 0.00840	0.00700 ± 0.0000430
W-850-05	5/11/05	0.170 ± 0.00210	0.0960 ± 0.00210	0.00250 ± 0.0000120	<0.007	0.0680 ± 0.000300	0.00570 ± 0.0000110
W-PIT7-16	4/26/05	0.310 ± 0.00350	0.210 ± 0.00350	0.00440 ± 0.0000500	<0.000058	0.100 ± 0.000780	0.00690 ± 0.000103
W-865-1802	5/10/05	1.60 ± 0.0210	1.10 ± 0.0200	0.0240 ± 0.000310	<0.00019	0.532 ± 0.00590	0.00716 ± 0.0000440
W-865-1803	5/17/05	6.10 ± 0.0530	3.90 ± 0.0490	0.0980 ± 0.00110	<0.00074	2.11 ± 0.0200	0.00724 ± 0.0000420
SPRING24	6/8/05	1.10 ± 0.0130	0.730 ± 0.0130	0.0170 ± 0.000190	<0.007	0.390 ± 0.00300	0.00702 ± 0.0000540
W8SPRNG	8/25/05	3.80 ± 0.0550	2.00 ± 0.0540	0.0700 ± 0.000760	<0.0034	1.80 ± 0.00930	0.00615 ± 0.0000590

OU5-ICMS [pCi/L; -] 2005 data (prepared 2006-03-13 10:13:03, Oracle)

A-13. Building 850 uranium isotopes by alpha spectrometry in ground water.

Sample Location	Sample Date	Uranium 234 and Uranium 233 (pCi/L)	Uranium 235 and Uranium 236 (pCi/L)	Uranium 238 (pCi/L)
K1-01C	2/22/05	1.82 ± 0.240	<0.1	0.907 ± 0.140
K1-01C	4/12/05	2.26 ± 0.280	<0.1	1.01 ± 0.150
K1-01C	7/5/05	2.29 ± 0.290	<0.1	1.01 ± 0.150
K1-01C	10/10/05	2.24 ± 0.280	<0.1	1.12 ± 0.160
K1-02B	2/23/05	1.77 ± 0.230	<0.1	0.980 ± 0.150
K1-02B	4/12/05	2.05 ± 0.250	<0.1	1.12 ± 0.160
K1-02B	04/12/05 DUP	1.87 ± 0.250	<0.1	0.964 ± 0.150
K1-02B	7/6/05	2.06 ± 0.270	<0.1	1.10 ± 0.160
K1-02B	10/4/05	1.93 ± 0.320	<0.1	1.18 ± 0.220
K1-02B	10/04/05 DUP	2.08 ± 0.300	<0.1	1.25 ± 0.210
K1-03	2/22/05	0.881 ± 0.130	<0.1	0.540 ± 0.0970
K1-03	4/13/05	1.05 ± 0.170	<0.1	0.530 ± 0.100
K1-03	7/28/05	1.05 ± 0.260	<0.1	0.564 ± 0.170
K1-03	10/4/05	1.07 ± 0.210	<0.1	0.590 ± 0.150
K1-04	2/24/05	0.950 ± 0.150	<0.1	0.642 ± 0.110
K1-04	4/12/05	1.10 ± 0.160	<0.1	0.537 ± 0.0950
K1-04	8/1/05	1.32 ± 0.320	<0.1	0.546 ± 0.180
K1-04	10/5/05	1.21 ± 0.200	<0.1	0.687 ± 0.140
K1-05	3/1/05	1.50 ± 0.210	<0.1	0.668 ± 0.120
K1-05	4/13/05	1.62 ± 0.210	<0.1	0.800 ± 0.130
K1-05	7/7/05	1.89 ± 0.250	<0.1	0.886 ± 0.140
K1-05	07/07/05 DUP	1.78 ± 0.240	<0.1	0.824 ± 0.140
K1-05	10/5/05	1.65 ± 0.250	<0.1	0.804 ± 0.150
K1-07	2/28/05	1.59 ± 0.210	<0.1	0.728 ± 0.110
K1-07	4/6/05	1.84 ± 0.230	<0.1	0.752 ± 0.110
K1-07	7/6/05	1.70 ± 0.230	<0.1	0.766 ± 0.120
K1-07	10/17/05	1.92 ± 0.240	<0.1	0.900 ± 0.130
K1-08	3/2/05	1.76 ± 0.240	<0.1	0.903 ± 0.140
K1-08	03/02/05 DUP	1.77 ± 0.230	<0.1	0.885 ± 0.130
K1-08	4/6/05	1.94 ± 0.240	<0.1	0.876 ± 0.130
K1-08	7/6/05	1.84 ± 0.250	<0.1	0.976 ± 0.150
K1-08	10/13/05	2.04 ± 0.280	<0.1	0.933 ± 0.150
K1-09	2/24/05	1.63 ± 0.210	<0.1	0.735 ± 0.120
K1-09	4/6/05	1.77 ± 0.220	<0.1	0.855 ± 0.120
K1-09	8/1/05	2.07 ± 0.420	<0.1	0.827 ± 0.240
K1-09	10/13/05	1.73 ± 0.240	<0.1	0.898 ± 0.150
K2-04D	4/20/05	1.71 ± 0.250	<0.1	1.04 ± 0.170
K2-04S	4/20/05	1.64 ± 0.230	<0.1	1.50 ± 0.220
NC2-11D	4/12/05	2.79 ± 0.340	<0.1	1.91 ± 0.240
NC2-12D	4/12/05	2.13 ± 0.270	<0.1	1.46 ± 0.200
NC7-61	4/21/05	2.28 ± 0.300	0.107 ± 0.0420	2.44 ± 0.320
NC7-61	04/21/05 DUP	2.13 ± 0.280	0.106 ± 0.0420	2.48 ± 0.310
NC7-69	4/14/05	<0.1	<0.1	<0.1

OU5-AS [pCi/L] 2005 data (prepared 2006-03-06 15:46:45, Oracle)

A-14. Building 850 nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
K1-01C	2/22/05	-	37	<4 E
K1-01C	4/12/05	-	37	<4 E
K1-01C	7/5/05	-	36.9	<4 E
K1-01C	10/10/05	-	31.4 D	<4 E
K1-02B	2/23/05	-	38	7.1
K1-02B	4/12/05	-	38	7.6
K1-02B	04/12/05 DUP	-	37	7
K1-02B	7/6/05	-	37.5	6.49
K1-02B	10/4/05	-	33.2 D	7.54
K1-02B	10/04/05 DUP	-	31.6 D	7.39
K1-03	2/22/05	-	32	<4 E
K1-03	4/13/05	-	32	<4 E
K1-03	7/28/05	-	28.3 D	<4 E
K1-03	10/4/05	-	27.5 D	<4 E
K1-04	2/24/05	-	33	<4 E
K1-04	4/12/05	-	27	<4 E
K1-04	8/1/05	-	29.6 D	<4 E
K1-04	10/5/05	-	5.95 D	<4 E
K1-05	3/1/05	-	38	<4
K1-05	4/13/05	-	39	<4
K1-05	7/7/05	-	37.9	<4
K1-05	07/07/05 DUP	-	37.9	<4
K1-05	10/5/05	-	30.8 D	<4
K1-06	4/13/05	-	43	-
K1-07	2/28/05	7.5	-	<4
K1-07	4/6/05	-	34	<4 E
K1-07	7/6/05	-	31.4	<4
K1-07	10/17/05	6.57 D	29.1 D	<4
K1-08	3/2/05	-	38	<4
K1-08	03/02/05 DUP	-	38	<4
K1-08	4/6/05	-	38	<4
K1-08	7/6/05	-	37.9	<4
K1-08	10/13/05	-	31.5 D	<4
K1-09	2/24/05	-	38	<4
K1-09	4/6/05	-	37	<4
K1-09	8/1/05	-	32.8 D	<4
K1-09	10/13/05	-	29.9 D	<4
K2-03	5/23/05	-	6.7	-
K2-04D	4/20/05	8.9	39	5.6
K2-04D	4/20/05	-	40 H	-
K2-04D	8/9/05	-	-	<4 E
K2-04D	10/6/05	-	-	4.15
K2-04S	4/20/05	8.9	39 H	9.9
K2-04S	4/20/05	-	39	-
K2-04S	8/9/05	-	-	8.7
K2-04S	10/6/05	-	-	10.2
NC2-05	5/9/05	7.3	32 H	<4
NC2-05	5/9/05	-	32	-
NC2-05A	5/10/05	7.9 D	35 D	<4
NC2-05A	5/10/05	-	35 D	-

A-14. Building 850 nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
NC2-06	5/25/05	8.4	37 DL	-
NC2-06	5/25/05	-	37	-
NC2-06A	5/25/05	0.16	0.7 L	<4
NC2-06A	5/25/05	-	0.7	-
NC2-09	5/25/05	<0.1	<0.1 L	-
NC2-09	5/25/05	-	<0.1	-
NC2-10	6/2/05	26 D	120 D	-
NC2-10	6/2/05	-	120 D	-
NC2-11D	4/12/05	7.2	32 H	<4 E
NC2-11D	4/12/05	-	32	-
NC2-11D	10/4/05	-	-	<4 E
NC2-11I	5/10/05	7.7 D	35 D	-
NC2-11I	5/10/05	-	34 D	-
NC2-11S	5/10/05	-	37 D	-
NC2-12D	4/12/05	6.1	27 H	4.2
NC2-12D	4/12/05	-	24	-
NC2-12D	10/11/05	-	-	4.49
NC2-12I	5/10/05	5.4 D	23 D	-
NC2-12I	5/10/05	-	24 D	-
NC2-12S	5/10/05	-	41 D	-
NC2-13	6/2/05	-	37 D	-
NC2-14S	6/2/05	5.4 D	24 D	6
NC2-14S	6/2/05	-	24 D	-
NC2-14S	8/30/05	-	-	6.1
NC2-15	9/15/05	7.67 D	-	-
NC2-16	6/2/05	2.8 D	12 D	<4
NC2-16	6/2/05	-	12 D	-
NC2-16	8/30/05	-	-	<4
NC2-17	9/15/05	6.12 D	-	-
NC2-18	9/8/05	8.21 D	-	-
NC2-19	6/8/05	18 D	81 D	-
NC2-19	6/8/05	-	80 D	-
NC2-20	6/6/05	0.6	7.2	-
NC2-20	6/6/05	-	2.7	-
NC2-21	6/6/05	6.1	27	-
NC2-21	6/6/05	-	27	-
NC7-10	4/25/05	7.2 D	33 D	8.5
NC7-10	4/25/05	-	32 D	-
NC7-10	8/1/05	-	-	16.5
NC7-11	4/25/05	13 D	60 D	10
NC7-11	4/25/05	-	59 D	-
NC7-11	8/1/05	-	-	15.5
NC7-14	4/26/05	-	26 D	-
NC7-15	4/26/05	8	36	<4
NC7-15	04/26/05 DUP	7.4 D	33 D	<4
NC7-15	04/26/05 DUP	-	33 D	-
NC7-15	4/26/05	-	36 H	-
NC7-19	4/26/05	6.2 D	28 D	<4
NC7-19	04/26/05 DUP	6.3 D	28 D	<4
NC7-19	04/26/05 DUP	-	28 D	-

A-14. Building 850 nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
NC7-19	4/26/05	-	28 D	-
NC7-27	5/20/05	12 D	53 D	11
NC7-27	5/20/05	-	50 D	-
NC7-28	4/26/05	10 D	46 D	43
NC7-28	8/10/05	-	-	66.3 D
NC7-28	11/9/05	-	-	75.2 D
NC7-29	6/6/05	31 D	140 D	9.7
NC7-29	6/6/05	-	140 D	-
NC7-43	4/26/05	4.3 D	19 D	6.1
NC7-43	4/26/05	-	15 D	-
NC7-44	6/7/05	14 D	65 D	<4
NC7-44	6/7/05	-	62 D	-
NC7-46	5/20/05	<0.1	0.35	<4
NC7-46	5/20/05	-	0.22	-
NC7-46	9/12/05	-	-	<4
NC7-54	4/25/05	8.2 D	37 D	11
NC7-54	4/25/05	-	36 D	-
NC7-54	8/10/05	-	-	14.1
NC7-56	6/1/05	8.4 D	37 D	7.2
NC7-56	6/1/05	-	37 D	-
NC7-56	9/12/05	-	-	10.9
NC7-58	5/19/05	8.6	36 D	6.8
NC7-58	5/19/05	-	38	-
NC7-58	8/25/05	-	-	10.3
NC7-59	6/2/05	8.1 D	38	8.2
NC7-59	06/02/05 DUP	8.6	38 H	11
NC7-59	06/02/05 DUP	-	38 D	-
NC7-59	9/12/05	-	-	9.46
NC7-60	5/23/05	0.11	0.49	<4
NC7-60	5/23/05	-	0.39	-
NC7-61	4/21/05	9.6	42	28
NC7-61	04/21/05 DUP	9.7	42	29
NC7-61	04/21/05 DUP	-	43 H	-
NC7-61	4/21/05	-	42 H	-
NC7-61	10/27/05	-	45.7 D	39 D
NC7-61	10/27/05 DUP	-	42.8 D	39.1 D
NC7-62	6/1/05	8.7 D	38 D	9.1
NC7-62	6/1/05	-	39 D	-
NC7-69	4/14/05	<0.5	<0.44 H	<4
NC7-69	4/14/05	-	<0.44	-
NC7-69	10/25/05	-	-	<4
NC7-70	5/11/05	11 D	49 D	46
NC7-70	5/11/05	-	48 D	-
NC7-70	8/10/05	-	-	51.6 D
NC7-71	5/11/05	<0.1	<0.1	-
NC7-71	5/11/05	-	<0.1	-
NC7-71	8/10/05	-	-	<4
NC7-72	6/1/05	9 D	41 D	7.7
NC7-72	6/1/05	-	390,000 D	-
NC7-72	9/12/05	-	-	8.71

A-14. Building 850 nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
NC7-73	6/1/05	12 D	41 D	7
NC7-73	6/1/05	-	54 D	-
NC7-73	9/12/05	-	-	9.29
NC7-76	8/25/05	-	25.4 D	-
W-850-05	5/11/05	<0.1	0.22	<4
W-850-05	5/11/05	-	0.15	-
W-PIT7-16	4/27/05	<0.5	<0.44	-
W-PIT7-16	4/27/05	-	<0.44 H	-
W-865-1802	3/3/05	-	-	<4
W-865-1802	03/03/05 DUP	-	-	<4
W-865-1802	5/10/05	6.9 D	32 D	<4
W-865-1802	5/10/05	-	30 D	-
W-865-1802	8/24/05	-	-	<4
W-865-1802	10/6/05	-	-	<4 L
W-865-1803	3/10/05	6.7	30	<4
W-865-1803	5/17/05	6.7	30	<4
W-865-1803	5/17/05	-	30	-
W-865-1803	8/30/05	-	-	<4 E
W-865-1803	11/3/05	-	-	<4 E
SPRING24	6/8/05	0.46	2.1	-
SPRING24	6/8/05	-	2.1	-
W8SPRNG	8/25/05	-	40.1 D	-

OU5-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-08 09:31:01, Oracle)

A-15. Building 850 metals in ground water and surface water.

Sample Location	Sample Date	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)
K1-03	6/7/05	-	0.031	-	-	-	-	-	-
K1-03	6/14/05	-	0.031	-	-	-	-	-	-
K2-04D	4/20/05	-	-	-	-	-	-	-	-
K2-04S	4/20/05	-	-	-	-	-	-	-	-
NC2-05	5/9/05	-	-	-	-	-	-	-	-
NC2-05A	5/10/05	-	-	-	-	-	-	-	-
NC2-06	5/25/05	-	-	-	-	-	-	-	-
NC2-06A	5/25/05	-	-	-	-	-	-	-	-
NC2-09	5/25/05	-	-	-	-	-	-	-	-
NC2-10	6/2/05	-	-	-	-	-	-	-	-
NC2-11D	4/12/05	-	-	-	-	-	-	-	-
NC2-11I	5/10/05	-	-	-	-	-	-	-	-
NC2-12D	4/12/05	-	-	-	-	-	-	-	-
NC2-12I	5/10/05	-	-	-	-	-	-	-	-
NC2-14S	6/2/05	-	-	-	-	-	-	-	-
NC2-16	6/2/05	-	-	-	-	-	-	-	-
NC2-19	6/8/05	-	-	-	-	-	-	-	-
NC2-20	6/6/05	-	-	-	-	-	-	-	-
NC2-21	6/6/05	-	-	-	-	-	-	-	-
NC7-10	4/25/05	-	-	-	-	-	-	-	-
NC7-11	4/25/05	-	-	-	-	-	-	-	-
NC7-15	4/26/05	-	-	-	-	-	-	-	-
NC7-15	04/26/05 DUP	-	-	-	-	-	-	-	-
NC7-19	4/26/05	-	-	-	-	-	-	-	-
NC7-19	04/26/05 DUP	-	-	-	-	-	-	-	-
NC7-27	5/20/05	-	-	-	-	-	-	-	-
NC7-28	4/26/05	-	-	-	-	-	-	-	-
NC7-29	6/6/05	-	-	-	-	-	-	-	-
NC7-43	4/26/05	-	-	-	-	-	-	-	-
NC7-44	6/7/05	-	-	-	-	-	-	-	-
NC7-46	5/20/05	-	-	-	-	-	-	-	-
NC7-54	4/25/05	-	-	-	-	-	-	-	-
NC7-56	6/1/05	-	-	-	-	-	-	-	-
NC7-58	5/19/05	-	-	-	-	-	-	-	-
NC7-59	6/2/05	-	-	-	-	-	-	-	-
NC7-59	06/02/05 DUP	-	-	-	-	-	-	-	-
NC7-60	5/23/05	0.012	0.03	0.0009	<0.001	<0.005	<0.0002	<0.002	<0.001

A-15. Building 850 metals in ground water and surface water.

Sample Location	Sample Date	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)
NC7-61	4/21/05	-	-	-	-	-	-	-	-
NC7-61	04/21/05 DUP	-	-	-	-	-	-	-	-
NC7-62	6/1/05	-	-	-	-	-	-	-	-
NC7-69	4/14/05	-	-	-	-	-	-	-	-
NC7-70	5/11/05	-	-	-	-	-	-	-	-
NC7-71	5/11/05	-	-	-	-	-	-	-	-
NC7-72	6/1/05	-	-	-	-	-	-	-	-
NC7-73	6/1/05	-	-	-	-	-	-	-	-
W-850-05	5/11/05	-	-	-	-	-	-	-	-
W-PIT7-16	4/27/05	-	-	-	-	-	-	-	-
W-865-1802	3/3/05	0.017	0.038	<0.001 E	<0.003 E	<0.001	<0.0002	<0.002 E	<0.001
W-865-1802	03/03/05 DUP	0.015	0.04	<0.0005	<0.001	<0.005	<0.0002	0.002	<0.001
W-865-1802	5/10/05	0.015	0.04	<0.0005	<0.001	<0.005	<0.0002	<0.002	<0.001
W-865-1802	8/24/05	0.014	0.03	<0.0005	<0.001	<0.005	<0.0002	<0.002	<0.001
W-865-1802	10/6/05	0.015	0.04 L	<0.0005	<0.001	<0.005	<0.0002	0.002	<0.001
W-865-1803	3/10/05	0.0075	<0.02	<0.0005	<0.001	<0.005	<0.0002	<0.002	<0.001
W-865-1803	5/17/05	0.0077	0.03	<0.0005	<0.001	<0.005	<0.0002	0.002	<0.001
W-865-1803	8/30/05	0.00771	0.0245	<0.0005	<0.001	<0.002	<0.0002	<0.002 E	<0.001
W-865-1803	11/3/05	0.00784	0.0281	<0.0005	<0.001	<0.002	<0.0002	<0.002 E	<0.001
SPRING24	6/8/05	-	-	-	-	-	-	-	-

OU5-METALS [mg/L] 2005 data (prepared 2006-03-06 15:48:04, Oracle)

A-16. Building 854 OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-854-01	5/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-01	11/30/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-02	4/5/05	E601	180 BD	<0.5	<0.5 E	<0.5	<0.5	<0.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-02	7/13/05	E601	160 D	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-02	10/5/05	E601	170 BDJ	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-03	4/5/05	E601	51	<0.5 E	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-04	5/26/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-04	10/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-05	5/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-05	11/29/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-06	5/20/05	E601	1.2 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-06	10/25/05	E601	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-06	10/25/05 DUP	E601	2.1 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-07	5/20/05	E601	29 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-07	10/25/05	E601	33	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-07	10/25/05 DUP	E601	33	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-08	5/20/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-08	11/30/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-09	5/20/05	E601	6.4 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-09	10/26/05	E601	7.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-10	5/25/05	E601	3.1 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-10	05/25/05 DUP	E601	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-10	11/29/05	E601	5.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-10	11/29/05 DUP	E601	4.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-13	5/20/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-13	12/7/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-14	5/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-15	5/26/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-15	11/29/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-17	5/24/05	E601	8	<0.5	11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-17	11/29/05	E601	8.8	<0.5	12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-18A	5/20/05	E601	24 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-18A	11/29/05	E601	20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-18A	11/29/05 DUP	E601	19	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-45	5/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-45	11/29/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1701	5/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1701	10/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1707	6/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1707	10/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1731	5/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1731	11/29/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1822	5/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1822	10/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-16. Building 854 OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-854-1823	5/24/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1823	10/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1902	5/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-854-1902	10/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	3/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	6/15/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	06/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	8/11/05	E601	0.81	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	10/25/05	E601	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING10	10/25/05 DUP	E601	1.9 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	3/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	6/14/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	06/14/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	8/11/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	08/11/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	10/25/05	E601	0.9	<0.5	<0.5 E	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING11	10/25/05 DUP	E601	1.2 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING18	6/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)
W-854-01	5/24/05	E601	0 of 18	-
W-854-01	11/30/05	E601	0 of 18	-
W-854-02	4/5/05	E601	0 of 19	-
W-854-02	7/13/05	E601	0 of 19	-
W-854-02	10/5/05	E601	0 of 19	-
W-854-03	4/5/05	E601	0 of 19	-
W-854-04	5/26/05	E601	0 of 18	-
W-854-04	10/26/05	E601	0 of 18	-
W-854-05	5/20/05	E601	0 of 18	-
W-854-05	11/29/05	E601	0 of 18	-
W-854-06	5/20/05	E601	0 of 18	-
W-854-06	10/25/05	E601	0 of 18	-
W-854-06	10/25/05 DUP	E601	0 of 18	-
W-854-07	5/20/05	E601	0 of 18	-
W-854-07	10/25/05	E601	0 of 18	-
W-854-07	10/25/05 DUP	E601	0 of 18	-
W-854-08	5/20/05	E601	0 of 18	-
W-854-08	11/30/05	E601	0 of 18	-
W-854-09	5/20/05	E601	0 of 18	-
W-854-09	10/26/05	E601	0 of 18	-
W-854-10	5/25/05	E601	0 of 19	-
W-854-10	05/25/05 DUP	E601	0 of 18	-
W-854-10	11/29/05	E601	0 of 18	-
W-854-10	11/29/05 DUP	E601	0 of 18	-
W-854-13	5/20/05	E601	0 of 18	-
W-854-13	12/7/05	E601	0 of 18	-
W-854-14	5/25/05	E601	0 of 18	-
W-854-15	5/26/05	E601	0 of 18	-
W-854-15	11/29/05	E601	0 of 18	-
W-854-17	5/24/05	E601	1 of 18	11
W-854-17	11/29/05	E601	1 of 18	12
W-854-18A	5/20/05	E601	0 of 18	-
W-854-18A	11/29/05	E601	0 of 18	-
W-854-18A	11/29/05 DUP	E601	0 of 18	-
W-854-45	5/24/05	E601	0 of 18	-
W-854-45	11/29/05	E601	0 of 18	-
W-854-1701	5/25/05	E601	0 of 18	-
W-854-1701	10/26/05	E601	0 of 18	-
W-854-1707	6/14/05	E601	0 of 18	-
W-854-1707	10/25/05	E601	0 of 18	-
W-854-1731	5/25/05	E601	0 of 18	-
W-854-1731	11/29/05	E601	0 of 18	-
W-854-1822	5/25/05	E601	0 of 18	-
W-854-1822	10/26/05	E601	0 of 18	-
W-854-1823	5/24/05	E601	0 of 18	-
W-854-1823	10/26/05	E601	0 of 18	-
W-854-1902	5/25/05	E601	0 of 18	-
W-854-1902	10/26/05	E601	0 of 18	-
SPRING10	3/10/05	E601	0 of 18	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)
SPRING10	6/15/05	E601	0 of 18	-
SPRING10	06/15/05 DUP	E601	0 of 19	-
SPRING10	8/11/05	E601	0 of 18	-
SPRING10	10/25/05	E601	0 of 18	-
SPRING10	10/25/05 DUP	E601	0 of 18	-
SPRING11	3/10/05	E601	0 of 18	-
SPRING11	6/14/05	E601	0 of 19	-
SPRING11	06/14/05 DUP	E601	0 of 18	-
SPRING11	8/11/05	E601	0 of 18	-
SPRING11	08/11/05 DUP	E601	0 of 18	-
SPRING11	10/25/05	E601	0 of 18	-
SPRING11	10/25/05 DUP	E601	0 of 18	-
SPRING18	6/23/05	E601	0 of 18	-

OU6-VOC [ug/L] 2005 data (prepared 2006-03-08 12:52:31, Oracle)

A-17. Building 854 OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-854-01	5/24/05	<0.1	<4
W-854-02	4/5/05	53	7.1
W-854-02	7/13/05	55	5.6
W-854-02	10/5/05	53	7
W-854-03	4/5/05	48	13
W-854-04	5/26/05	<0.1 L	<4
W-854-05	5/20/05	62 D	<4
W-854-06	5/20/05	<0.1	<4
W-854-07	5/20/05	36 D	4.1
W-854-08	5/20/05	34 D	<4
W-854-09	5/20/05	44 D	<4
W-854-10	5/25/05	7.9	<4
W-854-10	05/25/05 DUP	8.9	<4
W-854-13	5/20/05	0.96	15
W-854-13	12/7/05	-	<4
W-854-15	5/26/05	9.2 L	<4
W-854-17	5/24/05	15 D	4.4
W-854-18A	5/20/05	25 D	<4
W-854-45	5/24/05	21 D	<4
W-854-1701	5/25/05	<0.1	<4
W-854-1707	6/14/05	5.9	<4
W-854-1731	5/25/05	1.1	<4
W-854-1822	5/25/05	11	<4
W-854-1823	5/24/05	22 D	14
W-854-1902	5/25/05	7.7	<4
SPRING10	6/15/05	18 D	<4
SPRING10	06/15/05 DUP	18	<4
SPRING11	6/14/05	2.2 D	23
SPRING11	06/14/05 DUP	1.9	<4
SPRING11	10/25/05	-	<4
SPRING11	10/25/05 DUP	-	<4

OU6-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-08 08:00:27, Oracle)

A-18. Building 832 Canyon OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-832-2112	11/1/05	E624	<0.5 O	<0.5	<0.5 O	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 O	<0.5	<0.5
W-830-04A	2/17/05	E601	3.7	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-04A	02/17/05 DUP	E601	4.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-04A	7/27/05	E601	6.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-04A	07/27/05 DUP	E601	3.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-05	2/10/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-05	7/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-09	2/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 O	<0.5 O	<0.5	<0.5	<0.5 O	<0.5 O	<0.5	<0.5 O	<0.5
W-830-09	8/16/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-10	2/10/05	E601	91 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D
W-830-10	02/10/05 DUP	E601	89 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D	<1 D
W-830-10	7/26/05	E601	79 DL	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-10	07/26/05 DUP	E601	86 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-11	2/17/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-11	7/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-12	2/2/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 O	<0.5 O	<0.5	<0.5	<0.5 O	<0.5 O	<0.5	<0.5 O	<0.5
W-830-12	8/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-13	2/17/05	E601	6.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-13	7/26/05	E601	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-14	2/10/05	E601	1.9	<0.5	0.62	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-14	7/26/05	E601	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-14	07/26/05 DUP	E601	1.7 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-15	2/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-15	8/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-16	2/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-16	5/17/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-16	05/17/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-16	8/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-16	10/17/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-17	2/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-17	8/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-18	2/17/05	E601	5.4	<0.5	0.74	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-18	7/27/05	E601	4.8	<0.5	0.62	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-19	8/11/05	E601	6,400 BD	8	<0.5	<0.5	<0.5	1.7	<0.5	2.3	1.2	<0.5	1.2	0.67	<0.5	<0.5
W-830-19	10/5/05	E601	6,200 BDL	7.3	<0.5	<0.5	<0.5	1.8	<0.5	2.3	1.2	<0.5	1.2	0.62	<0.5	<0.5
W-830-20	1/20/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-20	5/17/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-20	7/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-20	10/17/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-21	2/17/05	E601	81 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-21	7/27/05	E601	66 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-21	07/27/05 DUP	E601	65 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-22	2/17/05	E601	5.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-22	8/15/05	E601	9.7 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-830-22	08/15/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-25	2/25/05	E601	690 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-830-25	8/16/05	E601	800 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-830-26	3/29/05	E601	4	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-26	8/17/05	E601	3.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-18. Building 832 Canyon OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-830-27	2/25/05	E601	810 D	0.93	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5 E	<0.5 E	<0.5	<0.5 E	<0.5	<0.5	<0.5
W-830-27	02/25/05 DUP	E601	1,100 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-830-27	8/16/05	E601	930 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-830-28	2/25/05	E601	61	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-28	8/16/05	E601	52	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-29	3/29/05	E601	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5	<0.5 O	<0.5 O	<0.5
W-830-29	8/16/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-30	2/2/05	E601	600 D	<10 D	<10 D	<10 D	<10 D	<10 DO	<10 DO	<10 D	<10 D	<10 DO	<10 DO	<10 D	<10 DO	<10 D
W-830-30	8/15/05	E601	400 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-830-34	2/2/05	E601	1,300 D	<25 D	<25 D	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 DO	<25 D
W-830-34	8/15/05	E601	1,300 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D	<12 D
W-830-49	2/2/05	E601	9,500 D	<250 D	<250 D	<250 D	<250 D	<250 DO	<250 DO	<250 D	<250 D	<250 DO	<250 DO	<250 D	<250 DO	<250 D
W-830-49	8/3/05	E601	8,800 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D	<100 D
W-830-50	2/15/05	E601	20	<0.5	0.54	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-50	7/27/05	E601	17	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-51	1/19/05	E601	89	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-51	4/18/05	E601	81	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-51	7/26/05	E601	76 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-51	8/11/05	E601	100 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-51	10/4/05	E601	97 BD	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-52	1/19/05	E601	87	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-52	4/18/05	E601	78	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-52	7/26/05	E601	69 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-52	8/11/05	E601	95 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-52	10/4/05	E601	98 BD	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-53	1/19/05	E601	82	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-53	4/18/05	E601	75	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-53	8/11/05	E601	82 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-53	10/4/05	E601	94 B	<0.5	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-54	2/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-54	8/16/05	E601	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
W-830-55	2/23/05	E601	6.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-55	8/17/05	E601	3	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
W-830-56	2/10/05	E601	1.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-56	7/26/05	E601	1.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-57	1/20/05	E601	30	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.53	<0.5	<0.5
W-830-57	4/13/05	E601	28	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5
W-830-57	7/12/05	E601	31	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5
W-830-57	10/12/05	E601	31	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-58	2/25/05	E601	250 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-830-58	8/16/05	E601	150 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-830-59	1/20/05	E601	2,300 D	10	<0.5	<0.5	<0.5	0.84	<0.5	2.7	<0.5	<0.5	0.87	<0.5	<0.5	<0.5
W-830-59	4/6/05	E601	3,700 BD	5.2	<0.5 E	<0.5	<0.5	1.4	<0.5	1.2	0.78	<0.5	0.64	<0.5 E	<0.5	<0.5
W-830-59	7/14/05	E601	3,000 D	4	<0.5	<0.5	<0.5	1.2	<0.5	1.1	0.78	<0.5	0.59	<0.5	<0.5	<0.5
W-830-59	10/5/05	E601	2,900 D	2.4	<0.5	<0.5	<0.5	1.2	<0.5	0.96	<0.5	<0.5	0.58	<0.5	<0.5	<0.5
W-830-60	2/15/05	E601	32	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-60	02/15/05 DUP	E601	27	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-60	7/27/05	E601	32	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-831-01	2/17/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

A-18. Building 832 Canyon OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-830-1730	2/25/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1730	7/26/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1730	12/7/05	E601	<0.5 O	<0.5	<0.5 O	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 O	<0.5	<0.5
W-830-1807	1/20/05	E601	2,200 D	10	<0.5	<0.5	<0.5	0.73	<0.5	2.6	0.51	<0.5	0.9	<0.5	<0.5	<0.5
W-830-1807	4/6/05	E601	2,100 BD	8.5	<0.5	<0.5	<0.5	0.57	<0.5	2.5	<0.5 E	<0.5	0.74	<0.5	<0.5	<0.5
W-830-1807	7/14/05	E601	1,800 D	5	<0.5	<0.5	<0.5	0.85	<0.5	1.4	<0.5	<0.5	0.63	<0.5	<0.5	<0.5
W-830-1807	10/5/05	E601	1,400 D	11	0.88	<0.5	<0.5	0.67	<0.5	3.8	<0.5	<0.5	0.57	<0.5	<0.5	<0.5
W-830-1829	2/2/05	E601	3,300 D	<50 D	<50 D	<50 D	<50 D	<50 DO	<50 DO	<50 D	<50 D	<50 DO	<50 DO	<50 D	<50 DO	<50 D
W-830-1829	8/3/05	E601	3,000 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
W-830-1830	2/2/05	E601	2,200 D	<25 D	<25 D	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 DO	<25 D
W-830-1830	8/3/05	E601	1,900 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
W-830-1831	3/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1831	8/3/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1831	10/17/05	E601	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1832	3/8/05	E601	4.3	5.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.55	<0.5	<0.5	<0.5	<0.5	<0.5
W-830-1832	8/3/05	E601	6.7 D	7 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-832-01	2/23/05	E601	210 D	<2.5 D	7.3 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-01	8/15/05	E601	180 D	<2.5 D	7.2 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-01	9/13/05	E601	160 BD	<0.5	5.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-01	9/28/05	E601	120 D	<0.5	5.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-09	2/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-09	8/17/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-10	3/8/05	E601	93 D	<2.5 D	5.1 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-10	7/27/05	E601	99 D	<2.5 D	3.3 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-10	9/13/05	E601	49 B	<0.5	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-10	9/28/05	E601	86	<0.5	3.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-11	3/8/05	E601	99 D	<2.5 D	5.1 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-11	7/27/05	E601	92 DL	<2.5 D	3.7 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-11	9/13/05	E601	86 BD	<0.5	4.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.64	<0.5	<0.5
W-832-11	9/28/05	E601	120 D	<0.5	4.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.89	<0.5	<0.5
W-832-12	4/13/05	E601	53 B	<0.5	1.4	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-12	10/6/05	E601	69 B	<0.5	1.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-14	4/13/05	E601	1.5 B	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-15	4/13/05	E601	33 B	<0.5	0.69	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-15	10/6/05	E601	36 B	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-17	4/13/05	E601	0.8	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-18	4/13/05	E601	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-1927	3/8/05	E601	20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-1927	9/22/05	E601	47	<0.5 L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5
W-832-20	4/13/05	E601	7.2	<0.5 E	72	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1
W-832-23	8/17/05	E601	430 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
W-832-24	3/8/05	E601	14	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-24	7/27/05	E601	19 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-25	3/8/05	E601	27	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-25	03/08/05 DUP	E601	20	<0.5	0.52	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-25	7/27/05	E601	41 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-SC1	3/31/05	E601	3.2 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5
W-832-SC1	8/15/05	E601	140 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
W-832-SC2	3/31/05	E601	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5

A-18. Building 832 Canyon OU VOCs in ground water and surface water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-832-SC3	3/29/05	E601	19	<0.5	0.6	0.51	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-SC3	03/29/05 DUP	E601	20 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5
W-832-SC3	8/15/05	E601	31	<0.5	1.5	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-832-SC4	2/23/05	E601	8.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-870-01	2/17/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-870-02	8/16/05	E601	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
SVI-830-031	2/2/05	E601	570 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 DO	<2.5 DO	<2.5 D	<2.5 D	<2.5 DO	<2.5 DO	<2.5 D	<2.5 DO	<2.5 D
SVI-830-031	8/15/05	E601	610 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D	<5 D
SVI-830-032	8/15/05	E601	2,600 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D	<25 D
SVI-830-033	8/15/05	E601	120 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D	<2.5 D
SVI-830-035	2/2/05	E601	2,200 D	<25 D	<25 D	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 D	<25 DO	<25 DO	<25 D	<25 DO	<25 D
SVI-830-035	8/15/05	E601	2,900 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D	<50 D
SPRING3	3/29/05	E601	26 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5	<0.5 O	<0.5 O	<0.5
SPRING3	8/15/05	E601	54	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-01	1/20/05	E601	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-01	4/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-01	8/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-01	10/4/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-02	1/20/05	E601	0.56	0.57	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	<0.5	<0.5	<0.5
W-880-02	4/21/05	E601	<0.5 E	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-02	04/21/05 DUP	E601	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-02	8/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-02	10/4/05	E601	<0.5	0.77	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-03	1/20/05	E601	<0.5 E	<0.5 E	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-03	4/21/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-03	8/8/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-880-03	10/4/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SPRING4	3/31/05	E601	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Methylene chloride (µg/L)	Total Trihalomethanes (µg/L)
W-832-2112	11/1/05	E624	0 of 30	-	-	-
W-830-04A	2/17/05	E601	0 of 19	-	-	-
W-830-04A	02/17/05 DUP	E601	0 of 19	-	-	-
W-830-04A	7/27/05	E601	0 of 19	-	-	-
W-830-04A	07/27/05 DUP	E601	0 of 19	-	-	-
W-830-05	2/10/05	E601	0 of 18	-	-	-
W-830-05	7/26/05	E601	0 of 18	-	-	-
W-830-09	2/2/05	E601	0 of 18	-	-	-
W-830-09	8/16/05	E601	0 of 17	-	-	-
W-830-10	2/10/05	E601	0 of 18	-	-	-
W-830-10	02/10/05 DUP	E601	0 of 18	-	-	-
W-830-10	7/26/05	E601	0 of 18	-	-	-
W-830-10	07/26/05 DUP	E601	0 of 18	-	-	-
W-830-11	2/17/05	E601	0 of 19	-	-	-
W-830-11	7/26/05	E601	0 of 19	-	-	-
W-830-12	2/2/05	E601	0 of 18	-	-	-
W-830-12	8/3/05	E601	0 of 18	-	-	-
W-830-13	2/17/05	E601	0 of 18	-	-	-
W-830-13	7/26/05	E601	0 of 18	-	-	-
W-830-14	2/10/05	E601	1 of 18	0.62	-	-
W-830-14	7/26/05	E601	0 of 18	-	-	-
W-830-14	07/26/05 DUP	E601	0 of 18	-	-	-
W-830-15	2/25/05	E601	0 of 18	-	-	-
W-830-15	8/3/05	E601	0 of 18	-	-	-
W-830-16	2/23/05	E601	0 of 18	-	-	-
W-830-16	5/17/05	E601	0 of 18	-	-	-
W-830-16	05/17/05 DUP	E601	0 of 18	-	-	-
W-830-16	8/3/05	E601	0 of 18	-	-	-
W-830-16	10/17/05	E601	0 of 18	-	-	-
W-830-17	2/23/05	E601	0 of 18	-	-	-
W-830-17	8/3/05	E601	0 of 18	-	-	-
W-830-18	2/17/05	E601	1 of 18	0.79	-	-
W-830-18	7/27/05	E601	1 of 18	0.79	-	-
W-830-19	8/11/05	E601	1 of 19	-	-	2
W-830-19	10/5/05	E601	1 of 19	-	-	2.1
W-830-20	1/20/05	E601	0 of 19	-	-	-
W-830-20	5/17/05	E601	0 of 18	-	-	-
W-830-20	7/26/05	E601	0 of 18	-	-	-
W-830-20	10/17/05	E601	0 of 18	-	-	-
W-830-21	2/17/05	E601	1 of 18	2.6 D	-	-
W-830-21	7/27/05	E601	0 of 18	-	-	-
W-830-21	07/27/05 DUP	E601	0 of 18	-	-	-
W-830-22	2/17/05	E601	0 of 18	-	-	-
W-830-22	8/15/05	E601	0 of 16	-	-	-
W-830-22	08/15/05 DUP	E601	0 of 18	-	-	-
W-830-25	2/25/05	E601	0 of 18	-	-	-
W-830-25	8/16/05	E601	0 of 17	-	-	-
W-830-26	3/29/05	E601	0 of 19	-	-	-
W-830-26	8/17/05	E601	0 of 19	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Methylene chloride (µg/L)	Total Trihalomethanes (µg/L)
W-830-27	2/25/05	E601	0 of 19	-	-	-
W-830-27	02/25/05 DUP	E601	0 of 18	-	-	-
W-830-27	8/16/05	E601	0 of 17	-	-	-
W-830-28	2/25/05	E601	0 of 18	-	-	-
W-830-28	8/16/05	E601	0 of 17	-	-	-
W-830-29	3/29/05	E601	0 of 18	-	-	-
W-830-29	8/16/05	E601	0 of 17	-	-	-
W-830-30	2/2/05	E601	0 of 18	-	-	-
W-830-30	8/15/05	E601	0 of 16	-	-	-
W-830-34	2/2/05	E601	0 of 18	-	-	-
W-830-34	8/15/05	E601	0 of 16	-	-	-
W-830-49	2/2/05	E601	0 of 18	-	-	-
W-830-49	8/3/05	E601	0 of 18	-	-	-
W-830-50	2/15/05	E601	1 of 18	0.54	-	-
W-830-50	7/27/05	E601	0 of 18	-	-	-
W-830-51	1/19/05	E601	0 of 19	-	-	-
W-830-51	4/18/05	E601	0 of 19	-	-	-
W-830-51	7/26/05	E601	0 of 18	-	-	-
W-830-51	8/11/05	E601	0 of 19	-	-	-
W-830-51	10/4/05	E601	0 of 19	-	-	-
W-830-52	1/19/05	E601	0 of 19	-	-	-
W-830-52	4/18/05	E601	0 of 19	-	-	-
W-830-52	7/26/05	E601	0 of 18	-	-	-
W-830-52	8/11/05	E601	0 of 19	-	-	-
W-830-52	10/4/05	E601	0 of 19	-	-	-
W-830-53	1/19/05	E601	0 of 19	-	-	-
W-830-53	4/18/05	E601	0 of 19	-	-	-
W-830-53	8/11/05	E601	0 of 19	-	-	-
W-830-53	10/4/05	E601	0 of 19	-	-	-
W-830-54	2/23/05	E601	0 of 18	-	-	-
W-830-54	8/16/05	E601	0 of 13	-	-	-
W-830-55	2/23/05	E601	0 of 18	-	-	-
W-830-55	8/17/05	E601	0 of 13	-	-	-
W-830-56	2/10/05	E601	0 of 18	-	-	-
W-830-56	7/26/05	E601	0 of 18	-	-	-
W-830-57	1/20/05	E601	0 of 19	-	-	-
W-830-57	4/13/05	E601	0 of 19	-	-	-
W-830-57	7/12/05	E601	0 of 19	-	-	-
W-830-57	10/12/05	E601	0 of 19	-	-	-
W-830-58	2/25/05	E601	0 of 18	-	-	-
W-830-58	8/16/05	E601	0 of 17	-	-	-
W-830-59	1/20/05	E601	0 of 19	-	-	-
W-830-59	4/6/05	E601	0 of 19	-	-	-
W-830-59	7/14/05	E601	0 of 19	-	-	-
W-830-59	10/5/05	E601	0 of 19	-	-	-
W-830-60	2/15/05	E601	0 of 18	-	-	-
W-830-60	02/15/05 DUP	E601	0 of 19	-	-	-
W-830-60	7/27/05	E601	0 of 18	-	-	-
W-831-01	2/17/05	E601	0 of 18	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Methylene chloride (µg/L)	Total Trihalomethanes (µg/L)
W-830-1730	2/25/05	E601	0 of 18	-	-	-
W-830-1730	7/26/05	E601	0 of 18	-	-	-
W-830-1730	12/7/05	E601	0 of 18	-	-	-
W-830-1807	1/20/05	E601	0 of 19	-	-	-
W-830-1807	4/6/05	E601	0 of 19	-	-	-
W-830-1807	7/14/05	E601	0 of 19	-	-	-
W-830-1807	10/5/05	E601	0 of 19	-	-	-
W-830-1829	2/2/05	E601	1 of 18	-	56 D	-
W-830-1829	8/3/05	E601	0 of 18	-	-	-
W-830-1830	2/2/05	E601	1 of 18	-	32 D	-
W-830-1830	8/3/05	E601	0 of 18	-	-	-
W-830-1831	3/8/05	E601	0 of 18	-	-	-
W-830-1831	8/3/05	E601	0 of 18	-	-	-
W-830-1831	10/17/05	E601	0 of 18	-	-	-
W-830-1832	3/8/05	E601	0 of 18	-	-	-
W-830-1832	8/3/05	E601	0 of 18	-	-	-
W-832-01	2/23/05	E601	1 of 18	7.3 D	-	-
W-832-01	8/15/05	E601	1 of 16	7.2 D	-	-
W-832-01	9/13/05	E601	1 of 19	5.9	-	-
W-832-01	9/28/05	E601	1 of 19	5.8	-	-
W-832-09	2/23/05	E601	0 of 18	-	-	-
W-832-09	8/17/05	E601	0 of 17	-	-	-
W-832-10	3/8/05	E601	1 of 18	5.7 D	-	-
W-832-10	7/27/05	E601	1 of 18	3.3 D	-	-
W-832-10	9/13/05	E601	1 of 19	2.1	-	-
W-832-10	9/28/05	E601	1 of 19	3.4	-	-
W-832-11	3/8/05	E601	1 of 18	5.4 D	-	-
W-832-11	7/27/05	E601	1 of 18	3.7 D	-	-
W-832-11	9/13/05	E601	1 of 19	4.1	-	-
W-832-11	9/28/05	E601	1 of 19	4.6	-	-
W-832-12	4/13/05	E601	1 of 19	1.4	-	-
W-832-12	10/6/05	E601	1 of 19	1.7	-	-
W-832-14	4/13/05	E601	0 of 19	-	-	-
W-832-15	4/13/05	E601	0 of 19	-	-	-
W-832-15	10/6/05	E601	0 of 19	-	-	-
W-832-17	4/13/05	E601	0 of 19	-	-	-
W-832-18	4/13/05	E601	0 of 19	-	-	-
W-832-1927	3/8/05	E601	0 of 18	-	-	-
W-832-1927	9/22/05	E601	0 of 17	-	-	-
W-832-20	4/13/05	E601	1 of 19	72	-	-
W-832-23	8/17/05	E601	0 of 17	-	-	-
W-832-24	3/8/05	E601	0 of 18	-	-	-
W-832-24	7/27/05	E601	0 of 18	-	-	-
W-832-25	3/8/05	E601	1 of 18	0.7	-	-
W-832-25	03/08/05 DUP	E601	1 of 18	0.6	-	-
W-832-25	7/27/05	E601	0 of 18	-	-	-
W-832-SC1	3/31/05	E601	0 of 18	-	-	-
W-832-SC1	8/15/05	E601	0 of 16	-	-	-
W-832-SC2	3/31/05	E601	0 of 18	-	-	-

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency	1,2-Dichloroethene (total) (µg/L)	Methylene chloride (µg/L)	Total Trihalomethanes (µg/L)
W-832-SC3	3/29/05	E601	1 of 19	1.1	-	-
W-832-SC3	03/29/05 DUP	E601	1 of 18	0.89	-	-
W-832-SC3	8/15/05	E601	1 of 16	3.2	-	-
W-832-SC4	2/23/05	E601	0 of 18	-	-	-
W-870-01	2/17/05	E601	0 of 18	-	-	-
W-870-02	8/16/05	E601	0 of 13	-	-	-
SVI-830-031	2/2/05	E601	0 of 18	-	-	-
SVI-830-031	8/15/05	E601	0 of 16	-	-	-
SVI-830-032	8/15/05	E601	0 of 16	-	-	-
SVI-830-033	8/15/05	E601	0 of 16	-	-	-
SVI-830-035	2/2/05	E601	0 of 18	-	-	-
SVI-830-035	8/15/05	E601	0 of 16	-	-	-
SPRING3	3/29/05	E601	1 of 18	0.53	-	-
SPRING3	8/15/05	E601	1 of 16	0.65	-	-
W-880-01	1/20/05	E601	0 of 19	-	-	-
W-880-01	4/21/05	E601	0 of 19	-	-	-
W-880-01	8/8/05	E601	0 of 19	-	-	-
W-880-01	10/4/05	E601	0 of 19	-	-	-
W-880-02	1/20/05	E601	0 of 19	-	-	-
W-880-02	4/21/05	E601	0 of 19	-	-	-
W-880-02	04/21/05 DUP	E601	0 of 18	-	-	-
W-880-02	8/8/05	E601	0 of 19	-	-	-
W-880-02	10/4/05	E601	0 of 19	-	-	-
W-880-03	1/20/05	E601	0 of 19	-	-	-
W-880-03	4/21/05	E601	0 of 19	-	-	-
W-880-03	8/8/05	E601	0 of 19	-	-	-
W-880-03	10/4/05	E601	0 of 19	-	-	-
SPRING4	3/31/05	E601	0 of 18	-	-	-

OU7-VOC [ug/L] 2005 data (prepared 2006-03-08 12:54:25, Oracle)

A-19. Building 832 Canyon OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-832-2112	11/1/05	<0.5	<4
W-830-04A	2/17/05	74.9	<4 E
W-830-04A	02/17/05 DUP	76.2	<4 E
W-830-05	2/10/05	76 D	4.1
W-830-09	2/2/05	<5 D	<4
W-830-10	2/10/05	67 D	5.1
W-830-10	02/10/05 DUP	67 D	<4 E
W-830-11	2/17/05	5.52	<4 E
W-830-12	2/2/05	<5 D	<4
W-830-13	2/17/05	64 D	<4 E
W-830-14	2/10/05	<5 D	<4
W-830-15	2/25/05	<5 D	<4
W-830-16	2/23/05	<5 D	<4
W-830-16	8/3/05	<5 D	<4 L
W-830-17	2/23/05	86 D	5
W-830-18	2/17/05	<5 D	<4
W-830-19	8/11/05	160 D	4.9
W-830-19	10/5/05	160 D	4.5
W-830-20	1/20/05	<0.88 D	<4
W-830-20	7/26/05	<1 D	<4
W-830-21	2/17/05	<5 D	<4
W-830-22	2/17/05	6.1 D	<4
W-830-25	2/25/05	82 D	11
W-830-26	3/29/05	<0.44 E	<4
W-830-27	2/25/05	74 D	8
W-830-27	02/25/05 DUP	68 D	5.3
W-830-28	2/25/05	9.1 D	<4
W-830-29	3/29/05	<5 D	<4
W-830-30	2/2/05	75 D	<4
W-830-34	2/2/05	110 D	<4
W-830-49	2/2/05	150 D	<4
W-830-50	2/15/05	13 D	<4
W-830-51	1/19/05	61.3	6
W-830-51	4/18/05	65	8.2
W-830-51	8/11/05	61	4.6
W-830-51	10/4/05	60	4.1
W-830-52	1/19/05	64.5	6.7
W-830-52	4/18/05	71	<4
W-830-52	8/11/05	63	7.3
W-830-52	10/4/05	64	4.5
W-830-53	1/19/05	53.7	6
W-830-53	4/18/05	59	<4
W-830-53	8/11/05	55	<4
W-830-53	10/4/05	45 D	<4
W-830-54	2/23/05	6 D	<4
W-830-55	2/23/05	0.67	<4
W-830-56	2/10/05	30 D	<4 E
W-830-57	1/20/05	16.9 D	6.4
W-830-57	2/24/05	-	<4
W-830-57	3/2/05	-	<4
W-830-57	4/13/05	18 D	<4
W-830-57	7/12/05	17 D	<4
W-830-57	10/12/05	17 D	<4
W-830-58	2/25/05	44 D	7.4
W-830-59	1/20/05	83.3	<4

A-19. Building 832 Canyon OU nitrate and perchlorate in ground water and surface water.

Sample Location	Sample Date	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
W-830-59	4/6/05	140 D	<4 L
W-830-59	7/14/05	140 D	<4
W-830-59	10/5/05	130 D	7.1
W-830-60	2/15/05	12 D	<4
W-830-60	02/15/05 DUP	7.9	<4
W-831-01	2/17/05	<5 D	<4
W-830-1730	2/25/05	5.8 D	<4
W-830-1730	7/26/05	5.6 D	<4 L
W-830-1807	1/20/05	84.3	<4
W-830-1807	4/6/05	95 D	<4 L
W-830-1807	7/14/05	110 D	<4
W-830-1807	10/5/05	96 D	<4
W-830-1829	2/2/05	92 D	<4
W-830-1830	2/2/05	83 D	6.5
W-830-1831	3/8/05	5.7 D	<4
W-830-1831	8/3/05	5.7 D	<4 L
W-830-1831	10/17/05	-	<4
W-830-1832	3/8/05	6.7 D	<4
W-832-01	2/23/05	80 D	6.6
W-832-09	2/23/05	<5 D	<4
W-832-10	3/8/05	74 D	6.6
W-832-11	3/8/05	73 D	6.2
W-832-12	4/13/05	110 D	-
W-832-12	10/6/05	110 D	8.6
W-832-14	4/13/05	6.2	-
W-832-15	4/13/05	120 D	-
W-832-15	10/6/05	130 D	12
W-832-17	4/13/05	110 D	-
W-832-18	4/13/05	15 D	-
W-832-1927	3/8/05	54 D	<4 E
W-832-20	4/13/05	46 D	-
W-832-24	3/8/05	62 D	4.6
W-832-25	3/8/05	91 D	6.5
W-832-25	03/08/05 DUP	91 D	7.2
W-832-SC1	3/31/05	63 D	<4
W-832-SC3	3/29/05	16	<4
W-832-SC3	03/29/05 DUP	19 D	<4
W-832-SC4	2/23/05	34	<4
W-870-01	2/17/05	11 D	<4
SVI-830-035	2/2/05	110 D	<4
SPRING3	3/29/05	42 D	<4 E
W-880-01	1/20/05	<0.44	<4
W-880-01	8/8/05	<0.5	<4
W-880-02	1/20/05	<2.2 D	4.7
W-880-02	8/8/05	<1 D	<4
W-880-03	1/20/05	<0.44	<4
W-880-03	8/8/05	<0.5	<4
SPRING4	3/31/05	37 D	<4 E

OU7-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-03 08:50:22, Oracle)

A-20. Building 801 Firing Table and Pit 8 Landfill VOCs in ground water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
K8-01	6/2/05	E601	3.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-01	10/20/05	E601	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-02B	6/7/05	E601	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-02B	10/20/05	E601	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-03B	5/20/05	E601	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-03B	12/8/05	E601	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-04	6/7/05	E601	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
K8-04	10/20/05	E601	1.2	<0.5	<0.5	<0.5	<0.5	<0.5 E	<0.5	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Sample Location	Sample Date	Method	Detection frequency
K8-01	6/2/05	E601	0 of 18
K8-01	10/20/05	E601	0 of 18
K8-02B	6/7/05	E601	0 of 18
K8-02B	10/20/05	E601	0 of 18
K8-03B	5/20/05	E601	0 of 18
K8-03B	12/8/05	E601	0 of 18
K8-04	6/7/05	E601	0 of 18
K8-04	10/20/05	E601	0 of 18

A-21. Building 801 Firing Table and Pit 8 Landfill nitrate and perchlorate in ground water.

Location	Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)	Perchlorate (µg/L)
K8-01	6/2/05	-	53 D	<4
K8-02B	6/7/05	-	33 D	<4
K8-03B	5/20/05	-	13	<4
K8-04	6/7/05	12 D	51 D	<4
K8-04	06/07/05 DUP	-	53 D	-

OU8D-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-03 08:55:57, Oracle)

A-22. Building 845 Firing Table and Pit 9 Landfill uranium isotopes by mass spectrometry in ground water.

Sample Location	Sample Date	Uranium (pCi/L)	Uranium 234 by mass (pCi/L)	Uranium 235 by mass (pCi/L)	Uranium 236 by mass (pCi/L)	Uranium 238 by mass (pCi/L)	Uranium 235/238
K9-01	5/27/05	0.0990 ± 0.00170	0.0640 ± 0.00170	0.00150 ± 0.0000270	<0.000011	0.0330 ± 0.000290	0.00720 ± 0.000113
K9-02	5/27/05	0.270 ± 0.00380	0.200 ± 0.00370	0.00280 ± 0.0000450	<0.000014	0.0610 ± 0.000700	0.00721 ± 0.0000800
K9-03	5/27/05	0.420 ± 0.00500	0.310 ± 0.00500	0.00480 ± 0.0000500	<0.00002	0.100 ± 0.000510	0.00726 ± 0.0000650
K9-04	5/27/05	0.230 ± 0.00440	0.170 ± 0.00430	0.00270 ± 0.0000450	<0.000014	0.0600 ± 0.000770	0.00694 ± 0.0000760

OU8B-ICMS [pCi/L; -] 2005 data (prepared 2006-03-13 10:13:49, Oracle)

A-23. Building 845 Firing Table and Pit 9 Landfill high explosive compounds in ground water.

Sample Location	Sample Date	HMX (µg/L)	RDX (µg/L)
K9-01	5/27/05	<1	<1
K9-02	5/27/05	<1	<1
K9-03	5/27/05	<1	<1
K9-04	5/27/05	<1	<1

OU8B-E8330 [ug/L] 2005 data (prepared 2006-03-03 08:54:17, Oracle)

A-24. Building 851 Firing Table uranium isotopes by mass spectrometry in ground water.

Sample Location	Sample Date	Uranium (pCi/L)	Uranium 234 by mass (pCi/L)	Uranium 235 by mass (pCi/L)	Uranium 236 by mass (pCi/L)	Uranium 238 by mass (pCi/L)	Uranium 235/238
W-851-05	5/13/05	0.0710 ± 0.00110	<0.062	0.000620 ± 0.0000110	<0.007	0.0210 ± 0.000160	0.00469 ± 0.0000730
W-851-05	12/15/05	<0.0627	<0.019	<0.00047	<0.00014	0.0100 ± 0.0000540	<0.007107
W-851-06	5/13/05	0.240 ± 0.00340	0.170 ± 0.00330	0.00260 ± 0.0000360	<0.000063	0.0660 ± 0.000530	0.00610 ± 0.0000690
W-851-06	12/15/05	0.240 ± 0.00890	0.180 ± 0.00890	0.00240 ± 0.0000460	<0.0004	0.0650 ± 0.000970	0.00585 ± 0.0000680
W-851-07	5/19/05	0.230 ± 0.00330	0.170 ± 0.00320	0.00270 ± 0.0000360	<0.000014	0.0590 ± 0.000630	0.00720 ± 0.0000560
W-851-07	11/8/05	0.230 ± 0.0190	0.170 ± 0.0190	0.00250 ± 0.0000530	<0.00028	0.0530 ± 0.000560	0.00727 ± 0.000135
W-851-08	5/19/05	0.360 ± 0.00420	0.220 ± 0.00420	0.00520 ± 0.0000370	<0.007	0.135 ± 0.000560	0.00601 ± 0.0000350
W-851-08	11/8/05	1.50 ± 0.0610	0.890 ± 0.0600	0.0220 ± 0.000450	<0.0019	0.570 ± 0.00850	0.00594 ± 0.0000860

OU8A-ICMS [pCi/L; -] 2005 data (prepared 2006-03-13 10:13:37, Oracle)

A-25. Building 851 Firing Table VOCs in ground water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-851-05	5/13/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-851-05	05/13/05 DUP	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Location	Date	Method	Detection frequency
W-851-05	5/13/05	E601	0 of 19
W-851-05	05/13/05 DUP	E601	0 of 18

OU8A-VOC [ug/L] 2005 data (prepared 2006-03-08 12:55:13, Oracle)

A-26. Building 833 VOCs in ground water.

Sample Location	Sample Date	Method	TCE (µg/L)	PCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	Carbon tetrachloride (µg/L)	Chloroform (µg/L)	1,1-DCA (µg/L)	1,2-DCA (µg/L)	1,1-DCE (µg/L)	1,1,1-TCA (µg/L)	1,1,2-TCA (µg/L)	Freon 11 (µg/L)	Freon 113 (µg/L)	Vinyl chloride (µg/L)
W-833-12	3/29/05	E601	7.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5 O	<0.5
W-833-30	2/23/05	E601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-833-30	8/16/05	E601	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5

Analytes detected but not reported in main table.

Sample Location	Sample Date	Method	Detection frequency
W-833-12	3/29/05	E601	0 of 18
W-833-30	2/23/05	E601	0 of 18
W-833-30	8/16/05	E601	0 of 13

OU8C-VOC [ug/L] 2005 data (prepared 2006-03-08 12:55:38, Oracle)

A-27. Pit 2 Landfill uranium isotopes by mass spectrometry in ground water.

Sample Location	Sample Date	Uranium (pCi/L)	Uranium 234 by mass (pCi/L)	Uranium 235 by mass (pCi/L)	Uranium 236 by mass (pCi/L)	Uranium 238 by mass (pCi/L)	Uranium 235/238
K2-01C	5/3/05	9.90 ± 0.150	5.00 ± 0.150	0.180 ± 0.00210	<0.007	4.66 ± 0.0320	0.00613 ± 0.0000580
NC2-08	5/25/05	3.00 ± 0.0380	1.80 ± 0.0370	0.0520 ± 0.000520	<0.00022	1.10 ± 0.00840	0.00721 ± 0.0000470
W-PIT2-1934	3/4/05	12.0 ± 0.0910	6.50 ± 0.0870	0.190 ± 0.00160	0.0100 ± 0.0000690	5.40 ± 0.0240	0.00543 ± 0.0000380
W-PIT2-1934	6/14/05	17.0 ± 0.160	8.40 ± 0.140	0.260 ± 0.00350	0.0160 ± 0.0000940	7.90 ± 0.0700	0.00522 ± 0.0000500
W-PIT2-1934	9/29/05	15.0 ± 0.250	8.00 ± 0.230	0.240 ± 0.00440	0.0130 ± 0.0000920	6.80 ± 0.0880	0.00540 ± 0.0000710
W-PIT2-1934	11/2/05	15.0 ± 0.210	7.80 ± 0.210	0.230 ± 0.00120	0.0130 ± 0.0000890	6.80 ± 0.0330	0.00526 ± 0.0000130
W-PIT2-1935	3/4/05	1.90 ± 0.0230	1.10 ± 0.0220	0.0300 ± 0.000230	<0.00082	0.720 ± 0.00340	0.00653 ± 0.0000380
W-PIT2-1935	9/29/05	5.00 ± 0.0660	3.00 ± 0.0640	0.0790 ± 0.000790	<0.002	1.90 ± 0.0170	0.00650 ± 0.0000260
W-PIT2-1935	11/2/05	5.70 ± 0.100	3.40 ± 0.100	0.0910 ± 0.000630	<0.0021	2.20 ± 0.0100	0.00642 ± 0.0000330

OU5A-ICMS [pCi/L; -] 2005 data (prepared 2006-03-13 10:24:04, Oracle)

A-28. Pit 2 Landfill nitrate in ground water.

Sample Location	Sample Date	Nitrate (as N) (mg/L)	Nitrate (as NO3) (mg/L)
K2-01C	5/3/05	5.3	21
K2-01C	5/3/05	-	24 H
NC2-08	5/25/05	9.1	39 DL
NC2-08	5/25/05	-	40
W-PIT2-1934	6/14/05	7.8	42
W-PIT2-1934	6/14/05	-	35
W-PIT2-1934	9/29/05	-	32.6 D
W-PIT2-1935	9/29/05	-	25.6 D
W-PIT2-1935	11/2/05	-	25.6 D

OU5A-E300.0 [mg/L; ug/L] 2005 data (prepared 2006-03-08 12:14:17, Oracle)

A-29. Pit 2 Landfill tritium in ground water.

Sample Location	Sample Date	Tritium (pCi/L)
K2-01C	1/27/05	3,360 ± 380
K2-01C	5/3/05	4,850 ± 520
K2-01C	7/6/05	6,810 ± 720
K2-01C	10/17/05	3,710 ± 400
NC2-08	2/18/05	1,100 ± 140
NC2-08	02/18/05 DUP	1,140 ± 83.6
NC2-08	5/25/05	9,190 ± 930
NC2-08	8/29/05	10,100 ± 1,000
NC2-08	11/9/05	10,000 ± 1,000
W-PIT2-1934	3/4/05	1,590 ± 250
W-PIT2-1934	6/14/05	1,340 ± 160
W-PIT2-1934	9/29/05	1,240 ± 140
W-PIT2-1934	11/2/05	1,210 ± 150
W-PIT2-1935	3/4/05	3,260 ± 500
W-PIT2-1935	9/29/05	2,370 ± 250
W-PIT2-1935	11/2/05	1,970 ± 220

OU5A-RADABH3 [pCi/L] 2005 data (prepared 2006-03-08 12:15:13, Oracle)

Appendix B

Modeling of Potential Ground Water Cleanup Standards

Appendix B

Modeling of Potential Ground Water Cleanup Standards

B-1. Introduction

As agreed in the Interim Site-Wide Record of Decision (ROD), the Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) conducted an evaluation to determine the economic and technical feasibility of achieving various potential ground water cleanup standards. DOE, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB) subsequently agreed that the evaluation of potential ground water cleanup standards contained in Appendices B, C, and D of this report will not be used to support the selection of ground water cleanup standards in the Site-Wide ROD. However, the evaluation of potential ground water cleanup standards contained in these appendices is retained in this report to demonstrate and document DOE's compliance with the requirements of the Interim Site-Wide ROD.

The approach for this evaluation is outlined in Section D-2 of Appendix D. This appendix discusses the ground water flow and contaminant transport modeling that was conducted to determine the time and resources needed to achieve various potential ground water cleanup standards (i.e., Maximum Contaminant Levels [MCLs], water quality numeric limits [WQNLs], background levels). Appendix C presents the cost estimates based on the results of this modeling evaluation. Appendix D summarizes the evaluation of the economic and technical feasibility of achieving the potential ground water cleanup standards.

The ground water modeling was conducted using up to five scenarios for operable units (OUs) 2 through 7, as specified in Appendix C of the Interim Site-Wide ROD. The numeric ground water cleanup levels selected for evaluation in the five scenarios are intended for modeling purposes only and do not presuppose any specific final cleanup standard. The five scenarios evaluated are:

1. Ground water extraction at source areas and at downgradient locations within the plume to maximize the rate of mass removal and reduce contaminant concentrations to MCLs, followed by natural attenuation to further reduce concentrations to background levels. As plume capture to the MCL concentration contour may not be complete under this scenario, natural attenuation may also be relied upon to reduce contaminant concentrations in ground water to MCLs at the plume fringes.
2. Ground water extraction with complete hydraulic capture of contaminant concentrations above MCLs, followed by natural attenuation to further reduce concentrations to background levels.

3. Ground water extraction with complete hydraulic capture of contaminant concentrations above the 2.3 micrograms per liter (μg/L) based on the California Environmental Protection Agency (Cal/EPA) one-in-one-million cancer potency factor for trichloroethylene (TCE), followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction at source areas and at downgradient locations within the plume to maximize the rate of mass removal and reduce contaminant concentrations to background levels. As plume capture may not be complete under this scenario, natural attenuation may be relied upon to reduce contaminant concentrations to background near the plume boundaries, except where there is a threat of offsite plume migration.
5. Ground water extraction with complete hydraulic capture of contaminant concentrations above background to reduce contaminant concentrations to background levels. (Note: The modeling of this "capture-to-background level for TCE" scenario is considered to be equivalent to the modeling of "capture to the California Office of Environmental Health Hazard Assessment (OEHHA) Public Health Goal (PHG) WQNL" scenario as the detection limit/background level for TCE [0.5 μg/L] is so close to the PHG for TCE [0.8 μg/L]). Where TCE was used as the indicator COC in the modeling, the 0.5 μg/L analytical method detection limit was used as the surrogate for TCE background concentrations.

As agreed in the Interim Site-Wide ROD, the modeling for the scenarios was conducted using the contaminant of concern (COC) plume of greatest areal extent to estimate the length of time to cleanup at each OU. In most cases, this was TCE, which generally has both the highest concentrations and the greatest areal extent in ground water (Building 834, HE Process Area, Building 854, and Building 832 Canyon OUs). The rationale for using an indicator COC in the modeling is that the COC plumes of lesser extent will be remediated before the largest COC plume is remediated. However, DOE/LLNL also evaluated the characteristics of the other COCs (i.e., retardation factors) to support this assumption. When the assumption that TCE is the most difficult COC to remediate does not prove valid, an evaluation of other COCs was conducted. For OUs where tritium is the COC with highest concentrations and areal extent in ground water and monitored natural attenuation is the selected interim remedy for tritium (Pit 6 Landfill and Building 850 OUs), up to two scenarios were modeled. These scenarios included monitoring the natural attenuation of tritium in ground water until the MCL and/or background activities were achieved. The specific cleanup standard scenarios modeled for each OU are described in Section B-4.

The modeling evaluation results include: (1) the estimated length of time to reach MCLs, WQNLs, and/or background concentrations in ground water, and (2) the design parameters and extraction well configurations necessary to achieve the results of these scenarios. The modeling evaluation also addresses known and potential technical challenges in implementing the remedy under the different scenarios.

B-2. Modeling Approach

DOE/LLNL developed a modeling approach to be able to compare the different scenarios in a consistent manner. For OUs where ground water and/or soil vapor extraction is the selected interim remedy (Building 834, High Explosives (HE) Process Area, Building 854, and Building 832 Canyon OUs), five scenarios were modeled that included cleanup to MCLs, WQNLs, and background concentrations using both partial and complete capture. For OUs where monitored natural attenuation is the selected interim remedy for tritium (Pit 6 Landfill and the Building 850 OU), only one or two scenarios were modeled. These scenarios included monitoring the natural attenuation of tritium in ground water until the MCL and/or background activities were achieved.

A non-optimized cleanup approach was used to model and cost the five cleanup scenarios using ground water extraction and treatment. In this approach, the existing or planned extraction wellfield configurations from the Remedial Designs (Scenario 1) were used in Scenarios 2 through 5 for source area mass removal and downgradient COC concentration reduction. A "fence" of hypothetical capture wells was then added to achieve the different capture and cleanup goals in Scenarios 2 through 5. This fence of extraction wells was placed downgradient of the contaminant isoconcentration contour for a particular cleanup standard scenario (i.e., 5 μg/L MCL in Scenario 2) to ensure complete capture of the plume with concentrations exceeding that cleanup standard. The primary variables are the extraction well locations, flow rates, and the duration of operation to reach a particular ground water cleanup standard. This consistent approach allowed for the development of wellfield configurations, cleanup times, and costs that could be compared for cost-benefit analyses. The approach is non-optimized because the primary objective is hydraulic capture, and the extraction wellfields developed to optimize capture may not be the most optimal for other objectives, such as minimizing cleanup times and maximizing mass removal rates.

Three modeling cases were developed using three extraction wellfield configurations, to evaluate the five scenarios. The scenarios and the equivalent modeling cases are described below and illustrated in Figure B-2.1:

- **Scenario 1 (Model Case I)** – The extraction wellfield configuration provides partial capture of contaminant concentrations above MCLs, and is designed to provide source control and cleanup, distal plume cleanup, and prevent contaminant migration offsite. This scenario is identical to DOE/LLNL's currently existing and/or planned extraction wellfield configuration as defined in the remedial design documents. The extraction wellfield is pumped until MCLs are achieved and then turned off. Ground water is then monitored until COCs naturally attenuate to background concentrations.
- **Scenario 2 (Model Case II)** - The extraction wellfield configuration provides complete capture of contaminant concentrations above MCLs. This extraction wellfield configuration was developed using the existing and planned extraction wellfield described in Scenario 1, and installing a fence of hypothetical extraction wells downgradient of the MCL contour. The extraction wellfield is pumped until MCLs are achieved and then turned off. Ground water is then monitored until COCs naturally attenuate to background concentrations.

- **Scenario 3 (Model Case II)** - The extraction wellfield configuration provides complete capture of contaminant concentrations above the 2.3 μg/L Cal/EPA one-in-one-million cancer potency factor for TCE. This extraction well configuration is identical to Scenario 2 since the 2.3 μg/L and the MCL contours defined by the concentrations measured in monitoring wells are spatially very similar for purposes of siting extraction wells. Scenario 3 differs from Scenario 2 only in duration required to reduce the TCE concentrations from the 5 μg/L MCL to the 2.3 μg/L WQNL. The extraction wellfield is pumped until the 2.3 μg/L WQNL is achieved and then turned off. Ground water is then monitored until COCs naturally attenuate to background concentrations.
- **Scenario 4 (Model Case II)** - The extraction wellfield provides partial capture of contaminant concentrations above background levels. The extraction well configuration is identical to Scenario 2 that provides complete capture to MCLs, but also provides partial capture to background levels. Scenario 4 also differs from Scenario 2 in the duration required to reduce the TCE concentrations from MCLs to background levels. The extraction wellfield is pumped until background levels are reached.
- **Scenario 5 (Model Case III)** - The extraction wellfield provides complete capture of contaminant concentrations above background levels. This extraction wellfield configuration was developed using the existing and planned extraction wellfield described in Scenario 1, and installing a fence of hypothetical extraction wells downgradient of the 0.5 μg/L background level contour. The extraction wellfield is pumped until background levels are reached.

Logistical constraints were considered in developing the "fence" of hypothetical extraction wells, such as terrain restrictions on suitable drilling locations. Once the wells were sited, well specifications were defined based on the relative depth to the HSU of interest at that location, for costing purposes. Where possible, extraction wells were sited near existing infrastructure (i.e., roads, power) to minimize treatment facility buildout costs.

The non-optimized approach described above limits the effectiveness of the existing/planned extraction wellfield based on the interim remedial design because:

- The amount of flow available for extraction in areas with the highest contaminant concentrations is reduced in order to remain below the sustainable yield of the hydrostratigraphic unit (HSU) and prevent dewatering of the aquifer.
- The reduced flow rates in areas of highest contamination limits the capture, allowing some of the higher concentration portion of the plume to migrate downgradient. As a result, downgradient capture wells must be relied on to capture this contamination, extending cleanup times.
- Pumping to ensure capture of the leading edge of the plume creates lower ground water gradients and stagnations zones near highly contaminated areas, reducing the effectiveness of the existing/planned remedial design wellfield.

In addition, to allow for a consistent comparison between cleanup scenarios, a non-optimized mode of extraction wellfield operation was also assumed. For example, it was assumed that the extraction wellfield configuration and operational mode (i.e., extraction rate) remained

unchanged over the entire duration of remediation until ground water cleanup standards are achieved in all extraction and monitor wells.

As a result, the cleanup approach was optimized for capture, yet optimization for other remediation objectives, such as maximizing mass removal and minimizing cleanup time, were not emphasized in the scenarios. The development of optimized wellfield configurations and operations for each scenario for every OU would have potentially generated hundreds of modeling cases with different levels of optimization. However, the results of these simulations would not have provided any meaningful comparison basis for the cleanup standard evaluation. Therefore, the non-optimized approach was used because it allowed for comparison between cleanup scenarios with equivalent objectives and levels of optimization.

Although the non-optimized approach allowed for the estimation of cleanup scenario times for comparison, this approach resulted in extended cleanup times due to lack of optimization. While the relative differences in cleanup times between scenarios are still valid for comparative purposes, it is important to note that optimized cleanup times would be significantly lower. Therefore, the non-optimized cleanup times in Appendix B and costs in Appendix C that were developed to evaluate the technical and economic feasibility of different cleanup standards should not be used for budgetary or planning purposes.

In order to illustrate the differences between an optimized and a non-optimized simulation, an example scenario was developed with minimal optimization using the TCE plume in the Tertiary Neroly Upper Blue Sandstone ($Tnbs_2$) HSU model at the HE Process Area OU. This optimization case incorporated extraction flow rate changes and the addition of only one existing well to the extraction wellfield. The flow rate adjustments were performed only three times at 30, 60, and 100 years into the operation of the extraction wellfield. All optimization decisions balanced the objectives of ensuring adequate capture of the contamination, preventing offsite plume migration, and minimizing cleanup times and costs.

Figure B-2.2 depicts a comparison of the three non-optimized modeling cases developed for the cleanup standard evaluation, as well as the optimized case based on the current remedial extraction wellfield design. By adjusting the operation only three times, it was possible to significantly reduce cleanup times and ensure maximum capture of the plume. For this optimized scenario, DOE/LLNL also looked at the fate of the residual contamination after the maximum concentration in the system reached MCL of 5 μg/L for TCE and the extraction wells are shut off. The remaining plume naturally attenuates below the WQNL of 2.3 μg/L in a period of several years. The remaining ground water contamination above background concentrations also attenuate and the plume is not detectable at the site boundary where $Tnbs_2$ HSU discharges into the more permeable Quaternary alluvium (Qal) HSU (Figure B-2.3).

The modeling tools used for the evaluation are described in Section B-3. The models developed for each OU using the non-optimized approach described above and their results are discussed in Section B-4.

B-3. Modeling Tools

DOE/LLNL selected four different modeling tools to estimate the time to achieve various potential ground water cleanup standards for OUs 2 through 7. These tools range from simple

analytical models to sophisticated numerical models. The most appropriate tool was selected for each modeling effort based on:

1. The type of remediation process used in a particular OU. For example, a tool was selected that is capable of simulating both ground water extraction (saturated flow and transport) and/or soil vapor extraction (soil vapor flow and transport) for areas where dual-phase ground water and soil vapor extraction are components of the interim remedy.
2. The complexity of the subsurface and interactions between HSUs. For example, a mixed-tank model with conservative assumptions was used when HSUs within an OU or area hydraulically communicate to a degree where they can be represented as an idealized conceptual model for the subsurface.

The four modeling tools used for the cleanup standard evaluation are:

- Mixed-Tank Model.
- Zone-Partitioning-Flux Model.
- WinFlow Model.
- FEFLOW Model.

These modeling tools are discussed in Section B-3.1 through B-3.4.

B-3.1. Mixed-Tank Model

A mixed-tank model, an analytical element model with conservative assumptions, was used for areas at Site 300 where the HSU being modeled hydraulically communicates to a degree where it can be represented as a single idealized subsurface horizon (e.g., Building 832 Canyon OU). In a mixed-tank model, the subsurface is assumed to be homogenous and each HSU is treated as a "mixed-tank." For example, any COC input to the HSU is assumed to be instantaneously mixed throughout the entire volume of ground water in that HSU, and ground water extraction is assumed to impact all parts of a contaminant plume equally. The COC concentration in the mixed-tank represents the average contaminant concentration within the capture zones of all extraction wells.

In the idealized mixed-tank model approach, the plume is assumed to contain two reservoirs of contaminant mass: (1) the contaminants dissolved in ground water and (2) contaminants adsorbed to saturated soil (Figure B-3.1). Additional sources of contaminants from the vadose zone are assumed to be negligible, and as ground water is extracted from the plume, clean ground water is assumed to flow inward from the plume margins. This clean ground water comes into contact with soil containing sorbed contaminants and a new concentration equilibrium is established. The equilibrium between ground water and COCs sorbed to soil is accounted for by using a retardation coefficient.

In addition, contaminants in ground water and in the soil may degrade through a first-order rate constant. The first-order degradation rate constant only accounts for mass loss due to contaminants irreversibly locked in dead-end pores or locked in the bedrock matrix due to unidirectional diffusive flux. The degradation rates used in the models are less than degradation rates reported for geochemical or biological degradation of contaminants (i.e., volatile organic compounds [VOCs]) in ground water, and therefore are conservative.

A mixed-tank model was used to estimate times to achieve cleanup under various cleanup standard scenarios for the Building 832 Canyon OU and part of the Pit 6 Landfill OU. The volume of contaminated ground water for each OU area was estimated using isoconcentration maps and the geological structure of each HSU. Where ground water extraction is part of the interim remedy (e.g., the Building 832 Canyon OU), the extraction flow rates were obtained from the results of the WinFlow capture zone analysis, and the average initial concentration in ground water was obtained by averaging the current concentration in proposed extraction wells. The WinFlow model used for extraction well capture zone analysis is described in Section B-3.3. The mixed-tank modeling conducted for part of the Pit 6 Landfill OU and the Building 832 Canyon OU are discussed in more details in Sections B-4.3 and B-4.7, respectively

The mixed-tank models have a high degree of uncertainty because of the idealization of the conceptual model and the difficulty in calculating accurate average values for the idealized parameters. However, conservative input values were used in this analysis yielding relatively long cleanup time estimates. These estimates should be considered worst-case values.

B-3.2. Zone-Partitioning-Flux Model

A zone-partitioning-flux model was used for OUs where both soil vapor and ground water (dual-phase) extraction occurs (Buildings 834, 854, and 830) because this modeling tool accounts for the mass removal from both the vadose zone and ground water. The zone-partitioning-flux model utilizes the MathCad (2004) computational platform to construct and evaluate a four-zone mixed-tank model. The four zones are the high-permeability matrix (i.e., sand) with embedded low-permeability lenses (i.e., clay) defined both in the vadose zone and in ground water (Figure B-3.2). The zone-partitioning-flux model describes the behavior of chlorinated VOCs, partitioned between dense non-aqueous-phase liquid (DNAPL), aqueous, gaseous, and adsorbed phases, in response to fluxes induced by concentration and pressure gradients. The modeling tool was developed at LLNL to evaluate contaminant source area related issues while incorporating ground water and soil vapor extraction. The zone-partitioning-flux model is built on the same principles as the mixed-tank model described in Section B-3.1 and adds the capability of simulating: (1) the vapor phase, and (2) the low and high-permeability zones observed in most source areas. Since the zone-partitioning-flux model was developed at LLNL for site-specific use, the key assumptions of the tool are described. The key assumptions include:

- Perfect mixing is assumed within each zone so that VOCs are distributed uniformly.
- Only diffusive flow (aqueous or gaseous) is modeled through low-permeability clay lenses in the vadose zone or ground water.
- Equilibrium partitioning with regard to Henry's law (aqueous-gaseous) and a specified soil distribution coefficient (aqueous-adsorbed) is assumed in each zone. TCE can be present in DNAPL form and is simulated using a dissolution rate.
- Separate yet time-constant water saturation values characterize both sand and clay in the vadose zone.
- Clay lenses are modeled as oblate spheroids, with a major axis and a minor axis.

- All ground water extraction within the source zone is modeled based on a constant flow rate that accounts for the total flow from all extraction wells.
- The vertical infiltration rate (net recharge from precipitation) is used by the zone-partitioning-flux model as a boundary condition to constrain mass balance on VOC mass fluxes within and out of the source area.
- All soil vapor extraction within the source zone is modeled based on a constant flow rate that accounts for the total flow from all extraction wells.

The zone-partitioning-flux model uses a simple linear isotherm, given by a distribution coefficient, to model equilibrium partitioning. As the model assumes Henry's law and equilibrium soil partitioning within each zone, the initial conditions used to compute a total VOC mass within the zone must be equilibrated. The equilibration calculations include: (1) gaseous diffusion from clay into sand, (2) gaseous diffusion across the water table, (3) aqueous diffusion from clay into sand in the vadose zone, and (4) aqueous diffusion from clay into sand in the saturated zone.

Assumed initial values for DNAPL masses within each zone are based on initial best estimates at representative average values. The quantities are used to develop an estimated total VOC inventory that is distributed within each zone, assuming equilibrium partitioning, as a set of initial conditions for the zone-partitioning-flux model. If the provided initial values are far from mutual equilibrium, then an iterative calibration of the initial values is necessary to reconcile all of the estimates. The zone-partitioning-flux model assumes that any DNAPL present in a particular zone at the beginning of a given time step will dissolve at a rate proportional to the DNAPL surface area and the difference between the aqueous concentration in that zone and the solubility of the VOC represented by a the effective intrinsic mass transfer coefficient. The coupled mass flux and mass conservation equations are solved by a simple finite difference approach using explicit time stepping.

To demonstrate the ability of the zone-partitioning-flux model for accurately simulating these idealized yet complex subsurface conditions, the zone-partitioning-flux model was calibrated to existing data from the Building 834 core area. Time-series data for treatment system influent soil vapor concentrations and ground water concentrations (Figure B-3.3), and cumulative VOC removal (Figure B-3.4) as a function of time were used to calibrate the zone-partitioning-flux model by varying model input parameters until a reasonable match was obtained between historical data and model results. The agreement between zone-partitioning-flux model results and observed data over the past ten years using the best available information from the site as input validates the usefulness of this tool in predicting cleanup times for source areas where dual-phase extraction is the interim remedy.

B-3.3. WinFlow

WinFlow (ESI, 1996) is an interactive, analytical model that simulates two-dimensional steady-state and transient ground water flow. A WinFlow model was used to evaluate the capture zones of existing and proposed extraction wells in the Building 834 and Building 832 Canyon OUs. The cleanup durations for these OUs were estimated using the mixed-tank model (Building 832 Canyon) and the zone-partitioning-flux model (Building 834) that were developed in conjunction with the capture zones resulting from the WinFlow models.

WinFlow simulates ground water flow in a horizontal plane using analytical functions (Strack, 1989) and uses the principle of superposition to evaluate the effects from multiple extraction wells in a uniform regional flow field. WinFlow can be applied to a wide variety of ground water flow problems including wellhead protection, and design of remediation extraction wellfields. The tool depicts the flow field using streamlines, particle traces, and contours of hydraulic head (Figure B-3.5). Statistical tools are incorporated to assist the calibration process. The particle-tracking techniques are implemented numerically to compute travel times and flow directions.

WinFlow requires regional gradient and direction of flow, hydraulic conductivity, aquifer top elevation and bottom elevation, and a reference head as basic input. Regional gradient and direction of flow are used to superimpose a uniform ground water flow field on the analytical model. Hydraulic conductivity is assumed to be homogeneous throughout the infinite aquifer. The aquifer top and bottom elevations are constant throughout the model however the transmissivity is computed based on saturated thickness for each analytical element. The particle-tracking technique requires the definition of porosity which is also assumed homogeneous.

A two-step modeling approach is used to evaluate the capture zones of the proposed extraction wellfields for each HSU within the Building 834 and Building 832 Canyon OU model areas. The first step was to develop a model that simulates current conditions in each HSU and calibrate the model to measured ground water elevations and if applicable, observed drawdown in existing wells. In the second step, the proposed extraction wellfield is modeled with initial estimates of flow rate for each well. The flow rates were adjusted to maximize capture zones while ensuring that the water levels remain above the pump intake for each well. When necessary, new wells were appended to the extraction wellfield to ensure capture of concentration contours relevant to each extraction scenario. New wells were only appended when there is an existing well in the area or a drilling rig can physically access the proposed location without any limitation due to topographical constraints.

The capture zones generated by the WinFlow model are conservative because: (1) the basic model parameters used for each model are selected conservatively (i.e., maximum aquifer thickness, hydraulic conductivity, or hydraulic gradient values), (2) the infinite aquifer assumption within WinFlow does not hold for some of the HSUs where the extent of saturation is limited, and (3) the porous medium assumption for some of the HSUs characterized as fractured bedrock may result in smaller capture zones than actual conditions.

B-3.4. FEFLOW

FEFLOW (Diersch, 1998) was selected as the code to simulate ground water flow and contaminant transport in OUs where sufficient data are available to allow a three-dimensional numerical analysis that incorporates the transport mechanisms in a heterogeneous domain with complex boundary conditions (Pit 6 Landfill, HE Process Area, Building 850, and Building 854 OUs). FEFLOW is an interactive finite element code capable of simulating many subsurface processes. FEFLOW was primarily used to model isothermal flow and contaminant transport under saturated ground water conditions in heterogeneous porous media with complex boundary conditions. The tool is capable of handling full three-dimensional discretization (Figure B-3.6), transient or steady-state flow simulation, and mass transport of contaminants such as tritium,

TCE, and RDX. An important feature of this tool is the convenience with which it handles a range of boundary conditions, including wells. The capability of FEFLOW to handle wells in a user-friendly fashion was very useful in this evaluation, and is one of the reasons the code was selected. Injection and extraction wells were easily located and relocated, and pumping rates modified during the evaluation of capture zones. For simulating the transport of tritium, radioactive decay, advection, and dispersion were the primary transport mechanisms. For simulating the transport of TCE and RDX, advection, dispersion, and adsorption were the primary transport mechanisms.

B-4. Model Assumptions and Results

The tool used to model each OU subarea, and the HSUs modeled are listed in Table B-2.1. The model domains, flow controlling features, and the inflow and outflow boundaries are shown in Figure B-4.1. The general approach used to develop each model is outlined as follows:

- Develop a site conceptual model by defining the HSU structure, inflow/outflow boundaries, the distribution of each COC, and gather all relevant historical data for each area.
- Evaluate available information on subsurface characteristics and select an appropriate modeling tool.
- Derive model input parameters from existing ground water elevation and chemistry data, hydraulic/pneumatic tests, and treatability study results.
- Develop a model representative of unstressed conditions and calibrate to historical data.
- When available, calibrate the model under stressed conditions (ground water and/or soil vapor extraction) using treatment facility data.
- For areas where the remedy includes extraction wellfields (i.e., OUs 2, 4, 6, and 7), develop three different modeling cases (I, II, III) representing the five scenarios defined in the Interim Record of Decision.
- For areas where the remedy does not involve extraction wellfields (i.e., OUs 3 and 5), predict the fate of the COCs over time.

The modeling approachs for each OU, the assumptions of each model, and the uncertainty of the results are discussed in Sections B-4.2 through B-4.7.

B-4.1. OU 1 – General Services Area (GSA)

OU 1 is not included in this evaluation because a final remedy and cleanup standards were already selected for the GSA OU in the Final Record of Decision for the GSA OU (U.S. DOE, 1997).

B-4.2. OU 2 – Building 834 Area

Ground water contamination at the Building 834 OU exists in two separate HSUs. VOCs, the silicone oils tetrabutylorthosilicate (TBOS) and tetra-kis-2-ethylbutyl silane (TKEBS) and

nitrate are present in perched ground water in the Tertiary sand and gravel of the Tpsg HSU. VOCs are also present in unsaturated Tertiary Pliocene non-marine sediments (Tps) underlying the Building 834 core area. VOC contamination is also present in ground water in the Tps-Tertiary Neroly Upper Claystone/Siltstone ($Tnsc_2$) HSU perching horizon. No contamination has been detected in ground water in the deeper Lower $Tnbs_1$ HSU. More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 6.1.3 and 6.1.5 of Chapter 6.

Because TCE is the COC with highest concentrations and areal extent in Building 834 OU ground water, TCE was used as the indicator COC in the modeling. It is assumed that other VOCs, TBOS/TKEBS, and nitrate plumes of lesser extent will be remediated before the TCE plume is remediated.

The following five scenarios were modeled for the Building 834 OU:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.

Because contamination, primarily TCE, is present in both the vadose zone and ground water in the Building 834 OU, dual-phase soil vapor and ground water extraction and treatment was selected as the interim remedy. Ground water contamination is present in both the higher permeability sands and gravels in the Tpsg HSU and the lower permeability Tps-$Tnsc_2$ claystone/siltstone HSU. The zone-partitioning-flux model was selected to assess the time required to achieve the potential ground water cleanup standards because this tool can incorporate soil vapor and ground water extraction for contaminant mass removal, as well as the rate-limited transfer between the low-permeability and higher-permeability sediments. In estimating cleanup times, the zone-partitioning-flux model is capable of incorporating: (1) natural ambient groundwater flow, (2) infiltration from recharge, (3) partitioning of TCE between dissolved, gaseous, adsorbed, and DNAPL phases, and (4) rate-limited transport between permeable, low-permeability sediments in both the vadose zone and saturated zones. The WinFlow model was selected to simulate the extraction well flow rates and the ground water capture zones.

The Building 834 OU is informally divided into three areas: the core, the septic system leachfield, and distal areas (Figure B-4.1 and Table B-2.1). Although the perched ground water horizon and the extent of saturation is conservatively shown as one continuous zone, each area

has different subsurface characteristics that are distinct enough to model them as three separate areas. The core area is the primary source area for all the contamination at Building 834 OU. However, the current distribution and trend of TCE concentrations in ground water indicate that each of these three areas is characterized by high concentrations of TCE. In addition, there is relatively higher hydraulic and pneumatic communication between wells within each area as compared to wells between separate areas. Because of the differences between the core, leachfield, and distal areas, separate zone-partitioning flux models were developed for each area. The extraction well flow rates and the ground water capture zones were also simulated separately for the core, leachfield, and distal areas using the Winflow model. The expected ground water extraction capture zones using WinFlow for all three areas are shown together in Figure B-4.2.1. Steady-state capture lines are shown until they interfere with another well's capture or until they reach the edge of saturation. Five-year capture zones are also shown in Figure B-4.2.1 as a different color. The predicted capture zones are conservative because the WinFlow model assumes infinite extent of saturation, while the extent of saturation in the Tpsg and Tpsg-$Tnsc_2$ HSUs is limited. The capture zones in each area are expected to be much larger once the extraction wellfields are operated continuously. For example, capture in the core area has already influenced the entire extent of saturation due to higher flow rates enhanced by soil vapor extraction and the limited extent of saturation. During the dry season, most of the flow rates in these wells reduce significantly, essentially dewatering the area. For this reason, only one extraction wellfield configuration was used in all models since the existing and planned remedial design extraction wellfield will capture the entire extent of saturation, completely capturing all ground water contaminated above the 0.5 μg/L TCE background. As a result, the partial and complete capture in Scenarios 1 and 2 where the cleanup standard is 5 μg/L TCE MCL, and in Scenarios 4 and 5 where the cleanup standard is 0.5 μg/L TCE background become identical scenarios.

The high TCE concentration and slow release rates from the low-permeability Tps-$Tnsc_2$ HSU is the primary process controlling the effectiveness of remediation and therefore, cleanup times associated with TCE plumes in the Building 834 OU. As such, the analysis of cleanup times for plumes focused on evaluating the constraints on TCE cleanup in the core, leachfield, and distal areas.

Constraints on reducing TCE concentrations using soil vapor and ground water extraction over time were evaluated using a two-step approach for each area that included:

1. Calibrating the zone-partitioning-flux model input parameters by matching the average concentration measured in each area to predicted concentrations. Figure B-4.2.2 shows the average measured concentrations as points and the calibrated model predictions for the period where remediation has already occurred as solid lines.
2. Once close match between measured and predicted values are obtained, the zone-partitioning-flux model was used to predict the time to reach cleanup for each ground water cleanup standard. Soil vapor remediation is completed before ground water goals are reached however, soil vapor extraction is continued because mass continues to be removed in the vapor-phase due volatilization from ground water. Soil vapor extraction also assists in maintaining ground water extraction flow rates. The predicted concentrations are shown in Figure B-4.2.2 as dashed lines.

For each area, data pertaining to TCE concentration and mass were used in developing each zone-partitioning-flux model. Because information in the core area was available for a majority of the input parameters required by the zone-partitioning-flux model, some of the calibrated model parameters for the core area were used in the leachfield and distal area models when data were not available (i.e. air permeability in the Tpsg HSU vadose zone). The key model parameters are listed in Table B-4.1.

In the core and leachfield areas, the current (2005) ground water and soil vapor extraction flow rates were used in the model. In the distal areas, only expected ground water extraction flow rates were used in the model because soil vapor extraction is not planned as part of the remedy. The presence of DNAPL, along with the initial mass estimates, were also incorporated in the saturated and vadose zones.

The model results show that once the maximum TCE concentration in the Tpsg HSU are reduced to levels between 10,000 and 1,000 μg/L, the remediation will become dependent on the rate of TCE release from the low-permeability sediments and will become diffusion limited. This limitation is represented by a step change and a delay in concentration reductions predicted by the zone-partitioning-flux model. Because of the uncertainty associated with estimating the TCE diffusion rate from the low-permeability sediments to higher-permeability sediments where TCE can be extracted at the wells, there is higher degree of uncertainty associated with cleanup time estimates for the Building 834 OU areas. The subsurface conditions for both ground water flow and TCE transport observed in the leachfield area represent average conditions at the Building 834 OU. Therefore, cleanup times for the leachfield area were selected to be representative for the entire Building 834 OU and are reported in Table B-4.2.

The model results show that maximum TCE concentration in the Tpsg HSU will be reduced to below the 5 μg/L MCL in 400 years for Scenarios 1 and 2. The maximum TCE concentration in Tpsg HSU will be reduced to below 2.3 μg/L WQNL in 510 years for Scenario 3. The maximum TCE concentration in Tpsg HSU will be reduced to below 0.5 μg/L background concentrations in 730 years for Scenarios 4 and 5. The predicted maximum TCE concentrations over time for all areas are shown in Figure B-4.2.2. The maximum time to reach TCE cleanup standards reported in Table B-4.2 are used in the long-term cost estimates.

However, the beneficial uses of ground water in the $Tnbs_1$ HSU regional aquifer, at water-supply wells, and in other HSUs at Site 300 will not be impacted at concentrations above background by contamination in the Tpsg and Tps-$Tnsc_2$ HSUs in the Building 834 OU because:

- The TCE plume and TBOS/TKEBS and nitrate contamination in Building 834 ground water are limited to perched ground water in the Tpsg HSU and the underlying Tps-$Tnsc_2$ HSU.
- The plumes are contained onsite in the vicinity of the Building 834 Complex and there are no pathways for them to migrate offsite or to existing ground water receptor points (i.e., onsite or offsite water-supply wells.)
- Contamination in perched ground water is isolated from the Lower $Tnbs_1$ HSU (regional aquifer) by two low-permeability claystone units that prevent downward contamination migration and 280 feet (ft) of unsaturated bedrock.
- No contamination has been detected in the Lower $Tnbs_1$ HSU regional aquifer.

A sensitivity analysis shows that the model predictions are dependent on mass transfer rates used to represent the diffusive flux from low-permeability units to high-permeability units. The model result indicate that even when low-permeability units are unrealistically assumed not to limit mass removal, the cleanup times are still in the range of hundreds of years because of the low pumping rates and high concentrations at the Building 834 OU.

B-4.3. OU 3 – Pit 6 Landfill

Ground water contamination at the Pit 6 Landfill OU exists in two separate HSUs. VOCs and tritium are present in Quaternary terrace deposits-Tertiary Neroly Lower Blue Sandstone (Qt-$Tnbs_1$) North HSU ground water north of the Carnegie-Corral Hollow Fault Zone (hereafter referred to as the fault zone). VOCs, tritium, perchlorate, and nitrate are present in Qt-$Tnbs_1$ South HSU ground water within the fault zone. No contamination has been detected in the deeper Lower $Tnbs_1$ HSU. More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 7.1.3 and 7.1.5 of Chapter 7.

Because tritium is the COC with highest concentrations and areal extent in Pit 6 Landfill OU ground water, tritium was used as the indicator COC in the modeling. It is assumed that the COC plumes of lesser extent (VOCs, perchlorate, and nitrate) will be remediated before the tritium plume is remediated. However, VOCs, which primarily consist of TCE, were also used in the model simulation for the Qt-$Tnbs_1$ South HSU as most VOC contamination is present in this HSU. Only one scenario was modeled for the Pit 6 Landfill because:

- Monitored natural attenuation is the selected interim remedy for tritium at the Pit 6 Landfill OU.
- Tritium activities in ground water are already well below the 20,000 picocuries per liter (pCi/L) MCL.
- There are no intermediate WQNLs for tritium between the MCL and background. (Note: At the time the guidance for evaluating potential ground water cleanup standards scenarios was written in the Interim Site-Wide ROD and when this evaluation was conducted, there were no intermediate WQNLs for tritium between the MCL and background. Since that time, OEHHA has established a 400 pCi/L PHG for tritium.)

Therefore, the Pit 6 Landfill modeling scenario included monitoring the natural attenuation of tritium in ground water until background activities (100 pCi/L) were achieved. The Qt-$Tnbs_1$ North and Lower $Tnbs_1$ HSUs located north of the fault zone and the Qt-$Tnbs_1$ South HSU located within the fault zone were modeled separately using two different tools (Table B-2.1). The modeling and results for these two HSUs are discussed in Sections B-4.3.1 and B-4.3.2.

B-4.3.1. FEFLOW Model of Qt-$Tnbs_1$ North and Lower $Tnbs_1$ HSUs Ground Water North of the Fault Zone

FEFLOW was selected as the tool to simulate tritium transport in the Qt-$Tnbs_1$ North and the Lower $Tnbs_1$ HSUs because of the code's ability to handle the transport mechanisms in a full three-dimensional heterogeneous model. Tritium contamination north of the fault zone is mainly confined to the upper $Tnbs_1$ portion of the Qt-$Tnbs_1$ North HSU. However, there are two active water-supply wells, CARNRW1 and CARNRW2, located about 1,000 feet (ft) east of the Pit 6

Landfill. These wells are screened over multiple zones of varying hydraulic conductivity from the (shallow) $Tnbs_1$ portion of the Qt-$Tnbs_1$ North HSU to the Lower $Tnbs_1$ HSU. Because of the long screens in these wells (e.g., 440 ft in CARNRW1), pumping of the wells influences ground water movement in the Pit 6 Landfill area. For this reason, a three-dimensional model such as FEFLOW was needed to simulate tritium transport in multiple zones of varying hydraulic conductivities and the influence of pumping from the water-supply wells. The fate of tritium contamination is affected mainly by radioactive decay, advection, and dispersion.

The model domain (Figure B-4.1) selected was larger than the extent of the tritium contamination to encompass the zone of influence for the water-supply wells. Inflow to the model domain is from the western boundary and infiltration from rainfall recharge. Outflow to the model domain is from the eastern boundary and extraction from the water-supply wells. Although the flow model is calibrated to both steady-state and transient conditions, the long-term fate of the tritium contamination is predicted using a steady-state model where the water-supply wells extract at average flow rates of 6.4 gallons per minute (gpm) for CARNRW1 and 8.3 gpm for CARNRW2. These wells are normally operated at higher flow rates for shorter periods of time. The steady-state model continuously draws ground water towards the water-supply wells, therefore it should be considered more conservative in relation to assessing potential impact to these wells. The Carnegie-Corral Hollow Fault Zone south of the domain and the northern limit of the model boundary are treated as impervious.

The three-dimensional model is comprised of thirteen layers totaling a thickness of 500 ft. Each layer is defined as either a high-conductivity layer (3.9 feet per day [ft/d]), or a low-conductivity layer (0.16 ft/d). The thirteen layers were developed based on borehole lithology and optical-televiewer data. Wells CARNRW1 and CARNRW2 have screen lengths of 440 ft and 150 ft, respectively. The Pit 6 Landfill ground water monitoring wells are completed in both the Qt-(upper) $Tnbs_1$ North HSU and in the Lower $Tnbs_1$ HSU. Tritium is detected only in the shallow upper $Tnbs_1$ portion of the Qt-$Tnbs_1$ North HSU. Ground water in the deeper, Lower $Tnbs_1$ HSU has not been impacted by contamination. The flow domain is assumed to be isotropic. The tritium activity in recharge water from the inflow boundaries is considered significantly below the detection limit/background concentrations of 100 pCi/L.

The model was initially calibrated using steady-state conditions for a time period when the water-supply wells were not operational. The model was then calibrated using transient conditions for a data set collected in 2001. The transient data set includes flow rate and water level information from the water-supply wells and water level data from wells K6-33 and K6-34. Once the model was calibrated for both steady-state non-pumping and transient conditions using the same set of flow parameters (Table B-4.1), the model was then used for predictive simulations.

Model results show that: (1) the maximum tritium activity in the Qt-$Tnbs_1$ North HSU was reduced below background concentrations of 100 pCi/L by year 2036, and (2) tritium activities in ground water in the CARNRW1 and CARNRW2 water-supply wells never exceed the detection limit. Figure B-4.3.1 shows the predicted distribution of tritium activity over time. The plume size, defined by a lower limit of 100 pCi/L, decreases from year 2008 to 2014, and by 2024 the peak activity decreases to below 300 pCi/L. By 2028, only a relatively small fraction of the original plume remains above the detection limit. The maximum time to reach a tritium cleanup standard of 100 pCi/L reported in Table B-4.2 are used in the long-term cost estimates.

Figure B-4.3.2c shows time-series plots of tritium activity for the water-supply wells, and the maximum activity in the Qt-$Tnbs_1$ North HSU. Maximum tritium activities of 2.7 pCi/L and 8.5 pCi/L are predicted in well CARNRW1 and CARNRW2, respectively. These predicted activities are considerably less than analytical method detection limit for tritium.

Beneficial uses of ground water in the Lower $Tnbs_1$ HSU regional aquifer, at water-supply wells, and in downgradient Qt-$Tnbs_1$ North HSU ground water will not be impacted at concentrations above background by contamination in the Qt-$Tnbs_1$ HSU in the Pit 6 Landfill OU. Tritium activities are already well below the 20,000 pCi/L MCL and continuing to decrease.

A sensitivity analysis was performed to examine the effect of input parameters on tritium activity reaching the water-supply wells. Water-supply well extraction rates for each of the two pumping wells were varied from zero to 26 gpm. The higher hydraulic conductivity was varied from 0.39 ft/d to 39 ft/d, and the lower hydraulic conductivity from 0.016 ft/d to 1.6 ft/d. Longitudinal and transverse dispersivity were varied over an order of magnitude, and the background hydraulic gradient increased by a factor of 5 during the sensitivity analysis. For all of these simulations the tritium activity in the water-supply wells remained below the detection limit, and the maximum activity in the model was reduced to below 50 pCi/L in less than 50 years for every case examined.

B-4.3.2. Mixed-Tank Model of Qt-$Tnbs_1$ South HSU Ground Water Within the Fault Zone

A mixed-tank model was selected as the tool to simulate tritium and VOC transport in the Qt-$Tnbs_1$ South HSU ground water because extraction from water-supply wells CARNRW1 and CARNRW2 does not hydraulically influence ground water in the Qt-$Tnbs_1$ South HSU. Therefore, the model did not need to account for multiple layers with variable hydraulic conductivity and a simpler, mixed-tank model was sufficient to simulate conditions in this HSU. The tritium and VOC contamination within the fault zone is present primarily in the upper $Tnbs_1$ portion in the Qt-$Tnbs_1$ South HSU. Two separate mixed-tank models were developed to predict the fate of the tritium activity and the VOC concentrations in this HSU. The models were calibrated to existing data assuming that tritium activities and VOC concentrations will continue to decrease.

In the mixed-tank model, the Qt-$Tnbs_1$ South HSU is assumed to be homogenous and is treated as a mixed-tank. Tritium and VOC concentrations in the mixed-tank represent the average contaminant concentration within the HSU. Additional sources of contaminants from the Pit 6 Landfill and the vadose zone are assumed to be negligible because the landfill has been capped and ground water data do not indicate any new releases.

The VOC contamination is mainly comprised of TCE and has been steadily declining since the late 1980s. The calibrated mixed-tank model results are shown in Figure B-4.3.2a. The maximum TCE concentration currently is around 6 μg/L. Assuming the mixed-tank approach is valid for this area, TCE concentrations in this area are expected to decrease to below the 5 μg/L MCL in 2007, decrease below the 2.3 μg/L WQNL in 2009, and decrease below the 0.5 μg/L background concentration by 2015. These results assume that there will not be any significant contribution from VOCs that may be in the vadose zone at residual levels. The 20-year history of the TCE contamination at Pit 6 Landfill OU indicates that there are no

additional VOC sources and the remaining TCE concentration in ground water will attenuate in a reasonable time period.

The tritium activity in this area has shown fluctuations based on the intensity of rainfall recharge over the years. The rapid decline in tritium activity in wells indicates that the attenuation occurs at a higher rate than can be accounted for by the tritium decay half-life of 12.3 years. The mixed-tank model attenuation factor was adjusted until there was a match between measured data and predicted values. Figure B-4.3.2b shows the maximum predicted tritium activity over time. Assuming the mixed-tank approach is valid for this area, the maximum tritium activity is expected to decrease below the background concentration of 100 pCi/L by 2010. Because the maximum time to reach a tritium cleanup standard of 100 pCi/L derived from the FEFLOW model are longer than those estimated in the mixed-tank model, the mixed-tank model results are not reported in Table B-4.2 or used in the long-term cost estimates.

B-4.4. OU 4 – High Explosives (HE) Process Area

Ground water contamination at HE Process Area OU is present primarily in the $Tnbs_2$ HSU. Ground water COCs detected in this HSU include VOCs, research department explosive (RDX), perchlorate, and nitrate. Although contamination is present in the perched Tpsg-Tps HSU in the vicinity of Building 815, the COC plumes in this HSU are of limited extent, and are assumed not to impact ground water in the $Tnbs_2$ HSU. Therefore, the Tpsg-Tps HSU was not included in the model. More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 8.1.3 and 8.1.5 of Chapter 8.

Because TCE is the COC with highest concentrations and areal extent in HE Process Area OU ground water, TCE was used as the indicator COC in the modeling. It is assumed that other VOCs, perchlorate, and nitrate plumes of lesser extent will be remediated before the TCE plume is remediated. RDX was also used in the model simulation because RDX is highly sorptive, significantly impeding both plume migration and RDX cleanup.

The following five scenarios were modeled for the HE Process Area OU:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case I). Although there is no MCL for RDX, this COC was included in this scenario to determine the fate of the RDX plume during VOC remediation.
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case II). Although there is no MCL for RDX, this COC was included in this scenario to determine the fate of the RDX plume during VOC remediation.
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels (Model Case II). Although no intermediate WQNL above background has been identified for RDX, this COC was

included in this scenario to determine the fate of the RDX plume during VOC remediation.

4. Ground water extraction with partial hydraulic capture to reduce TCE and RDX to background concentrations of 0.5 μg/L and 1.0 μg/L, respectively (Model Case II).
5. Ground water extraction with complete hydraulic capture to reduce TCE and RDX to background concentrations of 0.5 μg/L and 1.0 μg/L, respectively (Model Case III).

The $Tnbs_2$ HSU is unconfined near the upgradient recharge area and is confined downgradient near the site boundary. Artesian conditions exist in the downgradient area and $Tnbs_2$ HSU ground water eventually discharges into the Quaternary alluvium (Qal) HSU. The changing flow regime and the complex structure of the $Tnbs_2$ HSU required the development of a three-dimensional numerical model using FEFLOW (Table B-2.1). The model was used to evaluate the five scenarios, as well as the potential impact to offsite water-supply well GALLO1.

The FEFLOW model consists of a two-layer, three-dimensional domain. The model domain and the boundaries are shown in Figure B-4.1. The model domain is based on the lateral extent of saturation in the $Tnbs_2$ aquifer. The top and bottom surfaces of the model represent the saturated portions of the $Tnbs_2$ HSU. Inflow to the model domain is through the northern recharge boundary, the injection wells, and infiltration from rainfall applied to the unconfined portion of the aquifer that comprises approximately two-thirds of the northern portion of the domain. Outflow from the model is at southern boundary where $Tnbs_2$ HSU subcrops beneath the Qal HSU, extraction from remedial ground water extraction wells, and at the water-supply well GALLO1. The model is configured to allow the southern boundary to convert to an inflow boundary when the safe yield of the $Tnbs_2$ HSU is exceeded and the Qal HSU begins to recharge the $Tnbs_2$ HSU.

The model includes two hydraulic conductivity values. The primary value of 0.68 ft/d represents the overall average hydraulic conductivity for the $Tnbs_2$ HSU. A second value of 0.31 ft/d represents the hydraulic conductivity for the fault zone shown in Figure B-4.1. The extraction flow rate from the GALLO1 well was set at 1.0 gpm. The well is typically operated intermittently at higher flow rates, however a conservative average extraction flow rate is selected which is also consistent with the observed ground water elevations.

The steady-state flow model was calibrated to ground water elevations observed in 1999 under unstressed conditions. The flow model was then calibrated to ground water elevations during 2005 under stressed conditions when the extraction wellfield was operational. Model parameters (Table B-4.1) were adjusted until there was a close match between observed and simulated ground water elevations under both stressed and unstressed conditions. The resulting flow balance indicates that the safe-yield for the $Tnbs_2$ HSU is between 15 to 20 gpm.

The extraction wellfields for the five scenarios were developed primarily for the capture of the TCE plume, the primary ground water COC in the HE Process Area OU. The RDX plume was also modeled, because of its highly sorptive properties, using the extraction wellfield configurations developed for TCE capture. The transport properties used for the calibration of the TCE and RDX plume migration are listed in Table B-4.1. All plumes are modeled from an initial plume based on 2005 data. Long-term ground water data at the HE Process Area do not show any significant sources currently impacting the ground water, therefore no source terms were included in the model.

The extraction wellfield used for Model Case I (Scenario 1) is based on the current and planned extraction wellfield as discussed in the HE Process Area remedial design document (Madrid et al., 2002). For Model Case II (Scenarios 2, 3, and 4), five new hypothetical extraction wells were added to the wellfield used in Case I to completely capture the 5.0 μg/L TCE MCL and 2.3 μg/L WQNL concentration contours and partially capture the 0.5 μg/L TCE background concentration contours. For Model Case III (Scenario 5), ten new hypothetical extraction wells were added to the wellfield used in Case I to completely capture the 0.5 μg/L TCE background concentration contour. All hypothetical wells are modeled with an extraction flow rate of 1.5 gpm. This flow rate is similar to sustainable flow rates observed in nearby wells and allows continuous extraction without excessive drawdown in the wells.

The capture zones from extraction wells and the injection areas for each of the three extraction well configurations are shown in Figure B-4.4.1. These capture plots show the extent of capture after only five years of pumping. The capture zones presented in the figure are the most conservative representation of the predicted capture zones. The actual capture in the field is expected to be larger, primarily because of the fractured nature of the $Tnbs_2$ HSU. As the $Tnbs_2$ HSU in the FEFLOW model is simulated as a porous medium equivalent; the capture zones are conservatively smaller.

The model results show that the maximum TCE concentration in the $Tnbs_2$ HSU will be reduced to below the 5 μg/L MCL in 120 years for Scenario 1 and in 110 years for Scenario 2. The maximum TCE concentration in $Tnbs_2$ HSU will be reduced to below 2.3 μg/L WQNL in 120 years for Scenario 3. The maximum TCE concentration in $Tnbs_2$ HSU will be reduced to below 0.5 μg/L background concentrations in 155 years for Scenario 4 and 175 years for Scenario 5. The predicted maximum TCE concentration over time for all scenarios is shown in Figure B-4.4.2a. The maximum time to reach TCE cleanup standards reported in Table B-4.2 are used in the long-term cost estimates.

While TCE may migrate toward the site boundary at concentrations below the MCL but above background, the plume will not be detectable at the site boundary where $Tnbs_2$ HSU discharges into the more permeable Qal HSU. The beneficial uses of ground water in the lower $Tnbs_1$ HSU regional aquifer, water-supply wells, and in offsite ground water will not be impacted by contamination in the HE Process Area OU.

Although five new extraction wells are used in Scenario 2 to achieve complete capture of the TCE MCL plume, the overall change in the cleanup time is not significant when compared to Scenario 1 (partial capture of the TCE MCL plume). The same results can also be obtained by extraction wellfield optimization. The 20-year difference in cleanup time between Scenarios 4 and 5 is the result of the reduced gradients and the development of wide stagnation zones due to additional extraction. The high concentration areas of the TCE plume become trapped in extended stagnation zones and are not effectively captured by the wells. Therefore, increasing the number of extraction wells to fully capture a plume may extend cleanup times. This exemplifies the importance of extraction wellfield optimization over time. The optimization issue is further discussed in Section B-2.

There are no MCL or WQNLs defined for RDX. However, because RDX is highly sorptive which can impede cleanup, it was included in the models for Scenarios 1, 2, and 3 to determine the fate of the RDX plume during VOC remediation. The detection limit/background concentration of 1.0 μg/L is used as the background ground water cleanup standard for

predicting cleanup times in Scenarios 4 and 5. The model results show that the maximum RDX concentration will be reduced to below the 1.0 μg/L background concentration in 800 years for Scenario 1, in 900 years for Scenarios 2, 3, and 4, and in 1,000 years for Scenario 5. Since the extraction wellfields are developed primarily to capture the TCE plume, the effectiveness of the extraction wellfield in capturing the RDX plume is significantly reduced. When the highly sorptive nature of RDX is considered, the cleanup times are extended to hundreds of years. In implementation, DOE/LLNL will continuously monitor the remediation of the RDX plume and minimize further migration of the RDX plume by optimizing the extraction wellfield. Therefore, the cleanup times for RDX were not used in the long-term cost estimates discussed in Appendix C. The model results suggest that optimization will allow the remediation of the RDX plume, which has a smaller footprint, to be completed within the same duration of the TCE plume cleanup. The maximum RDX concentration for all scenarios is shown in Figure B-4.4.2b. The results show that the different extraction wellfield configurations near the leading edge of the TCE plume do not have a significant impact on the RDX plume cleanup over time.

A sensitivity analysis was performed to examine the effect of pumping of the GALLO1 water-supply well on the TCE plume. The extraction rate for the pumping well was increased to from 1 to 5 gpm. For this simulation, TCE concentrations in the GALLO1 water-supply well decreased and remained below the background.

B-4.5. OU 5 – Building 850 Area

Ground water contamination in the Building 850 area exists in two separate HSUs. Tritium, uranium, nitrate, and perchlorate are present in Qal/weathered bedrock (WBR) HSU ground water. Tritium, nitrate, and perchlorate are present in $Tnbs_1$/Tertiary Neroly Basal Sandstone ($Tnbs_0$) HSU ground water. More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 9.1.3 and 9.1.5 of Chapter 9.

Because tritium is the COC with highest concentrations and areal extent in Building 850 area, tritium was used as the indicator COC in the modeling. It is assumed that the COC plumes of lesser extent (perchlorate, and nitrate) will be remediated before the tritium plume is remediated. Because total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL, and the depleted uranium is not migrating in ground water, this COC was not included in the evaluation.

Only two scenarios were modeled for the Building 850 area because:

- Monitored natural attenuation is the selected interim remedy for tritium at the Building 850 area.
- There are no intermediate WQNLs for tritium between the MCL and background. (Note: At the time the guidance for evaluating potential ground water cleanup standards scenarios was written in the Interim Site-Wide ROD and when this evaluation was conducted, there were no intermediate WQNLs for tritium between the MCL and background. Since that time, OEHHA has established a 400 pCi/L PHG for tritium.)

Therefore, the Building 850 area modeling scenarios included:

1. Monitored natural attenuation to reduce tritium activities in ground water to the MCL of 20,000 pCi/L.

2. Monitored natural attenuation to reduce tritium activities in ground water to the background levels of 100 pCi/L.

As requested by the Regional Water Quality Control Board, the tritium plumes originating at both the Pit 7 Complex and the Building 850 firing table were included in the model. By modeling the entire tritium plume in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs, the potential impact of the tritium plume originating at the Pit 7 Complex on the Building 850 tritium plume could be evaluated.

The Qal/WBR HSU is unconfined and consists of variably-saturated alluvial sediments deposited in Doall and Elk Ravines and the underlying weathered bedrock. Ground water flow in the Qal/WBR HSU follows topography/ground elevation contours and is parallel to stream channel axes in Doall and Elk Ravines. The majority of the flow and transport in this HSU occurs during periods of winter rainfall recharge. The HSU becomes unsaturated in places where ground water flow and transport are significantly impeded because of flat gradients.

Ground water in the $Tnbs_1/Tnbs_0$ HSU exists under unconfined to confined conditions and generally flows to the east beneath Building 850 and Doall Ravine. East of the Elk Ravine Fault, ground water flows to the east-northeast. The extent of saturation in the $Tnbs_1/Tnbs_0$ HSU is limited by the geologic structure. The $Tnbs_1/Tnbs_0$ HSU is mostly recharged from the Qal/WBR HSU, however this bedrock HSU does not show significant fluctuations in its flow regime relative to those observed in the Qal/WBR HSU. The hydraulic conductivity of the $Tnbs_1/Tnbs_0$ HSU is lower relative to the Qal/WBR HSU. Although the $Tnbs_1/Tnbs_0$ HSU hydraulically communicates with the Qal/WBR HSU, they are modeled separately due to the differences in the flow regimes between the two HSUs. Because of the complex geometry of the Qal/WBR HSU and the three-dimensional structure of both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs, FEFLOW was selected as the appropriate numerical modeling code (Table B-2.1).

The modeling and results for the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs are discussed in Sections B-4.5.1 and B-4.5.2, respectively.

B-4.5.1. FEFLOW Model of Qal/WBR HSU Ground Water

FEFLOW was selected as the tool to simulate tritium transport in the Qal/WBR HSU because of the code's ability to handle the complex geometry of the Qal/WBR HSU and the transport mechanisms in a three-dimensional heterogeneous model. Ground water flow in the Qal/WBR HSU occurs along the axes of ephemeral drainage channels.

The model domain (Figure B-4.1) selected extends from the Pit 7 Complex, along Doall Ravine, Elk Ravine, to the eastern end of Site 300 boundary. The model consists of a three-dimensional single layer with varying thickness along the drainage channel under unconfined conditions. Inflow to the model domain is primarily from infiltration due to rainfall recharge. Outflow from the model domain occurs along the eastern boundary. The geometry of the Qal/WBR HSU and lack of recharge causes large portions of this HSU to become unsaturated for most of the year, significantly slowing the migration of contaminants. Ground water flow occurs only part of the year when there is adequate rainfall recharge. The long-term fate of the tritium contamination is predicted using a steady-state flow model and by using an average saturated thickness representative of conditions when there is continuous flow in the Qal/WBR HSU. The

continuous flow is a conservative assumption since tritium continues to decay in place even when there is no significant flow in the Qal/WBR HSU.

The Qal/WBR HSU has an average saturated thickness of 20 ft and a calibrated hydraulic conductivity of 1.4 ft/d. The model boundary values were initially estimated and were subsequently adjusted during the calibration process until a match with measured ground water elevation values was obtained. Once the model was calibrated for steady-state conditions using the flow parameters listed in Table B-4.1, the model was then used to predict the fate of tritium. Tritium migration is affected mainly by radioactive decay, advection, and dispersion. The initial distribution of tritium in ground water is based on the second semester 2005 data for the transport modeling. Ground water data do not show any significant sources at Building 850 currently releasing tritium to ground water, therefore no source terms were included in the model.

Model results show that: (1) the maximum tritium activity in the Qal/WBR HSU was reduced below the MCL of 20,000 pCi/L by year 2045, and (2) maximum tritium activity in ground water was reduced below the background level of 100 pCi/L by year 2140.

Figure B-4.5.1 shows the predicted distribution of tritium activity over time in the Qal/WBR HSU. The portion of the tritium above the MCL of 20,000 pCi/L does not advance significantly along the drainage channel and reduces below the MCL before reaching the site boundary. However, flow in the Qal/WBR HSU is not continuously saturated to the site boundary as is conservatively assumed in the model. Therefore, the tritium in Qal/WBR HSU ground water will not likely migrate a significant distance. In addition, the tritium activities originating from the Pit 7 Complex do not significantly increasing tritium activities in the Building 850 tritium plume in the Qal/WBR HSU. During the time period required for tritium activities to attenuate to background in the Qal/WBR HSU, the portion of the tritium plume with activities above background (100 pCi/L) may impact downgradient onsite ground water. However, the beneficial uses of ground water at water-supply wells, and in offsite ground water will not be impacted by tritium contamination in the Qal/WBR HSU above background levels during this time. Figure B-4.5.3 shows the maximum tritium activity in Qal/WBR HSU ground water over time.

A sensitivity analysis was performed to examine the effect of input parameters on tritium. When the flow through the entire HSU was increased, simulating significant rainfall recharge years, the maximum activity in the system decreased in much shorter periods of time due to additional dilution. When the flow was reduced simulating drought conditions, the estimated duration for maximum tritium activity for reaching the cleanup standards did not significantly change, however plume migration slowed considerably.

B-4.5.2. FEFLOW Model of $Tnbs_1/Tnbs_0$ HSU Ground Water

FEFLOW was selected as the tool to simulate tritium transport in the $Tnbs_1/Tnbs_0$ HSU because of the code's ability to handle transport mechanisms in a three-dimensional model. Ground water flow in the $Tnbs_1/Tnbs_0$ HSU is generally to the east towards the Elk Ravine fault. East of the Elk Ravine Fault, ground water flows to the east-northeast. The model domain (Figure B-4.1) selected extends from the Pit 7 Complex and Building 850 on the west to the eastern and northern Site 300 boundary.

The $Tnbs_1/Tnbs_0$ HSU dips northeast toward the Elk Ravine fault. Ground water elevation differences on either side of the Elk Ravine fault suggest that the fault zone is a significant barrier to ground water flow. However, the fault was included as a semi-permeable, low conductivity zone in the model to represent worst-case conditions for contaminant transport towards the site boundary. The $Tnbs_1/Tnbs_0$ HSU was modeled as a single-layer, three-dimensional, heterogeneous, confined HSU. Inflow to the model domain is primarily from the Qal/WBR HSU along the drainage channel. Since the $Tnbs_1/Tnbs_0$ HSU is primarily confined in most other areas, rainfall recharge was not included in the model. Outflow to the model domain is from the northeastern site boundary. The $Tnbs_1/Tnbs_0$ HSU also discharges near the area of Spring 24 along the Elk Ravine fault. However the discharge rate is insignificant compared to the overall flow balance, therefore it was not included as a boundary condition in the model. The ground water elevations in the $Tnbs_1/Tnbs_0$ HSU do not respond significantly to heavy rainfall events, therefore a steady-state flow assumption is used in the model.

The saturated thickness of the $Tnbs_1/Tnbs_0$ HSU varies throughout the domain from less than 10 ft in the west and to more than 100 ft to the east. An average calibrated hydraulic conductivity value of 0.14 ft/d was used for the $Tnbs_1/Tnbs_0$ HSU and hydraulic conductivity value of 0.07 ft/d was used for the Elk Ravine fault zone.

The flow field in the model was calibrated by adjusting the specified head boundary conditions and the hydraulic conductivity of the unit until there was match with measured ground water elevations and the gradient. The flow and transport parameters used in the final calibration are listed in Table B-4.1. The initial distribution of tritium in ground water is based on the second semester 2005 data for the transport modeling. Additional tritium that may inflow to the $Tnbs_1/Tnbs_0$ HSU from the Qal/WBR HSU after 2005 were not included when predicting the long-term fate of the tritium plume. This assumption is valid for the Building 850 area since tritium activities in ground water have been continuously decreasing over time.

Model results show that: (1) the maximum tritium activity in the $Tnbs_1/Tnbs_0$ HSU decreased to below the 20,000 pCi/L MCL by year 2035, and (2) maximum tritium activity in ground water decreased to below the background level of 100 pCi/L by year 2130.

Figure B-4.5.3 shows the predicted distribution of tritium activity over time in the $Tnbs_1/Tnbs_0$ HSU. During the time period required for tritium activities to attenuate to background activities, the portion of the tritium plume with activities above background (100 pCi/L) will likely expand into clean, onsite ground water. However, the beneficial uses of ground water at water-supply wells, and in offsite ground water will not be impacted by tritium contamination in the $Tnbs_1/Tnbs_0$ HSU above detection levels during this time. There is no ground water pathway from this HSU to a receptor point such as the City of Tracy water-supply wells located several miles to the northeast. Saturation of the $Tnbs_1/Tnbs_0$ HSU is limited to the northeast where these strata have been uplifted and eroded. The equivalent Neroly strata exist in the subsurface of the Central Valley, but at depths of about 2,000 ft below the Tracy water-supply wells. In addition, the tritium activities originating from the Pit 7 Complex do not significantly increase tritium activities in the Building 850 tritium plume in the $Tnbs_1/Tnbs_0$ HSU. Figure B-4.5.3 shows the maximum tritium activity in $Tnbs_1/Tnbs_0$ HSU over time.

A sensitivity analysis was performed to examine the effect of hydraulic conductivity within the Elk Ravine fault zone on the migration of tritium. If the hydraulic conductivity within the fault zone is lowered to a value that is an order of magnitude lower than the $Tnbs_1/Tnbs_0$ HSU,

the residual portions of the tritium plumes originating from the Building 850 area and Pit 7 Complex do not migrate beyond the Elk Ravine fault.

B-4.6. OU 6 – Building 854

Ground water contamination in the Building 854 OU is present primarily in the $Tnbs_1/Tnsc_0$ HSU. Ground water COCs detected in this HSU include VOCs, perchlorate, and nitrate. Although contamination is also present in the Quaternary landslide (Qls) HSU, the extent of saturation is ephemeral and the unit consists of limited perched ground water zones. Therefore, only the contaminated Qls and $Tnbs_1$/Tertiary Neroly Lower Siltstone/Claystone Basal Unit ($Tnsc_0$) HSUs in the Building 854 core area was modeled. More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 10.1.3 and 10.1.5 of Chapter 10.

Because TCE is the COC with highest concentrations and areal extent in Building 854 OU ground water, TCE was used as the indicator COC in the modeling. It is assumed that other VOCs, perchlorate, and nitrate plumes of lesser extent will be remediated before the TCE plume is remediated.

The following five scenarios were modeled for the Building 854 OU:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case I).
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case II).
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels (Model Case II).
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L (Model Case II).
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L (Model Case III).

A FEFLOW model was applied to simulate contaminant migration and estimate time to cleanup in the $Tnbs_1/Tnsc_0$ HSU in the Building 854 OU. FEFLOW was selected as the tool because of the three-dimensional structure of the HSU and the areal distribution of the TCE plume in ground water. In the Building 854 core area, a zone-partitioning-flux model was used to estimate time to cleanup in the $Qls/Tnbs_1/Tnsc_0$ HSU because this model accounts for mass removal from both the vadose zone and ground water through soil vapor and ground water extraction that is ongoing in this area. The FEFLOW and zone-partitioning flux modeling for the Building 854 OU are discussed in Sections B-4.6.1 and B-4.6.2, respectively.

B-4.6.1. FEFLOW Model of $Tnbs_1/Tnsc_0$ HSU Ground Water

The FEFLOW model for the $Tnbs_1/Tnsc_0$ HSU consists of a two-layer, three-dimensional domain. A map of the model location and model domain and boundaries are shown in Figure B-4.1. The model domain is based on the lateral extent of saturation in the $Tnbs_1/Tnsc_0$ HSU, which is extended to the east. The top and bottom surfaces of the model represent the saturated portions of the $Tnbs_1/Tnsc_0$ HSU. The numerical model was constrained to a minimum thickness of 10 ft along the northern and northeastern portions of the domain to accommodate inflow. Recharge was applied to the unconfined portion of the aquifer that comprises of approximately one-quarter of the northern portion of the domain. Discharge occurs at the southern boundary.

The model is divided into three hydraulic conductivity zones. The northern one-quarter of the model, that represents the unconfined portion of the $Tnbs_1/Tnsc_0$ HSU, was assigned a hydraulic conductivity of 0.85 ft/d. The middle-section of the model was assigned a hydraulic conductivity of 0.37 ft/d. The remaining southern one-quarter of the model was assigned a hydraulic conductivity of 0.45 ft/d. The conductivity estimates were based on hydraulic test data and model calibration. The flow and transport properties used for the calibration of the TCE plume migration are listed in Table B-4.1. The initial TCE distribution in ground water is based on 2005 data. Long-term ground water data at the Building 854 OU do not show any significant sources currently impacting the ground water, therefore no source terms were included in the model.

The steady-state flow model was calibrated using ground water elevations observed in 1999 under unstressed conditions. The flow model was then calibrated to ground water elevations during 2005 under stressed conditions when the extraction wellfield was operational. Model parameters were adjusted until there was a close match between observed and simulated ground water elevations under both stressed and unstressed conditions. The flow balance from the model was used as a basis to define the sustainable yield of the $Tnbs_1/Tnsc_0$ HSU. The sustainable yield defines the upper limit for total pumping from existing and hypothetical extraction wells.

The extraction wellfields for the five scenarios were developed to separately capture the TCE in the $Tnbs_1/Tnsc_0$ HSU in the northern part of the OU near the Building 854 Complex and in the southern part of the OU. The extraction wellfield used for Model Case I (Scenario 1) is based on the current and planned extraction wellfield as discussed in the Building 854 remedial design document (Daily et al., 2003). For Model Case II (Scenarios 2, 3, and 4), seven new hypothetical extraction wells were added to the wellfield used in Case I to completely capture the 5.0 μg/L TCE MCL and 2.3 μg/L WQNL concentration contours and partially capture the 0.5 μg/L TCE background concentration contours. Four of these wells were sited to capture the northern plume and three were sited to capture the southern plume. For Model Case III (Scenario 5), ten new hypothetical extraction wells were added to the wellfield used in Case I to completely capture the 0.5 μg/L TCE background concentration contour. Five of these wells were sited to capture the northern plume and five were sited to capture the southern plume. All hypothetical wells are modeled with an extraction flow rate of 0.2 gpm. This flow rate is similar to sustainable flow rates observed in nearby monitor wells and allows continuous extraction without excessive drawdown in the wells. The capture zones from extraction wells for each of the three extraction well configurations for Model Cases I, II, and III are shown in

Figure B-4.6.1. These capture plots show the extent of capture after only five years of pumping. The capture zones presented in the figure are the most conservative representation of the predicted capture zones. The actual capture in the field is also expected to be larger because of the fractured nature of the $Tnbs_1/Tnsc_0$ HSU. As the $Tnbs_1/Tnsc_0$ HSU in the FEFLOW model is simulated as a porous medium equivalent; the capture zones are conservatively smaller.

The model results show that the maximum TCE concentration in the $Tnbs_1$-$Tnsc_0$ HSU will be reduced to below the 5 μg/L MCL in 90 years for Scenarios 1 and 2. The maximum TCE concentration in $Tnbs_1$-$Tnsc_0$ HSU will be reduced to below 2.3 μg/L WQNL in 95 years for Scenario 3. The maximum TCE concentration in $Tnbs_1/Tnsc_0$ HSU will be reduced to below 0.5 μg/L background concentrations in 120 years for Scenarios 4 and 5. The predicted maximum TCE concentration over time for all scenarios is shown in Figure B-4.6.2. The maximum time to reach TCE cleanup standards reported in Table B-4.2 are used in the long-term cost estimates.

Although seven new extraction wells were used in Scenario 2 to achieve complete capture of the TCE MCL plume, the cleanup time is the same as for Scenario 1 (partial capture of the TCE MCL plume). Similarly, although ten new extraction wells were used in Scenario 5 to achieve complete capture of the TCE plume with concentrations exceeding the 0.5 μg/L background concentration, the cleanup time is the same as for Scenario 4 (partial capture of the TCE background plume). There is no difference in cleanup times between the partial and complete capture scenarios because:

- The amount of flow available for extraction in areas with the highest contaminant concentrations are reduced in order to remain below the sustainable yield of the HSU and prevent dewatering of the aquifer.
- The reduced flow rates in areas of highest contamination limits the capture, allowing some of the higher concentration portion of the plume to migrate downgradient. As a result, downgradient capture wells must be relied on to capture this contamination; extending cleanup times.
- Pumping to ensure capture of the leading edge of the plume creates lower ground water gradients and stagnations zones near highly contaminated areas, reducing the effectiveness of the existing/planned remedial design wellfield.

Therefore, increasing the number of extraction wells to fully capture a plume may not result in shorter cleanup times.

The FEFLOW model results for Scenario 1 was also used to evaluate if the TCE contamination from the Building 854 area would reach the site boundary or the nearest offsite water-supply wells CARNRW1 and CARNRW2. For this evaluation, the TCE concentrations that reach the FEFLOW modeling boundary were used as input concentrations in the inflow boundary of the Pit 6 Landfill FEFLOW model (Figure B-4.1). The results of this model predicted that TCE would not reach the CARNRW1 and CARNRW2 water-supply wells above background concentrations under Scenario 1.

The beneficial uses of ground water in onsite or offsite water-supply wells, and in offsite ground water will not be impacted by contamination in the Building 854 OU during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels.

A sensitivity analysis was conducted to evaluate the changes in capture zones by increasing the hydraulic conductivity of the $Tnbs_1/Tnsc_0$ HSU to represent fractured bedrock. The capture zones significantly expand under these conditions indicating that extraction wells that intersect fractured zones will likely have much larger capture zones than used in the model.

B-4.6.2. Zone-Partitioning Flux Model of the Vadose Zone and the Qls and $Tnbs_1/Tnsc_0$ HSU Ground Water in the Building 854 Core Area

The vadose zone and shallow ground water in the Qls and $Tnbs_1/Tnsc_0$ HSUs in the Building 854 core area contain relatively low levels of TCE. Soil vapor and ground water extraction is currently underway in the core area. Because contamination is present in both the vadose zone and ground water in the Qls and $Tnbs_1/Tnsc_0$ HSUs in the Building 854 core area, a zone-partitioning-flux model was used to assess cleanup time as a result of combined ground water and soil vapor extraction.

Input parameters used in the zone-partitioning-flux model are listed in Table B-4.1. A hydraulic conductivity of 5 ft/day was assigned to the Qls and $Tnbs_1/Tnsc_0$ HSUs. Although this is a high permeability, the extraction flow rates are limited by recharge in the Qls and $Tnbs_1/Tnsc_0$ HSUs. The volume of contaminated ground water for the core area was estimated using the TCE isoconcentration maps and the geological structure of the Qls and $Tnbs_1/Tnsc_0$ HSUs. The extraction flow rates were obtained from existing or planned soil vapor and ground water extraction wells in the Building 854 core area. The TCE concentration in soil vapor and ground water were based on the current (2005) TCE concentrations in existing extraction wells.

Contamination in the vadose zone and ground water in the Qls and $Tnbs_1/Tnsc_0$ HSUs is of limited extent. The existing remedial design extraction wells are expected to completely capture the TCE plume in ground water. The influence of ground water extraction is already observed in the Building 854 core area. Several wells have been dewatered and ground water elevations have significantly dropped since the beginning of extraction in 1999. Therefore, the existing extraction wellfield was used to estimate cleanup times for all potential ground water cleanup standard scenarios.

The estimated cleanup times using the remedial design extraction wells are between 20 to 40 years to reach the 5 μg/L TCE MCL of and between 40 to 80 years to reach 0.5 μg/L background concentration. However, the vadose zone remediation is expected to occur significantly sooner and will reduce TCE concentrations in soil vapor to levels that will no longer impact ground water. The Qls and $Tnbs_1/Tnsc_0$ HSUs ground water in the Building 854 source area is expected to be remediated before the downgradient TCE plumes in $Tnbs_1/Tnsc_0$ HSU ground water. Therefore, only the longer cleanup times estimated for the $Tnbs_1/Tnsc_0$ HSU are shown in Figure B-4.6.2 and used in the cost estimates.

B-4.7. OU 7 – Building 832 Canyon

Ground water contamination at the Building 832 Canyon OU originated from two separate sources at Buildings 832 and 830. At Building 832, VOCs, perchlorate and nitrate are present in ground water in the Qal/WBR HSU and the $Tnsc_{1b}$ HSU. At Building 830, VOCs, perchlorate and nitrate are present in the vadose zone and in Qal/WBR and $Tnsc_{1b}$ HSU ground water. VOCs are also present in the Upper $Tnbs_1$ HSU ground water downgradient of Building 830.

More detailed descriptions of these HSUs and the distribution of contamination are presented in Sections 11.1.3 and 11.1.5 of Chapter 11.

Because TCE is the COC with highest concentrations and areal extent in Building 832 Canyon OU ground water, TCE was used as the indicator COC in the modeling. It is assumed that other VOCs, perchlorate, and nitrate plumes of lesser extent will be remediated before the TCE plume is remediated.

The following five scenarios were modeled for the Building 832 Canyon OU:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case I).
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels (Model Case II).
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels (Model Case II).
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L (Model Case II).
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L (Model Case III).

Ground water flow conditions in the Building 832 Canyon OU are very complex because of the structure of the contaminated HSUs; the location of the contaminant source areas; the presence of faults; and the complex and localized nature of the extent of saturation and recharge conditions. Because the basic aquifer parameters such as the gradient, hydraulic conductivity, and unit thickness differ throughout the Building 832 Canyon OU, separate models were used to evaluate the five scenarios. (Table B-2.1).

The Qal/WBR and the $Tnsc_{1b}$ HSUs are in hydraulic communication in the Building 832 area, therefore they were combined together in a single domain and modeled using WinFlow for capture analysis and a mixed-tank model to estimate cleanup times. The Qal/WBR HSU at Building 830 was modeled using a zone-partitioning flux model because the interim remedy includes ground water and soil vapor extraction. The Building 830 TCE source and distal plumes in the $Tnsc_{1b}$ HSU were modeled separately using WinFlow for capture analysis and mixed-tank models to estimate cleanup times. The TCE plume in the Upper $Tnbs_1$ HSU near Building 830 was modeled using WinFlow and a mixed-tank model. The WinFlow and mixed-tank models and results for the: (1) Qal/WBR and $Tnsc_{1b}$ HSU TCE plume at Building 832, (2) $Tnsc_{1b}$ HSU in the Building 830 source area and distal TCE plumes, and (3) Upper $Tnbs_1$ HSU TCE plume at Building 830 are discussed in Section B-4.7.1. The zone-partitioning-flux model and results for the Qal/WBR HSU TCE plume in the Building 830 source area are discussed in Section B-4.7.2.

B-4.7.1. WinFlow and Mixed-Tank Models and Results

A WinFlow model was used to simulate ground water capture by the extraction wells and a mixed-tank model was used to estimate the TCE cleanup times in the Building 832 Canyon OU ground water as follows:

- TCE plume in Qal/WBR and $Tnsc_{1b}$ HSUs ground water at Building 832.
- TCE plume in $Tnsc_{1b}$ HSU ground water at the Building 830 source area.
- TCE in the Building 830 distal plume in $Tnsc_{1b}$ HSU ground water.
- TCE plume in the Upper $Tnbs_1$ HSU ground water at Building 830.

A mixed-tank modeling approach was selected for the Qal/WBR and $Tnsc_{1b}$ HSUs because these HSUs hydraulically communicate to a degree where they can be represented as an idealized subsurface horizon. The Building 830 source and distal plumes were modeled separately based on the capture zones of the extraction wells influencing these two plumes (Figure B-4.1). The Upper $Tnbs_1$ HSU was modeled separately because the vertical communication between this zone and the $Tnsc_{1b}$ HSU is very limited.

In the mixed-tank models, each modeled area is assumed to be homogenous and is treated as a mixed-tank. TCE concentrations in the mixed-tank represent the average contaminant concentration within each HSUs. Additional sources of contaminants from the vadose zone are assumed to be negligible because contaminated soil vapor in the vadose zone is being extracted. The volume of contaminated ground water for each area was estimated using the TCE isoconcentration maps and the geological structure of the Qal/WBR, $Tnsc_{1b}$, and Upper $Tnbs_1$ HSUs. The TCE concentrations in the mixed-tank models represent the average contaminant concentration within the combined capture zones of all the extraction wells. The average initial concentration in ground water was obtained by averaging the current (2005) TCE concentrations in existing extraction wells and extrapolated TCE concentrations from monitor wells located in the vicinity of added hypothetical extraction plume capture wells. The transport parameters used in the mixed-tank models are listed in Table B-4.1.

Calibrated model input parameters used in the WinFlow and mixed-tank models are listed in Table B-4.1. A hydraulic conductivity of 0.1 to 1 ft/day was assigned to the Qal/WBR and $Tnsc_1$ HSUs. The Upper $Tnbs_1$ HSU was assigned a hydraulic conductivity of 1 ft/day. Initially, each model was calibrated to current conditions in each area using measured ground water elevations and observed drawdown in existing wells. The additional extraction wellfield to evaluate scenarios 2, 3, 4 and 5 were then modeled with initial estimates of flow rate for each well. The flow rates of additional wells were adjusted to maximize capture zones while ensuring that the water levels remain above the pump intake for each well. New wells were only added when there is an existing well in the area or a drilling rig can physically access the proposed location without any limitation due to topographical constraints.

The extraction wellfield used for Model Case I (Scenario 1) is based on the current and planned extraction wellfield as discussed in the Building 832 remedial design document (Madrid et al., 2006). For Model Case II (Scenarios 2, 3, and 4), eleven hypothetical ground water extraction wells were added to the remedial design wellfield to completely capture the TCE plume with concentrations exceeding the 5 μg/L MCL and the 2.3 μg/L WQNL, and partially capture the TCE plume with concentrations above background (0.5 μg/L). Eight of

these wells were added to the Building 830 source area model, pumping at a rate of 0.75 gpm to capture the downgradient end of the TCE plumes originating from both Buildings 830 and 832. Three wells were added to the Building 830 distal model, pumping at an average rate of 2.0 gpm to capture the leading edge of the TCE plume. For Model Case III (scenario 5), eleven hypothetical ground water extraction wells were added to the remedial design wellfield to completely capture the TCE plume with concentrations above background (0.5 μg/L). No additional extraction wells were added for the Qal/WBR and $Tnsc_{1b}$ HSUs in the Building 832 source area for Model Cases II and III because the eight wells in the Building 830 source area already capture the downgradient extent of this plume. The same eleven wells used in Model Case II were used with the same pumping rates however, they were sited further downgradient in Model Case III to capture the 0.5 μg/L background isoconcentration contour. The flow rates used in the additional wells are similar to sustainable flow rates observed in existing wells and allow continuous extraction without excessive drawdown in the wells. There were no additional wells used in the Upper $Tnbs_1$ HSU WinFlow model because downgradient pumping in this HSU creates an undesired effect of drawing the plume near the potential area of influence of Site 300 water-supply Wells 18 and 20.

The expected capture zones from the all extraction wells for all three WinFlow models (Building 832, Building 830 source, and Building 830 distal) and for Model Cases I, II, and III are shown in Figure B-4.7.1. These capture plots show the extent of capture after only five years of pumping. The capture zones shown in the figures are conservative (i.e., minimum capture) because: (1) the basic parameters used for each model were selected to be conservative (i.e., maximum aquifer thickness, hydraulic conductivity, and hydraulic gradient values), and (2) the WinFlow infinite aquifer assumption does not hold everywhere in Building 832 Canyon due to the limited extent of saturation in the $Tnsc_{1b}$ HSU. Due to this conservative approach, the actual capture zone from each extraction well is expected to be significantly larger than the capture zones depicted in Figure B-4.7.1 for the $Tnsc_{1b}$ HSU.

The model results show that the maximum TCE concentration in the Qal/WBR and $Tnsc_{1b}$ HSUs will be reduced to below the 5 μg/L MCL in 149 years for Scenarios 1 and 2. The maximum TCE concentration in the Qal/WBR and $Tnsc_{1b}$ HSUs will be reduced to below 2.3 μg/L WQNL in 187 years for Scenario 3. The maximum TCE concentration in the Qal/WBR and $Tnsc_{1b}$ HSUs will be reduced to below 0.5 μg/L background concentrations in 263 years for Scenarios 4 and 5. The predicted maximum TCE concentration over time in the Qal/WBR and $Tnsc_{1b}$ HSUs combining all three model results together is shown in Figure B-4.7.2. The TCE plume in the Upper $Tnbs_1$ HSU is of limited extent with low concentrations. The existing extraction wellfield is expected to remediate the Upper $Tnbs_1$ plume before the Qal/WBR and $Tnsc_{1b}$ HSU plumes. The maximum time to reach TCE cleanup standards reported in Table B-4.2 are used in the long-term cost estimates.

While TCE may migrate toward the site boundary at concentrations below the MCL but above background, the plume will not be detectable at the site boundary where the $Tnsc_{1b}$ and Upper $Tnbs_1$ HSU ground water discharges into the more permeable Qal HSU in the Corral Hollow Creek floodplain. The beneficial uses of ground water in the Lower $Tnbs_1$ HSU regional aquifer, water-supply wells, and in offsite ground water will not be impacted by contamination in the Building 832 Canyon.

The mixed-tank models used to estimate cleanup times for the wellfield expansions have a high degree of uncertainty because of the idealized conceptual model and the difficulty in calculating accurate average values for input parameters. Highly conservative input values were used in this analysis yielding relatively long cleanup time estimates. These estimates should be considered worst-case results (i.e., the longest duration cleanup times).

B-4.7.2. Zone-partitioning-flux model for the Qal/WBR HSU TCE plume in the Building 830 source area

TCE is present in both the vadose zone and shallow ground water in the Qal/WBR HSU in the Building 830 source area. Soil vapor and ground water extraction is currently underway. Therefore, a zone-partitioning-flux model was used to assess cleanup time at the Building 830 source area.

Input parameters used in the zone-partitioning-flux model are listed in Table B-4.1. A hydraulic conductivity of 1 ft/day was assigned to the Qal/WBR HSU in the Building 830 source area. The volume of contaminated ground water for the Building 830 source area was estimated using the 2005 TCE isoconcentration maps for the Qal/WBR HSU. The extraction flow rates were obtained from the existing soil vapor and ground water extraction wells. The average initial TCE concentration in ground water was obtained by averaging the current (2005) TCE concentrations in existing extraction wells in the Building 830 source area.

Using the existing soil vapor and ground water extraction wells, cleanup time for the vadose zone and Qal/WBR HSU in the Building 830 source area were projected to be very long. Additional soil vapor and ground water extraction wells are planned for installation in the source area to increase VOC mass removal and shorten cleanup times. The additional soil vapor and ground water extraction wells are expected to fully capture the limited extent of TCE in the vadose zone and ground water. Cleanup of ground water contamination in the $Tnsc_{1b}$ HSU is likely to take longer, therefore $Tnsc_{1b}$ HSU cleanup times were used in the cost estimates. However, the cost estimates includes the operation of the extraction wells completed in the Qal/WBR HSU.

B-4.8. OU 8 – Buildings 801, 833, 845, and 851

OU 8 release sites (Building 801/Pit 8 Landfill, Building 845/Pit 9 Landfill, the Building 851 firing table, Building 833, and the Pit 2 Landfill) were not included in this evaluation because: (1) COCs were not identified in ground water, (2) COC concentrations in ground water do not exceed regulatory standards, and/or (3) the extent of contamination in ground water is limited. The interim remedy selected for these areas is monitoring as discussed in Chapter 12.

B-4.9. Conclusions

DOE/LLNL developed models and compared their results using a consistent approach for evaluating potential ground water cleanup standards. The modeling results provided:

- The estimated duration of cleanup for the potential cleanup standard scenarios (MCLs, WQNLs, and background levels, where applicable) for both extraction and treatment and monitored natural attenuation interim remedies. Where ground water and/or soil vapor

extraction was a component of the interim remedy for an OU, a cleanup time estimate was provided for both partial and complete plume capture. The cleanup time estimates were used in Appendix C to estimate long-term costs for each scenario.

- Extraction wellfield designs for OUs where the remedy is soil vapor and/or ground water extraction, including well construction details. This information was used in Appendix C to estimate the buildout cost for new extraction wells and treatment facilities.

The modeling results for each OU indicate that:

- The interim remedies will be effective in remediating the ground water contamination at Site 300 OUs.
- Contamination in the Building 834 OU HSUs will not impact beneficial uses of ground water in the regional aquifer, at water-supply wells, and in other HSUs at Site 300 at concentrations above background under any cleanup standard scenario.
- Contamination in the Pit 6 Landfill OU HSUs will not impact beneficial uses of ground water in the regional aquifer, at water-supply wells, and in downgradient ground water at concentrations above background under any cleanup standard scenario.
- The beneficial uses of ground water in the regional aquifer, water-supply wells and in offsite ground water will not be impacted by contamination in the HE Process Area OU under any cleanup standard scenario.
- There will be no adverse effects for downgradient and/or offsite receptors from the ground water contaminants in the Building 850 area (OU5) because these contaminants will naturally attenuate to background levels before reaching the site boundary or any receptor.
- The beneficial uses of ground water in onsite or offsite water-supply wells, and in offsite ground water will not be impacted by contamination in the Building 854 OU under any cleanup standard scenario.
- The beneficial uses of ground water in onsite or offsite water-supply wells, and in offsite ground water will not be impacted by contamination in the Building 832 Canyon OU under any cleanup standard scenario.

The longest duration of cleanup times estimated for each of the OUs are tabulated in Table B-4.2. These are the durations used in Appendix C for cost calculation purposes. As mentioned in Section B-4.2, to compare each scenario in a consistent manner, each extraction wellfield configuration was assumed to remain unchanged over the entire duration of operation until ground water cleanup standards are achieved. As a result, the cleanup approach was optimized for capture, yet not optimized for maximizing mass removal and minimizing cleanup times.

Although the non-optimized approach was the most practical method to compare potential cleanup scenario times and costs, this approach resulted in extended cleanup times due to lack of optimization. However, the relative differences in cleanup times between scenarios are still valid for comparative purposes.

In reality, DOE/LLNL reviews the performance of treatment facilities and extraction wellfields on an ongoing basis and makes necessary adjustments to optimize and expedite

cleanup. The performance of these remediation systems is also evaluated as part of the five-year review process. This continuous optimization approach is expected to result in cleanup times and costs significantly less than the scenarios developed for cost-benefit analysis. Therefore, the non-optimized cleanup times in Appendix B and costs in Appendix C that were developed to evaluate the technical and economic feasibility of different cleanup standards should not be used for budgetary or planning purposes.

B-5. References

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Appendix B

Figures

Interim ROD scenario	Extraction wellfield configuration	Model case
1	Partial capture to MCL	I
2	Complete capture to MCL	II
3	Complete capture to WQNL	
4	Partial capture to background	
5	Complete capture to background	III

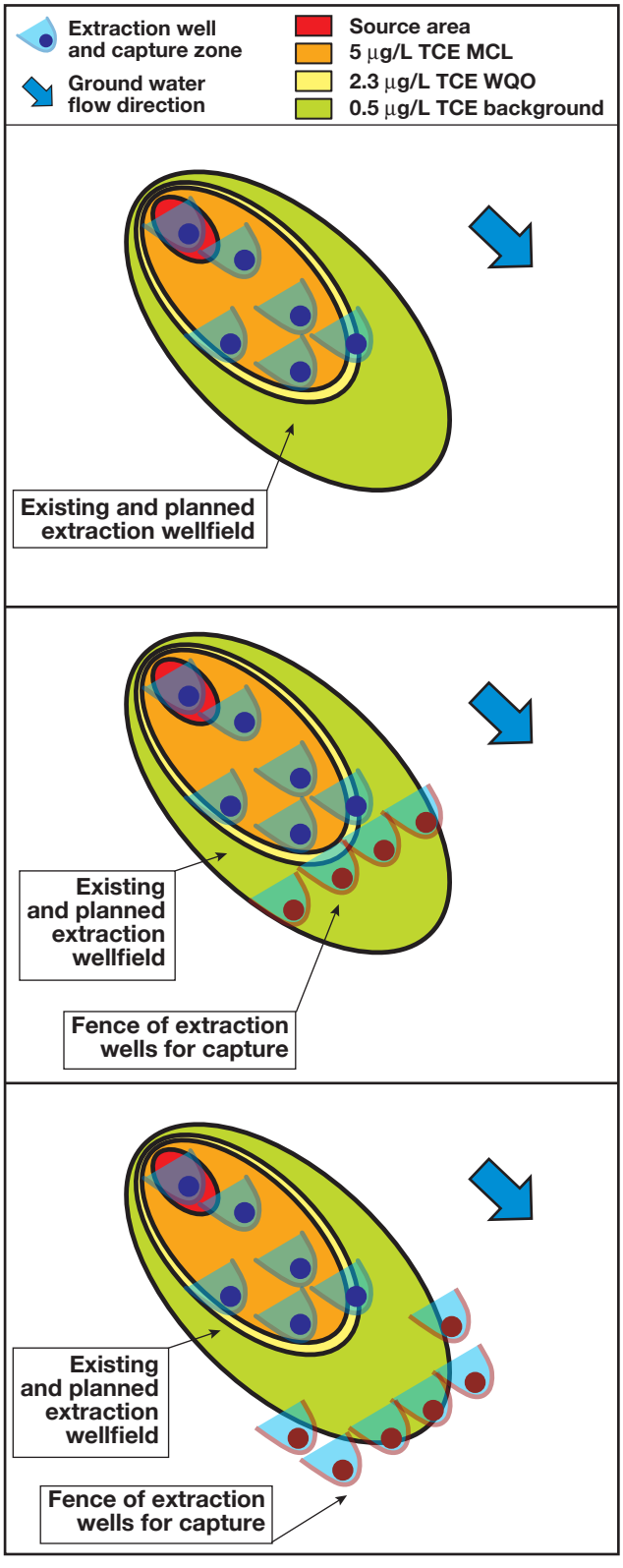

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Figure B-2.1. Interim Record of Decision scenarios, modeling cases and the approach used in determining extraction wellfield configuration for capture.

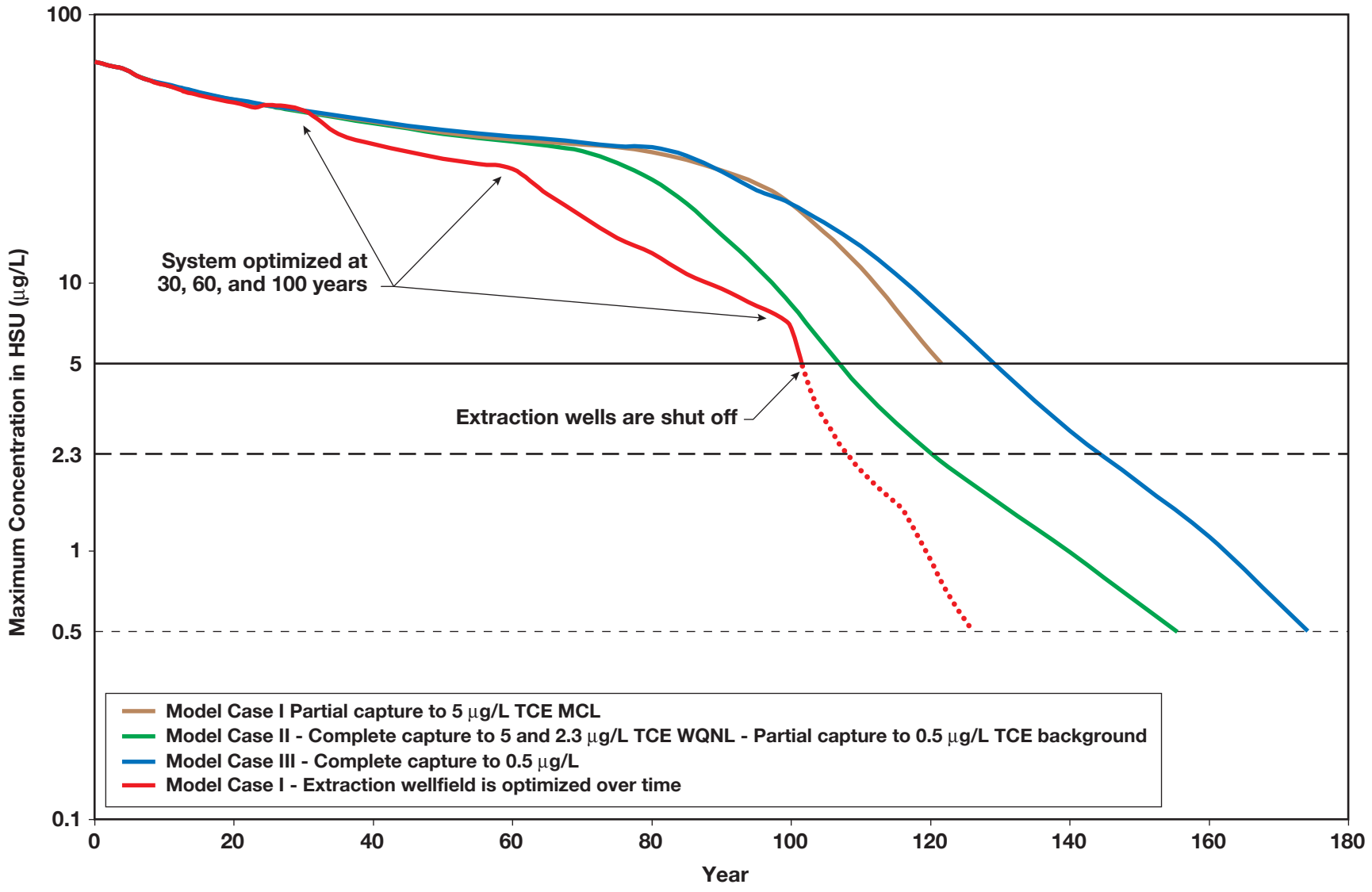

Figure B-2.2. Comparison of predicted maximum ground water concentration of TCE over time for the optimized and non-optimized extraction wellfields at the HE Process Area OU.

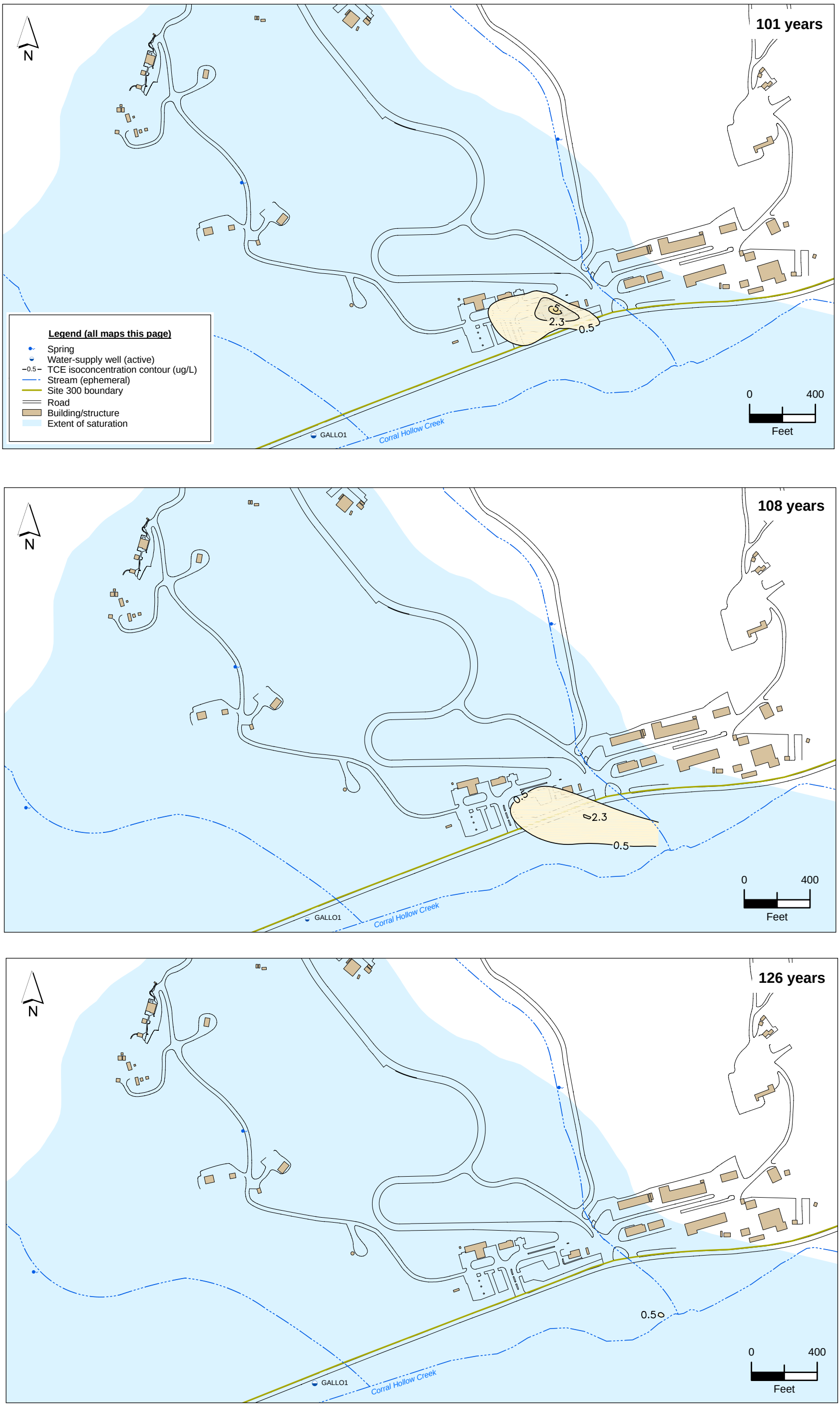

Figure B-2.3. Predicted distribution of TCE concentration over time after the extraction well field is shut-off when the MCL goal is achieved at the HE Process Area OU.

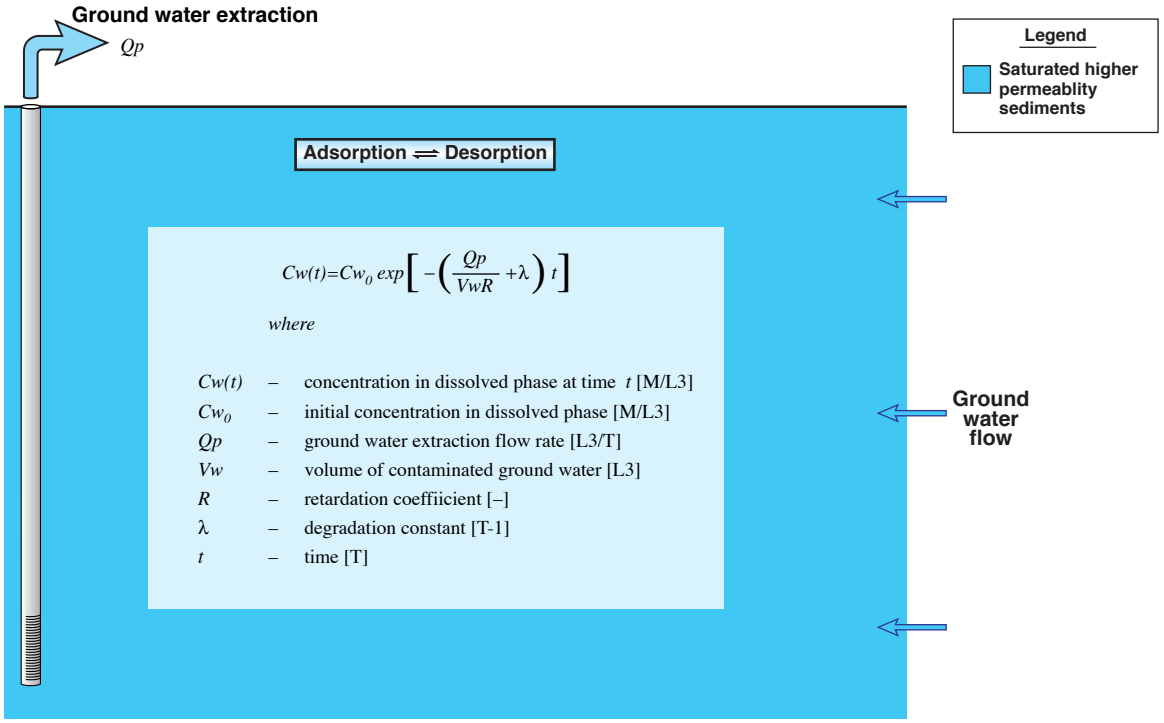

Figure B-3.1. Conceptual depiction of the mixed-tank model.

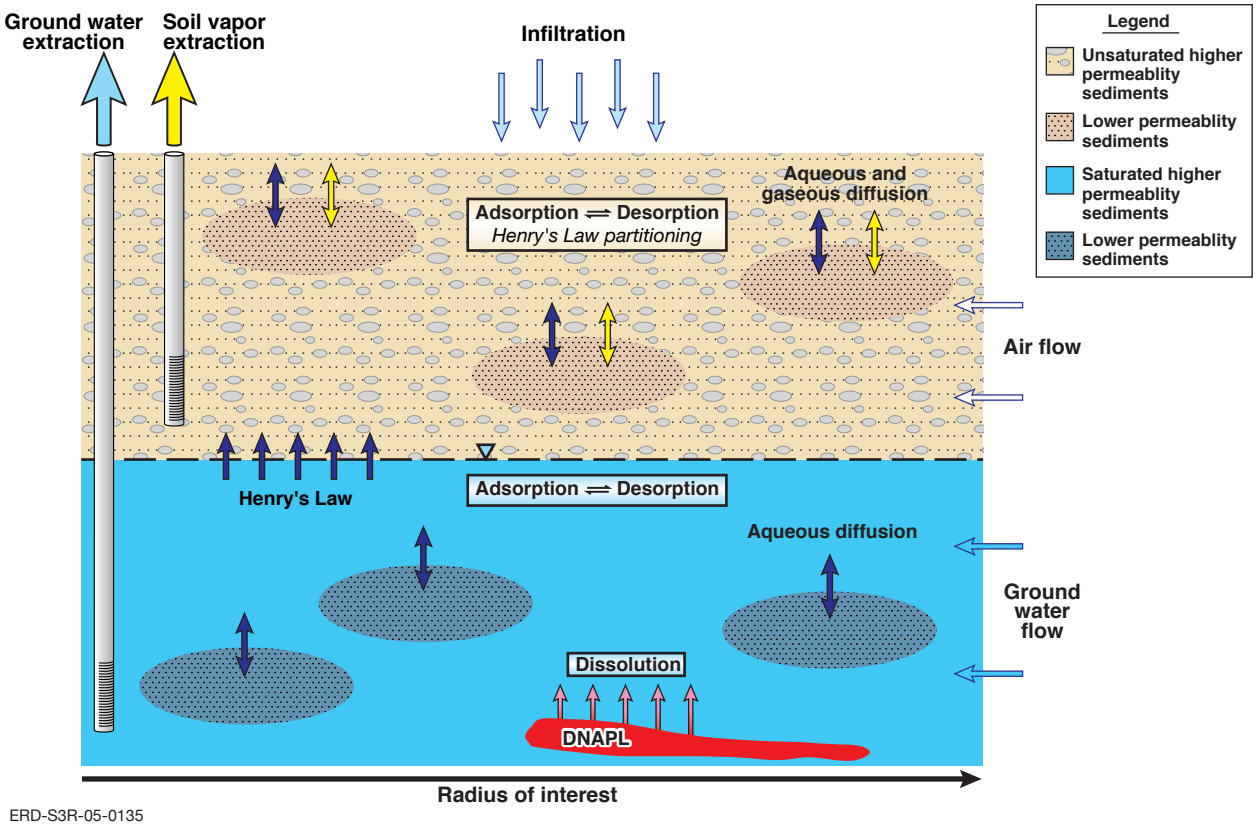

Figure B-3.2. Conceptual depiction of the zone-partitioning flux model.

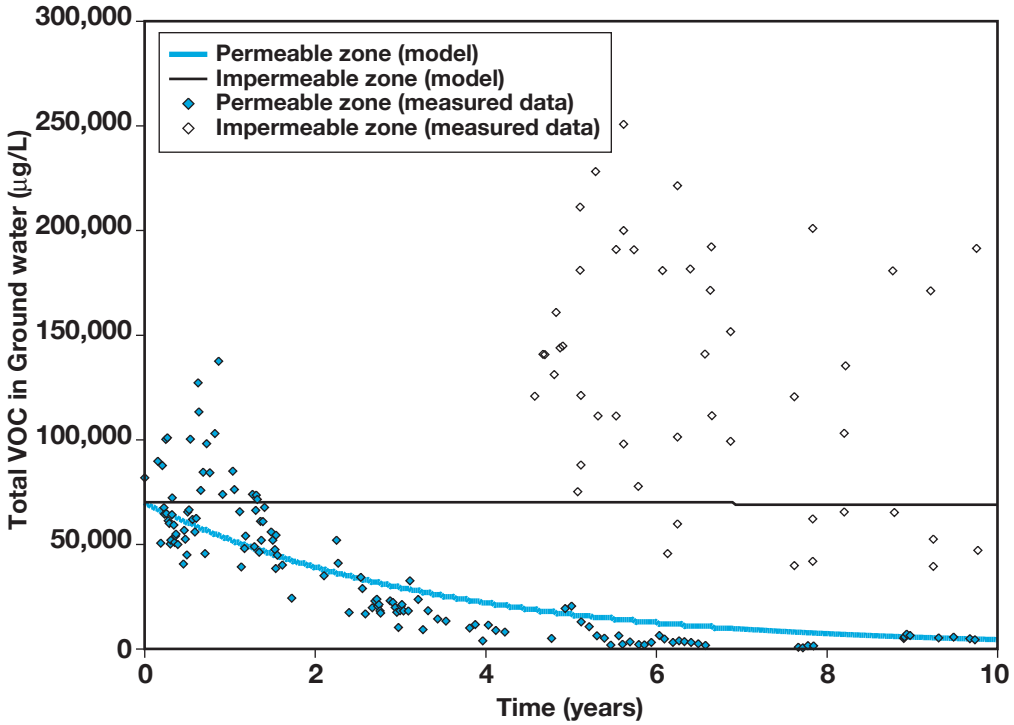

Figure B-3.3. Example comparison of modeled aqueous VOC concentrations with historical concentrations measured in the ground water extraction system influent showing zone-partitioning-flux model calibration at Building 834 OU Core Area.

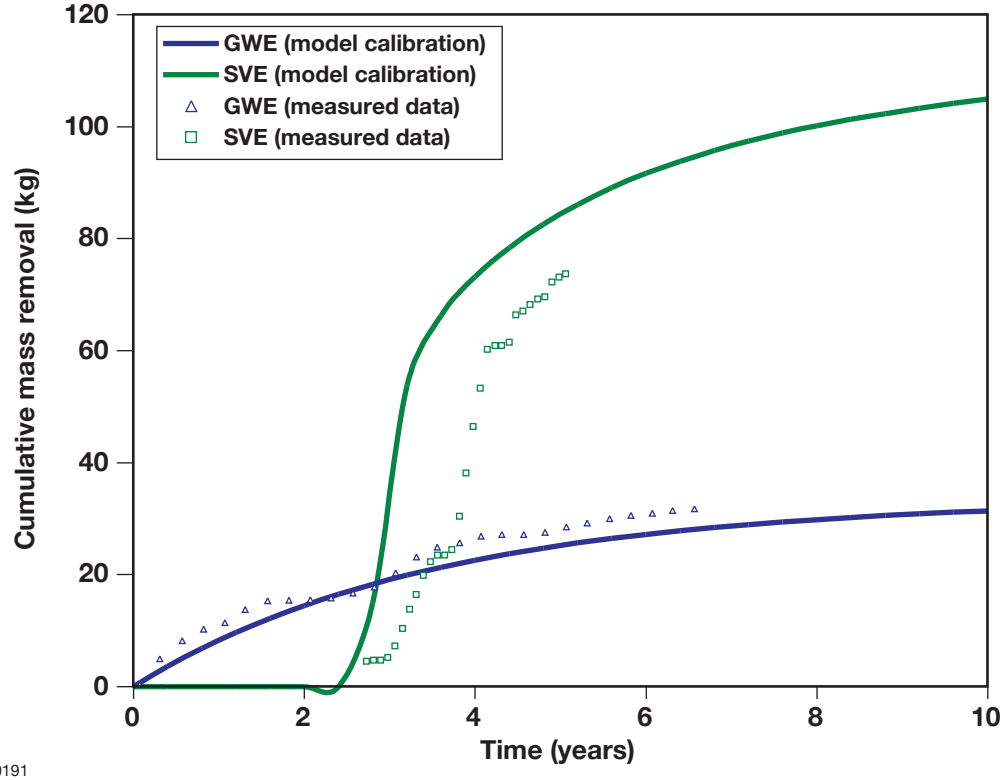

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Figure B-3.4. Example comparison of modeled and measured cumulative VOC mass removal derived from ground water extraction and soil vapor extraction operating histories, showing zone-partitioning-flux model calibration at Building 834 OU Core Area.

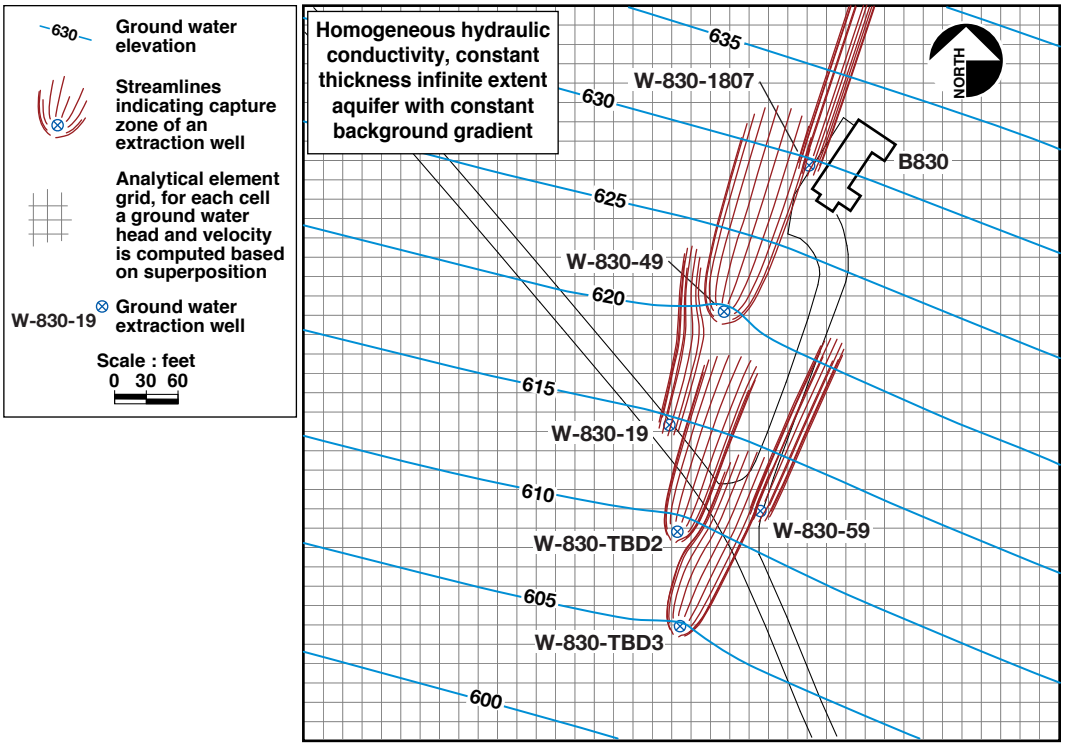

Figure B-3.5. Results from an example Winflow analytical element model with descriptions of model components (Example from Building 830 Source Area).

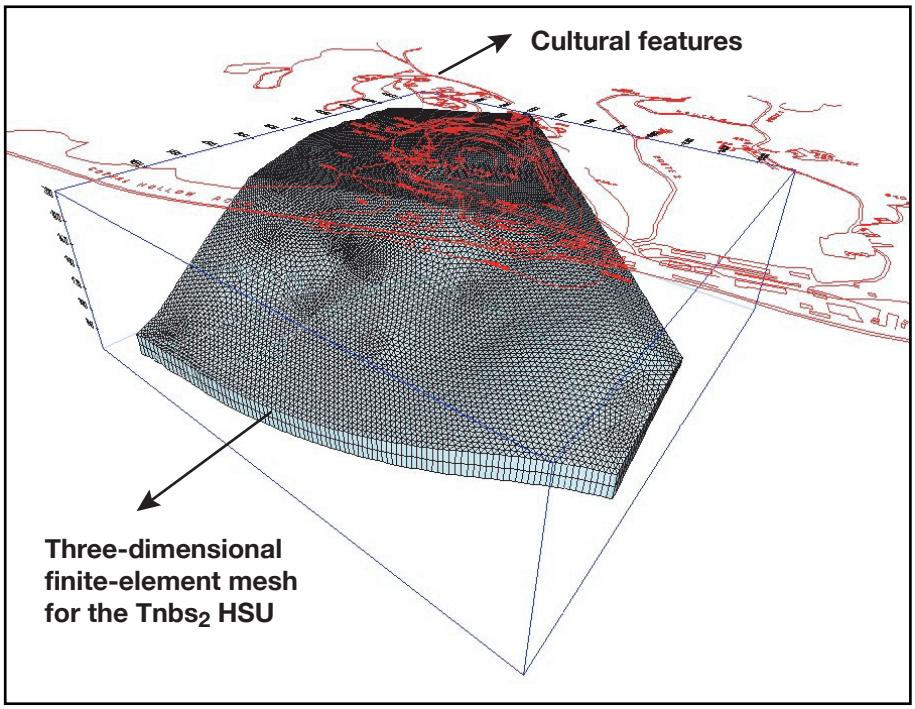

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Figure B-3.6. A three-dimensional FEFLOW finite-element model domain (Example from High Explosives Process Area).

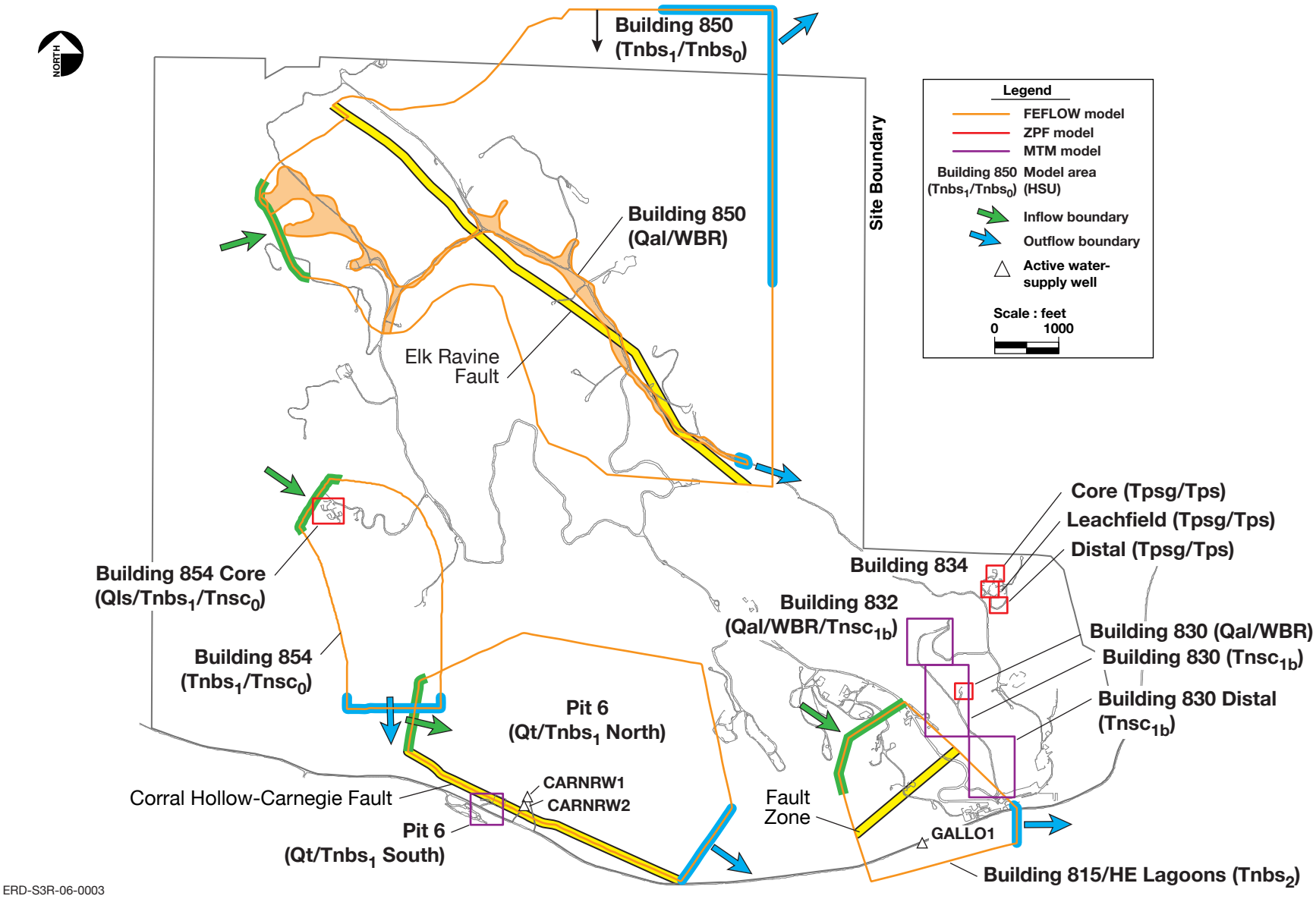


Figure B-4.1. Model domains, boundary locations and the selected modeling tool to estimate cleanup times for each OU.

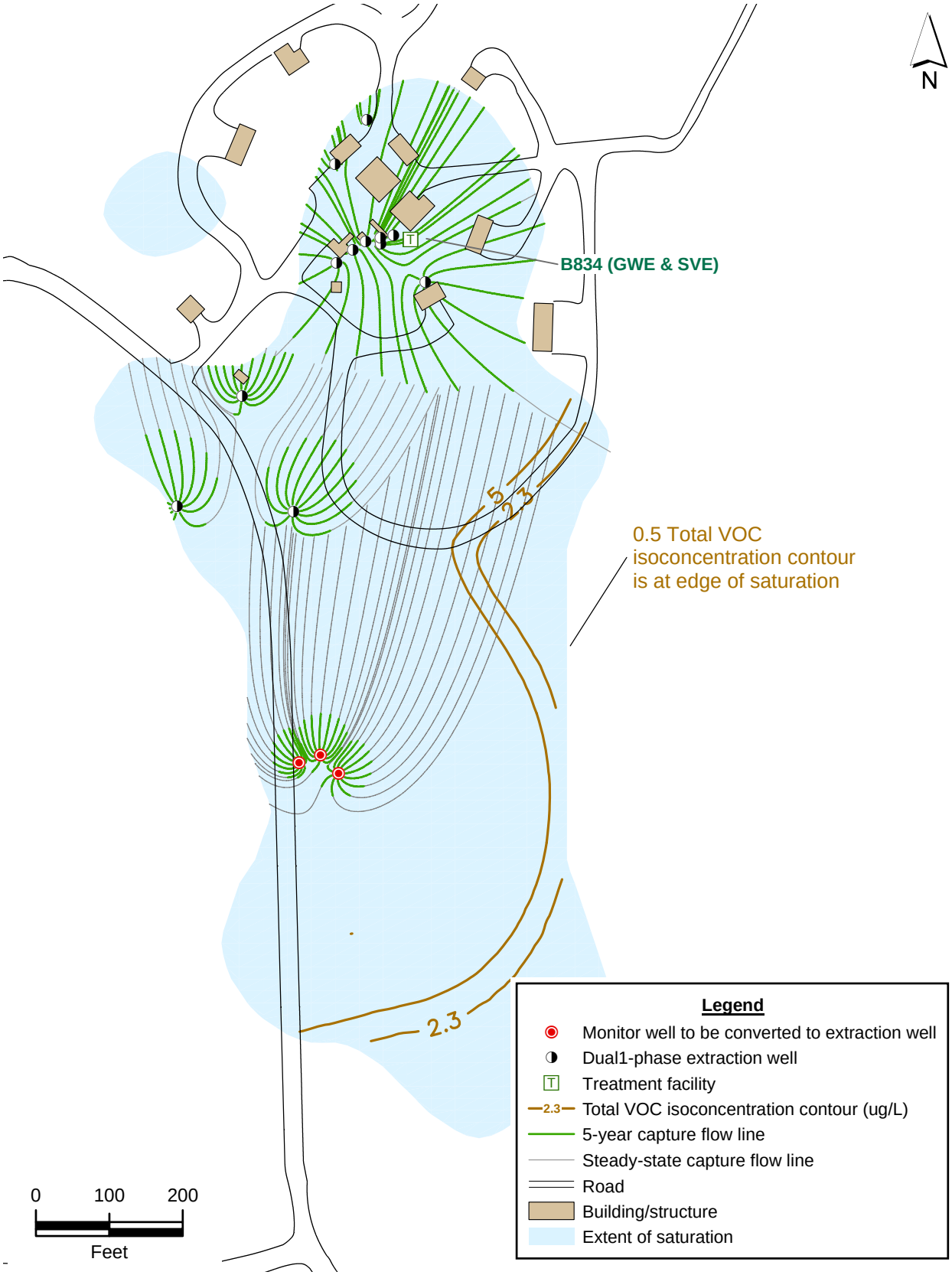


Figure B-4.2.1. Predicted groundwater capture zones based on existing and planned extraction wells at the Building 834 OU.

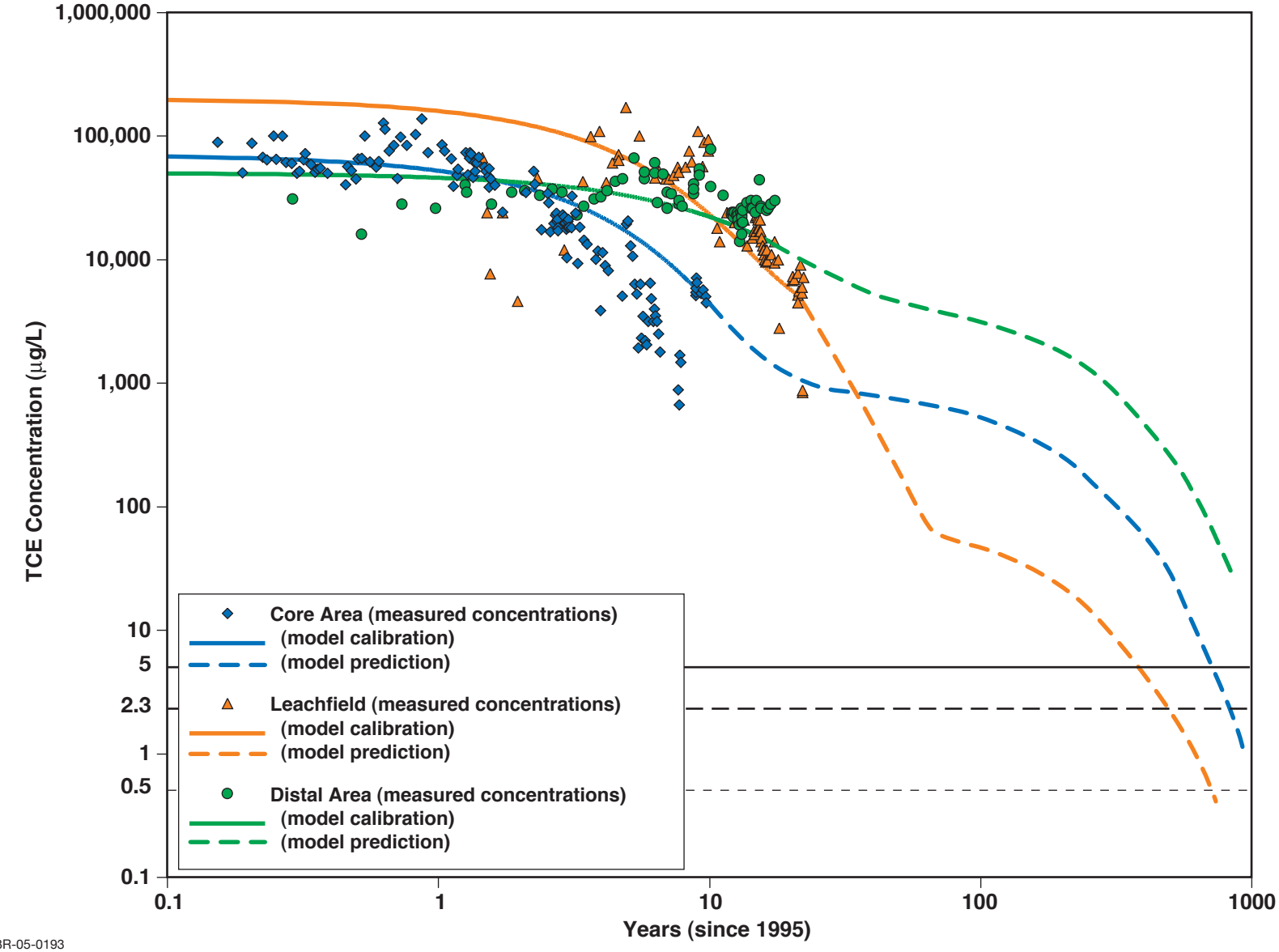
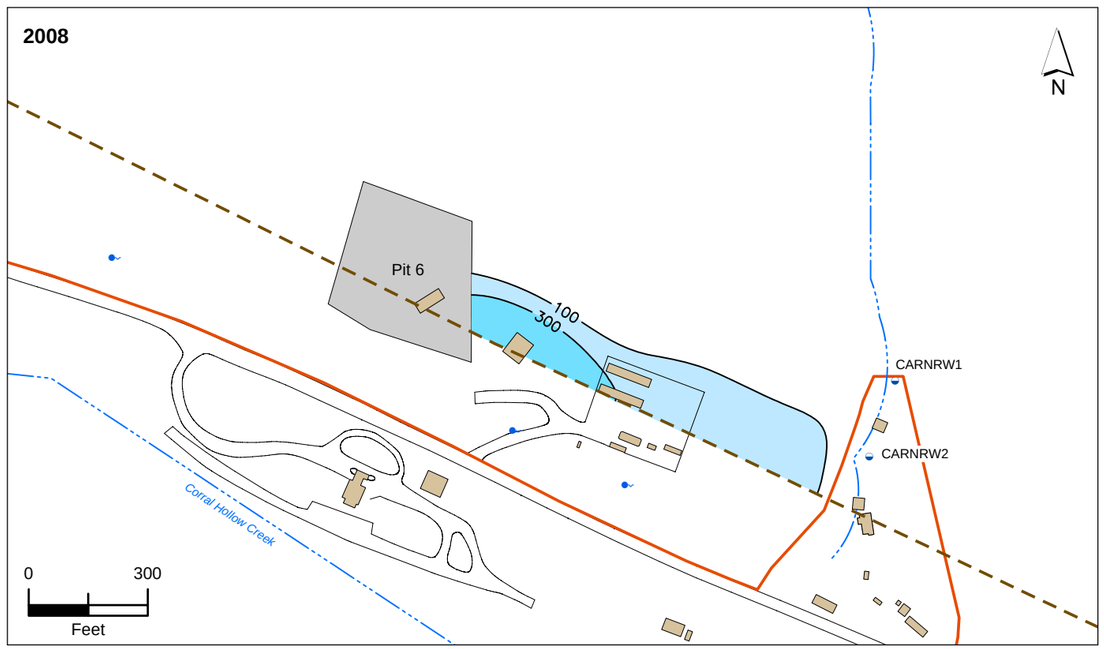
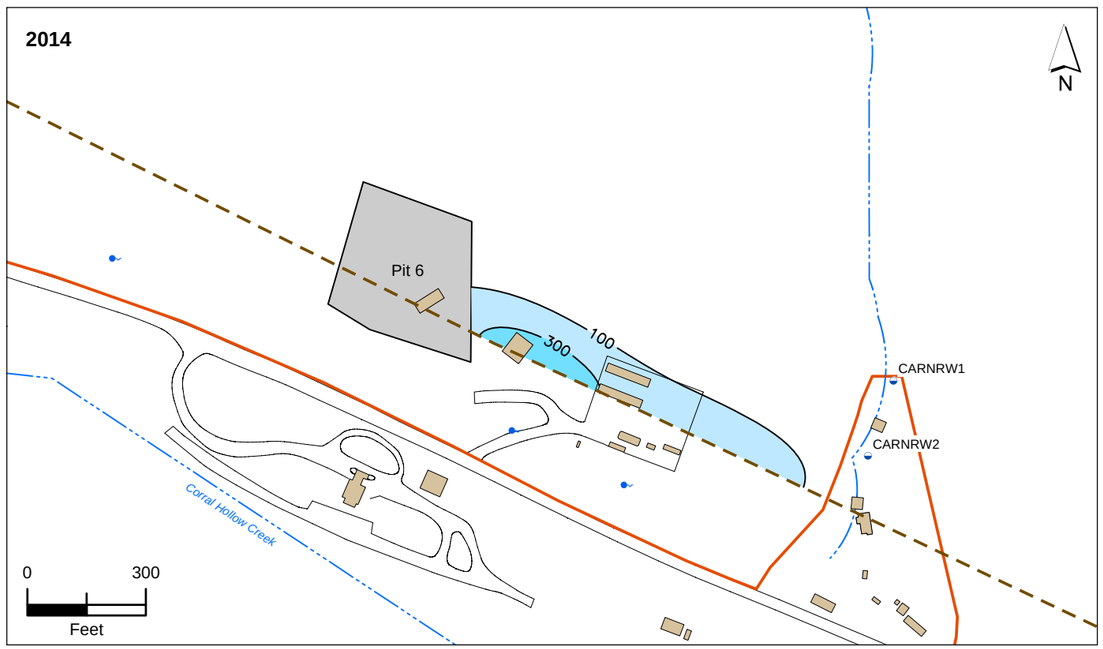
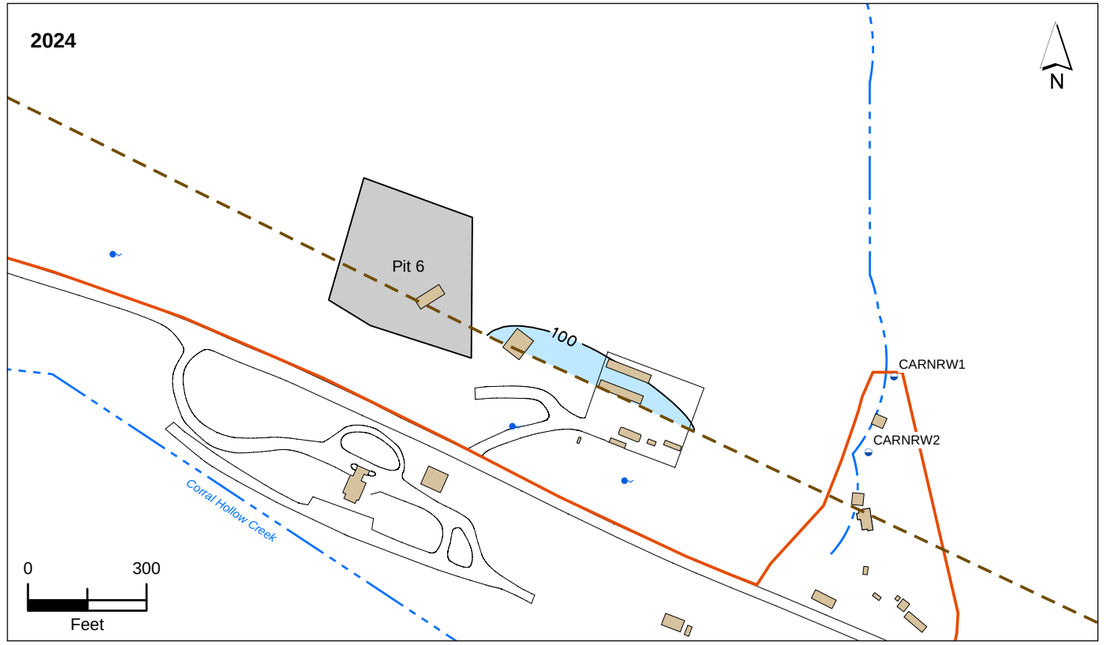


Figure B-4.2.2. Predicted maximum TCE concentration in ground water over time for the Core Area, Leachfield, and Distal Area at the Building 834 OU.







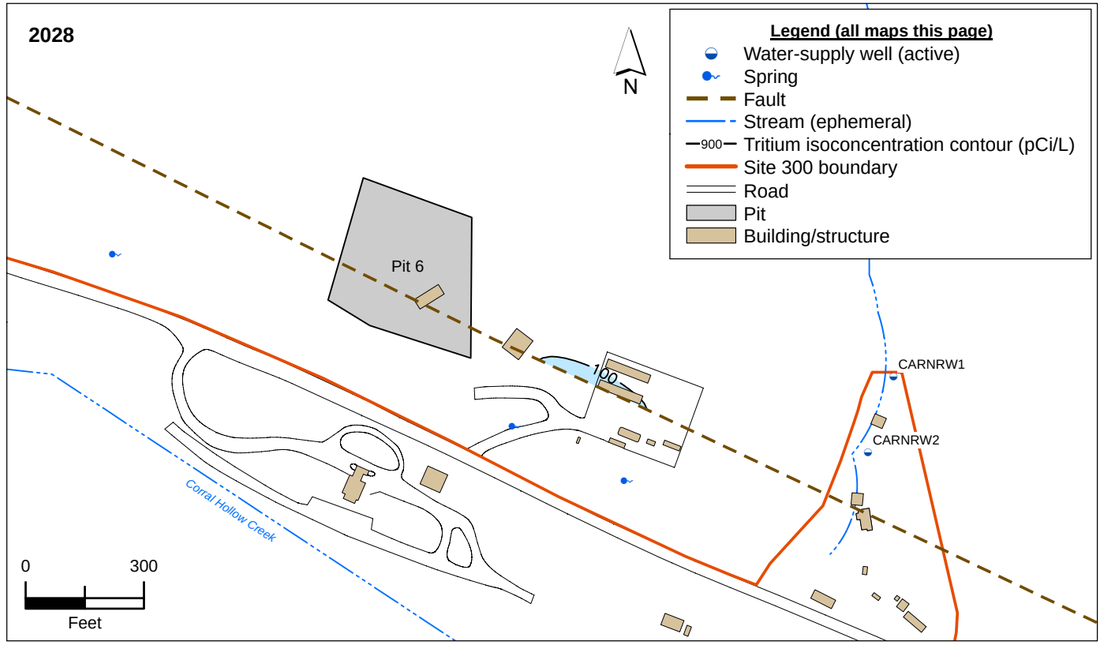


Figure B-4.3.1. Predicted distribution of the tritium activities in ground water over time north of the Corral Hollow-Carnegie Fault Zone at the Pit 6 Landfill OU.

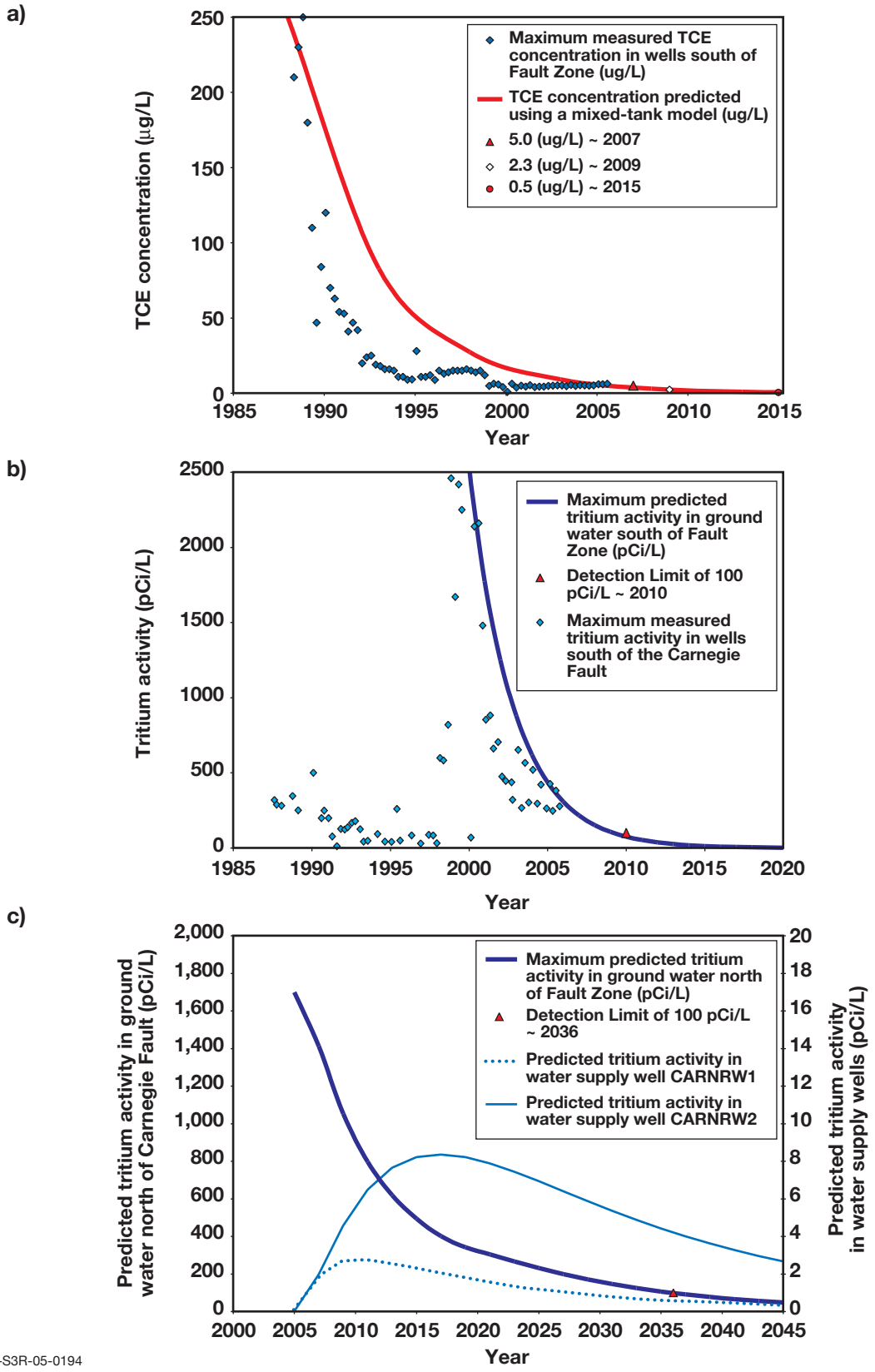


Figure B-4.3.2. Predicted maximum ground water activity/concentration over time for a) TCE, b) tritium south of Corral-Hollow-Carnegie Fault Zone , and c) tritium north of Corral-Hollow-Carnegie Fault Zone at the Pit 6 Landfill OU.

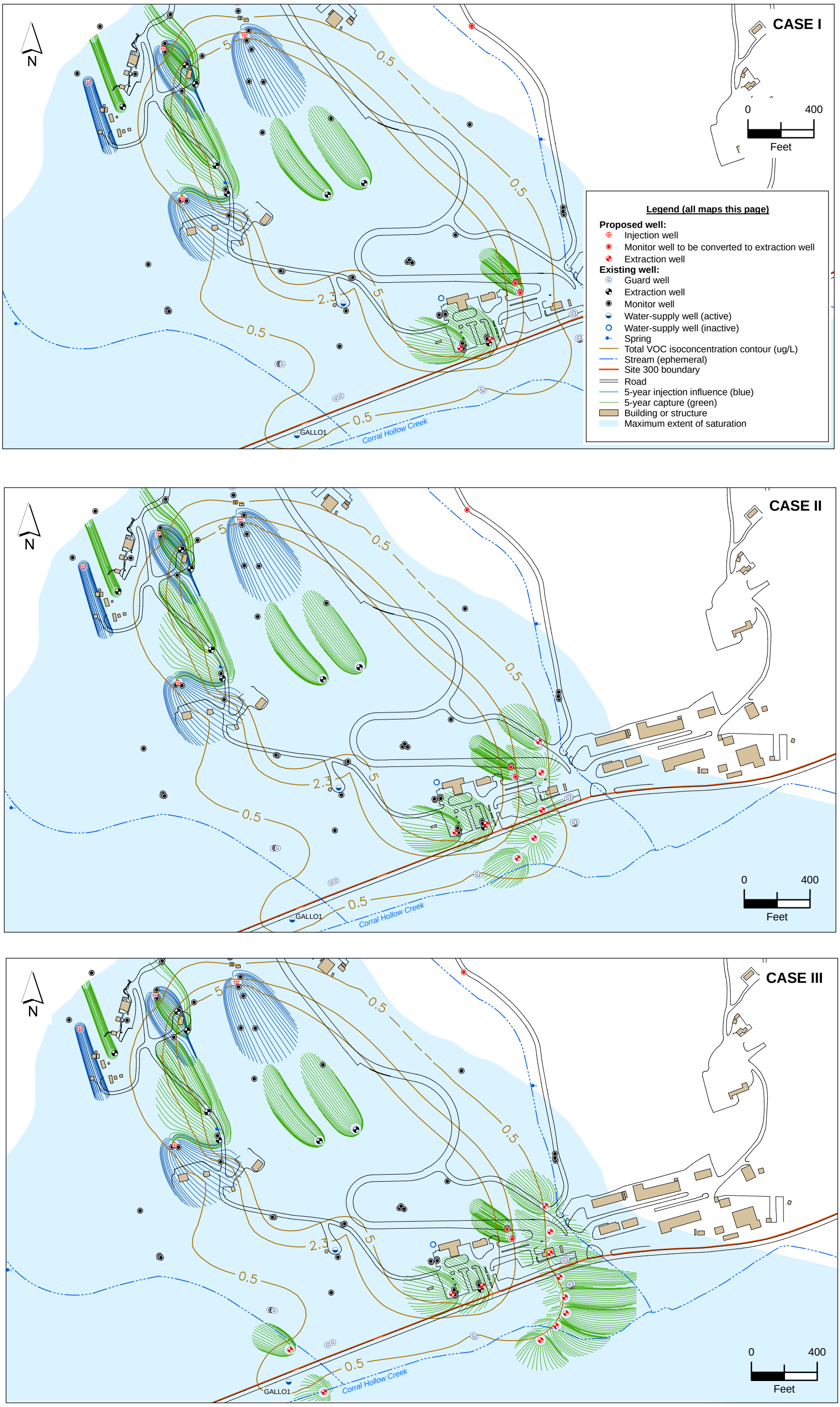


Figure B-4.4.1. Predicted ground water capture zones bases on modeling cases I, II, and III in the HE Process Area OU.

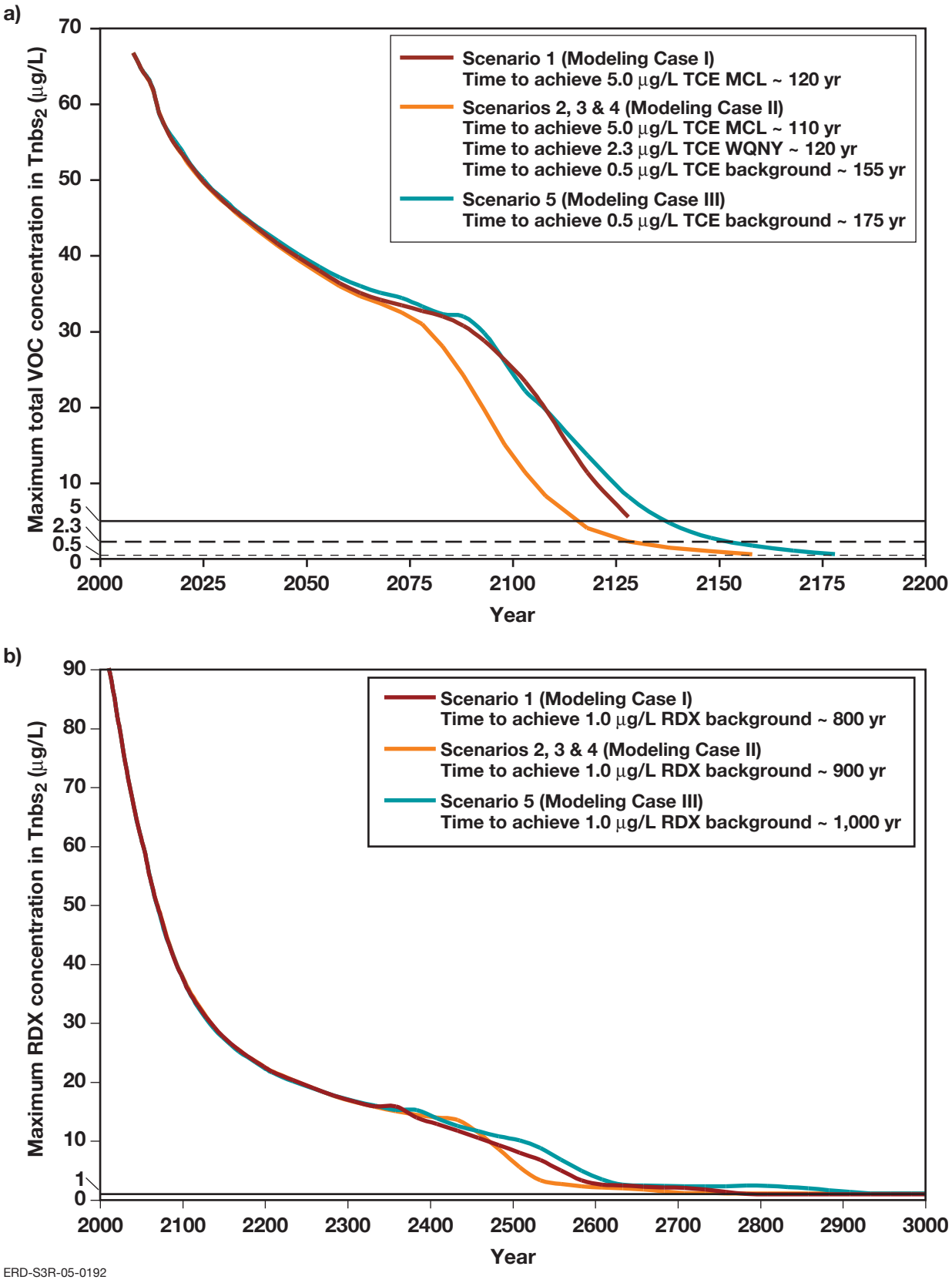
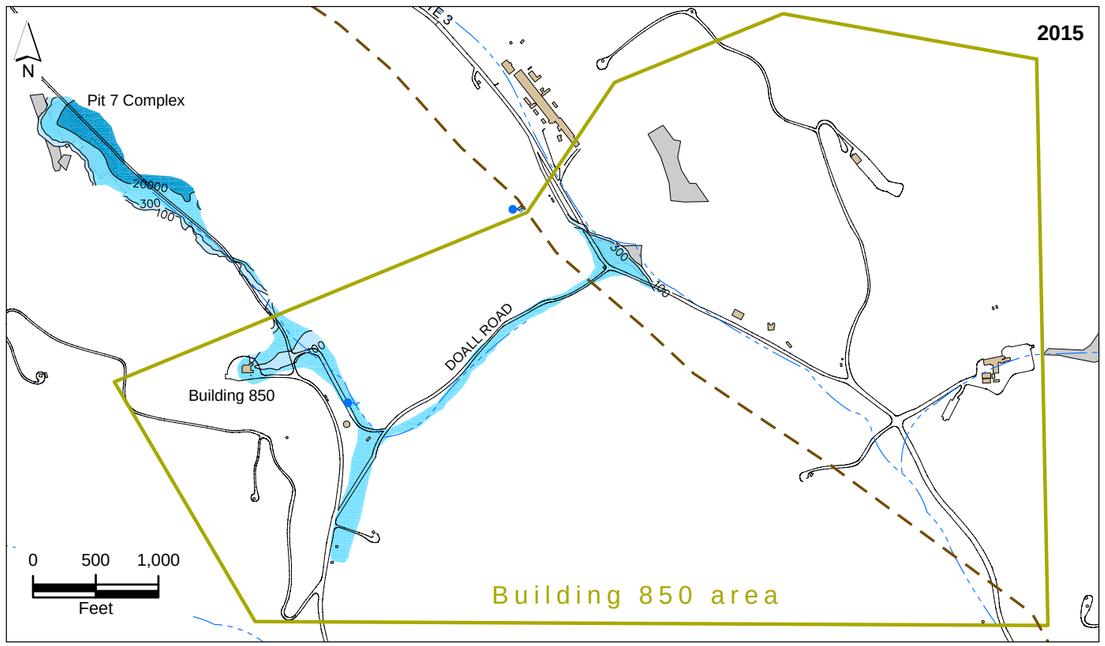
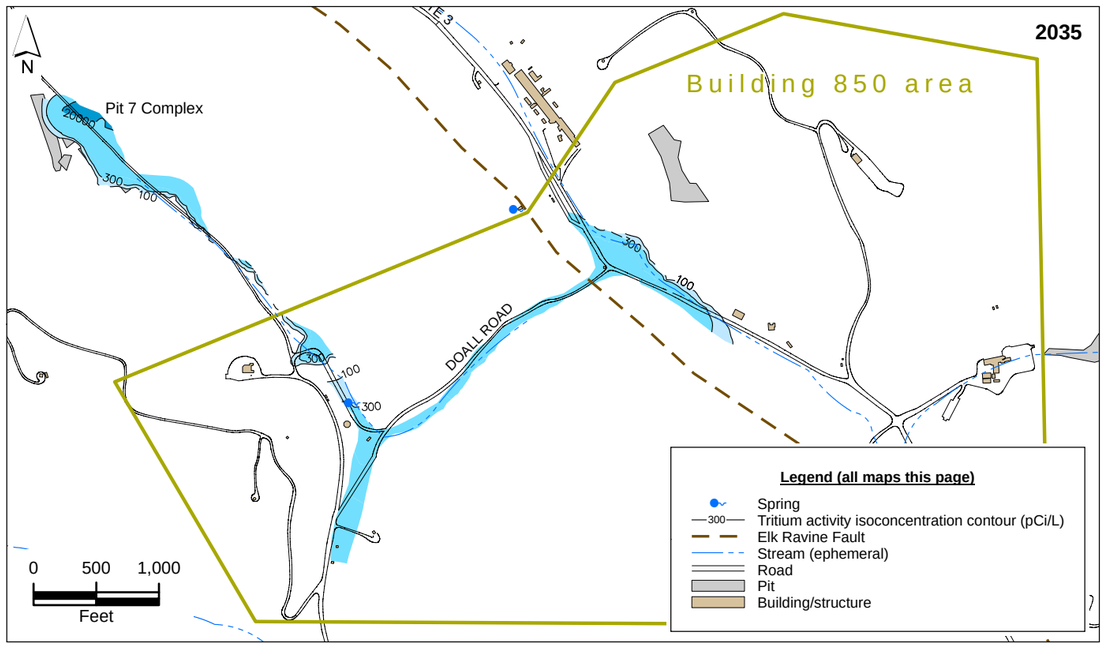
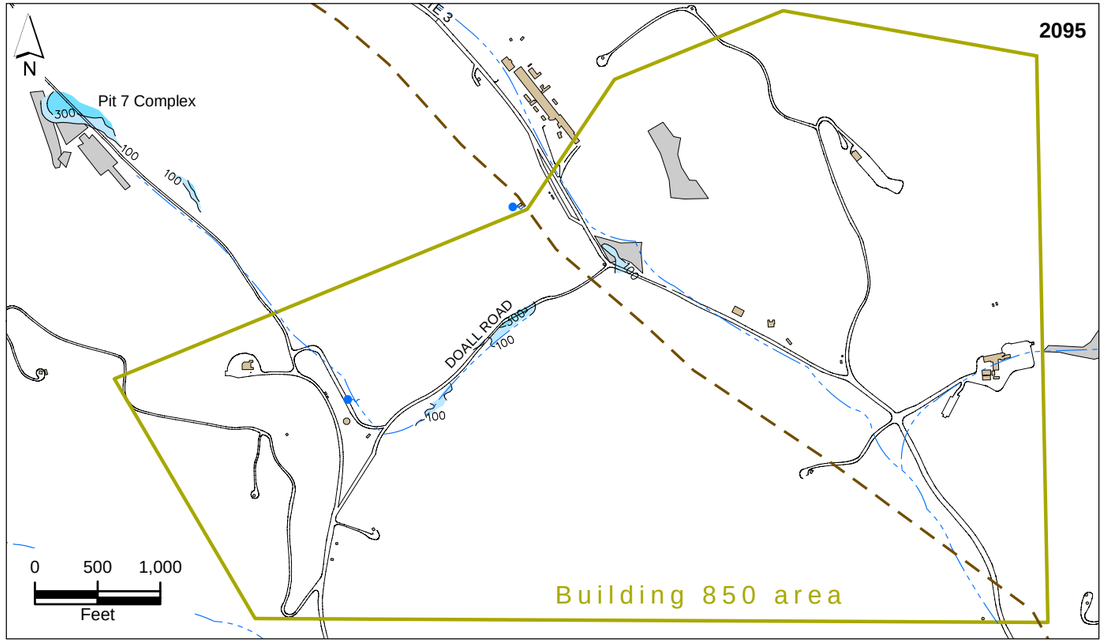


Figure B-4.4.2. Predicted maximum ground water concentration over time for a) TCE, and b) RDX at the HE Process Area.







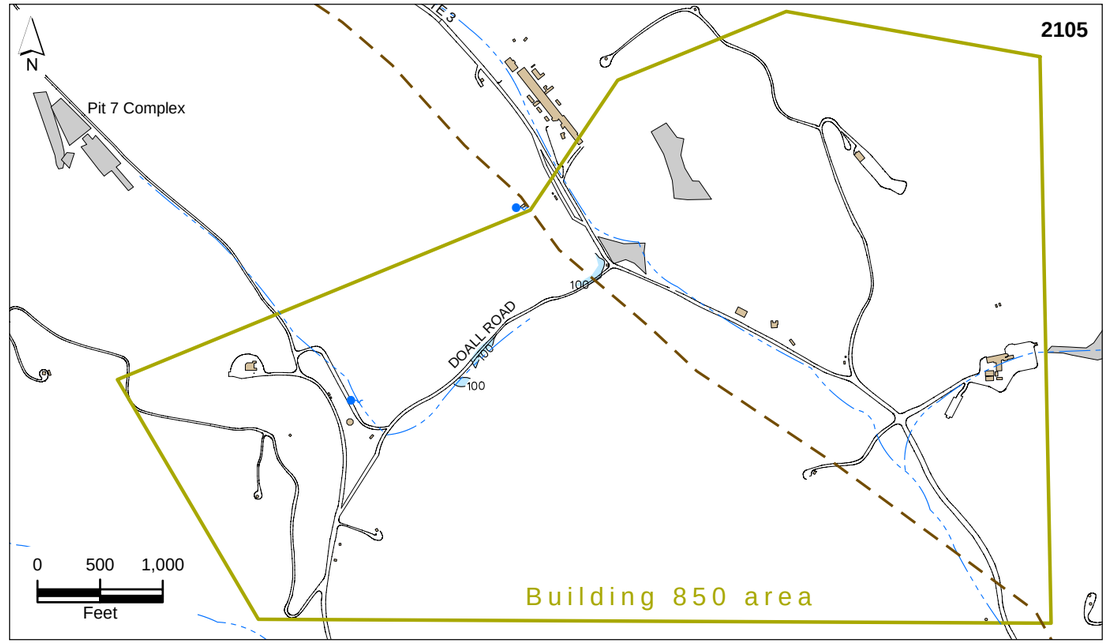
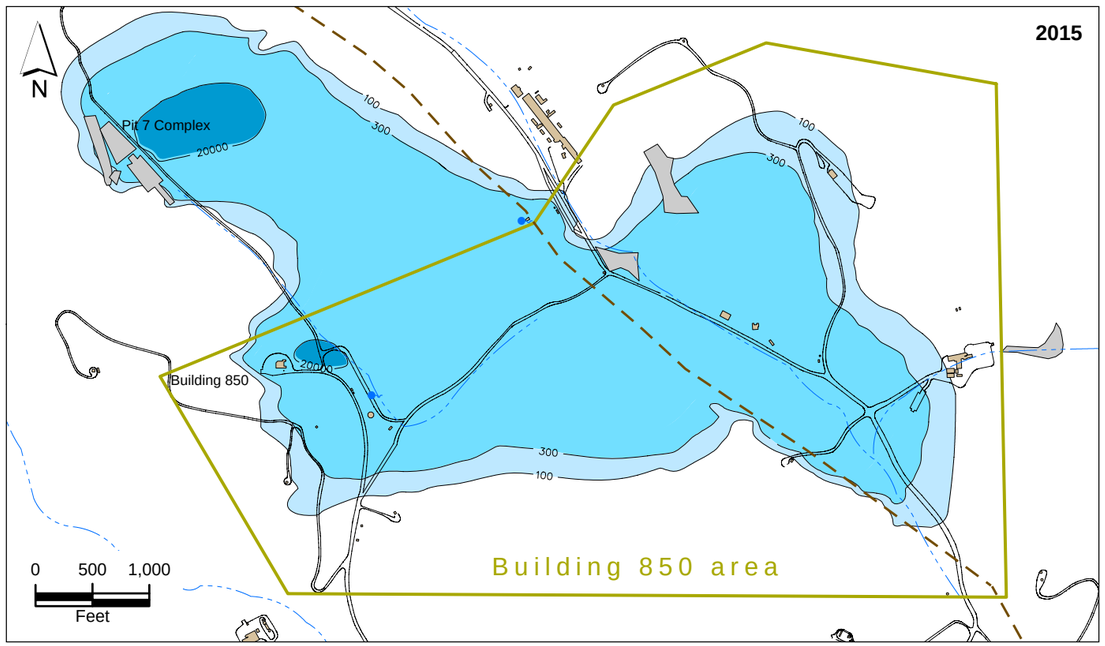
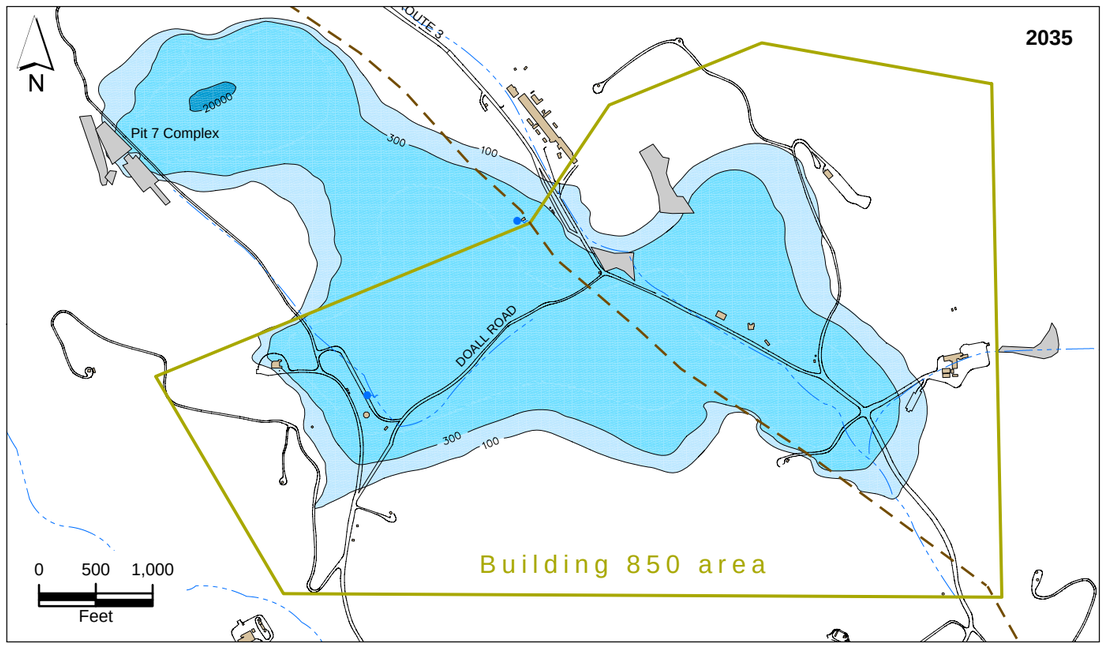
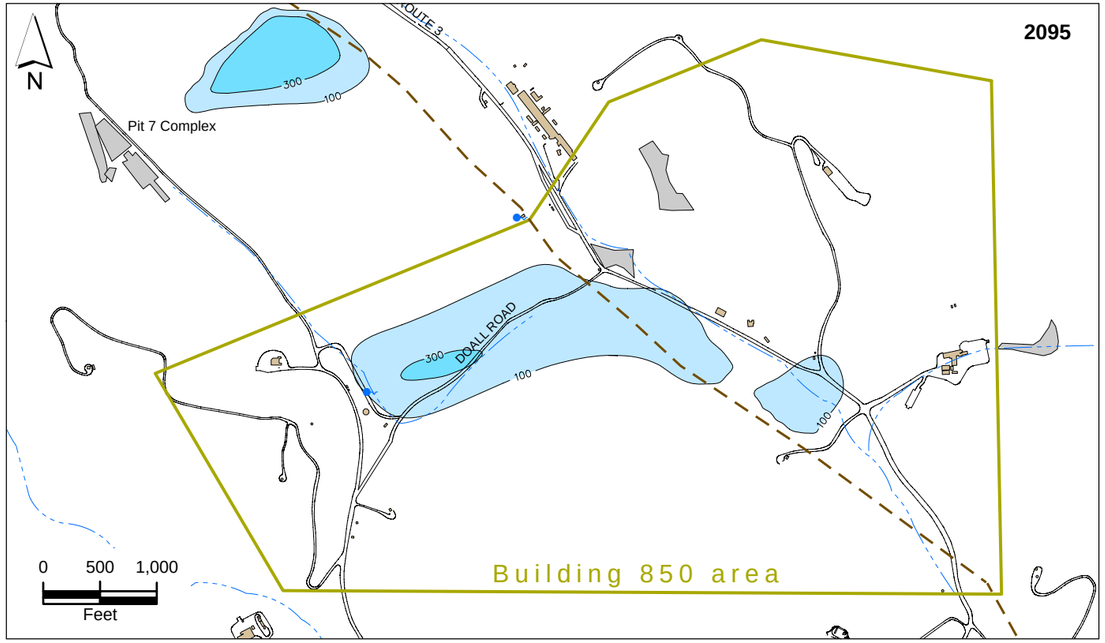


Figure B-4.5.1. Predicted distribution of the tritium activity in ground water over time in the Qal/WBR HSU at the Building 850 area.







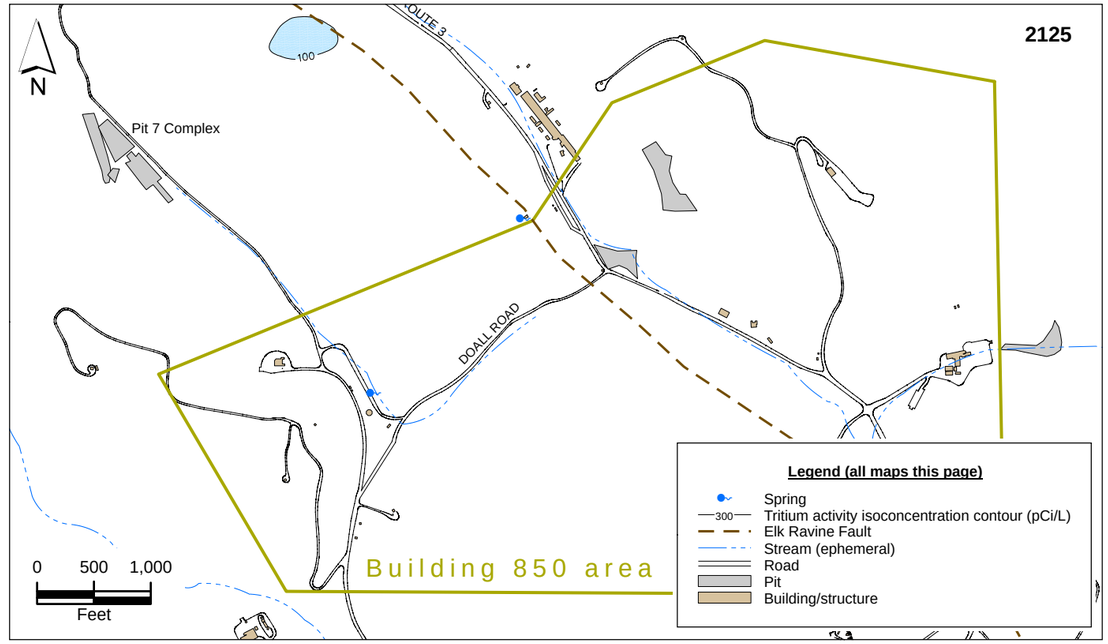


Figure B-4.5.2. Predicted distribution of the tritium activity in ground water over time in the $Tnbs_1/Tnbs_0$ HSU at the Building 850 area.

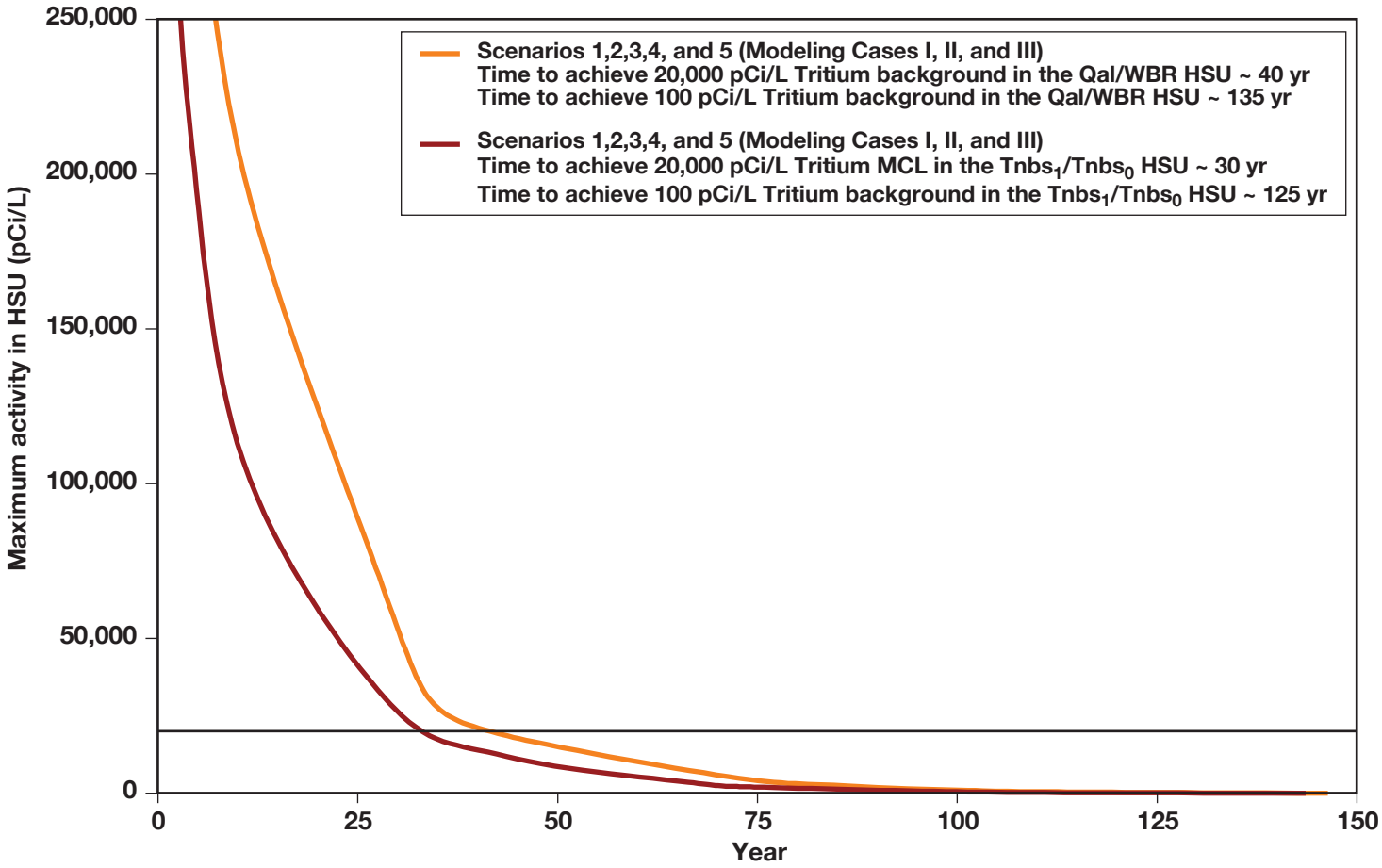


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Figure B-4.5.3. Predicted maximum ground water tritium activity over time at the Building 850 area.

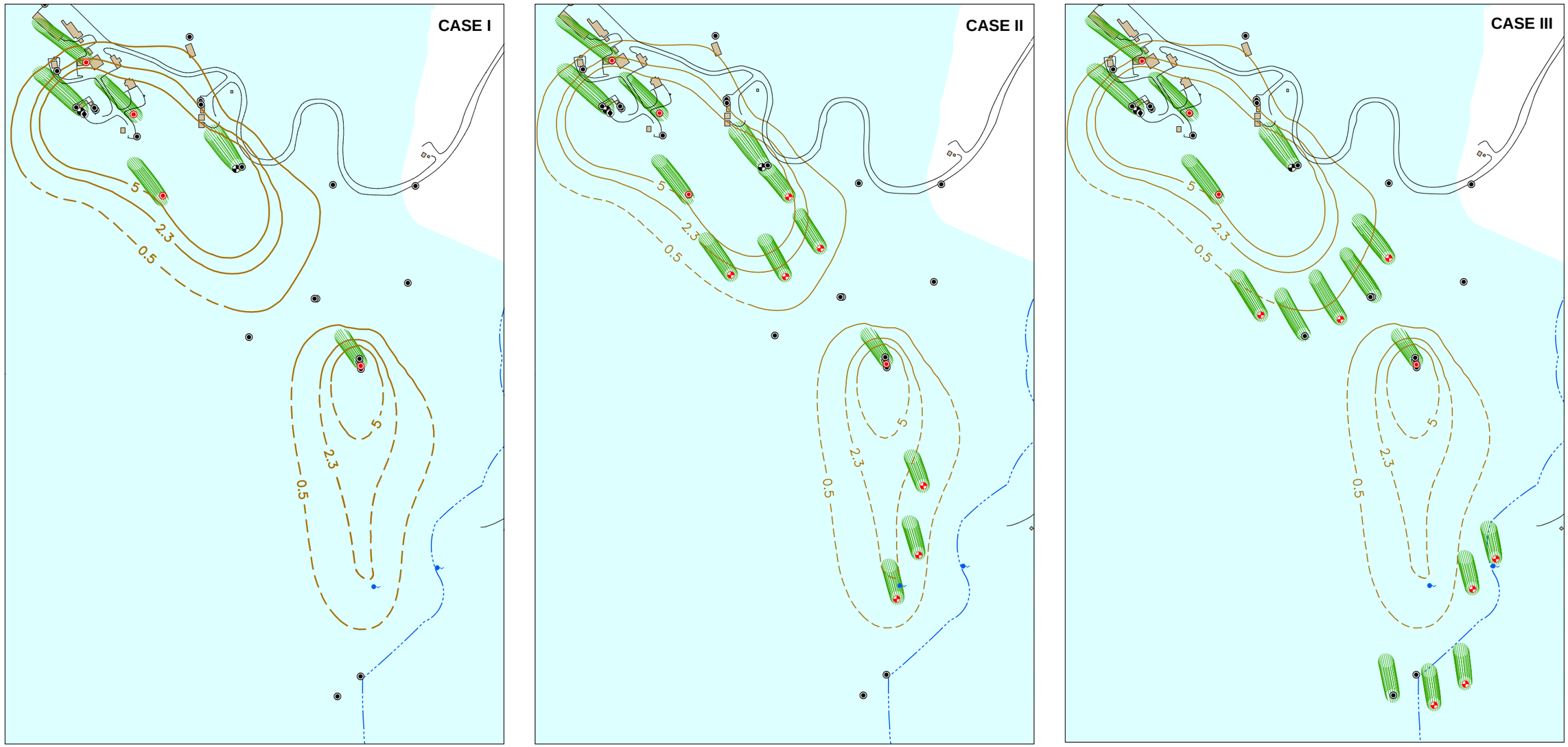

Figure B-4.6.1. Predicted ground water capture zones based on modeling cases I, II, and III at the Building 854 OU.

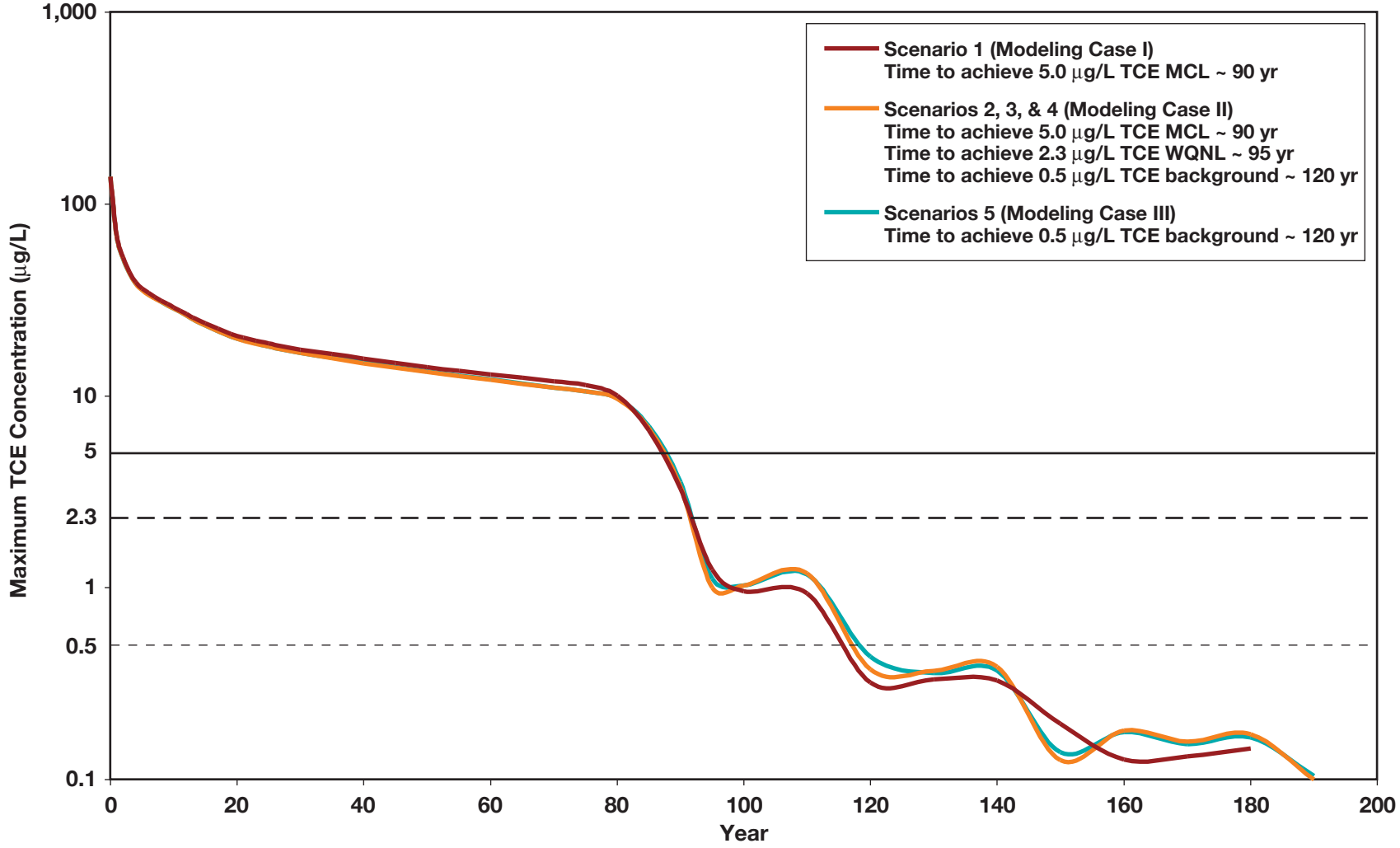

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Figure B-4.6.2. Predicted maximum TCE concentration in $Tnbs_1/Tnsc_0$ HSU ground water over time at the Building 854 OU.

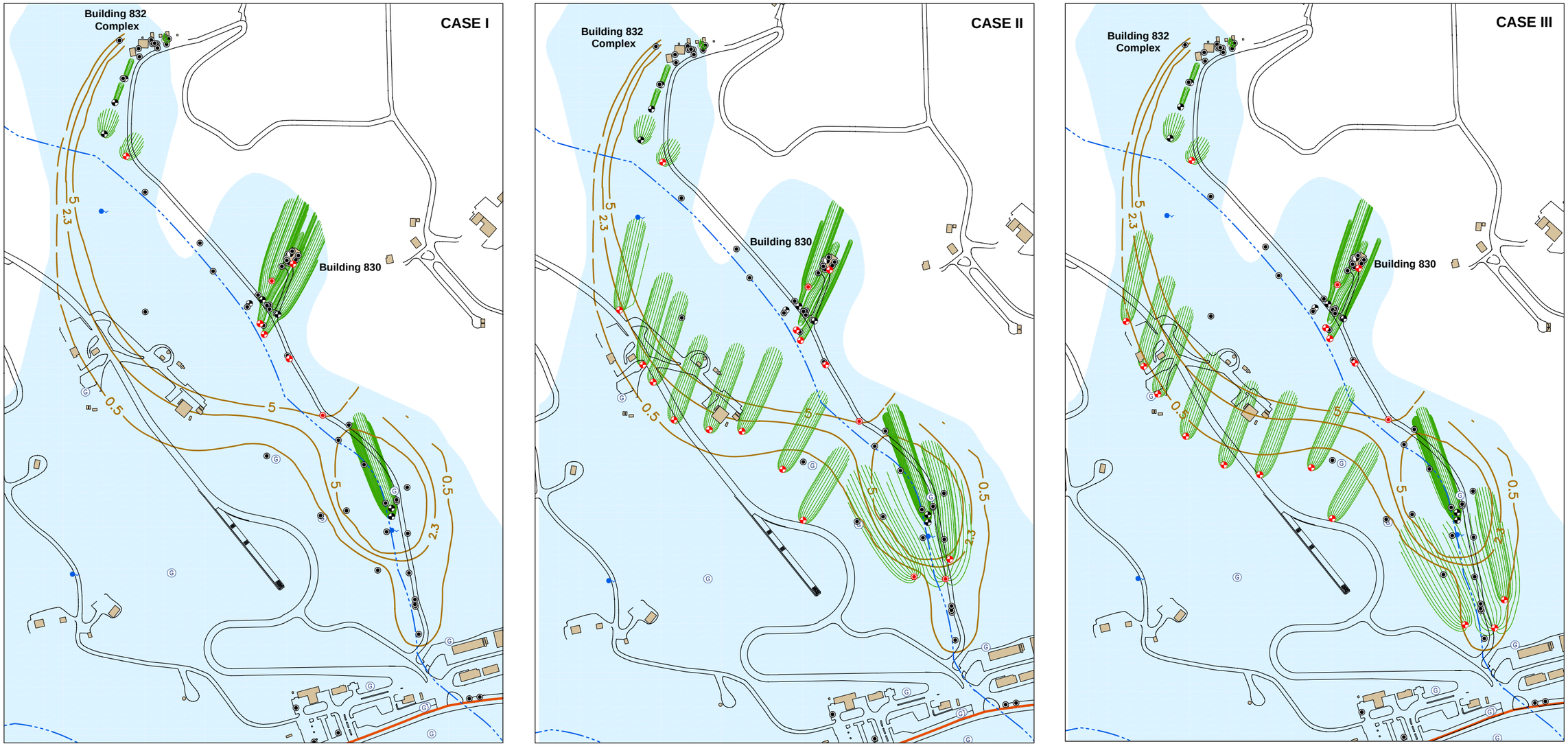

Figure B-4.7.1. Predicted ground water capture zones based on modeling cases I, II, and III at the Building 832 Canyon OU.

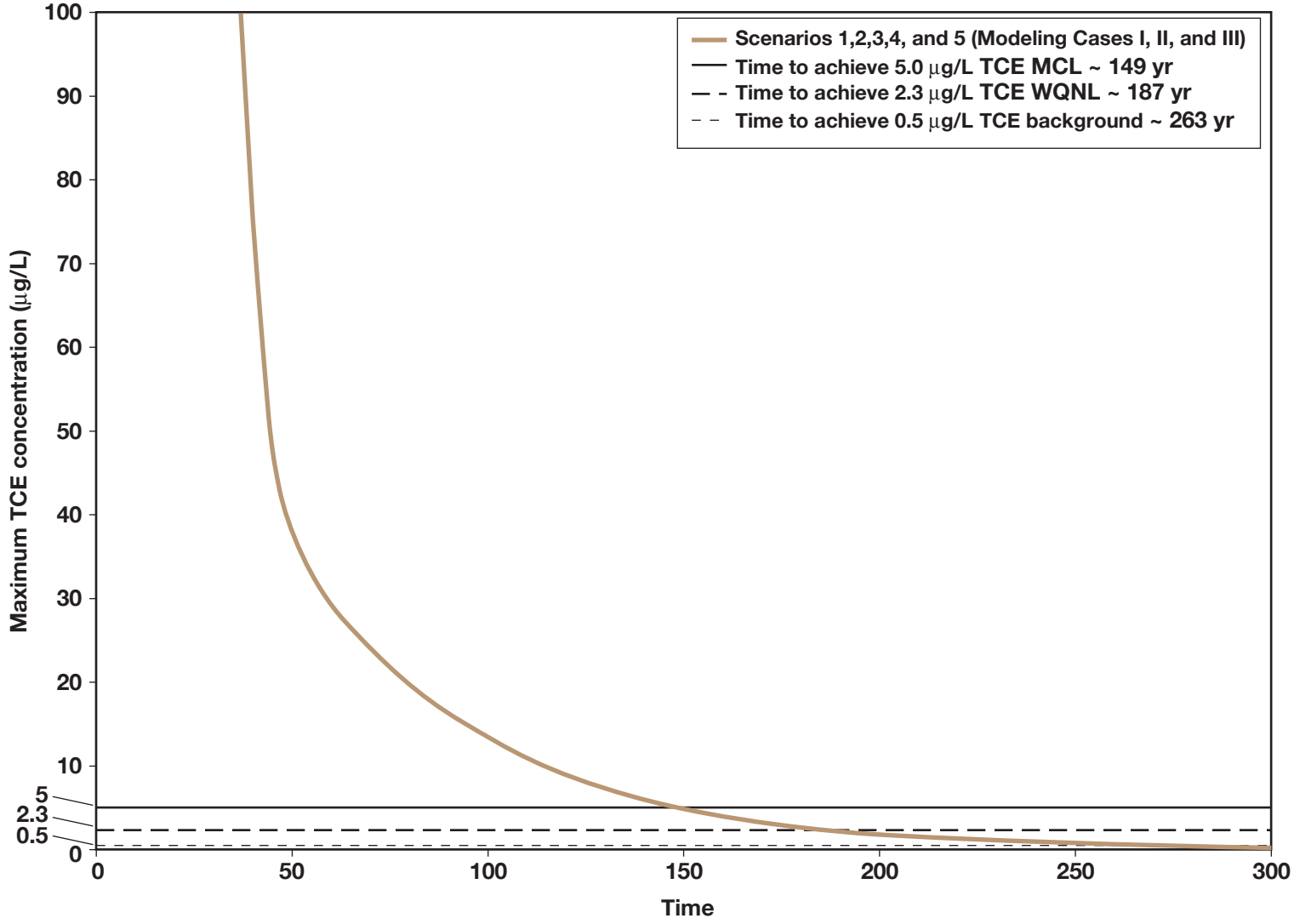

Figure B-4.7.2. Predicted maximum ground water concentration for TCE for the $Tnsc_{1b}$ HSU over time at the Building 832 Canyon OU.

Appendix B

Tables

Table B-2.1. Modeling tools used for operable units 2-7.

Operable unit (OU)	OU name	OU subarea	Hydrostratigraphic unit (HSU)	Modeling tool
OU1	General Services Area	Not included in the Site-Wide Remediation Evaluation Summary Report		
OU2	Building 834	Core	$Tpsg/Tps\text{-}Tnsc_2$	WinFlow & ZPF
		Leachfield	$Tpsg/Tps\text{-}Tnsc_2$	WinFlow & ZPF
		Distal (T2)	$Tpsg/Tps\text{-}Tnsc_2$	WinFlow & ZPF
OU3	Pit 6 Landfill	North of Carnegie-Corral Hollow Fault Zone	$Qt/Tnbs_1$ North	FEFLOW
		Within the Carnegie-Corral Hollow Fault Zone	$Qt/Tnbs_1$ South	MTM
OU4	High Explosives (HE) Process Area	Building 815/ HE Lagoons	$Tnbs_2$	FEFLOW
OU5	Building 850[a]/Pit 7 Complex	Building 850 Firing Table /Doall & Elk Ravine	Qal/WBR	FEFLOW
			$Tnbs_1/Tnbs_0$	FEFLOW
OU6	Building 854	Core	$Qls/Tnbs_1/Tnsc_0$	ZPF
		Core and Downgradient	$Tnbs_1/Tnsc_0$	FEFLOW
OU7	Building 832 Canyon	Building 832	$Qal/WBR/Tnsc_{1b}$	WinFlow & MTM
		Building 830	Qal/WBR	ZPF
		Building 830 Source	$Tnsc_{1b}$	WinFlow & MTM
		Building 830 Distal	$Tnsc_{1b}$	WinFlow & MTM
		Building 830	Upper $Tnbs_1$	WinFlow & MTM
OU8	OU8 sites	Not modeled in the Site-Wide Remediation Evaluation Summary Report		

Notes:

FEFLOW = Finite element FLOW system model.

HE = High explosives

HSU = Hydrostratigraphic unit.

MTM = Mixed-tank model

OU = Operable unit.

WinFlow = Two-dimensional analytic ground water capture model.

ZPF = Zone-partitioning-flux model.

[a] Only the Building 850 firing table portion of OU 5 was modeled.

Table B-4.1 Key model input parameters.

Operable Unit (OU)	Ground water flow parameters	Contaminant transport parameters
Building 834 (*OU 2*)	WinFlow Model (Tpsg/Tps-Tnsc$_2$ HSU core, leachfield, distal areas) Hydraulic conductivity (high): 0.05 to 0.8 ft/day Hydraulic gradient (ambient): 0.05 to 0.07 ft/ft Infiltration rate: 1 inch/year	Zone-Partitioning-Flux Model (Tpsg/Tps-Tnsc$_2$ HSU core, leachfield, distal areas) Porosity (high permeability sands): 0.3 Porosity (low permeability clays): 0.5 Vadose zone air permeability: 3.0E-07 cm^2 Saturation in the vadose zone: 0.5 to 0.95 Retardation coefficient for TCE: 1.5
Pit 6 Landfill (*OU 3*)	FEFLOW (Qt-Tnbs1 North) Hydraulic conductivity (low): 0.16 ft/day Hydraulic conductivity (high): 3.9 ft/day Infiltration rate: 1 in/year Steady state extraction flow rates for water supply wells: CARNRW1 flow rate: 6.4 gpm CARNRW2 flow rate: 8.3 gpm	FEFLOW (Qt-Tnbs$_1$ North) Porosity: 0.25 Longitudinal dispersivity: 102 ft Transverse dispersivity: 10.2 ft Decay constant for tritium: 1.8E-09 sec^{-1} Mixed-Tank Model (MTM) (Qt-Tnbs$_1$ South HSU) Porosity: 0.25 Decay constant for tritium: 1.8E-09 sec^{-1} Retardation coefficient for TCE: 1.5
HE Process Area (*OU 4*)	FEFLOW Model (Tnbs$_2$ HSU) Hydraulic conductivity: 0.68 ft/day Hydraulic conductivity (fault zone): 0.31 ft/day Infiltration rate to the unconfined area of Tnbs$_2$ HSU: 1.7 in/year (includes recharge from catchment basin) Steady state extraction flow rate for water supply well: GALLO1 flow rate: 1.0 gpm	FEFLOW Model (Tnbs$_2$ HSU) Porosity: 0.32 Longitudinal dispersivity: 33 ft Transverse dispersivity: 3.3 ft Retardation coefficient for TCE: 1.0 Retardation coefficient for RDX: 2.65

Table B-4.1. Key model input parameters. (Cont. Page 2 of 3)

Operable Unit (OU)	Ground water flow parameters	Contaminant transport parameters
Building 850 (*OU 5)*	**FEFLOW Model (Qal/WBR HSU)** Hydraulic conductivity: 1.4 ft/day Hydraulic conductivity (fault zone): 0.31 ft/day Infiltration rate: 1.5 in/year **FEFLOW Model ($Tnbs_1$/$Tnbs_0$ HSU)** Hydraulic conductivity: 0.14 ft/day Hydraulic conductivity of the Elk Ravine fault zone: 0.07 ft/day	**FEFLOW Model (Qal/WBR HSU)** Porosity: 0.3 Longitudinal dispersivity: 15 ft Transverse dispersivity: 1.5 ft Decay constant for tritium: 1.8E-09 sec^{-1} **FEFLOW Model ($Tnbs_1$/$Tnbs_0$ HSU)** Porosity: 0.3 Longitudinal dispersivity: 15 ft Transverse dispersivity: 1.5 ft Decay constant for tritium: 1.8E-09 sec^{-1}
Building 854 (*OU 6)*	**FEFLOW (Tnbs1/$Tnsc_0$ HSU)** Hydraulic conductivity: 0.85, 0.37, and 0.45 ft/day Infiltration rate to the unconfined area of $Tnbs_1$/$Tncs_0$ HSU: 1.25 in/year **ZPF Model (Qls/Tnbs1/$Tnsc_0$ HSU)** Hydraulic conductivity: 5.0 ft/day	**FEFLOW (Tnbs1/$Tnsc_0$ HSU)** Porosity: 0.3 Longitudinal dispersivity: 30 ft Transverse dispersivity: 3.0 ft Retardation coefficient for TCE: 1.0 **ZPF Model (Qls/Tnbs1/$Tnsc_0$ HSU)** Porosity (high permeability sands): 0.3 Porosity (low permeability clays): 0.5 Vadose zone air permeability: 3.0E-07 cm^2 Saturation in the vadose zone: 0.5 to 0.95 Retardation coefficient for TCE: 1.5

Table B-4.1. Key model input parameters (Cont. Page 3 of 3)

Operable Unit (OU)	Ground water flow parameters	Contaminant transport parameters
Building 832 Canyon *(OU 7)*	**WinFlow Models (Qal/WBR & $Tnsc_{1b}$ HSUs)** **Hydraulic conductivity: 0.1 to 1 ft/day** **Hydraulic gradient (ambient): 0.05 to 0.06 ft/ft** **WinFlow Model (Upper $Tnbs_1$ HSU)** **Hydraulic conductivity: 1 ft/day** **Hydraulic gradient (ambient): 0.05 to 0.06 ft/ft**	**MTM ($Tnsc_{1b}$ HSU and Upper $Tnbs_1$ HSU)** **Porosity: 0.25** **Retardation coefficient for TCE: 1.5** **ZPF Model (Qal/WBR)** **Porosity (high permeability sands): 0.3** **Porosity (low permeability clays): 0.5** **Vadose zone air permeability: 3.0E-07 cm^2** **Saturation in the vadose zone: 0.5 to 0.95** **Retardation coefficient for TCE: 1.5**

Notes:

cm^2 = Square centimeters
ft = Feet.
ft/day = Feet per day.
gpm = Gallons per minute.
HE = High explosives.
HSU = Hydrostratigraphic unit.
in/yr = Inches per year.
MTM = Mixed-tank model.
OU = Operable unit.
RDX = Research department explosive.
sec = Seconds.
TCE = Trichloroethylene.
VOCs = Volatile organic compound.
WBR = Weathered bedrock.
ZPF= Zone-partitioning-flux model.

Table B-4.2. Estimated cleanup times based on modeling results.

Operable Unit (OU)	OU Name	Scenario 1 (Model Case I) (years)	Scenario 2 (Model Case II (years)	Scenario 3 (Model Case II (years)	Scenario 4 (Model Case II (years)	Scenario 5 (Model Case III (years)
OU2	Building 834	400	400	510	730	730
OU3	Pit 6 Landfill	NA	NA	NA	35	35
OU4	High Explosives Process Area	120	110	120	155	175
OU5	Building 850[a]/ Pit 7 Complex	40	40	NA	135	135
OU6	Building 854	90	90	95	120	120
OU7	Building 832 Canyon	149	149	187	263	263

Notes:

NA = Not applicable.

[a] Only the Building 850 firing table portion of OU 5 was modeled.

Appendix C

Cost Estimates and Assumptions for Ground Water Cleanup Standard Scenarios

Appendix C

Cost Estimates and Assumptions for Ground Water Cleanup Standard Scenarios

C-1. Introduction

Cost estimates were prepared for the ground water cleanup scenarios for operable units (OUs) 2 through 8 as part of the evaluation to determine the economic feasibility of achieving various potential ground water cleanup standards. This appendix presents the cost estimates and assumptions for these cleanup scenarios. The assumptions are based on the conceptual remedial designs presented in Appendix B.

The cost estimates may be subject to:

- Variations in specific assumptions, such as design implementation, construction, effectiveness, and system life.
- Changes in dollar value at the time of construction.
- Changes in available equipment and technology at the time of construction.
- Changes in applicable Lawrence Livermore National Laboratory (LLNL) taxes such as General and Administrative taxes (G&A), Lab-Directed Research and Development tax (LDRD), and applicable LLNL charges such a Material Procurement Charge (MPC).
- Uncertainties associated with the hydrogeologic characteristics, subsurface heterogeneities, estimated contaminant mass and volume, and estimated life-cycle of remediation.
- Estimated cost accuracy of -30% to +50%.

Cost estimates are intended for evaluation of the relative cost of ground water remediation to meet various potential ground water cleanup standards. Because detailed design is beyond the scope of this document, costs presented here should not be used for budgetary purposes.

LLNL environmental restoration project funding occurs incrementally (i.e., annually) as the project proceeds rather than as a lump sum investment at the beginning of the project. Therefore, the cost estimates are presented as a total cost with no discount rate and no inflation.

C-2. Assumptions Used for Development of Cleanup Scenario Cost Estimates

This section discusses the assumptions that were used to develop capital costs for remedial action construction and costs for long-term operation and maintenance of the remedial action for each the ground water cleanup standard scenarios for OUs 2 through 7. Assumptions about these costs are presented in the same order as costs are presented in Tables C-1 through C-22.

C-2.1. Capital Cost Assumptions and Design Considerations

The following general assumptions apply to the estimation of capital costs for remedial action construction for the cleanup scenarios:

- The capital costs for the construction of existing treatment systems and extraction and monitor wellfields are not included for Scenario 1 (ground water extraction with partial hydraulic capture to reduce contaminant concentrations in ground water to MCLs). This is because these costs have already been incurred as part of the buildout of the selected interim remedies for OUs 2 through 8.
- Existing remediation systems constructed as part of the buildout of the selected OU interim remedies are included in the remedial designs for Scenarios 2 through 5, but the capital costs are not included in the cost estimates for these scenarios because these costs have already been incurred.
- The estimates of capital costs for Scenarios 2 through 5 are for additional treatment facilities and expansions of the existing extraction wellfields to accomplish hydraulic capture and cleanup goals for each of these scenarios.
- Vendor/contractor quotes, vendor catalog prices, and/or LLNL actual costs for construction of similar remediation systems were used to develop the costs for major construction work and the purchase of equipment.
- Full-time LLNL employees (FTEs) are included as required to cover design and fabrication of treatment facilities; site preparation and construction, extraction and monitor wellfield drilling, installation, and pipelines; startup sampling and testing; and any additional reporting. The FTE rate is based upon LLNL fiscal year 2005 resource estimates and includes all applicable LLNL taxes (G&A, LDRD, etc.).
- Drilling cuttings produced from ground water monitor and extraction well installation are assumed to be clean or contain low volatile organic compound (VOC) concentrations that can be disposed of on site.

The capital cost assumptions and design considerations used to estimate costs for treatment facility design and fabrication, treatment facility construction, extraction wellfield drilling and installation, pipeline design and construction, and compliance monitoring wellfield drilling and construction are discussed in Sections C-2.1.1 through C-2.1.5.

C-2.1.1. Treatment Facility Design and Fabrication

The cost to design and fabricate a treatment facility is estimated to be $76,760 for a ground water treatment unit (GTU). The cost was based on the actual cost to fabricate a GTU in fiscal year 2004. This estimate includes labor and materials for:

- Facility design (i.e., design of the treatment unit pad; influent and effluent piping; electrical power distribution and hookup to the treatment facility and extraction well pumps; and obtaining required Space and Site Planning documentation for facility siting).
- Facility fabrication (i.e., assembly of the ground water treatment units, associated valves, piping, and flow meters; control and data collection systems; the influent and effluent piping; and initial granular activated carbon (GAC) and ion-exchange resin canisters.

Assumptions for this activity include:

- Because the interim remedies for the Pit 6 Landfill and Building 850 OUs did not included active remediation, treatment facility design and fabrication costs were not included in the cost estimates prepared for these OUs.
- All new treatment facilities are ground water treatment units (GTUs).
- Each new treatment facility will have approximately 15.4 cubic feet of GAC and 7.2 cubic feet of ion-exchange resin.

C-2.1.2. Treatment Facility Site Preparation and Construction

The cost estimate to perform all activities needed to prepare the site for installation and activation of a treatment facility is estimated to be $100,000. The cost was based on the actual cost for this activity in fiscal year 2004. This estimate includes labor and materials for:

- Site preparation (i.e., grading; installing a concrete pad, trenching; and installing a fence around the treatment facility if required by Space and Site Planning).
- Treatment facility installation (i.e., electrical power hookup to the treatment facility; control system installation; and constructing and installing the effluent discharge pipeline and discharge system).

Assumptions for this activity include:

- Because the interim remedies for the Pit 6 Landfill and Building 850 OUs did not included active remediation, treatment facility site preparation and construction costs were not included in the cost estimates prepared for these OUs
- No additional underground utilities are found to impact facility design and/or hamper construction.
- Any soil removed during site preparation and grading is non-hazardous.
- Utility power is reasonably accessible.
- No road construction is required for access to the treatment facility site.
- Area access is not limited.
- There are no ecological restrictions at the treatment facility site, such as the presence of protected species or critical habitat.
- Injection wells can be used for discharge of treatment facility effluent and are located within 100 feet of the facility.

C-2.1.3. Monitor and Extraction Wellfield Drilling and Installation

The cost to drill and install a ground water monitor and extraction well is based on actual well drilling and construction costs in 2004. This estimate includes labor and materials for:

- Drilling preparation (i.e., drilling and sampling plan preparation; construction of access roads; and utility surveys and permits).
- Borehole drilling (i.e., drilling crew, geologist, and rig; drilling fluids, conductor casing, monitoring and personal protective equipment, and soil, rock, and water sampling, and analysis; geologic core logging; and downhole geophysics).

- Well design and construction (i.e., well development; wellhead installation; well location surveys; initial aquifer testing; and post-development ground water sampling and analyses).

Assumptions for this activity include:

- No extraction wells or additional ground water monitor wells were drilled in the Pit 6 Landfill and Building 850 OUs.
- Three ground water monitor wells are required per additional extraction well installed to monitor the effectiveness of the remedial action.
- No geographical, topographical, or physical difficulties are encountered.
- No major schedule delays are encountered due to inclement weather or conflicts with other programmatic activities.
- Drill rig access and setup can be completed in 8 hrs.
- Drill rig mobilization and setup/standby time is included.
- Gross Drilling rate (Total depth/time from mobilization to start of well construction) is 30 ft/day; drilling day is 8 hrs long.
- 5-inch diameter polyvinyl chloride (PVC) casing with 10 feet of slotted section will be used to construct extraction wells.
- Drilling rig does not need to be mobilized from an offsite location.
- Standby time during geophysical logging is included in number of drilling days.

C-2.1.4. Pipeline Design and Construction

The cost to design and install pipelines to convey extracted ground water to the treatment facilities are $150/linear feet for pipelines between extraction wells and the treatment facility and $125/linear feet for pipelines from the facility to the injection well. This estimate includes labor and materials for:

- Pipe, fittings, pipe supports, thermal expansion, site preparation, labor, utility clearance, wire pulls, and pressure testing.

Assumptions for this activity include:

- Because the interim remedies for the Pit 6 Landfill and Building 850 OUs did not included active remediation, pipeline design and construction costs were not included in the cost estimates prepared for these OUs.
- All pipelines are constructed above grade.
- No bridging, excavation, double containment, leak detection or road crossings are required to construct the pipeline.

C-2.2. Operation and Maintenance Cost Assumptions

Operation and maintenance (O&M) costs includes ground water extraction and treatment system O&M, compliance monitoring, remedial action optimization, data management, compliance reporting, project management, and infrastructure support. The assumptions used in costing these activities are described in Section C-2.2.1 through C-2.2.6.

C-2.2.1. Treatment Facility O&M

The cost to perform all activities needed to operate and maintain a treatment facility is based on actual costs to operate and maintain similar facilities at Site 300 in fiscal year 2004. This estimate includes labor and materials for:

- Mechanical O&M of the extraction wellfield and treatment facility to remove contaminant mass and meet water discharge requirements (i.e., facility operators; electricity; replacement and disposal of spent treatment media; and maintenance of filters, pumps, and extraction and monitor wells).
- Control system and monitoring instrumentation calibration and maintenance (i.e., electronics technicians; maintenance of control software; periodic testing of interlocks; calibration of sensors and control systems, and hardware).
- Facility documentation and data collection (i.e., documentation of operating parameters; compliance monitoring, and sampling and analyses of treatment facility influent and effluent and extraction wells).

Assumptions for this activity include:

- Because the interim remedies for the Pit 6 Landfill and Building 850 OUs did not included active remediation, treatment facility O&M costs were not included in the cost estimates prepared for these OUs.
- Facility O&M continues at all treatment facilities within an OU until cleanup standards have been achieved at all extraction and monitor wells within the OU.
- Treatment facilities operate 24 hours/day, 365 days/year.
- Treatment facility compliance monitoring requirements are consistent with current (2005) substantive requirements for effluent discharge and the Site-Wide Compliance Monitoring Plan.
- Monitoring requirements are OU-specific.
- All reactive media (GAC, resin) is replaced at a minimum frequency of 3 years.
- Costs to replace spent GAC and ion-exchange resin are based on vendor literature and quotes plus 15%.
- Spent GAC and ion-exchange resin (waste) is not classified as mixed waste.
- All costs associated with soil vapor extraction and treatment are accounted for in general facility O&M.
- Perchlorate and nitrate concentrations initially match typical facility input values and reach MCLs at the end of the facility design life.
- Reactive media capacities are based on vendor literature.

C-2.2.2. Well Compliance Monitoring

The annual cost to perform all activities needed to collect and analyze monitor well compliance samples is estimated to be $1,291 per well. The cost is based on the actual costs for well compliance monitoring in fiscal year 2004. The cost per well was derived by dividing the total annual cost for monitoring wells by the number of wells to be monitored to derive a

monitoring cost per well per year. This estimate includes labor and materials for:

- Water quality sampling and analyses (i.e., collecting ground water samples, laboratory analysis of physical, chemical, and/or radiological properties of these samples).
- Water level measurement (i.e., measurement and documentation of ground water elevations in monitor wells).

Assumptions for this activity include:

- Regulatory compliance monitoring requirements do not change significantly throughout the life of the project.
- No new contaminants are identified that significantly increase the amount of required sampling and analysis.
- The number of monitor wells to be sampled and/or frequency does not change significantly throughout the life of the project.

C-2.2.3. Remedial Action Optimization

The cost to perform all activities needed to optimize extraction wellfield operation and contaminant mass removal and expedite cleanup is estimated to be $36,342 per facility. This estimate includes labor and materials for:

- Wellfield and remedial action optimization which includes the review and evaluation of ground water elevation and contaminant concentration data, extraction well flow rates, and mass removal data.

  Periodic soil vapor and ground water rebound and zone-of-influence testing.

  The use of numerical models to evaluate hydraulic capture zones and test different pumping strategies.

Assumptions for this activity include:

- The treatment area for each facility is well characterized and that no new areas of contamination or new contaminants are discovered during remediation.
- Each treatment area requires the same effort to maintain optimal operations.
- The hydrogeologic conceptual model does not change significantly.
- The subsurface conditions do not change significantly.

C-2.2.4. Data Management

The cost to perform all activities needed to manage data collected to evaluate remediation effectiveness and demonstrate compliance with permits and other regulatory requirements is estimated to be $822 per well. The cost is based on the actual costs to manage well compliance monitoring data in fiscal year 2004. The cost per well was derived by dividing the total annual cost for data management by the number of wells to be monitored to derive a data management cost per well per year. This estimate includes labor and materials for:

- Receiving, logging, verifying, storing, manipulating, and distributing paper and electronic analytical data, chain-of custody forms, and QA documents.
- Validating data and other QA/QC activities.
- Preparing, reviewing, and distributing quarterly sampling plans.

Assumptions for this activity include:

- Volume of data managed will be similar to Fiscal Year 2008.
- Regulatory requirements for documentation and quality control measures do not change significantly through the life of the project.
- Infrastructure support provides necessary hardware and software to perform data management activities.

C-2.2.5. Compliance Reporting

The cost for compliance reporting activities needed to support the environmental restoration project is estimated to be $35,202 per facility. The cost is based on the actual costs for compliance reporting in fiscal year 2004. The cost per facility was derived by dividing the total annual cost for compliance reporting by the number of treatment facilities to derive a reporting cost per facility per year. This estimate includes labor and materials for:

- Preparation of semi-annual and annual Compliance Monitoring Reports for submittal to the regulatory agencies.
- Preparation of a 5-Year Review for each OU.

Assumptions for this activity include:

- Reporting frequencies and the scope of the reports do not change significantly over time.

C-2.2.6. Project Management and Infrastructure Support

The cost for project management and infrastructure activities and materials needed to support the Building 834 OU portion of environmental restoration project is estimated to be $132,850 per facility. The cost per facility was derived by dividing the total annual cost for project management and infrastructure support by the number of facilities to derive cost per facility per year. This estimate includes labor and materials for:

- Project management support including the management and oversight of project; providing technical, scientific, and fiscal guidance to project staff; regulatory and community interactions; budget, work scope, and schedule preparation, tracking, and reporting; personnel management.
- Infrastructure support including safety and quality assurance; vehicles; office space, equipment, supplies, telecommunications, maintenance, and utilities; computer and software acquisition and maintenance; clerical and procurement support; and network maintenance.

Assumptions for this activity include:

- The fiscal year 2008 costs for these activities used to estimate cost are valid.
- Cost reductions due to increased efficiencies over time will offset any additional project management and infrastructure support costs for managing the expanded remediation scenarios.
- Project management and infrastructure support activities continue until all treatment facilities shut down plus 2 years of post-shutdown monitoring has been completed.

C-3. Potential Cleanup Scenario Cost Estimates

Cost estimates were prepared for the ground water cleanup scenarios for OUs 2 through 8 as part of the evaluation to determine the economic feasibility of achieving various potential ground water cleanup standards. The cost estimates for cleanup standard scenarios for each OUs are presented as follows:

- Building 834 OU cleanup scenarios 1 through 5 (Tables C-1 through C-5).
- Pit 6 Landfill OU cleanup scenarios 4/5 (Table C-6). No costs are provided for scenarios 1/2 because tritium activities are below the MCL. No costs are provided for scenario 3 because no intermediate water quality numeric limits between the MCL and background has been identified for tritium.
- High Explosives Process Area OU cleanup scenarios 1 through 5 (Tables C-7 through C-11).
- Building 850 OU cleanup scenarios 1/2 and 4/5 (Tables C-12 and C-13). No costs are provided for scenario 3 because no intermediate water quality numeric limits between the MCL and background has been identified for tritium.
- Building 854 OU cleanup scenarios 1 through 5 (Tables C-14 through C-18).
- Building 832 Canyon cleanup scenarios 1 through 5 (Tables C-19 through C-23).

The U.S. Environmental Protection Agency (EPA) does not concur with the approach used to estimate costs because they are not based on a present value analysis as required by EPA.

Present-value analysis is a method to evaluate expenditures, either capital or O&M, which occur over different time periods. This standard methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This single number, referred to as the present-value, is the amount need to be set aside or invested at the start of the remediation project to assure that funds will be available in the future as they are needed. This process assumes that the funding invested at the beginning of the project would accrue interest at a rate of 3 to 5%. To account for this, a discount rate is applied to the project costs to derive a present-worth cost. However, the U.S. government funding process does not allow for funding for the entire project to be set aside or invested at the start of the process. Funding for government-funded remediation projects is allocated at the start of each fiscal year during which the work will occur. Therefore, the cost estimates that were provided in Appendix C did not assume initial, up-front investment of the total project cost and accrual of interest over the life of the project. These non-discounted cost estimates more accurately represent actual project costs and funding required to complete the remediation project than would present-value analysis costs.

In addition, the ground water cleanup standards proposed for inclusion in the Site-Wide Record of Decision (ROD) are not based on the economic and technical feasibility evaluation of the potential ground water cleanup scenarios required in the Interim Site-Wide ROD (DOE, 2001) and presented in the text and Appendices B through D of the Draft Site-Wide Remediation Evaluation Summary Report. For this reason and as agreed at the July 28th 2006 Remedial Project Manager's meeting, no further work was conducted for this evaluation, including revising cost estimates in Appendix C using present-value analysis. Because this economic and technical feasibility evaluation of the potential ground water cleanup scenarios was required in

the Interim Site-Wide ROD, the information related to this evaluation remains in Appendices B, C, and D of the draft final report to demonstrate DOE/LLNL compliance with the Interim Site-Wide ROD requirements.

Appendix C

Tables

Table C-1. Scenario 1 costs for the Building 834 OU (Partial capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$103,495
Well Compliance Monitoring		$77,460
Remedial Action Optimization		$36,342
Data Management		$49,320
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$132,850
Annual O&M Subtotal:		$434,669
Total O&M Life-Cycle Cost (Annual O&M cost × 400 years) =		$173,867,600
Total Cost for Scenario 1 (Capital cost + O&M) =	$173,867,600	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 1.

Table C-2. Scenario 2 costs for the Building 834 OU (Complete capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$103,495
Well Compliance Monitoring		$77,460
Remedial Action Optimization		$36,342
Data Management		$49,320
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$132,850
Annual O&M Subtotal:		$434,669
Total O&M Life-Cycle Cost (Annual O&M cost × 400 years) =		$173,867,600
Total Cost for Scenario 2 (Capital cost + O&M) =	$173,867,600	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 2. The capital costs shown for Scenario 2 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding the 5 μg/L MCL.

Table C-3. Scenario 3 costs for the Building 834 OU (Complete capture to TCE WQNL [2.3 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$103,495
Well Compliance Monitoring		$77,460
Remedial Action Optimization		$36,342
Data Management		$49,320
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$132,850
Annual O&M Subtotal:		$434,669
Total O&M Life-Cycle Cost (Annual O&M cost × 510 years) =		$221,681,190
Total Cost for Scenario 3 (Capital cost + O&M) =	$221,681,190	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

WQNL = Water quality numeric limit.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 3. The capital costs shown for Scenario 3 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding 2.3 μg/L WQNL.

Table C-4. Scenario 4 costs for the Building 834 OU (Partial capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$103,495
Well Compliance Monitoring		$77,460
Remedial Action Optimization		$36,342
Data Management		$49,320
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$132,850
Annual O&M Subtotal:		$434,669
Total O&M Life-Cycle Cost (Annual O&M cost × 730 years) =		$317,308,370
Total Cost for Scenario 4 (Capital cost + O&M) =	$317,308,370	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

a Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 4. The capital costs shown for Scenario 4 includes additional treatment facilities, extraction, and monitor wells needed for partial capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-5. Scenario 5 costs for the Building 834 OU (Complete capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$103,495
Well Compliance Monitoring		$77,460
Remedial Action Optimization		$36,342
Data Management		$49,320
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$132,850
Annual O&M Subtotal:		$434,669
Total O&M Life-Cycle Cost (Annual O&M cost × 730 years) =		$317,308,370
Total Cost for Scenario 5 (Capital cost + O&M) =	$317,308,370	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

a Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 5. The capital costs shown for Scenario 5 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-6. Scenarios 4/5 costs for the Pit 6 Landfill OU (MNA to tritium background [100 pCi/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$5,410
Well Compliance Monitoring		$54,222
Remedial Action Optimization		$0
Data Management		$34,524
Compliance Reporting		$35,202
Project Management and Infrastructure Support		$0
Annual O&M Subtotal:		$129,358
Total O&M Life-Cycle Cost (Annual O&M cost × 35 years) =		$4,527,530
Total Cost for Scenarios 4/5 (Capital cost + O&M) =	$4,527,530	

Notes:

MNA = Monitored natural attenuation.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

pCi/L = Picocuries per liter.

a Because the interim remedy for tritium is monitored natural attenuation, capital costs for treatment facility are not included. The capital costs for monitor wellfield construction and installation are also not included as these costs have already been incurred.

Table C-7. Scenario 1 costs for the HE Process Area OU (Partial capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$380,609
Well Compliance Monitoring		$56,804
Remedial Action Optimization		$181,710
Data Management		$36,168
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,495,551
Total O&M Life-Cycle Cost (Annual O&M cost × 120 years) =		$179,466,120
Total Cost for Scenario 1 (Capital cost + O&M) =	$179,466,120	

Notes:

HE = High explosives.

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield construction and installation have already been incurred, these costs are not included for Scenario 1.

Table C-8. Scenario 2 costs for the HE Process Area OU (Complete capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$205,525	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$616,574	
Capital costs subtotal:	$1,270,203	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$532,445
Well Compliance Monitoring		$82,624
Remedial Action Optimization		$254,394
Data Management		$52,608
Compliance Reporting		$246,414
Project Management and Infrastructure Support		$929,950
Annual O&M Subtotal:		$2,098,435
Total O&M Life-Cycle Cost (Annual O&M cost × 110 years) =		$230,827,850
Total Cost for Scenario 2 (Capital cost + O&M) =	$232,098,053	

Notes:

HE = High explosives.

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 2. The capital costs shown for Scenario 2 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding the 5 μg/L MCL.

Table C-9. Scenario 3 costs for the HE Process Area OU (Complete capture to TCE WQNL [2.3 μg/L])

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$205,525	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$616,574	
Capital costs subtotal:	$1,270,203	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$532,445
Well Compliance Monitoring		$82,624
Remedial Action Optimization		$254,394
Data Management		$52,608
Compliance Reporting		$246,414
Project Management and Infrastructure Support		$929,950
Annual O&M Subtotal:		$2,098,435
Total O&M Life-Cycle Cost (Annual O&M cost × 120 years) =		$251,812,200
Total Cost for Scenario 3 (Capital cost + O&M) =	$253,082,403	

Notes:

HE = High explosives.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

WQNL = Water quality numeric limit.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 3. The capital costs shown for Scenario 3 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding 2.3 μg/L WQNL.

Table C-10. Scenario 4 costs for the HE Process Area OU 4 (Partial capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$205,525	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$616,574	
Capital costs subtotal:	$1,270,203	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$532,445
Well Compliance Monitoring		$82,624
Remedial Action Optimization		$254,394
Data Management		$52,608
Compliance Reporting		$246,414
Project Management and Infrastructure Support		$929,950
Annual O&M Subtotal:		$2,098,435
Total O&M Life-Cycle Cost (Annual O&M cost × 155 years) =		$325,257,425
Total Cost for Scenario 4 (Capital cost + O&M) =	$326,527,628	

Notes:

HE = High explosives.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 4. The capital costs shown for Scenario 4 includes additional treatment facilities, extraction, and monitor wells needed for partial capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-11. Scenario 5 costs for the HE Process Area OU 4 (Complete capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$230,977	
Treatment facility construction/site preparation	$306,179	
Extraction wellfield drilling and installation	$473,620	
Pipeline design and construction	$225,000	
Monitor wellfield drilling and installation	$1,420,860	
Capital costs subtotal:	$2,656,636	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$613,079
Well Compliance Monitoring		$108,444
Remedial Action Optimization		$290,736
Data Management		$69,048
Compliance Reporting		$281,616
Project Management and Infrastructure Support		$1,062,800
Annual O&M Subtotal:		$2,425,723
Total O&M Life-Cycle Cost (Annual O&M cost × 175 years) =		$424,501,525
Total Cost for Scenario 5 (Capital cost + O&M) =	$427,158,161	

Notes:

HE = High explosives.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

µg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 5. The capital costs shown for Scenario 5 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-12. Scenarios 1/2 costs for the Building 850 OU 5 (MNA to tritium MCL [20,000 pCi/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$20,867
Well Compliance Monitoring		$148,170
Remedial Action Optimization		$28,915
Data Management		$110,726
Compliance Reporting		$90,182
Project Management and Infrastructure Support		$25,620
Annual O&M Subtotal:		$424,480
Total O&M Life-Cycle Cost (Annual O&M cost × 40 years) =		$16,979,200
Total Cost for Scenarios 1/2 (Capital cost + O&M) =	$16,979,200	

Notes:

MCLs = Maximum contaminant levels.

MNA = Monitored natural attenuation.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

pCi/L = Picocuries per liter.

[a] Because the interim remedy for tritium is monitored natural attenuation, capital costs for treatment facility are not included. The capital costs for monitor wellfield construction and installation are also not included as these costs have already been incurred.

Table C-13. Scenarios 4/5 costs for the Building 850 OU 5 (MNA to tritium background [100 pCi/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$20,867
Well Compliance Monitoring		$148,170
Remedial Action Optimization		$28,915
Data Management		$110,726
Compliance Reporting		$90,182
Project Management and Infrastructure Support		$25,620
Annual O&M Subtotal:		$424,480
Total O&M Life-Cycle Cost (Annual O&M cost × 135 years) =		$57,304,800
Total Cost for Scenarios 4/5 (Capital cost + O&M) =	$57,304,800	

Notes:

MNA = Monitored natural attenuation.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

pCi/L = Picocuries per liter.

[a] Because the interim remedy for tritium is monitored natural attenuation, capital costs for treatment facility are not included. The capital costs for monitor wellfield construction and installation are also not included as these costs have already been incurred.

Table C-14. Scenario 1 costs for the Building 854 OU6 (Partial capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$227,811
Well Compliance Monitoring		$30,984
Remedial Action Optimization		$109,026
Data Management		$19,728
Compliance Reporting		$105,606
Project Management and Infrastructure Support		$398,550
Annual O&M Subtotal:		$891,705
Total O&M Life-Cycle Cost (Annual O&M cost × 90 years) =		$80,253,450
Total Cost for Scenario 1 (Capital cost + O&M) =	$80,253,450	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

µg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield construction and installation have already been incurred, these costs are not included for Scenario 1.

Table C-15. Scenario 2 costs for the Building 854 OU 6 (Complete capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$402,834	
Pipeline design and construction	$36,750	
Monitor wellfield drilling and installation	$1,208,501	
Capital costs subtotal:	$2,006,189	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$384,382
Well Compliance Monitoring		$67,132
Remedial Action Optimization		$181,710
Data Management		$42,744
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,516,228
Total O&M Life-Cycle Cost (Annual O&M cost × 90 years) =		$136,460,520
Total Cost for Scenario 2 (Capital cost + O&M) =	$138,466,709	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 2. The capital costs shown for Scenario 2 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding the 5 μg/L MCL.

Table C-16. Scenario 3 costs for the Building 854 OU 6 (Complete capture to TCE WQNL [2.3 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$402,834	
Pipeline design and construction	$36,750	
Monitor wellfield drilling and installation	$1,208,501	
Capital costs subtotal:	$2,006,189	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$384,382
Well Compliance Monitoring		$67,132
Remedial Action Optimization		$181,710
Data Management		$42,744
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,516,228
Total O&M Life-Cycle Cost (Annual O&M cost × 95 years) =		$144,041,660
Total Cost for Scenario 3 (Capital cost + O&M) =	$146,047,849	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

WQNL = Water quality numeric limit.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 3. The capital costs shown for Scenario 3 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding 2.3 μg/L WQNL.

Table C-17. Scenario 4 costs for the Building 854 OU6 (Partial capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$402,834	
Pipeline design and construction	$36,750	
Monitor wellfield drilling and installation	$1,208,501	
Capital costs subtotal:	$2,006,189	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$384,382
Well Compliance Monitoring		$67,132
Remedial Action Optimization		$181,710
Data Management		$42,744
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,516,228
Total O&M Life-Cycle Cost (Annual O&M cost × 120 years) =		$181,947,360
Total Cost for Scenario 4 (Capital cost + O&M) =	$183,953,549	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 4. The capital costs shown for Scenario 4 includes additional treatment facilities, extraction, and monitor wells needed for partial capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-18. Scenario 5 costs for the Building 854 OU 6 (Complete capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$524,532	
Pipeline design and construction	$45,000	
Monitor wellfield drilling and installation	$1,573,597	
Capital costs subtotal:	$2,501,233	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$390,041
Well Compliance Monitoring		$82,624
Remedial Action Optimization		$181,710
Data Management		$52,608
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,547,243
Total O&M Life-Cycle Cost (Annual O&M cost × 120 years) =		$185,669,160
Total Cost for Scenario 5 (Capital cost + O&M) =	$188,170,393	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 5. The capital costs shown for Scenario 5 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-19. Scenario 1 costs for the Building 832 Canyon OU 7 (Partial capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	NA	
Treatment facility construction/site preparation	NA	
Extraction wellfield drilling and installation	NA	
Pipeline design and construction	NA	
Monitor wellfield drilling and installation	NA	
Capital costs subtotal:	NA	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$258,255
Well Compliance Monitoring		$114,899
Remedial Action Optimization		$109,026
Data Management		$73,158
Compliance Reporting		$105,606
Project Management and Infrastructure Support		$398,550
Annual O&M Subtotal:		$1,059,494
Total O&M Life-Cycle Cost (Annual O&M cost × 149 years) =		$157,864,606
Total Cost for Scenario 1 (Capital cost + O&M) =	$157,864,606	

Notes:

MCLs = Maximum contaminant levels.

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield construction and installation have already been incurred, these costs are not included for Scenario 1.

Table C-20. Scenario 2 costs for the Building 832 Canyon OU 7 (Complete capture to TCE MCL [5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$763,445	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$2,290,336	
Capital costs subtotal:	$3,501,885	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$423,334
Well Compliance Monitoring		$171,703
Remedial Action Optimization		$181,710
Data Management		$109,326
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,726,333
Total O&M Life-Cycle Cost (Annual O&M cost × 149 years) =		$257,223,617
Total Cost for Scenario 2 (Capital cost + O&M) =	$260,725,502	

Notes:

NA = Not applicable

O&M = Operation and maintenance

OU = Operable unit

TCE = Trichloroethylene

μg/L = Micrograms per liter

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 2. The capital costs shown for Scenario 2 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding the 5 μg/L MCL.

Table C-21. Scenario 3 costs for the Building 832 Canyon OU 7 (Complete capture to TCE WQNL [2.3 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$763,445	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$2,290,336	
Capital costs subtotal:	$3,501,885	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$423,334
Well Compliance Monitoring		$171,703
Remedial Action Optimization		$181,710
Data Management		$109,326
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,726,333
Total O&M Life-Cycle Cost (Annual O&M cost × 187 years) =		$322,824,271
Total Cost for Scenario 3 (Capital cost + O&M) =	$326,326,156	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

WQNL = Water quality numeric limit.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 3. The capital costs shown for Scenario 3 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding 2.3 μg/L WQNL.

Table C-22. Scenario 4 costs for the Building 832 Canyon OU 7 (Partial capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$763,445	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$2,290,336	
Capital costs subtotal:	$3,501,885	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$423,334
Well Compliance Monitoring		$171,703
Remedial Action Optimization		$181,710
Data Management		$109,326
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,726,333
Total O&M Life-Cycle Cost (Annual O&M cost × 263 years) =		$454,025,579
Total Cost for Scenario 4 (Capital cost + O&M) =	$457,527,464	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 4. The capital costs shown for Scenario 4 includes additional treatment facilities, extraction, and monitor wells needed for partial capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Table C-23. Scenario 5 costs for the Building 832 Canyon OU 7 (Complete capture to TCE background [0.5 μg/L]).

Activity	Capital costs[a]	Annual O&M
Remedial Action Construction:		
Treatment facility design & fabrication	$153,985	
Treatment facility construction/site preparation	$204,119	
Extraction wellfield drilling and installation	$785,523	
Pipeline design and construction	$90,000	
Monitor wellfield drilling and installation	$2,356,568	
Capital costs subtotal:	$3,590,195	
Operation & Maintenance (O&M):		
Maintenance Materials and O&M Labor		$423,334
Well Compliance Monitoring		$171,703
Remedial Action Optimization		$181,710
Data Management		$109,326
Compliance Reporting		$176,010
Project Management and Infrastructure Support		$664,250
Annual O&M Subtotal:		$1,726,333
Total O&M Life-Cycle Cost (Annual O&M cost × 263 years) =		$454,025,579
Total Cost for Scenario 1 (Capital cost + O&M) =	$457,615,774	

Notes:

NA = Not applicable.

O&M = Operation and maintenance.

OU = Operable unit.

TCE = Trichloroethylene.

μg/L = Micrograms per liter.

[a] Because the capital costs for treatment facility, and extraction and monitor wellfield that was constructed as part of the interim remedy have already been incurred, these costs are not included for Scenario 5. The capital costs shown for Scenario 5 includes additional treatment facilities, extraction, and monitor wells needed for complete capture of the TCE plume with concentrations exceeding background (0.5 μg/L).

Appendix D

Evaluation of Remediation to Meet Potential Cleanup Standards in Ground Water

Appendix D

Evaluation of Remediation to Meet Potential Cleanup Standards in Ground Water

D-1. Introduction

The State Water Resources Control Board (SWRCB) Resolution 92-49 requires that remediation of ground water must be continued until background conditions are restored, unless a waiver is granted or reaching this goal is technically or economically infeasible. As agreed in the Interim Site-Wide Record of Decision (ROD), the Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) conducted an evaluation to determine the economic and technical feasibility of achieving various potential ground water cleanup standards.

DOE, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB) subsequently agreed that the evaluation of potential ground water cleanup standards contained in Appendices B, C, and D of this report will not be used to support the selection of ground water cleanup standards in the Site-Wide ROD. However, the evaluation of potential ground water cleanup standards contained in these appendices is retained in this report to demonstrate and document DOE's compliance with the requirements of the Interim Site-Wide ROD.

Section D-2 describes the process DOE/LLNL used to evaluate the technical and economic feasibility of achieving potential ground water cleanup standards. Sections D-3 through D-8 present the results of the evaluations conducted for:

- Building 834 Operable Unit (OU) 2 (Section D-3).
- Pit 6 Landfill OU 3 (Section D-4).
- High Explosives (HE) Process Area OU 4 (Section D-5).
- Building 850 Firing Table OU 5 (Section D-6).
- Building 854 OU 6 (Section D-7).
- Building 832 Canyon OU 7 (Section D-8).

OU 8 release sites (Building 801/Pit 8 Landfill, Building 845/Pit 9 Landfill, the Building 851 firing table, Building 833, and the Pit 2 Landfill) were not evaluated because: (1) contaminants of concern (COCs) were not identified in ground water, (2) COC concentrations in ground water do not exceed regulatory standards, and/or (3) the extent of contamination in ground water is limited.

The numeric ground water cleanup levels used in the five scenarios are intended for evaluation purposes only and do not presuppose any specific final cleanup standard.

D-2. Process for Evaluation of Potential Ground Water Cleanup Standards

This section describes the process DOE/LLNL used to evaluate the economic and technical feasibility of achieving the potential ground water cleanup standards. The process consisted of three steps:

1. Ground water modeling to determine the time and resources needed to achieve various potential ground water cleanup standards (i.e., maximum contaminant levels [MCLs], water quality numeric limits [WQNLs], background) (Appendix B).
2. Preparing cost estimates to construct and operate remediation systems and wellfields and/or monitor until the potential ground water cleanup standards are achieved (Appendix C).
3. Comparing the estimated cost and predicted time to cleanup under potential ground water cleanup standard scenarios to evaluate the economic and technical feasibility of achieving these standards.

Ground water modeling was conducted using ground water extraction and/or monitoring for up to five potential ground water cleanup scenarios for OUs 2 through 7. The specific scenarios that were evaluated for each OU are discussed in Sections D-3 through D-7.

As agreed in the Interim Site-Wide ROD, the modeling for these scenarios was conducted using the COC plume of greatest areal extent to estimate the length of time to cleanup at each OU. In most cases, this was trichloroethylene (TCE), which generally has both the highest concentrations and the greatest areal extent in ground water. The rationale for using an indicator COC in the modeling is that the COC plumes of lesser extent will be remediated before the largest COC plume is remediated. However, DOE/LLNL also evaluated the characteristics of the other COCs (i.e., retardation factors) to support this assumption. Only one or two scenarios were modeled for OUs where tritium is the COC with highest concentrations and extent in ground water, and monitored natural attenuation is the selected interim remedy for tritium (e.g., Building 850 and the Pit 6 Landfill OU). These included natural attenuation of tritium to MCLs (Building 850 only), and natural attenuation of tritium to background activities (Building 850 and the Pit 6 Landfill).

The modeling results are presented in Appendix B and include: (1) the estimated length of time to reach MCLs, WQNLs, and background concentrations in ground water, and (2) the design parameters, treatment facilities, and extraction well configurations necessary to achieve the results for these scenarios. An evaluation of the known or potential technical challenges associated with implementing the remedy under the different scenarios is also presented in Appendix B.

The design parameters, treatment facilities, extraction well configurations, and estimated cleanup times under the modeling scenarios were then used to estimate the cost for implementing each remediation scenario. These estimates included capital costs to construct additional treatment facilities and expand extraction wellfields as necessary to achieve the cleanup standard for the scenarios. Estimates also included long-term costs to operate, maintain, and/or monitor the remedial action for each the ground water cleanup standard scenarios. The assumptions used to estimate costs, as well as the detailed cost estimates, are presented in Appendix C.

As discussed in Section B-2 of Appendix B, a non-optimized cleanup approach was used to model and cost the five cleanup scenarios in Appendices B and C. In this approach, the existing or planned extraction wellfield configuration from the Remedial Design (Scenario 1) was used in Scenarios 2 through 5 for source area mass removal and downgradient COC concentration reduction. A "fence" of hypothetical capture wells was then added to achieve the different capture and cleanup goals in Scenarios 2 through 5. This approach allowed for the development of wellfield configurations, cleanup times, and costs that could be compared for cost-benefit analyses. The development of optimized wellfield configurations for each scenario for every OU would have potentially generated hundreds of modeling cases with different levels of optimization for each cleanup scenario. Although the non-optimized approach allows for the creation of scenario costs and cleanup times for comparison, this approach results in extended cleanup times and high costs due to lack of optimization. However, the relative differences in cleanup times and costs between scenarios are still valid for comparative purposes. It is important to note that optimized cleanup times and costs would be significantly lower. Therefore the non-optimized cleanup times and costs developed to evaluate the technical and economic feasibility of different cleanup standards should not be used for budgetary or planning purposes.

In this appendix, the technical and economic feasibility of achieving potential ground water cleanup standards was evaluated by comparing the estimated cost and predicted time to cleanup under various scenarios. The technical and economic feasibility of the cleanup scenarios was based on their ability to:

- Achieve cost-effective ground water cleanup and meet the SWRCB Resolution 92-49 requirements cost-effectively and in a reasonable timeframe compared to other cleanup scenarios.
- Protect human health and the environment.

Scenario 1 is based on the interim remedial designs for OUs 2 through 7 with the minimum ground water cleanup standards agreed to in the Interim Site-Wide ROD. This includes active remediation with partial capture of the MCL plume and/or monitoring of ground water until contaminant concentrations are reduced to MCLs. Other cleanup standard scenarios (2, 3, 4, and 5) were compared to Scenario 1 to determine if they: (1) significantly reduced the time to cleanup at a comparable cost, and (2) provided a significantly higher level of protection for human health or the environment.

The results of the cleanup standard evaluation are presented for OUs 2 through 7 in Sections D-3 through D-8. A summary of these results is also included in the OU-specific Chapters 6 through 12.

D-3. Building 834 OU 2 Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the Building 834 OU. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for TCE under five scenarios:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 micrograms per liter (μg/L) followed by natural attenuation to further reduce concentrations to background levels.

2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (California Environmental Protection Agency [Cal/EPA] 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.

The modeling of partial and complete hydraulic capture-to-background for TCE in scenarios 4 and 5 is considered to be equivalent to the modeling of capture to the Office of Environmental Health Hazard Assessment (OEHHA) Public Health Goal (PHG) WQNL scenario because the detection limit/background level for TCE (0.5 μg/L) is so close to the PHG for TCE (0.8 μg/L). In addition, the 0.5 μg/L TCE analytical detection limit was used as a surrogate for TCE background concentrations.

TCE was used in the Building 834 OU evaluation because it is the predominant and most extensive ground water COC in this OU. It was assumed that other VOCs, the silicone oils tetrabutylorthosilicate (TBOS) and tetra-kis-2-ethylbutyl silane (TKEBS), and nitrate present in perched ground water at Building 834 would be remediated before the TCE plume is remediated. DOE/LLNL evaluated the characteristics of these other COCs (i.e., retardation factors) to support this assumption.

The treatment system, extraction wellfield configurations and capture zones, model input parameters, and assumptions used to estimate cleanup times for these scenarios are discussed in Section B-4.2 of Appendix B.

The predicted time for ground water cleanup from Appendix B and estimated costs from Appendix C under these five scenarios are presented in Tables D-1. Figure D-1 presents plots of the cleanup costs over time for the five cleanup scenarios. A comparison of the costs and time to cleanup under the five potential cleanup standards scenarios are discussed in Section D-3.1. Section D-3.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-3.1. Comparison of Cleanup Standard Scenarios

D-3.1.1. Scenarios 1 and 2

At the Building 834 OU, modeling indicates that complete hydraulic capture (Scenario 2) can be achieved using the ground water extraction wellfield for the interim remedy (Scenario 1) as described in the Remedial Design for the Building 834 OU (Gregory et al., 2002). Therefore, the modeling results and costs for Scenarios 1 and 2 (complete capture) are assumed to be the same. However, Scenario 1 (partial capture) is presented for consistency with the cleanup standard evaluation criteria as presented in the Interim Site-Wide ROD.

Modeling results indicate that it would take approximately 400 years to reduce TCE concentrations in ground water at the Building 834 OU to a cleanup standard of 5 μg/L (TCE

MCL) under Scenarios 1 and 2 (Table D-1). The estimated cost to achieve an MCL cleanup standard for TCE under these both these scenarios is $174 million (M).

D-3.1.2. Scenario 3

Modeling results indicate that it would take approximately 510 years to reduce TCE concentrations in ground water at the Building 834 OU to a cleanup standard of 2.3 μg/L (Cal/EPA WQNL) under Scenario 3. The estimated cost to achieve a 2.3 μg/L cleanup standard for TCE under this scenario is $222M.

As indicated in Table D-1, it would take an additional 110 years (22% longer) and cost $48M (22%) more to achieve the 2.3 μg/L WQNL cleanup standard in ground water than to achieve a 5 μg/L MCL cleanup standard.

D-3.1.3. Scenarios 4 and 5

As discussed in Section 3.1.1, modeling indicates that complete hydraulic capture can be achieved using the ground water extraction wellfield for the interim remedy. Therefore, the modeling results and costs for Scenarios 4 (partial capture) and 5 (complete capture) are assumed to be the same. However, Scenario 4 is presented for consistency with the cleanup standard evaluation criteria as presented in the Interim Site-Wide ROD.

Modeling results indicate that it would take approximately 730 years to reduce TCE concentrations in ground water at the Building 834 OU to background concentrations of 0.5 μg/L under Scenarios 4 and 5. The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under these scenarios is $317M.

As indicated in Table D-1, it would take an additional 330 years (45% longer) and cost $144M (45% more) to achieve the 0.5 μg/L background cleanup standard in ground water than to achieve a 5 μg/L TCE MCL cleanup standard.

D-3.2. Protection of Human Health and the Environment

Potential TCE ground water cleanup standards of 5 μg/L State and Federal MCL, 2.3 μg/L TCE WQNL, or 0.5 μg/L background (detection limit) were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the Building 834 OU. The evaluation of the characteristics of other VOCs, perchlorate, and nitrate in ground water (i.e., retardation factors) supported the assumption that these COCs will be remediated before the TCE plume.

To protect human health, the U.S. Environmental Protection Agency (EPA) and California Department of Health Services (DHS) have set standards for drinking water sources. MCLs are Federal and State standards for drinking water sources. Municipal and domestic water suppliers must treat water to meet these standards before distribution to the public. Water that meets these standards is considered safe to drink by EPA and the California DHS. The 2.3 μg/L Cal/EPA TCE WQNL is based on 10^{-6} cancer risk estimates. This WQNL represent levels of contaminants in drinking water that would pose no significant health risk to individuals consuming water on a daily basis over a lifetime. The 0.5 μg/L TCE background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

The TCE plume and TBOS/TKEBS and nitrate contamination in Building 834 ground water are limited to perched ground water in the Tpsg hydrostratigraphic unit (HSU) and the underlying Tps-$Tnsc_2$ HSU. The plumes are contained onsite in the vicinity of the Building 834 Complex and there are no pathways for them to migrate offsite or to existing ground water receptor points (i.e., onsite or offsite water-supply wells.) Contamination in perched ground water is isolated from the Lower $Tnbs_1$ HSU (regional aquifer) by two low permeability claystone units that prevent downward contamination migration and 280 feet (ft) of unsaturated bedrock. No contamination has been detected in the Lower $Tnbs_1$ HSU regional aquifer. There are no onsite water-supply wells in the Building 834 OU. In addition, ground water in the Tpsg and Tps-$Tnsc_2$ HSUs is considered an unlikely water-supply source due to poor water quality (total dissolved solid concentrations up to 1,800 milligrams per liter), and extremely low well yield (less than 100 gallons per day in many wells.)

A ground water cleanup standard of 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment than a 5 μg/L MCL cleanup standard because:

- Beneficial uses of ground water in the $Tnbs_1$ HSU regional aquifer, at water-supply wells, and in other HSUs at Site 300 will not be impacted at concentrations above background by contamination in the Tpsg and Tps-$Tnsc_2$ HSUs in the Building 834 OU under Scenarios 1 and 2 (cleanup to MCLs).
- The continued extraction and treatment of ground water until 2.3 μg/L TCE WQNL or 0.5 μg/L background concentrations are achieved (Scenarios 3 through 5) will not increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the Building 834 OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-3.3. Building 834 OU Evaluation Summary

This evaluation shows that the additional expense of remediating ground water at the Building 834 OU from health-protective MCLs (5 μg/L TCE) to the 2.3 μg/L WQNL or 0.5 μg/L background concentrations increases the time to cleanup by 110 years to 330 years (22 to 45%) and the costs by $48M to $144M (22 to 45%), respectively. These analyses show the economic impracticability and extremely low cost benefit of continuing active ground water extraction and treatment until TCE WQNL or background concentrations are achieved.

In addition, although cleanup times and costs under the interim cleanup remedy can be reduced through optimization, the modeling results and cost analyses indicate that it may not be technically or economically feasible to achieve the TCE MCL of 5 μg/L in ground water at the Building 834 OU. This is due to the presence of high concentrations of TCE as a Dense Non-Aqueous Phase Liquid (DNAPL) in the low-permeability Tps-$Tnsc_2$ claystone HSU that may continue to release TCE to ground water into the overlying Tpsg sediments. No proven technologies have been identified capable of addressing TCE in the low permeability Tps-$Tnsc_2$ claystone perching horizon without risk of breaching the integrity of this aquitard that prevents contamination of the underlying $Tnbs_1$ regional aquifer. DOE/LLNL will continue to evaluate

more aggressive, innovative technologies to address DNAPLs in the low-permeability claystone. However, an MCL cleanup standard may not be achievable for Building 834 ground water.

This evaluation concluded that a ground water cleanup standard of MCLs at the Building 834 OU would be protective of human health and the environment. Remediation to a ground water cleanup standard of 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment.

D-4. Pit 6 Landfill OU 3 Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the Pit 6 Landfill OU. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for tritium under two scenarios:

1. Monitored natural attenuation to reduce tritium activities in ground water to the MCL of 20,000 picocuries per liter (pCi/L) (considered as equivalent to cleanup to MCLs in Scenarios 1/2).
2. Monitored natural attenuation to reduce tritium activities in ground water to the background levels of 100 pCi/L (considered as equivalent to cleanup to background in Scenarios 4/5).

Tritium was used in the Pit 6 Landfill OU evaluation because it is the predominant and most extensive ground water COC in this OU. Because tritium activities in ground water at the Pit 6 Landfill are already an order of magnitude below the 20,000 pCi/L tritium MCL, no modeling was conducted and costs were assumed to be $0 for Scenarios 1/2. The monitoring of detection wells immediately downgradient of the landfill to identify any potential new releases, and of guard wells and offsite water-supply wells to indicate any migration of COCs in ground water that could impact human health or the environment would continue under both Scenarios 1/2 and 4/5. Therefore, the cost of this monitoring was not included in these scenarios.

There is no State WQNL for tritium between the MCL and background, therefore an intermediate WQNL cleanup standard scenario was not evaluated. (Note: At the time the guidance for evaluating potential ground water cleanup standards scenarios was written in the Interim Site-Wide ROD and when this evaluation was conducted, there were no intermediate WQLs for tritium between the MCL and background. Since that time, OEHHA has established a 400 pCi/L PHG for tritium.) The model input parameters and assumptions used in estimating cleanup times for Scenarios 4/5 are discussed in Section B-4.3 of Appendix B.

The predicted time for the natural attenuation of tritium in ground water to background levels from Appendix B and estimated costs from Appendix C for Scenarios 4/5 are presented in Table D-2. Figure D-2 presents plots of the cleanup costs over time for the cleanup scenarios. A comparison of the costs and time to cleanup under the potential cleanup standard scenarios are discussed in Sections D-4.1. Section D-4.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-4.1. Comparison of Cleanup Standard Scenarios

D-4.1.1. Scenarios 1/2

Because the maximum tritium activity (1,490 pCi/L) detected in ground water at the Pit 6 Landfill OU in 2005 is already well below the tritium MCL of 20,000 pCi/L, Scenarios 1/2 assume that the: (1) cleanup standard (MCL) has been achieved, and (2) monitoring of tritium plume would be discontinued. Therefore, there would be no costs associated with Scenarios 1/2 for the Pit 6 Landfill OU.

D-4.1.2. Scenario 3

Because no State WQNL for tritium between the MCL and background has been identified at the time this evaluation was conducted, an intermediate WQNL cleanup standard scenario (3) was not evaluated for the Pit 6 Landfill OU.

D-4.1.3. Scenarios 4/5

Modeling results indicate that it would take approximately 35 years for natural attenuation to reduce tritium activities in ground water at the Pit 6 Landfill OU to background concentrations of 100 pCi/L under Scenarios 4/5. The estimated cost to achieve a 100 pCi/L cleanup standard for tritium under these scenarios is $5M.

As indicated in Table D-2, it would take an additional 35 years and cost $5M more to achieve the 100 pCi/L background cleanup standard in ground water than for the 20,000 tritium MCL cleanup standard scenario (1/2).

D-4.2. Protection of Human Health and the Environment

Potential tritium cleanup standards of 20,000 pCi/L State and Federal MCL and 100 pCi/L background were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the Pit 6 Landfill OU. At the time this evaluation was conducted, no intermediate potential cleanup standards based on State WQNLs were identified for tritium.

Tritium activities in Pit 6 Landfill ground water are already an order of magnitude below the State and Federal 20,000 pCi/L MCL. VOC concentrations in ground water are near or below MCLs. Concentrations and the areal extent of both tritium and VOCs in ground water continue to decrease over time. Perchlorate concentrations are below the 6 μg/L Public Health Goal. Therefore, the ground water in this area is already considered safe to drink by EPA and the California DHS, with the exception of ground water from one onsite well that contains nitrate at concentrations above the MCL. The 100 pCi/L background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

The COC plumes are decreasing in size indicating that downgradient ground water is not being degraded. There are no onsite water-supply wells in this area and no contamination is present in downgradient offsite water-supply wells. These offsite water-supply wells will continue to be monitored for any impacts of contamination from the Pit 6 Landfill. Continued monitoring of guard wells will indicate any migration of COCs in ground water that could impact human health or the environment. An engineered landfill cap was installed on the Pit 6

Landfill that has been effective in preventing further releases from the Pit 6 Landfill. Continued detection monitoring of wells immediately downgradient of the landfill will indicate any potential new releases.

A ground water cleanup standard of 100 pCi/L background concentration for tritium would not provide a significantly higher level of protection for human health or the environment than a 20,000 pCi/L MCL cleanup standard because:

- The extent of COC plumes continues to decrease and are not degrading downgradient ground water above background concentrations.
- Beneficial uses of ground water in the Lower $Tnbs_1$ HSU regional aquifer, at water-supply wells, and in downgradient Qt-Tnbs1 HSU ground water will not be impacted at concentrations above background by contamination in the Qt-$Tnbs_1$ HSU in the Pit 6 Landfill OU under Scenarios 1/2 (monitoring of CERCLA compliance wells to MCLs).
- The continued monitoring of tritium in ground water until 100 pCi/L background concentrations are achieved (Scenarios 4/5) will not increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the Pit 6 Landfill OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-4.3. Pit 6 Landfill OU Evaluation Summary

This evaluation shows that the additional 35 years of ground water monitoring required to demonstrate that background activities (100 pCi/L) for tritium have been achieved would increase costs by $5M. This analysis shows the economic impracticability and extremely low cost benefit of continued monitoring of ground water tritium background activities are achieved.

This evaluation concluded that a ground water cleanup standard of MCLs at the Pit 6 Landfill OU would be protective of human health and the environment. Monitoring of ground water until a cleanup standard of 100 pCi/L tritium background activity is reached would not provide a significantly higher level of protection for human health or the environment.

D-5. High Explosives (HE) Process Area OU 4 Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the HE Process Area OU. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for TCE under five scenarios:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.

3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.

TCE was used in the HE Process Area OU evaluation because it is the predominant and most extensive ground water COC in this OU. The 0.5 μg/L TCE analytical detection limit was used as a surrogate for TCE background concentrations. The RDX plume was also modeled, because of its highly sorptive properties, using the extraction wellfield configurations developed for TCE capture. It was assumed that other VOCs, perchlorate, and nitrate in ground water in this OU will be remediated before the TCE plume is remediated. DOE/LLNL evaluated the characteristics of these other COCs (i.e., retardation factors) to support this assumption.

The treatment system, extraction wellfield configurations and capture zones, model input parameters, and assumptions used to estimate cleanup times for these scenarios are discussed in Section B-4.4 of Appendix B.

The predicted time for ground water cleanup from Appendix B and estimated costs from Appendix C under these five scenarios are presented in Table D-3. Figure D-3 presents plots of the cleanup costs over time for the five cleanup scenarios. A comparison of the costs and time to cleanup under the five potential cleanup standard scenarios are discussed in Sections D-5.1. Section D-5.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-5.1. Comparison of Cleanup Standard Scenarios

D-5.1.1. Scenario 1

Modeling results indicate that it would take approximately 120 years to reduce TCE concentrations in ground water at the HE Process Area OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 1 (partial capture) (Table D-3). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $179M.

D-5.1.2. Scenario 2

Modeling results indicate that it would take approximately 110 years to reduce TCE concentrations in ground water at the HE Process Area OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 2 (complete capture). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $232M.

As indicated in Table D-3, it would take 10 years less but cost $53M (23%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.

D-5.1.3. Scenario 3

Modeling results indicate that it would take approximately 120 years to reduce TCE concentrations in ground water at the HE Process Area OU to a cleanup standard of 2.3 μg/L

(Cal/EPA WQNL) under Scenario 3. The estimated cost to achieve a 2.3 μg/L cleanup standard for TCE under this scenario is $253M.

As indicated in Table D-3, it would take the same amount of time (120 years) but cost $74M (29%) more to achieve the 2.3 μg/L WQNL cleanup standard in ground water than to achieve a 5 μg/L MCL cleanup standard under Scenario 1.

D-5.1.4. Scenario 4

Modeling results indicate that it would take approximately 155 years to reduce TCE concentrations in ground water at the HE Process Area OU to background concentrations of 0.5 μg/L with partial capture conditions under Scenario 4. The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $326M.

As indicated in Table D-3, it would take an additional 35 years (23%) and cost $147M (45%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 4 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-5.1.5. Scenario 5

Modeling results indicate that it would take approximately 175 years to reduce TCE concentrations in ground water at the HE Process Area OU to background concentrations of 0.5 μg/L with complete capture conditions under Scenario 5. Section B-4.4 of Appendix B discusses the difference in cleanup times for partial and complete capture of background concentrations (e.g., 155 years for partial capture cleanup versus 175 years for complete capture cleanup). The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $427M.

As indicated in Table D-3, it would take an additional 55 years (31% longer) and cost $248M (58%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 5 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-5.2. Protection of Human Health and the Environment

Potential TCE ground water cleanup standards of 5 μg/L State and Federal MCL, 2.3 μg/L TCE WQNL, or 0.5 μg/L background (detection limit) were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the HE Process Area OU.

The evaluation of the characteristics of other VOCs, perchlorate, and nitrate in ground water supported the assumption that these COCs will be remediated before the TCE plume. When the highly sorptive nature of RDX was considered in the non-optimized modeling scenarios, the cleanup times were extended to hundreds of years. In implementation, DOE/LLNL will continuously monitor the remediation of the RDX plume and minimize further migration of the plume by optimizing the extraction wellfield. The model results suggest that optimization will allow the remediation of the RDX plume, which has a smaller footprint, to be completed within the same duration of the TCE plume cleanup.

To protect human health, the U.S. EPA and California DHS have set standards for drinking water sources. MCLs are Federal and State standards for drinking water sources. Municipal and domestic water suppliers must treat water to meet these standards before distribution to the public. Water that meets these standards is considered safe to drink by the EPA and the

California DHS. The 2.3 μg/L Cal/EPA TCE cancer potency factor WQNL is based on 10^{-6} cancer risk estimates. This WQNL represents levels of contaminants in drinking water that would pose no significant health risk to individuals consuming water on a daily basis over a lifetime. The 0.5 μg/L background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

Even under non-optimized extraction conditions (Scenario 1), modeling indicates that by the time the highest COC plume concentrations in the HE Process Area OU are reduced to below MCLs, COC concentrations in downgradient ground water will be below background. Even under non-optimized extraction conditions, modeling also indicates that COCs in ground water will not impact onsite or offsite water-supply wells or migrate offsite to ground water in the Corral Hollow alluvium above background concentrations during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels. Continued monitoring of guard wells will indicate any migration of COCs in ground water that could impact human health or the environment.

A ground water cleanup standard of the 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment because:

- The beneficial uses of ground water in the Lower $Tnbs_1$ HSU regional aquifer, water-supply wells, and in offsite ground water will not be impacted by contamination in the HE Process Area OU under Scenarios 1/2.
- The continued extraction and treatment of ground water until 2.3 µg/L TCE WQNL or 0.5 µg/L background concentrations are achieved (Scenarios 3 through 5) will not increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the HE Process Area OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-5.3. HE Process Area OU Evaluation Summary

This evaluation shows that:

- It would take 10 years less, but cost $53M (23%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.
- While it would take the same time to remediate TCE in ground water from MCLs (5 μg/L) under Scenario 1 as for cleanup to the 2.3 μg/L WQNL in Scenario 3, it would cost $74M (29%) more to achieve the WQNL cleanup standard.
- Remediating ground water at the HE Process Area OU from health-protective MCLs (5 μg/L) to the 0.5 μg/L background concentrations increases the time to cleanup by 35 to 55 years (23 to 31%) and the costs by $147M to $248M (45 to 58%).

These analyses show the economic impracticability and extremely low cost benefit of: (1) expanding the extraction wellfield to achieve complete capture of the TCE plume with

concentrations above the MCL, or (2) continuing active ground water extraction and treatment until TCE WQNL or background concentrations are achieved.

This evaluation concluded that a ground water cleanup standard of MCLs at the HE Process Area OU would be protective of human health and the environment. Remediation to a ground water cleanup standard of 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment.

D-6. Building 850 Area (OU 5) Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the Building 850 area in OU 5. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for tritium under Scenarios 1/2 and 4/5:

1. Monitored natural attenuation to reduce tritium activities in ground water to the MCL of 20,000 pCi/L (considered as equivalent to cleanup to MCLs in Scenarios 1/2).
2. Monitored natural attenuation to reduce tritium activities in ground water to the background levels of 100 pCi/L (considered as equivalent to cleanup to background in Scenarios 4/5).

Tritium was used in the Building 850 evaluation because it is the predominant and most extensive ground water COC in this portion of OU 5. There is no State WQNL for tritium between the MCL and background, therefore an intermediate WQNL cleanup standard scenario (3) was not evaluated. (Note: At the time the guidance for evaluating potential ground water cleanup standards scenarios was written in the Interim Site-Wide ROD and when this evaluation was conducted, there were no intermediate WQNLs for tritium between the MCL and background. Since that time, OEHHA has been established a 400 pCi/L PHG for tritium.) The model input parameters and assumptions used in estimating cleanup times for Scenarios 1/2 and 4/5 are discussed in Section B-4.5 of Appendix B.

It was assumed that the COC plumes of lesser extent (perchlorate, and nitrate) would be remediated before the tritium plume is remediated. DOE/LLNL evaluated the characteristics of these other COCs (i.e., retardation factors) to support this assumption. Because total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL, and the depleted uranium is not migrating in ground water, this COC was not included in the evaluation.

As requested by the Regional Water Quality Control Board, the tritium plumes originating at both the Pit 7 Complex and the Building 850 firing table were included in the model. By modeling the entire tritium plume in both the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs, the potential impact of the tritium plume originating at the Pit 7 Complex on the Building 850 tritium plume could be evaluated.

The predicted time for ground water cleanup to MCLs and background levels from Appendix B and estimated costs from Appendix C for the cleanup scenarios are presented in Table D-4. Figure D-4 presents plots of the cleanup costs over time for the two cleanup scenarios. A comparison of the costs and time to cleanup under the two potential cleanup standard scenarios are discussed in Sections D-6.1. Section D-6.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-6.1. Comparison of Cleanup Standard Scenarios

D-6.1.1. Scenarios 1/2

Modeling results indicate that it would take approximately 40 years for natural attenuation to reduce tritium activities in the Building 850 ground water to the MCL (20,000 pCi/L) under Scenario 1. The estimated cost for monitoring until the MCL cleanup standard is achieved for tritium under this scenario is $17M.

D-6.1.2. Scenario 3

Because no State WQNL for tritium between the MCL and background had been identified at the time this evaluation was conducted, an intermediate WQNL cleanup standard scenario (3) was not evaluated for the Building 850 area in OU 5.

D-6.1.3. Scenarios 4/5

Modeling results indicate that it would take approximately 135 years for natural attenuation to reduce tritium activities in ground water at the Building 850 to background concentrations of 100 pCi/L under Scenario 2. The estimated cost to monitor until a 100 pCi/L cleanup standard for tritium is achieved under this scenario is $57M.

As indicated in Table D-4, it would take an additional 95 years and cost $40M (70%) more to continue monitoring until the 100 pCi/L background cleanup standard in ground water is achieved than for the 20,000 tritium MCL cleanup standard scenarios (1/2).

D-6.2. Protection of Human Health and the Environment

Potential tritium cleanup standards of 20,000 pCi/L State and Federal MCL and 100 pCi/L background were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the Building 850 area of OU 5. At the time this evaluation was conducted, there were no intermediate potential cleanup standards based on State WQNLs identified for tritium. The 100 pCi/L background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

Tritium activities in ground water continue to decline both in the Building 850 source area and throughout the length of the plumes in both the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs over time. The extent of the tritium in ground water with activities above the MCL continues to decrease. The tritium activities originating from the Pit 7 Complex do not significantly increasing tritium activities in the Building 850 tritium plume in the Qal/WBR or $Tnbs_1$/$Tnbs_0$ HSUs. While the extent of the tritium plume in $Tnbs_1$/$Tnbs_0$ HSU ground water with activities above 100 pCi/L increased between 1998 and 2005, there is no ground water pathway from this HSU to onsite or offsite receptor points. The significant decreases in activities and extent of the tritium plume with activities exceeding the MCL indicate that natural attenuation (radioactive decay) continues to be effective in reducing tritium activities in ground water and protective of human health. Total uranium activities in Building 850 ground water remain below the 20 pCi/L MCL and the areal extent of depleted uranium has not changed. The extent of nitrate in the ground water above its 45 mg/L MCL is localized in the area downgradient of the Building 850 septic system leachfield.

Even under non-optimized extraction conditions (Scenario 1), modeling indicates that COCs in ground water will not impact offsite water-supply wells or migrate offsite above background levels during the time it takes for COCs to naturally attenuate to background levels. There are no water-supply wells located in the OU. Modeling also indicates that by the time the highest COC plume concentrations are reduced to below MCLs, COC concentrations in downgradient ground water will be near or below background. Continued monitoring of guard wells will indicate any migration of COCs in ground water that could impact human health or the environment.

A ground water cleanup standard of 100 pCi/L background concentration for tritium would not provide a significantly higher level of protection for human health or the environment than a 20,000 pCi/L MCL cleanup standard because:

- Beneficial uses of ground water at water-supply wells, and in offsite ground water will not be impacted at concentrations above background by contamination in the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs in the Building 850 OU under Scenarios 1/2 (monitoring of CERCLA compliance wells until the tritium MCL are achieved).
- The continued monitoring of tritium in ground water until 100 pCi/L background concentrations are achieved (Scenario 2) will not increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the Building 850 OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-6.3. Building 850 Area Evaluation Summary

This evaluation shows that it would require an additional 95 years of ground water monitoring to demonstrate that background concentrations (100 pCi/L) have been achieved and would cost $40M (70%) more under Scenarios 4/5 than required for monitoring until MCLs are achieved under Scenarios 1/2. This analysis shows the economic impracticability and extremely low cost benefit of continued monitoring of ground water tritium until background concentrations are achieved.

This evaluation concluded that a ground water cleanup standard of MCLs at the Building 850 area would be protective of human health and the environment. Monitoring of ground water until a cleanup standard of 100 pCi/L tritium background concentration is reached would not provide a significantly higher level of protection for human health or the environment.

D-7. Building 854 OU 6 Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the Building 854 OU. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for TCE under five scenarios:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.

2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.

TCE was used in the Building 854 OU evaluation because it is the predominant and most extensive ground water COC in this OU. The 0.5 μg/L TCE analytical detection limit was used as a surrogate for TCE background concentrations. It was assumed that other VOC, perchlorate, and nitrate plumes of lesser extent would be remediated before the TCE plume is remediated. DOE/LLNL evaluated the characteristics of these other COCs (i.e., retardation factors) to support this assumption.

The treatment system, extraction wellfield configurations and capture zones, model input parameters, and assumptions used to estimate cleanup times for these scenarios are discussed in Section B-4.6 of Appendix B.

The predicted time for ground water cleanup from Appendix B and estimated costs from Appendix C under these five scenarios are presented in Table D-5. Figure D-5 presents plots of the cleanup costs over time for the five cleanup scenarios. A comparison of the costs and time to cleanup under the five potential cleanup standards are discussed in Sections D-7.1. Section D-7.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-7.1. Comparison of Cleanup Standard Scenarios

D-7.1.1. Scenario 1

Modeling results indicate that it would take approximately 90 years to reduce TCE concentrations in ground water at the Building 854 OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 1 (partial capture). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $80M.

D-7.1.2. Scenario 2

Modeling results indicate that it would take approximately 90 years to reduce TCE concentrations in ground water at the Building 854 OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 2 (complete capture). Section B-4.6 of Appendix B discusses the cleanup times for partial and complete capture of MCL concentrations (e.g., 90 years for both partial capture [Scenario 4] and complete capture [Scenario 5] cleanup). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $139M.

As indicated in Table D-5, it would take the same amount of time (90 years), but cost $59M (42%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete

hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.

D-7.1.3. Scenario 3

Modeling results indicate that it would take approximately 95 years to reduce TCE concentrations in ground water at the Building 854 OU to a cleanup standard of 2.3 μg/L (Cal/EPA WQNL) under Scenario 3. The estimated cost to achieve a 2.3 μg/L cleanup standard for TCE under this scenario is $146M.

As indicated in Table D-5, it would only take an additional 5 years but cost $66M (45%) more to achieve the 2.3 μg/L WQNL cleanup standard in ground water than to achieve a 5 μg/L MCL cleanup standard under Scenario 1.

D-7.1.4. Scenario 4

Modeling results indicate that it would take approximately 120 years to reduce TCE concentrations in ground water at the Building 854 OU to background concentrations of 0.5 μg/L with partial capture conditions under Scenario 4. The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $184M.

As indicated in Table D-5, it would take an additional 30 years (25% longer) and cost $104M (56%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 4 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-7.1.5. Scenario 5

Modeling results indicate that it would take approximately 120 years to reduce TCE concentrations in ground water at the Building 854 OU to background concentrations of 0.5 μg/L with complete capture conditions under Scenario 5. Section B-4.6 of Appendix B discusses the cleanup times for partial and complete capture of background concentrations (e.g., 120 years for both partial capture [Scenario 4] and complete capture [Scenario 5] cleanup). The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $188M.

As indicated in Table D-5, it would take an additional 30 years (25% longer) and cost $108M (57%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 5 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-7.2. Protection of Human Health and the Environment

Potential TCE ground water cleanup standards of 5 μg/L State and Federal MCL, 2.3 μg/L TCE WQNL, or 0.5 μg/L background (detection limit) were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the Building 854 OU. The evaluation of the characteristics of other VOCs, perchlorate, and nitrate in ground water supported the assumption that these COCs will be remediated before the TCE plume.

To protect human health, the U.S. EPA and California DHS have set standards for drinking water sources. MCLs are Federal and State standards for drinking water sources. Municipal and domestic water suppliers must treat water to meet these standards before distribution to the public. Water that meets these standards is considered safe to drink by EPA and the California DHS. The 2.3 μg/L Cal/EPA TCE cancer potency factor WQNL is based on 10^{-6} cancer risk

estimates. This WQNL represent levels of contaminants in drinking water that would pose no significant health risk to individuals consuming water on a daily basis over a lifetime. The 0.5 μg/L background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

Modeling indicates that by the time the highest COC plume concentrations in the Building 854 OU are reduced to below MCLs, COC concentrations in downgradient ground water will be near or below background. Even under non-optimized extraction conditions (Scenario 1), modeling also indicates that COCs in ground water will not impact onsite or offsite water-supply wells or migrate offsite above background concentrations during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels. Continued monitoring of guard wells will indicate any migration of COCs in ground water that could impact human health or the environment.

A ground water cleanup standard of the 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment because:

- The beneficial uses of ground water in onsite or offsite water-supply wells, and in offsite ground water will not be impacted by contamination in the Building 854 OU during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels.
- The continued extraction and treatment of ground water until 2.3 μg/L TCE WQNL or 0.5 μg/L background concentrations are achieved (Scenarios 3 through 5) will not increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the Building 854 OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-7.3. Building 854 OU Evaluation Summary

This evaluation show that:

- Although it would take the same amount of time (90 years), it would cost $59M (42%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.
- While it would only take 5 more years to remediate TCE in ground water from MCLs (5 μg/L) under Scenario 1 as for cleanup to the 2.3 μg/L WQNL in Scenario 3, it would cost $66M (45%) more to achieve the WQNL cleanup standard.
- Remediating ground water at the Building 854 OU from health-protective MCLs (5 μg/L) to 0.5 μg/L background concentrations increases the time to cleanup by 30 years (25%) and the costs by $104M (56%) for partial capture of background concentrations to $108M (57%) for complete capture.

These analyses clearly show the economic impracticability and extremely low cost benefit of: (1) expanding the extraction wellfield to achieve complete capture of the TCE plume with concentrations above the MCL, or (2) continuing active ground water extraction and treatment until TCE WQNL or background concentrations are achieved.

This evaluation concluded that a ground water cleanup standard of MCLs at the Building 854 OU would be protective of human health and the environment. Remediation to a ground water cleanup standard of 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment.

D-8. Building 832 Canyon OU 7 Evaluation Results

This section presents the results of the potential ground water cleanup standard evaluation for the Building 832 Canyon OU. This evaluation compares the estimated costs and predicted time to achieve potential ground water cleanup standards for TCE under five scenarios:

1. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
2. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the MCL of 5 μg/L followed by natural attenuation to further reduce concentrations to background levels.
3. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to the WQNL of 2.3 μg/L (Cal/EPA 10^{-6} cancer risk) followed by natural attenuation to further reduce concentrations to background levels.
4. Ground water extraction with partial hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.
5. Ground water extraction with complete hydraulic capture to reduce TCE concentrations to background concentrations of 0.5 μg/L.

TCE was used in the Building 832 Canyon OU evaluation because it is the predominant and most extensive ground water COC in this OU. The 0.5 μg/L TCE analytical detection limit was used as a surrogate for TCE background concentrations. It was assumed that other VOC, perchlorate, and nitrate plumes of lesser extent would be remediated before the TCE plume is remediated. DOE/LLNL evaluated the characteristics of these other COCs (i.e., retardation factors) to support this assumption.

The treatment system, extraction wellfield configurations and capture zones, model input parameters, and assumptions used to estimate cleanup times for these scenarios are discussed in Section B-4.7 of Appendix B.

The predicted time for ground water cleanup from Appendix B and estimated costs from Appendix C under these five scenarios are presented in Table D-6. Figure D-6 presents plots of the cleanup costs over time for the five cleanup scenarios. A comparison of the costs and time to cleanup under the five potential cleanup standard scenarios are discussed in Sections D-8.1.

Section D-8.2 compares the level of protection for human health and the environment provided by the cleanup standards scenarios.

D-8.1. Comparison of Cleanup Standard Scenarios

D-8.1.1. Scenario 1

Modeling results indicate that it would take approximately 149 years to reduce TCE concentrations in ground water at the Building 832 Canyon OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 1 (partial capture). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $158M.

D-8.1.2. Scenario 2

Modeling results indicate that it would take approximately 149 years to reduce TCE concentrations in ground water at the Building 832 Canyon OU to a cleanup standard of 5 μg/L (TCE MCL) under Scenario 2 (complete capture). Section B-4.7 of Appendix B discusses the cleanup times for partial and complete capture of MCL concentrations (e.g., 149 years for both partial capture [Scenario 1] and complete capture [Scenario 2] cleanup). The estimated cost to achieve an MCL cleanup standard for TCE under this scenario is $261M.

As indicated in Table D-6, it would take the same amount of time (149 years) but cost $103M (40%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.

D-8.1.3. Scenario 3

Modeling results indicate that it would take approximately 187 years to reduce TCE concentrations in ground water at the Building 832 Canyon OU to a cleanup standard of 2.3 μg/L (Cal/EPA WQNL) under Scenario 3. The estimated cost to achieve a 2.3 μg/L cleanup standard for TCE under this scenario is $326M.

As indicated in Table D-6, it would take an additional 38 years (20% longer) and cost $168M (52%) more to achieve the 2.3 μg/L WQNL cleanup standard in ground water than to achieve a 5 μg/L MCL cleanup standard under Scenario 1.

D-8.1.4. Scenario 4

Modeling results indicate that it would take approximately 263 years to reduce TCE concentrations in ground water at the Building 832 Canyon OU to background concentrations of 0.5 μg/L with partial capture conditions under Scenario 4. The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $458M.

As indicated in Table D-6, it would take an additional 114 years (43% longer) and cost $300M (66%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 4 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-8.1.5. Scenario 5

Modeling results indicate that it would take approximately 263 years to reduce TCE concentrations in ground water at the Building 832 Canyon OU to background concentrations of 0.5 μg/L with complete capture conditions under Scenario 5. Section B-4.7 of Appendix B

discusses the cleanup times for partial and complete capture of background concentrations (e.g., 263 years for both partial capture [Scenario 4] and complete capture [Scenario 5] cleanup). The estimated cost to achieve a 0.5 μg/L cleanup standard for TCE under this scenario is $458M.

As indicated in Table D-6, it would take an additional 114 years (43% longer) and cost $300M (66%) more to achieve the 0.5 μg/L background cleanup standard in ground water under Scenario 5 conditions than to achieve a 5 μg/L TCE MCL cleanup standard under Scenario 1.

D-8.2. Protection of Human Health and the Environment

Potential TCE ground water cleanup standards of 5 μg/L State and Federal MCL, 2.3 μg/L TCE WQNL, or 0.5 μg/L background (detection limit) were evaluated to determine the relative level of protection for human health and the environment afforded by ground water cleanup to these levels at the Building 832 Canyon OU. The evaluation of the characteristics of other VOCs, perchlorate, and nitrate in ground water supported the assumption that these COCs will be remediated before the TCE plume.

To protect human health, the U.S. EPA and California DHS have set standards for drinking water sources. MCLs are Federal and State standards for drinking water sources. Municipal and domestic water suppliers must treat water to meet these standards before distribution to the public. Water that meets these standards is considered safe to drink by EPA and the California DHS. The 2.3 μg/L Cal/EPA TCE cancer potency factor WQNL is based on 10^{-6} cancer risk estimates. This WQNL represent levels of contaminants in drinking water that would pose no significant health risk to individuals consuming water on a daily basis over a lifetime. The 0.5 μg/L background concentration is based on the SWRCB Resolution 68-16 (anti-degradation policy) to protect beneficial uses of ground water and is not linked to any human health protection goal.

COCs in ground water will not likely impact onsite or offsite water-supply wells or migrate offsite above background concentrations during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels. While TCE may migrate toward the site boundary at concentrations below the MCL but above background, the plume will not be detectable at the site boundary where $Tnsc_{1b}$ and upper $Tnbs_1$ HSU ground water discharges into the more permeable Qal HSU in the Corral Hollow Creek floodplain. The beneficial uses of ground water in the Lower $Tnbs_1$ HSU regional aquifer, water-supply wells, and in offsite ground water will not likely be impacted by contamination in the Building 832 Canyon OU. Continued monitoring of guard wells will indicate any migration of COCs in ground water that could impact human health or the environment.

A ground water cleanup standard of the 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment because:

- The beneficial uses of ground water in the $Tnbs_1$ regional aquifer, onsite or offsite water-supply wells, and in offsite ground water will not likely be impacted by contamination in the Building 832 Canyon OU during the time it takes for the COCs to naturally attenuate from MCL concentrations to background levels.
- The continued extraction and treatment of ground water until 2.3 μg/L TCE WQNL or 0.5 μg/L background concentrations are achieved (Scenarios 3 through 5) will not

increase the level of protection to downgradient offsite receptors, onsite workers, or the environment.

A ground water cleanup standard of MCLs for the Building 832 Canyon OU will be protective of human health and the environment. The Contingency Plan provides a mechanism to address unexpected plume migration or other changes in conditions that could impact human health or the environment.

D-8.3. Building 832 Canyon OU Evaluation Summary

This evaluation shows that:

- Although it would take the same amount of time (149 years), it would cost $103M (39%) more to achieve the 5 μg/L TCE MCL cleanup standard in ground water with complete hydraulic capture of the TCE plume in Scenario 2 than for the partial capture of the TCE plume in Scenario 1.
- It would require an additional 38 years and cost $168M (52%) more to remediate TCE in ground water to the 2.3 μg/L WQNL in Scenario 2 than for cleanup to MCLs (5 μg/L) under Scenario 1.
- Remediating ground water at the Building 832 Canyon OU from health-protective MCLs (5 μg/L) under Scenario 1 to the 0.5 μg/L background concentrations in Scenarios 4 and 5 increases the time to cleanup by 114 years (43%) and the costs by $300M (66%).

These analyses show the economic impracticability and extremely low cost benefit of: (1) expanding the extraction wellfield to achieve complete capture of the TCE plume with concentrations above the MCL, or (2) continuing active ground water extraction and treatment until TCE WQNL or background concentrations are achieved.

This evaluation concluded that a ground water cleanup standard of MCLs at the Building 832 Canyon OU would be protective of human health and the environment. Remediation to a ground water cleanup standard of 2.3 μg/L TCE WQNL or 0.5 μg/L background concentration would not provide a significantly higher level of protection for human health or the environment.

D-9. Cleanup Standard Evaluation Summary

As agreed in the Interim Site-Wide ROD, DOE/LLNL conducted an evaluation to determine the technical and economic feasibility of achieving various potential ground water cleanup standards.

The evaluation results demonstrate the economic impracticability and very low cost benefit associated with attempting to reduce COC concentrations in ground water below MCLs to more stringent water quality objectives or background. The evaluation also concluded that a ground water cleanup standard of MCLs at Site 300 would be protective of human health and the environment. A ground water cleanup standard of the 2.3 μg/L TCE WQNL or 0.5 μg/L TCE and 100 pCi/L tritium background concentration would not provide a significantly higher level of protection for human health or the environment.

Subsequent to preparation of this evaluation, DOE, the U.S. EPA, DTSC, and the RWQCB agreed that the evaluation of potential ground water cleanup standards contained in Appendices B, C, and D of this report will not be used to support the selection of ground water

cleanup standards in the Site-Wide ROD. However, the evaluation of potential ground water cleanup standards contained in these appendices is retained in this report to demonstrate and document DOE's compliance with the requirements of the Interim Site-Wide ROD.

D-10. References

Gregory, S., V. Madrid, L. Ferry, R. Halden, Z. Demir (2002), *Interim Remedial Design for the Building 834 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-144919).

Appendix D

Figures

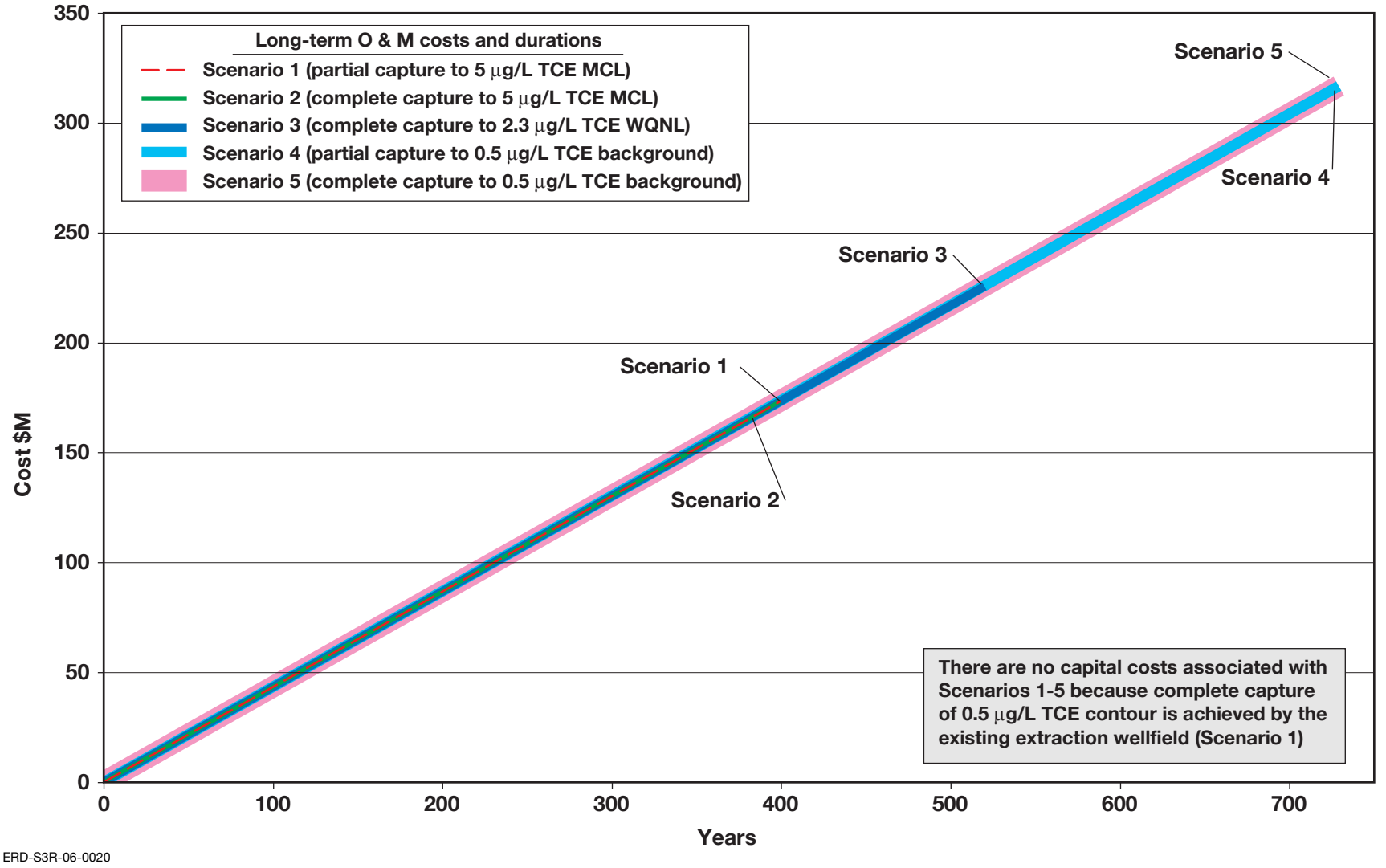

Figure D-1. Comparison of ground water cleanup standard scenarios 1 through 5 for the Building 834 OU.

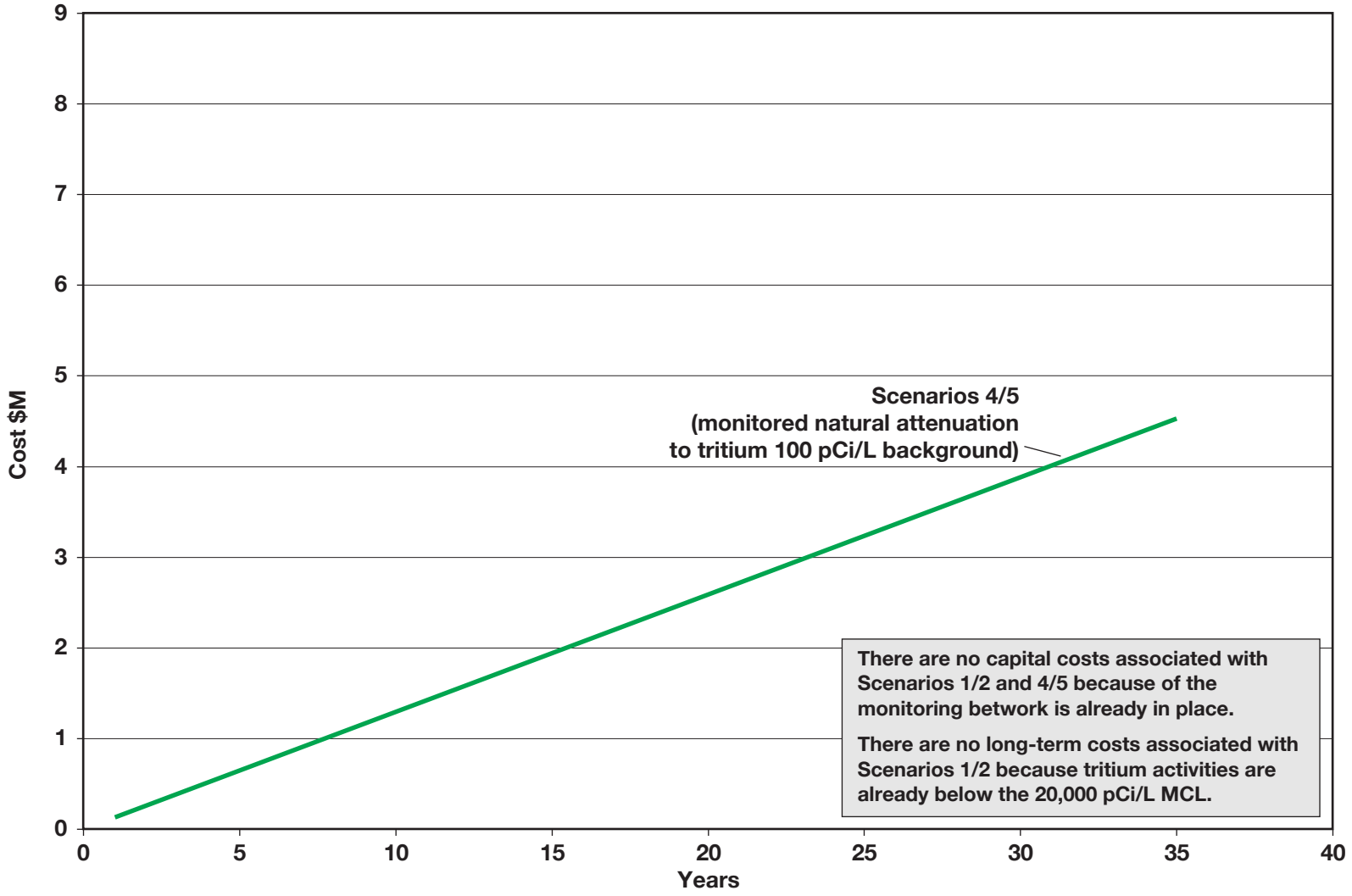

Figure D-2. Long-term monitoring cost and duration of ground water cleanup standard scenarios 4/5 for the Pit 6 Landfill OU.

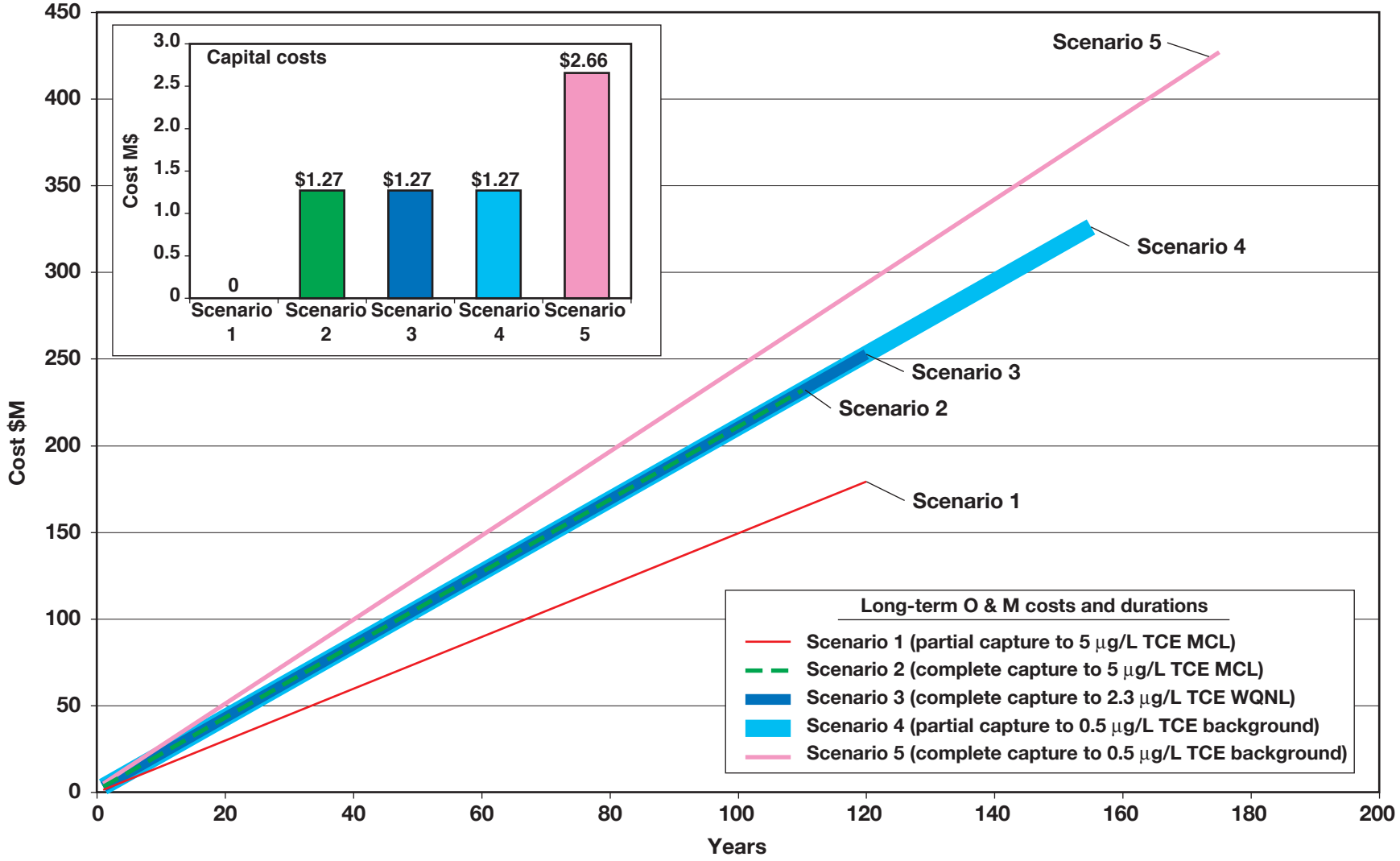

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Figure D-3. Comparison of ground water cleanup standard scenarios 1 through 5 for the HE Process Area OU.

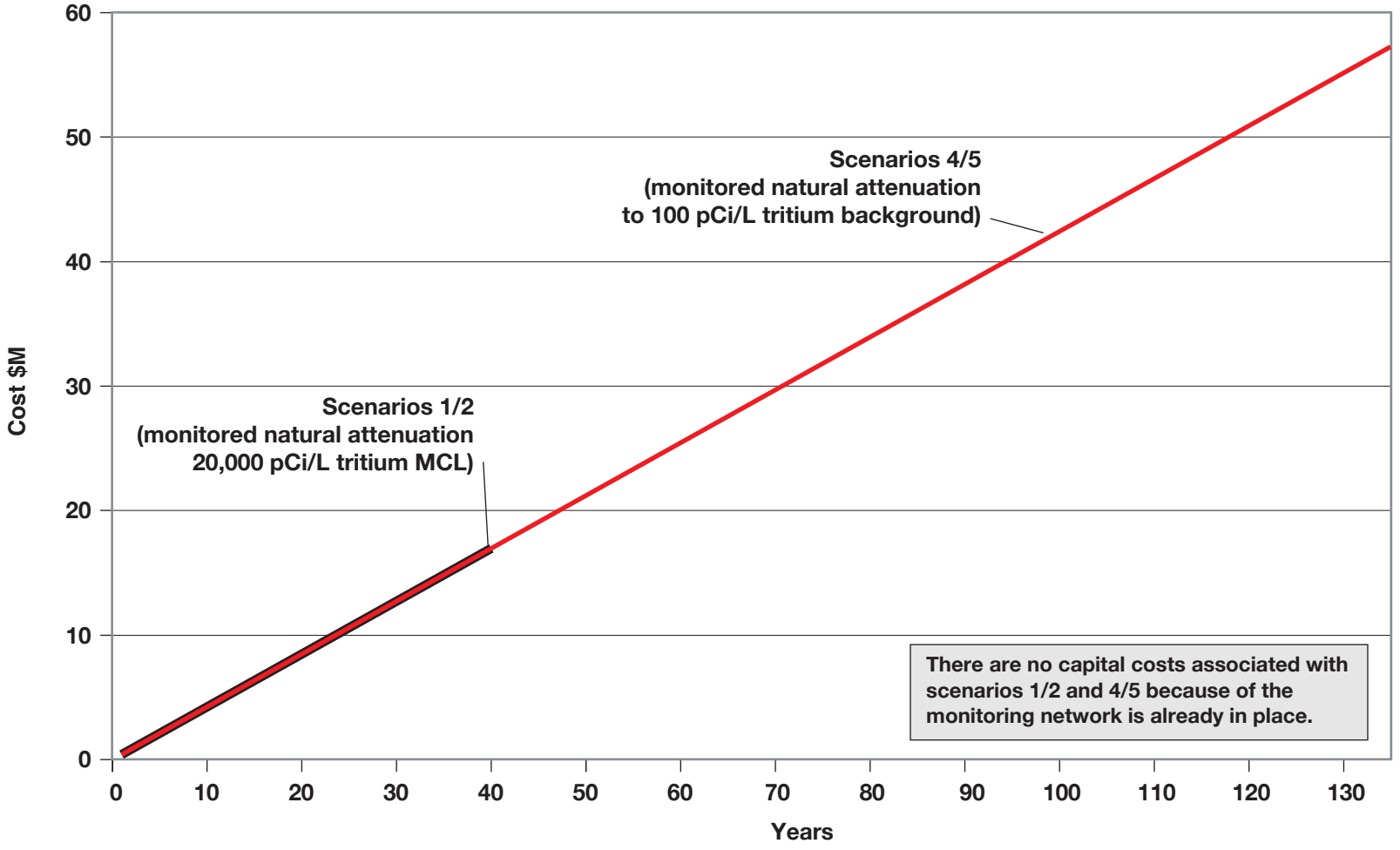

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Figure D-4. Comparison of long-term monitoring cost and durations for ground water cleanup standard scenarios 1/2 and 4/5 for the Building 850 Area OU.

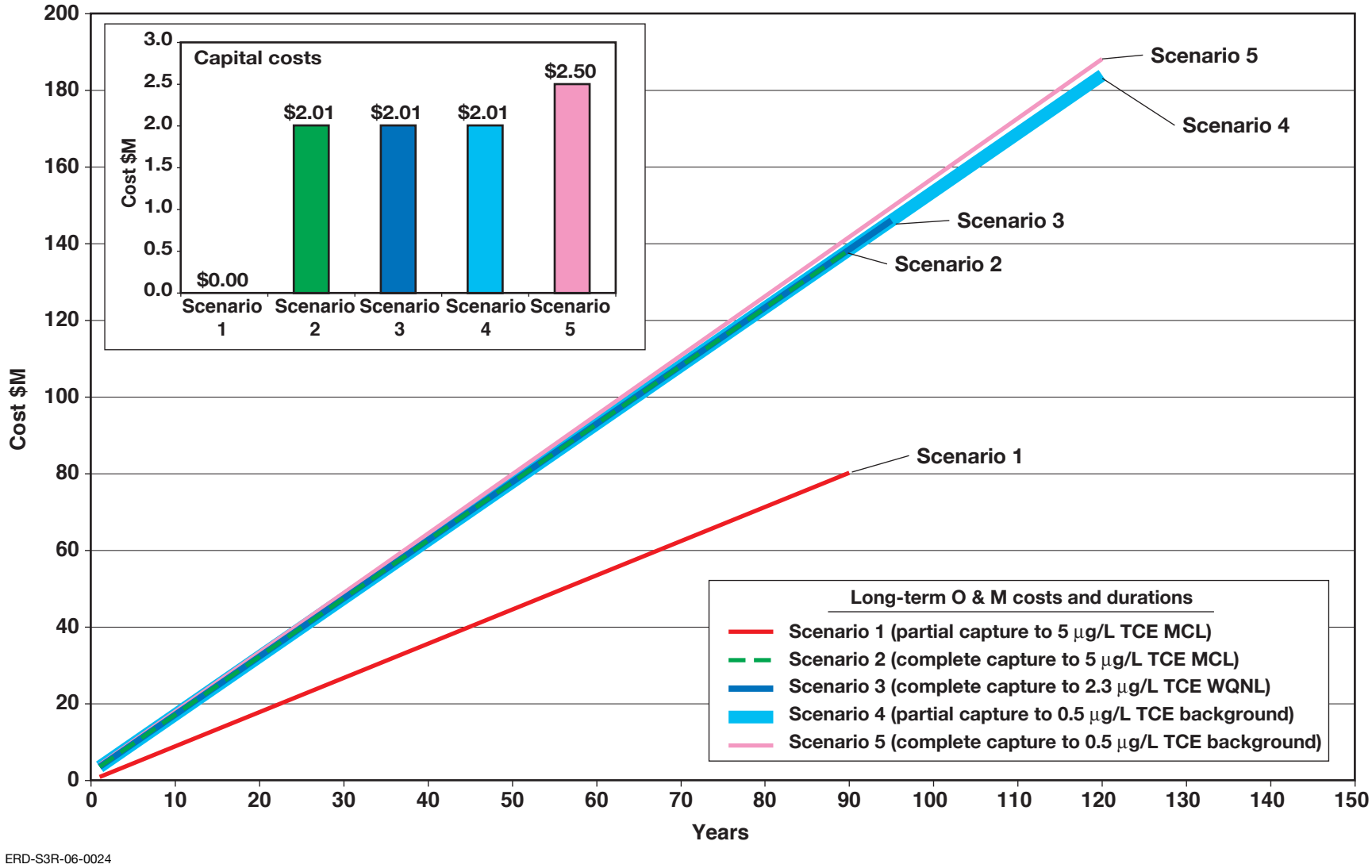


Figure D-5. Comparison of ground water cleanup standard scenarios 1 through 5 for the Building 854 OU.

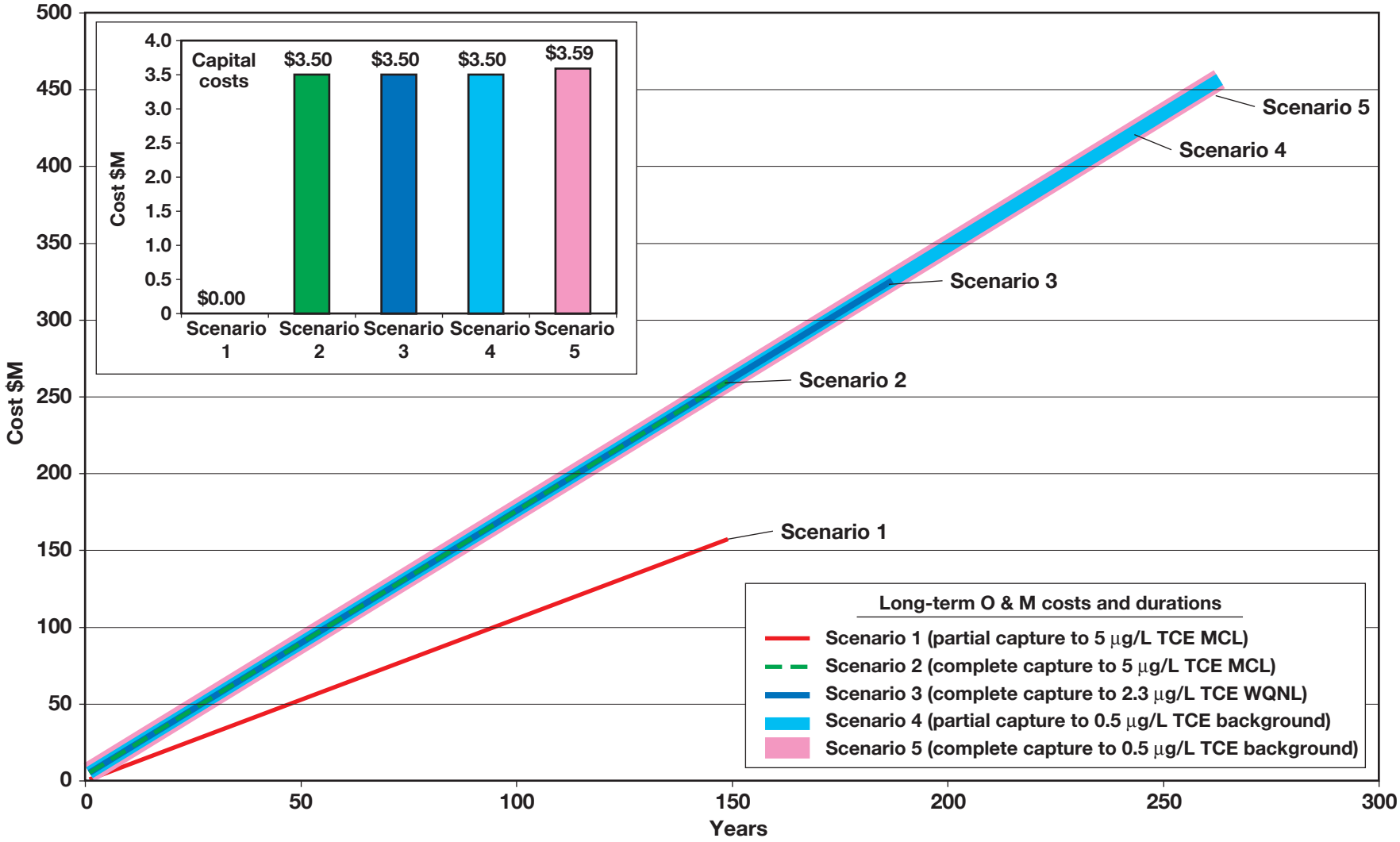
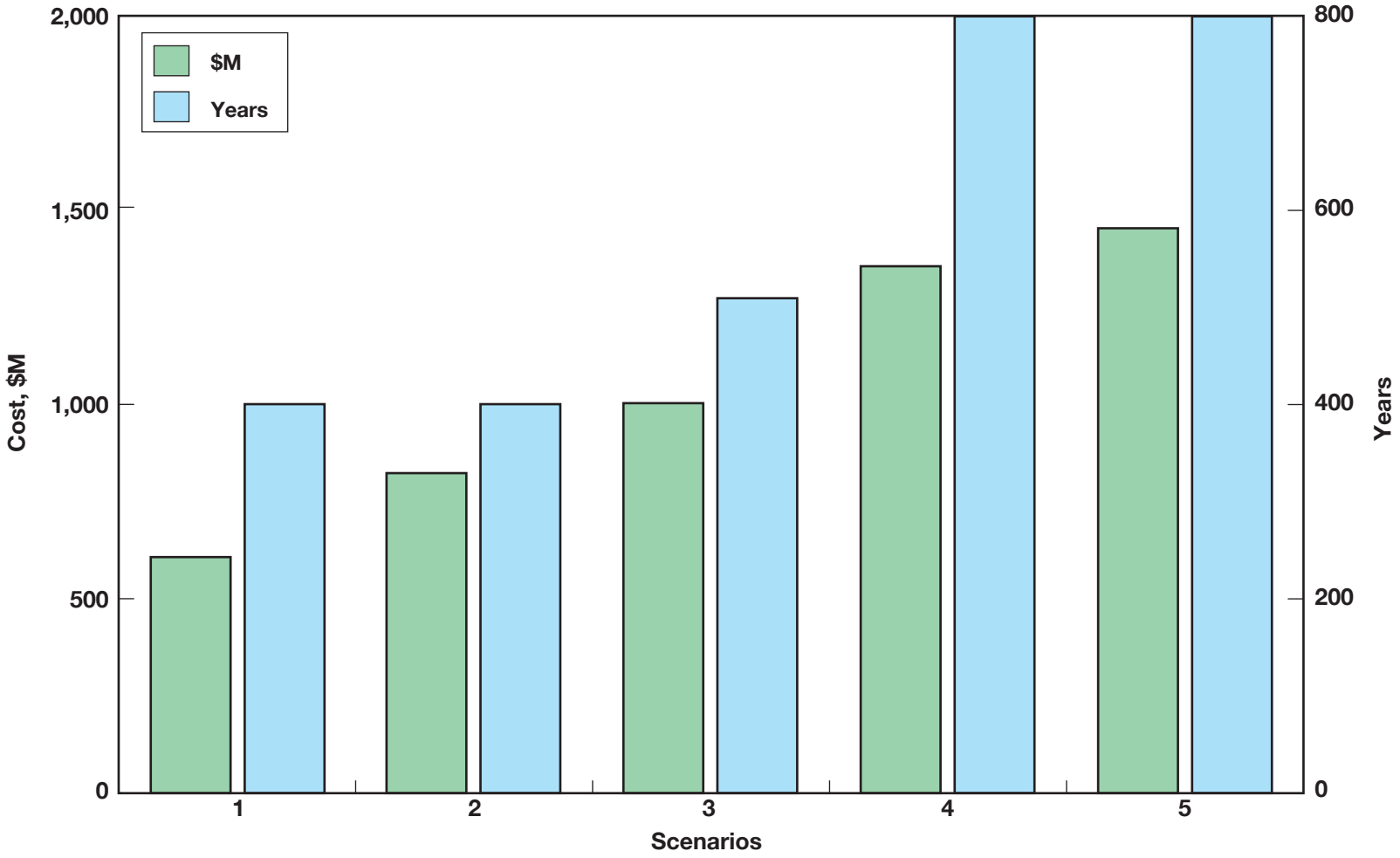


Figure D-6. Comparison of ground water cleanup standard scenarios 1 through 5 for the Building 832 OU.



Note: Cleanup costs presented are based on the sum of the costs for all OUs under each scenario. Cleanup times presented are based on the longest estimated OU cleanup time (Building 834 OU)

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Figure D-7. Total project cleanup costs and times to meet potential cleanup standards.

Appendix D

Tables

Table D-1. Summary of time and costs for Building 834 OU ground water cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1. Partial capture; cleanup to TCE MCL (5 μg/L)	400	174
2. Complete capture; cleanup to TCE MCL (5 μg/L)	400	174
3. Complete capture; cleanup to TCE Cal/EPA WQNL (2.3 μg/L)	510	222
4. Partial capture; cleanup to TCE background (0.5 μg/L)	730	317
5. Complete capture; cleanup to TCE background (0.5 μg/L)	730	317

Notes:

Cal/EPA = California Environmental Protection Agency.
MCL = Maximum contaminant level.
OU = Operable unit.
TCE = Trichloroethylene.
WQNL = Water quality numeric limit.
μg/L = Micrograms per liter.
$M = Millions of dollars.

Table D-2. Summary of time and costs for Pit 6 Landfill OU ground water cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1/2. Monitored natural attenuation: cleanup to tritium MCL (20,000 pCi/L)	NA	0
3. Monitored natural attenuation: cleanup to tritium WQNL (Not applicable [NA])	NA	NA
4/5. Monitored natural attenuation: cleanup to tritium background (100 pCi/L)	35	5

Notes:

MCL = Maximum contaminant level.
NA = Not applicable.
OU = Operable unit.
pCi/L = Picocuries per liter.
WQNL = Water quality numeric limit.
$M = Millions of dollars.

Table D-3. Summary of time and costs for the High Explosives Process Area OU ground water cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1. Partial capture; cleanup to TCE MCL (5 μg/L)	120	179
2. Complete capture; cleanup to TCE MCL (5 μg/L)	110	232
3. Complete capture; cleanup to TCE Cal/EPA WQNL (2.3 μg/L)	120	253
4. Partial capture; cleanup to TCE background (0.5 μg/L)	155	326
5. Complete capture; cleanup to TCE background (0.5 μg/L)	175	427

Notes:

Cal/EPA = California Environmental Protection Agency.
MCL = Maximum contaminant level.
OU = Operable unit.
TCE = Trichloroethylene.
WQNL = Water quality numeric limit.
μg/L = Micrograms per liter.
$M = Millions of dollars.

Table D-4. Summary of time and costs for Building 850 ground water cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1/2. Monitored natural attenuation; cleanup to tritium MCL (20,000 pCi/L)	40	17
3. Monitored natural attenuation: cleanup to tritium WQNL (Not applicable [NA])	NA	NA
4/5. Monitored natural attenuation; cleanup to tritium background (100 pCi/L)	135	57

Notes:

MCL = Maximum contaminant level.
NA = Not applicable.
OU = Operable unit.
pCi/L = Picocuries per liter.
WQNL = Water quality numeric limit.
$M = Millions of dollars.

Table D-5. Summary of time and costs for Building 854 OU ground water cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1. Partial capture; cleanup to TCE MCL (5 μg/L)	90	80
2. Complete capture; cleanup to TCE MCL (5 μg/L)	90	139
3. Complete capture; cleanup to TCE Cal/EPA WQNL (2.3 μg/L)	95	146
4. Partial capture; cleanup to TCE background (0.5 μg/L)	120	184
5. Complete capture; cleanup to TCE background (0.5 μg/L)	120	188

Notes:
Cal/EPA = California Environmental Protection Agency.
MCL = Maximum contaminant level.
OU = Operable unit.
TCE = Trichloroethylene.
WQNL = Water quality numeric limit.
μg/L = Micrograms per liter.
$M = Millions of dollars.

Table D-6. Summary of time and costs for Building 832 Canyon OU cleanup scenarios.

Cleanup scenarios	Estimated time to achieve potential cleanup standard (years)	Total project cost to achieve potential cleanup standard ($M)
1. Partial capture; cleanup to TCE MCL (5 μg/L)	149	158
2. Complete capture; cleanup to TCE MCL (5 μg/L)	149	261
3. Complete capture; cleanup to TCE Cal/EPA WQNL (2.3 μg/L)	187	326
4. Partial capture; cleanup to TCE background (0.5 μg/L)	263	458
5. Complete capture; cleanup to TCE background (0.5 μg/L)	263	458

Notes:
Cal/EPA = California Environmental Protection Agency.
MCL = Maximum contaminant level.
OU = Operable unit.
TCE = Trichloroethylene.
WQNL = Water quality numeric limit.
μg/L = Micrograms per liter.
$M = Millions of dollars.