FINAL 2004 ANNUAL GROUNDWATER MONITORING REPORT AND QUARTERLY GROUNDWATER MONITORING REPORT, QUARTER 4, 2004, OPERABLE UNIT 1 FRITZSCHE ARMY AIRFIELD FIRE DRILL AREA FORMER FORT ORD, CALIFORNIA

PROJECT: Fixed-Price Remediation with Insurance Delivery Order for Operable Unit 1, Former Fort Ord, California (Delivery Order CM01)

CLIENT: U.S. Army Corps of Engineers

CONTRACT NUMBER: DACA45-03-D-0029

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<td>ACL</td>
<td>aquifer cleanup level</td>
</tr>
<tr>
<td>AHTNA</td>
<td>AHTNA Government Services Corporation</td>
</tr>
<tr>
<td>BCT</td>
<td>BRAC Cleanup Team</td>
</tr>
<tr>
<td>bgs</td>
<td>below ground surface</td>
</tr>
<tr>
<td>BRAC</td>
<td>Base Realignment and Closure</td>
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<td>CalEPA</td>
<td>California Environmental Protection Agency</td>
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<tr>
<td>COC</td>
<td>contaminant of concern</td>
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<td>DCE</td>
<td>dichloroethene</td>
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<td>EDS</td>
<td>Environmental Data Services</td>
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<td>Fritzsche Army Air Field</td>
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<td>FDA</td>
<td>Fire Drill Area</td>
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<td>FODIS</td>
<td>Fort Ord Data Integration System</td>
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<td>FONR</td>
<td>Fort Ord Natural Reserve</td>
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<tr>
<td>FPRI</td>
<td>Fixed-Price Remediation with Insurance</td>
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<tr>
<td>GAC</td>
<td>granular activated carbon</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
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<tr>
<td>GWETS</td>
<td>groundwater extraction and treatment system</td>
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<td>HLA</td>
<td>Harding Lawson Associates</td>
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<td>HMP</td>
<td>Habitat Management Plan</td>
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<td>HGL</td>
<td>HydroGeoLogic, Inc.</td>
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<tr>
<td>LBNL</td>
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<tr>
<td>LCS</td>
<td>laboratory control sample</td>
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<td>LTM</td>
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<tr>
<td>µg/L</td>
<td>micrograms per liter</td>
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<td>MACTEC</td>
<td>MACTEC Engineering and Consulting, Inc.</td>
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<td>MCL</td>
<td>maximum contaminant level</td>
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<td>methyl ethyl ketone</td>
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<td>matrix spike</td>
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<td>MSD</td>
<td>matrix spike duplicate</td>
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<tr>
<td>msl</td>
<td>mean sea level</td>
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<tr>
<td>ND</td>
<td>non-detect</td>
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<tr>
<td>Acronym</td>
<td>Definition</td>
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<tr>
<td>NPL</td>
<td>National Priorities List</td>
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<tr>
<td>O&amp;M</td>
<td>operation and maintenance</td>
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<td>PDB</td>
<td>passive diffusion bag</td>
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<td>QA</td>
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<td>Sampling and Analysis Plan</td>
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<td>SVA</td>
<td>Salinas Valley Aquiclude</td>
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<td>TCE</td>
<td>trichloroethene</td>
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<tr>
<td>Tech Memo</td>
<td>technical memorandum</td>
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<tr>
<td>TPH</td>
<td>total petroleum hydrocarbons</td>
</tr>
<tr>
<td>UCNRS</td>
<td>University of California Natural Reserve System</td>
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<tr>
<td>USACE</td>
<td>U.S. Army Corps of Engineers</td>
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<tr>
<td>USEPA</td>
<td>U.S. Environmental Protection Agency</td>
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<td>VOC</td>
<td>volatile organic compound</td>
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EXECUTIVE SUMMARY

On behalf of the U.S. Army Corps of Engineers (USACE)-Sacramento District, under Contract Number DACA45-03-D-0029 (administered through the USACE-Omaha District), HydroGeoLogic, Inc. (HGL) has prepared this Groundwater Monitoring Report to present results from groundwater sampling activities conducted within Operable Unit (OU)-1 at the former Fort Ord located in Monterey County, California. Groundwater sampling is performed at the former Fort Ord as part of an on-going monitoring program to evaluate the presence and distribution of contaminants of concern (COC) under Fort Ord’s designation on the National Priorities List (NPL). This report presents the fourth Quarter (December) 2004 groundwater sampling results, bimonthly treatment system sampling results, and an annual evaluation of 2004 groundwater monitoring.

Groundwater samples were collected for laboratory analysis from the OU-1 groundwater extraction and treatment system (GWETS) and from a total of 36 monitoring wells during the December 2004 fourth quarter monitoring event. Groundwater samples were analyzed for the 10 COCs identified at OU-1 in the 1995 Record of Decision (ROD) (U.S. Army, 1995). The 10 COCs are members of the volatile organic compound (VOC) class of chemicals, which are analyzed by U.S. Environmental Protection Agency (USEPA) Method SW8260B. Of the 10 COCs, trichloroethene (TCE) has historically exhibited the highest concentrations and greatest distribution at OU-1, and, as such, is used to define the extent of all 10 identified COCs at OU-1.

The OU-1 GWETS currently consists of a granular activated carbon (GAC) treatment system and one extraction well (EW-OU1-17-A). The extraction well is located approximately 400 feet hydraulically downgradient (northwest) of the former Fire Drill Area (FDA) source area. The treatment system has been sampled bimonthly to monitor system efficiency and discharge compliance. The GWETS operated normally during the fourth quarter of 2004, and no contaminant breakthrough was detected in the lead vessel. The TCE concentration reported from EW-OU1-17-A in December and for the influent stream sampled in October remained below the TCE aquifer cleanup level (ACL) of 5.0 micrograms per liter (µg/L). The average operability was nearly 100 percent over the 2004 operating period. The total volume of treated water from December 26, 2003, through December 31, 2004, was 4.6 million gallons. The average annual flow rate was 8.6 gallons per minute (gpm). A total COC mass of 0.12 pounds was removed from the OU-1 GWETS between January and December 2004.

TCE was reported in samples collected from 19 of the 36 monitoring wells during the December 2004 fourth quarter groundwater monitoring event. Samples collected from eight monitoring wells during the December event exceeded the TCE ACL of 5.0 µg/L. These wells included: MW-B-10-A, MW-OU1-27-A, MW-OU1-46-AD, EW-OU1-49-A, PZ-OU1-49-A1, MW-OU1-50-A, MW-OU1-57-A, and MW-OU1-58-A. The highest TCE concentration was detected in MW-B-10-A at 47 µg/L.

The monitoring network program, as approved in the Final Sampling and Analysis Plan (SAP) (HGL, 2004), was reviewed against the actual monitoring activities conducted during 2004. Overall, the approved sample frequencies and sample depths were met with the exception of those wells tested by Lawrence Livermore National Laboratory (LLNL). Select wells installed
in summer and fall 2004 as part of the Remedial Action activities were monitored during the last two quarters. Proposed modifications to the current A-Aquifer Monitor Network include the following: adding several new wells at various frequencies to monitor the plume’s central axis and northern boundary; decreasing sample frequency for MW-OU1-46-A since MW-OU1-46-AD was installed in close proximity; and removing MW-OU1-ERD-08-A since new well EW-OU1-48-A was installed in close proximity and will be added to the program.

Generally, TCE concentrations in the original A-Aquifer plume within OU-1 have decreased over time. This trend is supported by the Mann-Kendall test where the majority of wells evaluated exhibit statistically decreasing TCE concentrations as the plume migrates from the original source area. As the plume diffuses away from the source, the outer wells exhibit increasing concentrations in a northwesterly direction. Monitoring activities conducted in 2004 further support this analysis given that TCE concentrations significantly increased at the leading edge of the plume to the northwest. Specifically, localized high concentrations found in MW-B-10-A and some of the new wells during Quarters 3 and 4 indicate the TCE plume is much larger in the downgradient direction (west-northwest) than originally understood. Consequently, the footprint of the original TCE plume at OU-1 has expanded. The plume is currently under investigation to evaluate the extent of TCE beyond the northwest OU-1 boundary.

An annual evaluation of the groundwater data collected quarterly in 2004 identified recommendations consistent with those presented each quarter. Annual evaluation recommendations include: continued operation and maintenance (O&M) of the OU-1 GWETS; continued updates to the groundwater monitoring schedule to include the new monitoring wells, extraction wells and injection wells; presenting any modifications to the sampling schedule approved in the Final SAP (HGL, 2004) in the annual reports for the subsequent years’ monitoring activities; and continuing to evaluate TCE migration to the west-northwest toward the OU-1 boundary.
1.0 INTRODUCTION

HydroGeoLogic, Inc. (HGL) was contracted by the U.S. Army Corps of Engineers (USACE)-Sacramento District, under Contract Number DACA45-03-D-0029 (administered through the USACE-Omaha District) to conduct a Fixed-Price Remediation with Insurance (FPRI) scope of work for Operable Unit (OU)-1 at the former U.S. Army Base Fort Ord located in Monterey County, California (Figure 1.1). This report presents December 2004 (Quarter 4, 2004) groundwater sampling and treatment system monitoring results. This report also presents the 2004 annual groundwater evaluation of the bimonthly treatment system and quarterly groundwater monitoring data collected throughout 2004 (January through December 2004).

Groundwater sampling is performed at former Fort Ord as part of an on-going monitoring program to evaluate the presence and distribution of contaminants of concern (COCs) under Fort Ord’s designation on the National Priorities List (NPL). This monitoring program is designed to provide data to evaluate changes in the concentration or distribution of the COCs, and to evaluate the performance of the groundwater treatment system that is currently operating at OU-1. All work was performed in accordance with the Final Sampling and Analysis Plan (SAP), Fritzsche Army Airfield (FAAF) Fire Drill Area (FDA), Former Fort Ord (HGL, 2004), and supporting documents including the Final Data Management Plan, Final Quality Assurance Management Plan, Final Operation and Maintenance (O&M) Manual Addendum, and Final Site Specific Safety and Health Plan (HGL, 2004a, 2004b, 2004c, and 2004d).

This Groundwater Monitoring Report consists of sections 1.0 through 8.0. Referenced tables and figures are provided in subsequent separate sections. Appendices A and B provide supporting technical information derived from field activities associated with the Quarter 4 groundwater monitoring event and historic data. The Quality Control Summary Report (QCSR) and data validation reports associated with the Quarter 4 groundwater monitoring event are provided in Appendix C. A detailed discussion of the Mann-Kendall analysis summarized in section 6.3.2.2 is provided in Appendix D with associated tables and figures. Appendices are provided in separate sections. The content of each section is summarized below:

- Section 1.0 Introduction: describes the purpose and organization of the report.
- Section 2.0 Project Background: provides a site description and history, and summarizes the information developed during the 2004 drilling activities as discussed in the Draft 60% Engineering Design Report, Volume 1 Geology and Conceptual Site Model, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord, California (HGL, 2005).
• Section 3.0 Quarter 4, 2004 Monitoring Activities: describes the groundwater monitoring and sampling activities conducted within OU-1 during December 2004; the field activities; the sampling and analysis program; and project variances.

• Section 4.0 2004 Annual Summary of Groundwater Monitoring Activities: summarizes the project activities conducted in 2004, including the groundwater long-term monitoring (LTM) Program, sampling methodology, and any modifications that were made to the existing groundwater remediation and monitoring program.

• Section 5.0 Groundwater Extraction and Treatment System (GWETS): describes the annual operation and maintenance activities; operating and monitoring performance data; influent monitoring; mass removed; and trend evaluation.

• Section 6.0 Discussion of Annual Groundwater Monitoring: describes the results of the chemical analyses, and evaluates the resultant data and trends.

• Section 7.0 Recommendations: provides the status of quarterly recommendations, and provides annual recommendations for the on-going groundwater monitoring program.

• Section 8.0 References: identifies references used in support of the information presented in this report.
2.0 PROJECT BACKGROUND

This section includes a physical description of the former Fort Ord, OU-1’s historical background as it relates to the project work, and a discussion of OU-1’s hydrogeologic setting.

2.1 AREA DESCRIPTION AND LAND USE

Former Fort Ord is located adjacent to Monterey Bay in Monterey County, California (Figure 1.1). The base consists of approximately 28,000 acres near the cities of Seaside, Sand City, Monterey, Del Rey Oaks, and Marina. Laguna Seca Recreation Area and Toro Regional Park border the former Fort Ord to the south and southeast, respectively. Monterey Bay marks the western boundary of the former Fort Ord. Land use east of the former Fort Ord is primarily agricultural (U.S. Army, 2003).

The former Fort Ord consists of developed and undeveloped land. The three principal developed areas are the East Garrison, the FAAF, and the Main Garrison; these areas collectively comprise approximately 8,000 acres. The remaining 20,000 acres are largely undeveloped.

Due to the presence of rare and/or endangered species, and because of its visual attributes, Monterey County has designated the former Fort Ord’s coastal zone an environmentally sensitive area. The California Natural Coordinating Council and the Heritage Conservation and Recreation Service have identified the dunes at the former Fort Ord as among the best coastal dunes in California. The coastal strand in the area of the former Fort Ord provides habitat for many exotic, rare, and endangered plant and animal species including the black legless lizard (Monterey County Planning Department, 1984).

2.2 OU-1 SITE HISTORY AND PREVIOUS INVESTIGATIONS

The FAAF FDA, designated as OU-1, is located in the northernmost portion of the former Fort Ord (Figure 2.1). The FDA was established in 1962 as a training area for the Fort Ord Fire Department. The FDA consisted of an unlined burn pit, a drum loading area, a storage tank, and underground piping that connected the storage tank to a discharge nozzle (U.S. Army, 1995). During training exercises, fuel was piped into the burn pit, ignited, and then extinguished. Training activities at the FDA ceased in 1985.

Environmental investigations began at OU-1 in 1984 under Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order No. 87-189. After closure of the FDA, remedial investigations (RI) were conducted between 1985 and 1987 to document the nature and extent of contamination in the soil and groundwater at OU-1 (Harding Lawson Associates [HLA], 1986, 1987, 1987a). The results of the RI indicated that light and heavy total petroleum hydrocarbons (TPH) were present in the shallow surface soils, and that benzene, trichloroethylene (TCE), trans-1,2-dichloroethene, and methyl ethyl ketone (MEK) were present in the groundwater. To address the soil contamination identified during the RI, approximately 4,000 cubic yards of TPH-contaminated soils were excavated and replaced with clean fill. In addition to the soil cleanup, a small-scale GWETS was constructed in 1988 to remediate TCE and other groundwater contaminants (HLA, 1987, 1987a).
Groundwater concentrations of volatile organic compounds (VOC) at the former Fort Ord exceeded the maximum contaminant levels (MCL) designated by the State of California. The discovery of these VOCs and subsequent investigations led to the inclusion of the former Fort Ord on the U.S. Environmental Protection Agency (USEPA) NPL in February 1990, and the implementation of a groundwater monitoring program. The groundwater remediation and monitoring program for OU-1 at former Fort Ord includes quarterly, semi-annual, and annual groundwater monitoring of wells within, or directly adjacent to, the groundwater remediation area. The original monitoring network was composed of 51 monitoring wells and piezometers. Data collected from the groundwater monitoring program are used to assess: 1) the groundwater elevations and any trends in groundwater flow, 2) concentrations, distribution, and trends of COCs, and 3) the need for any modifications to the existing groundwater remediation and monitoring program.

In July 1995, a Record of Decision (ROD) for OU-1 was signed by the U.S. Army, USEPA, and the California Environmental Protection Agency (CalEPA). The ROD indicates that the remediation of the contaminated soils at the FDA is complete and defines groundwater extraction and treatment as the selected remedial action for OU-1 groundwater. The primary remediation objectives specified in the ROD for OU-1 are 1) hydraulic control and containment of contaminated groundwater, and 2) extraction and treatment of groundwater exceeding aquifer cleanup levels (ACL). Since the ROD has been in place, groundwater samples from both the on-going quarterly groundwater monitoring and the GWETS at OU-1 have been analyzed for the following 10 COCs.

- 1,1-dichloroethane
- 1,2-dichloroethane
- 1,1-dichloroethene (1,1-DCE)
- 1,2-dichloroethene (total) (total 1,2-DCE)
- 1,1,1-trichloroethane
- benzene
- chloroform
- MEK
- tetrachloroethene
- TCE

Data collected from regular groundwater monitoring activities conducted since 1986 indicated that the VOC plume continued to migrate despite operation of the original GWETS. The need for re-evaluation of the GWETS became apparent in 1997 when COCs were detected at concentrations above ACLs in groundwater wells downgradient from the extraction zone. Groundwater modeling was performed to simulate flow paths within the aquifer in response to system operation. Based on the 2002 pumping rates, the model predicted that the majority of the southeastern portion of the OU-1 TCE plume would be captured by the GWETS but would not be captured northwest of extraction well EW-OU1-17A (AHTNA Government Services Corporation [AHTNA], 2003).
On-going studies have been conducted in the vicinity of OU-1 by LLNL/Lawrence Berkeley National Laboratory (LBNL). An overview of the Lawrence Livermore National Laboratory (LLNL)/LBNL studies is provided in the Final SAP (HGL, 2004).

In July 2003, the U.S. Army issued a Request for Proposal (RFP) to complete the OU-1 remediation effort as specified in the ROD under a FPRI contract. At that time, the OU-1 TCE plume was defined by the September 2002 TCE plume map generated by Harding ESE (Harding ESE, 2001). At that time the TCE plume was believed to cover an elongated, curvilinear area approximately 2,600 feet by 600 feet (or about 38 acres). Harding ESE’s interpretation of results at that time indicated that the leading edge of the TCE plume was at least 500 feet away from the downgradient, northwestern boundary of OU-1. In late 2003, HGL was assigned the FPRI contract by the USACE to manage the existing groundwater monitoring program, and design and install the expanded GWETS, at OU-1. In early 2004, HGL began the initial large-scale GWETS system design phase based upon the TCE plume extent and configuration illustrated in the September 2002 TCE plume map by Harding ESE. However, based on the drilling activities conducted in late 2004, and as discussed in the Draft 60% Engineering Design Report (HGL, 2005), TCE was identified at over 40 micrograms per liter (µg/L) within 75 feet of the northwest OU-1 boundary, and is believed to have been at that point for a significant period of time.

Dilute solvents (associated with past practices at the former Fort Ord) are distributed vertically within three aquifers over four separate plume areas; however, contamination at OU-1 has been found to be limited to the uppermost aquifer (A-Aquifer). Since January 1998, only benzene, 1,2-DCE total, and TCE have exceeded their respective ACL. However, TCE is the contaminant that is detected at the highest concentrations and across the greatest extent of the affected groundwater at OU-1. Data shows that the TCE plume encompasses that of the other nine COCs specified in the ROD. Consequently, TCE concentrations are used to define the boundary of groundwater contamination by the 10 COCs identified within OU-1.

The OU-1 GWETS currently consists of one extraction well, a granular activated carbon (GAC) treatment system, and the associated piping to transport the pumped water. COC concentrations in the source area and within the extraction system capture zone have steadily decreased over the years. In 2002, statistical tests showed significantly decreasing concentrations of TCE, 1,1-DCE, and chloroform (AHTNA, 2003). The remaining COCs were not detected consistently enough to calculate statistical trends.

The objective of this FPRI effort is to perform the necessary environmental restoration needed to achieve regulatory compliance with the OU-1 ROD by April 2012. This quarterly groundwater monitoring program is one of many project elements required to support the environmental restoration of OU-1.

2.3 HYDROLOGIC, GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

General surface conditions within OU-1 at the former Fort Ord have been updated based on the data collected during the drilling activities conducted in late 2004. Geology, climate, hydrology, and hydrogeology are discussed in the Draft 60% Engineering Design Report (HGL, 2005).
2.4 SENSITIVE ENVIRONMENTS

OU-1 is within a habitat reserve managed by the University of California and is part of the University of California Natural Reserve System (UCNRS). The habitat reserve is referred to as the Fort Ord Natural Reserve (FONR). The dominant habitats within the FONR are annual grassland, maritime chaparral, and coastal live oak woodland. HGL has been coordinating all OU-1 activities with the UCNRS management to minimize impacts to the FONR.

The Habitat Management Plan (HMP) (U.S. Army, 1997) identified sensitive habitats such as the maritime chaparrals pertinent to conservation. Maritime chaparral is a rare habitat endemic to the Monterey Bay region, and largely dependent on the former Fort Ord land for survival. Eleven plant species and six animal species that are considered rare, threatened or endangered reside in the maritime chaparral habitat (i.e., Sand gilia, Monterey spineflower, and Smith’s blue butterfly).

HGL submitted a Natural Resource Protection Plan (HGL, 2005, Appendix D), developed in accordance with the HMP and with input from the UCNRS management. All work performed by HGL at OU-1 is being conducted under the Natural Resource Protection Plan and HMP.
3.0 QUARTER 4, 2004 MONITORING ACTIVITIES

December 2004 OU-1 monitoring activities included GWETS monitoring and quarterly groundwater monitoring. Groundwater monitoring activities were conducted in accordance with procedures described in the Final SAP (HGL, 2004). Copies of the field forms are provided in Appendix A. The Sampling and Analysis Summary is presented in Table 3.1.

3.1 OU-1 GWETS MONITORING

HGL conducted bimonthly sampling for the COCs at the OU-1 GWETS on December 16, 2004 as part of the quarterly groundwater monitoring activities and in accordance with the Final SAP (HGL, 2004), and the Final O&M Manual Addendum (HGL, 2004c). Samples were collected from the treatment system influent, intermediate, and effluent locations. The OU-1 GWETS sampling locations are identified in Figure 3.1. Sample location TS-OU1-INF monitors treatment system influent. The treatment system influent sampled was groundwater extracted solely from well EW-OU1-17-A. Sample location TS-OU1-INTER is located between two carbon beds, in order to monitor organic compound breakthrough of the first carbon vessel. Sample location TS-OU1-EFF monitors the water after treatment by the two carbon beds, and is the discharge compliance monitoring point.

3.2 MONITORING WELL GAUGING

Depth-to-water was measured at 76 locations within OU-1 during December 14-16, 2004 (Table 3.2). Water levels were measured to 0.01 feet at all accessible locations which included piezometers and monitoring, extraction, and injection wells within OU-1. Depth-to-water was gauged using a decontaminated, electronic water-level indicator.

3.3 GROUNDWATER SAMPLING

Groundwater samples were collected from 36 monitoring wells (Figure 3.2) using passive diffusion bag (PDB) sampling devices. Vertical profiles were conducted on wells MW-OU1-46-AD, MW-OU1-50-A, MW-OU1-56-A, MW-OU1-57-A, MW-OU1-58-A, MW-OU1-59-A, IW-OU1-13-A, and EW-OU1-47-A to evaluate any vertical trends of contaminant concentrations within the A-Aquifer at these recently installed wells. All groundwater samples were analyzed for the 10 OU-1 COCs using USEPA Method SW8260B.

A PDB sampler consists of a low-density, polyethylene bag filled with deionized water. The bag, which acts as a semi-permeable membrane, is suspended in the saturated screen interval of a well, and is used to collect a sample that is representative of groundwater at a specific depth in the aquifer. Figure 3.3 presents a schematic of a typical PDB sampler installation. VOCs diffuse across the bag material until constituent concentrations within the bag equilibrate with concentrations in the surrounding groundwater (MACTEC Engineering and Consulting, Inc [MACTEC], 2003). Most PDB samplers deployed for the Quarter 4, 2004 groundwater monitoring event were installed during the previous quarterly sampling event in September, 2004. The sampling and analysis summary presented in Table 3.1 provides PDB sampler installation dates, depths, and retrieval information.
During the Quarter 4, 2004 sampling event, PDB samplers were installed in the monitoring wells scheduled for sampling during the next quarterly event (Quarter 1, 2005, conducted in March 2005). The PDB sampler placement and Quarter 1, 2005, sampling locations are provided in Table 3.3.

3.4 PROJECT VARIANCES

All work discussed within this groundwater monitoring report was performed in accordance with the OU-1 ROD (U.S. Army, 1995) and the Final SAP (HGL, 2004) with the following exception:

- Monitoring wells MW-OU1-05-A, MW-OU1-07-A, MW-OU1-37-A, MW-OU1-38-A, MW-OU1-39-A, and MW-OU1-40-A were not sampled during the Quarter 4, 2004 groundwater monitoring event. These monitoring wells are operated in cooperation with LLNL and were not operating during the sampling event. Following the Quarter 4 monitoring activities, HGL worked with LLNL to remove their equipment in these wells to allow HGL to hang PDB samplers. HGL installed PDB samplers in early March 2005 in MW-OU1-05-A, MW-OU1-07-A, MW-OU1-37-A, MW-OU1-38-A, MW-OU1-39-A, and MW-OU1-40-A. These wells were sampled during the Quarter 1, 2005 event (March 2005).
4.0 2004 ANNUAL SUMMARY OF GROUNDWATER MONITORING ACTIVITIES

Groundwater monitoring at OU-1 includes quarterly, semi-annual, and annual monitoring of wells within, or directly adjacent to, the groundwater remediation area. Data obtained from quarterly groundwater monitoring events are a key component of the remediation activities at OU-1. Sample frequencies as well as sample depths vary based on each well’s proximity to the plume. The sample frequencies and depths of most wells monitored in 2004 were conducted in accordance with the Final SAP (HGL, 2004). A summary of the 2004 monitoring program as approved in the Final SAP, and compared to actual activities conducted, is discussed below and provided in Table 4.1. A discussion of proposed changes and additions to the 2005 OU-1 monitoring program is also discussed below and provided in Table 4.1.

4.1 CURRENT A-AQUIFER MONITORING NETWORK

HGL assumed responsibility for the long-term monitoring of OU-1 in the first quarter of 2004. Because the Final SAP (HGL, 2004) had not yet been issued, and to comply with the quarterly requirements, HGL submitted a Technical Memorandum (Tech Memo) in February 2004 for regulatory review and approval (approval discussed during the Base Realignment and Closure [BRAC] Cleanup Team [BCT] meeting on March 16, 2004). The Tech Memo outlined the guidance and protocols under which the monitoring would be conducted. Guided by the existing OU-1 SAP (Harding ESE, 2003), and the Tech Memo, HGL performed the first and second quarterly monitoring events. The guidance and protocols provided in the Tech Memo were then further expanded in the Final SAP issued in July 2004. The third and fourth quarterly monitoring events were conducted in accordance with the Final SAP (HGL, 2004).

The monitoring program as approved in the Final SAP (HGL, 2004) was reviewed against the actual monitoring activities conducted during the 2004 period. Overall, the approved sample frequencies and sample depths were met or exceeded with the exception of those wells tested by LLNL (Table 4.1). Groundwater monitoring performed in March, June, and December 2004 included groundwater sampling and water level measurements at locations scheduled on a quarterly basis. Groundwater monitoring performed in September 2004 included groundwater sampling, water level and total depth measurements at quarterly- and annually-scheduled sampling locations. Select wells installed in summer and fall 2004 as part of the Remedial Action activities were also monitored for water quality and groundwater flow patterns (HGL, 2005). Details of sample frequency and sample depths for wells monitored in 2004 are summarized in Table 4.2. The current monitoring well location map and schedule are provided in Figure 3.2 and Table 4.3, respectively.

Variances from the approved monitoring network program are discussed below (HGL, 2004, 2004a, 2004b) and summarized in Table 4.1.

- Nine monitoring wells operated in cooperation with LLNL did not operate during their scheduled sampling event. Table 4.1 provides details showing actual sample frequencies achieved for these wells. LLNL wells not sampled are summarized as follows:
• Monitoring wells MW-OU1-04-A and MW-OU1-19-A were not sampled during the first quarter groundwater monitoring event conducted in March 2004.

• Monitoring well MW-OU1-04-A was not sampled during the second quarterly groundwater monitoring event conducted in June 2004.

• Annually scheduled monitoring wells MW-OU1-07-A, MW-OU1-37-A and quarterly scheduled monitoring well MW-OU1-40-A were not sampled during the Quarter 3 groundwater monitoring event conducted in September 2004.

• Quarterly scheduled monitoring wells MW-OU1-05-A, MW-OU1-38-A, MW-OU1-39-A, and MW-OU1-40-A; and annually scheduled MW-OU1-07-A and MW-OU1-37-A, were not sampled during the Quarter 4 (December 2004) groundwater monitoring event (as discussed in Section 3.4. of this report).

• Samples are normally collected from a sample port in conjunction with LLNL equipment. HGL asked LLNL to remove their equipment in order for HGL to install PDB samplers in these wells. These wells were sampled during the Quarter 1, 2005 monitoring event (March 2005).

• Select monitoring wells, extraction wells and piezometers installed by HGL in June and July 2004 were added to the OU-1 Groundwater Monitoring Schedule for quarterly monitoring wells during the September and December events. Groundwater samples from MW-OU1-46-AD, EW-OU1-47-A, EW-OU1-49-A, PZ-OU1-49-A1, MW-OU1-50-A and MW-OU1-51-A were collected from PDB samplers during the September 2004 groundwater monitoring event. Details of these field activities are presented in the Draft 60% Engineering Design Report (HGL, 2005).

• Modifications to the groundwater monitoring schedule during 2004 included adding vertical interval sampling and the first time sampling of the new remedial action wells (Table 4.1). Multiple depth samples were collected at select existing monitoring wells. In accordance with the approved Final SAP (HGL, 2004), vertical interval sampling was performed at several wells during Quarter 2, and as needed to support remedial design efforts in subsequent quarters. Additionally, vertical samples at MW-B-10-A and MW-ERD-OU1-08-A were collected to provide better definition of the contaminated groundwater zone northwest of the original plume. Multiple-depth sample collection locations are listed below, and details are provided in Table 4.1:

  • MW-B-10-A
  • MW-OU1-08-A
  • MW-OU1-09-A
  • MW-OU1-19-A
  • MW-OU1-20-A
  • MW-OU1-25-A
  • MW-OU1-27-A
  • MW-OU1-34-A
  • MW-OU1-41-A
  • MW-OU1-42-A
  • MW-ERD-OU1-08-A
Multiple depth and single depth samples were collected from the following new remedial action wells following their installation during the spring and fall of 2004 (HGL, 2005),

- MW-OU1-46-AD
- MW-OU1-50-A
- MW-OU1-51-A
- MW-OU1-56-A
- MW-OU1-57-A
- MW-OU1-58-A
- MW-OU1-59-A
- EW-OU1-47-A
- EW-OU1-49-A
- PZ-OU1-49-A1
- IW-OU1-13-A

Table 4.1 provides additional details regarding sample frequencies and intervals. The purpose of monitoring these wells in relation to the plume is also provided.

4.2 PROPOSED MODIFICATIONS TO THE GROUNDWATER MONITORING PROGRAM

Proposed modifications to the current A-Aquifer Monitoring Well Network and sampling protocol are presented in Table 4.1. To summarize, HGL proposes the following modifications to the existing OU-1 monitoring network program and sample schedule:

Existing Monitoring Wells

- **MW-OU1-46-A.** Well does not extend deep enough to detect contamination. Propose moving to an annual sample frequency, but maintain quarterly depth-to-water measurements. Propose to sample new well MW-OU1-46-AD, which was installed adjacent to shallow well MW-OU1-46-A, at a quarterly sample frequency instead.

- **MW-ERD-OU1-08-A.** Well was added to monitoring program during Quarter 1, 2004 to help define northwestern extent of original plume. Propose eliminating sampling at this location, but maintain quarterly depth to water measurements. New wells installed as part of the Remedial Action effort that are in close proximity (specifically EW-OU1-48-A) are proposed for sampling instead (see below, new wells).

- **EW-OU1-18-A.** Pumping resumed in February, 2005. Sampling has resumed with the existing GWETS bimonthly sampling schedule.

New Wells

- **MW-OU1-46-AD.** Well installed adjacent to MW-OU1-46-A (which did not reach the Salinas Valley Aquiclude [SVA]). Propose to sample quarterly to replace MW-OU1-46-A.

- **MW-OU1-50-A.** Propose to sample annually to monitor groundwater quality along the central flow path of plume.
• MW-OU1-51-A. Propose to sample twice yearly to monitor northwestern boundary of VOCs.

• MW-OU1-56-A. Propose to sample quarterly to monitor north-northwestern boundary of VOCs.

• MW-OU1-57-A. Propose to sample twice annually to monitor groundwater quality along the central flow path of plume. Alternate twice annually schedule with nearby well MW-OU1-58-A.

• MW-OU1-58-A. Propose to sample twice annually to monitor groundwater quality along the central flow path. Alternate twice annually schedule with nearby proposed well MW-OU1-57-A.

• MW-OU1-59-A. Propose to sample quarterly to monitor northwestern limit of VOCs.

• EW-OU1-47-A. Propose to sample quarterly to monitor north-northwestern limit of VOCs. Propose to sample bimonthly (every other month) following connection to the expanded GWETS.

• EW-OU1-48-A. Propose to sample twice yearly to monitor groundwater quality along the central flow path. Alternate twice yearly schedule with nearby well MW-OU1-27-A. Propose to sample bimonthly (every other month) following connection to the expanded GWETS.

• PZ-OU1-49-A1. Propose to sample quarterly to monitor plume migration along its main axis.

• IW-OU1-10-A. Propose to sample twice yearly to monitor plume migration along its main axis. Alternate twice yearly schedule with other nearby twice yearly monitoring wells. Sampling will cease after the well is connected to the expanded GWETS.

• IW-OU1-13-A. Propose to sample twice yearly to monitor northeastern boundary of plume. Sampling will cease after the well is connected to the expanded GWETS.

• Sampling will not be proposed for the following new wells: EW-OU1-49-A, EW-OU1-52-A, EW-OU1-53-A, EW-OU1-54-A, EW-OU1-55-A, PZ-OU1-02-A1, IW-OU1-01-A, IW-OU1-02-A, IW-OU1-05-A, IW-OU1-24-A and IW-OU1-25-A. These wells are in close proximity to existing monitoring wells in the southern area of the plume that are already sampled on a quarterly basis (Table 4.1). The “EW” series wells will be sampled bi-monthly after they are connected to the expanded GWETS.
5.0 GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

The GWETS operates by extracting groundwater through one submersible, positive-displacement groundwater extraction pump located in extraction well EW-OU1-17A (HGL, 2004c). The original system included a second extraction well, but that well was taken off-line in June 2001 because groundwater monitoring data showed that remediation goals had been met in the well’s capture area. OU-1 VOCs are treated by pumping groundwater from EW-OU1-17A, piping it directly through two, 1,000-pound GAC vessels connected in a series. A third, 1,000-pound GAC vessel with inactive carbon is kept as a reserve. The treated groundwater is then discharged through a spray irrigation system to recharge the underlying groundwater. The OU-1 groundwater treatment schematic is shown in Figure 3.1. A discussion of the GWETS operations and monitoring performance over the 2004 period is presented in the following sections.

5.1 OPERATING PERFORMANCE

The OU-1 GWETS operated nearly continuously during the period January through December 2004. Routine maintenance over the year and a carbon change out performed in July 2004 resulted in minimal downtime of the GWETS. Overall, the average operability in 2004 was nearly 100 percent. A total of 4.6 million gallons of water was treated from December 26, 2003 through December 31, 2004. The average annual flow rate was 8.6 gallons per minute (gpm). An operational data summary of the OU-1 GWETS for the period January through December 2004 is shown in Table 5.1.

5.2 MONITORING DATA SUMMARY AND EVALUATION

The treatment system has been sampled bimonthly to monitor system efficiency and discharge compliance. Bimonthly samples were collected from the treatment system influent, intermediate, and effluent locations. The operating extraction well, EW-OU1-17-A, was sampled bimonthly starting in April 2004. Extraction well EW-OU1-17-A was the only well connected to the GWETS in 2004.

HGL conducted bimonthly sampling for COCs at the OU-1 GWETS on February 18, April 15, July 1, August 12, October 14, and December 16, 2004. Sampling was conducted in accordance with the Final SAP (HGL, 2004) and the Final O&M Manual Addendum (HGL, 2004c). As discussed in Section 3.1, sample location TS-OU1-INF monitors treatment system influent. Sample location TS-OU1-INTER is located between the two carbon beds to monitor organic compound breakthrough of the first carbon vessel. Sample location TS-OU1-EFF monitors the water after treatment and is the discharge compliance monitoring point.

Influent results (including the influent sample port and extraction well EW-OU1-17-A) reported from each sampling event were non-detect (ND) for all COCs except TCE. TCE concentrations from the influent locations show a decrease throughout 2004. By April 2004, TCE concentrations were below the ACL of 5.0 µg/L.

Figure 5.1 presents a graph of TCE concentrations over time for extraction wells EW-OU1-17-A and EW-OU1-18-A. Figure 5.2 presents a graph of TCE concentrations from November 1999 to
November 2004, reported from the GWETS influent. EW-OU1-18-A was off-line during 2004 as mentioned previously. Data obtained from the GWETS are presented in the Quarter 1, 2, and 3, 2004 Groundwater Monitoring Reports (HGL, 2004e, 2005a, 2005b). The Quarter 4 data is provided in this annual report.

An intermediate sample is collected from the treated water between the two activated carbon beds, to monitor contaminant breakthrough. The 2004 intermediate sample location results indicated all COCs were ND during 2004, with the exception of 0.41J µg/L TCE reported in July 2004. In response to the detection, the reserve tank (holding a new carbon bed) was changed to the lag position, and the current lag tank was switched to the lead position. This was the only carbon replacement during the 2004 operating period. The analytical report on the spent carbon is provided in the Final Quarterly Groundwater Monitoring Report, Quarter 2, 2004 (HGL 2005a).

Effluent sampling results were reported as ND during 2004. Discharge requirements, as specified in the ROD as 0.5 µg/L for each COC, were met for the treatment system.

5.3 TREATMENT SYSTEM PERFORMANCE

The total mass of COC (largely TCE) removed was calculated using the influent data collected during 2004 and from 1999-2003 data that was downloaded from the Fort Ord Data Integration System (FODIS) database. The total mass removed is estimated to be 1.66 pounds since October 1999. A total mass of 0.12 pounds was removed from the OU-1 GWETS between January and December 2004. Table 5.2 presents the 1999 to 2004 OU-1 GWETS Extraction Summary. Since the inception of the treatment system in August 1988, over 25 pounds COC have been removed.
6.0 DISCUSSION OF ANNUAL GROUNDWATER MONITORING

A discussion of the OU-1 plume monitoring data collected between January and December 2004 is presented in this section. An evaluation of the groundwater elevations and sample analytical data will enable a comparison of seasonal changes in groundwater flow and chemical distribution. These data will then be used to evaluate hydraulic control and the performance of the GWETS.

6.1 GROUNDWATER ELEVATIONS AND FLOW DIRECTIONS

Water level data measured during the Quarter 4 groundwater monitoring activities are presented in Table 3.2. Quarterly water elevation data measured in 2004 were used to develop the interpretive groundwater level contour maps presented in Figures 6.1a through 6.1d. To evaluate groundwater flow patterns within OU-1, 59 to 63 monitoring, extraction, and injection wells and piezometers within OU-1 were gauged for depth to groundwater during each 2004 quarterly sampling event. From the former FDA source area toward the original plume boundary wells MW-OU1-45-A and MW-B-10-A, the groundwater elevation data indicates a northwestern flow, at a gradient of approximately 0.006 feet per foot. This is consistent over the 2004 period and with previous flow data.

Groundwater elevation trends are shown on Figure 6.2. Nine wells were selected to depict the 10-year groundwater elevation trends at OU-1. Between June 1994 and June 1998, groundwater elevations were below +48 feet mean sea level (msl), rising more than 10 feet in the late 1990s. This large rise in groundwater elevations is consistent with regional observations likely related to the El Nino weather patterns that occurred during that time period. Groundwater elevations in December 2004 are consistent with those observed during previous quarters in 2004, or inferred in the early 2000’s following the last, most significant El Nino event.

6.2 DATA VALIDATION

HGL contracted Environmental Data Services (EDS) of Concord, New Hampshire, to conduct an independent level-III data validation of the OU-1 laboratory analytical data packages. Results were validated at a frequency of 100 percent and data qualifiers were assigned in accordance with the Final SAP (HGL, 2004). A QCSR was prepared for each quarterly report. The QCSR documents the field quality assurance (QA)/quality control (QC) program for the quarterly groundwater sampling activities within OU-1, and provides an assessment of data validation results. The QCSR prepared for Quarterly Groundwater Monitoring Reports, Quarters 1, 2, and 3 are provided in the appendices of their respective reports (HGL, 2004e, 2005a, 2005b). Appendix C of this report presents the QCSR from the Quarter 4 (December 2004) sampling event. A summary of laboratory and field QC sample results are also provided in the validation reports in Appendix C.

The QA/QC program includes the field QC samples collected and laboratory QC samples associated with organic analyses. Field QC samples evaluated quarterly included rinse blanks, field duplicates, and trip blanks. Laboratory QC samples included matrix spike (MS)/matrix spike duplicate (MSD) pairs, laboratory blanks, laboratory control samples (LCSs), and laboratory control sample duplicates (LCSDs). In addition to the results of field and laboratory
QC samples, QC elements used to assess data quality include sample delivery and condition, laboratory blanks, instrument tuning, initial and continuing calibrations, internal standards, retention time windows, and surrogate recoveries. Overall, the data reported for Quarters 1 through 4, 2004 were considered usable for the purposes of the OU-1 groundwater LTM program.

6.3 ANALYTICAL RESULTS

Groundwater samples were collected and analyzed quarterly to evaluate the presence and distribution of the COCs within OU-1. Analytical results were compared to the ACLs established for OU-1 in the ROD (U.S. Army, 1995). The OU-1 plume consists of 10 COCs as defined by the ROD with the overall extent of the plume defined by TCE. The 10 COCs are listed in Section 2.2 of this report. TCE is the most extensive COC observed in the A-Aquifer within OU-1, and is used to monitor the plume. TCE was selected as an indicator of the overall extent of groundwater to be extracted and treated because it is the most widespread COC that fails to meet the ACLs established in the ROD. Data obtained from the quarterly groundwater monitoring activities were used to ascertain whether the distribution of COCs is being effectively controlled and concentrations reduced by the existing groundwater remedy, or whether modifications are needed to address new or changing conditions, in order to meet the primary remediation objectives specified in the ROD for OU-1.

The original monitoring program, as approved in the Final SAP (HGL, 2004), included sampling and analysis at 40 monitoring wells on a quarterly, semi-annual or annual basis (Table 4.1). In the summer and fall of 2004, as part of the Remedial Action, wells MW-OU1-46-AD, EW-OU1-47-A, MW-OU1-50-A, and MW-OU1-51-A and several extraction wells, piezometers and injection wells were installed within OU-1. Details are discussed in the Draft 60% Engineering Design Report (HGL, 2005). All new monitoring wells and select piezometers and extraction wells were included in the quarterly sampling activities. A total of 49 locations were monitored at various frequencies and depths within OU-1 during 2004 (Table 4.1). The following sub-sections provide a discussion of the analytical results. To aid in review, a summary of 2004 analytical results (including GWETS results) is provided in Table 4.1. For historic reference, a summary of FODIS database analytical results reported between 1999 and 2003 are summarized in Appendix B in Table B-1. Recent analytical results (2004) are presented in Table 6.1. Figures 6.3a through 6.3d illustrate the TCE plume based on March, June, September and December 2004 concentrations, respectively.

6.3.1 Monitoring Well Data

Monitoring well data reported between 1999 and 2003 demonstrate that most of the 10 COCs were reported at concentrations below their respective ACLs to ND (Appendix B, Table B-1). Table B-1 shows that since 1999, only total 1,2-DCE, benzene, and TCE have exceeded their respective ACLs. Data reported during 2004 found only TCE exceeded its respective ACL. Low to trace concentrations (below their respective reporting limits [RLs]) of 1,1,1-trichloroethane, total 1,2-DCE, chloroform, and MEK were detected at monitoring wells during the 2004 reporting period (Table 6.1).
Historically, between April 1999 and December 2002, 34 detections of total 1,2-DCE exceeded the 6.0 µg/L ACL at wells MW-OU1-26-A or MW-OU1-27-A along the spine of the TCE plume (Appendix B, Table B-1).

Historically, nine samples collected between 1999 and 2003 at six monitoring wells exceeded the 1.0 µg/L ACL for benzene (Appendix B, Table B-1). Over time, sample results from these wells have demonstrated a decrease in benzene concentrations to below the ACL. All sample results obtained from OU-1 over the four quarterly sampling events in 2004 were reported with benzene as ND (Table 6.1).

Historically, between 1999 and December 2003, TCE was reported above its ACL (5.0 µg/L) in 16 wells (Appendix B, Table B-1). Over time, most of these wells have demonstrated a decrease in TCE concentrations to levels below the ACL to ND, with the exception of MW-OU1-04-A, MW-OU1-20-A, MW-OU1-23-A, MW-OU1-26-A and MW-OU1-27-A. Between 1999 and 2003, the highest TCE concentrations consistently reported above the ACL were found in wells located along the main axis of plume migration including: MW-OU1-19-A, MW-OU1-20-A, MW-OU1-23-A, MW-OU1-26-A, and MW-OU1-27-A.

Samples from 12 wells, including existing wells MW-B-10-A, MW-OU1-04-A, MW-OU1-20-A, MW-OU1-23-A, MW-OU1-26-A, MW-OU1-27-A and new wells MW-OU1-46-AD, MW-OU1-50-A, MW-OU1-57-A, MW-OU1-58-A, EW-OU1-49-A and PZ-OU1-49-A1, had TCE concentrations above the ACL of 5.0 µg/L during 2004 activities (Table 6.2 and Figure 6.3a-d). Samples from well MW-B-10-A historically did not contain detectable TCE, but was reported with 11 µg/L, 25.6 µg/L, and 47 µg/L in September, October, and December 2004, respectively (Table 6.1).

Samples collected from eight wells during the December 2004 event exceeded the TCE ACL of 5.0 µg/L. These wells included MW-B-10-A, MW-OU1-27-A, MW-OU1-46-AD, EW-OU1-49-A, PZ-OU1-49-A1, MW-OU1-50-A, MW-OU1-57-A, and MW-OU1-58-A which are located along the main axis of plume migration or along the northern boundary. The highest TCE concentration reported was at MW-B-10-A as 47 µg/L, demonstrating a significant increase since September 2004, when TCE was first detected in the well.

### 6.3.2 TCE Concentration Trends

The following sections provide a discussion on TCE concentration trends within OU-1 using a series of graphs of select wells, and the Mann-Kendall statistical analysis test.

### 6.3.2.1 Monitoring Well Graphs

Figures 6.4 and 6.5 present a series of graphs in which the concentration of TCE is plotted as a function of time for selected wells located throughout the footprint of the OU-1 TCE plume. Linear regression lines have been included on selected charts. Three basic patterns and at least one complex pattern are observed as follows:

MW-OU1-19-A, MW-OU1-20-A, MW-OU1-22-A, MW-OU1-23-A, MW-OU1-26-A, MW-OU1-36-A, MW-OU1-39-A, MW-OU1-43-A, and PZ-OU1-35-A. All but three of these wells (MW-OU1-22-A, MW-OU1-43-A and PZ-OU1-35-A) are situated around the former source area (FDA). The decline in concentrations at these wells is likely attributable to the current GWETS. Data collected from MW-OU1-43-A, and perhaps MW-OU1-22-A, may be interpreted to reflect the downgradient migration of TCE slugs (that escaped capture by the GWETS) followed by declining concentrations. The GWETS had been in operation approximately nine years when MW-OU1-22-A was installed. During the first 15 months in which MW-OU1-22-A was sampled, the five results showed TCE declining from 39 µg/L to 10 µg/L; thereafter, TCE has never exceeded its ACL of 5.0 µg/L in samples from that well. In general, TCE appears to be declining at MW-OU1-22-A, although concentrations since mid-2001 appear to oscillate between 4.0 and 2.0 µg/L. The distance from the capture zone of the GWETS to MW-OU1-22-A is approximately 600 feet. The elapsed time between GWETS startup and the decline in TCE concentration to <5.0 µg/L (10 years) would correspond to a migration rate of approximately 60 feet per year. A groundwater flow velocity of 60 feet per year is well within the range expected for the observed gradient and estimated range of hydraulic conductivity values in the A-Aquifer. Groundwater samples taken from MW-OU1-26-A, located along the main plume axis, demonstrate TCE concentrations have decreased from 54.1 µg/L in early 1999 to 31 µg/L in late 2003. Recent 2004 data show TCE concentrations continued to decrease in June 2004 to 16 µg/L, then increased to 25 µg/L in September 2004.

MW-OU1-08-A is northeast and cross gradient of the FDA. MW-OU1-08-A previously was shown as an upward trending well as it demonstrated a strong upward trend until (approximately) late 2001, when TCE concentrations peaked, followed by a gradual decline. Although TCE concentrations initially showed a general increase with time in MW-OU1-08-A, data since late 2002 show concentrations have declined below the ACL. As of December 2004 TCE was reported ND (Table 6.1).

- **Upward Trends** – Three wells display upwards trends of TCE concentrations: MW-OU1-09-A, MW-OU1-25-A, and MW-B-10-A. Both MW-OU1-09-A and MW-OU1-25-A are northwest and slightly down-to-cross-gradient of the FDA. Similar to MW-OU1-08-A, MW-OU1-25-A demonstrated a strong upward trend until (approximately) late 2002, when TCE concentrations peaked, then gradually declined thereafter. This increase and decrease in concentration corresponds to similar trends of groundwater elevation observed at select wells within OU-1 (Figure 6.2). MW-OU1-09-A showed a flat ND trend until late 2002 when TCE was then detected at 3.2 µg/L. TCE concentrations have gradually increased from late 2002 to late 2004. Although TCE concentrations generally increase with time in MW-OU1-09-A and MW-OU1-25-A, recent data show all concentrations are below the ACL in these wells (Table 6.1). Well MW-B-10-A, located at the most northwest boundary of the plume, has historically reported TCE concentrations as ND since before 1999 and through June 2004 (Appendix B, Table B-1 and Table 6.1). Between September and December 2004, however, the TCE concentration in MW-B-10-A increased significantly from 11 µg/L to 47 µg/L. This conspicuous increase demonstrates that contamination from the former
FDA source area has reached the downgradient boundary of the FONR in the area of this well (Figure 6.3d).

- **Flat Trends** – MW-OU1-01A and MW-OU1-10-A both exhibit relatively flat trends in TCE concentrations. MW-OU1-01-A is located upgradient of the FDA and has remained at or near 1.0 µg/L. MW-OU1-10-A is north of MW-OU1-19-A (on the southwest side of the plume and downgradient of the FDA). Samples from this well revealed a relatively large TCE concentration spike in 2001 (to >7.0 µg/L at 89 feet below ground surface [bgs]), but quickly declined back to concentrations below 1.0 µg/L. Data collected in 2004 show TCE concentrations at wells MW-OU1-01A and MW-OU1-10-A are below the ACL or ND, respectively (Table 6.1).

- **Complex Trends** – Complex trends are those trends characterized by conspicuous concentration spike(s) and rapid declines. The complex trends show erratic concentrations, rather than continuous upward or downward trending concentrations. MW-OU1-27-A, MW-OU1-29-A, and MW-OU1-40-A exhibit such trends.

MW-OU1-27-A, located in the plume axis, shows a history of at least two slugs, and, as of June 2004, TCE concentrations appeared to be in decline (Table 4.1). However, December 2004 data indicate TCE concentrations have now increased at MW-OU1-27-A. MW-OU1-29-A, northeast of the plume axis and downgradient near MW-OU1-27-A, shows a complex history of potential TCE slugs, and has shown a consistent decline (since March 2004) in TCE concentrations to below 1.0 µg/L. In December 2004, TCE concentrations were ND at MW-OU1-29-A. MW-OU1-40-A is situated on the northeast side of the plume (north of the FDA) and has shown erratic results, which may represent contaminant spikes or analytical scatter. TCE concentrations at MW-OU1-40-A have been reported below the ACL since late 2003 (Appendix B, Table B-1, and Table 6.1).

Previous investigations performed by MACTEC were interpreted as showing TCE concentrations gradually decreasing with time (MACTEC, 2004). However, recent data reported from September and December 2004 indicate the plume is expanding to the northwest. Reductions are observed in the plume axis near and downgradient of the former source area at concentrations near or above the 10 µg/L contour, where historical concentrations ranged up to 100 µg/L (June 2002) in MW-OU1-27-A (Appendix B, Table B-1, and Table 6.1). Recent localized high concentrations found in MW-B-10-A and new wells (MW-OU1-46-AD, MW-OU1-50-A, MW-OU1-57-A, and MW-OU1-58-A) located northwest of the original leading edge of the plume delineates a larger plume boundary in the downgradient direction, that may have existed for some time. The leading edge of the plume is currently under investigation (for the deeper part of the A-Aquifer to the SVA interface) to evaluate if possible TCE slugs/spikes detected in past quarters in downgradient wells have migrated closer to, or beyond, the OU-1 boundary.

final remedial design, and to evaluate the northwesternmost extent of TCE migration toward the 
OU-1 boundary. Details are provided in the Draft 60% Engineering Design Report (HGL 2005). 
Samples from EW-OU1-49-A and PZ-OU1-49-A1, located along the main axis of the original 
plume, upgradient from MW-OU1-27-A, contained TCE concentrations above the ACL (5.0 
µg/L) since first sampled in fall 2004 (Figure 6.3d, Table 6.1, and Table 6.2). Wells EW-OU1-
47-A and MW-OU1-51-A, located at the northwestern and northeastern edges of the plume, 
respectively, have consistently contained no detectable TCE (Table 6.1).

Wells that have remained at or below RLs during 2004 are shown on Table 6.1.

6.3.2.2 Mann-Kendall Test
The Mann-Kendall test was performed to evaluate the trend of TCE concentrations at various 
monitoring wells located within OU-1. A detailed analysis and discussion are presented in 
Appendix D. To summarize, the majority of evaluated wells exhibit statistically decreasing TCE 
concentration trends from the source area and points downgradient. Further from the source, 
outer wells exhibit increasing concentrations in a northwesterly direction. The statistical analysis 
supports the previous discussion of TCE trends within OU-1.
7.0 RECOMMENDATIONS

The following sections provide a review and status of the quarterly recommendations and a summary list of recommendations based on the annual review.

7.1 STATUS OF QUARTERLY RECOMMENDATIONS

Recommendations contained in the reports generated from each quarter of 2004 included the following:

- Continue bimonthly monitoring of the existing GWETS.
- Implement monitoring schedule as proposed in the Final SAP (HGL, 2004), and continue to evaluate concentrations’ trends throughout the plume with future analytical results.

Status

The bimonthly GWETS monitoring continued throughout 2004, as recommended. The monitoring program met or exceeded the approved sample frequencies and sample depths with the exception of those wells tested by LLNL. Results and trends have been discussed and updated in each monitoring report. In addition, multiple depth and single samples were collected from the new remedial action wells following their installation during the spring and fall of 2004.

Recommendations specific to Quarter 1 included the following:

- Install two additional monitoring wells: one located between the northwestern sentry wells (MW-B-10-A, MW-OU1-45-A, and MW-OU1-41-A), and well MW-OU1-43-A, to further evaluate the extent of TCE migration; the second located adjacent to MW-OU1-46-A to explore the presence of TCE in the deeper portion of the A-Aquifer near the toe of the plume, since the existing well, MW-OU1-46-A, did not penetrate the saturated thickness of the A-Aquifer.
- Work with LLNL to obtain data or determine another method of sampling at MW-OU1-04-A and MW-OU1-19-A, since TCE concentrations were reported above ACL when last sampled in September 2003. These locations were not sampled in March 2004 because the sampling ports were not working.
- Deploy PDBs in March 2004 in selected wells for vertical profiling. The resultant data would be evaluated during the second quarter of 2004 to assess vertical concentration gradients in the selected wells.

Status

New monitoring wells, extraction wells, and piezometers were installed in 2004 as part of the Remedial Action Activities. Additional wells were installed at the recommended locations as discussed in the Draft 60% Engineering Design Report (HGL, 2005).
LLNL removed their equipment from MW-OU1-19-A to allow HGL to hang PDB samplers. MW-OU1-19-A was sampled in subsequent quarters as scheduled. The LLNL equipment from MW-OU1-04-A was not removed, since the well was still in operation.

HGL discussed the vertical profile results in the Final Operable Unit 1, Quarterly Groundwater Monitoring Report, Quarter 2, 2004 (HGL, 2005a).

Recommendations specific to Quarter 2 included the following:

- Evaluate water quality conditions west of the currently depicted plume boundary.
- Work with LLNL to obtain data or determine another method of sampling at MW-OU1-04-A, since TCE concentrations were reported above ACL when last sampled in September 2003. These locations were not sampled in June 2004 because the sampling ports were not working.
- Sample six new wells, installed as part of the remedial design investigation in August and September 2004, to support decisions concerning the final system modification design (scheduled for the fall 2004), and to evaluate the westernmost extent of TCE migration toward the FONR boundary. The resultant data would be evaluated and included in the remedial design report, as well as the upcoming third quarter groundwater monitoring report. The new monitoring wells were included on the groundwater monitoring schedule presented in Table 2.1. PDB samplers were deployed per the schedule during the third quarter groundwater sampling event conducted September 20-23, 2004.

**Status**

New monitoring wells, extraction wells, and piezometers were installed in 2004 as part of the Remedial Action Activities, in part, to evaluate water quality conditions west of the currently depicted plume boundary. A detailed discussion of these field activities was provided in the Draft 60% Engineering Design Report (HGL, 2005).

The LLNL equipment in MW-OU1-04-A was not removed since the well was planned for operation.

Recommendations specific to Quarter 3 included the following:

- Update the groundwater monitoring schedule to include the new monitoring wells, extraction wells, and injection wells installed by HGL during the recent remedial action drilling activities. Monitoring wells, extraction wells, and select injection wells should be monitored to refine the remedial design, establish trends, and to evaluate the westernmost extent of TCE migration toward the FONR boundary.

**Status**

As recommended, the groundwater monitoring schedule was updated in Section 4.0 of this report.
7.2 ANNUAL RECOMMENDATIONS

Based on the preceding evaluation and review of current and historic data, HGL recommends the following:

- Continue O&M and bimonthly sampling of the OU-1 GWETS.
- Update the groundwater monitoring schedule to include the new monitoring wells, extraction wells, and injection wells installed by HGL during the recent remedial action drilling activities.
- Present any modifications to the sampling schedule approved in the Final SAP (HGL, 2004) in the annual reports for the subsequent years’ monitoring activities.
- Continue to evaluate TCE migration to the west-northwest, toward the OU-1 area boundary.
8.0 REFERENCES


