ANNUAL SITE STATUS REPORT
FOR THE YEAR 2010

UST SITE 957/970
FORMER DEPARTMENT OF DEFENSE HOUSING FACILITY
NOVATO, CALIFORNIA

Contract No. N62473-08-D-8824
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Prepared for:

Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, California 92108

Prepared by:

Battelle
The Business of Innovation
505 King Avenue
Columbus, OH 43201

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society of Testing and Materials
BCT	BRAC Cleanup Team
bgs	below ground surface
BRAC	Base Realignment and Closure (Act of 1990)
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CAP	Corrective Action Plan
CSM	conceptual site model
DO	dissolved oxygen
DoDHF	Department of Defense Housing Facility
DQO	data quality objective
DTSC	Department of Toxic Substances Control
IAS	in situ air sparging
LDC	Laboratory Data Consultants, Inc.
MCL	maximum contaminant level
MNA	monitored natural attenuation
MTBE	methyl tert-butyl ether
NAVFAC	Naval Facilities Engineering Command
NEX	Naval Exchange
NUSD	Novato Unified School District
ORP	oxidation reduction potential
PBC	Public Benefit Conveyance
PVC	polyvinyl chloride
PWC	Public Works Center
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
SSR	Site Status Report
SVE	soil vapor extraction
TBA	tert-butyl alcohol
TBF	tert-butyl formate
TO	Task Order
U.S. EPA	U.S. Environmental Protection Agency
UST	underground storage tank

Section 1.0: INTRODUCTION

This Annual Site Status Report (SSR) describes activities performed under Task Order (TO) No. 0009 of the Naval Facilities Engineering Command (NAVFAC) Southwest Contract No. N62473-08-D-8824 at Former Underground Storage Tank (UST) Site 957/970 at the Department of Defense Housing Facility (DoDHF) Novato in Novato, California. In accordance with the TO, this report presents the results of the annual groundwater monitoring activities as well as the corrective action activities as detailed in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c). Currently, ongoing reporting for former UST Site 957/970 is conducted on a semi-annual basis, with the Semi-Annual SSR presenting results from field activities conducted during the first half of the calendar year (i.e., January through June, with a focus on the semi-annual monitoring event in May), and the Annual SSR presenting results from field activities conducted during the second half of the calendar year (i.e., July through December, with a focus on the annual monitoring event in November).

In August 2007, the *Final Groundwater Monitoring Plan Update for Former UST Site 957/970 at Department of Defense Housing Facility, Novato, California* (Battelle, 2007) was issued for the Site. The November 2010 sampling event (i.e., annual sampling event) represents the twelfth event in which groundwater monitoring has been conducted in accordance with this updated report. Therefore, this Annual SSR specifically addresses the data quality objectives (DQOs) contained in the Sampling and Analysis Plan (SAP) that was included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007).

Furthermore, this Annual SSR establishes a framework to address the DQOs presented in the SAP of the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b), which outlines the corrective action activities to be conducted at the leading edge area of the methyl tert-butyl ether (MTBE) plume. Overall, this Annual SSR presents results from the annual groundwater monitoring activities conducted in November 2010 and discusses the corrective action activities conducted at the leading edge area from October through December 2010.

1.1 Location

Former UST Site 957/970 at DoDHF Novato is located approximately 20 miles north of San Francisco, in Marin County, California. A site location map depicting former UST Site and vicinity is provided in Figure 1. The Site comprises an approximate 13 acre area with dimensions of approximately 1,100 ft by 500 ft bounded on the south by Main Entrance Road and on the north by railroad tracks operated by the Golden Gate Bridge, Highway, and Transportation District. Pacheco Creek is the nearest surface water body, located approximately 800 ft northwest of Former UST Site 957/970 (see Figure 1).

1.2 Site History and Background

The Site is the location of a former Naval Exchange (NEX) gas station and a former Public Works Center (PWC) gas station (see Figure 2). The NEX gas station was located at the northwest corner of Main Entrance Road and C Street, where Building 970 and associated pump islands were in operation from the mid-1970s through the early 1990s. The NEX gas station was closed in the early 1990s and subsequently, the three USTs supporting the station (970-1 [10,000-gallon UST], 970-2 [10,000-gallon UST], and 970-3 [10,000-gallon UST], collectively referred to as UST 970) were excavated and removed from the Site. The PWC gas station was located approximately 700 ft north of the NEX gas station and

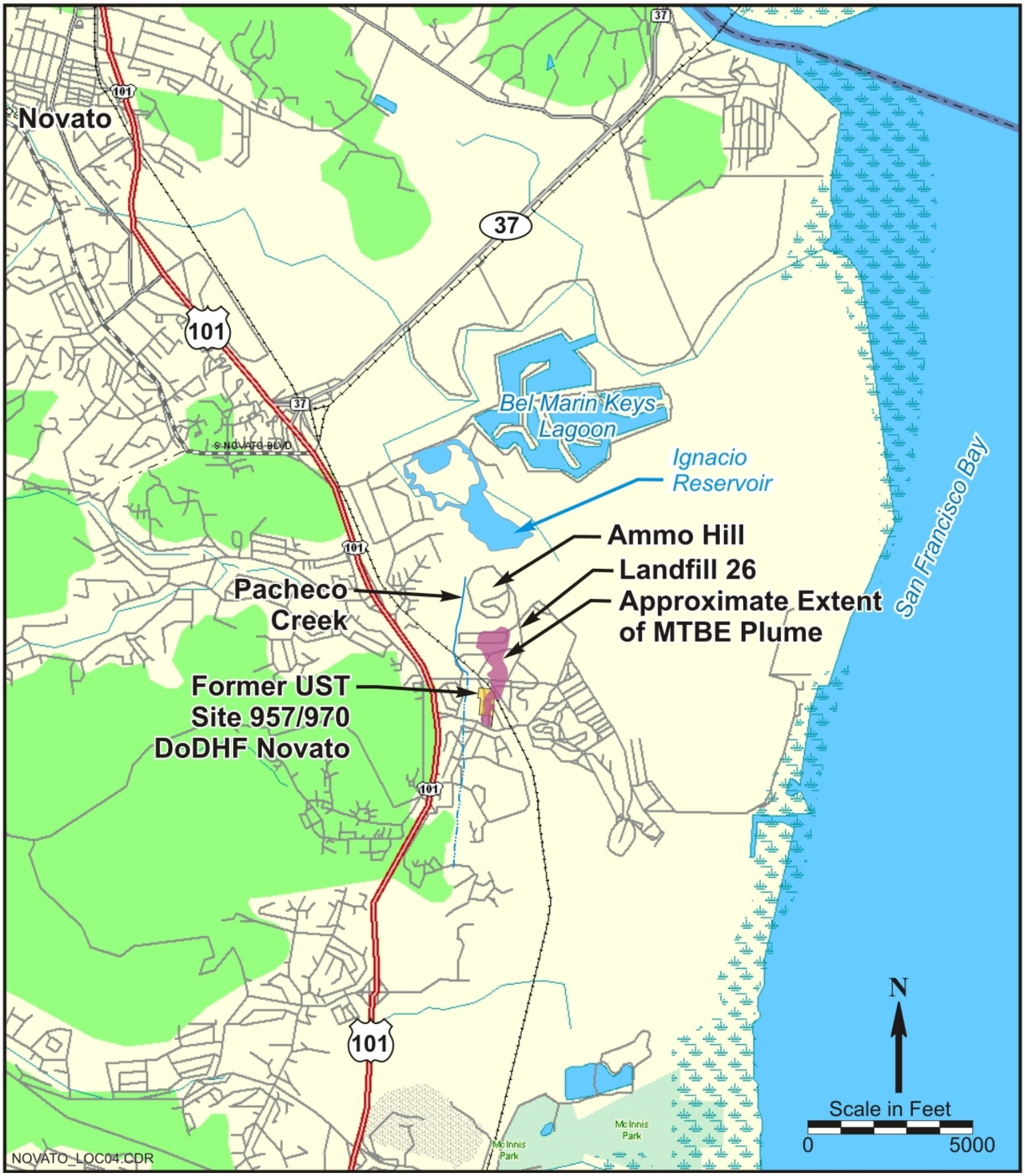


Figure 1. Site Location Map

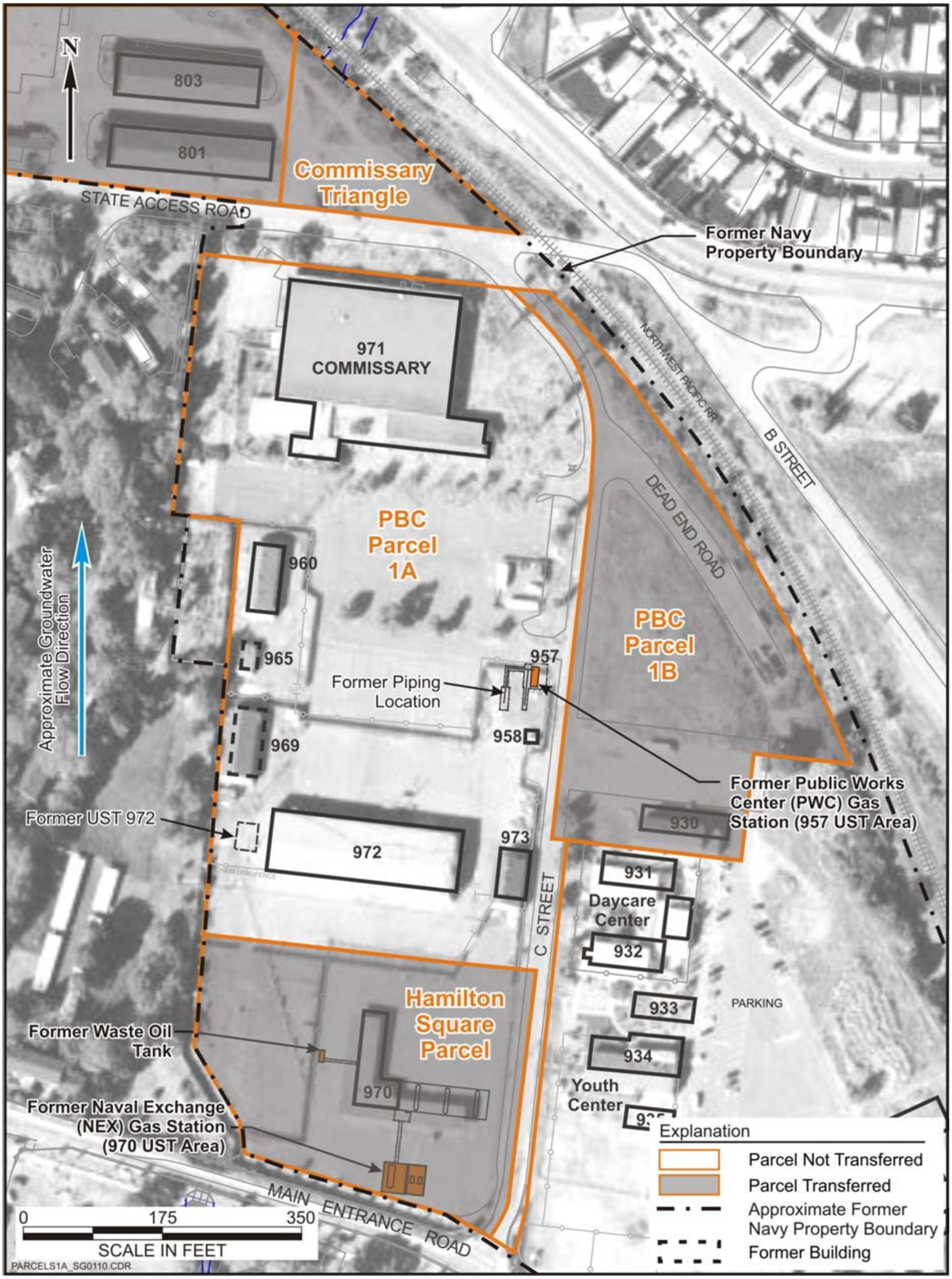


Figure 2. Location of Former NEX and PWC Gas Station

was the site of UST 957 (12,000-gallon UST), which was removed along with its associated underground piping in 1992.

In 1992, groundwater and soil samples were collected from excavations during the tank removal activities in the areas of former USTs 957 and 970. Analytical results from these samples indicated that gasoline was released to the environment from the USTs. Since the initial release, concentrations of gasoline constituents, such as benzene, toluene, ethylbenzene, and xylenes (BTEX), have been significantly reduced as a result of active treatment on Navy property as well as attenuation mechanisms, leaving MTBE as the only chemical of concern remaining in groundwater. Because the MTBE groundwater plumes underlying these two areas have merged and are no longer distinguishable, the individual site designations have been combined and relabeled as "Former UST Site 957/970."

Although the California State Water Resources Control Board (CA Water Board) has not formally acknowledged that groundwater at the Site meets Resolution 88-63 criteria for a municipal beneficial use exemption (Water Board, 1988), impacted groundwater beneath the Site is arguably not a potential drinking water source because the water in the shallow aquifer underneath and downgradient of the Site has a high total dissolved solids concentration and low yield. No domestic, irrigation, or agricultural wells are currently impacted by the dissolved-phase gasoline constituents released from the Site.

Starting in June 1998, an interim remedial action consisting of air sparging and soil vapor extraction (SVE) was implemented to reduce gasoline constituent mass in areas where the highest hydrocarbon concentrations were detected in groundwater. Significant mass removal was achieved by the air sparging and SVE systems, and subsequently the systems were shut down in early October 1999 because of greatly diminished mass removal rates.

In September 2002, a biosparging treatment system was initiated at the Site to mitigate elevated groundwater concentrations of MTBE on Navy property. This active treatment system was temporarily shut down for one year (from March 2005 to March 2006) with approval from the Water Board because asymptotic mass removal was achieved by the system. No significant rebound of MTBE concentrations was observed during this interim shutdown phase. The system was restarted in March 2006 and operated on a pulsed schedule until system shutdown and initiation of the one-year rebound monitoring period began on January 30, 2009 with Water Board approval. During the one-year rebound monitoring period, no significant MTBE rebound was measured in any of the performance goal monitoring wells. Subsequently, the Navy requested permanent shutdown and removal of the biosparging treatment system which was approved by the Water Board on April 15, 2010.

Overall, Former UST Site 957/970 is comprised of former Navy property that is currently in the process of being transferred under the Base Realignment and Closure (BRAC) Program. Accordingly, the Navy has segregated the property into various land parcels to support property transfer activities. Figure 2 illustrates the boundary of the four parcels that comprise or are within the immediate vicinity of Former UST Site 957/970. As depicted in Figure 2, three of the four parcels within this area have already been transferred, including Public Benefit Conveyance (PBC) Parcel 1B, Hamilton Square, and the Commissary Triangle. PBC Parcel 1A is scheduled for transfer to the Novato United School District (NUSD).

1.3 Summary of Current Activities

On December 10, 2008, the Navy presented plans to the BRAC Cleanup Team (BCT) for managing unstable to increasing MTBE groundwater concentrations at the leading edge area of the plume. Afterwards, the Navy submitted the draft addendum to the *Final Corrective Action Plan for*

Groundwater for Former UST Site 957/970 (Battelle, 2002) to the Water Board for review on December 23, 2008. Based on these plans, the Water Board granted conditional shutdown of the biosparging system on January 16, 2009. Overall, the biosparging treatment system was operating on a pulsed schedule from March 2006 (when the system was reinitiated) through January 30, 2009 (when the system was shut down and the one-year rebound monitoring period began). Since no significant rebound was measured during the rebound monitoring period, the Navy formally requested permanent system shutdown and removal in a letter dated January 22, 2010, which was subsequently approved by the Water Board on April 15, 2010.

On May 5, 2009, the *Final Corrective Action Plan Addendum, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* was issued for the Site (Battelle, 2009a). The Corrective Action Plan (CAP) Addendum describes the current site conditions and recommends a remedial action strategy for the leading edge area of the MTBE plume that would ensure protection of human health and the environment in compliance with Water Board Order No. 00-64, Task 6. After evaluating several remedial technology alternatives, the Navy concluded that air sparging and monitored natural attenuation (MNA) with a phytoremediation contingency would achieve a stable to decreasing MTBE plume at the leading edge in the most effective and efficient manner to move towards site closure.

On November 24, 2009, the *Draft Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2009b) was submitted to the regulatory agencies (i.e., Water Board and California Department of Toxic Substances Control [DTSC]) for review. After addressing all regulatory comments, the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) was submitted to all project stakeholders on April 26, 2010. After reviewing the results from the preliminary grab sampling event conducted in May 2010, the air sparge system layout and performance goal monitoring wells were finalized with approval from the regulatory agencies and are presented in the *Final Leading Edge Area Corrective Action Work Plan Addendum* (Battelle, 2010c).

As outlined in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c), installation, shakedown, and start-up of the air sparge system and installation of five additional groundwater monitoring wells to support system performance monitoring were conducted from October through December 2010. Section 3.0 of this Annual SSR provides a detailed description of the field implementation of the corrective action activities and establishes a framework to address the DQOs presented in the SAP of the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b), specifically for managing unstable to increasing MTBE groundwater concentrations in the leading edge area of the plume.

Section 2.0: GROUNDWATER MONITORING PROGRAM

According to the updated SAP provided in the *Annual Site Status Report for the Year 2009, UST Site 957/970, Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010a), water level measurements were collected from across the Site during August and November 2010. However, groundwater monitoring activities were only conducted during November 2010 (i.e., the annual sampling event). Water level measurements were collected for the third quarter on August 26 and 27, 2010 and September 12, 2010 and for the fourth quarter on November 8 and 9, 2010. For the groundwater monitoring activities, 84 monitoring wells were sampled during the fourth quarter from November 10 through 12, November 15 through 19, and November 22 through 23, 2010. This section summarizes the results from the water level measurements and groundwater monitoring activities conducted during August and November 2010. All measurements and groundwater samples were collected and analyzed in accordance with the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) and the *Updated Health and Safety Plan* (Battelle, 2006).

2.1 Summary of Monitoring Program

Each monitoring well was inspected during water level measurements and groundwater monitoring activities and secured upon completion according to the protective measures described in the *Monitoring Well Protection Plan* (Battelle, 2000). All monitoring well observations including condition and any odors from the November 2010 sampling event are documented on the well purge and maintenance log sheets provided in Appendix A.

For the groundwater sampling event, low flow purging and sampling were conducted at all monitoring wells based on the methodology provided in *Groundwater Sampling Guidelines for Superfund and Resource Conservation and Recovery Act (RCRA) Project Managers* (United States Environmental Protection Agency [U.S. EPA], 2002) and the American Society for Testing and Materials (ASTM) Standard D 6771-02 (ASTM, 2002). During purging, water quality parameters including pH, conductivity, dissolved oxygen (DO), temperature, oxidation reduction potential (ORP), and turbidity were measured at each monitoring well every 3 to 5 minutes and recorded on the purge logs (see Appendix A). Once the stabilization criterion for each water quality parameter was achieved, groundwater sample collection was initiated at the monitoring well. The final set of water quality parameter measurements collected after parameter stabilization and immediately prior to sample collection during the November 2010 sampling event and historical sampling events are provided in Appendix B. All purged groundwater and wastewater used to decontaminate the sampling equipment were contained in a 5,000-gal polyethylene tank located on Navy property.

In the SAP attached to the *Final Groundwater Monitoring Plan Update* (Battelle, 2007), a summary of the monitoring analytical program for all groundwater wells and surface water locations is provided in Table 2-1, analytical preparation and methods are summarized in Table 2-2, analytical reference limits are provided in Table 2-3, and the number of quality control (QC) samples is provided in Table 2-4. As part of annual reporting, the Navy has provided optimization recommendations that have been adopted to support the implementation of the monitoring program for former UST Site 957/970 more effectively. While the current monitoring program is generally based on the *Final Groundwater Monitoring Plan Update* (Battelle, 2007), the analyses and number of samples conducted throughout 2010 account for modifications to the program that have been implemented based on these annual optimization recommendations. A summary of the analyses and number of samples for the November 2010 sampling event are as follows:

- MTBE was analyzed in all monitoring wells (total of 84 wells).

- MTBE degradation products, tert-butyl alcohol (TBA) and tert-butyl formate (TBF), were analyzed in 25 monitoring wells.
- Nitrate, sulfate, and dissolved iron were analyzed in 35 monitoring wells.

The laboratory analytical reports for the November 2010 sampling event, including chain-of-custody documentation and quality assurance (QA)/QC summary reports, are provided in Appendix C. All analytical results through November 2010 are available in Microsoft® Excel format (see Appendix D). In addition, the analytical results from the November 2010 sampling event have been uploaded to GeoTracker, the California State Water Resources Control Board's database. The GeoTracker upload confirmation sheets for the November 2010 sampling event are provided in Appendix E.

QA/QC samples were collected in the field to ensure that meaningful and representative data sets were generated during the sampling event. In general, results from duplicate samples were consistent with the primary sample and MTBE was not detected in any of the QA/QC samples (i.e., field blanks, trip blanks, or equipment rinsate blank) collected during the November 2010 sampling event (see Appendix C). These results indicate that no cross-contamination occurred during sampling activities, and that laboratory detections are indicative of actual groundwater conditions at the Site. Table 1 summarizes the frequency of QA/QC samples collected during the November 2010 sampling event.

Table 1. Summary of QA/QC Sample Collection

Sampling Event	# of Field Duplicates	# of Equipment Rinsates	# of Field Blanks	# of Trip Blanks
November 2010	11	9	9	9

Data generated for the Site were verified by the Battelle Project QC Manager and validated by an independent contractor, Laboratory Data Consultants, Inc. (LDC). The independent data validation reports are provided in Appendix F. Data validation involved ensuring that the holding times were met and samples were analyzed according to the frequency and methodology specified in the SAP that was included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007). In general, results of the data validation indicated that sample analyses were conducted according to the frequency and methodology specified in the SAP (Battelle, 2007), all data were considered acceptable for the intended use, and no data were rejected during the data validation process.

Based on the first two quarters in which low flow purging and sampling were implemented at the Site (i.e., February and May/June, 2007), most wells were amenable for sampling using the low flow technique. However, due to varying aquifer conditions encountered during the sampling events and technical difficulties, several wells were not able to be sampled using low flow purging according to the SAP that was included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007). All technical difficulties encountered in the field were corrected as efficiently as possible and all deviations from the low flow sampling protocol are described below.

November 2010 Sampling Event:

- The following monitoring wells purged dry before water levels and water quality parameters stabilized; however, samples were collected from these wells after 2+ hours of recharging and submitted for analyses: MW-3B, MW-M25S, MW-M8-BR, NA-0, and PZ-1.

- The following monitoring wells had drawdown greater than 0.3 feet; however, the water level either stabilized or low flow sampling procedures were followed as stated in the SAP included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) regarding this situation and samples were collected and submitted for analyses: MW-9A, NA-4, MW-4A, NA-0, MW-6B, NA-7, 970-MW3, MW-3D, PG-MW5, MW-M10, MW-2D, MW-M8, MW-M20D, MW-M15, 957-MW4, MW-M25S, MW-M8-BR, MW-M26S, MW-M2-BR, MW-M12, MW-M14S, MW-4B, 957-MW1, MW-M22, MW-M25D, MW-M13, IT-GMP-16, IT-GMP-18, MW-86S, IT-MW-81D, IT-MW-81S, IT-1MW-4A, IT-EW-91-3, IT-GMP-15, IT-EW-91-1, and IT-MW-92-39.

The sampling technique employed at each monitoring well included in Table 2-1 of the SAP included as part of the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) has been documented since the February 2007 sampling event, when low flow purging and sampling were initiated at the Site. This historical documentation will continue to be used during future sampling events to determine the most appropriate and consistent sampling technique for each monitoring well. However, it should be noted that in some instances, consistent sampling techniques may not be feasible due to changing environmental conditions but, in every instance, low flow purging and sampling will first be attempted at the well (with the exception of bedrock monitoring wells).

2.2 Water-Level Measurements

A water-level measurement was collected from each monitoring well across the Site and recorded in accordance with the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) prior to any purging and sampling activities. From the water-level measurements, potentiometric maps for August 2010 and the November 2010 sampling event were developed and are presented in Figures 3a and 3b, respectively. Potentiometric maps for both August and November 2010 have been included to observe any seasonal variations. Groundwater elevations at each monitoring well have been included on the potentiometric maps to illustrate the accuracy of the interpolated groundwater surface. Overall, the potentiometric maps , for August and November 2010, including groundwater flow direction and hydraulic gradient, are consistent with historical potentiometric maps for August and November as well as those for February (first quarter) and May (second quarter), demonstrating that groundwater flows toward the north and northeast across Landfill 26 with a decreasing hydraulic gradient. All historical water-level measurements collected at each monitoring well are included as Appendix G.

During August and November 2010, water level measurements were collected from several wells located in and around Landfill 26 (i.e., MW-78, MW-87, EW-91-07, EW-91-08, MW-82S, MW-82D, EW-91-10, MW-L26-1, EW-91-14, MW-92-43, MW-92-40, and MW-125) to determine the groundwater flow patterns in Landfill 26 and the leading edge area of the MTBE plume (see Figures 3a and 3b). These wells are screened within a deeper portion of the aquifer. The resulting groundwater surface indicates that the hydraulic gradient in Landfill 26 and the leading edge area of the MTBE plume is relatively low as the groundwater flows toward the northeast. These hydraulic conditions are consistent with previous observations and indicate that the MTBE plume may be controlled, and MTBE concentrations at the leading edge of the plume may be stabilized and/or decreased more effectively than upgradient portions of the plume due to the relatively slower groundwater flowrate, thus confirming previous interpretations presented in updates to the conceptual site model (CSM).

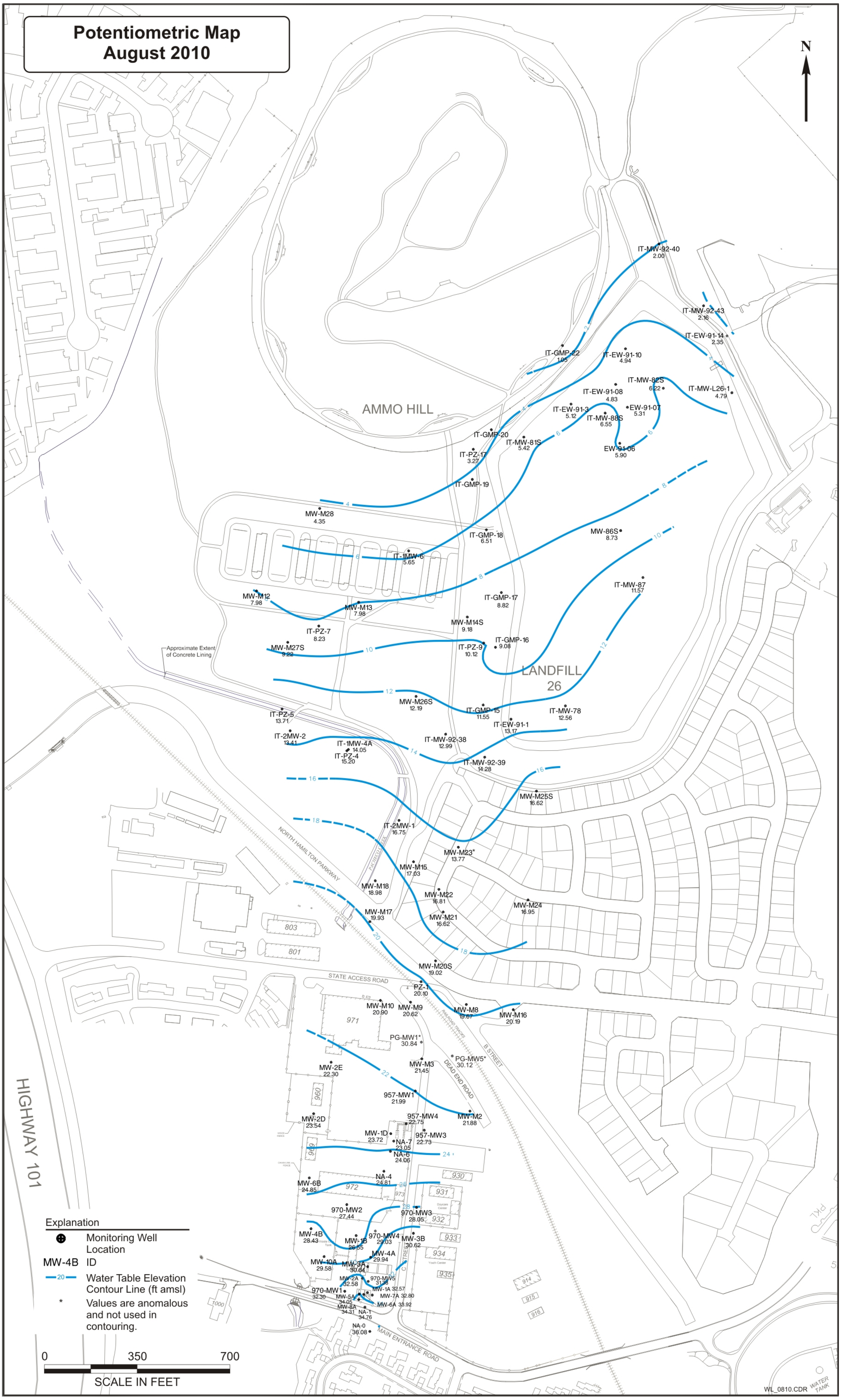


Figure 3a. Potentiometric Map, August 2010

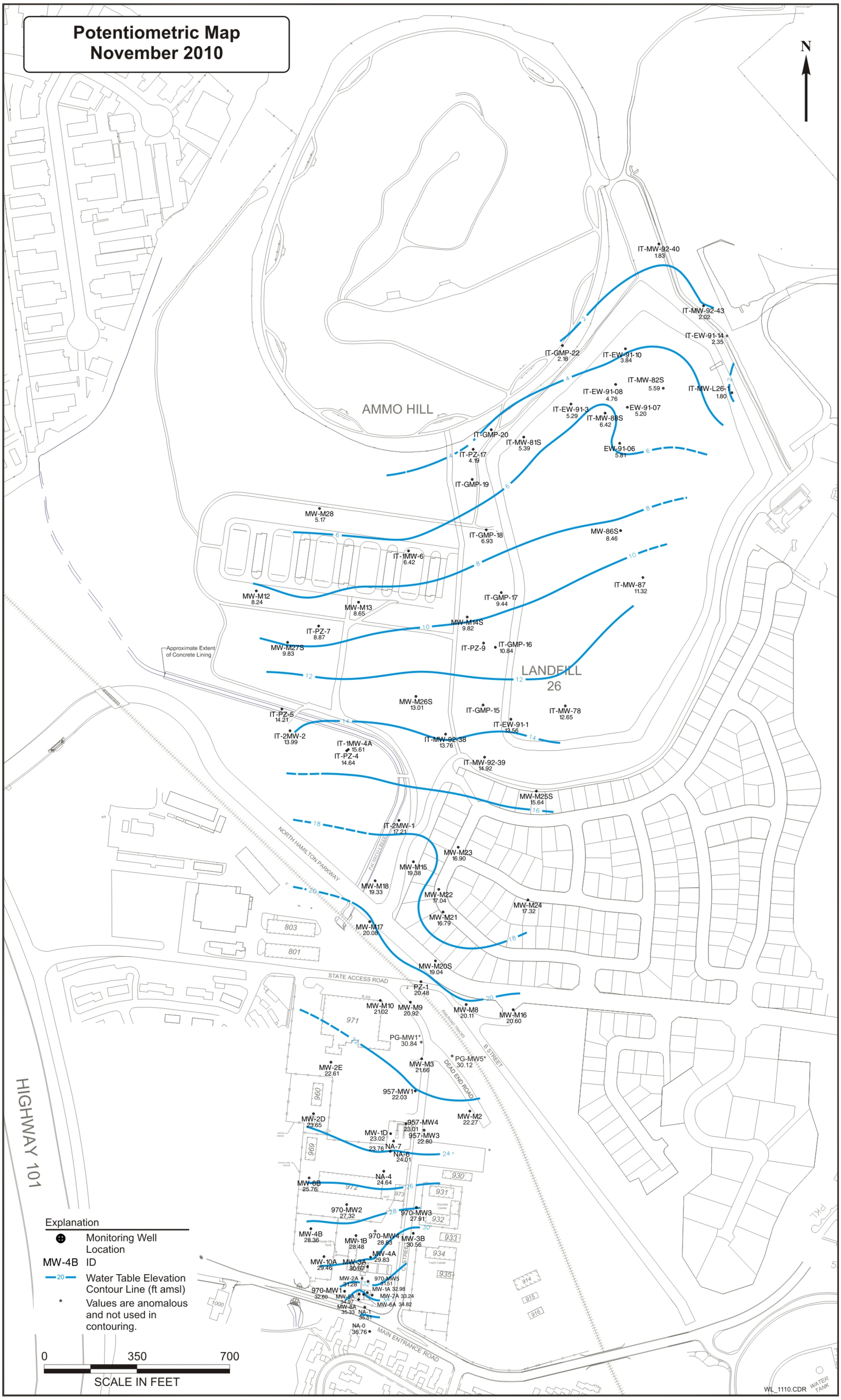


Figure 3b. Potentiometric Map, November 2010

2.3 MTBE Plume Status

During the November 2010 sampling event, the maximum MTBE concentration measured on Navy property (i.e., south of the railroad tracks) was 230 μg/L at PG-MW1, compared to 23,000 μg/L in PG-MW1 in June 2002, prior to operation of the biosparging treatment system. Since the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) was issued for the Site in August 2007, the maximum MTBE concentration measured on Navy property has been at either monitoring well PG-MW1 or PG-MW5, located near the corner of C Street and State Access Road. The maximum MTBE concentration measured off Navy property has historically been detected near Landfill 26 in MW-M14D, with a historic maximum detected concentration of 980 μg/L in August 2006. However, during the November 2010 sampling event, the maximum MTBE concentration measured off Navy property was 660 μg/L at LEA-MW4, one of the five new monitoring wells installed in the leading edge area to evaluate the performance of the air sparge treatment system.

An MTBE groundwater plume map for the November 2010 sampling event is presented in Figure 4. It should be noted that MTBE concentrations posted in parentheses were not used to develop the MTBE plume contour because these data were either produced from a monitoring well that was not screened in the target geologic interval known to host the highest MTBE concentrations (e.g., bedrock monitoring wells or shallow wells near the leading edge treatment area) or it was the lesser concentration in a well cluster or duplicate sample. During the November 2010 sampling event, the furthest extent of MTBE-impacted groundwater from the source area was detected in IT-GMP-19 at 3.5 μg/L. Consistent with past observations, MTBE was not detected in any monitoring wells within Landfill 26, thus bounding the plume on its northeastern edge (see Figure 4).

According to the updated SAP provided in the *Annual Site Status Report for the Year 2009, UST Site 957/970, Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010a), all bedrock monitoring wells (i.e., MW-3D, MW-9A, MW-M8-BR, and MW-M2-BR) are sampled during annual groundwater sampling events at the Site. During the November 2010 sampling event, the maximum MTBE concentration detected was 20.0/30.0 μg/L in MW-M8-BR located near the intersection of B Street and State Access Road. The analytical results from the November 2010 sampling event and all historical sampling events are provided in Appendix D.

2.4 Surface Water

Surface water sampling results for all locations sampled during the annual monitoring events in November 2005, 2006, 2007, 2008, 2009, and 2010 are illustrated in Figure 5 (although since 2007, PC-SW-CE is the only location included in the monitoring program). A comprehensive electronic dataset of all surface water sampling results is provided in Appendix D. The updated surface water sampling program presented in the *Annual Site Status Report for the Year 2009, UST Site 957/970, Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010a) includes MTBE analysis once per year during annual sampling events (i.e., November) at PC-SW-CE to confirm MTBE is not being discharged from this culvert outlet into Pacheco Creek.

During the November 2010 sampling event, a surface water sample could not be collected from PC-SW-CE because the culvert outlet was dry. Although the culvert outlet was dry in November 2009 and 2010, historical surface water sampling results indicate that MTBE has not been detected in Pacheco Creek (i.e., PC-SW-1, PC-SW-2, PC-SW-3, PC-SW-4, and PC-SW-5) or the culvert outlet (i.e., PC-SW-CE) since November 2004 (see Figure 5 and Appendix D) suggesting that the MTBE groundwater plume is no longer impacting Pacheco Creek.

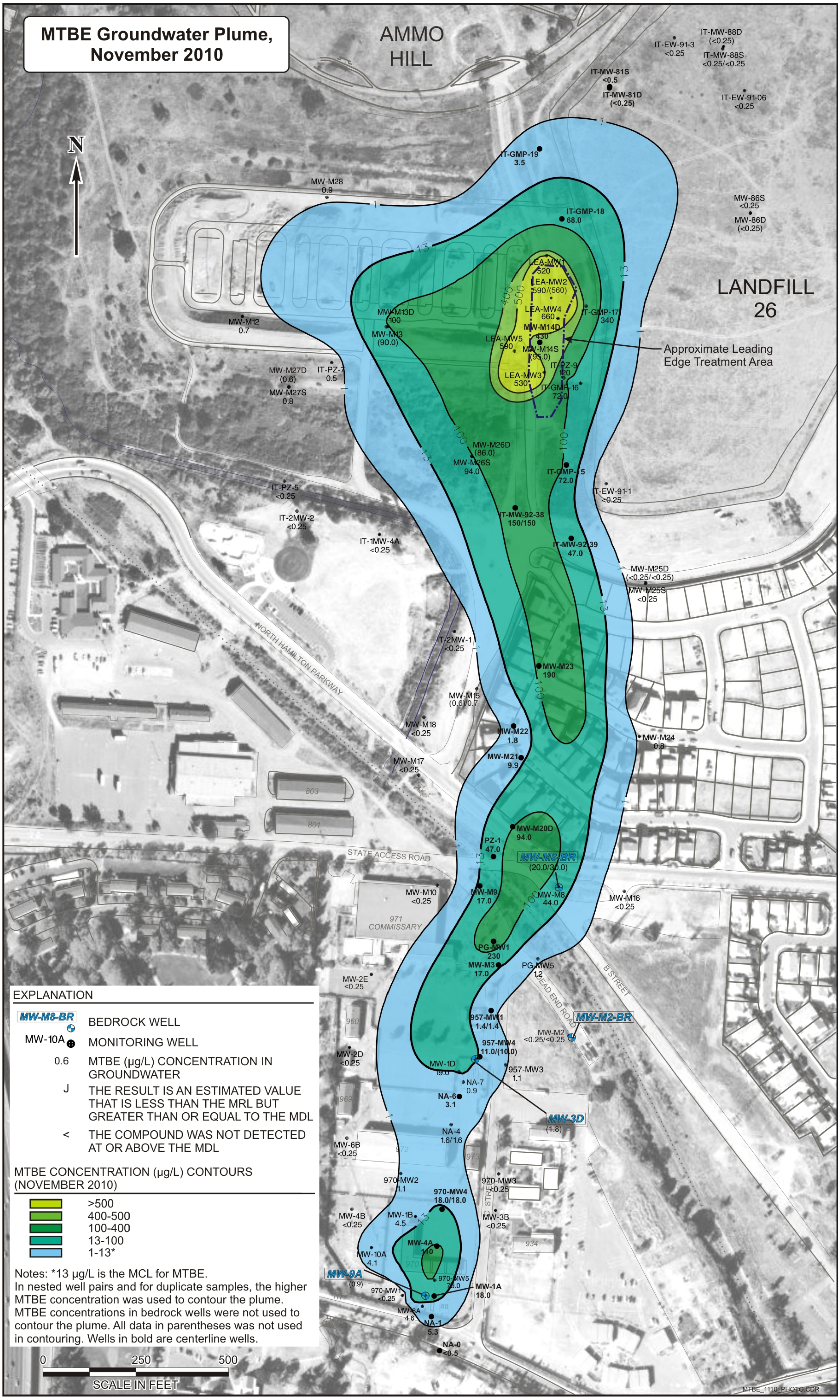
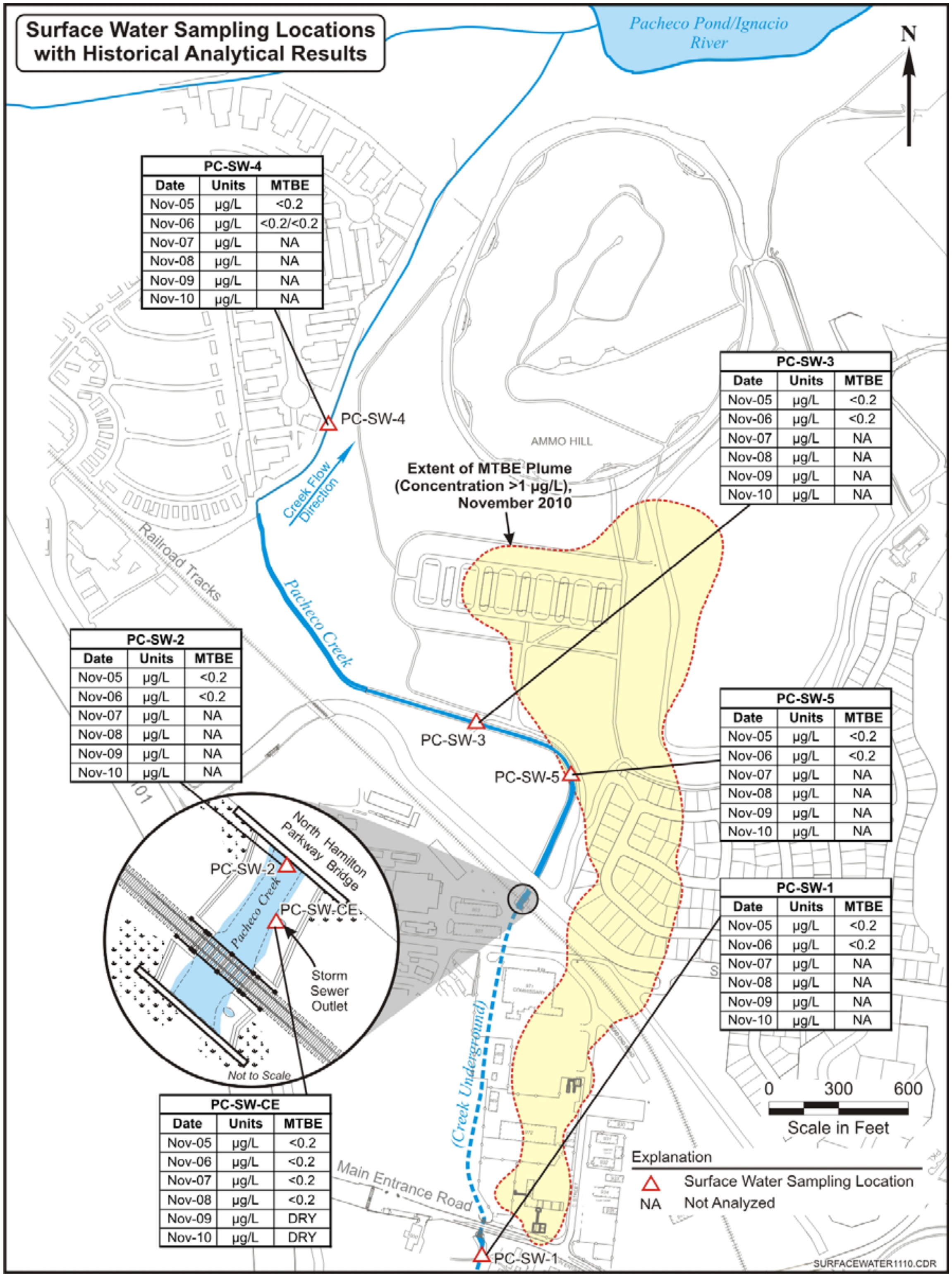


Figure 4. MTBE Groundwater Plume, November 2010



PC-SW-4		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2/<0.2
Nov-07	µg/L	NA
Nov-08	µg/L	NA
Nov-09	µg/L	NA
Nov-10	µg/L	NA

PC-SW-3		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2
Nov-07	µg/L	NA
Nov-08	µg/L	NA
Nov-09	µg/L	NA
Nov-10	µg/L	NA

PC-SW-2		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2
Nov-07	µg/L	NA
Nov-08	µg/L	NA
Nov-09	µg/L	NA
Nov-10	µg/L	NA

PC-SW-5		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2
Nov-07	µg/L	NA
Nov-08	µg/L	NA
Nov-09	µg/L	NA
Nov-10	µg/L	NA

PC-SW-1		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2
Nov-07	µg/L	NA
Nov-08	µg/L	NA
Nov-09	µg/L	NA
Nov-10	µg/L	NA

PC-SW-CE		
Date	Units	MTBE
Nov-05	µg/L	<0.2
Nov-06	µg/L	<0.2
Nov-07	µg/L	<0.2
Nov-08	µg/L	<0.2
Nov-09	µg/L	DRY
Nov-10	µg/L	DRY

Figure 5. Surface Water Sampling Locations with Historical Analytical Results

Section 3.0: LEADING EDGE AREA OF MTBE PLUME

This section provides a brief overview of key features of the CSM for the leading edge of the MTBE plume, which were used to develop the remedial strategy, including the design, installation, and operation of the leading edge area treatment system. In addition, the following section includes: (1) an overview of activities conducted during installation of the air sparge system; (2) a summary of baseline groundwater concentrations in the leading edge area performance goal monitoring wells; and (3) a discussion of performance monitoring that will be conducted on a quarterly basis through 2011 to evaluate the performance of the air sparge treatment system.

3.1 Conditions at the Leading Edge

The *Final Groundwater Monitoring Plan Update* (Battelle, 2007) presents an updated CSM, including a comprehensive understanding of the hydrogeologic conditions near and directly underlying Landfill 26 at the leading edge area of the MTBE plume. The updated CSM indicates that the water-bearing capacity at the leading edge far exceeds that of the upgradient portions of the aquifer and that the hydrogeologic conditions underneath Landfill 26 may potentially limit the migration of the plume and stabilize and/or provide amenable conditions for reducing MTBE concentrations more effectively than conditions upgradient of Landfill 26.

To evaluate the hydrogeologic conditions underneath Landfill 26, water levels were collected from monitoring wells located in the leading edge area of the MTBE plume (specifically within and downgradient of Landfill 26) during August 2010 and the November 2010 sampling event. As described in Section 2.2, potentiometric surfaces were developed from the water-level measurements collected in August 2010 and during the November 2010 sampling event (see Figures 3a and 3b, respectively). The potentiometric surfaces from both events demonstrate that groundwater flows to the north and northeast across Landfill 26 and that the hydraulic gradient in the leading edge area appears to be relatively low compared to the upgradient portion of the plume.

The portion of the aquifer near and underlying Landfill 26 has a greater water-bearing capacity compared to upgradient portions of the aquifer. From well IT-MW-92-38 to MW-82D/S across the landfill, the aquifer thickness increases from approximately 22 to 45 feet. As previously stated, this larger water-bearing capacity underneath Landfill 26 may potentially control the plume and stabilize and/or reduce MTBE concentrations more effectively than conditions upgradient of Landfill 26. In addition to water level measurements, nine monitoring wells within Landfill 26 (i.e., IT-MW-81S/D, MW-86S/D, MW-88S/D, IT-EW-91-1, IT-EW-91-3, and EW-91-06) were sampled during the November 2010 sampling event to delineate the downgradient extent of the MTBE plume. MTBE was not detected in any of these monitoring wells, which is consistent with all historical sampling events, thus bounding the plume on its northeastern edge. Overall, the existing landfill monitoring well network is within the estimated flow path of the MTBE plume and is sufficient to ensure that the MTBE plume continues to be fully delineated at the leading edge (see Figure 4).

3.2 Corrective Action Activities

From October through December 2010, the Navy successfully completed air sparging system installation within the planned target treatment area in accordance with the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c). The treatment system location and layout is presented in Figure 6. Because the air sparge system is considered temporary, all system piping and associated gauges were installed above ground surface within the fenced area depicted in Figure 6.

All applicable and reusable equipment was disconnected from the former biosparging treatment system on Navy property and installed at the leading edge to support the air sparge system operation. The leading edge area shed houses all noise producing equipment (primarily the 2-Busch® Mink 20-hp, 460-V three-phase blowers used to operate the system) and was furnished with acoustical controls and a vibration resistant floor to reduce noise nuisances to nearby residents. Notably, noise monitoring conducted throughout the day and night during system startup indicated that ambient decibel levels at the Hamilton Meadows housing development boundary ranged between 50 and 60 decibels, which is below the 60 decibel standard for residential areas in the City of Novato.

Electrical power was successfully routed from the former biosparging treatment system on Navy property using overhead power lines. The electrical routing was coordinated with the City of Novato and the Sonoma Marin Area Rail Transit and appropriate permits were obtained from each stakeholder.

Prior to the commencement of field activities, all direct push and hollow stem auger drilling locations were checked for utilities by reviewing past utility drawings and notifying Underground Service Alert. The locations of all sparge wells and groundwater monitoring wells were marked with a handheld global positioning system unit prior to installation. A detailed discussion of sparge and monitoring well installation activities is provided in the following subsections.

3.2.1 Sparge Well Installation. The sparge wells are grouped into five injection zones, each consisting of 10 sparge wells. Figure 6 presents the layout of the sparge well network along with the IDs for all 50 wells. Sparge well installation was conducted from October 19, 2010 to November 1, 2010. In general, sparge wells were installed moving from east to west across the site to minimize cross contamination from areas of higher concentration to areas of lower concentration. All 50 sparge wells were constructed of 1-inch Sch-40 polyvinyl chloride (PVC) pipe with a 0.020-inch slot width and a 2-ft screened interval. As stated in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c) and confirmed by field observations, the 2 ft-screened interval was installed such that the screen was nested within the deep water-bearing zone directly overlying the impermeable bedrock. To support accurate screen placement, core samples from each location were collected using a direct push dual core sampling method. The geologic cores were inspected onsite to ensure that the sparge wells were screened within the sandy interval overlying the top of the bedrock surface. Based on these observations the average total depth for the sparge wells was approximately 20 ft, with some variation correlating to the elevation changes of the bedrock surface. Table 2 provides a summary of the construction details for all 50 sparge wells.

In general, sparge well installation was conducted using direct push techniques that employed a Geoprobe rig to advance each boring to the target depth using the previously drilled soil core as a pilot hole. Sparge well installation was conducted by advancing a 3¼ inch diameter hollow steel drive rod fitted with a solid expendable tip which prohibits soil from entering the drive rod as it advances through the subsurface. The target depth was confirmed using a measuring tape. Upon reaching the target depth, a 2-inch diameter steel rod was placed inside the drive rod so that the expendable tip could be disconnected. Once the 2-inch rod was removed from inside the drive rod, the 1-inch PVC piping was inserted down the drive rod to the target depth. A sand (#3 gradation) filter pack was then poured around the well casing to approximately 1 ft above the top of the screened interval on the PVC piping. During construction, the drive rod was retracted in 1-ft intervals to allow the sand to settle into the annular space. This method was repeated at 1-ft intervals during construction of the sand pack and the well seal. Prior to

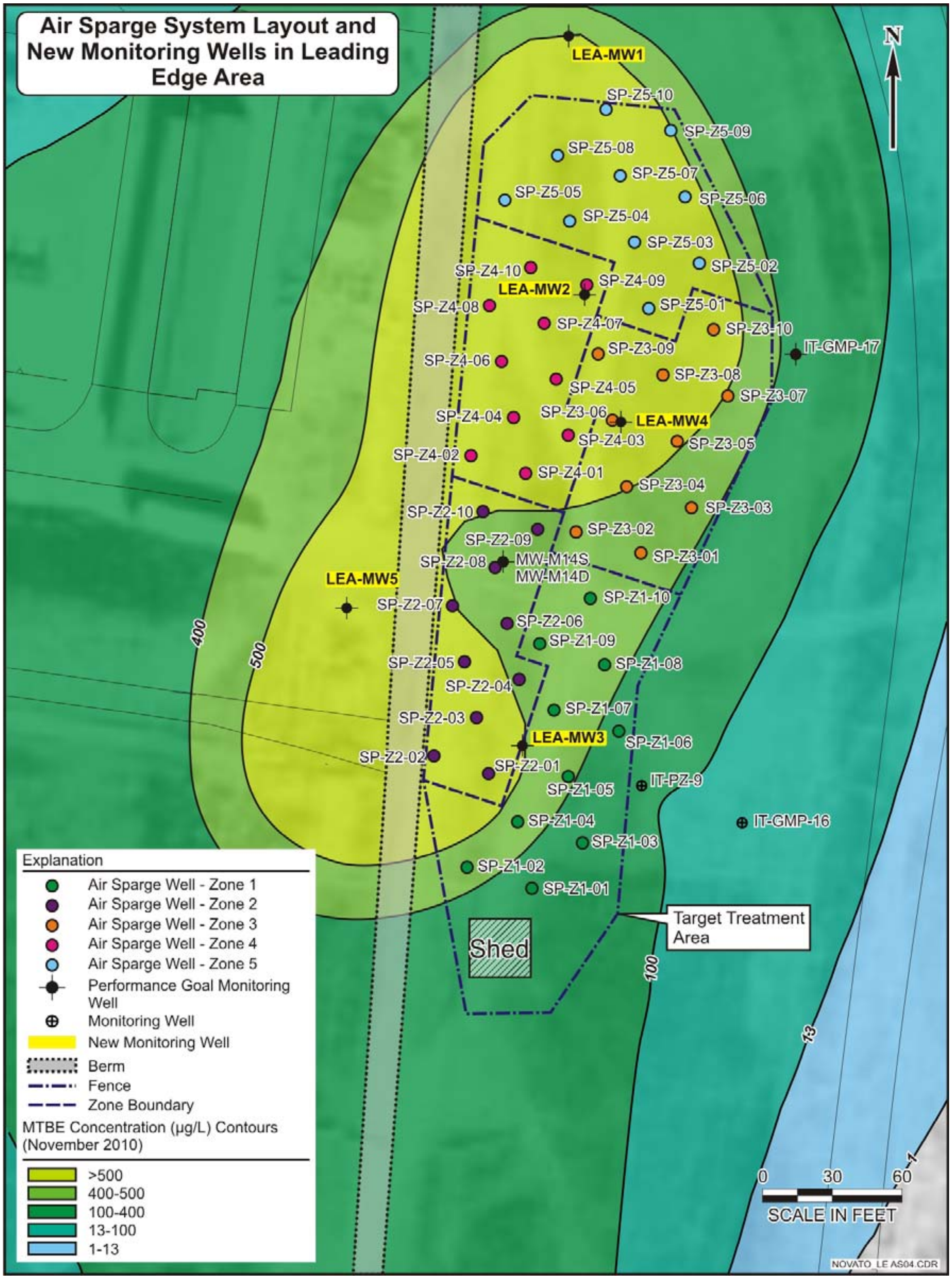


Figure 6. Air Sparge System Layout and New Monitoring Wells in Leading Edge Area

Table 2. Summary of Construction Details for Air Sparge Wells

Well ID	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs)		Date of Initial Purge	Date of Final Purge
			Bottom	Top		
Zone 1						
SP-Z1-01	11/1/2010	20.15	20.15	18.15	11/1/2010	11/8/2010
SP-Z1-02	11/1/2010	20.9	20.9	18.9	11/1/2010	11/8/2010
SP-Z1-03	11/1/2010	23.25	23.25	21.25	11/1/2010	11/8/2010
SP-Z1-04	11/1/2010	16.7	16.7	14.7	11/1/2010	11/8/2010
SP-Z1-05	10/29/2010	12.42	12.42	10.42	10/29/2010	11/8/2010
SP-Z1-06	10/29/2010	21.13	21.13	19.13	10/29/2010	11/8/2010
SP-Z1-07	10/29/2010	21.26	21.26	19.26	10/29/2010	11/8/2010
SP-Z1-08	10/29/2010	20.72	20.72	18.72	10/29/2010	11/8/2010
SP-Z1-09	10/27/2010	21.1	21.1	19.1	10/27/2010	11/8/2010
SP-Z1-10	10/27/2010	24.55	24.55	22.55	10/27/2010	11/8/2010
Zone 2						
SP-Z2-01	11/1/2010	19.8	19.8	17.8	11/1/2010	11/8/2010
SP-Z2-02	10/29/2010	21.83	21.83	19.83	10/29/2010	11/8/2010
SP-Z2-03	10/28/2010	22.63	22.63	20.63	10/28/2010	11/8/2010
SP-Z2-04	10/28/2010	24.15	24.15	22.15	10/28/2010	11/8/2010
SP-Z2-05	10/28/2010	20.75	20.75	18.75	10/28/2010	11/8/2010
SP-Z2-06	10/28/2010	24.58	24.58	22.58	10/28/2010	11/8/2010
SP-Z2-07	10/28/2010	24.37	24.37	22.37	10/28/2010	11/8/2010
SP-Z2-08	10/27/2010	15.1	15.1	13.1	10/27/2010	11/8/2010
SP-Z2-09	10/27/2010	17.21	17.21	15.21	10/27/2010	11/8/2010
SP-Z2-10	10/27/2010	16.1	16.1	14.1	10/27/2010	11/8/2010
Zone 3						
SP-Z3-01	10/22/2010	19.56	19.56	17.56	10/22/2010	11/8/2010
SP-Z3-02	10/27/2010	16	16	14	10/27/2010	11/8/2010
SP-Z3-03	10/20/2010	18.58	18.58	16.58	10/20/2010	11/8/2010
SP-Z3-04	10/22/2010	19.2	19.2	17.2	10/22/2010	11/8/2010
SP-Z3-05	10/22/2010	20.1	20.1	18.1	10/22/2010	11/8/2010
SP-Z3-06	10/22/2010	19.67	19.67	17.67	10/22/2010	11/8/2010
SP-Z3-07	10/19/2010	19.2	19.2	17.2	10/19/2010	11/8/2010
SP-Z3-08	10/21/2010	19.8	19.8	17.8	10/21/2010	11/8/2010
SP-Z3-09	10/22/2010	19.9	19.9	17.9	10/22/2010	11/8/2010
SP-Z3-10	10/19/2010	19.25	19.25	17.25	10/19/2010	11/8/2010
Zone 4						
SP-Z4-01	10/27/2010	17.75	17.75	15.75	10/27/2010	11/8/2010
SP-Z4-02	10/26/2010	17	17	15	10/26/2010	11/8/2010
SP-Z4-03	10/26/2010	20.18	20.18	18.18	10/26/2010	11/8/2010
SP-Z4-04	10/26/2010	19.71	19.71	17.71	10/26/2010	11/8/2010
SP-Z4-05	10/26/2010	23.39	23.39	21.39	10/26/2010	11/8/2010
SP-Z4-06	10/26/2010	20.1	20.1	18.1	10/26/2010	11/8/2010
SP-Z4-07	10/25/2010	21.55	21.55	19.55	10/25/2010	11/8/2010
SP-Z4-08	10/26/2010	21.4	21.4	19.4	10/26/2010	11/8/2010
SP-Z4-09	10/22/2010	20.15	20.15	18.15	10/22/2010	11/8/2010
SP-Z4-10	10/25/2010	23.19	23.19	21.19	10/25/2010	11/8/2010

Table 2. Summary of Construction Details for Air Sparge Wells (Continued)

Well ID	Date Installed	Total Depth (ft bgs)	Screened Interval (ft bgs) Bottom	Screened Interval (ft bgs) Top	Date of Initial Purge	Date of Final Purge
Zone 5						
SP-Z5-01	10/21/2010	24.9	24.9	22.9	10/21/2010	11/8/2010
SP-Z5-02	10/20/2010	23.5	23.5	21.5	10/20/2010	11/8/2010
SP-Z5-03	10/21/2010	21.1	21.1	19.1	10/21/2010	11/8/2010
SP-Z5-04	10/25/2010	20.2	20.2	18.2	10/25/2010	11/8/2010
SP-Z5-05	10/25/2010	21.37	21.37	19.37	10/25/2010	11/8/2010
SP-Z5-06	10/20/2010	20.3	20.3	18.3	10/20/2010	11/8/2010
SP-Z5-07	10/21/2010	19.91	19.91	17.91	10/21/2010	11/8/2010
SP-Z5-08	10/25/2010	19.41	19.41	17.41	10/25/2010	11/8/2010
SP-Z5-09	10/20/2010	21.12	21.12	19.12	10/20/2010	11/8/2010
SP-Z5-10	10/21/2010	21.85	21.85	19.85	10/21/2010	11/8/2010

construction of the well seal, a partial well development was performed to settle the filter pack, thus minimizing the potential for subsidence and maximizing the competency of the well seal.

Based on guidance from the County of Marin Environmental Health Services inspector, the bentonite well seal was placed from 1-ft above the top of screen to the ground surface for all sparge wells. Bentonite pellets were placed and hydrated in 1-ft increments to ensure a competent seal. Because the annular space of the borehole was relatively narrow, spherical time-release bentonite pellets were used to reduce friction along the well casing and allow retraction of the drive rod without impacting the placement of the well casing. The spherical shape of the time release bentonite pellets also prevented bridging within the narrow annular space. The bentonite pellets were hydrated continuously during installation using potable water. Sufficient time was allowed for the bentonite seals to hydrate prior to revisiting each sparge well for a second purge to complete the well development. Sparge well development was considered complete when purge water was observed to be clear and with no sediment. Sparge wells were completed at the surface with an irrigation vault and furnished with a pressure gauge and flow control valve which was connected to the main air distribution system.

3.2.2 Monitoring Well Installation. As stated in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c), the Navy proposed that five additional monitoring wells (i.e., LEA-MW1, LEA-MW2, LEA-MW3, LEA MW4, and LEA-MW5) be installed and sampled along with two existing monitoring wells (MW-14D and IT-GMP-17) to effectively evaluate the performance of the air sparge treatment system. The five additional groundwater monitoring wells were installed and completed in locations based on the results of the preliminary grab sampling event conducted in May 2010 and discussions with the regulatory agencies. Figure 6 presents the locations of the five additional monitoring wells along with the air sparge system layout.

Monitoring well installation was conducted from November 1 through November 4, 2010. The monitoring wells were installed within the deeper portion of the aquifer to a depth of approximately 22 to 23.5 ft below ground surface (bgs) with a 5-ft screened interval. The screen placement methodology was the same as that detailed above for the sparge wells, with the bottom of the screened interval being installed at or near the bedrock surface. Monitoring wells were constructed of Schedule 40 PVC pipe with a 2-in diameter. The screened interval also included 2-inch-diameter Schedule 40 PVC with 0.01-inch slots. The filter packs were constructed of #2/12 silica sand placed uniformly within the annular space between the formation and the screen interval. Table 3 presents a summary of the well construction details for the five additional monitoring wells. Additionally, the boring logs and monitoring well completion diagrams for LEA-MW1, LEA-MW2, LEA-MW3, LEA MW4, and LEA-MW5 are provided in Appendix H.

For the drilling effort, a Geoprobe drill rig with hollow-stem auger drilling capability was used to advance soil borings to the target depth. The top of the filter pack was installed to approximately 1 ft above the top of the screen. Prior to construction of the well seal, a partial development was performed to settle the filter pack, thus minimizing the potential for subsidence and maximizing the competency of the well seal. A 2-ft transition seal of medium bentonite chips was set in the annular space around the well casing directly overlying the filter pack. The bentonite chips were hydrated continuously during installation using potable water to form a tight seal. The bentonite seal was permitted to swell for approximately 30 minutes before the grout seal was installed. The remaining annular space was backfilled with a bentonite grout slurry to approximately 1 ft bgs. A concrete surface seal was placed above the bentonite grout slurry to complete the well construction. The top of the PVC well casing was terminated at approximately 3.0 ft above ground surface and sealed with a locking gasket plug. Additionally, a locking stand pipe and two opposing crash posts were installed to protect the well casing (see Appendix H).

Well development was conducted following stabilization of the water table within each monitoring well. Final well development was considered complete when three consecutive measurements of pH, temperature, and specific conductivity taken for every one-half borehole volume (after the first borehole volume was purged) varied less than 10% and turbidity was 5 nephelometric turbidity units or less. Approximately four borehole volumes of water were purged from each monitoring well during development. Purged groundwater and wastewater produced from well development activities was collected and stored in a 5,000-gal polyethylene tank located on Navy property.

Table 3. Summary of Construction Details for Performance Goal Monitoring Wells

ID	Date Installed	Location		Total Depth (ft bgs)	Screened Interval (ft bgs)	
		Northing	**Easting**		**Bottom**	**Top**
LEA-MW1	11/2/2010	2216044.66	5978596.32	22	22	17
LEA-MW2	11/2/2010	2215931.71	5978604.08	23	23	18
LEA-MW3	11/2/2010	2215734.57	5978578.20	23.5	23.5	18.5
LEA-MW4	11/3/2010	2215876.23	5978620.31	22	22	17
LEA-MW5	11/4/2010	2215794.12	5978501.21	23	23	18

3.3 Performance Monitoring

As stated in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c), time-series groundwater analytical results have indicated that MTBE concentrations were stable to decreasing throughout the majority of the plume; however, concentrations were determined to be unstable to increasing in five monitoring wells, including MW-M13, MW-M13D, MW-M14S, MW-M14D, and IT-GMP-18 at the leading edge of the MTBE plume (see Figure 4). The corrective action (i.e., air sparge treatment system) is being implemented to establish stable to decreasing concentrations throughout the entire MTBE plume, so that MNA can be implemented as the final remedy at the Site. To support this objective, treatment system performance goals have been established to ensure that MTBE concentrations are reduced in the target treatment area such that a stable to decreasing plume is established once sufficient time has been allowed for the treatment effects to be realized throughout the leading edge area.

The Navy has specified an average MTBE concentration reduction of 75% in the target treatment area as the primary performance goal for the air sparging system. Figure 7 depicts the seven monitoring wells that will be used to evaluate the performance of the air sparging system, including two existing monitoring wells (i.e., IT-GMP-17, MW-M14D) and five recently installed monitoring wells (i.e., LEA-MW1, LEA-MW2, LEA-MW3, LEA-MW4, and LEA-MW5).

Average MTBE concentration reductions will be confirmed through quarterly performance monitoring conducted in February, May, August, and November 2011. All performance monitoring wells (i.e., IT-GMP-17, MW-M14D, LEA-MW1, LEA-MW2, LEA-MW3, LEA-MW4, and LEA-MW5) will be sampled and the MTBE groundwater concentrations will be evaluated using the baseline sampling results from November 2010. Figure 7 provides a summary of the performance goal monitoring wells, the baseline MTBE result for each monitoring well, and the equation that will be used to calculate the percent reduction in each performance goal monitoring well. The performance of the air sparging system will be evaluated using the framework established in Figure 7 and the results of each quarterly performance monitoring event will be submitted via e-mail to regulatory agencies for review. The Navy plans to operate the air sparging system for one year, but would discontinue operation of the system if the performance goal of 75% reduction is achieved within the target treatment area.

In addition to sparge and monitoring wells, three soil gas probes were installed between the target treatment area and the housing development to ensure that there is no significant migration of MTBE in soil gas resulting from sparging activities at the leading edge. Each soil gas probe was installed using a Geoprobe and the sampling screens were placed as deep as possible while ensuring the screen did not intersect the groundwater table. The construction details and locations for the soil gas monitoring points are presented in Table 4 and Figure 7, respectively.

Table 4. Summary of Construction Details for Leading Edge Area Soil Gas Monitoring Points

ID	Date Installed	Location		Total Depth (ft bgs)	Screened Interval (ft bgs)	
		Northing	Easting		Bottom	Top
LEA-SG1	11/5/2010	2215247.825	5978533.083	2.5	2.5	2.3
LEA-SG2	11/6/2010	2215219.352	5978713.848	2.5	2.5	2.3
LEA-SG3	11/7/2010	2215408.501	5978690.466	2.5	2.5	2.3

On December 23, 2010, soil gas sampling was attempted at all three soil gas monitoring points. However, a sample could only be collected and analyzed from LEA-SG1 due to moisture observed in the sample tubing at LEA-SG2 and LEA-SG3. MTBE was not detected above the MDL (i.e., < 1.1 ppbv) in LEA-SG1. Although moisture was observed in the sample tubing at LEA-SG2 and LEA-SG3, this first round of sampling was attempted during the month of December, which is seasonally subject to high precipitation rates which increases the likelihood of encountering moisture in the shallow subsurface (i.e., due to the elevated water table or infiltration). The next round of soil gas sampling is planned for February 2011 and it is expected that moisture may be an issue during this sampling event as well. However, the Navy is hopeful that future soil gas sampling conducted during May and August 2011 (i.e., months that are seasonally subject to lower precipitation rates than February and December) will yield soil gas samples from all three monitoring points.

Leak detection was conducted using compressed helium and an impermeable shroud draped over the sampling apparatus during sample collection. However, the soil gas sample collected from LEA-SG1 was not analyzed for helium, which limits the ability to evaluate sample collection for potential leaks; in the future helium analysis will be conducted so that leaks can be evaluated appropriately. The laboratory analytical report for the soil gas sampling activities is provided in Appendix I.

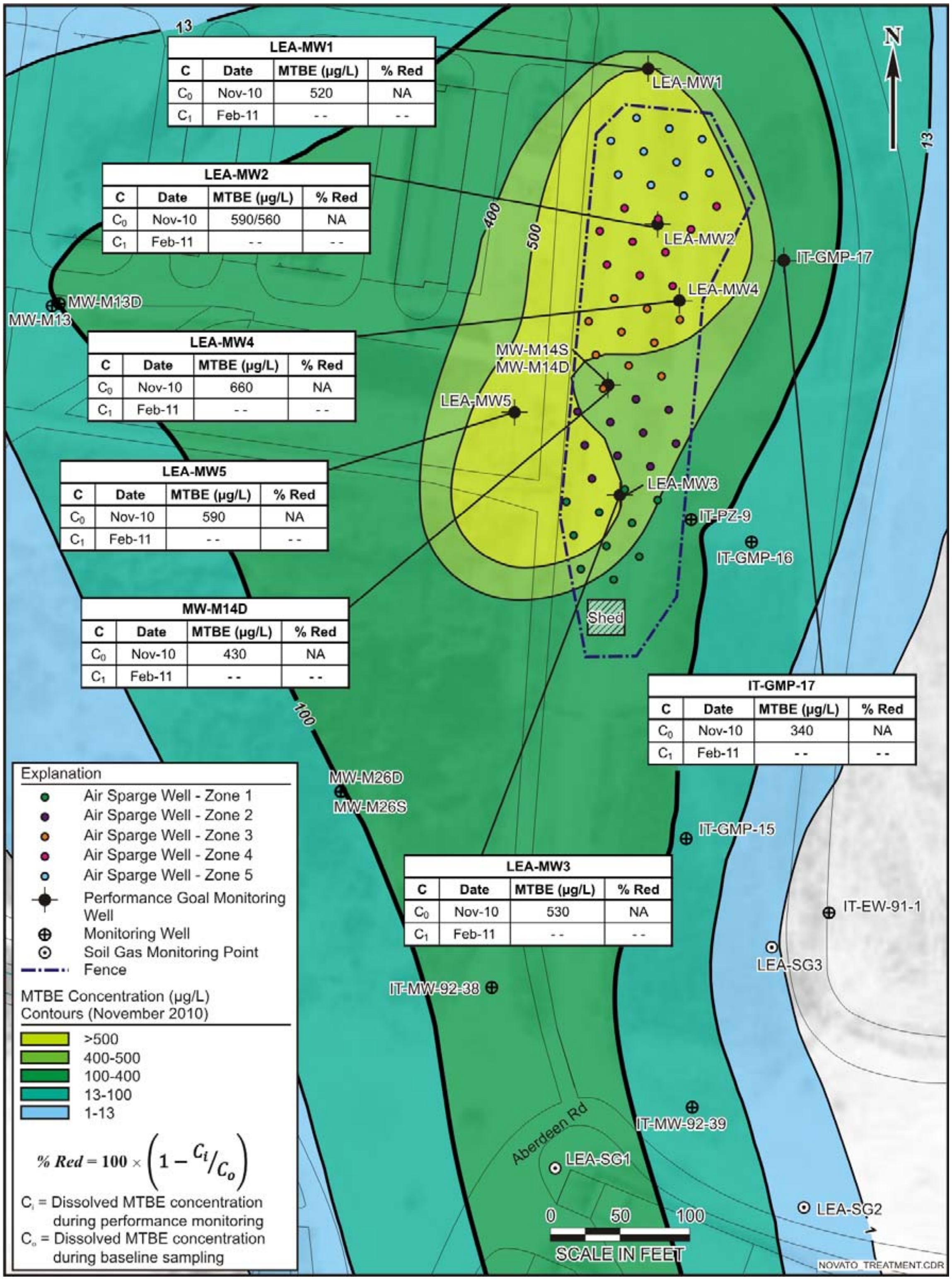


Figure 7. Leading Edge of the MTBE Plume Showing the Treatment System Layout, Performance Goal Monitoring Wells, and Leading Edge Soil Gas Monitoring Points

Section 4.0: EVALUATION OF MNA THROUGHOUT MTBE PLUME

MNA is defined by the U.S. EPA as “an alternative means of achieving remediation objectives that may be appropriate for specific, well-documented site circumstances where its use meets the applicable statutory and regulatory requirements” (U.S. EPA, 2005). Natural attenuation relies on naturally-occurring processes, such as biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization, to reduce contaminant concentrations in groundwater; however, due to the complexity of environmental systems it is not technically practicable to quantify the individual contribution of each mechanism to observed concentration reductions (U.S. EPA, 2005). This section addresses specific DQOs included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) to evaluate the occurrence of MNA throughout the MTBE plume. The lines of evidence that have been established to assess MNA include evaluations of: (1) plume stability; (2) changes in dissolved MTBE mass over time; and (3) geochemical indicators of biodegradation processes.

4.1 Plume Stabilization

Notably, Former UST Site 957/970 is a large site at which multiple active treatment systems have operated in the past including the biosparging system for which the treatment area approximately extended from the former PWC 957 gas station to the Navy property boundary. Prior to the November 2010 sampling event, this area has not been evaluated for plume stability because the biosparging system operated until January 30, 2009 and adequate time-series data (i.e., since system shutdown) was not available. Therefore, this represents the first time in which the entire monitoring well network has been evaluated for plume stability (i.e., with the exception of the five new monitoring wells in the leading edge area for which time-series data are not available, including LEA-MW1, LEA-MW2, LEA-MW3, LEA-MW4, and LEA-MW5). Overall, the evaluation of plume stability focuses on trends in individual monitoring wells and emphasizes the differences observed in monitoring wells located in the leading edge area compared to those wells located in the upgradient areas of the MTBE plume.

This evaluation is based on a statistical analysis of time series MTBE data at each monitoring well, which is then interpreted throughout the site to determine areas of the plume where MTBE is unstable to increasing or stable to decreasing. Parametric regression analyses were conducted using MTBE data collected through November 2010 to quantify MTBE concentration trends at each monitoring well based on MTBE MNA guidance published by the U.S. EPA (U.S. EPA, 2005). Appendix I provides a detailed summary of the statistical analysis performed for each monitoring well.

Based on the results of the statistical analysis, each well is grouped into one of four categories, as follows:

- **Statistically Significant Decreasing Trend** – This designation indicates that MTBE concentrations are decreasing over time and that these trends are statistically significant based on a comparison to historical concentration trends. MTBE concentrations in these monitoring wells can be expected to decrease over time.
- **Statistically Insignificant Decreasing Trend** – This designation indicates that MTBE concentrations are decreasing over time, however the decreasing trend is not statistically significant based on a comparison to historical concentration trends. If consistent decreases in MTBE concentrations continue to be observed, it is possible for this trend to change to a statistically significant decreasing trend. At that time, MTBE concentrations in these monitoring wells can be expected to continue to decrease over time.

- **Statistically Insignificant Increasing Trend** – This designation indicates that MTBE concentrations are increasing over time, however the increasing trend is not statistically significant based on a comparison to historical concentration trends.
- **Statistically Significant Increasing Trend** – This designation indicates that MTBE concentrations are increasing over time and that these trends are statistically significant based on a comparison to historical concentration trends. MTBE concentrations in these monitoring wells can be expected to increase over time.

The Navy has continually evaluated statistical trends throughout the MTBE plume. The results of these evaluations have indicated that MTBE concentrations in monitoring wells located in the upgradient area of the plume (i.e., outside of the leading edge area) have demonstrated statistically significant decreasing trends. However, due to the northern migration of the residual MTBE mass, concentrations in some monitoring wells located in the leading edge area of the plume have demonstrated unstable or increasing trends. Figure 8 presents the results from the statistical analysis evaluating concentration trends throughout the MTBE plume. Overall, the results of the November 2010 statistical evaluation are similar to previous evaluations and indicate that there is a distinct difference in MTBE concentration trends in the leading edge area compared to the upgradient area.

Leading Edge Area – Increasing MTBE concentration trends are more prevalent in the leading edge area as compared to the upgradient area of the plume. In November 2010, MTBE concentration trends were examined at 28 monitoring wells within the leading edge area (see Figure 8). MTBE concentrations exceeded the maximum contaminant level (MCL) for MTBE (i.e., 13 μg/L) in 13 of the 28 monitoring wells evaluated in the leading edge area. Overall, 12 monitoring wells demonstrated statistically significant decreasing trends or non-detect concentrations (two of which exceeded the MCL), four monitoring wells demonstrated a statistically insignificant decreasing trend (two of which exceeded the MCL), three monitoring wells demonstrated a statistically insignificant increasing trend (one of which exceeded the MCL), and nine monitoring wells demonstrated a statistically significant increasing trend (eight of which exceeded the MCL).

Upgradient Area – MTBE concentrations in the upgradient area have consistently demonstrated decreasing trends. In November 2010, the MTBE concentration trend was examined at 47 monitoring wells in the remaining portion of the plume (see Figure 8). MTBE concentrations exceeded the MCL for MTBE (i.e., 13 μg/L) in only 10 of the 47 wells evaluated in the upgradient portion of the plume. Overall, 45 monitoring wells demonstrated statistically significant decreasing trends or non-detect concentrations (10 of which exceeded the MCL) and two monitoring wells demonstrated a statistically insignificant decreasing trend (neither of which exceeded the MCL). No monitoring wells demonstrated a statistically insignificant increasing trend or significant increasing trend.

Overall, there is a considerable difference between the MTBE concentration trends in each area. In the leading edge area, 32% of the monitoring wells have shown a statistically significant increasing trend, while in the upgradient area, no wells have shown this trend. In contrast, 43% of the monitoring wells in the leading edge area have shown a statistically significant decreasing trend or non-detect concentrations, as compared to 96% of the monitoring wells in the upgradient area. In addition, a majority of the monitoring wells that exceeded the MCL are now observed in the leading edge, with 13 wells exceeding the MCL in the leading edge area (18 when counting the five newly installed leading edge wells that were not included in the statistical evaluation) compared to only 10 wells throughout the upgradient portion of the plume.

The statistical evaluation discussed above is highly dependent on the magnitude of the initial concentrations of the time-series data available for each well. In some cases, the determination that a well is unstable or increasing is attributable to a starting MTBE concentration that is below the MCL or non-detect. This is primarily the case in the leading edge area where wells were installed and monitored as the MTBE plume was migrating into this formerly non-impacted area. In an attempt to better understand recent trends and inform corrective action activities, the *Final Corrective Action Plan Addendum* (Battelle, 2009a) evaluated time-series plots for all monitoring wells in the leading area to identify specific wells that had not reached a maximum MTBE concentration (i.e., such that recent trends were decreasing). The *Final Corrective Action Plan Addendum* identified five monitoring wells, including MW-M13, MW-M13D, MW-M14S, MW-MW14D, and IT-GMP-18, in the leading edge area that exhibited time-series MTBE plots that were unstable or increasing. The leading edge treatment system was specifically designed to address the area of highest MTBE concentrations so that these five wells would begin to show a decrease in the overall MTBE trend. In order to better relate this MNA evaluation to the underlying objective of ongoing active treatment in the leading edge area, time-series plots for these five monitoring wells have been added to Figure 8.

Interestingly, the most recent plots for these five wells show that conditions have changed in four of the five wells (i.e., since the *Final Corrective Action Plan Addendum* [Battelle, 2009a]), where MTBE concentrations are close to stabilizing in MW-M13 and MW-M13D and MTBE concentrations have begun to decrease in MW-M14S and MW-M14D (see Figure 8). The time-series data for these five monitoring wells will continue to be evaluated as to whether the effects of the leading edge treatment further promote decreasing trends in these wells.

4.2 Mass Estimates

The estimated total mass of MTBE in groundwater has decreased significantly from May 2002 (142.2 kg), prior to initiation of the biosparging treatment system, to November 2010 (47.1 kg), approximately 21 months after system shutdown on January 30, 2009. Figure 9 illustrates the estimated MTBE mass trend along with the percent reduction in dissolved MTBE mass for areas of the plume on and off Navy property since May 2002. As shown in Figure 9, there was a significant decrease in the dissolved MTBE concentration in November 2009 which was followed by an increase in the dissolved MTBE concentration in November 2010. Based on a comparison of the November 2009 mass result to the previous three years (i.e., November 2006 through November 2008), this result is somewhat inconsistent with past trends. Based on a comparison of MTBE concentrations throughout the plume from November 2008 to November 2010, the anomalous decrease in dissolved MTBE concentrations in November 2009 was primarily attributable to a variation in the MTBE concentration in IT-MW-92-38 and IT-MW-92-39:

Well ID	2008 (μg/L)	2009 (μg/L)	2010 (μg/L)
IT-MW-92-38:	270	1.6	150
IT-MW-92-39:	25	< 0.25	47

As shown above, there were significant decreases in the MTBE concentration in IT-MW-92-38 and IT-MW-92-39 in November 2009 compared to November 2008 and 2010. Low MTBE concentrations in these two wells resulted in a “contouring gap”, where the 2009 MTBE plume contained a sizable separation in the 13 and 100 μg/L contour areas, extending from the northernmost extent of the Hamilton Meadows Subdivision to the southernmost extent of the leading edge area. This separation was a product of the three-dimensional contaminant modeling conducted using EarthVision® software, which is also used to estimate the total dissolved mass. Another potential contribution to the increased mass

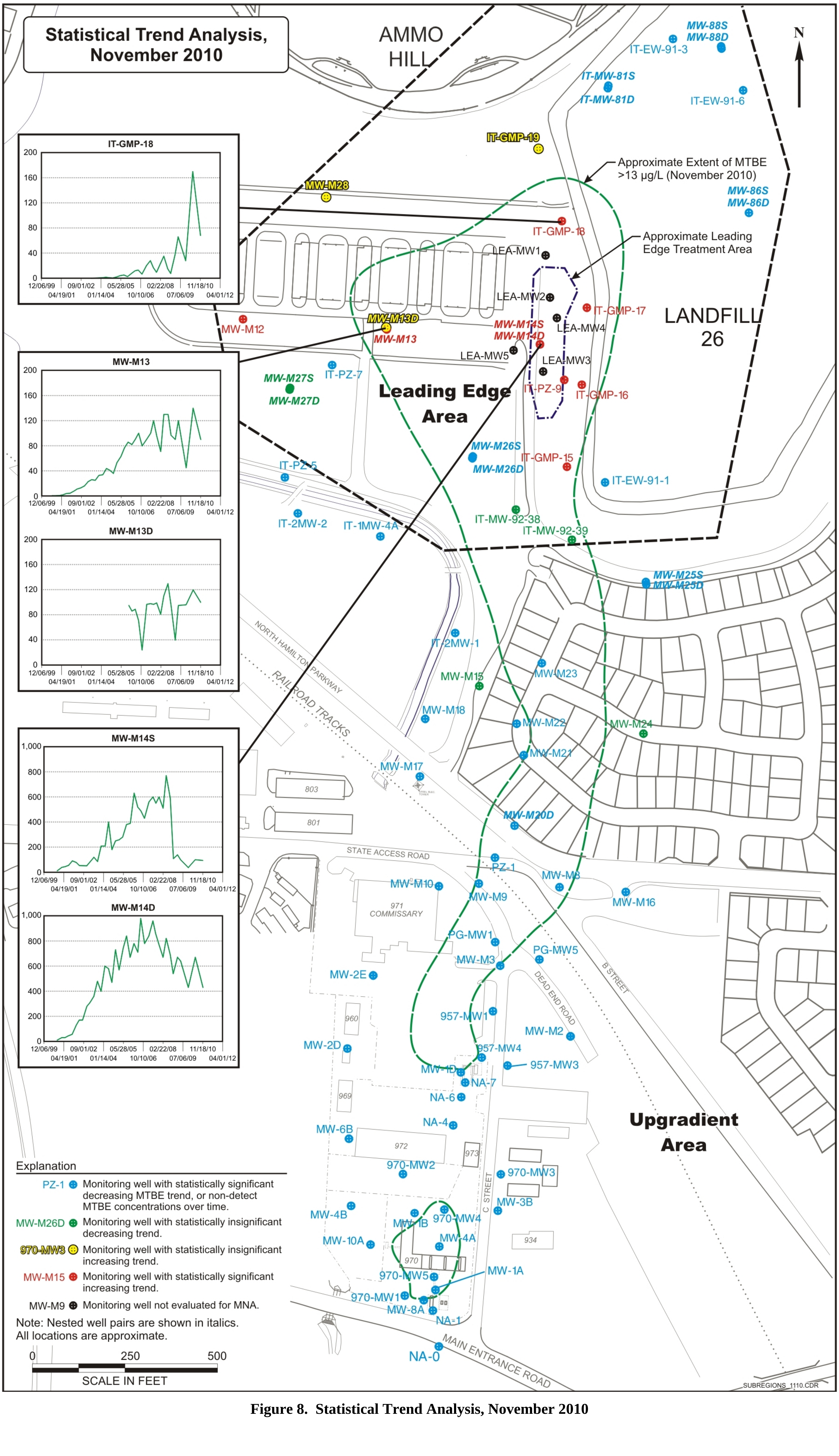


Figure 8. Statistical Trend Analysis, November 2010

estimated in November 2010 is the addition of the five new monitoring wells in the leading edge area of the site model, in which some of the highest MTBE concentration were observed. Overall, these two factors are most likely the cause for the increase in the calculated MTBE mass from November 2009 to November 2010. Although the calculated mass estimate for November 2010 is greater than that from November 2009 (26.8 kg), based on Figure 9 there is clearly a definitive decreasing trend in MTBE mass throughout the plume.

As shown in Figure 9, MTBE mass estimates from the November sampling events are represented because the entire monitoring well network is sampled during these events providing the most accurate and consistent mass estimates over time. The bar chart tracks the total mass and details the percentage of total mass that has been present on and off Navy property during operation and after shutdown of the biosparging treatment system. The relative amount of MTBE mass on Navy property has decreased dramatically and currently represents less than 1% of the total dissolved MTBE mass in groundwater. The line plots presented in Figure 9 correspond to the percent reduction in MTBE mass on and off Navy property. MTBE mass has been reduced both on and off Navy property, although a higher reduction rate is consistently demonstrated on Navy property compared to off Navy property. This difference is primarily attributed to the historical operation of the in situ air sparging (IAS)/SVE and biosparging treatment systems on Navy property. The portion of the plume off Navy property has not been subject to active treatment, so it is likely that the observed reduction trends are attributable to natural attenuation mechanisms. If natural attenuation was not occurring, MTBE mass downgradient of the treatment system (i.e., off Navy property) would be expected to increase as MTBE mass migrated past the property boundary. However, because consistent decreases in MTBE mass have been observed off Navy property, MNA is considered a viable long-term remedy to achieve site closure.

4.3 Geochemical Conditions

In addition to data indicating plume stabilization and loss of contaminant mass over time, geochemical MNA indicators (i.e., DO, ORP, nitrate, sulfate, and ferrous [or dissolved] iron) and MTBE degradation products (i.e., TBA and TBF) have also been evaluated to assess the occurrence of biodegradation processes in the subsurface. During the November 2010 sampling event, geochemical parameters and MTBE degradation products were collected from centerline and leading edge area monitoring wells as detailed in the updated SAP provided in the *Annual Site Status Report for the Year 2009, UST Site 957/970, Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010a). The analytical results for the geochemical parameters and degradation products from the November 2010 sampling event are provided in the laboratory analytical reports in Appendix C.

In an attempt to characterize the occurrence of biodegradation in the subsurface, MTBE concentrations were compared to analytical results for nitrate, sulfate, ferrous iron, and TBA as well as DO and ORP field measurements along the MTBE plume centerline. Figure 10 presents the results of this evaluation by depicting the spatial trends of geochemical parameters and MTBE degradation products with respect to MTBE concentrations along the plume centerline.

Based on the evaluation presented in Figure 10, the following conclusions regarding MNA have been made:

- ***Sulfate & Nitrate*** – Sulfate and nitrate are terminal electron acceptors that are expected to decrease in impacted areas and then increase (i.e., return to background conditions) in non-impacted areas. Based on Figure 10 nitrate concentrations are consistently low throughout most of the plume, but show a notable increase in the area of the former biosparging treatment system. Sulfate concentrations exhibit a notable decrease from NA-0 and NA-1 to MW-1A (within the former UST 970 source are), but are generally variable throughout the plume centerline, with a noticeable increase occurring at IT-GMP-15 (in the leading edge area). Overall, sulfate and nitrate concentrations are variable along the plume centerline and are generally present at low concentrations. The general lack of sulfate and nitrate within the plume (specifically in the former UST 970 source area) suggest that biodegradation may be occurring as non-impacted groundwater flows into the most upgradient portions of the MTBE plume (see Figure 10).

- ***Dissolved Iron*** – Dissolved iron is a metabolic byproduct of petroleum hydrocarbon biodegradation which often increases in impacted areas and can decrease in non-impacted areas during anaerobic biodegradation processes. As indicated in Figure 10, dissolved iron concentrations are relatively high in the 970 source area, where MTBE concentrations have decreased dramatically (to levels less than those in the leading edge area). The occurrence of elevated dissolved iron further supports that biodegradation is occurring, specifically in the former 970 source area where non-impacted groundwater flows into the MTBE plume.

- ***TBA*** – TBA is a degradation product of MTBE and in some cases can demonstrate that biodegradation of MTBE is occurring. As shown in Figure 10, detected concentrations of TBA were only present in the vicinity of the former 970 source area; TBA was not detected in any other areas of the plume. This trend generally corroborates the findings supported by other biogeochemical indicators, specifically dissolved iron, which suggest that biodegradation is occurring in the most upgradient portions of the plume. TBA analytical results have been collected from select monitoring wells at the Site since January 1999. Historically, the maximum detected concentration of TBA was 2,500 μg/L in PG-MW1 in May 2005, which occurred within the one year temporary biosparging shutdown period. Since then, TBA concentrations in PG-MW1 have decreased to non-detect concentrations. The lack of TBA accumulation (specifically in areas downgradient of the former 970 source area) suggests that the biodegradation mechanisms occurring at the site are effectively reducing MTBE to non-toxic byproducts.

- ***TBF*** – TBF is a degradation product of MTBE and was not detected in any monitoring wells during the November 2010 sampling event. Therefore, the TBF analytical results were not included in the geochemical evaluation presented in Figure 10.

- ***DO*** – DO is a terminal electron acceptor that is expected to decrease in impacted areas and then increase (returning to background conditions) in non-impacted areas. As indicated in Figure 10, DO levels are highly variable through the plume centerline, ranging from 0.0 to 7.6 mg/L. Based on the challenges associated with collecting reliable DO data in the field, it is difficult to make conclusions regarding whether DO results support the occurrence of MTBE biodegradation in the subsurface.

- ***ORP*** – ORP values vary throughout the plume, but appear to show some discernable trends. Specifically, ORP values in the former 970 source area indicate highly reducing conditions, which then transition to oxidizing conditions within the former biosparging treatment area. Conditions remain oxidizing from 957-MW4 to MW-M23 (approximately 400 ft upgradient of the leading edge area). The leading edge area is characterized by slightly reducing conditions from IT-MW-92-39 to MW-M14D which clearly corresponds to an increase in the MTBE concentration in the leading edge area. Conditions transition back to oxidizing as MTBE concentrations decrease in IT-GMP-18 and IT-GMP-19 and then become slightly reducing in IT-MW-81D, which underlies Landfill 26. The ORP trends observed are expected with reducing conditions occurring in the former 970 source area and the leading edge area and oxidizing conditions occurring within or downgradient of areas that were recently treated by the biosparging system.

Based on the evaluation presented in Figure 10, geochemical MNA indicators seem to support that biodegradation is occurring in certain areas of the Site, most notably in the former 970 source area where non-impacted groundwater flows into the plume. It also appears that biosparging treatment has altered the geochemistry within and downgradient of the area of former treatment. The presence of TBA in the former 970 source area and the lack of accumulation of TBA in downgradient areas of the plume suggest that degradation stall is not occurring. In general, the geochemical evaluation presented above, in addition to the statistical evaluation of plume stability and the time-series mass evaluation, support the conclusion that MNA is occurring.

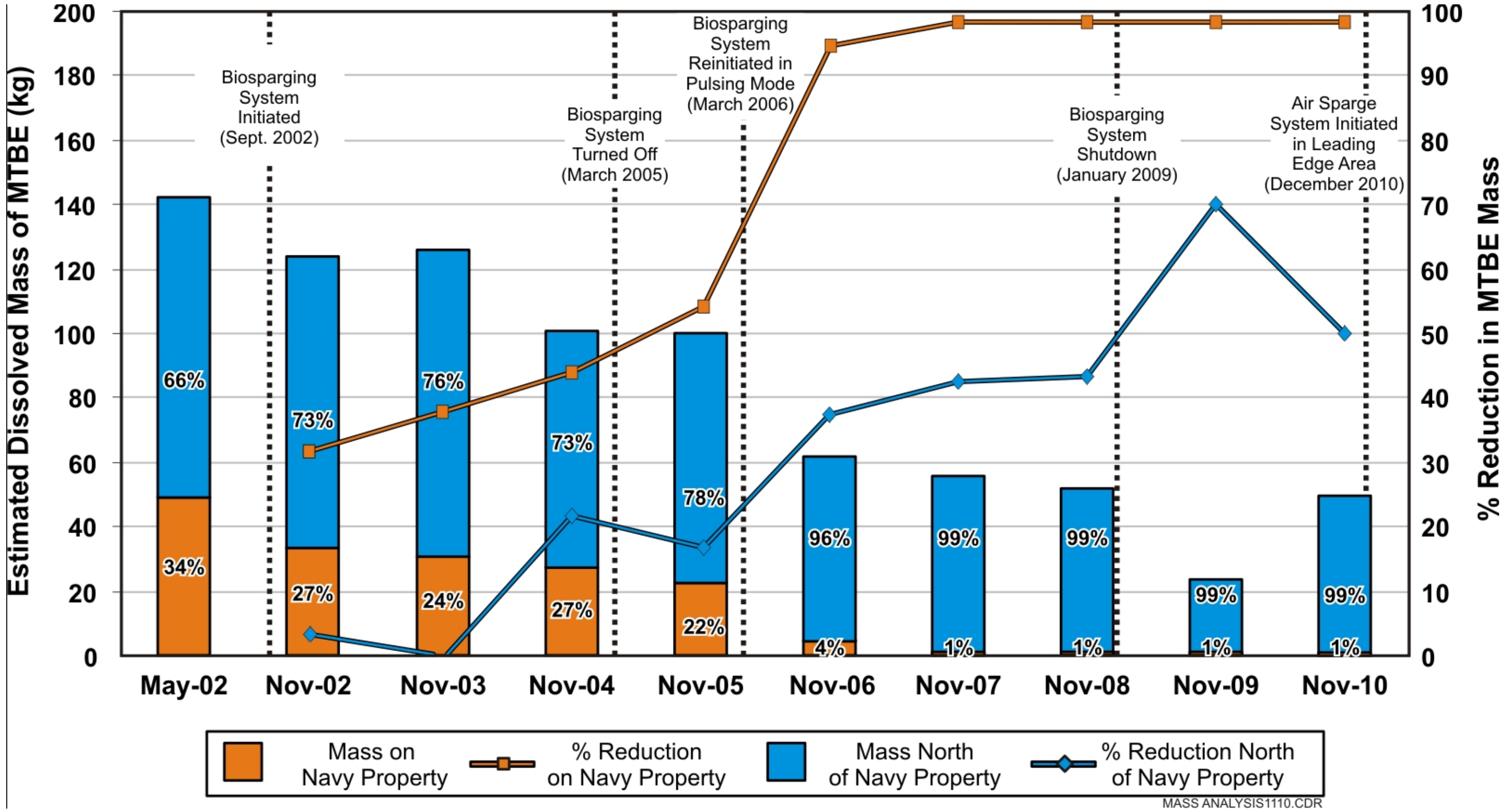


Figure 9. Change in Estimated Dissolved Mass of MTBE over Time

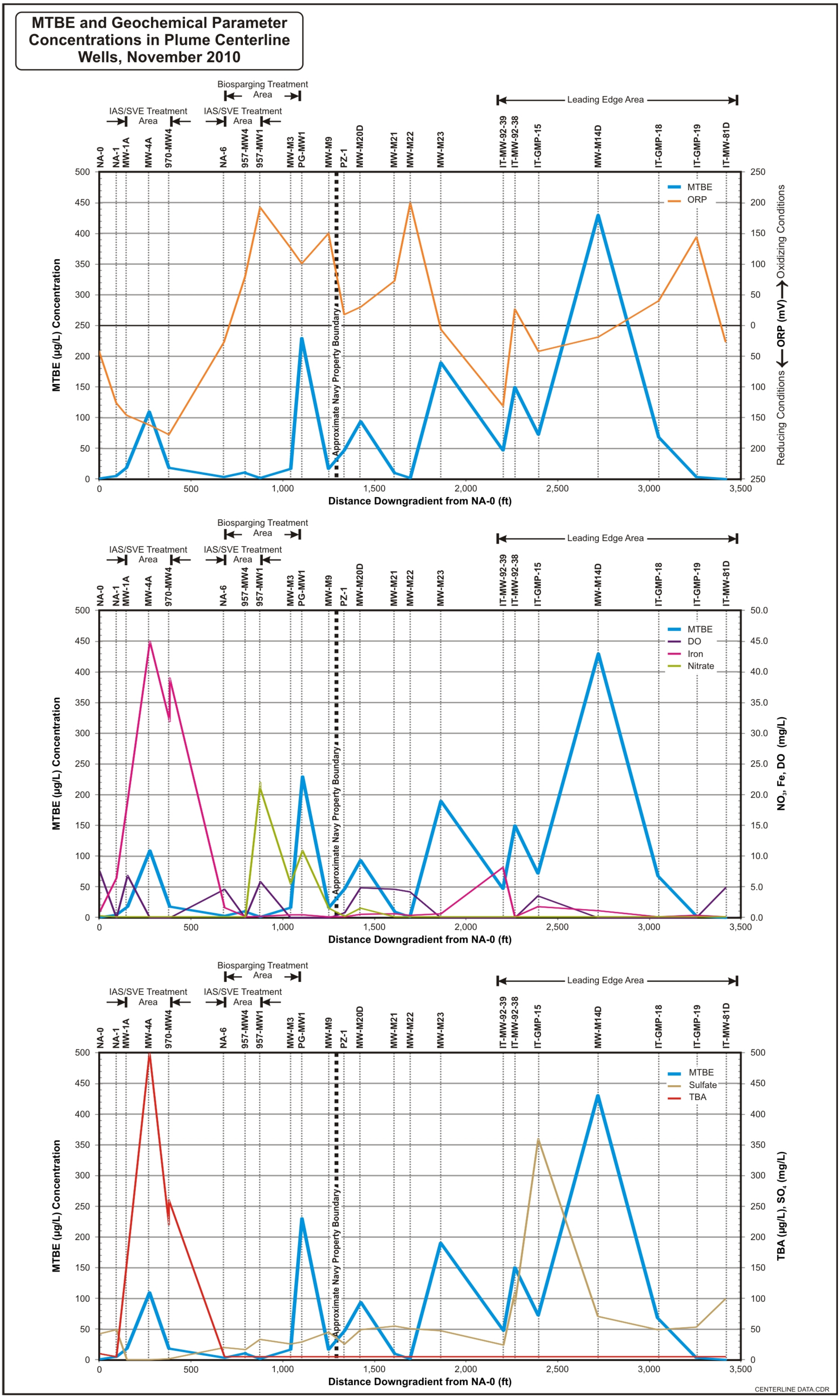


Figure 10. MTBE and Geochemical Parameter Concentrations in Plume Centerline Wells, November 2010

Section 5.0: CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions based on the analytical results collected during the November 2010 groundwater and surface water monitoring activities, and provides recommendations based on the evaluation of the data to more effectively address the DQOs presented in the SAP that was included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) and the SAP contained in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b).

5.1 Conclusions

During the November 2010 sampling event, the maximum MTBE concentration measured on Navy property (i.e., south of the railroad tracks) was 230 µg/L at PG-MW1, compared to 23,000 µg/L in PG-MW1 in June 2002, prior to operation of the biosparging treatment system. Since the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) was issued for the Site in August 2007, the maximum MTBE concentration measured on Navy property has been at either monitoring well PG-MW1 or PG-MW5, located near the corner of C Street and State Access Road. The maximum MTBE concentration measured off Navy property has historically been detected near Landfill 26 in MW-M14D, with a historic maximum detected concentration of 980 µg/L in August 2006. However, during the November 2010 sampling event, the maximum MTBE concentration measured off Navy property was 660 µg/L at LEA-MW4, one of the five new monitoring wells installed in the leading edge area to evaluate the performance of the air sparge treatment system. The furthest extent of MTBE-impacted groundwater from the source area was detected in IT-GMP-19 at 3.5 µg/L. MTBE was not detected in any monitoring wells within Landfill 26, thus bounding the plume on its northeastern edge (see Figure 4).

To evaluate the occurrence of MNA, data indicating (1) plume stabilization; (2) loss of contaminant mass over time; and (3) geochemical conditions suitable for biodegradation processes were evaluated through the MTBE plume. Statistical analyses were conducted using MTBE data collected through November 2010 to quantify MTBE concentration trends at each monitoring well and thereby indicating plume stabilization (see Figure 8). Overall, there is a considerable difference between the MTBE concentration trends in each area. In the leading edge area, 32% of the monitoring wells have shown a statistically significant increasing trend, while in the upgradient area, no wells have shown this trend. In contrast, 43% of the monitoring wells in the leading edge area have shown a statistically significant decreasing trend or non-detect concentrations, as compared to 96% of the monitoring wells in the upgradient area.

The estimated total mass of MTBE in groundwater has decreased significantly from May 2002 (142.2 kg), prior to initiation of the biosparging treatment system, to November 2010 (47.1 kg), approximately 21 months after system shutdown on January 30, 2009. Although the calculated mass estimate for November 2010 is greater than that from November 2009 (26.8 kg), a definitive decreasing trend in MTBE mass has been observed throughout the plume. The relative amount of MTBE mass on Navy property has decreased dramatically and currently represents an estimated 1% or less of total dissolved MTBE mass in groundwater. MTBE mass has been reduced both on and off Navy property, although a higher reduction rate is consistently demonstrated on Navy property compared to off Navy property. This difference is expected to be due to the historical operation of the IAS/SVE and biosparging treatment systems on Navy property. In addition, the observed reduction trends indicate that natural attenuation mechanisms are likely responsible for the mass decreases off Navy property (see Figure 9).

Overall, the potentiometric maps, including groundwater flow direction and hydraulic gradient for August and November 2010 are consistent with historical potentiometric maps for August and November as well as those for February (first quarter) and May (second quarter), demonstrating that groundwater flows toward the north and northeast across Landfill 26 with a decreasing hydraulic gradient (see Figures 3a and 3b). In the leading edge area of the MTBE plume, the hydraulic gradient is relatively flat in the area of Landfill 26. The portion of the aquifer underneath Landfill 26 has a greater water-bearing capacity than upgradient portions of the aquifer. This larger water-bearing capacity underneath Landfill 26 may potentially control the plume and stabilize and/or reduce MTBE concentrations more effectively than conditions upgradient of Landfill 26, therefore confirming and supporting the updated CSM. Additionally, the landfill monitoring network is within the estimated flow path of the MTBE plume and is sufficient to ensure that the leading edge area of the plume continues to be fully delineated (see Figure 4).

Due to unstable to increasing MTBE groundwater concentrations detected in five leading edge area monitoring wells (i.e., MW-M13, MW-M13D, MW-M14S, MW-M14D, and IT-GMP-18), the Navy issued the *Final Corrective Action Plan Addendum, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2009a) to describe the current site conditions and provide recommendations for a remedial action strategy at the leading edge area of the MTBE plume. After evaluating several remedial technology alternatives, the Navy concluded that air sparging and MNA with a phytoremediation contingency would achieve a stable to decreasing MTBE plume at the leading edge in the most effective and efficient manner.

The *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) which details the field implementation of the corrective action was submitted to all project stakeholders on April 26, 2010. After reviewing the results from the preliminary grab sampling event conducted in May 2010, the air sparge system layout and performance goal monitoring wells were finalized with approval from the regulatory agencies and are presented in the *Final Leading Edge Area Corrective Action Work Plan Addendum* (Battelle, 2010c).

As outlined in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b) and its associated *Addendum* (Battelle, 2010c), installation, shakedown, and start-up of the air sparge system and installation of five additional groundwater monitoring wells to support system performance monitoring were conducted from October through December 2010. Operation of the air sparge system officially began on December 17, 2010 and performance monitoring will begin on a quarterly basis starting in February 2011 to evaluate the effectiveness of the system in decreasing MTBE groundwater concentrations in the leading edge area.

5.2 Recommendations

All recommendations including decision criteria for optimizing the groundwater monitoring program are reflected in Table 5, a modified version of Table 2-1 of the SAP included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007). As the environmental remediation effort at the Site had shifted from the biosparging area to the leading edge area, these recommendations serve as a bridge between the DQOs presented in the SAP included in the *Final Groundwater Monitoring Plan Update* (Battelle, 2007) and DQOs presented in the SAP contained in the *Final Leading Edge Area Corrective Action Work Plan, Former UST Site 957/970 at the Former Department of Defense Housing Facility, Novato, California* (Battelle, 2010b). The significant recommended modifications to the groundwater monitoring program are as follows:

1. ***Semiannual Water-Level Measurements:*** Water level measurements have generally been collected from the Site on a quarterly basis since 1995. All historical measurements and resulting potentiometric surfaces have consistently indicated that groundwater flow is towards the north and northeast across Landfill 26 with a decreasing hydraulic gradient from the source area. Since the potentiometric surfaces have been seasonally consistent (i.e., February, May, August, and November potentiometric surfaces), it is recommended that water level measurements be conducted on a semiannual basis (i.e., May and November). This will represent groundwater conditions during the dry (i.e., May) and wet (i.e., November) seasons and coincide with the semiannual and annual groundwater sampling events at the Site.

2. ***Annual Site Status Reporting:*** Currently, 40 monitoring wells are sampled during the semi-annual sampling event and 84 monitoring wells are sampled during the annual sampling event at the Site. Since the monitoring well network has decreased over time and the remedial effort at the Site has shifted from the biosparging area to the leading edge area, the Navy recommends a quarterly electronic submission (i.e., e-mail transmittals) of performance goal monitoring results (as depicted in Figure 7) to the BCT to document the performance of the leading edge treatment system. In addition, the Navy recommends that formal site status reporting be reduced from a semi-annual to an annual basis.

3. ***Monitoring Well MW-M14D Plume Centerline Well:*** Based on the nature and extent of the MTBE plume in the leading edge area (see Figure 4), it is recommended that monitoring well MW-M14D serve as a plume centerline well in replacement of monitoring wells IT-GMP-16 and IT-GMP-17, located to the east of the actual plume centerline. As a result, MW-MW14D would be sampled for MTBE, TBA, TBF, sulfate, iron, and nitrate, while IT-GMP-16 and IT-GMP-17 would solely be sampled for MTBE.

4. ***Sulfate, Iron, and Nitrate Analyses:*** Geochemical parameters including sulfate, iron, and nitrate analysis are recommended to be removed from the SAP at monitoring wells LEA-MW1, LEA-MW2, LEA-MW3, LEA-MW4, LEA-MW5, and MW-M14S. These monitoring wells are not plume centerline wells and are located within the target treatment area which is currently subject to ongoing active treatment. Therefore, the analytical results cannot be properly evaluated for MNA due to operation of the air sparge system.

5. ***Surface Water Sampling:*** Active treatment and MNA have significantly reduced the magnitude of concentrations and areal extent of the MTBE plume at the Site. As a result of these reductions, MTBE has not been detected in Pacheco Creek (i.e., PC-SW-1, PC-SW-2, PC-SW-3, PC-SW-4, and PC-SW-5) or the culvert outlet (i.e., PC-SW-CE) since November 2004 (PC-SW-3 at 3.3 μg/L and PC-SW-4 at 2.2 μg/L, both below the MTBE MCL of 13 μg/L), suggesting that the MTBE plume is no longer impacting Pacheco Creek. Therefore, it is recommended that surface water sampling from PC-SW-CE be removed from the SAP.

Table 5. Proposed Modifications to Sampling and Analysis Plan

Well ID	Matrix	Monitoring Frequency	Analytical Group				Decision Criteria
			MTBE	DO	Sulfate, Iron, and Nitrate	TBA, TBF	
970-MW1	GW	A	✓	✓	-	-	
970-MW2	GW	A	✓	✓	-	-	
970-MW4	GW	S	✓	✓	✓	✓	Plume centerline well
970-MW5	GW	A	✓	✓	-	-	
IT-1MW-4A	GW	A	✓	✓	-	-	
IT-2MW-1	GW	A	✓	✓	-	-	
IT-2MW-2	GW	A	✓	✓	-	-	
IT-PZ-5	GW	A	✓	✓	-	-	
MW-10A	GW	A	✓	✓	-	-	
MW-1A	GW	S	✓	✓	✓	✓	Plume centerline well
MW-1B	GW	A	✓	✓	-	-	
MW-2D	GW	A	✓	✓	-	-	
MW-2E	GW	A	✓	✓	-	-	
MW-3D	GW	A	✓	✓	-	-	
MW-4A	GW	S	✓	✓	✓	✓	Plume centerline well
MW-4B	GW	A	✓	✓	-	-	
MW-6B	GW	A	✓	✓	-	-	
MW-8A	GW	A	✓	✓	-	-	
MW-9A	GW	A	✓	✓	-	-	
MW-M15	GW	S	✓	✓	-	-	Plume centerline well
MW-M16	GW	A	✓	✓	-	-	
MW-M17	GW	A	✓	✓	-	-	
MW-M18	GW	A	✓	✓	-	-	
MW-M2	GW	A	✓	✓	-	-	
MW-M20D	GW	S	✓	✓	✓	✓	Plume centerline well
MW-M21	GW	S	✓	✓	✓	✓	Plume centerline well
MW-M22	GW	S	✓	✓	✓	✓	Plume centerline well
MW-M23	GW	S	✓	✓	✓	✓	Plume centerline well
MW-M24	GW	A	✓	✓	-	-	
MW-M25D	GW	A	✓	✓	-	-	
MW-M25S	GW	A	✓	✓	-	-	
MW-M2-BR	GW	A	✓	✓	-	-	
NA-0	GW	S	✓	✓	✓	✓	Plume centerline well
NA-1	GW	S	✓	✓	✓	✓	Plume centerline well
Biosparging Monitoring Wells							
957-MW1	GW	S	✓	✓	✓	✓	Plume centerline well
957-MW3	GW	A	✓	✓	-	-	
957-MW4	GW	S	✓	✓	✓	✓	Plume centerline well
MW-1D	GW	A	✓	✓	-	-	
MW-M10	GW	A	✓	✓	-	-	
MW-M3	GW	S	✓	✓	✓	✓	Plume centerline well
MW-M8	GW	A	✓	✓	-	-	
MW-M8-BR	GW	A	✓	✓	-	-	
MW-M9	GW	S	✓	✓	✓	✓	Plume centerline well
NA-4	GW	A	✓	✓	-	-	
NA-6	GW	S	✓	✓	✓	✓	Plume centerline well
NA-7	GW	A	✓	✓	-	-	Analyze for BTEX
PG-MW1	GW	S	✓	✓	✓	✓	Plume centerline well
PG-MW5	GW	A	✓	✓	-	-	
PZ-1	GW	S	✓	✓	✓	✓	Plume centerline well
Daycare Monitoring Wells							
970-MW3	GW	A	✓	✓	-	-	
MW-3B	GW	A	✓	✓	-	-	
Leading Edge Monitoring Wells							
IT-EW-91-1	GW	S	✓	✓	-	-	
IT-GMP-15	GW	S	✓	✓	✓	✓	Plume centerline well
IT-GMP-16	GW	S	✓	✓	✓	✓	Plume centerline well
IT-GMP-17	GW	Q	✓	✓	✓	✓	Plume centerline well, part of performance/rebound monitoring program at leading edge.
IT-GMP-18	GW	S	✓	✓	✓	✓	Plume centerline well
IT-MW-92-38	GW	S	✓	✓	✓	✓	Plume centerline well
IT-MW-92-39	GW	S	✓	✓	✓	✓	Plume centerline well
IT-PZ-7	GW	A	✓	✓	-	-	
IT-PZ-9	GW	S	✓	✓	✓	-	
LEA-MW1	GW	Q	✓	✓	✓	-	Part of the performance/rebound monitoring program at leading edge.
LEA-MW2	GW	Q	✓	✓	✓	-	
LEA-MW3	GW	Q	✓	✓	✓	-	
LEA-MW4	GW	Q	✓	✓	✓	-	
LEA-MW5	GW	Q	✓	✓	✓	-	
MW-M13	GW	S	✓	✓	-	-	
MW-M13D	GW	S	✓	✓	-	-	
MW-M14D	GW	Q	✓	✓	✓	✓	**Plume centerline well**, part of performance/rebound monitoring program at leading edge.
MW-M14S	GW	S	✓	✓	✓	-	
MW-M26D	GW	A	✓	✓	-	-	
MW-M26S	GW	A	✓	✓	-	-	

Table 5. Proposed Modifications to Sampling and Analysis Plan (Continued)

Well ID	Matrix	Monitoring Frequency	Analytical Group				Decision Criteria
			MTBE	DO	Sulfate, Iron, and Nitrate	TBA, TBF	
IT-EW-91-3	GW	S	✓	✓	-	-	
IT-GMP-19	GW	S	✓	✓	✓	✓	Plume centerline well
IT-MW-81D	GW	S	✓	✓	✓	✓	Plume centerline well
IT-MW-81S	GW	S	✓	✓	✓	✓	Plume centerline well
MW-86D	GW	S	✓	✓	-	-	
MW-86S	GW	S	✓	✓	-	-	
MW-M12	GW	S	✓	✓	✓	-	
MW-M27D	GW	A	✓	✓	-	-	
MW-M27S	GW	A	✓	✓	-	-	
MW-M28	GW	S	✓	✓	✓	-	
Landfill 26 Monitoring Wells							
MW-78	GW	Q (S)	- [(a)]	-	-	-	
MW-82	GW	Q (S)	- [(a)]	-	-	-	
MW-82D	GW	Q (S)	- [(a)]	-	-	-	
MW-87	GW	Q (S)	- [(a)]	-	-	-	
MW-88S	GW	S	✓	✓	-	-	
MW-88D	GW	S	✓	✓	-	-	
MW-92-40	GW	Q (S)	- [(a)]	-	-	-	
MW-92-43	GW	Q (S)	- [(a)]	-	-	-	
MW-125	GW	Q (S)	- [(a)]	-	-	-	
MW-L26-1	GW	Q (S)	- [(a)]	-	-	-	
EW-91-06	GW	S	✓	✓	-	-	
EW-91-07	GW	Q (S)	- [(a)]	-	-	-	
EW-91-08	GW	Q (S)	- [(a)]	-	-	-	
EW-91-10	GW	Q (S)	- [(a)]	-	-	-	
EW-91-14	GW	Q (S)	- [(a)]	-	-	-	
Surface Water Sampling Locations							
PC-SW-CE	SW	A	✓	-	-	-	

A = annually
BTEX = benzene, toluene, ethylbenzene, xylenes
DO = dissolved oxygen
GW = groundwater
MTBE = methyl tert butyl ether
NA = not applicable
Q = quarterly
S = semi-annually
SW = surface water
TBA = tert-butyl alcohol
TBF = tert-butyl formate
Notes:
(a) Only water level measurements well be obtained from these wells; samples will not be collected for laboratory analyses.
Analyses and comments highlighted in pink are recommended to be removed from the sampling and analysis plan.
Sampling locations highlighted in grey are recommended to be removed from the sampling and analysis plan.
Recommended modifications to the monitoring frequency are in parentheses.
Recommended additions to the sampling and analysis plan are in bold.

Section 6.0: REFERENCES

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APPENDIX A

WELL PURGE AND MAINTENANCE LOGS (NOVEMBER 2010)

(Included on CD)

APPENDIX B

TABULATED FIELD PARAMETERS FOR GROUNDWATER

(Included on CD)

APPENDIX C

LABORATORY ANALYTICAL REPORTS FOR GROUNDWATER (NOVEMBER 2010)

(Included on CD)

APPENDIX D

COMPREHENSIVE DATA SUMMARY IN EXCEL FORMAT

(Included on CD)

APPENDIX E

GEOTRACKER CONFIRMATION SHEETS

(Included on CD)

APPENDIX F

DATA VALIDATION REPORTS

(Included on CD)

APPENDIX G

TABULATED WATER-LEVEL DATA

(Included on CD)

APPENDIX H

BORING LOGS AND WELL COMPLETION DIAGRAMS

(Included on CD)

APPENDIX I

MONITORED NATURAL ATTENUATION STATISTICAL ANALYSIS RESULTS

(Included on CD)