FINAL

FORSCOM

CORRECTIVE ACTION PLAN

3d Inf Div (Mech)

OLD PROPERTY DISPOSAL (PDO) YARD AT HUNTER ARMY AIRFIELD, GEORGIA

Prepared for

US Army Corps of Engineers®

SAVANNAH DISTRICT

Contract No. DACA21-95-D-0022
Delivery Order 0036

April 2000

SAIC®

DOCUMENT 9

FINAL

CORRECTIVE ACTION PLAN FOR THE OLD PROPERTY DISPOSAL (PDO) YARD HUNTER ARMY AIRFIELD, GEORGIA

REGULATORY AUTHORITY
RESOURCE CONSERVATION AND RECOVERY ACT
40 *CFR* 264, TITLE II, SUBPART C, SECTION 3004;
42 USC 6901 ET SEQ.

Prepared for:

U.S. Army Corps of Engineers
Savannah District
Under Contract DACA21-95-D-0022
Delivery Order Number 0036

Prepared by:

Science Applications International Corporation
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

April 2000

The undersigned certifies that I am a qualified groundwater scientist who has received a baccalaureate or postgraduate degree in the natural sciences or engineering and have sufficient training and experience in groundwater hydrology and related fields, as demonstrated by state registration and completion of accredited university courses, to enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or by a subordinate working under my direction.

GEORGIA REGISTERED No. 020201 PROFESSIONAL ENGINEER BRUCE J. HAAS

4/26/00

Bruce Haas, P.E.
Technical Manager
SAIC

00-024(doc)/042500

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

CONTENTS

APPENDICES

FIGURES

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

amsl	above mean sea level
AST	aboveground storage tank
AT123D	Analytical Transient 1-, 2-, 3-Dimensional (model)
bgs	below ground surface
CAP	Corrective Action Plan
CO	Consent Order
COPC	contaminant of potential concern
CSR	Compliance Status Report
DAF	dilution attenuation factor
DO	dissolved oxygen
ECOPC	ecological contaminant of potential concern
Eh	oxidation-reduction potential
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
GEPD	Georgia Environmental Protection Division
GSSL	generic soil screening level
HAAF	Hunter Army Airfield
HHCOPC	human health contaminants of potential concern
IR	interim removal
IWQS	In-stream Water Quality Standard
JP	jet propulsion
MCL	maximum contaminant level
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PDO	Old Property Disposal
PRE	preliminary risk evaluation
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RL	remedial level
RRS	Risk Reduction Standards
SAIC	Science Applications International Corporation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TPH	total petroleum hydrocarbons
UIC	Underground Injection Control
USAEHA	U.S. Army Environmental Hygiene Agency
USDA	U.S. Department of Agriculture
UST	underground storage tank
VOC	volatile organic compound
WDES	Waste Disposal Engineering Study

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

This report presents the Corrective Action Plan (CAP) for remediation of the Old Property Disposal (PDO) Yard, at Hunter Army Airfield (HAAF), Georgia. This CAP Report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0036.

Corrective action is required at the PDO Yard pursuant to applicable requirements in the Consent Order No. EPD-HW-1068 (March 11, 1994), the Georgia Hazardous Waste Management Act, as amended, O.C.G.A. §12-8-60, *et seq*, and the Rules for Hazardous Waste Management, Chapter 391-3-11, promulgated pursuant thereto, as amended (Rules), which incorporates by reference the *Code of Federal Regulations* found in 40 *CFR* Parts 124, 260–268, 270, 273, and 279. The CAP has been prepared in accordance with the recommendations of the Revised Final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report, approved by the GEPD in January 2000.

HAAF is located in Savannah, Chatham County, Georgia, and covers approximately 5,400 acres. HAAF is a sub-installation to the Fort Stewart Military Reservation, which is located approximately 30 miles to the southwest. The PDO Yard is located near the northwestern boundary of HAAF and consists of a parcel containing approximately 0.955 acres. The fenced area of the site is approximately 136 feet by 300 feet. Much of the site is paved with the remainder covered in crushed stone. The PDO Yard contains three newly installed aboveground storage tanks (ASTs) that serve as an accumulation point for used oil and off-specification jet propulsion (JP-4) fuel, a 90-day hazardous waste storage area, and several paved open storage bays.

Prior to 1998, the PDO Yard contained three ASTs set within a bermed area in the southeast corner of the fenced site area. Those ASTs included two 20,000-gallon tanks for storage of waste oil and one 18,000-gallon tank for storage of off-specification JP-8. These tanks were removed in 1998 and replaced with the three new ASTs set in a concrete-lined tank area on the northwest side of the fenced PDO Yard area.

Results of the RFI concluded that groundwater at the PDO Yard is contaminated with benzene and tetracholorethene (PCE). This CAP report evaluates options for achieving the Remedial Levels (RLs) required by the Revised Final RFI Report for these two constituents. The feasibility of applicable remedial technologies is analyzed, then a conceptual design and implementation plan for the selected corrective action is presented.

RESULTS OF THE RFI

The RFI was conducted in two phases of field sampling: Phase I was conducted in 1996, and Phase II was conducted in 1998. The Revised Final RFI Report (Metcalf & Eddy 1999) summarized the results of both phases.

Nature and Extent of Soil Contamination. Previous investigations had revealed petroleum hydrocarbon and organic solvent contamination within the former bermed AST area, which was the suspected source of benzene and PCE identified in the groundwater. During Phase I RFI activities in 1996, 20 shallow soil samples were collected from 10 hand auger locations, 4 monitoring well boreholes, and 15 soil boring locations. Although benzene was not detected in any of those samples, PCE as high as 43 μg/kg was reported in a single soil sample from within the bermed area. As a result, the contaminated soil in the former AST area was removed during interim remediation (IR) activities that were conducted at the PDO Yard in July 1998. The ASTs were removed from the facility, cleaned, and taken offsite for recycling. The soil around the former AST locations, including the berms, was excavated to a depth of about 3 feet below ground surface (bgs) with the exception of the northeast corner where the depth was 4.2 feet bgs. The excavation pit was approximately 50 feet by 75 feet and produced about 450 cubic yards of soil. Eight confirmatory soil samples were collected from the excavation prior to backfilling, and no elevated concentrations of target compounds were present in the confirmatory soil samples.

Soil samples were collected from seven new monitoring well boreholes during Phase II RFI activities in July and August 1998. No organic target analyte exceeded screening criteria in soil. Although human health contaminants of potential concern (HHCOPCs) were identified in the screening value comparison for surface and subsurface soil, none were retained as human health contaminants of concern (HHCOCs) following further quantitative evaluation in the Revised Final RFI Report.

Nature and Extent of Groundwater Contamination. Benzene was detected in the following monitoring wells during Phase II sampling activities: MW01 (64 μg/L), MW02 (4 μg/L), MW06 (36 μg/L), MW1-23 (13 μg/L), and MW1-25 (29 μg/L). The suspected source of benzene was near the former bermed AST area; the benzene plume extends to the north-northwest (downgradient) from the source area. The concentration of benzene in MW01 increased slightly when compared to Phase I sample results; however, benzene in all other wells decreased slightly since the Phase I investigation. The maximum contaminant level (MCL) for benzene of 5 μg/L was exceeded at 4 of 18 groundwater monitoring wells.

PCE was detected in groundwater samples from MW02 (16 μg/L), MW05 (47 μg/L), MW1-22 (11 μg/L), and MW1-24 (15 μg/L). PCE was not detected in MW03 during the Phase II RFI sampling, although PCE was detected in MW03 during Phase I RFI sampling at 4.8 μg/L. PCE detections seem to be localized outside the fenced site area and extend to the west-northwest, in the area between the storage bays, the railroad tracks, and Lamar Canal. The MCL for PCE is 5 μg/L.

Neither benzene nor PCE was detected in any of the deep monitoring wells located on the site.

Nature and Extent of Surface Water and Sediment Contamination. No HHCOPCs were identified in surface water or sediment in Lamar Canal. Benzene was not identified in any surface water sample even though the identified extent of the benzene plume indicates that benzene-contaminated groundwater is reaching the banks of Lamar Canal at concentrations below the In-stream Water Quality Standard (IWQS) for benzene (71.28 μg/L). Similarly, PCE was not identified in any surface water sample collected from Lamar Canal, even though the identified extent of the PCE plume suggests that PCE-contaminated groundwater is reaching the banks of Lamar Canal at concentrations exceeding its IWQS (8.85 μg/L).

Contaminant Fate and Transport. At the PDO Yard, benzene and PCE in groundwater were the only organic compounds consistently identified at concentrations above their respective screening criteria. Benzene is a volatile aromatic hydrocarbon that can migrate readily through the soil column toward groundwater. Benzene is less dense than water and as a non-aqueous phase liquid (NAPL) tends to float on top of the water table. Benzene is biodegradable under aerobic conditions with a biodegradation half-life of approximately 2 years. PCE is a chlorinated aliphatic hydrocarbon that is very mobile. Being denser than water, PCE may migrate vertically (downward) through a saturated medium as a separate phase. PCE is somewhat biodegradable under anaerobic conditions with a biodegradation half-life of approximately 4 years. Both benzene and PCE are highly volatile; therefore, volatilization is a major mechanism for removal of these constituents from groundwater and surface waters.

Human Health Risk Assessment. A Human Health Baseline Risk Assessment (HHBRA) was completed during the Phase II RFI. Although four public/commercial supply wells were identified within a 1-mile radius of the site, human exposure to contaminants identified in the shallow groundwater at the PDO Yard through these wells is unlikely. The groundwater use investigation conducted as part of the potential receptor survey (PRS) indicated that no shallow groundwater is used for potable water supply within

PAGE xi MISSING

PAGE xii MISSING

since they are appropriate for this site only when combined with other technologies, such as Monitored Natural Attenuation.

Each of the following alternatives for benzene and PCE is considered applicable to the site, cost-effective, and implementable. Therefore, two primary evaluation factors were used in the selection of the preferred corrective action alternative: time to implement and life-cycle cost. Time to implement the action is an important evaluation factor for this site; preferably, the site would be remediated to meet RLs in the shortest possible time. Life-cycle cost estimates are budget estimates based on conceptual design and are not adjusted to present worth costs or for escalation.

Benzene. The following three corrective action alternatives were evaluated for benzene:

Alternative 1: Monitored Natural Attenuation,
Alternative 2: Air Sparging, and
Alternative 3: Enhanced Bioremediation.

PCE. The following four corrective action alternatives were evaluated for PCE:

Alternative 1: Monitored Natural Attenuation,
Alternative 2: Air Sparging,
Alternative 3: Geo-Cleanse® with Monitored Natural Attenuation, and
Alternative 4: Geo-Cleanse® Full Plume Treatment.

CONCEPTUAL DESIGN AND IMPLEMENTATION PLAN

Justification of Selection

Benzene. Monitored Natural Attenuation has been selected as the most appropriate corrective action for benzene in groundwater at the PDO Yard because the source of soil contamination has been removed, and contaminant levels in groundwater will attenuate to concentrations below the MCL of 5 μg/L in approximately 2 years. Geochemical conditions in the groundwater at the site indicate aerobic conditions are present that are conducive to biodegradation of benzene. The presence of elevated methane gas in monitoring well MW01 suggests that active biodegradation of benzene is occurring. The site will be monitored during the 2-year attenuation period to ensure that attenuation of benzene in the groundwater continues.

PCE. An in-situ chemical oxidation treatment system has been selected as the most appropriate corrective action for PCE in groundwater at the PDO Yard because PCE concentrations in groundwater have not decreased significantly over time, suggesting that biodegradation of PCE is not occurring. The aerobic conditions in groundwater are not conducive to biodegradation of PCE, and its daughter compounds have not been observed in groundwater at the site. Chemical oxidation using the Geo-Cleanse® system was selected because it is a proven in-situ technology to remediate chlorinated hydrocarbons, such as PCE, in a matter of days. The effectiveness of chemical oxidation is more reliable than Monitored Natural Attenuation because any unidentified source of PCE contamination in soil would also be eliminated, and because PCE concentrations in groundwater adjacent to Lamar Canal would be reduced to below their IWQS.

Conceptual Design

Geo-Cleanse® will be injected into the shallow PCE plume using approximately 29 separate injection points covering an area approximately 200 feet wide by 100 feet long. The actual number will depend on analytical results from the baseline groundwater sampling event. A 15-foot radius of influence is used for the conceptual design, based upon a similar pilot test conducted at the Wright Army Airfield Bulk Fuel System (Solid Waste Management Unit 35) at Fort Stewart, Georgia, in September 1998. Each injection point will consist of 1-1/4-inch-diameter carbon steel pipe having a 3-foot-long stainless steel screen. Fenton's reagent, a mixture of hydrogen peroxide and ferrous iron catalyst, will be injected into the subsurface at 2 separate levels (10 feet and 20 feet bgs). An injection rate of 7,000 pounds per day is planned over a 5-day treatment period, for a total of 87,000 pounds. Chemical injection is anticipated to reduce concentrations of PCE by 90 percent with a single application of Geo-Cleanse® reagent, so that residual PCE concentrations in groundwater will not exceed 5 µg/L. A contingency polishing step has been addressed in the Operation and Maintenance (O&M) Plan in Appendix D. Confirmation groundwater sampling will be conducted 6 months following chemical oxidation treatment to verify that the MCL for PCE has been reached and maintained at the PDO Yard.

The site will be monitored for attenuation of benzene on a semiannual basis for 2 years, when concentrations are predicted to decline to less than its MCL. Confirmation groundwater sampling will be conducted 6 months following this Monitored Natural Attenuation period to verify that the MCL for benzene has been reached and maintained at the PDO Yard.

Two additional shallow monitoring wells (MW26 and MW27) and one additional deep monitoring well (MW28) will be installed within the contamination plume where PCE concentrations in existing wells have consistently exceeded their MCLs. The shallow wells will be screened to bisect the water table, for a total depth of less than 20 feet. The deep well will be screened between a depth of 35 and 45 feet, similar to the adjacent deep wells. The wells will be constructed using carbon steel casing and stainless steel screens to withstand the high temperatures during Geo-Cleanse® treatment. The cost estimate also includes costs for replacement of the existing monitoring wells with steel casings and stainless steel screens in case the existing PVC wells become damaged during Geo-Cleanse® treatment. The monitoring wells will be used to more accurately observe the reduction in PCE concentrations following chemical oxidation treatment and to verify the effectiveness of treatment after remedial activities are completed.

Implementation Plan. Upon approval of this CAP by GEPD, the Installation will request funding, procure a contractor for implementing the corrective action, and implement the specified action. A corrective action Work Plan will be prepared to guide implementation of the corrective action, but will not require GEPD review or approval. Any revisions required to the O&M Plan (Appendix D) or the Implementation Schedule (Figure 5-3) that become apparent during preparation of the Work Plan will be submitted to GEPD for concurrence.

During the corrective action, progress reports as defined in Section 5.6 of this CAP will be prepared and submitted to GEPD for review and approval. Upon completion of the corrective action, a Corrective Action Completion Report will be prepared and submitted to GEPD for review and approval.

1.0 INTRODUCTION

1.1 SCOPE OF THE CORRECTIVE ACTION PLAN

The Old Property Disposal (PDO) Yard, at Hunter Army Airfield (HAAF), Georgia, has been used by the Installation as an accumulation point for used oil and off-specification jet propulsion (JP-4) fuel in aboveground storage tanks (ASTs) set within a former earthen bermed area. A Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report has been completed for the PDO Yard. The Revised Final RFI Report, which was approved by Georgia Environmental Protection Division (GEPD) on January 10, 2000, recommended submittal of a Corrective Action Plan (CAP) for this site to address benzene and tetrachloroethene (PCE) contamination in groundwater.

The following conclusions and recommendations were made based on the results of the RFI and supplemental soil and groundwater investigations:

1. There are no human health contaminants of potential concern (HHCOPCs) in surface water or sediment.

2. An Interim Removal (IR) action conducted in July 1998 eliminated risks associated with direct exposure to contaminants in soil within the former bermed AST area. Arsenic and benzo(*a*)pyrene were evaluated as HHCOPCs in soil and were found to be present at concentrations within acceptable risk levels for both present industrial conditions and potential future residential use. Therefore, additional remediation of soil is not required.

3. There are no identified ecological contaminants of potential concern (ECOPCs) in surface soil, surface water, sediment, or groundwater at concentrations that exceed acceptable levels of risk. Therefore, remediation is not required for protection of ecological receptors.

4. Benzene and PCE were identified as HHCOPCs in groundwater. Risk calculations indicate neither constituent exceeds acceptable levels of risk under a future residential use scenario. However, concentrations of both constituents exceeded their respective risk-based concentrations (RBCs) and maximum contaminant levels (MCLs). Therefore, the MCLs for benzene and PCE were selected as remedial levels (RLs).

5. The horizontal and vertical extent of groundwater contamination has been adequately delineated by activities conducted during the RFI.

6. A CAP is required to evaluate measures to mitigate the effects of benzene and PCE in groundwater due to the fact that concentrations of these HHCOPCs exceed their respective MCLs. The CAP will evaluate the effectiveness of "hot-spot" treatment and Monitored Natural Attenuation in remediating these organic compounds. Fate and transport modeling will be used in evaluating effects associated with both treatment and natural attenuation remedial options. In addition, the CAP will also evaluate the implementation or continuance of institutional controls for the site.

This CAP report utilizes information from the RFI to evaluate institutional controls and various remedial actions for achieving the RLs proposed in the Revised Final RFI Report. The options analyzed for achieving the stated RLs included an evaluation of Monitored Natural Attenuation, in accordance with published guidance documents [U.S. Environmental Protection Agency (EPA) 1999]. This report analyzes the feasibility of the applicable remedial actions, Monitored Natural Attenuation, and institutional controls on a site-specific basis.

This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers, Savannah District, under Contract No. DACA21-95-D-0022, Delivery Order No. 0036.

1.2 SITE BACKGROUND

During a site visit to the PDO Yard in April 1993, GEPD noted deficiencies in waste management practices at the PDO Yard and several other HAAF locations. As a result, a site assessment was conducted to determine whether the environment had been impacted as a result of the PDO Yard's use. This inspection led to issuing a Consent Order (CO) (No. EPD-HW-1068) in March 1994.

From November 1993 to January 1994, the U.S. Army Environmental Hygiene Agency (USAEHA) conducted a site assessment at the PDO Yard under Waste Disposal Engineering Study (WDES) No. 37-26-J2KZ-94. Samples were collected from soil borings and hydropunch locations. Surface soil samples collected from within the bermed area exceeded the then current screening criteria for total petroleum hydrocarbons (TPH) and BTEX (the sum of benzene, toluene, ethylbenzene, and total xylenes) established by the GEPD Underground Storage Tank Management Program. The average concentration of TPH in composite surface soil samples collected from within the berm was 12,000 mg/kg. The average TPH concentration dropped to 1,900 mg/kg in composite samples taken at a depth of 6 to 18 inches below ground surface (bgs). While not statistically exceeding background, arsenic exhibited a mean concentration of 7.50 mg/kg, which exceeded the screening criteria of 1.6 mg/kg used during the USAEHA investigation. All other inorganics identified in soil samples were below their respective screening criteria. PCE and metals were identified in groundwater samples. The USAEHA concluded that further assessment of soil and groundwater contamination at the PDO Yard was required (Metcalf & Eddy 1999).

In April 1994, the USAEHA conducted a groundwater assessment at the PDO Yard (WDES No. 38-26-K2KZ-94). Seven monitoring wells were installed during this investigation. PCE was present in a groundwater sample collected from monitoring well MW1-23 at a concentration of 145 μg/L, above its MCL of 5 μg/L. Metals (antimony, iron, manganese, nickel, lead, and thallium) exceeded their corresponding MCLs or Secondary Drinking Water Standards but could be naturally occurring since they were detected upgradient from the PDO Yard (Metcalf & Eddy 1999). As a result, the PDO Yard was not identified as the source of elevated nickel, lead, thallium, iron, or manganese in groundwater, and further investigation into an antimony anomaly was recommended (Metcalf & Eddy 1999).

The RFI was conducted in two phases of field sampling. The Phase I RFI was summarized in a Final RFI Report that was submitted to the GEPD in April 1998. Recommendations from the GEPD included conducting additional subsurface investigation to define the extent of contamination at the PDO Yard, completion of interim removal measures (i.e., AST removal, soil excavation, and AST replacement), and incorporation of the data into a Revised Final RFI report. Additional investigation activities (Phase II) were conducted in August 1998 and reported in the December 1998 Revised Final RFI Report. The GEPD then recommended the collection of additional surface water and sediment samples from Lamar Canal directly downgradient of monitoring well MW06 (Metcalf & Eddy 1999). The subsequent Revised Final RFI Report was submitted to the GEPD in September 1999 and approved by GEPD on January 10, 2000. The results of the RFI are discussed in Section 2.0.

1.3 REGULATORY BACKGROUND

The corrective action at the PDO Yard is regulated by CO No. EPD-HW-1068, executed between GEPD and Fort Stewart on March 11, 1994 (specifically see condition No. 7), the Georgia Hazardous Waste Management Act, as amended, O.C.G.A. §12-8-60, *et seq*, and the Rules for Hazardous Waste Management, Chapter 391-3-11, promulgated pursuant thereto, as amended (Rules), which incorporates by reference the *Code of Federal Regulations* found in 40 *CFR* Parts 124, 260–268, 270, 273, and 279.

1.4 REPORT ORGANIZATION

This CAP consists of six sections. Section 1.0 summarizes the scope of the CAP, describes the background of the site and regulatory authority, and gives the report organization. Section 2.0 discusses the site characterization and RFI results and summarizes the supplemental sampling and natural attenuation modeling results. Section 3.0 describes the justification and purpose of the corrective action and presents the remedial response objectives and RLs developed in the RFI. Section 4.0 presents the screening of the corrective actions. Section 5.0 summarizes the report conclusions and recommendations for the corrective action. The references are presented in Section 6.0.

This report also contains five appendices. Appendix A provides the results of supplemental groundwater and soil sampling. Appendix B presents the detailed results of the natural attenuation modeling. Appendix C contains a cost estimate summary for corrective action alternatives. Appendix D is an operation and maintenance (O&M) plan for the selected corrective action, Monitored Natural Attenuation of benzene in groundwater and Geo-Cleanse® treatment with Monitored Natural Attenuation of PCE in groundwater. Appendix E lists considerations for the selection of Monitored Natural Attenuation for the benzene plume, following the guidance of Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P (EPA 1999).

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 SITE CHARACTERIZATION

HAAF is located in the City of Savannah, Chatham County, Georgia (Figure 2-1). The airfield covers approximately 5,400 acres, and it is bounded on the north by lightly populated areas, on the east and south by residential and light commercial areas, and on the west by the Little Ogeechee River. HAAF is a subinstallation to the Fort Stewart Military Reservation, which is located approximately 30 miles to the southwest.

From the early days of aviation, the area now known as HAAF was used by practice flyers, barnstormers, and aerial circuses. In 1928, the city of Savannah took possession of the field for use as a municipal airport. In the spring of 1940, the property was designated as a military airfield. Except for a short period when military activities were moved to Travis Field west of the city, the Army Air Corps (and later the separately organized Air Force) made extensive use of the base for approximately two decades. Users included the U.S. Air Force Strategic Air Command and the Military Air Transport Command (Metcalf & Eddy 1999).

The Air Force ceased using the base in the early 1960s, and deactivation efforts were undertaken. However, the Army acquired the facility in 1967 to support the increased need for helicopter pilot training during the Vietnam conflict. Advanced helicopter training for Vietnamese Air Force flight students was conducted at HAAF from 1970 to 1972. In 1975, the airfield became an important component of nearby Fort Stewart when the 24th Infantry Division (reflagged the 3rd Infantry Division–Mechanized, in May 1996) was reactivated and stationed at the Fort Stewart/HAAF complex (Metcalf & Eddy 1999).

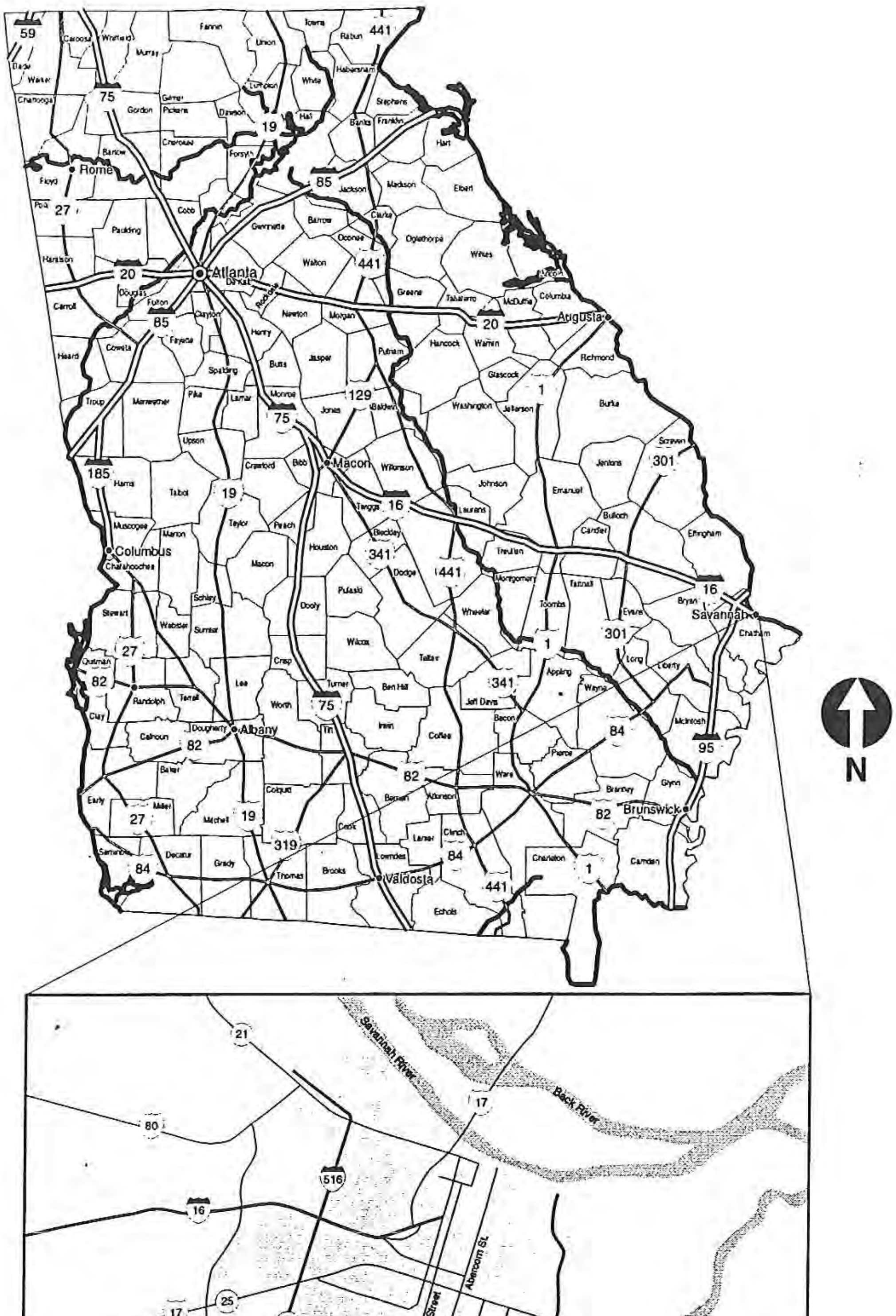
2.1 SITE DESCRIPTION AND HISTORY

The PDO Yard is located near the northwestern boundary of HAAF and consists of a fenced parcel containing approximately 0.955 acres (Figure 2-2). The site is approximately 136 feet by 300 feet. Much of the site is paved with the remainder covered in crushed stone. The ground surface is relatively flat except for a manmade hill located to the southeast and southwest. Trees are scattered along this hill; otherwise, there is no vegetation at the site. A railroad track formerly ran along the northwest side of the PDO Yard. Lamar Canal lies further to the north, approximately 400 feet from the former bermed AST area. An area used to stockpile coal reserves for 20 to 30 years was located toward the north, outside the fenced area (Metcalf & Eddy 1999).

The PDO Yard has been used as a storage facility for used oil and off-specification JP-4, for scrap metal storage, and as a temporary (i.e., 90-day) storage facility for hazardous waste. Originally, the site included an earthen bermed area located in the southeast corner of the fenced area. The bermed area contained two 20,000-gallon tanks used to store waste oil and one 18,000-gallon tank used to store off-specification JP-4.

During their visit to the site in April 1993, GEPD noted that containers of freon, liquid petroleum gas, industrial debris, and waste solvent existed within the PDO Yard. Containers of antifreeze, paint, acetone, electrolyte (potassium hydroxide), polychlorinated biphenyl (PCB) waste, jet propulsion (JP) pads, and filters were present in the 90-day hazardous waste storage area. Six transformers were also being stored in the hazardous waste storage area. The inspection led to the issuance of a CO (No. EPD-HW-1068) in March 1994.

During the subsequent RFI investigation, oil staining of surface soils within the former earthen bermed area was observed. In July 1998, the ASTs were removed from the facility, cleaned, and taken offsite for recycling. The soil around the former AST locations, including the berms, was excavated to a depth of about 3 feet bgs with the exception of the northeast corner where the excavation was taken down to a depth of



31-102797-063 A

Figure 2-1. Location Map for PDO Yard at HAAF, Georgia.

5.5 IMPLEMENTATION SCHEDULE

Implementation of the corrective action will begin once approval of this CAP is received from GEPD. It is anticipated that a drilling contractor and specialty vendor for PCE remediation can be procured within 4 months following approval of the CAP, and that the final corrective action Work Plan (including appropriate reviews by the Army) will be completed within 4 months thereafter.

Geo-Cleanse® treatment of the PCE plume is estimated to take less than 2 weeks. In addition, the implementation schedule provides for implementation of a second Geo-Cleanse® application as a polishing step. Based on the AT123D modeling results presented in Section 2.9, the required monitoring time for Monitored Natural Attenuation of the benzene plume is approximately 2 years. In addition, the implementation schedule allows for implementing two semiannual groundwater monitoring events as a contingent measure for Monitored Natural Attenuation. Confirmatory sampling will be conducted 6 months following Monitored Natural Attenuation to verify that RLs have been achieved and maintained in groundwater. Remediation will therefore be complete within an estimated 2.5 to 3.5 years. A Corrective Action Completion Report will be prepared and submitted to GEPD for review within 4 months thereafter. The anticipated implementation schedule is presented in Figure 5-3.

5.6 PROGRESS REPORTS

A progress report will be prepared following Geo-Cleanse® treatment of the PCE plume. The report will summarize the installation, injection process, sampling, and analysis performed for the Geo-Cleanse® treatment. Any revisions to this CAP that are required based on review and interpretation of the baseline groundwater sampling results will be summarized in the Geo-Cleanse® treatment completion report and/or the first semiannual progress report, as appropriate.

A progress report will be prepared semiannually during the 2-year Monitored Natural Attenuation period. These reports will summarize the sampling and analytical results of the groundwater monitoring. An analysis of trends and effectiveness of the corrective action will be presented. The need for any contingent action will also be discussed, as required.

A checklist is presented in the O&M Plan (Appendix D) summarizing the items to be addressed in each Progress Report.

A final Corrective Action Completion Report will be prepared following the completion of the corrective action and confirmation sampling. The Corrective Action Completion Report will summarize the corrective measures taken at the site, provide a summary of sampling data, and give results of the confirmation groundwater sampling.

5.7 IMPLEMENTATION PLAN

Upon approval of this CAP by GEPD, Fort Stewart will request funding, procure a contractor for implementing the corrective actions, and implement the specified actions. A corrective action Work Plan will be prepared to guide implementation of the corrective action but will not require GEPD review or approval. Any revisions required to the O&M Plan (Appendix D) or the Implementation Schedule (Figure 5-3) that become apparent during preparation of the Work Plan will be submitted to GEPD for concurrence. No other submittals will need to be provided to GEPD prior to implementing the selected corrective action.

ACTIVITY ID	REM DUR	MONTHS
		CONTRACT NEGOTIATIONS
PD000 000	0	CAP Approved
PD000 010	120	Contract Negotiations
		WORKPLAN
PD100 100	121	Work Plan
PD100 110	60	Draft Workplan
PD100 111	0	Submit Draft Workplan
PD100 120	30	Review by Fort Stewart & USACE of Draft WorkPlan
PD100 130	31	Final Workplan
PD100 131	0	Submit Final Workplan
		REMEDIATION
PD200 100	72	Remediation
PD200 110	30	Mobilization and Baseline Sampling
PD200 120	14	Install Wells/Injection Points
PD200 130	14	Inject Geo-Cleanse Reagent
PD200 140	14	Contingent Operation (Polishing Step)
		MONITORED NATURAL ATTENUATION
PD300 100	1080	Monitored Natural Attenuation
PD300 110	30	1st Semiannual Sampling
PD300 120	30	2nd Semiannual Sampling
PD300 130	30	3rd Semiannual Sampling
PD300 140	30	4th Semiannual Sampling
PD300 150	30	Contingency Sampling
PD300 160	30	Contingency Sampling

Months: 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70

Plot Date	21APR00
Data Date	1JAN00
Project Start	1JAN00
Project Finish	13NOV05

(c) Primavera Systems, Inc.

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

SCOE HAAG Sheet 1 of 2

CORRECTIVE ACTION SCHEDULE
PDO YARD
HUNTER ARMY AIRFIELD, GEORGIA

Date	Revision	Checked	Approved

Figure 5-3. Corrective Action Implementation Schedule.

1.0 INTRODUCTION/PURPOSE

This plan presents preliminary procedures for the operation and maintenance (O&M) of the Geo-Cleanse® chemical oxidation and groundwater monitoring systems for remediation of groundwater contamination at the Old Property Disposal (PDO) Yard, Hunter Army Airfield (HAAF), Georgia. This O&M Plan is based on the remediation system components as understood at this time. If system components change during installation, then a revised/updated O&M Plan will be submitted to the Georgia Environmental Protection Division (GEPD).

Groundwater at the PDO Yard is contaminated with benzene and tetrachloroethene (PCE). Corrective action is required to reduce the concentrations of these two contaminants within their respective source plumes and to achieve the remedial levels (RLs) presented in the GEPD-approved Revised Final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report dated September 1999. The selected corrective action consists of in-situ chemical oxidation in the shallow groundwater within the PCE plume using the patented Geo-Cleanse® system and Monitored Natural Attenuation of the benzene plume. A description of the system components is presented in Section 5.0 of the Corrective Action Plan (CAP) and includes the following:

- Air compressors, variable speed pumps, and associated electrical connections.
- Twenty-nine reagent injection points, each consisting of 1¼-inch-diameter carbon steel casing and 2-inch- diameter stainless steel screen. Injection points will be completed at two separate injection levels (10 feet and 20 feet below land surface) and will be screened over the bottom 3 feet.
- Aboveground hydrogen peroxide, ferrous iron catalyst, and air storage tanks and supply lines consisting of 1-inch flexible tubing with quick-connect couplings and other fittings (pressure valves and gauges).
- A total of 18 monitoring wells, including 12 existing shallow wells, 3 existing deep wells, 2 additional new shallow wells, and 1 additional new deep well. Existing monitoring wells will be replaced if damaged during Geo-Cleanse® treatment.

2.0 TRAINING

Personnel who participate in field activities during remediation or subsequent O&M activities are subject to the training requirements presented in Table D-1. Casual visitors, such as package deliverers, who access only the staging areas of the site, are not subject to these training requirements.

Subcontractor personnel involved in the installation, adjustment, startup, and operation of the Geo-Cleanse® treatment system will be subject to the training requirements specified by the subcontracted system vendor, Geo-Cleanse® International, Inc., who specializes in the system installation. Personnel will also be subject to the requirements specified in this O&M Plan, the Sampling and Analysis Plan (SAP) as contained within the project-specific Work Plan and the project Site Safety and Health Plan (SSHP). Training will be in accordance with Science Applications International Corporation (SAIC) Quality Assurance Administrative Procedure (QAAP) 2.1, *Indoctrination and Training*. The Site Supervisor is responsible for (1) assessing qualifications and determining skill needs of personnel; (2) assuring that appropriate training is provided to personnel and that the training (classroom, reading assignments, or on-the-job) is completed; and (3) forwarding training records for personnel to the SAIC Central Records

Facility located in Oak Ridge, Tennessee. Health and safety-related documentation will also be maintained in on-site project files, in accordance with the SSHP.

Table D-1. Training Requirements
PDO Yard, Hunter Army Airfield, Georgia

Training	Type	Remediation Worker	Groundwater Monitoring Worker	Site Supervisor
Health and Safety Training				
Site Safety and Health Plan	Reading	✓	✓	✓
Hazardous Waste Safety (40 hours)	Classroom	✓	✓	✓
Hazardous Waste Safety Annual Refresher (8 hours)	Classroom	✓	✓	✓
Hazardous Waste Safety Supervisors Training (8 hours)	Classroom			✓
General Hazard Communication Training (contained in 40- and 8-hour courses)	Classroom	✓	✓	✓
Respiratory Protection Training (required only if Respirators are worn; contained in 40-hour course)	Classroom	✓	✓	✓
Hearing Conservation Training (contained in 40- and 8-hour courses)	Classroom	✓	✓	✓
Pre-entry Briefing (including site-specific hazards Communication	OTJ	✓	✓	✓
Safety Briefing (daily and whenever conditions or tasks change)	OTJ	✓	✓	✓
First Aid/CPR (standard Red Cross or equivalent)	Classroom	At least 2 workers		
Quality Assurance Training				
O&M Plan	Reading	✓	✓	✓
Sampling and Analysis Plan (with Addendum)	Reading	✓	✓	✓
Quality Assurance Project Plan (QAPjP), including applicable QA program elements	Reading	✓	✓	✓
General criteria, including applicable codes, standards, and regulations, and the purpose, scope, and implementation of manuals, instructions, and procedures	Reading	✓	✓	✓
Job responsibilities and authority	Reading	✓	✓	✓
Quality Assurance Administrative Procedures (QAAP)	Reading	✓	✓	✓
Quality Assurance Technical Procedures (QATP) for sampling and analysis	Reading	✓	✓	✓
Demonstration of proficiency for task-specific procedures and equipment	OTJ	✓	✓	✓

CPR = cardiopulmonary resuscitation.
O&M = operation and maintenance.
OTJ = on-the-job.
✓ = required training.

Table E-1. Implementation Checklist for Monitored Natural Attenuation for Benzene[a]
PDO Yard, Hunter Army Airfield, Georgia

ROLE OF MONITORED NATURAL ATTENUATION	
Source Control	• The source of contamination was removed in an Interim Removal action in 1998. Contaminated soil was excavated and removed from the site. There is no free petroleum product (NAPL) or residual soil contamination. There is, therefore, no principal-threat waste at the PDO Yard. • No other source control measures are needed to control long-term threat of release.
Restoration of Groundwater	• Groundwater will be restored to "beneficial use" through reduction of benzene concentrations to less than the MCL. Groundwater is not used at this site as a source of drinking water, and exposure by a future resident is highly unlikely. • The timeframe is reasonable for restoration of groundwater to this beneficial use. Results of AT123D modeling predict that benzene concentrations in groundwater will decline to less than the MCL of 5 μg/L in just 2 years. This is reasonable compared to the 4 to 12 months predicted for active remediation systems. • Further migration of the plume will be prevented. Downgradient migration is precluded through discharge to Lamar Canal; benzene has not been detected in Lamar Canal. Lateral migration is unlikely as evidenced by the historical reduction in benzene concentrations at the edge of the plume. Vertical migration is unlikely because benzene is lighter than water, and benzene has not been detected in deeper wells at the site. • Exposure to contaminated groundwater will be prevented through continuation of groundwater use restrictions and excavation permit restrictions at HAAF. Groundwater is not used at this site as a source of drinking water. • Further reduction in risk will occur as contaminant concentrations in groundwater continue to decline due to biodegradation, advection, and dispersion.
Soil Remediation	• Soils have been excavated from the source area in 1998, and there is no residual soil contamination. There is, therefore, no risk due to exposure to soils. • Similarly, transfer of contaminants from soil to other media is prevented because the soils have been excavated, and there is no residual contamination.
Protective of Human Health and the Environment	• MNA is protective of human health and the environment at the PDO Yard. Based on the conclusions of the Revised Final RFI Report, there is no current human health or ecological risk associated with benzene in groundwater. Potential future exposure is unlikely because the shallow groundwater is not a viable source of drinking water in the HAAF area. Attainment of the benzene MCL will effectively eliminate any potential future risk. • The maximum concentration of benzene in groundwater (68 μg/L) is less than its IWQS of 71.28 μg/L, so that MNA is protective of human health and the environment through direct exposure within Lamar Canal.
Capable of Achieving Remedial Objectives	• The remedial objective is to attain media cleanup standards (MCL) for benzene in groundwater. Results of AT123D modeling predict that benzene concentrations in groundwater will decline from a current maximum of 68 μg/L to less than the MCL of 5 μg/L, thereby achieving remedial objectives.
Capable of Achieving Objectives in Reasonable Time Frame	• Results of AT123D modeling predict that benzene concentrations in groundwater will decline to less than the MCL of 5 μg/L in just 2 years. This is reasonable compared to the 4 to 12 months predicted for active remediation systems.

Table E-1. Implementation Checklist for Monitored Natural Attenuation for Benzene[a] PDO Yard, Hunter Army Airfield, Georgia (continued)

ROLE OF MONITORED NATURAL ATTENUATION (CONTINUED)	
Demonstrated Effectiveness	• MNA is demonstrated to be effective through technical analysis of historical trends in groundwater, analysis of geochemical data, and AT123D numerical analysis. • Performance monitoring will include semiannual groundwater sampling to demonstrate the effectiveness of MNA. Performance monitoring of surface water is not necessary at the PDO Yard because benzene concentrations in groundwater have been consistently less than its IWQS and benzene has not been detected in Lamar Canal in historical sampling. Performance monitoring in groundwater will provide sufficient demonstration of natural attenuation for protection of surface waters. • Contingency (backup) measures are identified in the O&M Plan to ensure attainment of remedial objectives. Contingency measures include extension of MNA monitoring, addition of oxygen-releasing compounds to enhance natural biodegradation, or active injection of air, oxygen, and/or nutrients into the subsurface.
DEMONSTRATION OF EFFICACY	
Site-Specific Characterization: <u>Conceptual Site Model</u>	Former releases of petroleum-related constituents from ASTs located in an earthen bermed area resulted in contamination of soil and groundwater. The soil was excavated in 1998 and removed from the site. Groundwater contaminated with benzene at concentrations exceeding its MCL extends from the former earthen bermed area northward to Lamar Canal.
<u>Nature and Distribution of Contamination in Groundwater</u>	Benzene contamination is confined to a narrow plume less than 80 feet wide, approximately 275 feet in length, and less than 25 feet deep. Historical monitoring of both shallow and deep wells since 1996 have shown decreasing benzene concentrations in the shallow wells near the former source (MW1-23) and laterally (MW02 and MW1-24). Increases in downgradient shallow wells (MW01 and MW06) are consistent with the migration of a slug of contamination toward Lamar Canal. Benzene has not been detected in any of the deep monitoring wells in any historical sampling event. No other constituents of concern are present.
<u>Nature and Distribution of Contaminant Sources</u>	All contaminated soil was excavated to a depth of about 3 to 4 feet during Interim Removal activities. Eight confirmatory soil samples were analyzed for VOCs, SVOCs, and priority pollutant metals to document the source removal. No target analytes, including benzene, were identified in any of the confirmatory soil samples above screening criteria. There is, therefore, no residual source of benzene contamination in soil.
<u>Potential Risk or Impacts to Receptors</u>	There is no current human health or ecological risk associated with exposure to benzene. Potential future exposure is unlikely because the shallow groundwater is not a viable source of drinking water in the HAAF area. Attainment of the benzene MCL will effectively eliminate any potential future risk. The maximum concentration of benzene in groundwater (68 µg/L) is less than its IWQS of 71.28 µg/L, so that MNA is protective of human health and the environment through direct exposure within Lamar Canal. Benzene has not been detected in Lamar Canal.
<u>Proximity of Receptors</u>	Surficial groundwater is not used as a source of drinking water. The underlying Principal (Floridan) Aquifer is the primary source of drinking water in the vicinity of HAAF. Four water supply wells (Principal Aquifer) are located within a one-mile radius of the PDO Yard. Shallow groundwater discharges to Lamar Canal, located approximately 275 feet north of the former earthen bermed area.

**Table E-1. Implementation Checklist for Monitored Natural Attenuation for Benzene[a]
PDO Yard, Hunter Army Airfield, Georgia (continued)**

APPROPRIATENESS (CONTINUED)	
Whether Contamination will Exert Long-term Detrimental Impact on Water Supplies/Resources	The shallow aquifer is not a viable source of drinking water. Benzene contamination will be remediated at all points within the aquifer to less than the MCL of 5 μg/L within 2 years. There will, therefore, be no long-term detrimental impact to water resources within the vicinity of the PDO Yard.
Whether the Estimated Time Frame of Remediation is Reasonable	Results of AT123D modeling predict that benzene concentrations in groundwater will decline to less than the MCL of 5 μg/L in just 2 years. This is reasonable compared to the 4 to 12 months predicted for active remediation systems, such as addition of oxygen-releasing compounds, air sparging, or enhanced biodegradation through oxygen and/or nutrient injection.
Whether the Sources of Contamination can be Adequately Controlled	All contaminated soil was excavated to a depth of about 3 to 4 feet during Interim Removal activities. Eight confirmatory soil samples were analyzed for VOCs, SVOCs, and priority pollutant metals to document the source removal. No target analytes, including benzene, were identified in any of the confirmatory soil samples above screening criteria. There is no free-phase product (NAPL) present at the PDO Yard. There is, therefore, no residual source of benzene contamination.
Whether Transformation Products Present a Greater Risk	Methane is a biodegradation product of benzene that has been found at the PDO Yard as evidence that biodegradation is occurring. Methane is an odorless, colorless gas that is physiologically inert and poses no health risk. Methane is a simple asphyxiate; at high concentrations it can supplant oxygen in the air creating an oxygen deficient environment. It is also flammable and has a lower explosive limit in air of 5 percent. Other transformation products formed through subsequent biodegradation of methane include carbon dioxide and water, which pose no health risk.
Whether Active Remediation Measures will Impact the MNA	Other remedial activities at the site, in particular the Interim Removal activities conducted in 1998 to remove contaminated soil, have had a positive impact on the benzene contamination in groundwater by removing the source of contamination. Remediation measures consisting of in-situ chemical oxidation using hydrogen peroxide are proposed for the adjacent PCE plume. However, those measures will not impact the benzene plume because the plumes are present in separate areas and because chemical oxidation also degrades benzene. If any hydrogen peroxide treatment reagent were to drift into the benzene plume area, then the natural microbial population may be temporarily impacted.
Whether Reliable Institutional Controls are Available for Monitoring and Enforcement	The U.S. Government will retain ownership of HAAF, including the area of the PDO Yard, to ensure that monitoring and enforcement of the MNA O&M Plan are completed. Other institutional controls at HAAF include groundwater use restrictions and excavation permits. These controls are reliable for the short-term duration (2 years) for MNA and until the facility is closed.
REASONABLENESS OF REMEDIATION TIMEFRAME	
Comparison to Other Alternatives	Results of AT123D modeling predict that benzene concentrations in groundwater will decline to less than the MCL of 5 μg/L in just 2 years. This is reasonable compared to the 4 to 12 months predicted for active remediation systems, such as air sparging or enhanced biodegradation through oxygen injection.
Balancing of Tradeoffs: Classification, Value of Resource	According to the Pollution Susceptibility Map of Georgia (GDNR 1992), HAAF is located in an average or higher groundwater pollution susceptibility area. Shallow groundwater is not a viable source of drinking water.
Timeframe in Which Aquifer will be Needed	Shallow groundwater is not a viable source of drinking water. The underlying Principal (Floridan) Aquifer is the primary source of drinking water in the vicinity of HAAF. Four water supply wells (Principal Aquifer) are located within a one-mile radius of the PDO Yard. Within the short timeframe of this remediation (2 years), there will be no demand for the affected groundwater resource.

Table E-1. Implementation Checklist for Monitored Natural Attenuation for Benzene"
PDO Yard, Hunter Army Airfield, Georgia (continued)

REASONABLENESS OF REMEDIATION TIMEFRAME (CONTINUED)	
Plume Stability Over Time	The benzene plume at the PDO Yard is not increasing in extent, but is shrinking. Results of historical monitoring have shown that benzene concentrations are decreasing at the former source area (MW1-23), and at the edges of the plume (MW02 and MW1-24). Increases in downgradient shallow wells (MW01 and MW06) are consistent with the migration of a slug of contamination toward Lamar Canal. Benzene has not been detected in any of the deep monitoring wells in any historical sampling event.
Detrimental Impacts	The shallow aquifer is not a viable source of drinking water. Benzene contamination will be remediated at all points within the aquifer to less than the MCL of 5 μg/L within 2 years. There will therefore be no long-term detrimental impact to water resources within the vicinity of the PDO Yard.
Uncertainties in Mass or Time Estimates	Chemical, hydrogeologic, and geochemical data are of adequate quality and usability. Data collection and laboratory analysis have been in accordance with approved USACE procedures for assessing data quality, including data validation. Lateral and vertical extent of contamination has been defined adequately to provide accurate estimates of the mass of benzene contamination in groundwater. Time estimates have been made based on AT123D numerical modeling using site-specific chemical, hydrogeologic and geochemical data and a conservative literature-based value for the biodegradation rate of benzene. Uncertainties inherent in these estimates are therefore acceptable. The O&M Plan has identified contingent measures to address uncertainties.
Reliability of Monitoring and Institutional Controls	The U.S. Government will retain ownership of the HAAF, including the area of the PDO Yard, to ensure that monitoring and enforcement of the MNA O&M Plan are completed. Other institutional controls at HAAF include groundwater use restrictions and excavation permits. Because the timeframe for MNA remediation is relatively short (2 years), monitoring and institutional controls can be reliably implemented and will be continued until the facility is closed.
Provisions for Availability of Adequate Funding	Funding is assured through the U.S. Department of Defense, Environmental Remedial Action (ERA) Program.
REMEDIATION OF SOURCES	
Removal of Contaminated Soil	Not applicable. All contaminated soil was excavated to a depth of about 3 to 4 feet during Interim Removal activities in 1998. There is no remaining source of contamination at the PDO Yard.
Free-Phase NAPL Removal	Not applicable. No free-phase product (NAPL) is present. There is no principal threat waste at the PDO Yard.
Treatment	Not applicable. There is no remaining source.
Principal-Threat Waste Treatment	Not applicable. There is no principal threat waste.
Containment	Not applicable. There is no remaining source.

1.0 INTRODUCTION

1.1 SCOPE OF THE CORRECTIVE ACTION PLAN

The Old Property Disposal (PDO) Yard, at Hunter Army Airfield (HAAF), Georgia, has been used by the Installation as an accumulation point for used oil and off-specification jet propulsion (JP-4) fuel in aboveground storage tanks (ASTs) set within a former earthen bermed area. A Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report has been completed for the PDO Yard. The Revised Final RFI Report, which was approved by Georgia Environmental Protection Division (GEPD) on January 10, 2000, recommended submittal of a Corrective Action Plan (CAP) for this site to address benzene and tetrachloroethene (PCE) contamination in groundwater.

The following conclusions and recommendations were made based on the results of the RFI and supplemental soil and groundwater investigations:

1. There are no human health contaminants of potential concern (HHCOPCs) in surface water or sediment.

2. An Interim Removal (IR) action conducted in July 1998 eliminated risks associated with direct exposure to contaminants in soil within the former bermed AST area. Arsenic and benzo(*a*)pyrene were evaluated as HHCOPCs in soil and were found to be present at concentrations within acceptable risk levels for both present industrial conditions and potential future residential use. Therefore, additional remediation of soil is not required.

3. There are no identified ecological contaminants of potential concern (ECOPCs) in surface soil, surface water, sediment, or groundwater at concentrations that exceed acceptable levels of risk. Therefore, remediation is not required for protection of ecological receptors.

4. Benzene and PCE were identified as HHCOPCs in groundwater. Risk calculations indicate neither constituent exceeds acceptable levels of risk under a future residential use scenario. However, concentrations of both constituents exceeded their respective risk-based concentrations (RBCs) and maximum contaminant levels (MCLs). Therefore, the MCLs for benzene and PCE were selected as remedial levels (RLs).

5. The horizontal and vertical extent of groundwater contamination has been adequately delineated by activities conducted during the RFI.

6. A CAP is required to evaluate measures to mitigate the effects of benzene and PCE in groundwater due to the fact that concentrations of these HHCOPCs exceed their respective MCLs. The CAP will evaluate the effectiveness of "hot-spot" treatment and Monitored Natural Attenuation in remediating these organic compounds. Fate and transport modeling will be used in evaluating effects associated with both treatment and natural attenuation remedial options. In addition, the CAP will also evaluate the implementation or continuance of institutional controls for the site.

This CAP report utilizes information from the RFI to evaluate institutional controls and various remedial actions for achieving the RLs proposed in the Revised Final RFI Report. The options analyzed for achieving the stated RLs included an evaluation of Monitored Natural Attenuation, in accordance with published guidance documents [U.S. Environmental Protection Agency (EPA) 1999]. This report analyzes the feasibility of the applicable remedial actions, Monitored Natural Attenuation, and institutional controls on a site-specific basis.

This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers, Savannah District, under Contract No. DACA21-95-D-0022, Delivery Order No. 0036.

1.2 SITE BACKGROUND

During a site visit to the PDO Yard in April 1993, GEPD noted deficiencies in waste management practices at the PDO Yard and several other HAAF locations. As a result, a site assessment was conducted to determine whether the environment had been impacted as a result of the PDO Yard's use. This inspection led to issuing a Consent Order (CO) (No. GA4210022733) in March 1994.

From November 1993 to January 1994, the U.S. Army Environmental Hygiene Agency (USAEHA) conducted a site assessment at the PDO Yard under Waste Disposal Engineering Study (WDES) No. 37-26-J2KZ-94. Samples were collected from soil borings and hydropunch locations. Surface soil samples collected from within the bermed area exceeded the then current screening criteria for total petroleum hydrocarbons (TPH) and BTEX (the sum of benzene, toluene, ethylbenzene, and total xylenes) established by the GEPD Underground Storage Tank Management Program. The average concentration of TPH in composite surface soil samples collected from within the berm was 12,000 mg/kg. The average TPH concentration dropped to 1,900 mg/kg in composite samples taken at a depth of 6 to 18 inches below ground surface (bgs). While not statistically exceeding background, arsenic exhibited a mean concentration of 7.50 mg/kg, which exceeded the screening criteria of 1.6 mg/kg used during the USAEHA investigation. All other inorganics identified in soil samples were below their respective screening criteria. PCE and metals were identified in groundwater samples. The USAEHA concluded that further assessment of soil and groundwater contamination at the PDO Yard was required (Metcalf & Eddy 1999).

In April 1994, the USAEHA conducted a groundwater assessment at the PDO Yard (WDES No. 38-26-K2KZ-94). Seven monitoring wells were installed during this investigation. PCE was present in a groundwater sample collected from monitoring well MW1-23 at a concentration of 145 μg/L, above its MCL of 5 μg/L. Metals (antimony, iron, manganese, nickel, lead, and thallium) exceeded their corresponding MCLs or Secondary Drinking Water Standards but could be naturally occurring since they were detected upgradient from the PDO Yard (Metcalf & Eddy 1999). As a result, the PDO Yard was not identified as the source of elevated nickel, lead, thallium, iron, or manganese in groundwater, and further investigation into an antimony anomaly was recommended (Metcalf & Eddy 1999).

The RFI was conducted in two phases of field sampling. The Phase I RFI was summarized in a Final RFI Report that was submitted to the GEPD in April 1998. Recommendations from the GEPD included conducting additional subsurface investigation to define the extent of contamination at the PDO Yard, completion of interim removal measures (i.e., AST removal, soil excavation, and AST replacement), and incorporation of the data into a Revised Final RFI report. Additional investigation activities (Phase II) were conducted in August 1998 and reported in the December 1998 Revised Final RFI Report. The GEPD then recommended the collection of additional surface water and sediment samples from Lamar Canal directly downgradient of monitoring well MW06 (Metcalf & Eddy 1999). The subsequent Revised Final RFI Report was submitted to the GEPD in September 1999 and approved by GEPD on January 10, 2000. The results of the RFI are discussed in Section 2.0.

1.3 REGULATORY BACKGROUND

The regulatory authority governing the action at the PDO Yard at HAAF is the RCRA 40 *Code of Federal Regulations* 264, Title II, Subpart C, Section 3004 (42 USC 690 et seq.). With the promulgation of RCRA and the subsequent approval of the Georgia Hazardous Waste Management Act by the EPA, the State was granted RCRA permitting authority. In accordance with RCRA, the State issued to Fort Stewart, in August 1987, a Hazardous Waste Permit [Georgia Environmental Division Permit HW-045 (S&T)]. The permit was renewed in August 1997. HAAF (EPA ID No. GA4 022 733) is operated under Fort Stewart's permit.

1.4 REPORT ORGANIZATION

This CAP consists of six sections. Section 1.0 summarizes the scope of the CAP, describes the background of the site and regulatory authority, and gives the report organization. Section 2.0 discusses the site characterization and RFI results and summarizes the supplemental sampling and natural attenuation modeling results. Section 3.0 describes the justification and purpose of the corrective action and presents the remedial response objectives and RLs developed in the RFI. Section 4.0 presents the screening of the corrective actions. Section 5.0 summarizes the report conclusions and recommendations for the corrective action. The references are presented in Section 6.0.

This report also contains five appendices. Appendix A provides the results of supplemental groundwater and soil sampling. Appendix B presents the detailed results of the natural attenuation modeling. Appendix C contains a cost estimate summary for corrective action alternatives. Appendix D is an operation and maintenance (O&M) plan for the selected corrective action, Monitored Natural Attenuation of benzene in groundwater and Geo-Cleanse® treatment with Monitored Natural Attenuation of PCE in groundwater. Appendix E lists considerations for the selection of Monitored Natural Attenuation for the benzene plume, following the guidance of Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P (EPA 1999).

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 SITE CHARACTERIZATION

HAAF is located in the City of Savannah, Chatham County, Georgia (Figure 2-1). The airfield covers approximately 5,400 acres, and it is bounded on the north by lightly populated areas, on the east and south by residential and light commercial areas, and on the west by the Little Ogeechee River. HAAF is a subinstallation to the Fort Stewart Military Reservation, which is located approximately 30 miles to the southwest.

From the early days of aviation, the area now known as HAAF was used by practice flyers, barnstormers, and aerial circuses. In 1928, the city of Savannah took possession of the field for use as a municipal airport. In the spring of 1940, the property was designated as a military airfield. Except for a short period when military activities were moved to Travis Field west of the city, the Army Air Corps (and later the separately organized Air Force) made extensive use of the base for approximately two decades. Users included the U.S. Air Force Strategic Air Command and the Military Air Transport Command (Metcalf & Eddy 1999).

The Air Force ceased using the base in the early 1960s, and deactivation efforts were undertaken. However, the Army acquired the facility in 1967 to support the increased need for helicopter pilot training during the Vietnam conflict. Advanced helicopter training for Vietnamese Air Force flight students was conducted at HAAF from 1970 to 1972. In 1975, the airfield became an important component of nearby Fort Stewart when the 24th Infantry Division (reflagged the 3rd Infantry Division–Mechanized, in May 1996) was reactivated and stationed at the Fort Stewart/HAAF complex (Metcalf & Eddy 1999).

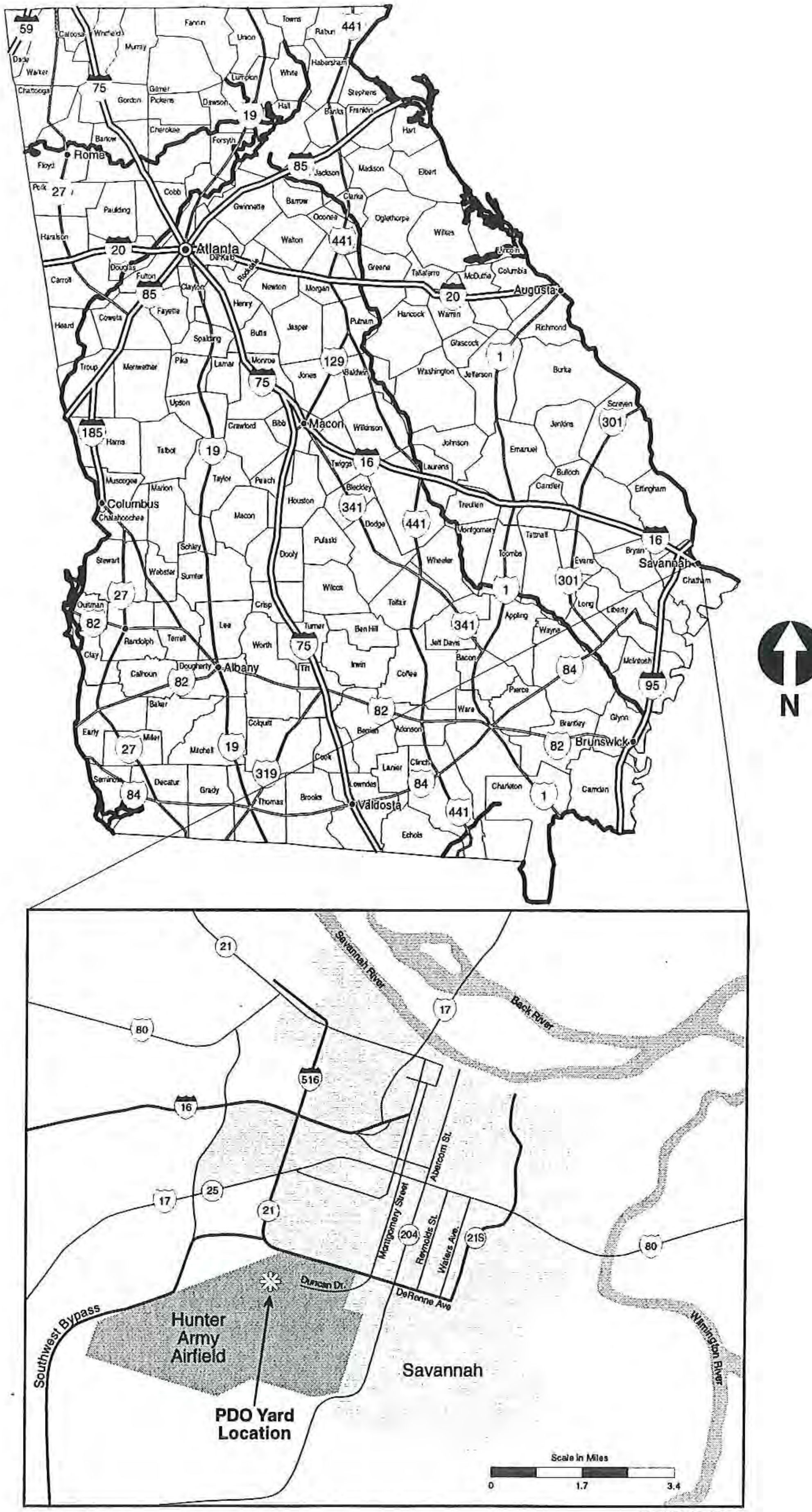
2.1 SITE DESCRIPTION AND HISTORY

The PDO Yard is located near the northwestern boundary of HAAF and consists of a fenced parcel containing approximately 0.955 acres (Figure 2-2). The site is approximately 136 feet by 300 feet. Much of the site is paved with the remainder covered in crushed stone. The ground surface is relatively flat except for a manmade hill located to the southeast and southwest. Trees are scattered along this hill; otherwise, there is no vegetation at the site. A railroad track formerly ran along the northwest side of the PDO Yard. Lamar Canal lies further to the north, approximately 400 feet from the former bermed AST area. An area used to stockpile coal reserves for 20 to 30 years was located toward the north, outside the fenced area (Metcalf & Eddy 1999).

The PDO Yard has been used as a storage facility for used oil and off-specification JP-4, for scrap metal storage, and as a temporary (i.e., 90-day) storage facility for hazardous waste. Originally, the site included an earthen bermed area located in the southeast corner of the fenced area. The bermed area contained two 20,000-gallon tanks used to store waste oil and one 18,000 gallon tank used to store off-specification JP-4.

During their visit to the site in April 1993, GEPD noted that containers of freon, liquid petroleum gas, industrial debris, and waste solvent existed within the PDO Yard. Containers of antifreeze, paint, acetone, electrolyte (potassium hydroxide), polychlorinated biphenyl (PCB) waste, jet propulsion (JP) pads, and filters were present in the 90-day hazardous waste storage area. Six transformers were also being stored in the hazardous waste storage area. The inspection led to the issuance of a CO (No. GA4210022733) in March 1994.

During the subsequent RFI investigation, oil staining of surface soils within the former earthen bermed area was observed. In July 1998, the ASTs were removed from the facility, cleaned, and taken offsite for recycling. The soil around the former AST locations, including the berms, was excavated to a depth of about 3 feet bgs with the exception of the northeast corner where the excavation was taken down to a depth of



31-102797-063 A

Figure 2-1. Location Map for PDO Yard at HAAF, Georgia.

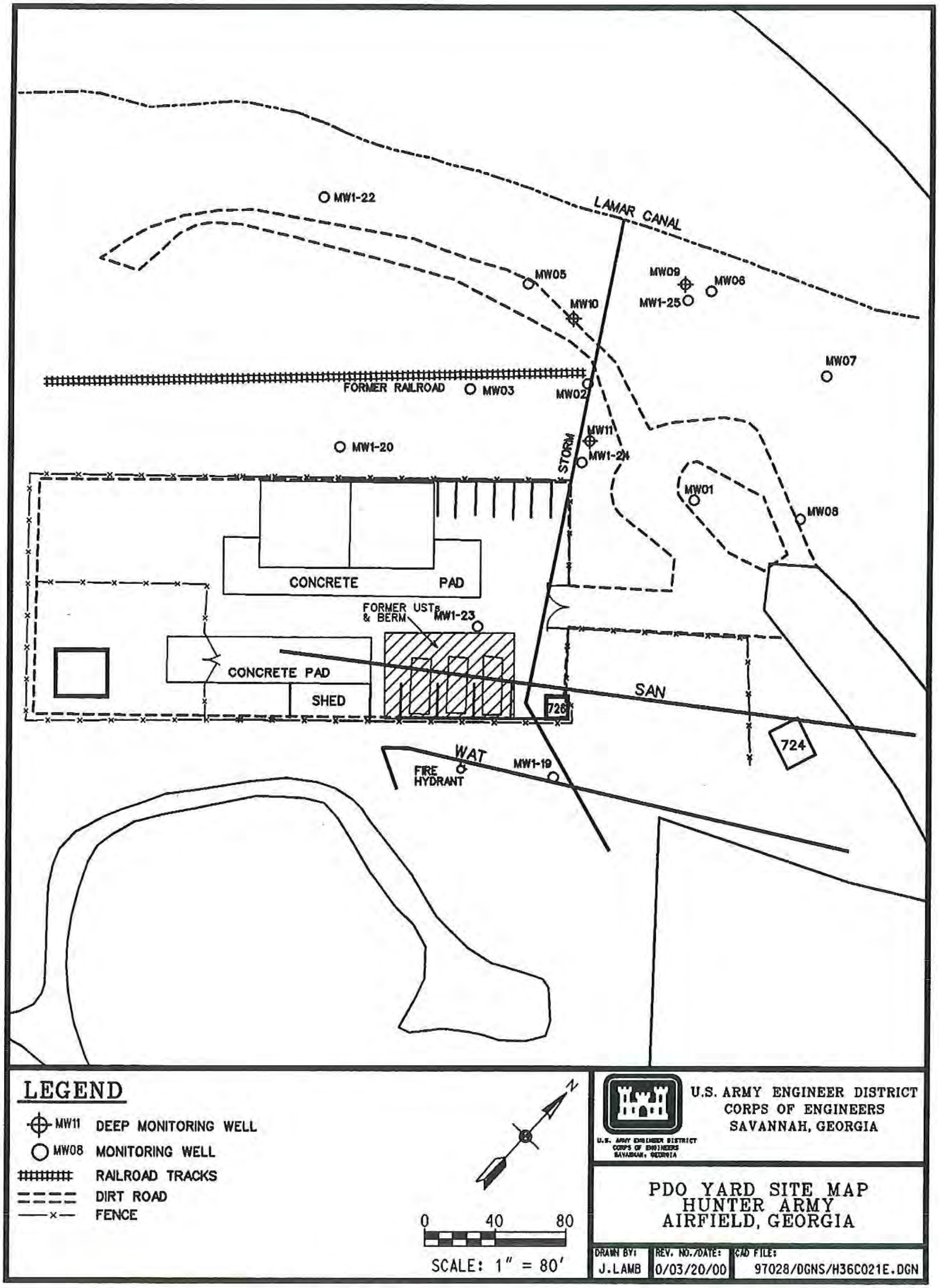


Figure 2-2. PDO Yard Site Map, HAAF, Georgia.

4.2 feet bgs. The excavation pit was approximately 50 feet by 75 feet and produced about 450 cubic yards of soil. The area was replaced to grade with clean, compacted fill material and covered with gravel (Metcalf & Eddy 1999).

Three new ASTs were installed in a newly constructed concrete-lined tank area on the north side of the PDO Yard in July 1998. The three new ASTs, a 90-day hazardous waste storage area, and several paved open storage bays are currently located within the PDO Yard.

2.2 SITE GEOLOGY

HAAF is located toward the north end of the Barrier Island Sequence District of the Coastal Plain Physiograpahic Province. The Barrier Island Sequence in Chatham and Bryan Counties is characterized by the existence of several marine terraces (step-like topographic surfaces that decrease in elevation toward the coast). Topographic relief basewide ranges from approximately 2 to 42 feet above mean sea level. These marine terraces, and their associated deposits, are the results of sea level fluctuations that occurred during the Pleistocene Epoch.

HAAF, as well as most of Chatham County, is underlain by the Satilla Formation within the Pleistocene Pamlico Terrace. The Satilla Formation is a lithogically heterogeneous unit that consists of variably bedded sand and silty to sandy clay. During the Pleistocene, these sand and clay deposits were formed in offshore and inner continental shelf, barrier island, and marsh/lagoon-type environments (Huddlestun 1988). According to the Geologic Map of Georgia (GA DNR 1976), clay beds of marsh origin, which were deposited on the northwest side of the former Pamlico Barrier Island complex, exist in the western quarter of HAAF. Very fine- to coarse-grained sand deposits of barrier island origin are more common throughout the remaining areas of HAAF, including the area of the PDO Yard.

2.3 SITE SOILS

The PDO Yard is underlain primarily by Chipley soils of the Chipley Urban Land Complex within the Chipley-Leon-Ellabelle soil association. The Chipley-Leon-Ellabelle soil association consists of moderately well drained and poorly drained, sandy soils on broad, low ridges and very poorly drained soils that have loamy underlying layers in depressions and drainage ways. Slopes range from about 0 to 2 percent (Metcalf & Eddy 1999).

According to the United States Department of Agriculture (USDA) report, the texture of the Chipley soils is a fine sand to a depth of 6 feet or more. A seasonal high water table is 15 to 36 inches bgs. In some places within the investigation area, the soil profile has been altered by cutting, filling, grading, and landscaping. In this urban land, the identification of soils is impractical due to the presence of urban facilities (Metcalf & Eddy 1999).

2.4 SITE HYDROLOGY

2.4.1 Groundwater Hydrology

The hydrogeology in the vicinity of HAAF is mostly influenced by two aquifer systems. These are referred to as the Principal (Floridan) Aquifer and the Surficial Aquifer (Miller 1990). The Principal Aquifer is the lowermost hydrologic unit and is regionally extensive from South Carolina through Georgia, Alabama, and most of Florida. The aquifer, approximately 800 feet in total thickness, is composed primarily of

Tertiary-age limestone including the Bug Island Formation, the Ocala Group, and the Suwannee Limestone. Groundwater from the Floridan is used primarily for drinking water (Arora 1984). According to Miller (1990), one of the largest cones of depression produced in the Upper Floridan Aquifer exists directly beneath Savannah, Georgia. Net water-level decline in the Floridan system, between the predevelopment period and 1980, exceeded 80 feet beneath Savannah. In addition, according to 1980 estimates, more than 500 million gallons of water per day were withdrawn from the Floridan for public and industrial use in southeast Georgia, more than any other region.

The confining layer for the Floridan Aquifer is the phosphatic clay of the Hawthorn Group. There are minor occurrences of aquifer material within the Hawthorn Group; however, they have limited utilization (Miller 1990). The Surficial Aquifer overlies the Hawthorn confining unit.

The Surficial Aquifer consists of widely varying amounts of sand and clay, ranging from 55 to 150 feet in thickness, and is composed primarily of the Satilla and Cypresshead Formations in the Savannah vicinity (Arora 1984). This aquifer is primarily used for domestic lawn and agricultural irrigation. Groundwater in the Surficial Aquifer system is under unconfined, or water table, conditions. The top of the water table typically ranges from approximately 2 to 10 feet bgs (Miller 1990) and was measured at a depth of 5 to 7 feet bgs at the PDO Yard during the RFI. Based on the site potentiometric map (Figure 2-3), groundwater flow is north to northwest toward Lamar Canal (Metcalf & Eddy 1999).

Aquifer tests were not performed at the PDO Yard, but have been done at the former Building 728 site, which is similar and is located only 1800 feet east-northeast of the PDO Yard. The average laboratory hydraulic conductivity of two Shelby tube samples collected within the saturated zone at the former Building 728 site was 1.15×10^{-4} feet/second. The average hydraulic conductivity calculated from slug tests for shallow monitoring wells was 5.48×10^{-4}feet/second, and for the deep monitoring wells was 7.55×10^{-4} feet/second. Results of the PDO Yard Revised Final RFI Report indicated an average groundwater seepage velocity of 0.72 foot/day, which was calculated using a hydraulic gradient of 1.3×10^{-2} feet/feet, an average hydraulic conductivity of 1.15×10^{-4} feet/second, and an effective porosity of 0.18 (Metcalf & Eddy 1999).

2.4.2 Surface Water Hydrology

Surface water runoff from the site is through overland flow to Lamar Canal. Flow within Lamar Canal is to the southwest, ultimately discharging to the Little Ogeechee River, which is part of the Lower Ogeechee watershed. Water depth in Lamar Canal averaged about 6 inches to 1 foot during RFI sampling, but it is higher during periods of heavy rain. The water was clear with large amounts of aquatic plants growing along the banks. Flow was consistent with a low velocity (Metcalf & Eddy 1999).

2.5 CONTAMINANT NATURE AND EXTENT

The nature and extent of contamination is described below for conditions evaluated during the RFI (Metcalf & Eddy 1999) and subsequent soil and groundwater sampling. Soil data from within the former earthen bermed area are not presented, because these soils were excavated during IR activities to a depth of 3 to 4 feet bgs. Eight confirmatory soil samples were collected and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and priority pollutant metals to document the source removal. No target analytes were identified in any of the confirmatory soil samples above screening criteria. Soil data from outside the bermed area are presented from both the RFI sampling events, because soil sampling locations were not duplicated. Groundwater, surface water, and sediment data are presented for the Phase II sampling only, because those are the most recent data.

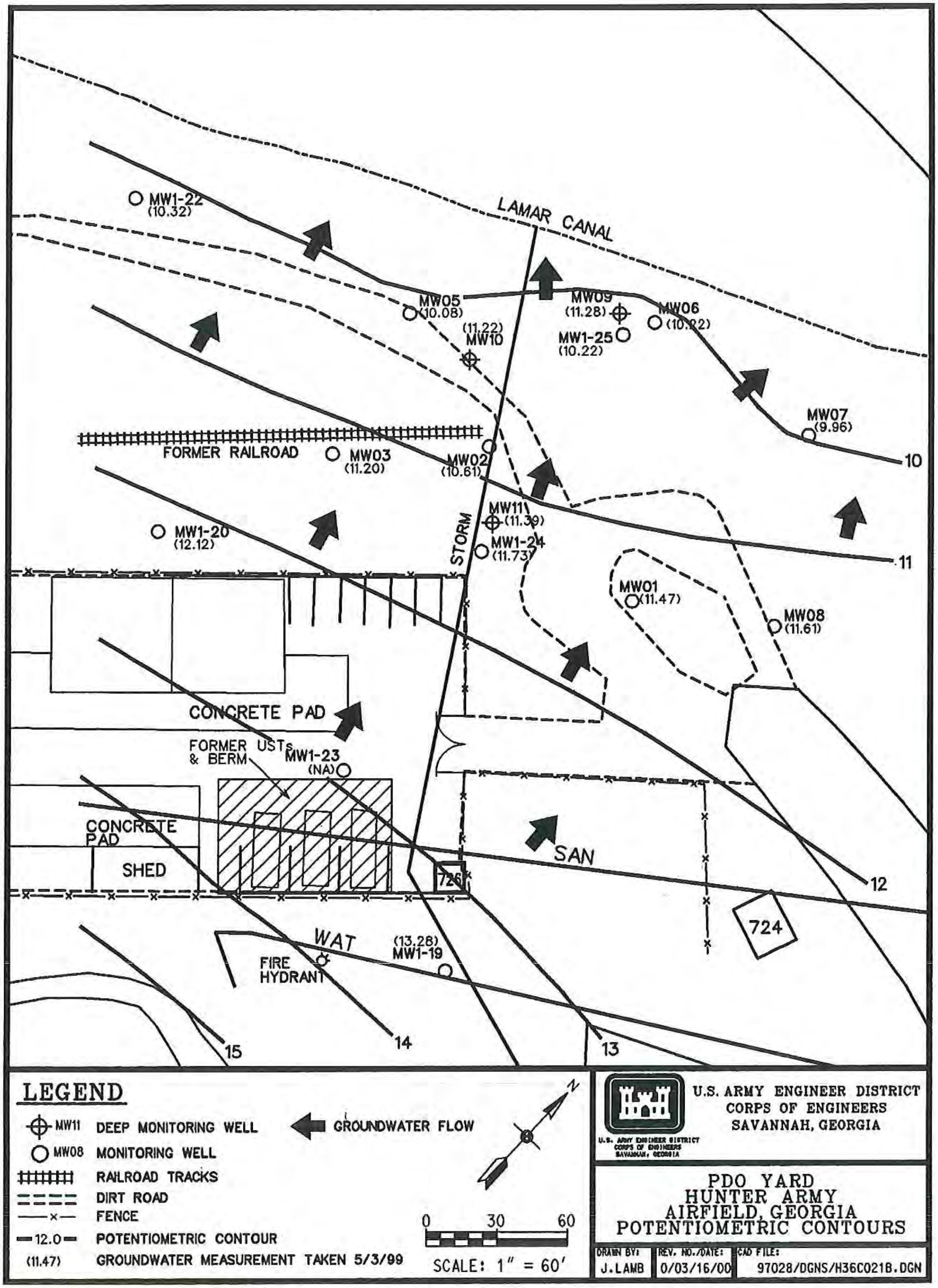


Figure 2-3. Potentiometric Map of PDO Yard, HAAF, Georgia.

2.5.1 RFI Results

Surface Soil. Twenty-three shallow soil samples were collected from 0 to 2 feet bgs during the Phase I and Phase II field activities at the PDO Yard. Arsenic, cadmium, and chromium concentrations exceeded screening criteria in a number of soil samples. Concentrations of cadmium and chromium were all below residential RBCs. However, several samples exceeded the EPA generic soil screening level (GSSL) for leaching to groundwater based on a dilution attenuation factor (DAF) of 1. The detection limit for arsenic exceeded the residential RBC of 0.43 mg/kg at all locations; the lowest detection limit for arsenic was <1.1 mg/kg. For comparison purposes, arsenic concentrations were evaluated with respect to the industrial RBC of 3.8 mg/kg. The industrial RBC was exceeded at 10 of 23 sampling locations. No other inorganic constituents were identified at concentrations above screening criteria.

Benzo(*a*)pyrene was the only organic compound identified in the 23 surface soil samples at a concentration exceeding screening criteria. The detection limit for benzo(*a*)pyrene was greater than the residential RBC of 0.088 mg/kg for all soil samples. Concentrations of benzo(*a*)pyrene exceeded the industrial RBC of 0.78 mg/kg in only 1 of 23 locations (SB-1 at 1.6 mg/kg) but were below the GSSL of 8 mg/kg (Metcalf & Eddy 1999).

Subsurface Soil. No organic parameters were identified in any subsurface soil sample collected at concentrations above the EPA Region 3 Industrial RBCs. The only metal that exceeded the industrial RBC was arsenic. Arsenic was identified in 4 of 50 locations at concentrations exceeding the industrial RBC of 3.8 mg/kg. Arsenic and chromium also exceeded their respective GSSLs in several subsurface soil samples.

Groundwater. During the Phase II sampling (August 1998), benzene was detected in 5 of 18 shallow groundwater monitoring well samples: MW01 (64 μg/L), MW02 (4 μg/L), MW06 (36 μg/L), MW1-23 (13 μg/L), and MW1-25 (29 μg/L). The benzene MCL of 5 μg/L was exceeded in four of those wells. The former bermed AST area is the suspected source of benzene identified in the shallow groundwater; the benzene plume extends to the north-northwest (downgradient) from the source area. Benzene was not detected in any of the three deep groundwater monitoring wells.

Other BTEX compounds were also detected in shallow monitoring wells. Ethylbenzene was detected at a maximum concentration of 16 μg/L, toluene at a maximum concentration of 7 μg/L, and o-xylene at a maximum concentration of 25 μg/L, all of which are much less than their respective MCLs.

PCE was detected in groundwater samples from four shallow wells: MW02 (16 μg/L), MW05 (47 μg/L), MW1-22 (11 μg/L), and MW1-24 (15 μg/L). The PCE MCL of 5 μg/L was exceeded in each of those four wells. PCE detections seem to be localized outside the fenced site area, extending to the west-northwest in the area between the storage bays, the railroad tracks, and Lamar Canal. PCE was not detected in any of the three deep groundwater monitoring wells.

Other organic compounds were detected, including p-isopropyltoluene (97 μg/L), naphthalene (19 μg/L), 1,2,4-trimethylbenzene (27 μg/L), and 2-methylnaphthalene (18 μg/L). None of these organic compounds exceeded its respective RBC or MCL. Bis(2-ethylhexyl)phthalate was detected in the August 1998 groundwater sample from monitoring well MW10 at 14 mg/L but was not detected in subsequent quarterly sampling events. Bis(2-ethylhexyl)phthalate is suspected to be associated with laboratory contamination or an anomaly and is, therefore, not considered to be significant.

Analytical results indicate that the only inorganic detected in groundwater samples was barium. Barium was detected at a maximum of 100 μg/L, below its MCL of 2,000 μg/L.

Surface Water. Bis(2-ethylhexyl)phthalate was identified in surface water sample SWE02 at 16 µg/L in August 1998, which is above both the In-stream Water Quality Standard (IWQS) (5.92 µg/L) and the chronic freshwater surface water screening value (<0.3 µg/L). This compound was present near its detection limit of 10 µg/L and, like the single detection in the groundwater sample from MW10, is likely associated with laboratory contamination or an anomaly. Additionally, bis(2-ethylhexyl)phthalate was not identified in any Phase I or quarterly surface water sample.

Arsenic, lead, and zinc were identified in surface water samples at concentrations exceeding their respective IWQS. However, concentrations were highest in the upstream sample, and results may be heavily dependent on sediment load in the canal.

Sediment. Arsenic, cadmium, chromium, and lead were identified at concentrations above one or more screening criteria. Arsenic (0.9 mg/kg) exceeded its residential RBC in one sample (PD1500) collected in April 1999. Cadmium (0.74 mg/kg) exceeded the EPA GSSL based on a DAF of 1. Chromium (135 mg/kg) exceeded both the GSSL and the residential RBC. Lead (100 mg/kg) exceeded its EPA Region IV screening value, but was highest in the upstream sample.

2.6 CONTAMINANT FATE AND TRANSPORT

A contaminant fate and transport analysis, which provided an assessment of the potential migration pathways and transport mechanisms affecting the constituents found at the site, was performed in the Revised Final RFI Report.

Arsenic and chromium were reported in surface soil, subsurface soil, and sediment at concentrations that exceed their respective EPA GSSLs for leaching to groundwater. No organic compound was found in any soil or sediment sample at a concentration above its GSSL.

Benzene and PCE were the only organic compounds consistently identified in groundwater at concentrations above the risk-based screening criteria. Benzene is a volatile aromatic hydrocarbon that can migrate readily through the soil column toward groundwater. Benzene is less dense than water, and when it comes in contact with groundwater, tends to float on top of the water column. Degradation of benzene by hydrolysis is minimal in the subsurface; benzene is biodegradable under aerobic conditions with a biodegradation half-life of approximately 2 years. PCE is a chlorinated aliphatic hydrocarbon that is very mobile. Being denser than water, PCE may migrate vertically (downward) through a saturated medium as a separate phase. PCE is somewhat biodegradable under anaerobic conditions with a biodegradation half-life of approximately 4 years. Both benzene and PCE are highly volatile; therefore, volatilization is a major mechanism for removal of these constituents from groundwater and surface waters.

2.7 PRELIMINARY RISK EVALUATION

2.7.1 Human Health Risk Assessment

The human health risk assessment, presented in Section 6.0 of the RFI Report, consisted of a comparison of soil, sediment, groundwater, and surface water data to risk-based screening values. Based on the results of the risk assessment, the following were concluded (Metcalf & Eddy 1999):

- HHCOPCs in soil are not present at concentrations that require remediation for the protection of on-site workers under current use of potential residents under a future use scenario.

- There are no HHCOPCs in surface water or sediment.
- Benzene and PCE were identified as HHCOPCs in groundwater, and concentrations of both constituents exceeded their respective RBCs and MCLs.
- Risk calculations for benzene and PCE indicate the calculated carcinogenic and noncarcinogenic human health risks are below the recommended threshold values as defined by GEPD and the EPA. Therefore, further human health risk assessment is not required for the PDO Yard.
- Proposed RLs for benzene and PCE are their respective MCLs of 5 μg/L.

2.7.2 Ecological Risk Assessment

The ecological risk assessment (ERA), presented in Section 7.0 of the RFI Report, consisted of conducting a preliminary risk evaluation (PRE) which compared surface soil, surface water, sediment, and groundwater detections to ecological screening values published by EPA Region 4. The following summarizes the findings of the PRE (Metcalf & Eddy 1999):

- There are no identified ECOPCs in surface soil, surface water, or groundwater.
- Barium concentrations in sediment do not pose a risk to potential receptors near the PDO Yard.
- An ERA is not required for the PDO Yard based on the data evaluation conducted in the PRE.

2.8 SUPPLEMENTAL SAMPLING

2.8.1 Supplemental Groundwater Sampling

The Installation elected to sample groundwater, surface water, and sediment on a quarterly basis to monitor potential trends in contaminant migration and/or degradation associated with former releases from the PDO Yard. A total of four quarters of sampling events, three in addition to the Phase II RFI data, were conducted at the PDO Yard between August 1998 and May 1999. Results of this sampling were presented in reports to the U.S. Army Corps of Engineers–Savannah District and Fort Stewart Directorate of Public Works. A copy of the data was also submitted to GEPD. Groundwater analytical results for benzene and PCE are presented in Table 2-1 for the supplemental sampling in addition to the RFI sampling. For this CAP, fate and transport modeling was then performed using the fourth-quarter data (May 1999) to develop constituent-specific DAFs for chemicals of concern at the site.

Groundwater analytical results from the Phase I RFI and quarterly sampling events indicate benzene concentrations steadily increased in two downgradient wells (MW01 and MW06), remained relatively constant in MW1-25, and steadily decreased to below the MCL in two wells (MW02 and MW1-23). The variation in concentrations could be attributed to slugs of contamination, remaining after the soil excavation, migrating through the shallow groundwater at the site toward Lamar Canal. Maximum benzene concentrations have been reported in wells MW01 (68 μg/L) and MW06 (62 μg/L) at concentrations exceeding the MCL of 5 μg/L. However, the maximum benzene concentration (68 μg/L) is less than its IWQS of 71.28 μg/L. No benzene has been detected in any of the deep monitoring wells. Figure 2-4 depicts the extent of the benzene plume based on the most recent (May 1999) groundwater data.

Trends for PCE indicate groundwater contamination levels have remained relatively constant in four wells (MW03, MW05, MW1-22, and MW1-24). PCE concentrations have shown a slight decline in well MW02. The maximum PCE concentration from the most recent sampling event was reported at well MW05 (40 μg/L in May 1999), exceeding its MCL of 5 μg/L. PCE has not been detected in any of the

Table 2-1. Summary of Analytical Results in Groundwater (Benzene and PCE), PDO Yard, Hunter Army Airfield

Well ID	Phase I RFI (9/96)	Sampling Event: 1st Quarter (Phase II RFI) (8/98)	2nd Quarter (11/98)	3rd Quarter (2/99)	4th Quarter (CAP Modeling) (5/99)
Benzene Results (µg/L)					
MW01	**24**	**64**	**6**	**52**	**68**
MW02	15	4	2	0	0
MW03	0	0	0	0	0
MW04	0	0	0	0	0
MW05	NS	0	0	0	0
MW06	NS	**36**	**46**	**46**	**62**
MW07	NS	0	0	0	0
MW08	NS	0	0	0	0
MW09	NS	0	0	0	0
MW10	NS	0	0	0	0
MW11	NS	0	0	0	0
MW1-19	0	0	0	0	0
MW1-20	0	0	0	0	0
MW1-21	0	0	0	0	0
MW1-22	0	0	0	0	0
MW1-23	**19**	**13**	5	**8**	4
MW1-24	4.8	0	0	0	0
MW1-25	**48**	**29**	**41**	**54**	**50**
PCE Results (µg/L)					
MW01	0	0	0	0	0
MW02	**13**	**16**	**15**	**9**	**9**
MW03	4.8	0	4	0	5
MW04	0	0	0	0	0
MW05	NS	**47**	**56**	**37**	**40**
MW06	NS	0	0	0	0
MW07	NS	0	0	0	0
MW08	NS	0	0	0	0
MW09	NS	0	0	0	0
MW10	NS	0	0	0	0
MW11	NS	0	0	0	0
MW1-19	0	0	0	0	0
MW1-20	0	0	0	0	0
MW1-21	0	0	0	0	0
MW1-22	0	**11**	**16**	**13**	**13**
MW1-23	0	0	0	0	0
MW1-24	**15**	**15**	**11**	**17**	**15**
MW1-25	0	0	0	0	0

bold = value greater than the maximum contaminant level (MCL) of 5 µg/L.
CAP = Corrective Action Plan.
MW = monitoring well.
NS = not sampled; well was not installed until later date.
PCE = tetrachloroethene.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.

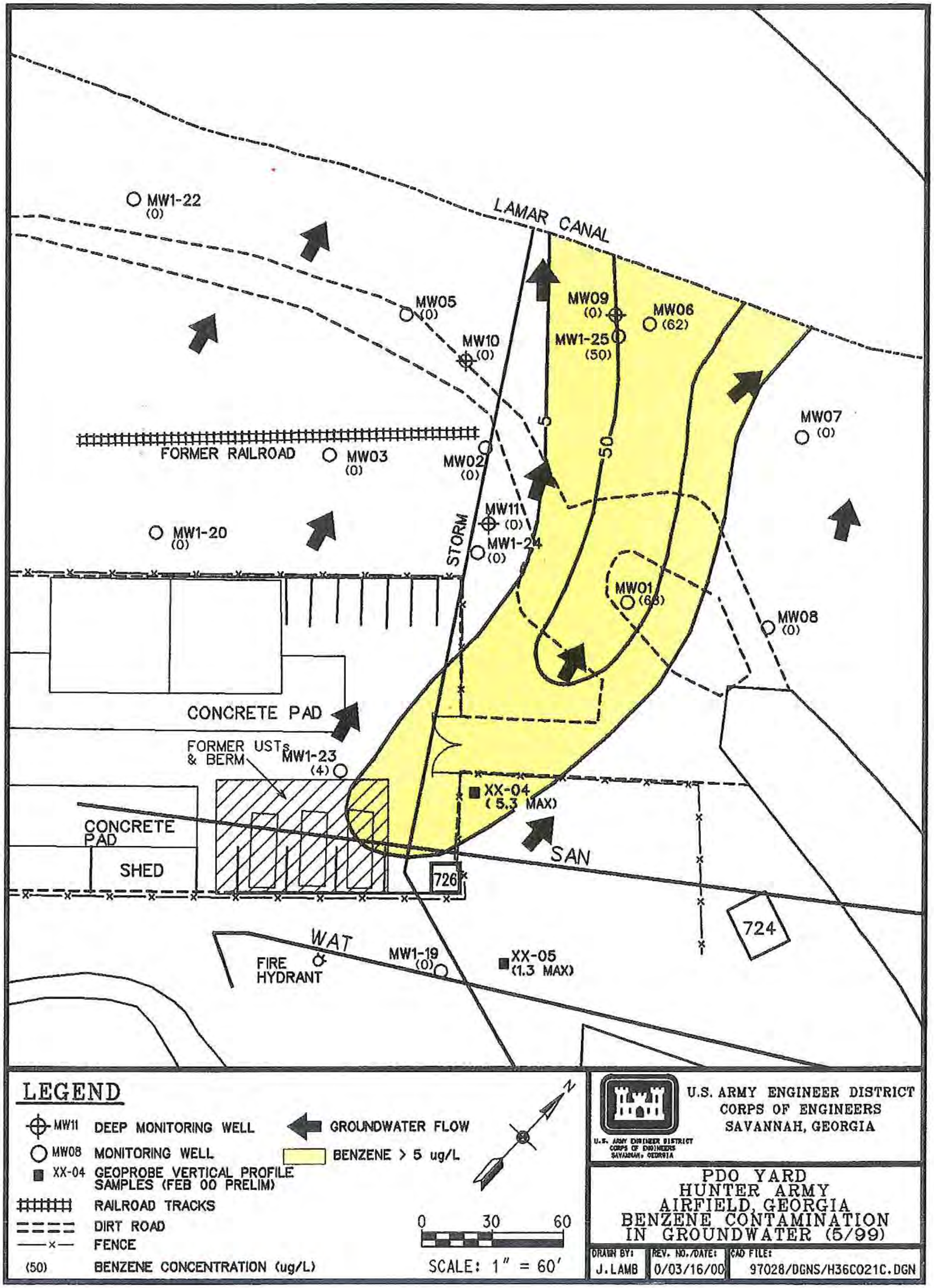


Figure 2-4. Benzene Concentrations in Groundwater at the PDO Yard (May 1999).

deep monitoring wells. Figure 2-5 depicts the extent of the PCE plume based on the most recent fourth-quarter data (May 1999).

In April 1999, groundwater samples were collected from four selected on-site wells (MW01, MW05, MW07, and MW1-19) for geochemical analysis of natural attenuation parameters. Results of those analyses (Appendix A) indicate elevated methane (564 μg/L) concentrations in well MW01, which is located within the area of highest benzene contamination at the PDO Yard. These results suggest that active biodegradation of the benzene is occurring.

In February 2000, the installation collected a series of geoprobe vertical profile samples of groundwater in conjunction with an assessment of the MCA barracks. Two geoprobe vertical profile sampling points, XX-04 and XX-05, were located in the vicinity of the PDO Yard (Figures 2-4 and 2-5). Although results of that investigation are still pending, preliminary analytical results indicate possible detections of benzene and/or PCE. Benzene was tentatively detected in XX-04 at a maximum of 5.3 μg/L at the sampling depth of 8.5 to 12.0 feet bgs but was generally undetected below 12 feet bgs to the maximum depth explored (47.0 feet bgs). Benzene was not detected in XX-05 in the shallow groundwater zone but was tentatively detected between depths of 36.5 and 50.0 feet bgs at concentrations less than 1.3 μg/L. PCE was tentatively detected in XX-04 between depths of 13.5 and 22.0 feet bgs at a maximum of 7.9 μg/L but was not detected at other depths. PCE was tentatively detected in XX-05 at a single depth interval (16.5 to 20.0 feet bgs) at a concentration of 0.88 μg/L but was not detected at other depths.

2.8.2 Supplemental Soil Sampling

Due to the fact that the areas encompassing the respective benzene and PCE plumes do not coincide and because PCE concentrations have remained relatively constant in many of the monitoring wells, the Installation elected to conduct supplemental soil sampling in November 1999 to evaluate whether a secondary source of PCE contamination is present in soil. Six soil samples were taken in the vicinity and upgradient of well MW05 (Appendix A). PCE was not detected in any of the soil samples, indicating that a secondary source of the PCE could not be found. Appendix A presents the analytical results from the November 1999 sampling event.

2.9 MODELING FOR EVALUATING CONTAMINANT NATURAL ATTENUATION

The Analytical Transient 1-, 2-, 3-Dimensional (AT123D) Model was selected for further refining the fate and transport analysis for this site. AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model. The model computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a constituent in one, two, or three dimensions in the groundwater resulting from a mass release (continuous, instant, or depleting source) over a source area (i.e., point, line, area, or volume source).

AT123D was used for modeling the fate and transport of both benzene and PCE at the PDO Yard. A steady-state AT123D model was developed by calibrating it against observed maximum concentrations of benzene in the groundwater beneath the PDO Yard and assuming the source of contamination leaching to groundwater has been removed during IR activities. Results of this modeling, shown in Figure 2-6, indicate that benzene concentrations in groundwater will degrade from the existing concentrations to levels less than the MCL of 5 μg/L at all monitoring well locations in approximately 2 years, based on a conservative benzene biodegradation half-life of 2 years. These results suggest that Monitored Natural Attenuation may be appropriate as a remedial approach for achieving the RL of 5 μg/L for benzene at the site.

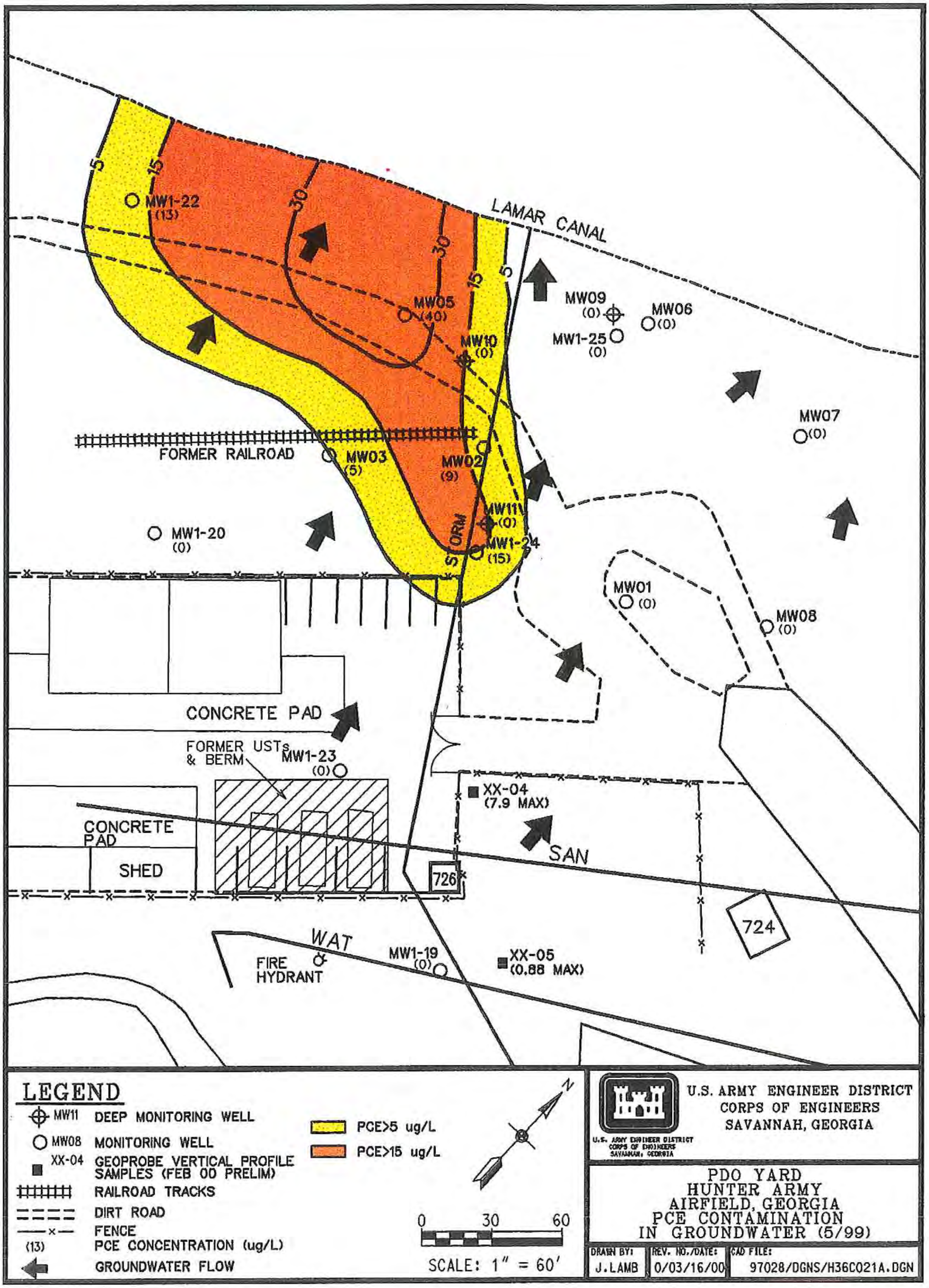
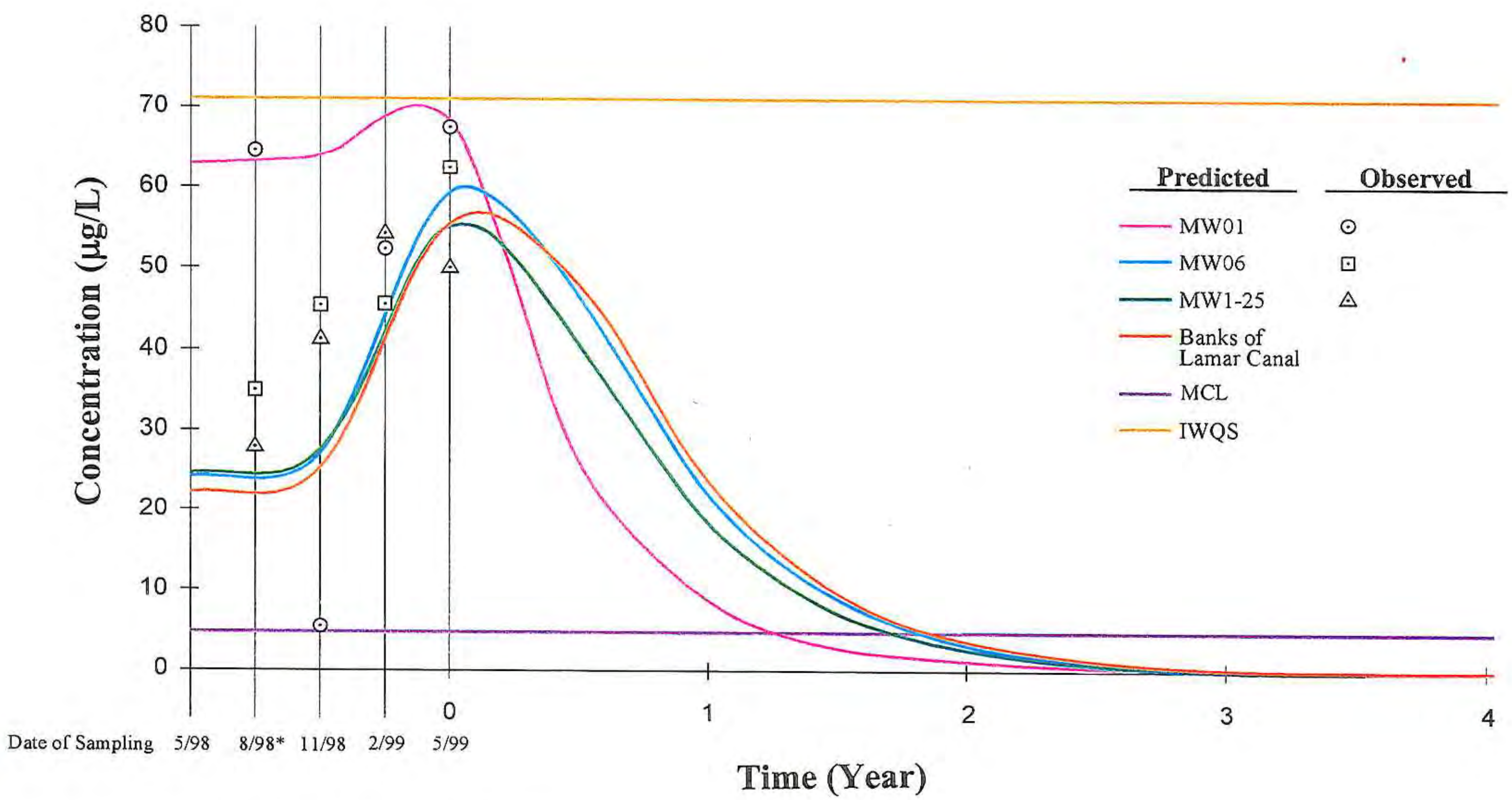


Figure 2-5. PCE Concentrations in Groundwater at the PDO Yard (May 1999).



* Source removal completed in July 1998.

Figure 2-6. Predicted Natural Attenuation of Benzene.

The AT123D model was also used to predict the degradation in PCE concentrations in groundwater over time. Because the most recent soil sampling does not indicate the presence of an existing PCE source in soil, it is assumed that the primary source has been removed, and the concentration of PCE in groundwater is expected to decline due to advection and dispersion. Biodegradation is not considered in this modeling because PCE daughter products (i.e., an evidence of biodegradation) were not detected at this site. The existing PCE plume is considered as the initial condition for natural attenuation modeling, and an approach to calibrate the PCE plume was undertaken. The results of the modeling for PCE are shown in Figure 2-7. The results indicate that the concentration of PCE in groundwater will decline to less than its MCL of 5 μg/L within the next 5 years. However, it should be noted that, if there exists a source that is continuing to leach PCE to groundwater at the same rate as was done in the past, the concentration of PCE will not decline in the near future.

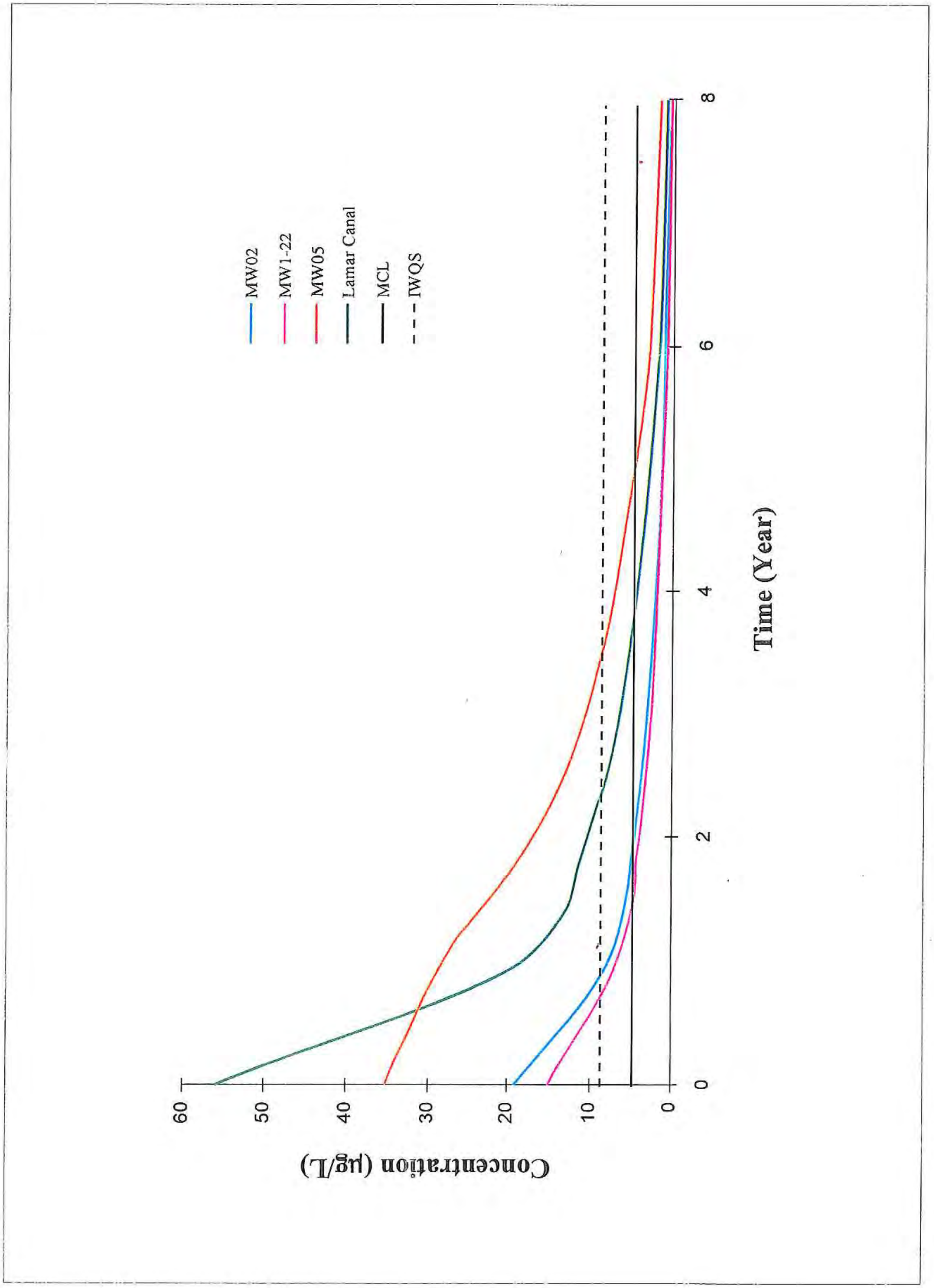


Figure 2-7. Predicted Natural Attenuation of PCE.

3.0 JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION

3.1 PURPOSE

The EPA has established corrective action standards that reflect the major technical components that should be included with a selected remedy (EPA 1994a). These include the following: (1) protect human health and the environment; (2) attain media cleanup standards set by the implementing agency; (3) control the source of the releases so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment; (4) comply with any applicable standards for management of wastes; and (5) other factors.

3.2 REMEDIAL RESPONSE OBJECTIVES

Due to the presence of benzene and PCE in groundwater at concentrations exceeding MCLs, corrective action is warranted at the PDO Yard. The remedial response objectives for the PDO Yard are to reduce concentrations of benzene and PCE in groundwater to the RLs presented in the approved Revised Final RFI Report. The selected remedy would provide the technology necessary to minimize levels of contaminants in the groundwater and to achieve the best overall results with respect to such factors as effectiveness, implementability, and cost.

3.3 IDENTIFICATION OF REMEDIAL LEVELS

Groundwater RLs for both benzene and PCE are their respective MCLs of 5 µg/L. The groundwater RLs are protective of direct exposure to hypothetical future residents by hazardous constituents in groundwater, and take into consideration both human health and technological limitations. However, it is recognized that groundwater is not used at this site as a source of drinking water and that exposure by a future resident is highly unlikely. The groundwater RLs are also lower than the respective IWQSs for benzene (71.28 µg/L) and PCE (8.85 µg/L), so that they are protective of any direct exposure to these constituents within Lamar Canal. Table 3-1 summarizes the RLs for groundwater at the PDO Yard.

Table 3-1. Remedial Levels for Groundwater, PDO Yard, Hunter Army Airfield, Georgia

Analyte	Groundwater Remedial Level (µg/L)	Maximum Observed Level in Groundwater in Most Recent Sampling (µg/L)
Benzene	5	68
Tetrachloroethene (PCE)	5	40

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 SCREENING OF CORRECTIVE ACTIONS

This section presents the identification of technologies applicable to remediation of the PDO Yard and screening of the technologies with respect to effectiveness, implementability, and cost. The technologies that are retained following screening are then combined into corrective action alternatives that address benzene and PCE contamination in groundwater. These alternatives are then evaluated with respect to time to implement and total life-cycle cost.

4.1 SCREENING CRITERIA

The first step in the development of corrective action alternatives involves the identification and screening of technologies applicable to the site. The purpose of this step is to list and evaluate the general suitability of remedial technologies for meeting the stated corrective action objectives. The technologies are evaluated for their general ability to protect human health and the environment. Technologies that pass the initial screening phase will be retained for subsequent evaluation as corrective actions.

The technologies are compared using three general criteria: effectiveness, implementability, and cost. The explanation of each criterion is described below.

4.1.1 Effectiveness

This criterion evaluates the extent to which a corrective action reduces overall risk to human health and the environment. It also considers the degree to which the action provides sufficient long-term controls and reliability to prevent exposures that exceed levels protective of human and environmental receptors. Factors considered include performance characteristics and the ability to reduce contaminant concentration.

4.1.2 Implementability

This criterion evaluates the technical and administrative factors affecting implementation of a corrective action and considers the availability of services and materials required during implementation. Technical factors assessed include ease and reliability of initiating construction and operations, prospects for implementing any additional future actions, and adequacy of monitoring systems to detect failures. Technical feasibility considers the performance history of the technologies in direct applications, or considers the expected performance for similar applications. Uncertainties associated with construction, operation, and performance monitoring are also considered.

Service and material considerations include equipment and operator availability and applicability or development requirements for prospective technologies. The availability of services and materials is addressed by considering the material components of the proposed technologies and the locations and quantities of those materials. Administrative factors include ease of obtaining permits, enforcing deed restrictions, or maintaining long-term control of the site.

Remedies that would require permitting under the Underground Injection Control (UIC) Program within the GEPD Geologic Survey Branch are identified in Tables 4-1 and 4-2.

Table 4-1. Evaluation of Corrective Actions/Technologies for Benzene

Action/ Technology	Description	Effectiveness	Implementability	Costs
No Action	The "No Action" alternative provides a baseline against which other actions can be compared. Under the "No Action" alternative, the groundwater would be left "as is," without implementing any removal, treatment, or other mitigating actions to reduce existing or potential future exposure.	This alternative would not address the remedial response objectives of the site. This alternative does not provide protection of human health or the environment because attainment of MCLs would not be confirmed.	There is no implementability involved for this alternative because no action is taken.	There would be no cost associated with the "No Action" alternative.
Institutional Controls	Technologies associated with institutional controls will reduce potential hazards by limiting exposure of humans to contaminated surface water and/or groundwater. Groundwater use restrictions would prohibit use of groundwater as a drinking water supply. Excavation permit restrictions would prohibit any construction at the site that might disturb the soil or allow contact with groundwater.	This technology alone would not meet the site objectives (i.e., RLs). Assuming compliance with groundwater use restrictions, this technology would be effective and provide reliability with respect to eliminating human exposure to contaminated groundwater within the boundaries of the site. Use of surficial groundwater at this site for drinking water is unlikely.	Very few factors limit implementability of the institutional controls. The property is not expected to be developed in the near future and will remain under Federal ownership. This alternative is readily implementable.	Low; to establish groundwater use restrictions, approximately $5,000.
Monitored Natural Attenuation	This action would require the monitoring of contaminant levels to ensure that the mass of contamination is being reduced over time in accordance with OSWER Directive 9200.4-17P. A total of 6 wells would be sampled annually for 2 years and analyzed for benzene and natural attenuation parameters (e.g., methane).	Natural attenuation of benzene constituents through biodegradation is known to be occurring at the site and would be effective. This action would require approximately 2 years to successfully meet the site objectives (i.e., RLs).	This alternative is readily implementable and would only require monitoring of a total of 6 wells at the site for approximately 2 years.	Low; monitoring of 6 wells is required for approximately 2 years.
Air Sparging	Air sparging involves injecting a gas, usually air, under pressure, into the subsurface to volatilize groundwater contaminants and to promote biodegradation by increasing subsurface oxygen concentrations. Volatilized vapors migrate into the vadose zone where they can be extracted via vacuum, generally by a soil vapor extraction system.	Technology proven for light petroleum products, such as benzene, present at the site.	Equipment readily available. Air injection system components would be operated for two or more years. Approximately nine injection wells would have to be installed. Monitoring and maintenance of the wells would be required. UIC permit would be required for injection of air.	Moderate; $20 to $50 per ton of saturated soil (EPA 1995).

Table 4-1 (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Enhanced Bioremediation (Pure Oxygen Injection)	Enhanced biodegradation is the enhancement of one aspect of natural attenuation. The activity of naturally occurring microbes is stimulated by injecting 98 percent pure oxygen to enhance in-situ biological degradation of organic contaminants. Nutrients or other additives may be used to encourage the natural biodegradation processes, as is done using the patented PHOSter II® system.	Technology proven for benzene; site geochemical conditions are aerobic, which is conducive to biodegradation of benzene.	Equipment readily available, applicable to a small site. Approximately 45 injection points would be installed. Bioremediation process may require continuous monitoring and maintenance to prevent plugging of injection wells by microbial growth or mineral precipitation. UIC permit would be required for injection of oxygen or nutrients.	Moderate; similar to air sparging based on quote from manufacturer.
Oxygen-releasing Compounds (ORC)	Use of formulations that release oxygen when they contact water to promote biodegradation.	Technology proven for treatment of fuel-related constituents, such as benzene, in groundwater.	Equipment and ORC formulation readily available. Approximately 18 injection points would be installed. Time to reach MCLs only nominally faster than natural attenuation. UIC permit would be required for injection of reagent.	High; capital costs of $50,000, with minimal O&M costs.
Geo-Cleanse®	The Geo-Cleanse® process is an aggressive, pressurized injection of concentrated hydrogen peroxide and ferrous iron catalyst (together known as Fenton's reagent) that generates a hydroxyl-free radical that acts as the active oxidizing agent. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction.	Expected to provide accelerated performance over air sparging. However, more than one application may be required to achieve RLs. Chemical oxidation would temporarily destroy the natural bioremediation processes observed at the site.	Would be compatible with any Geo-Cleanse® treatment for the adjacent PCE plume. Approximately 15 injection points would be installed. Time to reach MCLs would be a matter of days. UIC permit would be required for injection of reagent.	High; requires injection of a minimum volume of peroxide per injection point for small contaminant mass.

COC = Chemical/contaminant of concern.
EPA = U.S. Environmental Protection Agency.
MCL = Maximum contaminant level.
O&M = Operation and maintenance.
OSWER = Office of Solid Waste and Emergency Response.
PCE = Tetrachloroethene.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RL = Remedial level.
UIC = Underground Injection Control (Program).

Table 4-2. Evaluation of Corrective Actions/Technologies for PCE

Action/ Technology	Description	Effectiveness	Implementability	Costs
No Action	The "No Action" alternative provides a baseline against which other actions can be compared. Under the "No Action" alternative, the groundwater would be left "as is," without implementing any removal, treatment, or other mitigating actions to reduce existing or potential future exposure.	This alternative would not address the remedial response objectives of the site. This alternative does not provide protection of human health or the environment because attainment of MCLs would not be confirmed.	There is no implementability involved for this alternative because no action is taken.	There would be no cost associated with the "No Action" alternative.
Institutional Controls	Technologies associated with institutional controls will reduce potential hazards by limiting exposure of humans to contaminated surface water and/or groundwater. Groundwater use restrictions would prohibit use of groundwater as a drinking water supply. Excavation permit restrictions would prohibit any construction at the site that might disturb the soil or allow contact with groundwater.	This technology alone would not meet the site objectives (i.e., RLs). Assuming compliance with groundwater use restrictions, this technology would be effective and provide reliability with respect to eliminating human exposure to contaminated groundwater within the boundaries of the site. Use of surficial groundwater at this site for drinking water is unlikely.	Very few factors limit implementability of the institutional controls. The property is not expected to be developed in the near future and will remain under Federal ownership. This alternative is readily implementable.	Low; to establish deed restrictions, approximately $5,000.
Monitored Natural Attenuation	This action would require the monitoring of contaminant levels to ensure that the mass of contamination is being reduced over time in accordance with OSWER Directive 9200.4-17P. A total of 10 wells would be sampled annually for 5 years and analyzed for PCE and natural attenuation parameters (e.g., methane).	Natural attenuation of PCE through biodegradation is not occurring at the site. However, the AT123D model predicts degradation through advection and dispersion would require approximately 5 years to successfully meet the site objectives (i.e., RL).	This alternative is readily implementable; would involve installation of three new monitoring wells and monitoring of a total of 10 wells at the site for approximately 5 years.	Moderate; installation of 3 new wells and annual sampling/ monitoring of a total of 10 wells.
Air Sparging	Air sparging involves injecting a gas, usually air, under pressure, into the subsurface to volatilize groundwater contaminants. Volatilized vapors migrate into the vadose zone where they can be extracted via vacuum, generally by a soil vapor extraction system.	Technology proven for remediation of volatile organic compounds such as PCE by means of volatilization. Air sparging would not promote biodegradation of PCE.	Equipment readily available. Air injection system components would be operated for two or more years. Approximately 8 injection wells would be installed. Monitoring and maintenance of the wells would be required. UIC permit would be required for injection of air.	Moderate; $20 to $50 per ton of saturated soil (EPA 1995).

Table 4-2 (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Enhanced Bioremediation (Methane Injection)	Enhanced biodegradation is the enhancement of one aspect of natural attenuation. The activity of naturally occurring microbes is stimulated by injecting methane to enhance in-situ biological degradation of organic contaminants by methanotropic bacteria. Oxygen may be injected simultaneously to encourage the natural biodegradation of less chlorinated daughter products.	Biodegradation is not considered to be effective since conditions are naturally aerobic. Technology has been demonstrated for removal of PCE, but is not proven. Removal by volatilization alone (air sparging) would be just as effective.	Equipment available, although limited field demonstrations have been performed on this technology. Approximately 40 injection points would be installed. Time to reach MCLs only nominally faster than air sparging. UIC permit would be required for injection of methane.	High; similar to air sparging plus additional cost of methane.
Geo-Cleanse®	The Geo-Cleanse® Process is an aggressive, pressurized injection of concentrated hydrogen peroxide and ferrous iron catalyst (together known as Fenton's reagent) that generates a hydroxyl free radical that acts as the active oxidizing agent. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction.	Expected to provide accelerated performance over air sparging. Technology proven for site contaminant (PCE).	Equipment readily available. Approximately 15 injection points would be installed for hot spot treatment; 29 points for full plume treatment. Time to reach MCLs would be a matter of days UIC permit would be required for injection of reagent.	High; requires injection of a minimum volume of peroxide per injection point for small contaminant mass.

AT123D = Analytical Transient 1-, 2-, 3-Dimensional (Model).
EPA = U.S. Environmental Protection Agency.
MCL = Maximum contaminant level.
OSWER = Office of Solid Waste and Emergency Response.
PCE = Tetrachloroethene.
RL = Remedial level.
UIC = Underground Injection Control (Program).

4.1.3 Cost

Relative costs are included for each corrective action technology to facilitate evaluation and comparison among them. Detailed cost estimates are not prepared at this screening stage. Typical cost estimating contingencies have been excluded from the relative costs.

4.2 EVALUATION OF CORRECTIVE ACTION TECHNOLOGIES

Four general categories of corrective actions were identified. These include (1) no action, (2) institutional controls, (3) Monitored Natural Attenuation, and/or (4) active remediation. The technologies were separately evaluated for benzene and PCE because the plumes are not commingled and because these constituents respond differently to specific corrective action technologies.

4.2.1 Technologies for Benzene

In addition to no action, institutional controls, and Monitored Natural Attenuation, various corrective action technologies were identified for active remediation of benzene in groundwater, including air sparging and enhanced bioremediation (pure oxygen injection). The corrective action technologies for benzene are described in Table 4-1. The technologies were evaluated using the screening criteria of effectiveness, implementability, and cost. Results of that screening evaluation are also shown on Table 4-1.

The "No Action" alternative was not considered to be viable due to the need to ensure that benzene concentrations reach the MCL. Institutional controls were not considered further as the sole remedial alternative since they are appropriate for this site only when combined with other technologies, such as Monitored Natural Attenuation. Pump-and-treat technologies have not been retained because of their relatively high cost and time to achieve RLs. The remaining technologies were retained for further evaluation. These include Monitored Natural Attenuation, air sparging, and enhanced bioremediation using pure oxygen injection.

4.2.2 Technologies for PCE

In addition to no action, institutional controls, and Monitored Natural Attenuation, various corrective action technologies were identified for active remediation of PCE in groundwater, including air sparging, enhanced bioremediation (methane injection), and chemical oxidation (Geo-Cleanse®).

The corrective action technologies are described in Table 4-2. The technologies were evaluated using the screening criteria of effectiveness, implementability, and cost. Results of that screening evaluation are also shown on Table 4-2.

The "No Action" alternative was not considered to be viable due to the need to ensure that PCE concentrations reach the MCL. Institutional controls were not considered further as the sole remedial alternative since they are appropriate for this site only when combined with other technologies, such as Monitored Natural Attenuation. Passive treatment systems, such as permeable treatment walls using zero valence iron, have not been retained because of their high capital cost for such low levels of contamination and because passive systems would only prevent migration rather than aquifer restoration to below the MCL. The remaining technologies were retained for further evaluation. These include Monitored Natural Attenuation, air sparging, and Geo-Cleanse®. Because PCE adsorbs more readily than benzene to soils and because the vadose zone is at least 6 feet deep at this site, soil vapor extraction was considered applicable as an auxiliary technology for use in conjunction with air sparging.

Because PCE daughter products (i.e., evidence of biodegradation) have not been detected in past sampling events at the site, natural attenuation of PCE at the PDO Yard may not be effective. However, Monitored Natural Attenuation has been retained for PCE because (1) no continuing source of PCE has been found in soil at the site, and (2) results of fate and transport modeling have shown that PCE concentrations may decline to less than the MCL in as little as 5 years through advection and dispersion, disregarding any effect of biodegradation.

4.3 CORRECTIVE ACTION ALTERNATIVES

The technologies retained following the screening step were used in various combinations to meet the remedial response objectives for groundwater. Three alternatives were identified for remediation of the benzene plume, and four alternatives were identified for remediation of the PCE plume.

4.3.1 Alternatives for Benzene

Three alternatives were identified, and subsequently evaluated, that included the following:

- Alternative 1: Monitored Natural Attenuation,
- Alternative 2: Air Sparging, and
- Alternative 3: Enhanced Bioremediation.

4.3.2 Alternatives for PCE

Four alternatives were identified, and subsequently evaluated, that included the following:

- Alternative 1: Monitored Natural Attenuation,
- Alternative 2: Air Sparging,
- Alternative 3: Geo-Cleanse® with Monitored Natural Attenuation, and
- Alternative 4: Geo-Cleanse® Full Plume Treatment.

4.3.3 Evaluation Factors

Based on the results of the technology screening, each of the retained technologies is considered applicable to the site, cost-effective, and implementable. Therefore, two primary evaluation factors were used in the selection of the preferred corrective action alternative: time to implement and life-cycle cost.

Time to Implement

Time to implement the action is an important evaluation factor for this site. Preferably, the site would be remediated to meet RLs for groundwater in the shortest possible time. For each alternative, an estimate was made of the duration of any active remediation system, or the duration of any natural attenuation period. For all alternatives, confirmatory groundwater sampling would be performed following the remediation/attenuation period to verify that RLs in groundwater have been met.

Life-Cycle Cost

The life-cycle cost estimates are budget estimates based on conceptual design and are to be used for comparison purposes. Costs are estimated for capital construction and for O&M. Cost estimates are derived from current information including vendor quotes, conventional cost estimating guides (e.g., Means 1996 and ECHOS 1999), and costs associated with similar projects. The actual costs of the project would depend on labor and material costs, site conditions, competitive market conditions, final project scope, and implementation schedule at the time that the corrective action is initiated. The life-cycle cost estimates are not adjusted to present worth costs, and no escalation factors have been applied. Appendix C presents the estimated life-cycle costs for each alternative.

4.3.4 Evaluation of Corrective Action Alternatives for Benzene

The three corrective action alternatives for benzene are summarized in Table 4-3 with the associated time to reach RLs and associated life-cycle costs. All of the alternatives would include the following common features:

- monitoring of benzene to track the effectiveness of the corrective action. The existing monitoring well network provides suitable coverage for monitoring lateral and vertical conditions within the benzene plume. The existing wells associated with monitoring of the benzene plume include seven shallow wells (MW01, MW02, MW06, MW07, MW08, MW1-23, and MW1-25) and one deep well (MW09).
- post-remediation confirmatory groundwater sampling to verify that the groundwater RL for benzene has been achieved and maintained.

The following paragraphs summarize the evaluation of the three corrective action alternatives for the benzene plume with respect to the primary evaluation factors of time to implement and life-cycle cost:

Alternative 1: Monitored Natural Attenuation

Monitored Natural Attenuation would involve semiannual monitoring of seven shallow wells and one deep well at the site for approximately 2 years. During that time, benzene concentrations in groundwater are predicted to decline below the 5 μg/L MCL for benzene at all monitoring well locations. After 6 months following this Monitored Natural Attenuation period, confirmation groundwater sampling would be conducted to verify that the RL for benzene has been met and maintained. This is the least expensive alternative with a life-cycle cost of approximately $100,000 but is the longest to implement, at 30 months (2.5 years).

Alternative 2: Air Sparging

In groundwater, approximately nine air sparging wells would be installed to treat the benzene-contaminated groundwater. Treatment would continue until the concentration of benzene has declined to a level below its MCL of 5 μg/L, estimated to require approximately 12 months. Monitoring would include monthly sampling of the eight existing monitoring wells to verify that treatment is progressing. This active treatment period would be followed by confirmation groundwater sampling (once after 6 months) to verify that the RL for benzene has been met and maintained. The total time to implement would, therefore, be approximately 18 months (1.5 years). This alternative is more expensive than Monitored Natural Attenuation with life-cycle costs estimated at approximately $340,000.

Alternative 3: Enhanced Bioremediation (Pure Oxygen Injection)

Approximately 45 oxygen injection points would be installed to treat the benzene-contaminated groundwater. Treatment would consist of enhanced bioremediation using 98 percent pure oxygen injection and would continue until the concentration of benzene has declined to a level below its MCL of 5 μg/L, estimated to require approximately 4 months. Monitoring would include monthly sampling of the eight existing

Table 4-3. Corrective Action Alternatives, Implementation Time, and Costs for Benzene Remediation

Corrective Action	Description	Time to Implement	Cost	Comments
Alternative 1. Monitored Natural Attenuation	The action would require the monitoring of contaminant levels to ensure the reduction of these levels through biodegradation and dispersion.	The estimated time to reach the RL of 5 µg/L in groundwater is approximately 2 years.	Approximately $100,000 (semiannual monitoring of 8 wells during attenuation period, confirmatory sampling after 6 months).	Least expensive, yet longer time to implement.
Alternative 2. Air Sparging	Air sparging of groundwater to 5 µg/L. Treatment using 9 injection wells operated at 10 scfm each (90 scfm total).	Air sparging treatment would require approximately 12 months to reduce benzene to 5 µg/L.	Approximately $340,000 (monthly monitoring of 8 wells during treatment, treatment with nine injection wells, confirmatory sampling after 6 months).	More costly than Alternative 1.
Alternative 3. Enhanced Bioremediation	Enhanced bioremediation of groundwater to 5 µg/L. Treatment using 45 injection points operated at 0.7 scfm each (32 scfm total).	Oxygen injection treatment would require approximately 4 months to reduce benzene to 5 µg/L.	Approximately $329,000 (monthly monitoring of 8 wells during treatment, treatment with 45 injection points, confirmatory sampling after 6 months).	More costly than Alternatives 1 and 2, yet shortest time to implement.

RL = Remedial level.
scfm = Standard cubic feet per minute.

monitoring wells to verify that treatment is progressing. This active treatment period would be followed by confirmation groundwater sampling (once after 6 months) to verify that the RL for benzene has been met and maintained. This alternative is approximately the same cost as Alternative 2, with life-cycle costs estimated at approximately $329,000. Implementation time (approximately 10 months) is the least of any of the three alternatives.

4.3.5 Evaluation of Corrective Action Alternatives for PCE

The four corrective action alternatives for remediating PCE-contaminated groundwater are summarized in Table 4-4 with the associated time to reach RLs and associated life-cycle costs.

All of the alternatives would include the following common features:

- Monitoring of PCE to track the effectiveness of the corrective action. The existing wells associated with monitoring of the PCE plume include five shallow wells (MW02, MW03, MW05, MW1-22, and MW1-24) and two deep wells (MW10 and MW11).

- Installation of three additional monitoring wells, two shallow and one deep, in the center of the groundwater plume to augment the existing PCE monitoring well network of five shallow wells and two deep wells.

- Post-remediation confirmatory groundwater sampling to verify that the groundwater RL for PCE has been achieved and maintained.

The following paragraphs summarize the evaluation of the three corrective action alternatives with respect to the primary evaluation factors of time to implement and life-cycle cost:

Alternative 1: Monitored Natural Attenuation

Monitored Natural Attenuation would involve long-term, semi-annual monitoring of seven shallow wells and three deep wells at the site for approximately 5 years. During that time, PCE concentrations in groundwater are predicted to decline below the 5 µg/L MCL as a result of advection and dispersion. However, it should be noted that, if there exists a source of contamination in soil that continues to leach PCE to groundwater, the concentration of PCE would not be expected to decline at the predicted rate. Semi-annual sampling will be conducted during this attenuation period. This Monitored Natural Attenuation period would be followed by confirmation groundwater sampling 6 months later to verify that the RL for PCE has been met and maintained. This is the least expensive alternative with a life-cycle cost of approximately $283,000, but it is also the longest to implement, at 5.5 years, and there is greater uncertainty as to the rate of attenuation.

Alternative 2: Air Sparging

In groundwater, approximately eight air-sparging wells would be installed to treat the contaminated groundwater. The air sparging wells would be coupled with soil vapor extraction (SVE) wells that would be used to remove the vapor-phase PCE from the vadose zone immediately above the water table. The SVE off-gas would be treated, if required to meet air quality regulations, using vapor phase carbon adsorption. Treatment would continue until the concentration of PCE has declined to a level below its MCL of 5 µg/L, estimated to require approximately 12 months. Monitoring would include monthly sampling of the 10 PCE plume wells to verify that treatment is progressing. This active treatment period would be followed by confirmation groundwater sampling 6 months later to verify that the RL for PCE

Table 4-4. Corrective Action Alternatives, Implementation Time, and Costs for PCE Remediation

Corrective Action	Description	Time to Implement	Cost	Comments
Alternative 1. Monitored Natural Attenuation	The action would require the monitoring of contaminant levels to ensure the reduction of these levels through advection and dispersion.	The estimated time to reach the RL of 5 µg/L in groundwater is approximately 5 years.	Approximately $283,000 (installation of 3 monitoring wells, semiannual monitoring of a total of 10 wells during attenuation period, and confirmatory sampling after 6 months).	Least expensive, but longest implementation time.
Alternative 2. Air Sparging	Air sparging of groundwater to the MCL of 5 µg/L. Treatment using 8 injection wells operated at 10 scfm each (80 scfm total).	Air sparging treatment would require approximately 12 months to reduce the maximum concentration of PCE from 40 µg/L to 5 µg/L.	Approximately $503,000 (installation of 3 monitoring wells, monthly monitoring of a total of 10 wells during treatment, treatment with 8 injection wells, and confirmatory sampling after 6 months).	Moderately expensive to implement and moderately short time frame.
Alternative 3. Geo-Cleanse® with Monitored Natural Attenuation	Injection of Fenton's reagent in the plume "hot spot," followed by natural attenuation of residual contamination in groundwater. Treatment using 15 injection points and injecting 3,000 lbs of reagent in each (45,000 lbs total).	Injection of Fenton's reagent would require a few days to decrease the PCE contamination to levels below 15 µg/L. The estimated time for subsequent natural attenuation to reach the RL of 5 µg/L in groundwater is approximately 2 years.	$459,000 (installation of a minimum 3 monitoring wells, treatment with 15 injection wells, semi-annual monitoring of a total of 10 wells during natural attenuation period, and confirmatory sampling after 6 months).	Moderately expensive to implement and moderately short time frame.
Alternative 4. Geo-Cleanse® Full Plume Treatment	Injection of Fenton's reagent in the full plume. Treatment using 29 injection points and injecting 3,000 lbs of reagent in each (87,000 lbs total).	Injection of Fenton's reagent would require about 2 weeks to decrease PCE concentrations to below 5 µg/L over the full plume area.	$626,000 (installation of 3 monitoring wells, treatment with 29 injection wells, and confirmatory sampling after 6 months).	Most expensive alternative to implement, yet shortest time frame and less uncertainty.

MCL = Maximum contaminant level.
PCE = tetrachloroethene.
RL = Remedial level.
scfm = Standard cubic feet per minute.

has been met and maintained. The total time to implement would, therefore, be approximately 18 months (1.5 years). This alternative is moderately expensive, with life-cycle costs estimated at approximately $503,000.

Alternative 3: Geo-Cleanse® with Monitored Natural Attenuation

Approximately 15 Geo-Cleanse® injection points would be installed within the groundwater "hot spot." The actual number will depend on analytical results from baseline groundwater sampling. Peroxide injection and treatment would be completed in approximately 7 days to decrease the PCE contamination levels from 40 μg/L to below 15 μg/L. The area to be treated would be approximately 135 feet by 30 feet; therefore, PCE concentrations in groundwater outside of the area to be treated could remain as high as 15 μg/L. For this reason, Monitored Natural Attenuation with semiannual groundwater sampling would be provided for approximately 2 years following active treatment to verify that PCE concentrations in groundwater continue to decline to below 5 μg/L in all PCE plume wells. As with the other alternatives, confirmation groundwater sampling would be conducted 6 months later to verify that the RL for PCE has been met and maintained. The estimated life-cycle cost for this alternative, $459,000, is less than Alternative 2, and the alternative would require approximately 2.5 years to implement.

Alternative 4: Geo-Cleanse® Full Plume Treatment

This alternative is similar to Alternative 3, except that the Geo-Cleanse® treatment would be applied across the full extent of the PCE plume rather than within the plume "hot spot." Peroxide injection and treatment would decrease the PCE contamination to below 5 μg/L throughout the plume using approximately 29 Geo-Cleanse® injection points. The actual number will depend on analytical results from baseline groundwater sampling. Treatment would be complete in less than 2 weeks. Confirmation groundwater sampling would be conducted 6 months later to verify that the RL for PCE has been met and maintained. The estimated life-cycle cost for this alternative is the highest of any alternative ($626,000); however, implementation would be complete within just 6 months.

5.0 CONCEPTUAL DESIGN AND IMPLEMENTATION PLAN

This section presents a conceptual design and plan for implementation of the selected corrective action alternative. Based on the available groundwater data and modeling results, a cost-effective corrective action was selected that would reduce the COCs in groundwater to the required RLs. The technology evaluation presented in Section 4.0 evaluated three different corrective action alternatives for the benzene plume and three for the PCE plume, based on the time needed to implement them and their life-cycle cost. Based on that evaluation, Alternative 1, Monitored Natural Attenuation, was selected for the benzene plume and Alternative 4, Geo-Cleanse® Full Plume Treatment, was selected for the PCE plume due to their short implementation times and cost-effectiveness.

5.1 SELECTED CORRECTIVE ACTION

The selected corrective action alternative for the benzene plume involves Monitored Natural Attenuation. The selected corrective action alternative for PCE involves Geo-Cleanse® chemical oxidation for treatment of the full plume.

5.1.1 Justification for Selection of Corrective Action for Benzene Plume

Monitored Natural Attenuation has been selected for remediation of benzene in groundwater because it will effectively achieve the RL for benzene in a reasonable period of time and at a low cost. Monitored Natural Attenuation is expected to achieve the RL in as little as 2 years. Other corrective action alternatives, such as air sparging or pure oxygen injection, might provide a higher degree of reliability and less uncertainty in their effectiveness than Monitored Natural Attenuation; however, they would cost substantially more and require only a slightly shorter time to achieve the RL.

Monitored Natural Attenuation is appropriate for addressing benzene in groundwater at the PDO Yard as a follow-up to active remedial measures that have already been implemented to excavate and remove the source of contamination in soil. Appendix E lists considerations for the selection of Monitored Natural Attenuation for the benzene plume, following the guidance of OSWER Directive 9200.4-17P (EPA 1999).

Justification for the selection of this corrective action alternative is detailed in the following evaluations of effectiveness, implementability, and cost.

Effectiveness. The selected corrective action will be effective in protecting human health and the environment. Based on the conclusions of the RFI, there is no current human health or ecological risk associated with benzene at the PDO Yard. Potential exposure is extremely unlikely because the shallow groundwater is not a viable source of drinking water in the HAAF area. The selected alternative will achieve the RL within a relatively short time frame (2 years), thereby effectively eliminating any potential future risk. The selected alternative will not require long-term O&M beyond the 2-year monitoring period and 6-month confirmatory sampling period; it, therefore, provides long-term reliability. Short-term risks to human health or the environment are minimal because attenuation occurs in-situ. There are no air emissions or surface water discharges associated with the selected corrective action. Potential exposure by remediation workers to contaminants is limited. Minimal exposure could result during sampling events; any exposure will be minimized and maintained below acceptable levels with the use of proper protective clothing and strict adherence to the project health and safety plan.

The time required to achieve RLs has been estimated using benzene as the primary COC and assuming a degradation half-life of 730 days. In groundwater, the time required to degrade benzene from a maximum of 68 μg/L to its MCL of 5 μg/L has been estimated to require 2 years (refer to Appendix B).

Implementability. The selected corrective action can be readily implemented. The RL for benzene will be achieved in a relatively short period of time (within 2 years). The selected corrective action utilizes monitoring of benzene concentrations to ensure that the RL for the site is being met. The project implementation schedule is presented in detail in the conceptual design later in this section (Figure 5-3).

Cost. The estimated total life-cycle cost of operation, maintenance, and confirmatory sampling for the selected corrective action is $100,000. Monitored Natural Attenuation is the least expensive alternative and will require 2 years to achieve the RL. Costs estimated for the other corrective action alternatives were much higher than the selected Monitored Natural Attenuation, ranging from $329,000 to $340,000.

5.1.2 Justification for Selection of Corrective Action for PCE Plume

Chemical oxidation using the patented Geo-Cleanse® process has been selected for remediation of PCE in groundwater because it will effectively achieve the RL in the shortest period of time and with less uncertainty. Although Monitored Natural Attenuation would be much less costly, the RL would not be expected to be achieved in groundwater for nearly 5 years using natural attenuation alone. Furthermore, the effectiveness of Monitored Natural Attenuation is much less certain because any unidentified source of PCE contamination in soil could continue to leach PCE to groundwater, and because concentrations of PCE in the groundwater adjacent to Lamar Canal could exceed the IWQS.

Alternative 3, Geo-Cleanse® treatment of the PCE plume "hot spot" followed by Monitored Natural Attenuation would be less costly; however, the effectiveness of the Monitored Natural Attenuation component of Alternative 3 is much less certain than treating the full PCE plume. Geo-Cleanse® treatment is expected to achieve PCE concentrations of less than 5 μg/L in as little as 2 weeks. If the results of baseline groundwater monitoring conducted prior to the Geo-Cleanse® treatment within the PCE plume indicate that PCE concentrations are already less than 5 μg/L, then Geo-Cleanse® treatment will not be necessary for those areas of the site. Justification for selection of this corrective action alternative is detailed in the following evaluations of effectiveness, implementability, and cost.

Effectiveness. The selected corrective action will be effective in protecting human health and the environment. Based on the conclusions of the RFI, there is no current human health or ecological risk associated with PCE at the PDO Yard. The selected alternative will achieve the RL within a relatively short time frame (2 weeks), thereby effectively eliminating any potential future risk. The selected alternative will not require long-term O&M beyond the 6-month confirmatory sampling period; it, therefore, provides long-term reliability and no need for replacement of system components. Short-term risks to human health or the environment are minimal because treatment occurs in-situ, although remediation will entail handling of a large volume of hydrogen peroxide reagent. There are no air emissions or surface water discharges associated with the selected corrective action. Potential exposure by remediation workers to contaminants is limited. Minimal exposure could result during monitoring or injection well installation; any exposure will be minimized and maintained below acceptable levels with the use of proper protective clothing, monitoring of airborne VOCs in the breathing zone, and strict adherence to the project health and safety plan.

The Geo-Cleanse® system has been shown to be effective for remediation of groundwater contaminated with PCE and other aliphatic chlorinated hydrocarbons. The system has been implemented successfully by Fort Stewart for aromatic hydrocarbons in a pilot test conducted at the Wright Army Airfield in September 1998.

The selected corrective action will be effective in controlling contaminant migration. The shallow groundwater plume will be treated in-situ using the Geo-Cleanse® injection system to remediate the plume to below 5 μg/L. The Geo-Cleanse® process provides complete oxidation of the contaminants, and typical degradation (daughter) products of PCE (i.e., vinyl chloride and dichloroethylene) are not created during and/or after treatment. The Geo-Cleanse® system is considered more reliable than either Monitored Natural Attenuation alone or "hot spot" treatment followed by Monitored Natural Attenuation. Geo-Cleanse® treatment is much quicker to achieve the RL than air sparging. Contingent actions, including a second application of Geo-Cleanse® reagent as a polishing step, are identified in the O&M Plan (Appendix D) to ensure that the RL will be met.

Implementability. The selected corrective action can be readily implemented. Construction involves conventional drilling techniques for which numerous qualified construction contractors and equipment are readily available. Injection of hydrogen peroxide will be overseen by a specialty vendor (Geo-Cleanse® International, Inc.) who has specific experience and qualifications for remediation using their patented process. The action will comply with RCRA waste management standards for sampling of any contaminated soil excavated during drilling and off-site disposal at a permitted landfill. The action will require that a UIC permit be obtained from GEPD, prior to operation, for injection of hydrogen peroxide for groundwater remediation. The action will also require that a construction permit be obtained from the Installation prior to any below-ground drilling.

The implementation schedule allows for initiating and completing the remedial activities within a reasonable period of time. The RL will be achieved in the shortest period of time of any of the corrective action alternatives (2 weeks). The selected corrective action utilizes a relatively new, yet successfully demonstrated, technology to accelerate remediation.

Cost. The estimated total life-cycle cost of construction, operation, maintenance, and confirmatory sampling for the selected corrective action is $626,000. Monitored Natural Attenuation is much less expensive ($283,000), but would require 5 years to achieve the RL and with much greater uncertainty. The significant savings in implementation schedule and greater reliability in achieving the RL using the Geo-Cleanse® system justify the higher life-cycle cost of the selected system.

5.2 CONCEPTUAL DESIGN

The conceptual design and cost estimate presented in this section for the PDO Yard are based on the subsurface stratigraphy information presented on the drilling logs, the most recent contaminant chemistry for the soil and groundwater, and past experience with similar remediation systems.

5.2.1 Monitored Natural Attenuation for Benzene

Groundwater Monitoring. The conceptual design includes semiannual monitoring of seven shallow wells (MW01, MW02, MW06, MW07, MW08, MW1-23, and MW1-25) and one deep well (MW09) in the benzene plume area (Figure 5-1).

Baseline groundwater sampling will be conducted prior to the start of the Monitored Natural Attenuation period. The eight groundwater monitoring wells will be sampled and analyzed for benzene and natural attenuation parameters. If results of this baseline sampling indicate that benzene concentrations are less than 5 μg/L, then Monitored Natural Attenuation will not be necessary for this area of the site, and remediation may proceed directly to the confirmatory sampling event 6 months later. GEPD will be advised via e-mail and/or facsimile on the analytical results of the baseline groundwater sampling. Any

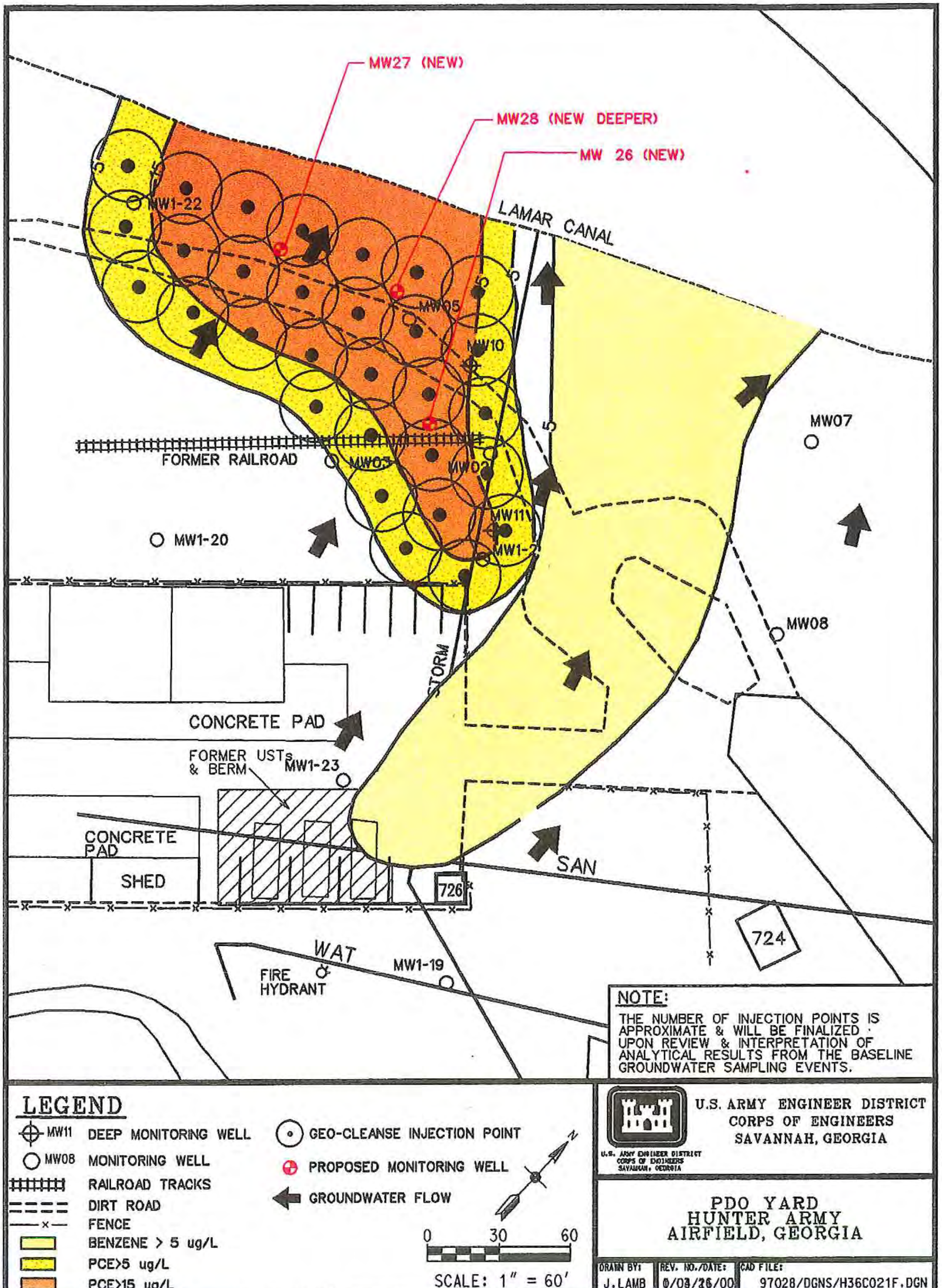


Figure 5-1. PDO Yard Conceptual Design and Monitoring Well Layout.

revisions to the recommendations in this CAP will be summarized in the first semiannual progress report for the Monitored Natural Attenuation.

During the Monitored Natural Attenuation period, the eight groundwater monitoring wells will be sampled on a semiannual basis to verify that benzene concentrations are declining and that active biodegradation is occurring. Samples will be analyzed at an off-site laboratory for benzene and for natural attenuation parameters (methane, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron). Field measurements will be made of dissolved oxygen (DO), temperature, oxidation-reduction potential (Eh), conductivity, pH, and ferrous iron. Based upon the results of groundwater modeling, the Monitored Natural Attenuation period is predicted to be 2 years in duration.

Completion Criteria. Monitored Natural Attenuation will be ceased upon attaining a maximum benzene concentration in groundwater in each of the wells of 5 μg/L, as measured during the semiannual groundwater monitoring event. Confirmation groundwater sampling will be conducted at the end of the Monitored Natural Attenuation period to verify that the groundwater RL for benzene has been achieved and maintained. Groundwater will be sampled once, 6 months following completion of Monitored Natural Attenuation. Samples will be collected from each of the eight wells and analyzed for benzene.

5.2.2 Chemical Oxidation Treatment for PCE

The Geo-Cleanse® groundwater treatment system conceptual design is based on initial estimates provided by the system vendor. Figure 5-1 indicates the location of the PCE groundwater plume that requires corrective action and the conceptual design layout. Figure 5-2 is a process flow schematic and shows the conceptual design components of the Geo-Cleanse® system.

Geo-Cleanse® Conceptual Design Layout. The contaminated groundwater plume extends over an irregularly shaped area about 200 feet wide by 100 feet long. The depth of the groundwater contamination is limited predominantly to the upper 20 feet of the shallow aquifer zone; no PCE has been detected in any deep well at the site in any previous sampling event. The conceptual design includes the installation of approximately 29 injectors located as shown on Figure 5-1. The actual number of injector points will depend on the analytical results of the baseline groundwater sampling event. Previous experience by the vendor has indicated that a radius of influence of 15 feet is reasonable in silty sands similar to those at the site.

The Geo-Cleanse® system will chemically oxidize the groundwater by injection of Fenton's reagent (hydrogen peroxide and a ferrous iron catalyst) into the subsurface at 2 separate injection levels (10 feet and 20 feet below land surface). Because of the low concentrations and small mass of PCE reported in groundwater at the PDO Yard, the amount of 50% hydrogen peroxide required for groundwater treatment is not stoichiometrically controlled. Less than 26 pounds of hydrogen peroxide would be needed to treat the estimated 6 pounds of total chlorinated hydrocarbons at the site. However, experience has shown that a minimum of 3,000 pounds of hydrogen peroxide is needed at each injector for effective treatment. Therefore, the conceptual design includes the injection of a total of 87,000 pounds of hydrogen peroxide.

Operational Life Model. At a reagent injection rate of 7,000 pounds per day, treatment will be completed in less than 14 days, including site preparation and demobilization. Based on previous case studies in treatment of PCE-contaminated groundwater, Geo-Cleanse® chemical oxidation is expected to result in at least a 90 percent reduction in PCE concentrations. Given a maximum of 40 μg/L PCE concentration in the most recent groundwater sampling at the site, treatment using a single application of hydrogen peroxide reagent is expected to be reliable in achieving a residual PCE concentration of less than 5 μg/L. In addition, contingent actions (including a second application as a polishing step) are identified in the O&M Plan (Appendix D) to ensure that treatment objectives will be met.

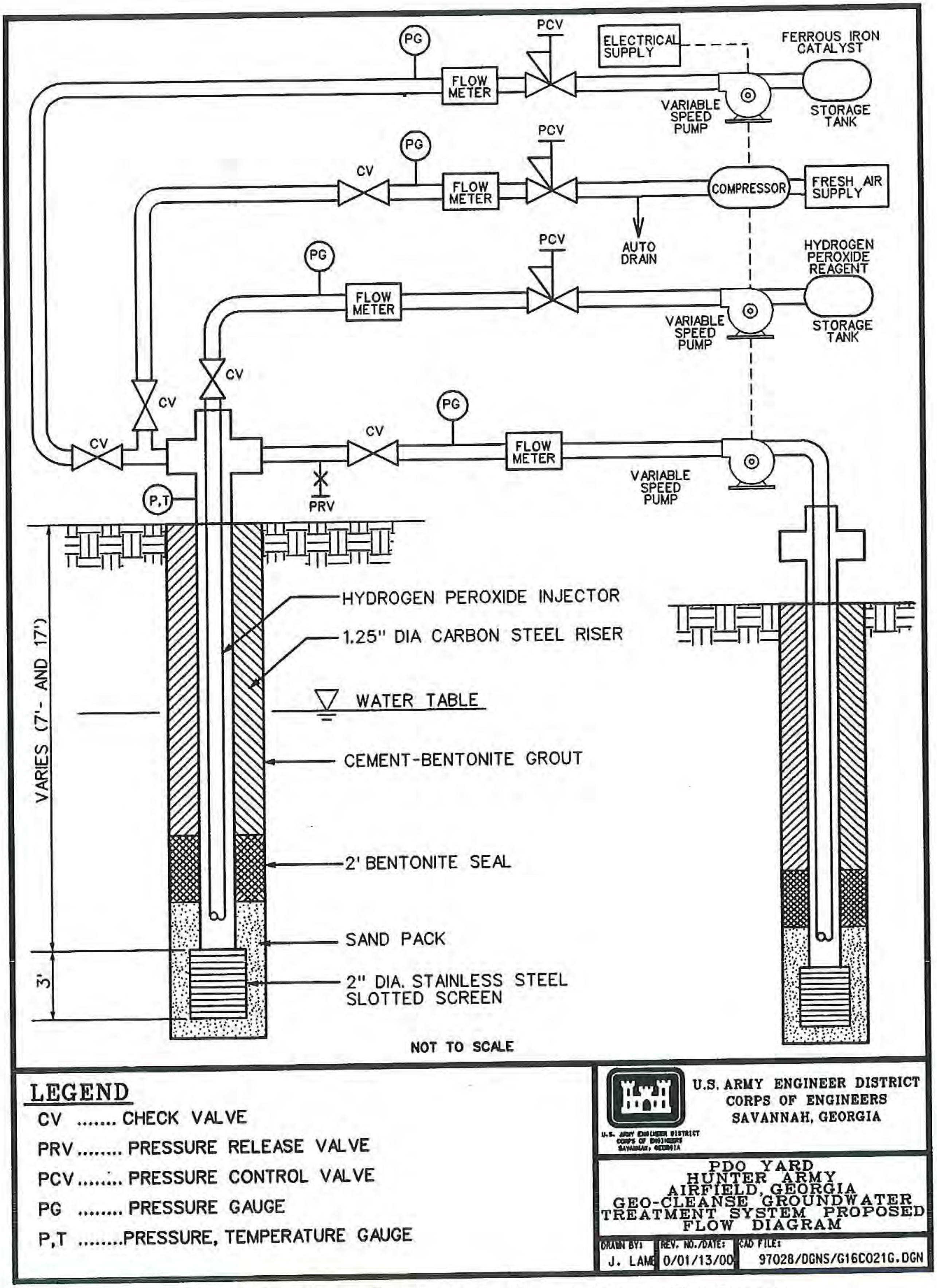


Figure 5-2. Geo-Cleanse® Groundwater Treatment Process Flow Diagram.

Operation and Maintenance. The Geo-Cleanse® hydrogen peroxide injection system is simple to implement. The patented injectors are specially designed to withstand the elevated temperatures and pressures associated with chemical oxidation during the Geo-Cleanse® process. The vendor provides the screens, riser pipe, and other fittings. A conventional drilling company is used to install the injectors, with oversight provided by the vendor.

The proprietary treatment unit is a trailer containing the equipment necessary to inject hydrogen peroxide and catalyst into the subsurface. Patented mixing heads are attached to the injectors and connected via supply lines to the treatment unit. Once the initial injection begins, ferrous iron catalyst is injected simultaneously with the hydrogen peroxide to maintain the appropriate chemical environment. Typical delivery rates are 0.2 to 5.0 gallons/minute with pressures averaging 20 to 40 pounds per square inch. Reaction progress and efficiency are monitored in a number of ways. Carbon dioxide and oxygen outgassing from adjacent monitoring wells provide a sensitive measure of reaction progress. Carbon dioxide is a product of the oxidation of the carbon bonds of the organic contaminant, and outgassing increases rapidly during the initial stages of injection. As injection proceeds and the remaining contaminant mass is reduced, carbon dioxide production stabilizes and then begins to decrease. The decrease in carbon dioxide outgassing is accompanied by an increase in oxygen outgassing. The oxygen is a product of hydrogen peroxide decomposition in the absence of organic contaminants. Chloride ion concentration in groundwater is another measure of reaction progress. Chloride ion is an oxidation product of chlorinated hydrocarbons; thus, an increase in the groundwater chloride concentration is observed as the chlorinated hydrocarbons are oxidized. Hydrogen peroxide injection is discontinued once these field measures become stabilized.

Groundwater Monitoring. The conceptual design includes the installation of three additional monitoring wells (two shallow and one deep) to augment the existing monitoring network of five shallow wells (MW02, MW03, MW05, MW1-22, and MW1-24) and two deep wells (MW10 and MW11). The proposed wells (MW26, MW27, and MW28) will be located, as shown on Figure 5-2, in the middle of the contamination plume where PCE concentrations in groundwater samples taken during the RFI were highest. The shallow wells (MW26 and MW27) will be screened to bisect the water table, for a total depth of less than 20 feet. The deep well (MW28) will be screened between a depth of 35 and 45 feet below land surface. Monitoring wells will be constructed using carbon steel casing and stainless steel screen to withstand high temperatures during Geo-Cleanse® treatment. The cost estimate also includes costs for replacement of the existing wells with steel casing and stainless steel screen in case the existing PVC wells become damaged during Geo-Cleanse® treatment. The monitoring wells will be used to more accurately observe the reduction in PCE concentrations following chemical oxidation treatment and to verify the effectiveness of treatment after remedial activities are completed.

Baseline groundwater sampling will be conducted prior to Geo-Cleanse® treatment. The 10 groundwater monitoring wells will be sampled and analyzed for PCE. If results of this baseline monitoring indicate that PCE concentrations are less than 5 μg/L, then Geo-Cleanse® treatment will not be necessary for this area of the site. GEPD will be advised via email and/or facsimile on the analytical results of the baseline groundwater sampling. Any revisions to the recommendations in this CAP will be summarized in the Geo-Cleanse® treatment completion report.

Following chemical oxidation treatment, the 10 groundwater monitoring wells will be sampled to verify that PCE concentrations have declined to less than 5 μg/L.

Groundwater Treatment Completion Criteria. Completion criteria for the Geo-Cleanse® treatment are listed in the O&M Plan (Appendix D). In-situ treatment of groundwater will be ceased upon attaining a maximum PCE concentration of 5 μg/L in each of the on-site wells listed above.

Confirmation groundwater sampling will be conducted to verify that the groundwater RL for PCE has been achieved and maintained. Groundwater will be sampled once, 6 months following completion of the Geo-Cleanse® treatment. Samples will be collected from each of the 10 wells and analyzed for PCE. Results of this confirmatory sampling for the PCE plume will be documented in the first semiannual progress report.

5.3 OPERATION AND MAINTENANCE PLAN

Appendix D presents the O&M Plan for the selected remedial alternatives. For the benzene plume, O&M includes semiannual monitoring of benzene contamination trends in groundwater throughout the estimated 2-year Monitored Natural Attenuation period plus confirmation sampling after 6 months. For the PCE plume, O&M includes monitoring of off-gas and groundwater field parameters during hydrogen peroxide injection, plus confirmation sampling after 6 months.

5.4 LIFE-CYCLE COST ESTIMATE

The total life-cycle cost estimate for the selected alternatives for both the benzene plume and the PCE plume is $726,000 (see Appendix C for cost components). Table 5-1 summarizes the combined life-cycle costs estimated for remediation of the benzene plume and the PCE plume.

Table 5-1. Combined Life-Cycle Cost Estimates for Benzene and PCE Plumes

Cost Element	Benzene Plume	PCE Plume	Total
Total Capital Costs	$14,945	$225,531	$240,476
Total Treatment Costs (1 week)	$0	$187,573	$187,573
Year 1 Monitoring (18 wells, semiannually)	$21,204	$11,215	$32,419
Year 2 Monitoring (18 wells, semiannually)	$21,204	$0	$21,204
Year 3 Monitoring (18 wells, once after 6 months)	$10,602	$0	$10,602
Total Indirect Costs	$32,278	$201,552	$233,830
Total Project Costs	$100,233	$625,871	$726,104

For the benzene plume, capital costs, including indirect costs, are estimated to be $22,000 and include engineering services (Work Plan, Site Safety and Health Plan, contracting/procurement, permitting, and baseline monitoring). The O&M costs, including indirect costs, are estimated to be approximately $78,000. Total costs of Monitored Natural Attenuation for the benzene plume are estimated to be $100,000.

For the PCE plume, capital costs, including indirect costs, are estimated to be $333,000 and include engineering services and the installation of monitoring wells and injector points. The O&M costs, including indirect costs, are estimated to be approximately $293,000 and include implementation of the Geo-Cleanse® treatment as well as groundwater monitoring. Total costs of Geo-Cleanse® treatment for the PCE plume are estimated to be $626,000.

5.5 IMPLEMENTATION SCHEDULE

Implementation of the corrective action will begin once approval of this CAP is received from GEPD. It is anticipated that a drilling contractor and specialty vendor for PCE remediation can be procured within 4 months following approval of the CAP, and that the final corrective action Work Plan (including appropriate reviews by the Army) will be completed within 4 months thereafter.

Geo-Cleanse® treatment of the PCE plume is estimated to take less than 2 weeks. In addition, the implementation schedule provides for implementation of a second Geo-Cleanse® application as a polishing step. Based on the AT123D modeling results presented in Section 2.9, the required monitoring time for Monitored Natural Attenuation of the benzene plume is approximately 2 years. In addition, the implementation schedule allows for implementing two semiannual groundwater monitoring events as a contingent measure for Monitored Natural Attenuation. Confirmatory sampling will be conducted 6 months following Monitored Natural Attenuation to verify that RLs have been achieved and maintained in groundwater. Remediation will therefore be complete within an estimated 2.5 to 3.5 years. A Corrective Action Completion Report will be prepared and submitted to GEPD for review within 4 months thereafter. The anticipated implementation schedule is presented in Figure 5-3.

5.6 PROGRESS REPORTS

A progress report will be prepared following Geo-Cleanse® treatment of the PCE plume. The report will summarize the installation, injection process, sampling, and analysis performed for the Geo-Cleanse® treatment. Any revisions to this CAP that are required based on review and interpretation of the baseline groundwater sampling results will be summarized in the Geo-Cleanse® treatment completion report and/or the first semiannual progress report, as appropriate.

A progress report will be prepared semiannually during the 2-year Monitored Natural Attenuation period. These reports will summarize the sampling and analytical results of the groundwater monitoring. An analysis of trends and effectiveness of the corrective action will be presented. The need for any contingent action will also be discussed, as required.

A checklist is presented in the O&M Plan (Appendix D) summarizing the items to be addressed in each Progress Report.

A final Corrective Action Completion Report will be prepared following the completion of the corrective action and confirmation sampling. The Corrective Action Completion Report will summarize the corrective measures taken at the site, provide a summary of sampling data, and give results of the confirmation groundwater sampling.

5.7 IMPLEMENTATION PLAN

Upon approval of this CAP by GEPD, Fort Stewart will request funding, procure a contractor for implementing the corrective actions, and implement the specified actions. A corrective action Work Plan will be prepared to guide implementation of the corrective action but will not require GEPD review or approval. Any revisions required to the O&M Plan (Appendix D) or the Implementation Schedule (Figure 5-3) that become apparent during preparation of the Work Plan will be submitted to GEPD for concurrence. Substantive changes in the remediation approach or schedule will require that the public be provided with an opportunity for review and comment, in accordance with the Fort Stewart Hazardous Waste Facility Permit. No other submittals will need to be provided to GEPD prior to implementing the selected corrective action.

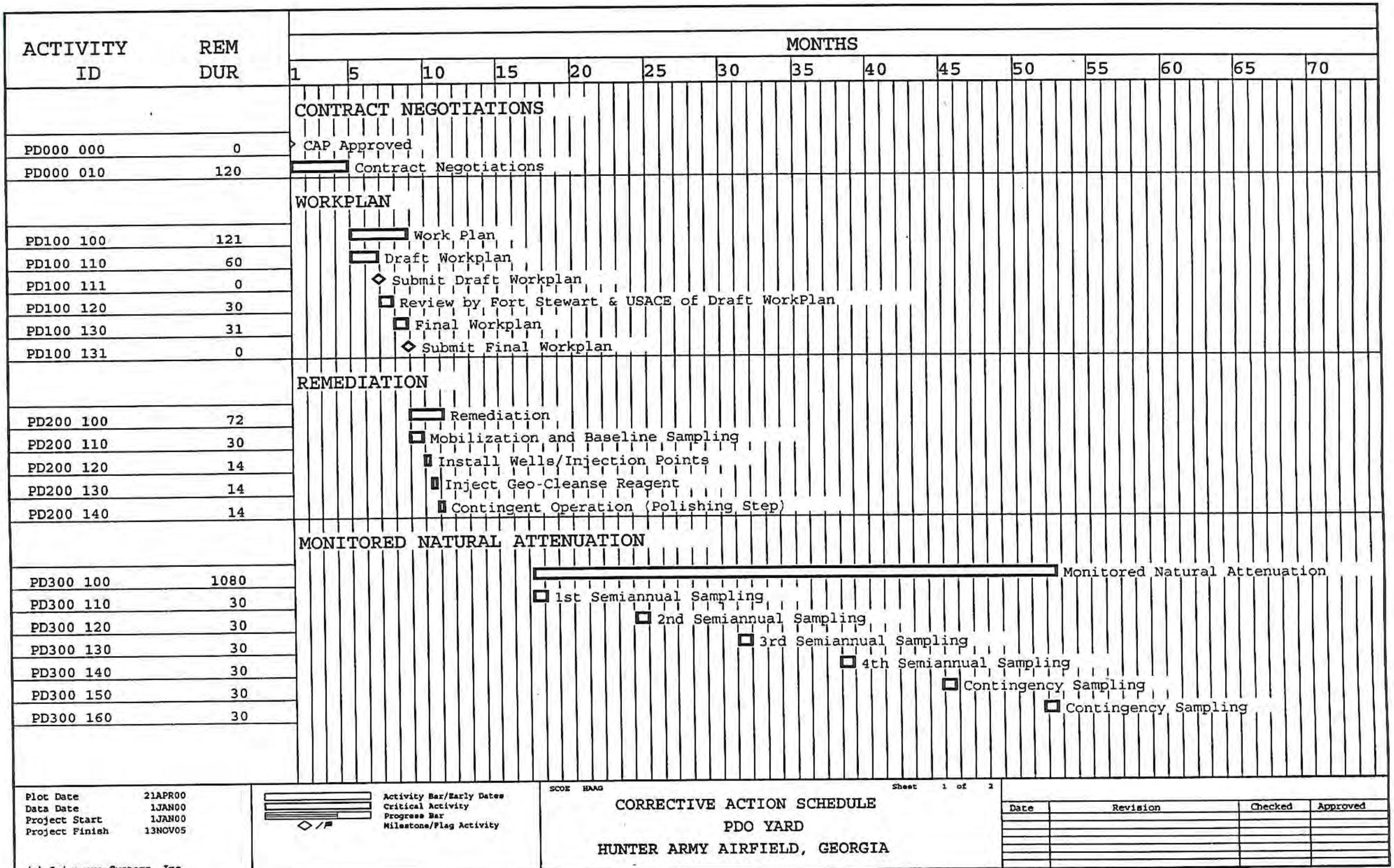


Figure 5-3. Corrective Action Implementation Schedule.

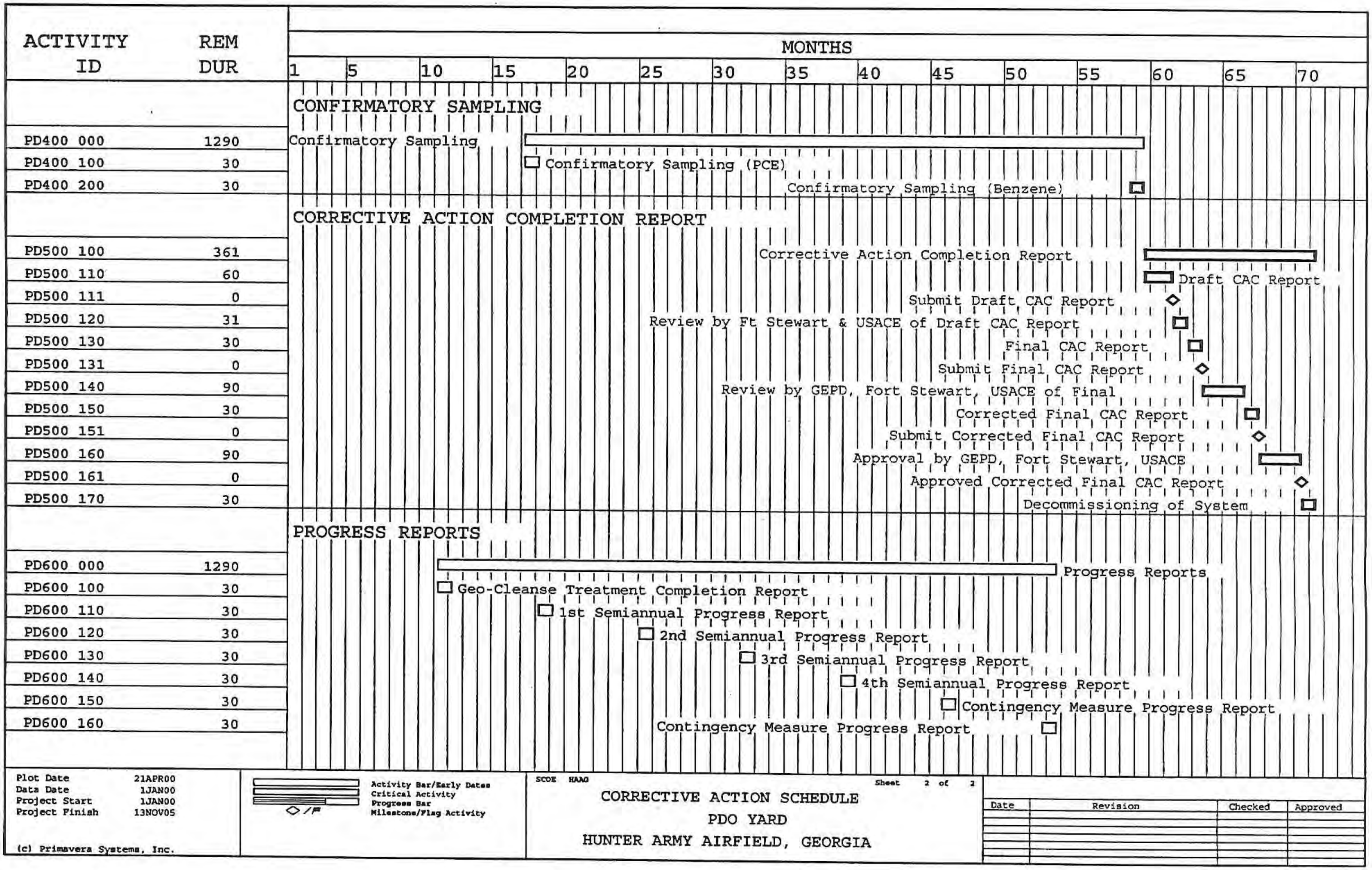


Figure 5-3. (continued)

During the corrective action, progress reports as defined in Section 5.6 will be prepared and submitted to GEPD for review and approval. Upon completion of the corrective action, a Corrective Action Completion Report as defined in Section 5.6 will be prepared and submitted to GEPD for review and approval.

6.0 REFERENCES

American Society for Testing and Materials (ASTM). 1995. Risk-Based Corrective Action Guidance, Philadelphia, Pa.

Arora, Ram. 1984. Hydrologic Evaluation for Underground Injection Control in the Coastal Plain of Georgia, Department of Natural Resources, Environmental Protection Division, Georgia Geological Survey.

Clark, W. Z. Jr., and A. C. Zisa. 1976. Physiographic Map of Georgia, Department of Natural Plain of Georgia, Department of Natural Resources, Environmental Protection Division, Georgia Geological Survey.

EPA (U.S. Environmental Protection Agency). 1994. RCRA Corrective Action Plan (Final), OSWER Directive 9902.3-2A, Office of Waste Programs Enforcement, Office of Solid Waste and Emergency Response, May 1994.

EPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, Directive 9200.4-17P, April 21, 1999.

GA DNR (Georgia Department of Natural Resources). 1976. Geologic Map of Georgia, Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey (reprinted 1997).

General Sciences Corporation (GSC). 1996. RiskPro's SESOIL for Windows, Revision 3.0.

Georgia Environmental Protection Division (GEPD). 1998. Guidelines for Calculating Alternate Threshold Levels for Contaminated Soils, Table 1, May 1998.

Huddlestun, P. F. 1988. A Revision of Lithostratigraphic Units of the Coastal Plain of Georgia, The Miocene through Holocene, Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Bulletin 104.

Metcalf & Eddy. 1999. Revised Final RCRA Facility Investigation Report, Old Property Disposal (PDO) Yard at Hunter Army Airfield, Georgia, September 1999.

Miller, J. A. 1990. Groundwater Atlas of the United States, Segment 6, U.S. Department of the Interior, U.S. Geological Survey, Hydrologic Inventory Atlas 730G, 28 pp.

SAIC (Science Applications International Corporation). 1999a. Addendum #1 to Sampling and Analysis Plan for Corrective Action Plan–Part A and B Investigations at Former Underground Storage Tank Sites, Hunter Army Airfield, Georgia, March 1999.

SAIC. 1999b. Addendum #4 to Sampling and Analysis Plan for Corrective Action Plan–Part A and B Investigations at Former Underground Storage Tank Sites, Hunter Army Airfield, Georgia, November 1999.

Wilkes, R. L., J. H. Johnson, H. T. Stoner, and D. D. Bacon. 1974. Soil Survey of Bryan and Chatham Counties, Georgia, U.S. Department of Agriculture Soil Conservation Service, 71 pp.

Yeh, G. T. 1981. AT123D: Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tenn. Publication No. 1439.

APPENDIX A

RESULTS OF SUPPLEMENTAL GROUNDWATER AND SOIL SAMPLING

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

This letter report summarizes the results of the supplemental characterization of groundwater and soil at the Old Property Disposal (PDO) Yard at Hunter Army Airfield (HAAF), Georgia. This characterization was conducted to support preparation of a Corrective Action Plan (CAP), augmenting the results of the Revised Final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report, Old Property Disposal Yard at Hunter Army Airfield, Georgia (Metcalf & Eddy 1999). This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract No. DACA21-95-D-0022, Delivery Order No. 0036. The supplemental groundwater and soil sampling activities were conducted in accordance with the USACE guidance EM200-1-3 and the procedures described in Addendum #1 and Addendum #4 to the Sampling and Analysis Plan (SAIC1999a; SAIC 1999b).

The purpose of the supplemental groundwater and soil sampling was to support fate and transport modeling performed as part of this CAP and to evaluate whether a secondary source of tetrachloroethene (PCE) contamination is present in the soil. The scope of work included sampling four existing on-site monitoring wells and analyzing the samples for geochemical parameters that affect biodegradation (nitrate/nitrite, sulfate, sulfides, methane, carbon dioxide, total dissolved solids, and iron); collecting three soil samples for geotechnical parameters; and collecting six soil samples and analyzing them for chlorinated solvent parameters. The four wells (MW-01, MW-05, MW-07, and MW1-19) were previously installed as part of the RFI, while the soil borings used to collect the geotechnical and chlorinated solvent soil samples were installed in April and November 1999, respectively (Figure A-1).

2.0 SUMMARY OF INVESTIGATION ACTIVITIES

2.1 GROUNDWATER SAMPLING METHODOLOGY

The supplemental groundwater sampling at the PDO Yard was conducted on April 6, 1999, and consisted of purging and sampling four existing monitoring wells (MW-01, MW-05, MW-07, and MW1-19) according to the procedures outlined in the Sampling and Analysis Plan (SAIC 1999a). Purging and sampling were conducted using a positive displacement submersible pump. Prior to conducting purging activities, the static water level was recorded. During purging activities, field parameters (pH, conductivity, temperature, dissolved oxygen, oxidation-reduction potential, and turbidity) were monitored. Purging was considered complete when the field parameters stabilized within plus or minus 10 percent or after 5 well volumes had been removed from each well. Sampling of each monitoring well began immediately after completion of purging using a Teflon bailer. Groundwater samples were transferred directly into laboratory sample containers and sent offsite for laboratory analysis for geochemical water quality parameters including methane, iron, carbon dioxide, sulfides, sulfate, total dissolved solids, and nitrate/nitrite.

2.2 SOIL SAMPLING METHODOLOGY

On April 30, 1999, supplemental soil sampling activities at the PDO Yard consisted of collecting one undisturbed (Shelby tube) soil sample (PG1400) from boring location G-1 and two disturbed soil samples (PG2400 and PG3400) from boring locations G-2 and G-3. Sampling activities were conducted according to the procedures outlined in the Sampling and Analysis Plan (SAIC 1999a). Sample depth selection was

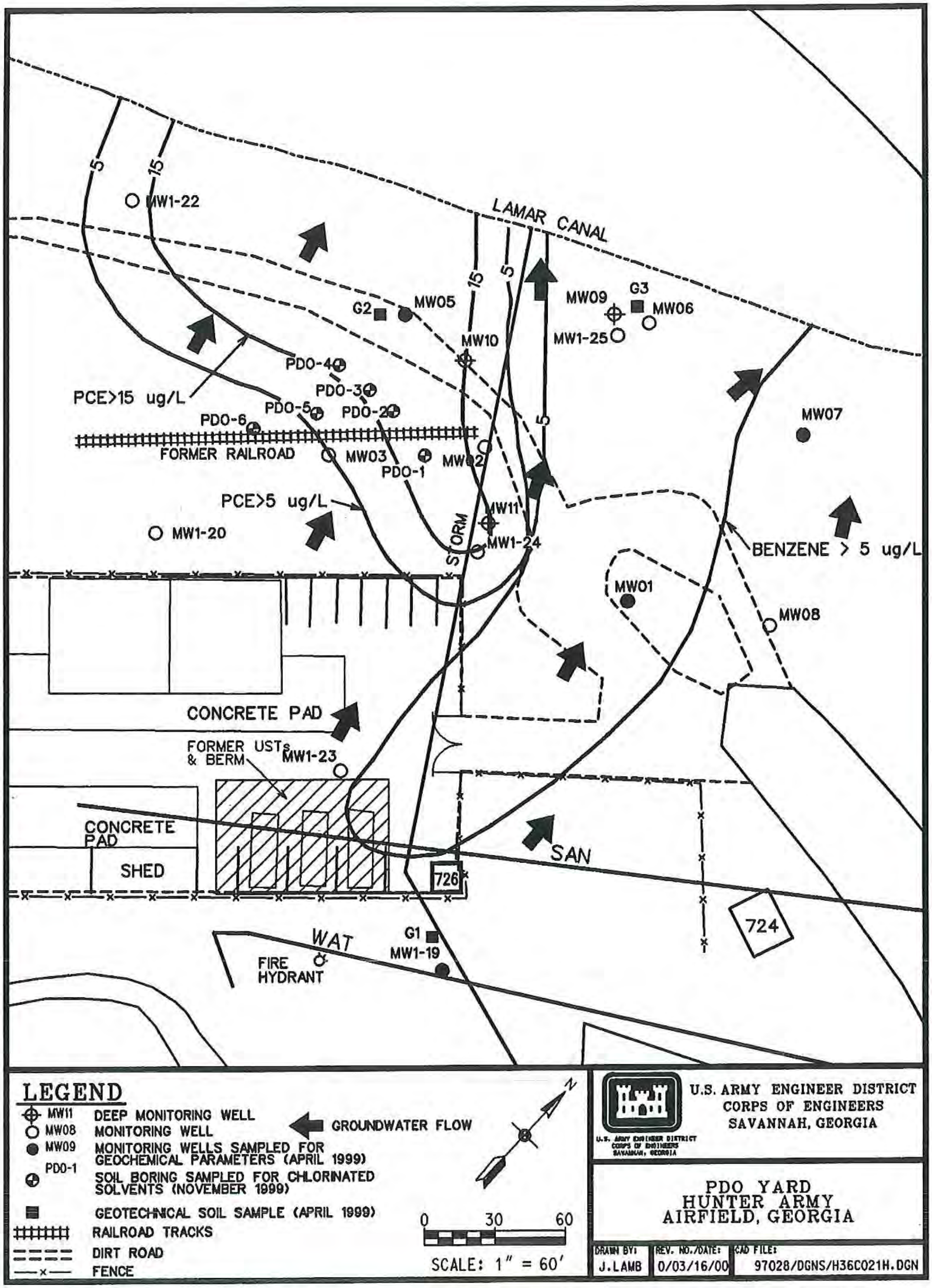


Figure A-1. Supplemental Groundwater and Soil Sampling Locations, April and November 1999.

based on a visual description of the lithology and was found to be representative of the site soil. The boreholes were abandoned after the samples were collected by filling the entire volume of the borehole with bentonite powder.

Soil sample PG1400 was collected as an undisturbed soil sample from a depth of 6 to 8 feet below ground surface (bgs) using a 2-inch-diameter, 2-foot-length, stainless-steel Shelby tube, and analyzed by an off-site laboratory for geotechnical parameters consisting of grain size distribution, moisture content, total organic carbon, permeability, specific gravity, porosity, and bulk density. Soil samples PG2400 and PG3400 were collected as disturbed samples from depths of 6 to 8 feet bgs using a 2-inch-diameter macrocore sampler with a 1.75-inch-diameter acetate liner. The soil samples were transferred from the liners to zip-lock bags and sent to an off-site laboratory to be analyzed for grain size distribution, moisture content, specific gravity, porosity, bulk density, permeability, total organic carbon, and Atterburg Limits.

On November 30, 1999, supplemental soil sampling activities at the PDO Yard consisted of collecting six soil samples (PD0111 through PD0611) from boring locations PDO-1 through PDO-6. Sampling activities were conducted according to the procedures outlined in the Sampling and Analysis Plan (SAIC 1999b). Soil samples were collected from the boreholes using direct-push techniques in combination with a 4-foot, acetate-lined, steel macro-coring device. Upon retrieval of the sampling device, the acetate liner containing the soil core was removed from the steel macro-coring device. The soil core was removed from the protective sleeve using an acetate-liner-cutting device. The exposed soil core was split into two 2-foot sections using a stainless-steel knife. The portion of each 2-foot section immediately above the saturated zone from each borehole was collected using Encore Samplers and sent to an off-site laboratory to be analyzed for chlorinated solvent parameters. The boreholes were abandoned after the samples were collected by filling the entire volume of the borehole with bentonite powder.

3.0 SUMMARY OF INVESTIGATION RESULTS

3.1 RESULTS OF GROUNDWATER ANALYSES

Analytical results for the geochemical groundwater samples from the four existing monitoring wells are summarized in Table A-1. Total iron was detected at concentrations ranging from 1.95 mg/L in monitoring well MW-01 to 6.16 mg/L in MW-07. Carbon dioxide varied between 32.3 mg/L and 218 mg/L (the lowest concentration was at MW-07 and the highest at MW-05). Sulfate ranged from 17.2 mg/L in MW-05 to 43.2 mg/L in MW1-19. Total dissolved solids remained relatively constant varying between 67 mg/L in MW-005 to 180 mg/L in MW1-19. Nitrate was detected in MW-01 at a concentration of 0.150 mg/L and in MW1-19 at a concentration of 0.130 mg/L. Methane gas was detected at 564 μg/L (.564 mg/L) in MW-1. This suggests that active biodegradation is occurring within the area of highest benzene contamination at the PDO Yard, as methane is a breakdown product of benzene (Figure A-1).

3.2 RESULTS OF SOIL ANALYSES

The analytical results for the three geotechnical soil samples and the six chemical (chlorinated solvent parameters) soil samples are summarized in Tables A-2 and A-3, respectively. None of the chlorinated solvent compounds, including PCE and its biodegradation products (chloroethane, vinyl chloride, and 1,2-dichloroethane), were detected in any of the six soil samples. This indicates that a secondary source of PCE contamination is not present in the soil at the PDO Yard in the vicinity and upgradient of MW-05.

Table A-1. Summary of Geochemical Analytical Results in Groundwater (April 1999) PDO Yard, HAAF, Georgia

	Monitoring Well ID			
Parameter	MW-01	MW-05	MW-07	MW1-19
Sample ID	P01200	P05200	P07200	P19200
Date	04/06/99	04/06/99	04/06/99	04/06/99
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Methane	.564 =	0.027 =	0.016 =	0.009 =
Iron	1.950 =	3.440 =	6.160 =	4.360 =
Carbon Dioxide	0.00 U	218 =	32.3 =	0.00 U
Sulfides	1.10 J	0.021 U	0.005 U	0.020 U
Sulfate	41.8 =	17.2 =	35.4 =	43.2 =
Total Dissolved Solids	77.0 =	67.0 =	115.0 =	180.0 =
Nitrate/Nitrite	0.150 =	0.040 U	0.040 U	0.130 =

Laboratory Qualifiers

U- Indicates the compound was not detected at the concentration reported.
J - Indicates the value for the compound is an estimated value.
= - Indicates the compound was detected at the concentration reported.

Table A-2. Summary of Geotechnical Analytical Results in Soil (April 1999) PDO Yard, HAAF, Georgia

Soil Boring ID	Sample ID	Date	Depth (bgs)	Moisture Content (%)	Total Organic Carbon (%)	Specific Gravity	Porosity (n)	Per-meability (cm/s)	Bulk Density (pcf)
G-1	PG1400	04/15/99	6.0–8.0	20.6	.286	2.65	0.38	1.03E-6	103.22
G-2	PG2400	04/15/99	6.0–8.0	20.5	1.31	–	–	–	–
G-3	PG3400	04/15/99	6.0–8.0	26.4	.588	–	–	–	–

bgs - below ground surface.
cm/s - centimeters per second.
ID - identification number.
pcf - pounds per cubic foot.

Table A-3. Summary of Chlorinated Solvent Analytical Results in Soil (November 1999)
PDO Yard, HAAF, Georgia

	Soil Boring ID					
Parameter	**PDO-1**	**PDO-2**	**PDO-3**	**PDO-4**	**PDO-5**	**PDO-6**
Sample ID	**PD0111**	**PD0211**	**PD0311**	**PD0411**	**PD0511**	**PD0611**
Depth (bgs)	**5.6–6.6**	**5.0–7.0**	**4.7–6.7**	**4.0–6.0**	**4.7–6.7**	**4.0–5.7**
Date	**11/30/99**	**11/30/99**	**11/30/99**	**11/30/99**	**11/30/99**	**11/30/99**
Unit	**(µg/kg)**	**(µg/kg)**	**(µg/kg)**	**(µg/kg)**	**(µg/kg)**	**(µg/kg)**
Chloromethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Vinyl Chloride	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Chloroethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Methylene chloride	5.1 U	8.0 U	3.6 U	8.7 U	3.6 U	7.4 U
1,1-Dichloroethylene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,1-Dichloroethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Chloroform	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,2-Dichloroethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,1,1-Trichloroethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Carbon tetrachloride	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,2-Dichloropropane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
cis-1,3-Dichloropropylene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Trichloroethylene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,1,2-Trichloroethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
trans-1,3-Dichloropropylene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
Tetrachloroethene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,1,2,2-Tetrachloroethane	1.1 U	1.2 UJ	1.1 UJ	1.5 UJ	1.4 UJ	1.6 UJ
Chlorobenzene	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,2-Dibromoethane	1.1 U	1.2 U	1.1 U	1.5 U	1.4 U	1.6 U
1,2-Dichloroethylene (total)	2.1 U	2.4 U	2.2 U	3.1 U	2.9 U	3.3 U

bgs - below ground surface. ID - Identification Number.

Laboratory Qualifiers

U- Indicates the compound was not detected at the concentration reported.
J - Indicates the value for the compound is an estimated value.
UJ - Indicates the compound was not detected at the reported concentration, and the concentration was estimated.
= - Indicates the compound was detected at the concentration reported.

4.0 ATTACHMENTS

Attached are laboratory analytical results for the supplemental groundwater and soil sampling events.

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT A-1

ANALYTICAL RESULTS
FOR
GROUNDWATER SUPPLEMENTAL SAMPLING
(APRIL 1999)
AT THE
OLD PROPERTY DISPOSAL (PDO) YARD
HUNTER ARMY AIRFIELD, GEORGIA

THIS PAGE INTENTIONALLY LEFT BLANK

SAIC An Employee-Owned Company
Science Applications International Corporation
800 Oak Ridge Turnpike, Oak Ridge, TN 37831 (423) 481 4600

CHAIN OF CUSTODY RECORD

COC NO.: HAAF04079901

PROJECT NAME: HAAF CAP-OLD PROPERTY DISPOSAL (PDO) YARD

PROJECT NUMBER: DACA21-95-D-0022, DO # 36

PROJECT MANAGER: Allison Bailey

Sampler (Signature): Mitchell Hall (Printed Name): Mitchell

LABORATORY NAME: General Engineering Laboratory

LABORATORY ADDRESS: 2040 Savage Road, Charleston, SC 29407

PHONE NO: (843) 556-8171

REQUESTED PARAMETERS

Sample ID	Date Collected	Time Collected	Matrix	Nitrate/Nitrite MH 4/6/99	Sulfate	Sulfide	Methane	Carbon Dioxide	Iron		VOCs	RCRA Metals	Oil and Grease	TPH	Total Phenols		Total Organic Carbon				No. of Bottles/Vials	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
P01200	04/06/99	1513	WATER	1	1	1	2	1	1												7	0.0ppm	99D4Z05-01
P07200	04/06/99	1225	WATER	1	1	1	2	1	1												7	0.0ppm	02
P05200	04/06/99	1750	WATER	1	1	1	2	1	1												7	0.0ppm	03
P19200	04/06/99	2015	WATER	1	1	1	2	1	1												7	0.0ppm	04

RELINQUISHED BY: Mitchell Hall	Date/Time 4-7-99 1315	RECEIVED BY: [illegible]	Date/Time 4/7/99 1555	TOTAL NUMBER OF CONTAINERS: 28
COMPANY NAME: SAIC		COMPANY NAME: gel		Cooler ID: 296 Temp 4°C
RECEIVED BY: [illegible]	Date/Time 4-7-99 1315	RELINQUISHED BY:	Date/Time	COOLER INCLUDES 1 TEMP BLANK
COMPANY NAME: GEL		COMPANY NAME:		
RELINQUISHED BY: [illegible]	Date/Time 4-7-99 1555	RECEIVED BY:	Date/Time	
COMPANY NAME: GEL		COMPANY NAME:		

Cooler Temperature: 4°C

FEDEX NUMBER: NA

THIS PAGE INTENTIONALLY LEFT BLANK

FORM 1
VOLATILE ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

P01200

Lab Name: GENERAL ENGINEERING LABOR Contract: NA

Lab Code: NA Case No.: NA SAS No.: NA SDG No.: HPDY01W

Matrix: (soil/water) WATER Lab Sample ID: 9904205-01

Sample wt/vol: 1.000 (g/mL) mL Lab File ID: 019B1901

Level: (low/med) LOW Date Received: 04/07/99

% Moisture: ______ decanted: (Y/N)___ Date Extracted:04/23/99

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 04/23/99

Injection Volume: 1.0(uL) Dilution Factor: 10.0

GPC Cleanup: (Y/N) N pH: 7.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-82-8	---------Methane	564	B

= F08

DATA VALIDATION COPY

FORM I VOA

17

Form 1: Inorganic Analyses Data Sheet

SDG No.: HPDY01W

Method Type: Total Metals

Sample ID: 9904205-01

Client ID: P01200

Contract: SAIC00599 Lab Code: GEL Case No.: SAS No.:

Matrix: WATER Date Received: 4/7/99 Level: LOW

% Solids: 0.00

CAS No.	Analyte	Concentration	Units	C	Qual	M	DL	Instrument ID	Analytical Run
7439-89-6	Iron	1950	µg/L			P	8.4	TJA61 Trace ICPAES	990412-2

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

DATA VALIDATION

Client:	Science Applications International Corp. P.O. Box 2502 800 Oak Ridge Turnpike Oak Ridge, Tennessee 37831
Contact:	Ms. Leslie Barbour
Project Description:	Old Property Disposal (PDO) Yard

cc: SAIC00599 Report Date: April 20, 1999

Sample ID	: P01200
Lab ID	: 9904205-01
Matrix	: Water
Date Collected	: 04/06/99
Date Received	: 04/07/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
CARBON DIOXIDE, FREE	U	0.00 U	0.500	1.00	mg/l	1.0	JBK	04/12/99	1300	146494	1
SULFIDES		1.10 J H D2	0.0450	0.500	mg/l	5.0	JBK	04/08/99	1100	146292	2
Sulfate		41.8 =	0.0380	0.200	mg/l	1.0	RWS	04/07/99	2213	146228	3
TOTAL DISSOLVED SOLIDS		77.0 =	5.04	10.0	mg/l	1.0	TSM2	04/08/99	1145	146242	4
NITRATE/NITRITE		0.150 =	0.00860	0.0500	mg/l	1.0	THL	04/14/99	1809	146698	5

M = Method	Method-Description
M 1	SM 18th ed. 4500-CO2
M 2	EPA 376.2
M 3	EPA 300.0
M 4	EPA 160.1
M 5	EPA 353.1

Notes:

The qualifiers in this report are defined as follows:

ND indicates that the analyte was not detected at a concentration greater than the detection limit.

J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).

U indicates that the analyte was not detected at a concentration greater than the detection limit.

* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

FORM 1
VOLATILE ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

P05200

Lab Name: GENERAL ENGINEERING LABOR Contract: NA

Lab Code: NA Case No.: NA SAS No.: NA SDG No.: HPDY01W

Matrix: (soil/water) WATER Lab Sample ID: 9904205-03

Sample wt/vol: 1.000 (g/mL) mL Lab File ID: 012B1201

Level: (low/med) LOW Date Received: 04/07/99

% Moisture: ______ decanted: (Y/N)___ Date Extracted:04/23/99

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 04/23/99

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 7.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
74-82-8	---------Methane	27.3	B	= FΦ8

FORM I VOA

Form 1: Inorganic Analyses Data Sheet

SDG No.: HPDY01W

Method Type: Total Metals

Sample ID: 9904205-03

Client ID: P05200

Contract: SAIC00599 Lab Code: GEL

Case No.:

SAS No.:

Matrix: WATER

Date Received: 4/7/99

Level: LOW

% Solids: 0.00

CAS No.	Analyte	Concentration	Units	C	Qual	M	DL	Instrument ID	Analytical Run
7439-89-6	Iron	3440	µg/L			P	8.4	TJA61 Trace ICPAES	990412-2

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

Client: Science Applications International Corp.
P.O. Box 2502
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831
Contact: Ms. Leslie Barbour
Project Description: Old Property Disposal (PDO) Yard

cc: SAIC00599 Report Date: April 20, 1999

Sample ID	: P05200
Lab ID	: 9904205-03
Matrix	: Water
Date Collected	: 04/06/99
Date Received	: 04/07/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
CARBON DIOXIDE, FREE		218 =	0.500	1.00	mg/l	1.0	JBK	04/12/99	1300	146494	1
SULFIDES	J	0.0210U F01,F06	0.00900	0.100	mg/l	1.0	JBK	04/08/99	1100	146292	2
Sulfate		17.2 =	0.0380	0.200	mg/l	1.0	RWS	04/07/99	2336	146228	3
TOTAL DISSOLVED SOLIDS		67.0 =	5.04	10.0	mg/l	1.0	TSM2	04/08/99	1145	146242	4
NITRATE/NITRITE	J	0.0400U F01,F06	0.00860	0.0500	mg/l	1.0	THL	04/14/99	1809	146698	5

M = Method	Method-Description
M 1	SM 18th ed. 4500-CO2
M 2	EPA 376.2
M 3	EPA 300.0
M 4	EPA 160.1
M 5	EPA 353.1

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
" indicates that a quality control analyte recovery is outside of specified acceptance criteria.

FORM 1
VOLATILE ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

P07200

Lab Name: GENERAL ENGINEERING LABOR Contract: NA

Lab Code: NA Case No.: NA SAS No.: NA SDG No.: HPDY01W

Matrix: (soil/water) WATER Lab Sample ID: 9904205-02

Sample wt/vol: 1.000 (g/mL) mL Lab File ID: 011B1101

Level: (low/med) LOW Date Received: 04/07/99

% Moisture: ______ decanted: (Y/N)___ Date Extracted:04/23/99

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 04/23/99

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 7.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
74-82-8	---------Methane	16.2	B	= FD8

DATA VALIDATION COPY

FORM I VOA

18

Form 1: Inorganic Analyses Data Sheet

SDG No.: HPDY01W

Method Type: Total Metals

Sample ID: 9904205-02

Client ID: P07200

Contract: SAIC00599 | Lab Code: GEL | Case No.: | SAS No.:

Matrix: WATER | Date Received: 4/7/99 | Level: LOW

% Solids: 0.00

CAS No.	Analyte	Concentration	Units	C	Qual	M	DL	Instrument ID	Analytical Run
7439-89-6	Iron	6160	µg/L			P	8.4	TJA61 Trace ICPAES	990412-2

Color Before: | Clarity Before: | Texture:

Color After: | Clarity After: | Artifacts:

Comments:

DATA VALIDATION COPY

Client:	Science Applications International Corp. P.O. Box 2502 800 Oak Ridge Turnpike Oak Ridge, Tennessee 37831
Contact:	Ms. Leslie Barbour
Project Description:	Old Property Disposal (PDO) Yard

cc: SAIC00599 Report Date: April 20, 1999

Sample ID	: P07200
Lab ID	: 9904205-02
Matrix	: Water
Date Collected	: 04/06/99
Date Received	: 04/07/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
CARBON DIOXIDE, FREE		32.3 =	0.500	1.00	mg/l	1.0	JBK	04/12/99	1300	146494	1
SULFIDES	U	-0.00500 U	0.00900	0.100	mg/l	1.0	JBK	04/08/99	1100	146292	2
Sulfate		35.4 =	0.0380	0.200	mg/l	1.0	RWS	04/07/99	2322	146228	3
TOTAL DISSOLVED SOLIDS		115 =	5.04	10.0	mg/l	1.0	TSM2	04/08/99	1145	146242	4
NITRATE/NITRITE	J	0.0400 U FO1,FO2	0.00860	0.0500	mg/l	1.0	THL	04/14/99	1809	146698	5

M = Method	Method-Description
M 1	SM 18th ed. 4500-CO2
M 2	EPA 376.2
M 3	EPA 300.0
M 4	EPA 160.1
M 5	EPA 353.1

Notes:

The qualifiers in this report are defined as follows:

ND indicates that the analyte was not detected at a concentration greater than the detection limit.

J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).

U indicates that the analyte was not detected at a concentration greater than the detection limit.

* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

CLIENT SAMPLE NO.

FORM 1
VOLATILE ORGANICS ANALYSIS DATA SHEET

P19200

Lab Name: GENERAL ENGINEERING LABOR Contract: NA

Lab Code: NA Case No.: NA SAS No.: NA SDG No.: HPDY01W

Matrix: (soil/water) WATER Lab Sample ID: 9904205-04

Sample wt/vol: 1.000 (g/mL) mL Lab File ID: 013B1301

Level: (low/med) LOW Date Received: 04/07/99

% Moisture: ______ decanted: (Y/N)___ Date Extracted:04/23/99

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 04/23/99

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 7.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
74-82-8	---------Methane	9.55	B	=F08

FORM I VOA

Form 1: Inorganic Analyses Data Sheet

SDG No.: HPDY01W

Method Type: Total Metals

Sample ID: 9904205-04

Client ID: P19200

Contract: SAIC00599 Lab Code: GEL Case No.: SAS No.:

Matrix: WATER Date Received: 4/7/99 Level: LOW

% Solids: 0.00

CAS No.	Analyte	Concentration	Units	C	Qual	M	DL	Instrument ID	Analytical Run
7439-89-6	Iron	4360	µg/L	=		P	8.4	TJA61 Trace ICPAES	990412-2

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

Client:	Science Applications International Corp. P.O. Box 2502 800 Oak Ridge Turnpike Oak Ridge, Tennessee 37831
Contact:	Ms. Leslie Barbour
Project Description:	Old Property Disposal (PDO) Yard

cc: SAIC00599 Report Date: April 20, 1999

Sample ID	: P19200
Lab ID	: 9904205-04
Matrix	: Water
Date Collected	: 04/06/99
Date Received	: 04/07/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
CARBON DIOXIDE, FREE	U	0.00 U	0.500	1.00	mg/l	1.0	JBK	04/12/99	1300	146494	1
SULFIDES	J	0.0200 U F01, F06	0.00900	0.100	mg/l	1.0	JBK	04/08/99	1100	146292	2
Sulfate		43.2 =	0.0380	0.200	mg/l	1.0	RWS	04/07/99	2350	146228	3
TOTAL DISSOLVED SOLIDS		180 =	5.04	10.0	mg/l	1.0	TSM2	04/08/99	1145	146242	4
NITRATE/NITRITE		0.130 =	0.00860	0.0500	mg/l	1.0	THL	04/14/99	1809	146698	5

M = Method	Method-Description
M 1	SM 18th ed. 4500-CO2
M 2	EPA 376.2
M 3	EPA 300.0
M 4	EPA 160.1
M 5	EPA 353.1

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

ATTACHMENT A-2

ANALYTICAL RESULTS
FOR
SOIL SUPPLEMENTAL SAMPLING
(APRIL AND NOVEMBER 1999)
AT THE
OLD PROPERTY DISPOSAL (PDO) YARD
HUNTER ARMY AIRFIELD, GEORGIA

THIS PAGE INTENTIONALLY LEFT BLANK