FINAL

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FIELD SAMPLING PLAN

FOR THE

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

Prepared for

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

Contract No. DAHA90-94-D-0007
Delivery Order NGB134

January 2001

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CONTRACT NUMBER DAHA90-94-D-0007
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January 2001

COMMITMENT TO IMPLEMENT THE ABOVE FIELD SAMPLING PLAN		
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TABLES

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ACRONYMS

AST	aboveground storage tanks
ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
CCQC	Contractor Chemical Quality Control
CFR	Code of Federal Regulations
COC	chain of custody
CQC	Chemical Quality Control
DCQCR	Daily Chemical Quality Control Report
DO	dissolved oxygen
DOT	U.S. Department of Transportation
DQCR	Daily Quality Control Report
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FCR	Field Change Request
FSP	Field Sampling Plan
FTP	Field Technical Procedure
GCI	Geo-Cleanse© International, Inc.
GEPD	Georgia Environmental Protection Division
HAAF	Hunter Army Airfield
HHCOC	human health contaminant of concern
HHCOPC	human health contaminant of potential concern
IDW	investigation-derived waste
IR	Interim Remediation
JP	jet propulsion
NCR	Nonconformance Report
ORP	Oxygen reduction potential
PCB	polychlorinated biphenyl
PCE	tetrachloroethane
PDO	Old Property Disposal
PID	photoionization detector
PPE	personal protective equipment
PRE	Preliminary Risk Evaluation
QA	quality assurance
QAAP	Quality Assurance Administrative Procedure
QC	quality control
RCRA	Resource Conservation and Recovery Act of 1976
RD	Remedial Design
RFI	RCRA Facility Investigation
RL	remedial level
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
TCLP	Toxicity Characteristic Leaching Procedure
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers

USAEHA	U.S. Army Environmental Hygiene Agency
USDA	U.S. Department of Agriculture

1. PROJECT DESCRIPTION

This document represents the Field Sampling Plan (FSP) for conducting the corrective action required to prepare a Completion Report in accordance with the Final Corrective Action Plan (CAP) as revised (SAIC 2000) for the Old Property Disposal (PDO) Yard (HAA-12) at Hunter Army Airfield (HAAF), Georgia. The PDO Yard is located near the northwestern boundary of HAAF and has been used as a storage facility for used oil and off-specification jet propulsion (JP)-4, for scrap metal storage, and as a temporary (i.e., 90-day) storage facility for hazardous waste. The PDO Yard consists of a fenced parcel containing approximately 0.955 acres. Prior to 1998, the PDO Yard contained three aboveground storage tanks (ASTs) within a bermed area located in the southeast corner of the fenced area. The ASTs included two 20,000-gallon tanks for storage of waste oil and one 18,000-gallon tank for storage of off-specification JP-4. These tanks were removed in 1998 and replaced with three new ASTs set in a concrete-lined tank area on the northwest side of the fenced PDO Yard area.

Several investigations were conducted at the site from 1993 to 1999. (See Section 1.2.2.) The Resource Conservation and Recovery Act of 1976 (RCRA) Facility Investigation (RFI) Report concluded that groundwater at the PDO Yard was contaminated with benzene and tetrachloroethene (PCE). Neither benzene nor PCE were detected in any of the deep monitoring wells at the site. Soil, sediment, and surface water were not considered media of concern. Upon evaluation of several remedial technologies, the CAP recommended monitored natural attenuation for the benzene plume and Geo-Cleanse® chemical oxidation treatment for the PCE plume.

The FSP presents the environmental setting, site history and contaminants, data quality objectives, and sampling rationale. The FSP further provides an overview of the proposed field activities and chemical testing, and the procedures to be used in executing the field activities. Site history and background information, along with past data collection activities and existing site data, are contained in Chapter 1 of this FSP. Primary project organization and responsibilities are presented in Chapter 2, while the project scope and objectives are found in Chapter 3. Sampling design, procedures, methods, and rationales are discussed in detail in Chapter 4. Sample matrix types, analytical parameters, and analytical methods can also be found in Chapter 4. The remaining chapters summarize requirements for chain-of-custody (COC) documentation, sample packaging and shipping, management of investigation-derived wastes (IDW), quality control, project schedule, and instrumentation.

Appendix A of this FSP presents the references cited in the text. The Injection Work Plan for the Geo-Cleanse® Treatment Program is presented in Appendix B and the Data Management Plan is presented in Appendix C. A listing of abbreviations and acronyms used throughout the FSP are presented in the front matter of the FSP.

1.1 ENVIRONMENTAL SETTING

1.1.1 Demographics

HAAF is located in the City of Savannah, Chatham County, Georgia (Figure 1-1). 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 southwest.

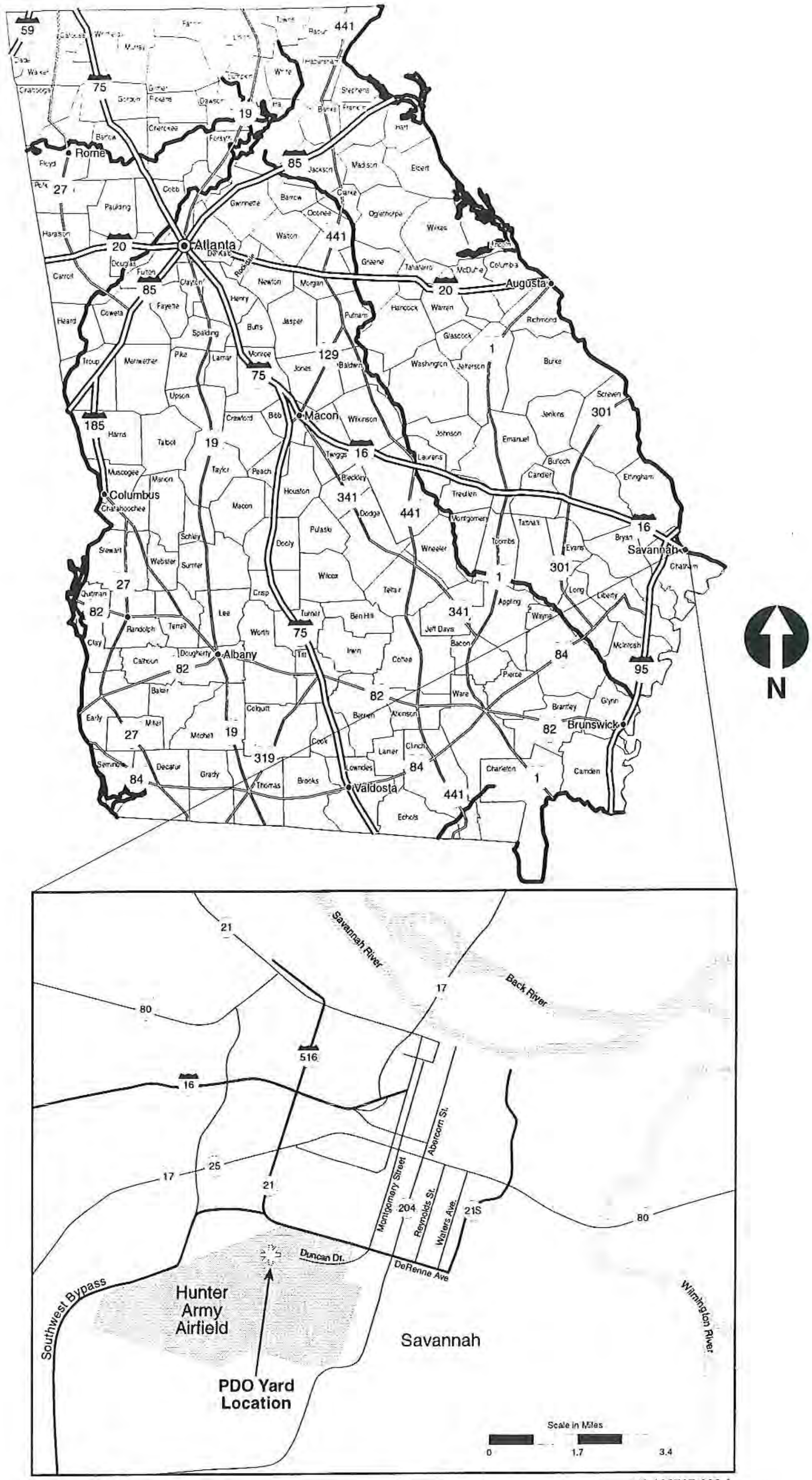

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Figure 1-1. Location Map of the PDO Yard, Hunter Army Airfield, Georgia

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 installation 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. Then, 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).

The PDO Yard is located near the northwestern boundary of HAAF and consists of a fenced parcel containing approximately 0.955 acres (Figure 1-2). 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 years to 30 years was located toward the north, outside the fenced area (Metcalf & Eddy 1999).

1.1.2 Geology

HAAF is located toward the north end of the Barrier Island Sequence District of the Coastal Plain Physiographic 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 feet 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 Epoch, 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.

1.1.3 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 approximately 0 percent to 2 percent (Metcalf & Eddy 1999).

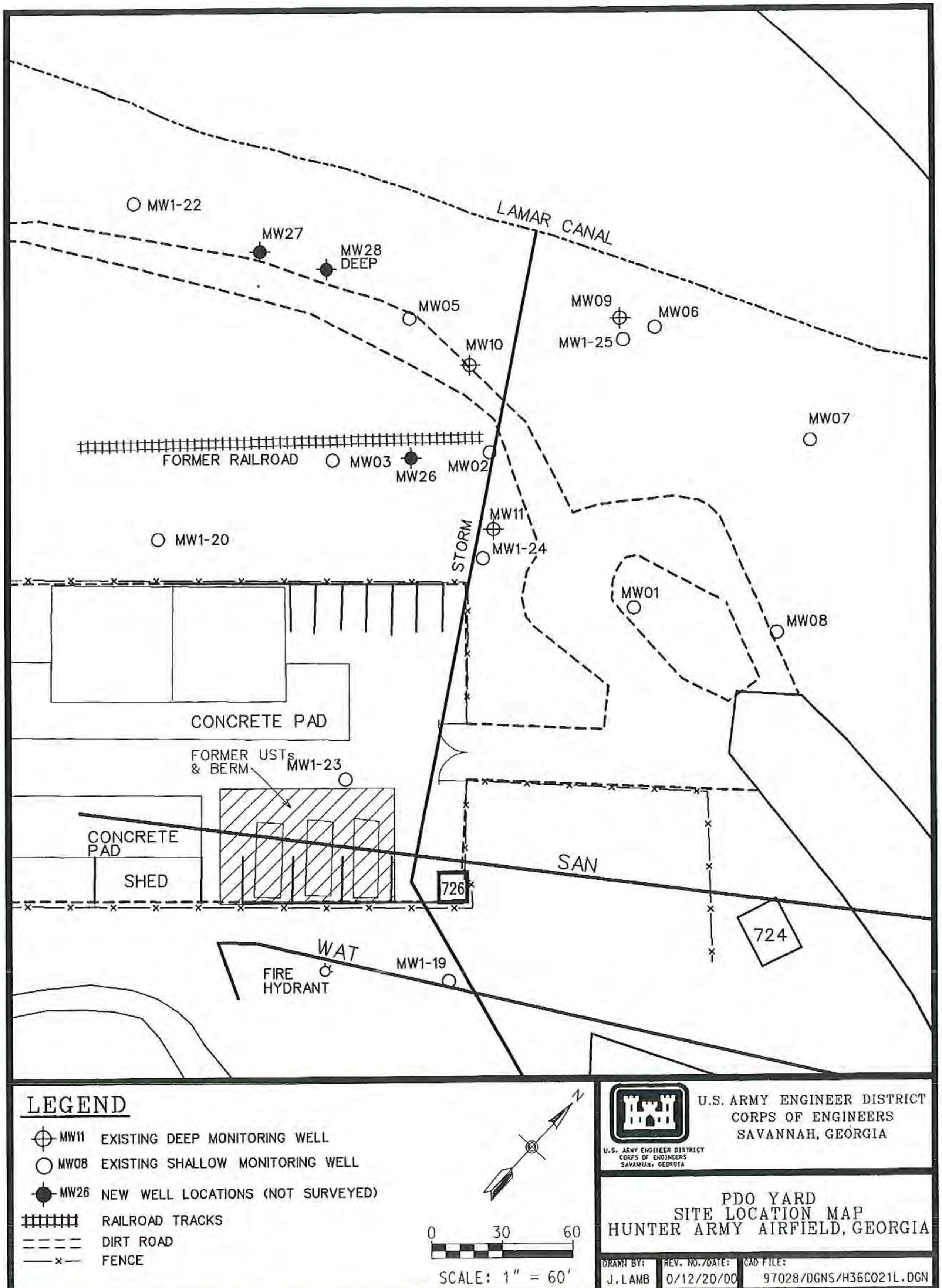

Figure 1-2. PDO Yard Site Map, Hunter Army Airfield, Georgia

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 inches to 36 inches below ground surface (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).

1.1.4 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, which is 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, one of the largest cones of depression produced in the Upper Floridan Aquifer exists directly beneath Savannah, Georgia (Miller 1990). 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 feet 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 feet to 10 feet bgs (Miller 1990) and was measured at a depth of 5 feet 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/foot, an average hydraulic conductivity of 1.15×10^{-4} feet/second, and an effective porosity of 0.18 (Metcalf & Eddy 1999).

1.1.5 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 from approximately 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).

1.2 SITE HISTORY AND CONTAMINANTS AT THE PDO YARD

1.2.1 Site History

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. A fenced area that is approximately 136 feet by 300 feet surrounds the facility. Originally, the site included an earthen bermed area, located in the southeast corner of the fenced area, that contained two 20,000-gallon ASTs used to store waste oil and one 18,000-gallon AST used to store off-specification JP-4.

During their visit to the site in April 1993, the Georgia Environmental Protection Division (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, JP pads, and filters were present in the 90-day hazardous waste storage area. Six transformers also were being stored in the hazardous waste storage area. The inspection led to the issuance of a Consent Order (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 berm, was excavated to an approximate depth of 3 feet bgs except for the northeast corner where the excavation was taken down to a depth of 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.

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 currently are located within the PDO Yard.

1.2.2 Previous Investigations

1.2.2.1 Site assessment

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, ethybenzene, 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 inches to 18 inches 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.

1.2.2.2 Groundwater assessment

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 (i.e., 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. 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.

1.2.2.3 RCRA facility investigation

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 bgs except for 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 the 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 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 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 Baseline Human Health Risk Assessment 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 indicated that no shallow groundwater is used for potable water supply within 0.5 miles of the site. The potential receptor survey indicated that a potential exists for exposure to HHCOPCs in the open drainage ditch (Lamar Canal) located north of the PDO Yard. The sides of the ditch, being heavily vegetated and steep, are not conducive to casual human contact; therefore, the potential for human exposure to water or sediment in the ditch is remote.

No current groundwater exposure exists. Risk calculations indicate that even under the highly unlikely future residential exposure scenario, the levels of contamination are within acceptable risk ranges determined by the U.S. Environmental Protection Agency (EPA) and GEPD. The calculated levels were based on the highest contaminant concentrations at the PDO Yard and very conservative assumptions resulting in a risk estimation strongly biased toward the protection of human health. Concentrations of both benzene and PCE in groundwater, however, exceed their respective MCLs.

Ecological risk assessment. A Preliminary Risk Evaluation (PRE) was conducted during the Phase II RFI. There are no identified ecological contaminants of potential concern in surface soil, surface water, or groundwater. Although barium was found in sediment, it does not pose a risk to potential receptors near the PDO Yard. An ecological risk assessment is not required for the PDO Yard, based on the data evaluation conducted in the PRE, and no corrective action is required for protection of ecological receptors.

1.2.2.4 Supplemental sampling

Supplemental groundwater sampling. The Installation elected to sample groundwater, surface water, and sediment on a quarterly basis to monitor potential contaminant migration associated with former releases from the PDO Yard. A total of four quarters of sampling events were conducted at the PDO Yard between August 1998 and May 1999. The first quarter data were evaluated and presented in the Revised Final RFI Report. Data from the three additional quarterly sampling events (which also have been submitted to GEPD) show no significant changes in the potentiometric surface, flow direction, or gradient.

Benzene concentrations are observed to be increasing in two downgradient wells (MW01 and MW06), which is consistent with the expected plume migration following removal of the source area soils.

Benzene concentrations in two wells peripheral to the groundwater plume (MW02 and MW1-23) have shown consistent decline over the sampling period. Benzene concentrations in one well (MW1-25) have remained relatively constant. During the most recent quarterly sampling event in May 1999, the maximum benzene concentrations were reported at MW01 (68 μg/L) and MW06 (62 μg/L), exceeding the MCL of 5 μg/L. PCE concentrations have remained relatively constant in four wells (MW03, MW05, MW1-22, and MW1-24) and have shown a slight decline in well MW02. In the most recent quarterly sampling event, the maximum PCE concentration was reported at MW05 at 40 μg/L, exceeding its MCL of 5 μg/L.

Supplemental soil sampling. Because 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 MW05. PCE was not detected in any of the soil samples, indicating that a secondary source of the PCE could not be found.

1.2.2.5 Baseline sampling for PCE

The seven shallow and three deep wells that monitor the PCE plume were sampled in August 2000 to aid in the design of the Geo-Cleanse® system and to provide baseline data. PCE was detected in groundwater samples from shallow wells MW02 (9.9 μg/L), MW03 (1.9 μg/L), MW05 (30.7 μg/L), MW1-22 (12.7 μg/L), MW1-24 (4 μg/L), MW26 (26.9 μg/L), and MW27 (28.8 μg/L). PCE was not detected in the three deep wells MW10, MW11, and MW28. Ethylbenzene, toluene, trichloroethlynene, and total xylenes were also detected during the sampling event, but at concentrations below their respective remedial level (RL). The results of the baseline sampling for PCE is presented in Table 1-1 and Figure 1-3.

1.2.2.6 Baseline sampling for benzene

The six shallow wells and one deep well that monitor the benzene plume were sampled in October 2000 to determine whether it was necessary to proceed with the Monitored Natural Attenuation. Benzene was detected in groundwater samples from shallow wells MW01 (4.4 μg/L), MW06 (46.7 μg/L), MW1-23 (1.8 μg/L), and MW1-25 (44.1 μg/L). Benzene was not detected in the two shallow wells MW07 and MW08, and one deep well MW09. Ethylbenzene, toluene, and total xylenes also were detected during the sampling event, but at concentrations below their respective RL. The results of the baseline sampling for benzene is presented in Table 1-2 and Figure 1-3.

1.2.3 Remedial Action

Due to the presence of benzene and PCE in groundwater at concentrations exceeding maximum contaminant levels (MCLs), remedial action was recommended 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 (Metcalf & Eddy 1999).

For the benzene plume, the CAP recommended Monitored Natural Attenuation as the remedial action for benzene in groundwater. Monitored Natural Attenuation is expected to achieve the benzene RL of 5 μg/L in as few as 2 years.

For the PCE plume, the CAP recommended chemical oxidation using the patented Geo-Cleanse® process as the remedial action for PCE in groundwater. The Geo-Cleanse® Process, which is proprietary to Geo-Cleanse® International, Inc. (GCI), is a technology to inject hydrogen peroxide and trace quantities of metallic salts into the impacted media via patented methodology and equipment (U.S. Patents 5,525,008 and 5,611,642). This in situ oxidation system is capable of complete, nonselective oxidation of organic

Table 1-1. Baseline Sampling Results (August 2000) for PCE at the PDO Yard, Hunter Army Airfield

Sample Location	Sample ID	Date Sampled	Detected VOCs (mg/l)				
			PCE	TCE	Toluene	Ethyl-benzene	Xylenes
AP-MW-02	AP0212	8/28/00	9.9 =	0.35 J	0.48 J	0.48 J	3.0 U
AP-MW-03	AP0312	8/28/00	1.9 =	1.0 U	1.0 U	1.0 U	3.0 U
AP-MW-05	AP0512	8/28/00	30.7 =	0.55 J	1.0 U	1.0 U	3.0 U
AP-MW-10	AP1012	8/28/00	1.0 U	1.0 U	1.0 U	1.0 U	3.0 U
AP-MW-11	AP1112	8/28/00	1.0 U	1.0 U	1.0 U	0.19 J	0.5 J
AP-MW1-22	AP2212	8/28/00	12.7 =	0.15 J	1.0 U	1.0 U	3.0 U
AP-MW1-24	AP2412	8/28/00	4 =	0.21 J	1.0 U	0.17 J	3.0 U
AP-MW-26	AP2612	8/28/00	26.9 =	0.6 J	1.0 U	0.054 J	3.0 U
AP-MW-27	AP2712	8/28/00	28.8 =	0.64 J	1.0 U	1.0 U	3.0 U
AP-MW-28	AP2812	8/28/00	1.0 U	1.0 U	1.0 U	0.069 J	3.0 U
Remedial Level			5	5	700	1,000	10,000

Table 1-2. Baseline Sampling Results (October 2000) for Benzene at the PDO Yard, Hunter Army Airfield

Sample Location	Sample ID	Date Sampled	Detected VOCs (mg/l)			
			Benzene	Toluene	Ethyl-benzene	Xylenes
AP-MW-01	AP0112	10/31/00	4.4 =	1 U	1.7 =	2.3 J
AP-MW-06	AP0612	10/31/00	46.7 =	1 U	6.6 =	3 U
AP-MW-07	AP0712	10/31/00	1 U	1 U	1 U	3 U
AP-MW-08	AP0812	10/31/00	1 U	1 U	1 U	3 U
AP-MW-09	AP0912	10/31/00	1 U	1 U	1 U	3 U
AP-MW1-23	AP2312	10/31/00	1.8 =	1 U	0.62 J	3 U
AP-MW1-25	AP2512	10/31/00	44.1 =	0.73 J	15.7 =	17.3 =
Remedial Level			5	700	1,000	10,000

compounds in soil and groundwater. A detailed description of the Geo-Cleanse® Process is provided in the Injection Work Plan prepared by GCI and is presented in Appendix B.

The Geo-Cleanse® Process delivers a calculated dose of hydrogen peroxide and a catalyst to the contaminated region via its patented injection methodology and equipment. The methodology and equipment are the keys to the Geo-Cleanse® Process. Each injector contains a mixing head that promotes mixing of reagents and stimulating circulation of groundwater, which in turn promote rapid reagent diffusion and dispersion. All reagents are injected into the subsurface through the injectors. When acceptable conditions are established, hydrogen peroxide and a catalyst are injected simultaneously. The mixing heads also ensure that catalyst and peroxide will not mix in the sealed system until they are at the screened interval of the injector. The injector is designed with a check valve and a constant-pressure delivery system that prevents mixing of the chemicals before they have reached the zone of contamination/treatment, eliminating the chance of reaction within the injection system. This process maximizes the dispersion and diffusion of the reagent through the soil or an affected aquifer. The patented injectors are also specially designed to withstand the elevated temperatures and pressures resulting from the chemical oxidation reaction, based on Fenton's Reaction chemistry.

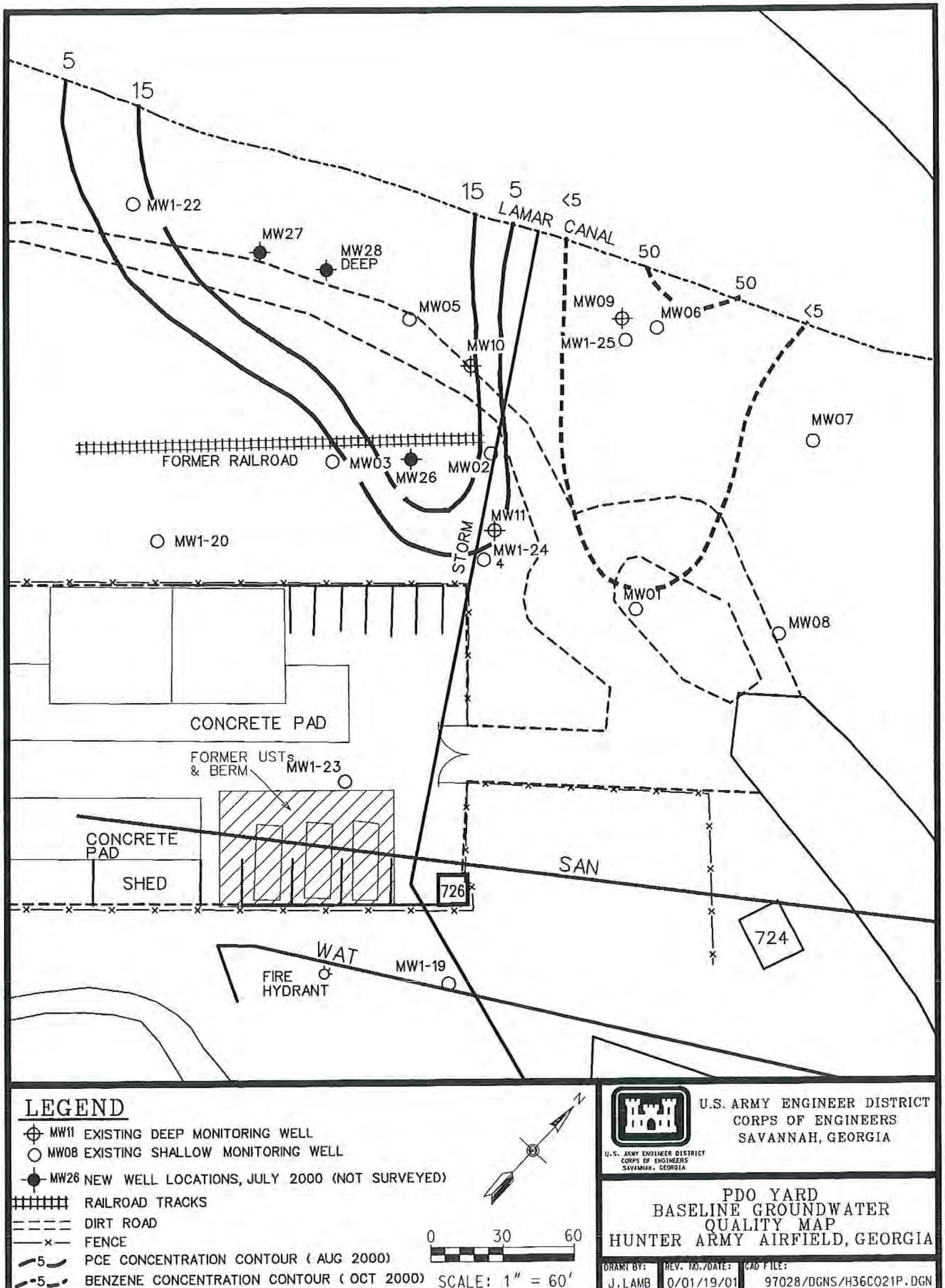

Figure 1-3. Groundwater Quality Map for Baseline Sampling Events (August & October 2000) at the PDO Yard

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

This portion of the project FSP represents the Project Management Plan for project activities to be performed by Science Applications International Corporation (SAIC) at the PDO Yard at HAAF. This plan designates the key SAIC and subcontractor personnel who will participate in the project and provides a summary of their responsibilities.

2.1 PROJECT ORGANIZATION

The organizational chart illustrated in Figure 2-1 outlines the management structure that will be used to implement the project. The functional responsibilities of key personnel are described in the following parts of this plan. The assignment of personnel to each project position is based on a combination of (1) experience in the type of work to be performed, (2) experience working with government personnel and procedures, (3) a demonstrated commitment to high quality and timely job performance, and (4) staff availability. The key project personnel have been assigned based upon the minimum education and qualification requirements for each assigned position, as shown in Table 2-1. In the event that personnel identified in Figure 2-1 and Table 2-1 must be replaced after issuance of these documents, SAIC will provide the names and resumes for the replacement individuals to the U.S. Army Corps of Engineers (USACE), Savannah District, Project Manager prior to mobilization for field work.

The subcontractors selected by SAIC to support the project, and the services to be performed by these companies, are as follows:

Miller Drilling Company:	Soil borehole drilling and monitoring/injection well installation
General Engineering Laboratories, Inc.:	Chemical analytical testing for groundwater, surface water, and sediment samples
Cranston Robertson & Whitehurst:	Topographic and location surveys for boreholes and monitoring wells
Safety Kleen:	Transport and disposal of IDW
Geo-Cleanse International, Inc.:	In situ chemical oxidation

2.2 KEY PERSONNEL RESPONSIBILITIES

2.2.1 SAIC Program Manager

The SAIC Program Manager manages the overall performance and quality of projects under USACE Savannah District, in conjunction with the National Guard general contract DAHA90-94-D-0007. This individual will oversee the SAIC Project Manager in meeting project goals and objectives in a high-quality and timely manner. Quality assurance issues will be addressed by this individual, in coordination with the SAIC Project Manager and Quality Assurance/Quality Control Officer (QA/QC), including identification of nonconformances and verification of corrective action.

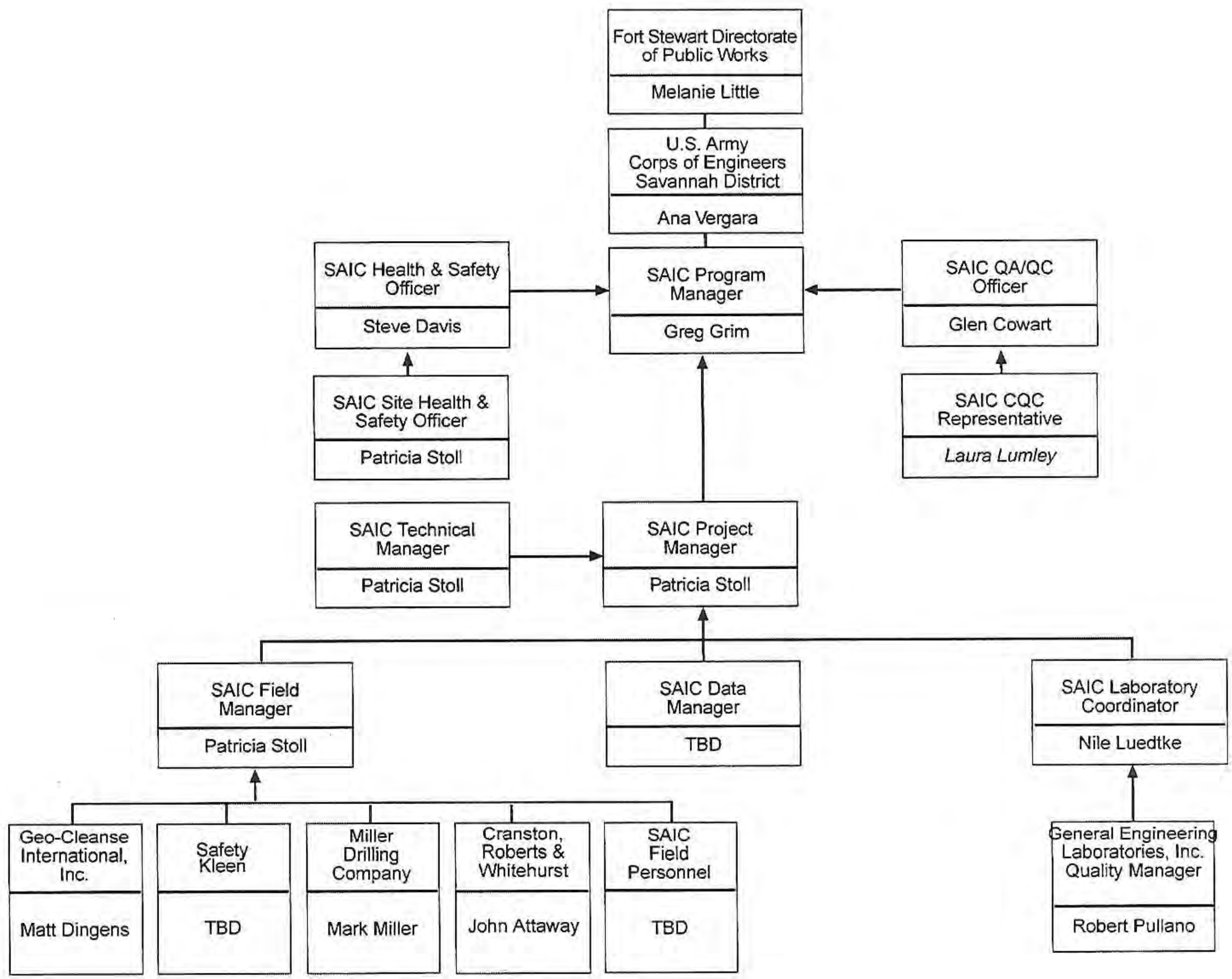

Figure 2-1. Organizational Chart for the Corrective Action at the PDO Yard, Hunter Army Airfield, Georgia

Table 2-1. Key Field Personnel Assignments and Qualifications for the Corrective Action at the PDO Yard, Hunter Army Airfield, Georgia

Project Assignment	Minimum Degree Requirements	Minimum Qualifications
Project Manager Patricia Stoll	B.S., Civil Engineering, Geology, or related field	10+ years of experience in HTRW projects including site investigations and related environmental evaluations/studies
Site Safety and Health Officer Patricia Stoll	B.S., Safety, Engineering, or related field	5+ years of experience in HTRW projects including providing health and safety oversight for site investigations, remedial investigations, and related environmental evaluations/studies
Chemical QC Site Representative Laura Lumley	A.S., Science or Engineering Technology or related field or equivalent fieldwork experience	3+ years of experience in HTRW projects including site investigations, remedial investigations, and related environmental evaluations/studies
Field Manager Patricia Stoll	B.S., Civil Engineering, Geology, or related field	5+ years of experience in HTRW projects including management of field projects for site investigations, remedial investigations, and related environmental evaluations/studies
Laboratory Coordinator Nile Luedtke	B.S., Chemistry	5+ years of experience in HTRW projects including laboratory interface for site investigations, remedial investigations, and related environmental evaluations/studies
Site Geologists TBD	B.S., Civil Engineering, Geology, or related field	3+ years of experience in HTRW projects including soil and rock logging, and monitoring well installation
Sampling Technicians TBD	A.S., Science or Engineering Technology or related field or equivalent fieldwork experience	3+ years of experience in HTRW projects including soil and groundwater sampling and monitoring well installation

HTRW = Hazardous, toxic, and radioactive waste.
TBD = To be determined.

2.2.2 SAIC Project Manager

The SAIC Project Manager is a Professional Engineer registered in the State of Georgia and has responsibility for oversight of all project activities, including work plan development, field activities, data management, and report preparation. This individual also will provide the overall financial management of the project, and serve as the point of contact with the USACE, Savannah District, Project Manager (Ms. Ana Vergara) and USACE, Savannah District, Technical Manager (Mr. Wes Smith). The SAIC Project Manager also will develop, monitor, and fill project staffing needs, delegate specific responsibilities to project team members, and coordinate with administrative staff to maintain a coordinated and timely flow of project activities. The SAIC Project Manager reports directly to the SAIC Program Manager.

2.2.3 SAIC Health and Safety Officer

The SAIC Health and Safety Officer is responsible for confirming that health and safety procedures designed to protect personnel are maintained throughout the field activities conducted for the project. This will be accomplished by strict adherence to the project SSHP. This individual, in coordination with the SAIC Site Safety and Health Officer (SSHO), will have the authority to halt field work if health and/or safety issues arise that are not immediately resolvable in accordance with the project SSHP. The SAIC Health and Safety Manager and SSHO report directly to the SAIC Program Manager, but will inform the SAIC Project Manager of all information and decisions reported.

2.2.4 SAIC Quality Assurance/Quality Control Officer

The SAIC QA/QC Officer is responsible for the project QA/QC in accordance with the requirements of work plan documentation and appropriate management guidance. This individual, in coordination with the SAIC Chemical Quality Control (CQC) Representative, will be responsible for participating in the project field activity readiness review; approving variances during field activities before work continues; approving, evaluating, and documenting the disposition of Nonconformance Reports (NCRs); overseeing and approving any required project training; and designing audit/surveillance plans followed by supervision of these activities. The SAIC QA/QC Officer and CQC Representative report directly to the SAIC Program Manager and also will inform the SAIC Project Manager of all information and decisions reported.

2.2.5 SAIC Laboratory Coordinator

The SAIC Laboratory Coordinator is responsible for coordination of sample collection, and subsequent chemical analysis and data reporting performed by the subcontract laboratories, in accordance with the requirements defined in the FSP. This individual will be responsible for obtaining required sample containers from the laboratory for use during field sample collection, resolving questions the laboratory may have regarding FSP requirements and deliverables, and coordination of reduction, validation, and documentation activities related to sample data package deliverables received from the laboratory. The SAIC Laboratory Coordinator reports directly to the SAIC Project Manager.

2.2.6 Subcontractor Laboratory Quality Manager

General Engineering Laboratories, Inc., will be subcontracted by SAIC to perform laboratory services regarding chemical analyses of soil and groundwater samples collected during the project. Similarly, Catlin Engineers will be subcontracted by SAIC to perform laboratory services regarding geotechnical testing of soil samples. The Subcontractor Laboratory Quality Manager is responsible for the laboratory QA/QC. In coordination with the SAIC Laboratory Coordinator, this individual will be responsible for documenting that samples received by the laboratory are analyzed in accordance with required and approved methodologies, that instrument calibration is performed properly and documented, that field and internal laboratory QC samples are analyzed and documented, and that all analytical results for both field and QC samples are reported to SAIC in the format required in the laboratory scope of work. This individual is also responsible for processing laboratory NCRs in a timely manner and for implementing Corrective Action Report recommendations and/or requirements. The Subcontractor Laboratory Quality Manager reports directly to the SAIC Laboratory Coordinator.

2.2.7 SAIC Data Manager

The SAIC Data Manager, and data management personnel, will be responsible for managing the field and analytical data generated during the project. The data management team will be responsible for the accumulation, control, reduction, validation, documentation, and storage of project data in accordance with the Data Management Plan, which is presented in Appendix C. The SAIC Data Manager also will assist the SAIC QA/QC Officer in the review of laboratory procedures if required. The SAIC Data Manager reports directly to the SAIC Project Manager.

2.2.8 SAIC Field Manager

The SAIC Field Manager is responsible for implementing field activities conducted during the project in accordance with the project FSP. This individual is responsible for proper technical performance of field sampling activities, adherence to required sample custody and other related QA/QC field procedures, coordination of field personnel activities, management of IDW, field documentation, and preparation of Field Change Requests (FCRs), if required. The SAIC Field Manager reports directly to the SAIC Project Manager, except with regard to significant QA/QC matters, which are reported directly to the SAIC QA/QC Officer, and significant health and safety matters, which are reported directly to the SAIC Health and Safety Officer.

2.2.9 SAIC Chemical Quality Control Representative

The SAIC CQC Representative is responsible for the preparatory, initial, and followup phases of the project, including completion of the Daily Chemical Quality Control Report (DCQCR). The CQC Representative also is responsible for QA/QC activities on-site and reports on them to the SAIC QA/QC Officer.

2.2.10 SAIC Field Personnel

In addition to the SAIC Field Manager, other SAIC field personnel participating in the implementation of field activities for the project will include geologists and sampling technicians. These individuals, in coordination with field subcontractor personnel, will be responsible for performance of drilling operations, installation of monitoring wells, collection of soil and groundwater samples, and preparation of field logbooks and other required documentation. These individuals will perform all field activities in accordance with the project FSP and report directly to the SAIC Field Manager.

2.2.11 Subcontractor Field Personnel

Companies that will be subcontracted by SAIC to perform various field services during the project were previously identified at the beginning of this Project Management Plan. Subcontractor field personnel, under the supervision of the SAIC Field Manager, will be responsible for performing their specific scopes of work that have been incorporated into the project work. These individuals will be required to review applicable sections of the project FSP and the SSHP, prior to field mobilization. Subcontractor field personnel report directly to the SAIC Field Manager.

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3. PROJECT SCOPE AND OBJECTIVES

3.1 SCOPE OF THE REMEDIAL ACTION

The scope of the remedial action can be defined by its three main components: (1) develop a Work Plan describing the requirements of the remedial action at the PDO Yard, (2) perform the remedial action, and (3) complete a Completion Report. The specific scope for this FSP includes the following:

- describe the rationale for performing monitored natural attenuation of the benzene plume,
- describe the rationale for performing the in situ chemical oxidation remedial action and system monitoring of the PCE plume,
- describe the data quality objectives (DQOs), and
- list the samples that need to be taken including: media to be sampled, lists of analytes, sample locations, and sampling procedures.

3.2 PROJECT OBJECTIVES

The objectives for the in situ chemical oxidation remedial action and monitored natural attenuation at the PDO Yard, HAAF, Georgia, are the following:

- to permanently reduce the concentrations of benzene and PCE in groundwater to the RLs, and
- to protect surface water in Lamar Canal from being adversely affected by contaminated groundwater

To achieve these objectives, data (of sufficient quality and quantity for evaluation of the remedial action) should be collected.

3.3 DATA QUALITY OBJECTIVES

DQOs are used to identify the data to be collected so that the data are suitable to fulfill the objectives of the project and are obtained in an efficient and cost-effective manner. The DQO process culminates in the reduction of uncertainty associated with decisions related to remedial action. There are three steps to the DQO process:

1. identify decision types,
2. identify data needs, and
3. specify data collection.

The following sections contain the DQO rationale for the remedial action design and sampling.

3.3.1 DQO Stage 1: Identify Decision Types

The RFI indicated that groundwater at the PDO Yard is contaminated with benzene and PCE. The CAP determined that in situ chemical oxidation for remediation of the PCE and that monitored natural attenuation of the benzene were the appropriate technologies at the PDO Yard. The decisions to be made using data obtained during the remedial action are as follows:

- Are the benzene concentrations in groundwater at the PDO Yard decreasing with time due to natural attenuation?

- What is the final concentration of PCE in groundwater at the PDO Yard after injecting oxidation chemicals?

The baseline and final concentrations of contaminants in the groundwater will be used to determine the effectiveness of monitored natural attenuation of benzene and in situ chemical oxidation of PCE at the PDO Yard and to decide if additional subsurface injection is required to remediate the site.

3.3.2 DQO Stage 2: Identify Data Needs

Data to be collected for the remedial action are to satisfy the following two general data needs:

- the data are to be sufficient to determine the effectiveness of natural attenuation and

- the data are to be of sufficient quality to evaluate the effectiveness of the in situ chemical oxidation at the PDO Yard.

Sufficient groundwater data are to be collected to determine the effectiveness of the remedial action. No soil, sediment, or surface water samples will be collected.

QC samples are to be collected and analyzed to provide data of sufficient quality to be legally defensible. Duplicate samples and equipment rinsate samples will be collected at rates of 10 percent and 5 percent, respectively, of the total number of samples. Trip blanks will be included in each cooler containing water samples designated for volatile organic analysis. Temperature blanks also will be placed in each cooler for shipment.

3.3.3 DQO Stage 3: Specify Data Collection

Types and sample locations to determine the effectiveness of the remedial action are based on the DQOs and nature and extent of contamination identified in the RFI Report and on the requirements to evaluate the effectiveness of the remedial action as specified in the CAP Report. The sampling requirements are divided into monitoring of natural attenuation and monitoring of the remedial system. Baseline sampling was conducted in August 2000 in order to refine the design on the in situ chemical oxidation system.

3.3.3.1 Monitored natural attenuation monitoring 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.

Baseline groundwater sampling was conducted in October 2000 prior to the start of the Monitored Natural Attenuation period. The eight groundwater monitoring wells were sampled and analyzed for BTEX. The results of the baseline sampling indicated that benzene concentrations remain above the RL of 5 μg/L (Figure 3-1); thus, Monitored Natural Attenuation is still necessary for this area of the site.

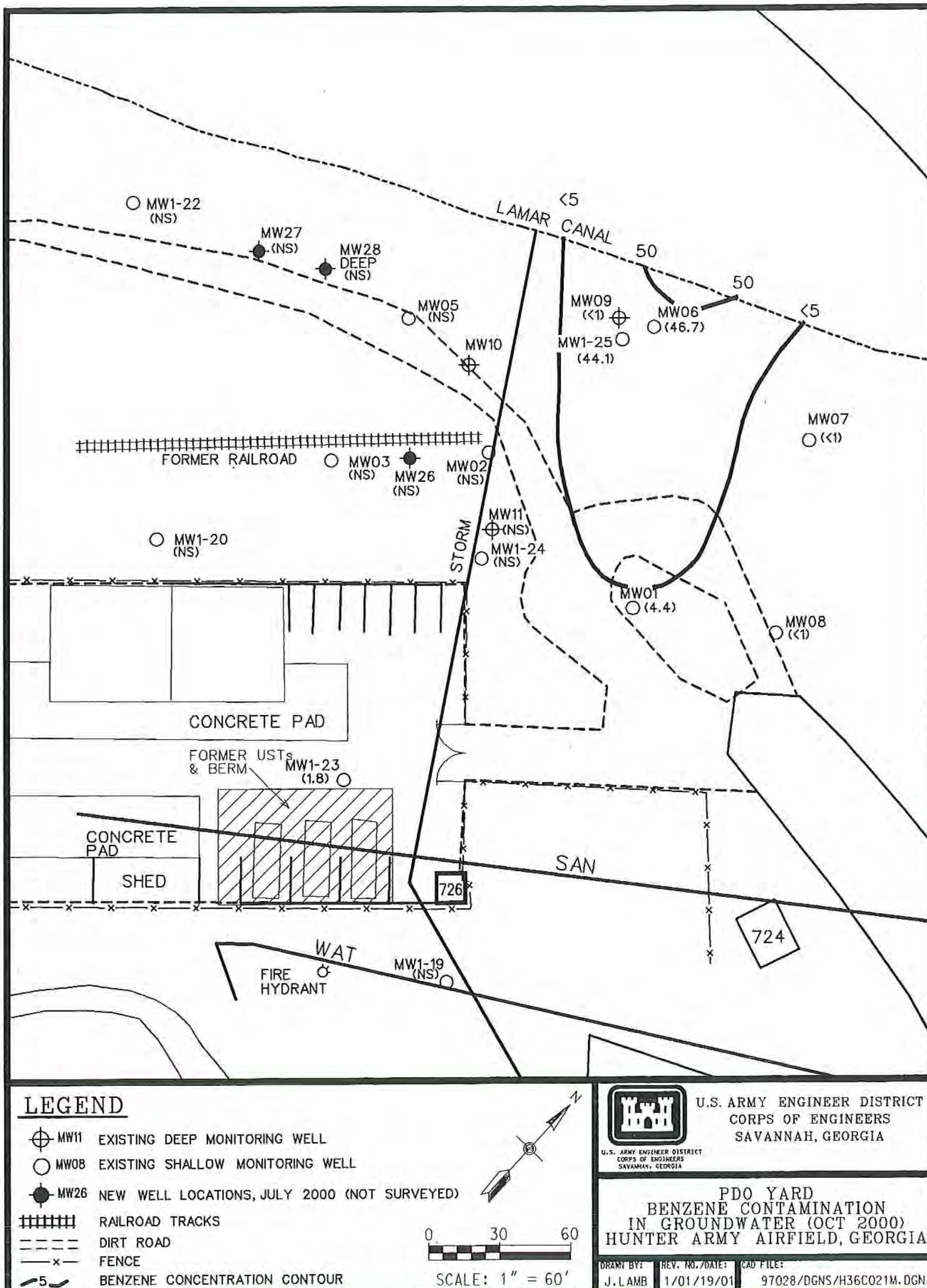

Figure 3-1. Benzene Concentrations in Groundwater at the PDO Yard (October 2000)

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 BTEX 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. The first semiannual sampling event is scheduled to be conducted in July 2001. 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 6 months following completion of the Monitored Natural Attenuation period to verify that the groundwater RL for benzene has been achieved and maintained. Samples will be collected from each of the eight wells and analyzed for BTEX.

3.3.3.2 Remedial action for remediation of PCE

The Geo-Cleanse® groundwater treatment system design is based on the baseline analytical sampling conducted in August 2000 and was provided by the system vendor. Figure 3-2 indicates the location of the PCE groundwater plume that requires corrective action and the design layout is presented in Figure 3-3.

Geo-Cleanse® design layout. The contaminated groundwater plume extends over an irregularly shaped area about 200 feet wide and 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 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 bgs). The treatment area has been separated into two areas for the injector design and installation. The first area is defined as the "source" area, which surrounds MW-26 and is approximately 50 feet x 70 feet x 90 feet x 85 feet and includes the former rail bed which is no longer present on site. The second area is defined as the "residual" area, which surrounds MW-27, MW-28, MW-5 & MW-10, is approximately 90 feet x 70 feet x 200 feet x 160 feet, includes the dirt road, and is bound in the northwest by Lamar Canal. The design includes the installation of ten shallow injectors and nineteen deep injectors for a total of 29 injectors as shown on Figure 3-3. For the source area treatment, GCI plans to utilize five shallow injectors screened from 9 feet to 12 feet bgs and eight deep injectors screened from 17 feet to 20 feet bgs. For the residual area treatment, GCI will utilize five shallow injectors screened from 9 feet to 12 feet bgs and eleven deep injectors screened from 17 feet to 20 feet bgs. Injector locations and depths may be adjusted based upon field conditions observed during injector installation.

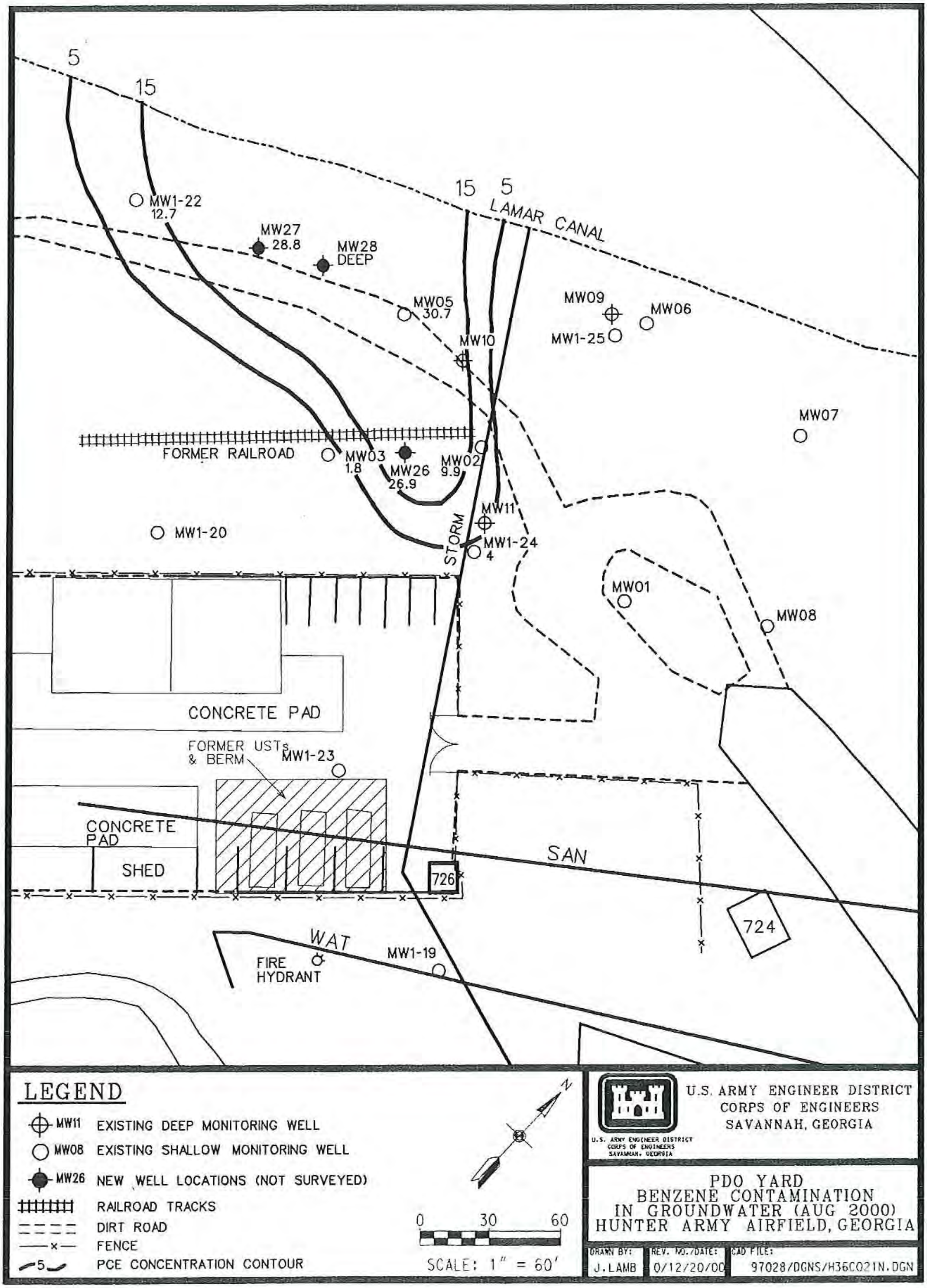

Figure 3-2. PCE Concentrations in Groundwater at the PDO Yard (August 2000)

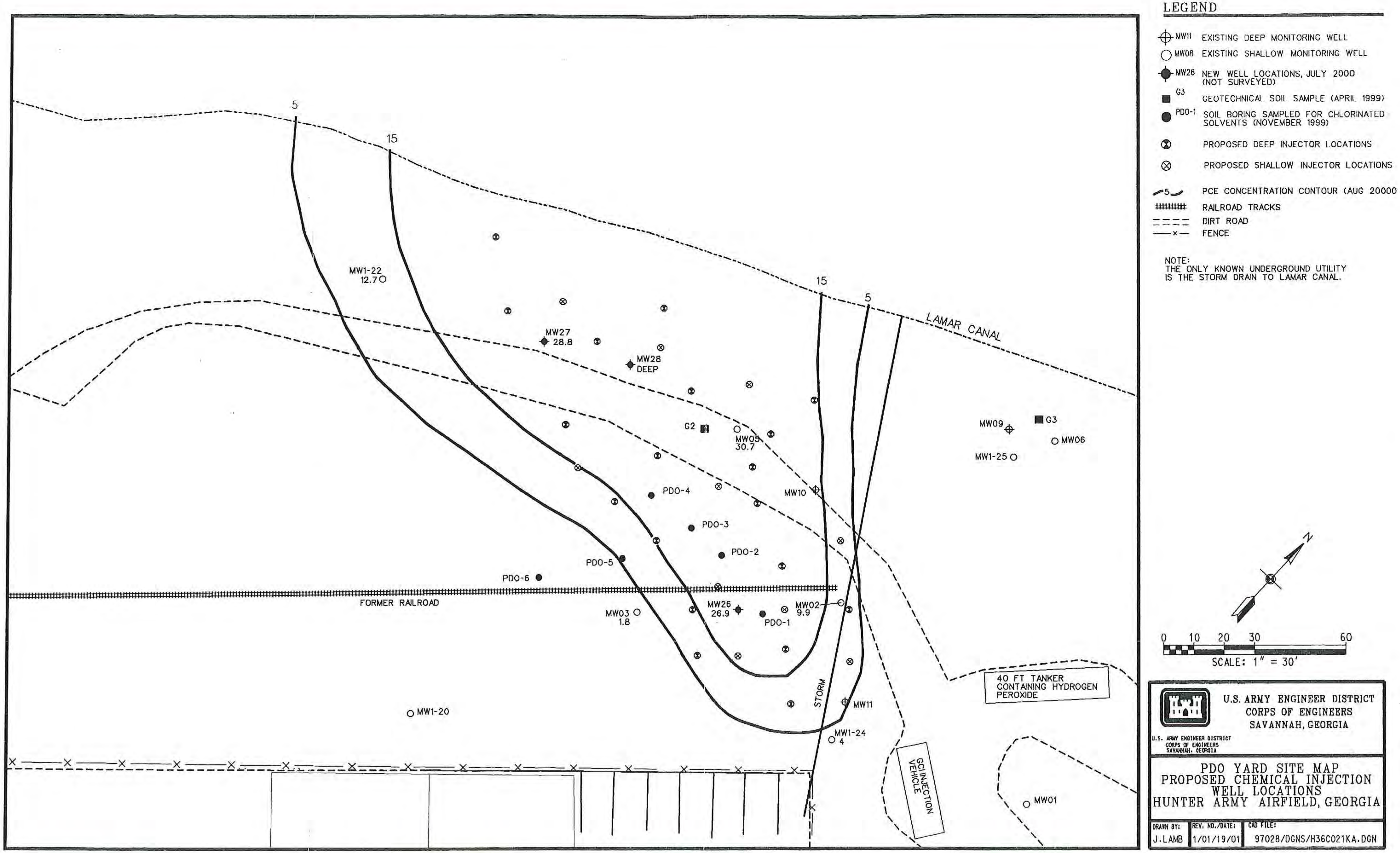

Figure 3-3. Proposed Chemical Injection Well Locations at the PDO Yard

Operational life model. The primary phase of the Geo-Cleanse® Treatment Program at the PDO Yard is anticipated to require approximately 9 days of injection activities, which include mobilization, injection, and demobilization. An estimated 70,000 pounds (7,000 gallons) of 50 percent hydrogen peroxide are anticipated for injection. A similar volume of catalyst solution is also anticipated for injection, but the exact volume required that is necessary to achieve the groundwater quality conditions will be determined based upon the process monitoring. The primary treatment phase is intended to address the levels of contamination. Polishing treatments might be conducted if necessary. The objective of a polishing treatment is to address any residual contaminant mass that was not destroyed during the primary treatment phase. A polishing treatment phase, if necessary, will include installation of up to two additional injectors, injection of up to 10,000 pounds (1,000 gallons) of 50 percent hydrogen peroxide solution and a similar volume of catalyst solution, and up to 3 days of injection activities.

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 a 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, the 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 per minute with pressures averaging 20 pounds 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 proposed in the CAP included 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). These wells (MW26, MW27, and MW28) were installed in July 2000, as shown in Figure 3-2, 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) were screened to bisect the water table, for a total depth of less than 20 feet. The deep well (MW28) was screened between a depth of 35 feet and 45 feet bgs. These three monitoring wells were constructed using carbon steel casing and stainless steel screen to withstand high temperatures during Geo-Cleanse® treatment. The other existing wells might need to be replaced with steel casing and stainless steel screen in case the existing PVC wells become damaged during the 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.

Following chemical oxidation treatment, the seven shallow monitoring wells (i.e., MW02, MW03, MW05, MW1-22, MW1-24, MW26, and MW27) and three deep monitoring wells (i.e., MW10, MW11, and MW28) will be sampled to verify that PCE concentrations have declined to less than 5 μg/L. The quantitation limits for chemicals analyzed should be sufficiently low to allow evaluation against regulatory levels. Table 3-1 lists the project-required quantitation limits for chemicals analyzed in water samples and the associated regulatory levels. There are no soil samples being collected as part of the corrective action.

Groundwater treatment completion criteria. Completion criteria for the Geo-Cleanse® treatment are listed in the O&M Plan, Appendix D, of the CAP. 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.

Table 3-1. Comparison of Project-required Quantitation Limits for Water Samples to Regulatory Levels

Constituent	Project Quantitation Levels (μg/L)	Remedial Level (μg/L)
Benzene	1	5
Tetrachloroethene	1	5

4. FIELD ACTIVITIES

4.1 MONITORED NATURAL ATTENUATION FOR BENZENE PLUME

4.1.1 Rationale

During the Monitored Natural Attenuation period, seven shallow wells (MW01, MW02, MW06, MW07, MW08, MW1-23, and MW1-25) and one deep well (MW09) will be sampled on a semiannual basis for a period of 2 years (i.e., 4 sampling events) to verify that benzene concentrations are declining and that active biodegradation is occurring. Samples will be analyzed at an off-site laboratory for BTEX and for natural attenuation parameters (methane, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron). The first semiannual sampling event is scheduled to be conducted in July 2001.

Confirmation groundwater sampling will be conducted 6 months following the completion of the Monitored Natural Attenuation period to verify that the groundwater RL for benzene has been achieved and maintained. Samples will be collected from each of the eight wells and analyzed for BTEX.

4.1.2 Field Measurements

Groundwater field measurements performed during the project will include measurement of water level, pH, specific conductance, temperature, oxygen reduction potential (ORP), DO, and ferrous iron. Descriptions of each field instrument, associated calibration requirements, and performance checks for field measurements are presented in Table 4-1. A summary of the procedures and criteria to be used for the measurement of field parameters of groundwater samples is presented below. If sample temperatures are not compatible with requirements for measuring key parameters, samples will be placed in a location at which they will be allowed to stabilize to the ambient temperature appropriate for the required tests to be performed.

Table 4-1. Summary of Field Instruments and Calibration/Performance Requirements for Groundwater Sampling

Instrument and Use	Calibration	Performance
QED Water Quality Monitoring System[a]: used for determination of water temperature	1 point comparison to mercury thermometer on a daily basis	+0.4°C
QED Water Quality Monitoring System[a]: used for determination of water conductivity	1 point using conductivity standard solution on a daily basis	±3 percent of reading
QED Water Quality Monitoring System[a]: used for determination of water pH or equivalent	2 points using pH 4.0 and 7.0 standard solutions on a daily basis	±0.1 units
QED Water Quality Monitoring System[a]: used for determination of water ORP	2 points using Eh standard solutions on a daily basis	±2%
QED Water Quality Monitoring System[a]: used for determination of water DO	2 points using calculated value for water at atmospheric temperature and pressure	±0.1 ppm

[a]Or equivalent instrument.
DO = dissolved oxygen
ORP = oxygen reduction potential

Water level measurement. A complete round of water level measurements will be collected prior to initiating the semiannual groundwater sampling activities at the site. These measurements will include a notation for the presence of any streams, lakes, or open water bodies (natural and man-made) within

300 feet of these wells. Static groundwater level measurements will be made using an electronic water level indicator. Initially, the indicator probe will be lowered into each monitoring well without touching the probe to the well casing until the alarm sounds or the indicator light illuminates. The probe will then be withdrawn several feet and slowly lowered again until the groundwater surface is contacted, as noted by the alarm or indicator light. All probe cords used for measurement will be incrementally marked at 0.02-foot intervals. Water level measurements will be estimated to the nearest 0.01 foot based on the difference between the nearest probe cord mark and the top of the well casing.

The distance between the top of casing and the groundwater surface will be recorded to within 0.01 foot. The static water level measurement procedure will be repeated two or three times to ensure that the water level measurements are consistent (plus or minus 0.01 foot). If this is the case, then the first measured level will be recorded as the depth to groundwater. If this is not the case, the procedure will be repeated until consistent readings are obtained from three consecutive measurements.

pH, specific conductance, temperature, oxygen reduction potential, and dissolved oxygen. pH, specific conductance, temperature, ORP, and DO measurements will be recorded for groundwater during well development, well purging, and groundwater sampling. These measurements will be made using a combination meter designed to measure these parameters. Initially, a groundwater sample will be retrieved from each monitoring well and either monitored using a flow through cell or immediately poured into a clean glass container placed on a stable surface at the well location. The sample's pH will be recorded to the nearest 0.1 pH unit. The pH measurement procedure will be repeated, using a new sample each time, until the pH measurements are consistent (less than 0.2-pH unit variation). The sample's conductivity will be recorded to the nearest 10 µmhos/cm and the temperature to the nearest 0.1°C. The conductivity and temperature measurement procedure will be repeated at least three times using a new sample each time until the measurements are consistent (less than 10-percent variation for conductance and less than 0.5°C variation for temperature). The sample Eh will be recorded to the nearest 10 mV. The ORP measurement will be repeated, using a new sample each time, until the Eh measurements are consistent (less than 20-mV variation). The sample dissolved oxygen will be recorded to the nearest 0.01 ppm. The dissolved oxygen measurement procedure will be repeated until the dissolved oxygen measurements are consistent (less than 0.02-ppm variations).

4.1.3 Groundwater Sampling

Collection of groundwater samples from monitoring wells will be accomplished in three general steps: (1) measurement of field parameters, (2) well purging, and (3) groundwater sample collection. Purging and sampling of monitoring wells will be accomplished using a decontaminated, nondedicated, low-flow downhole pump, bailer, or similar equipment.

The inlet of the sampling pump will be placed at the midpoint of the screened interval. This level will be adjusted for wells at which the static water level is within the well screen. Prior to installation of the sampling pump, the static water level will be recorded. Purging and sampling activities can not begin until either the static water level returns to within 10 percent of the initial static water level or 12 hours have passed since installation of the pump, whichever occurs first.

The well will be purged using either a downhole pump or micropurging techniques to minimize the volume of purge water, disturbance of the aquifer, and disturbance of the samples. The field parameters pH, conductivity, temperature, ORP, and DO will be monitored during purging. The purge rate will be adjusted, as necessary, to avoid purging any well to dryness and to equal the recharge of the aquifer. Purging will be considered complete when the field parameters stabilize within plus or minus 10 percent after a minimum of three readings at 5-minute intervals.

Sampling of the monitoring well will begin immediately after completion of purging. The groundwater sample volume initially obtained will be used for laboratory chemical testing. All groundwater samples will be transferred directly into laboratory sample containers from the sampler. The portion of the sample designated for volatile organic analysis will be poured into laboratory sample containers first, followed by pouring of the remaining sample portion into containers designated for other types of chemical analyses. Sample containers designated for volatile organic analysis will be filled so that no headspace is present in the containers. Immediately after collection of samples and completion of sample container label information, each container will be placed into an ice-filled cooler to ensure preservation.

4.1.3.1 Sample analysis

Samples will be analyzed at an off-site laboratory for BTEX and for natural attenuation parameters (i.e., those for methane, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron). A summary of the number of groundwater samples and analytical parameters to be collected from the monitoring wells is presented in Table 4-2.

Purging and sampling for groundwater from monitoring wells will be performed with a low-flow, nondedicated downhole pump or bailer. Field measurements of pH, specific conductance, temperature, ORP, and DO will be conducted during purging and sampling. Groundwater samples will be collected immediately after completion of purging.

4.1.3.2 Quality control/quality assurance samples

Three different types of QC samples will be collected during performance of groundwater sampling activities. These sample types will be duplicates, rinsate blanks, and trip blanks.

QC duplicate samples. During the sampling of groundwater from monitoring wells, QC duplicates will be collected along with groundwater samples. The monitoring well locations selected for duplicate sampling will be based on review of historical information indicating which wells have shown elevated concentrations of contaminants of concern. The exact number of duplicate samples will depend on the total number of groundwater samples collected for the project; however, the total number will be at least 10 percent of the entire sample population. The QC duplicates will be analyzed for the groundwater analytes listed in Table 4-2.

QC rinsate blank samples. During the decontamination of sampling equipment used for groundwater purging and collection, QC rinsate blanks will be collected from the bladder pumps and/or Teflon bailers used to collect groundwater samples from groundwater monitoring wells. The total number of rinsate blanks to be collected from the monitoring wells will represent approximately 5 percent of the entire sample population. These samples will be collected on a regular basis throughout the implementation of investigation activities. The QC rinsate blanks will analyzed for the groundwater analytes listed Table 4-2.

QC trip blank samples. QC trip blanks consisting of sealed containers of American Society for Testing and Materials (ASTM) Type II or equivalent water will be used for the project. One trip blank will be placed into each cooler used to store portions of groundwater samples designated for volatile organic analysis at the on-site and off-site laboratories. These blanks will remain with the other sample containers until groundwater sampling is completed and the samples are shipped to the off-site laboratory for chemical analysis.

Table 4-2. Sampling and Analytical Requirements for the Corrective Action at the PDO Yard, Hunter Army Air Field, Georgia

Samples			Field QC Samples					QA Samples					
Matrix	Parameter	Analytical Methods[a]	No. Field Samples	No. Dups.	No. Sampler Rinsates	No. Trip Blanks[b]	Total Samples	QA Dups.	QA Trip Blank[b]	Total QA Samples	Holding Times	Preservation	Sample Containers
Groundwater (benzene plume MNA, 4 semiannual events and, 1 confirmation event with 8 wells/event)	BTEX	8260B	40	4	2	5	51	0	0	0	14 days	Ice to 4°C HCl to pH<2 No headspace	Two 40-mL GSV
	methane		32	4	2		38	0	0	0	14 days	Ice to 4°C	Two 40-mL GSV
	carbon dioxide	SM 4500	32	4	2		38	0	0	0	7 days	Ice to 4°C No headspace	one 250-mL glass
	nitrate/nitrite	353.3	32	4	2		38	0	0	0	28 days	Ice to 4°C H_2SO_4 to pH<2	one 250-mL HDPE
	sulfate	300.0	32	4	2		38	0	0	0	28 days	Ice to 4°C	one 250-mL HDPE
	sulfide	376.2	32	4	2		38	0	0	0	7 days	Ice to 4°C zinc acetate and NaOH	one 500-mL HDPE
	total iron	6010B	32	4	2		38	0	0	0	180 days	Ice to 4°C HNO_3 to pH<2	one 250-mL HDPE
Groundwater (PCE plume remediation)	VOCs (screening)	8260B	15	0	0	2	19	0	0	0	14 days	Ice to 4°C HCl to pH<2 No headspace	Two 40-mL GSV
	VOCs (post remediation)	8260B	20	2	2	4	28	0	0	0	14 days	Ice to 4°C HCl to pH<2 No headspace	Two 40-mL GSV
Groundwater IDW	VOCs	8260B	2	0	0	0	2	0	0	0	14 days	Ice to 4°C HCl to pH<2 No headspace	Two 40-mL GSV
	Total Phenols	420.3	2	0	0	0	2	0	0	0	28 days	Ice to 4°C H_2SO_4 to pH<2	One 1-L AG
	Oil & Grease	413.2	2	0	0	0	2	0	0	0	28 days	Ice to 4°C H_2SO_4 to pH<2	One 1-L AG
	pH	150.1	2	0	0	0	2	0	0	0	upon receipt	Ice to 4°C	one 250-mL HDPE
Soil IDW	TCLP VOCs	8260B	29	0	0	0	29	0	0	0	14 days	Ice to 4°C	4-oz CWM

[a]SW-846.
[b]One trip blank with each cooler containing VOC samples.
AG = Amber glass.
GSV = Glass septa vial.
CWM = Clear, widemouth glass jar.
HDPE = High-density polyethylene.

Temperature blank samples. Each cooler of samples shipped to the laboratory or to other facilities for analysis will have a temperature blank included for purposes of verifying that adequate preservation temperatures have been maintained during transit.

A summary of the QA/QC groundwater sample types to be collected during the project is presented in Table 4-2.

4.2 REMEDIAL ACTION FOR PCE PLUME

4.2.1 Rationale

As part of the Geo-Cleanse Process®, chemical injection wells will be installed for the injection of hydrogen peroxide and a catalyst into the contaminated region. A detailed description of the remedial design is provided in the Injection Work Plan prepared by GCI and is presented in Appendix B.

The overall monitoring program consists of two parts: (1) performance monitoring and (2) process monitoring. Performance monitoring refers to pre-, during, and post-test analyses of groundwater samples collected within (and adjacent to) the treatment area, for target chlorinated hydrocarbon compounds, to evaluate overall treatment effectiveness. Process monitoring refers to analyses of groundwater and offgas samples collected within and adjacent to the treatment area, during implementation of the in situ chemical oxidation treatment, for purposes of determining if appropriate geochemical conditions are established in the aquifer, reagents are distributed effectively, and an efficient oxidation reaction is occurring. SAIC will be responsible for conducting the performance monitoring and GCI will be responsible for conducting process monitoring.

4.2.2 Chemical Injection Wells

Twenty nine injection wells will be installed in unconsolidated material using hollow-stem augering. The ten shallow injection wells will be screened from 9 feet to 12 feet bgs and the 19 deep injection wells will be screened from 17 feet to 20 feet bgs. The location of the injection wells were presented in Figure 3-3. A schematic of a typical injection well is presented in the Injection Work Plan in Appendix B. Documentation of boring logs and well installation diagrams is presented in Section 4.3.

4.2.2.1 Drilling methods

The hollow-stem-auger drilling method will be used during the project for drilling of soil boreholes for the installation of injection wells. This method will be implemented as a dry drilling method for the project. The augers used for drilling of boreholes for injection wells will have a 4.25-inch inside diameter and will create an approximate 9.5-inch boring. During all borehole drilling, soil samples will be collected continuously on 5-foot centers from the ground surface to the water table for lithology and IDW characterization.

Soil drilling using the hollow-stem-auger method will be accomplished using truck-mounted CME-55 auger rigs, or equivalent, of sufficient size and power to advance augers to the anticipated maximum drilling depth. The depth at which the injection well screen should be set will dictate the total depth of each borehole. After the hollow-stem augers have been advanced to the desired depth at each borehole location, 2-inch stainless steel injection wells (approximate outside diameter depending on casing and screen manufacturer) will be installed.

4.2.2.2 Injection well installation

Well casing and screen. The injection wells will be constructed with 2-inch outside diameter (OD) stainless steel screen and 1.25-inch OD Schedule 80 black iron riser pipe and couplings. The screens for the injection wells will be placed a minimum of 1 foot below the contaminated interval, corresponding to (or below) the zone of maximum contamination (the "smear zone"), resulting in an estimated borehole depth of 14 feet to 22 feet. The installation depths indicated in the figures are based upon available site information and may be adjusted in the field. All screens used for injection well construction will be installed such that the bottom of each well screen is placed no more than 2 feet above the bottom of the drilled borehole. The screen bottom will be securely fitted with a threaded cap or plug. The cap/plug will be within 6 inches of the open portion of the screen. The injection well screen will be 0.01-inch slot and will be 3 feet in length. The top of each installed injection well casing will be level so that the difference in elevation between the highest and lowest points on the top of the well casing is less than or equal to 0.2 inch. A schematic of the injection well is provided in the Injection Work Plan in Appendix B.

Filter pack placement. Granular filter pack material used for injection well construction will be placed within the annular space around the well screen using a tremie pipe. If approved water is used to place the filter pack, the amount of this water will be recorded. The filter pack will extend from the bottom of the borehole to 1 foot above the top of the well screen. In addition, 6 inches of sand will be placed under the bottom of the well screen to provide a firm footing. The final depth to the top of the filter pack will be measured directly with a weighted tape and recorded on the associated well construction diagram.

Bentonite seal. The type of bentonite material used for construction of injection well seals will be composed of commercially available pellets. Pellet seals will be at least 1-foot thick as measured immediately after placement, without allowance for swelling. A tremie pipe will not be used for placement of the pellets unless significant bridging occurs or is suspected of being a problem. Placement of the bentonite will include periodic tamping of the bentonite pellets to prevent bridging during emplacement. After placement of the bentonite pellets, a small volume of approved water will be used, if necessary, to hydrate the pellets, and the hydration time for the pellets will be a minimum of 1 hour. The final depth to the top of the bentonite seal will be measured directly with a weighted tape and recorded on the associated well construction diagram.

Cement/bentonite grout placement. All prescribed portions of grout material used for injection well construction will be combined in an aboveground, rigid container and mechanically blended to produce a thick, lump-free mixture throughout the mixing vessel. The grout will be placed using a rigid tremie pipe with side discharge, initially located just over the top of the bentonite seal.

Based on the anticipated method to be implemented for well construction, the hollow-stem augers will be incrementally removed during the grouting operation. After grouting has been completed to within approximately 10 feet of the ground surface, the remaining augers will be removed from the boring, and the remaining annulus will be grouted from the surface. For flush-mounted well completions, grout will be poured to 2 feet bgs.

Upon initiation of grouting operations, the process will be conducted continuously until the surface casing is installed or the well is grouted to the required levels. After 24 hours, the site will be checked for grout settlement, and more grout will be added at that time to fill any depression. This process will be repeated until firm grout remains at or near the required depth. Incremental quantities of grout added in this manner will be recorded on the well construction diagram.

Protective casing. All the injection wells will be flush-mount installations as described in Section 4.2.3.3.

4.2.3 Monitoring Well Installation

4.2.3.1 Drilling methods and equipment

The hollow-stem-auger drilling method will be used during the project for drilling of soil boreholes for groundwater monitoring well installation. This method will be implemented as a dry drilling method for the project. The augers used for drilling of boreholes for groundwater monitoring well installation will have a 4.25-inch inside diameter and will create an approximately 9.5-inch boring. During the borehole drilling for the installation of shallow monitoring wells, soil samples will be collected continuously on 5-foot centers from ground surface. Soil sampling during the installation of the groundwater wells will be for only the purposes of lithology and IDW characterization. For installation of the shallow monitoring wells, the boreholes will be drilled to allow 5 feet of the 10-foot screen to be placed below the water table.

Soil drilling using the hollow-stem-auger method will be accomplished using truck-mounted CME-55 auger rigs, or equivalent, of sufficient size and power to advance augers to the anticipated maximum drilling depth. At selected locations where replacement wells are required, after the hollow-stem augers have been advanced to the maximum drilling depths, 2-inch carbon steel with stainless steel screen groundwater monitoring wells will be installed.

4.2.3.2 Materials and installation

As noted previously, one type of monitoring well surface completion will be required for the project: flush-mounted surface completion. Figure 4-1 conceptually illustrates the proposed construction for this type of well. A discussion of the monitoring well installation process for the project is presented below.

Well casing and screen

Well casing. The well casing materials used for construction of monitoring wells will be composed of new, precleaned, 2-inch carbon steel. Casing sections will be flush-threaded, and thermal- or solvent-welded couplings will not be used. Gaskets, pop rivets, and screws will also not be used during monitoring well construction. The top of each installed monitoring well casing will be level, so that the difference in elevation between the highest and lowest points on the top of the well casing is less than or equal to 0.2 inch.

Well screen. The well-screen materials used for construction of monitoring wells will be composed of new, precleaned, 2-inch stainless steel screen. Screen sections will be commercially fabricated and slotted with openings equal to 0.010-inch. Screen sections will be flush-threaded, and thermal- or solvent-welded couplings will not be used. Gaskets, pop rivets, and screws will also not be used during monitoring well construction. Each screen section will measure 10 feet in length, and a threaded stainless steel cap or plug will be placed onto the bottom of each screen. All screens used for monitoring well construction will be installed such that the bottom of each well screen is placed no more than 2 feet above the bottom of the drilled borehole. All materials used for monitoring well construction will be as chemically inert as technically practical with respect to the site environment.

Filter pack, bentonite seal, and grout mixture

Filter pack. The filter pack will be appropriately sized for use with the preselected screen slot size. The granular filter pack material will be visually clean (as seen through a 10-power hand lens), free of material that would pass through a No. 200 sieve, inert, siliceous, and composed of rounded grains. The filter material will be packaged in bags or buckets by the supplier and delivered intact to the site.

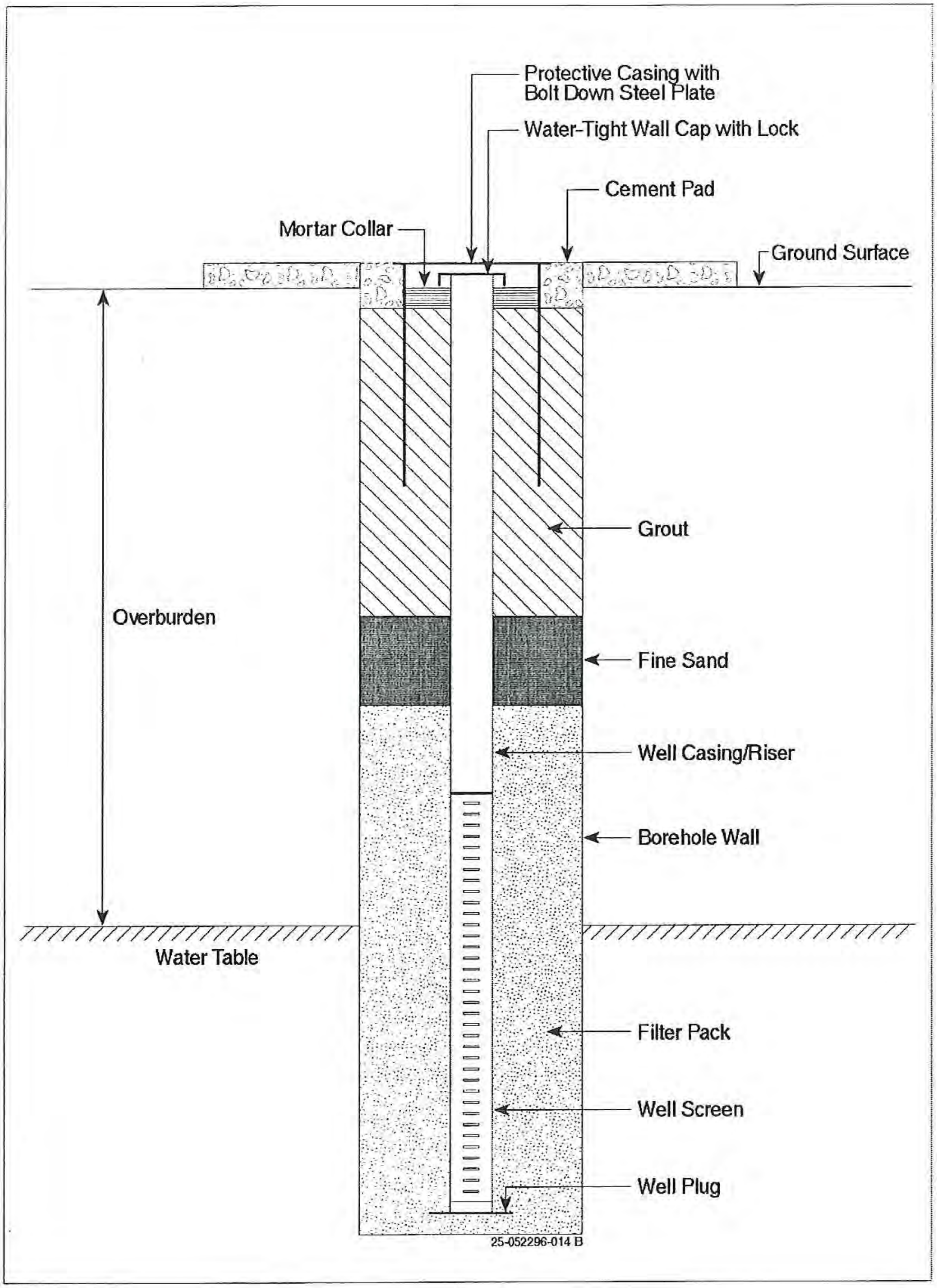

Figure 4-1. Flush-mounted Surface Monitoring Well Completion

Granular filter pack material used for monitoring well construction will be placed within the annular space around the monitoring well screen using a tremie pipe. If approved water is used to place the filter pack, the amount of this water will be recorded and added to the volume of water to be removed during well development. The filter pack will extend from the bottom of the borehole to 2 feet above the top of the well screen. In addition, 6 inches of sand will be placed under the bottom of the well screen to provide a firm footing. The final depth to the top of the filter pack will be measured directly with a weighted tape and recorded on the associated well construction diagram.

Bentonite seal. Compressed, powdered bentonite pellets, generally measuring 0.25 inch in size, will be used for annular seal applications. Powdered bentonite will be used for grout additive applications. For installing the bentonite seal in the deep wells, a bentonite slurry might be used until the seal is installed above the water table, at which time bentonite pellets will be used.

Bentonite seals will be at least 2-feet thick as measured immediately after placement, without allowance for swelling. A tremie pipe will not be used for placement of the pellets unless significant bridging occurs or is suspected of being a problem. Placement of the bentonite will include periodic tamping of the bentonite pellets to prevent bridging during emplacement. After placement of the bentonite pellets, a small volume of approved water will be used, if necessary, to hydrate the pellets, and the hydration time for the pellets will be a minimum of 1 hour. The final depth to the top of the bentonite seal will be measured directly with a weighted tape and recorded on the associated well construction diagram.

Grout mixture. Grout used for monitoring well installation or borehole abandonment (if required) will be composed of Type I Portland cement; 3 pounds of dry, powdered bentonite per 94-pound sack of dry cement; and a maximum of 7 gallons of approved water per sack of cement for an approximate grout weight of 12 pounds to 15 pounds per gallon. All grout materials will be combined in an aboveground, rigid container or mixer and mechanically blended on-site to produce a thick, lump-free mixture throughout the mixing vessel. The grout will be placed using a tremie pipe of rigid construction for vertical control of grout placement. The tremie pipe will be equipped with side discharge holes rather than an open end to help maintain the integrity of the underlying material onto which the grout is placed.

Based on the method expected to be implemented for well construction, the hollow-stem augers will be incrementally removed during the grouting operation. After grouting has been completed to within approximately 10 feet of the ground surface, the remaining augers will be removed from the boring, and the remaining annulus will be grouted from the surface. For abovegrade monitoring well installations, grout will be poured to the ground surface.

Upon initiation of grouting operations, the process will be conducted continuously until the surface casing is installed or the well is grouted to the required levels. After 24 hours, the site will be checked for grout settlement, and more grout will be added at that time to fill any depression. This process will be repeated until firm grout remains at or near the required depth.

4.2.3.3 Surface completion

Well caps. The well caps used for construction of monitoring wells will be composed of new, precleaned PVC. The tops of all monitoring well casings will be covered with locking, expanding well caps. The caps will be fitted to the casings and will be designed to preclude binding to the casing as a result of tightness of fit, unclean surface, or frost and to allow for equilibration between hydrostatic and atmospheric pressures (vented). The caps also will be designed to fit securely enough to preclude debris and insects from entering the monitoring well.

Well protection assembly. Flush-mounted surface completions will be installed for monitoring wells located at the site. The wells will be located in an open field where mowing is routinely performed.

The protective casing used for construction of all monitoring wells will be composed of new iron/steel. The diameter of all protective casings will be 8 inches. The length of the protective casing used for flush-mounted surface completions will be 1 foot. The protective casing will be surrounded by 3-foot-square, 4-inch-thick concrete pads sloped away from the casing. The protective casings for flush-mounted installations will be set flush with the surrounding concrete surface and will be equipped with bolt-down covers. All protective casings will be installed so that the distance between the top of the protective casing and the top of the well casing is no more than 3 inches.

Following the placement of each protective casing, a mortar collar will be poured on the day firm grout remains at the ground surface. The collar will be poured within the annulus between the protective casing and the well casing to approximately 5 inches bgs. During the placement of the mortar collar, a sloping concrete pad measuring approximately 3 square feet by 3 square feet will be poured around the exterior of the protective casing. The thickness of each concrete pad will be 4 inches.

4.2.3.4 Water source

Water will be used for the following purposes:

- tremie granular filter pack or bentonite, if necessary;
- preparation of grout mixture used for monitoring well installation or borehole abandonment;
- preparation of cement mixture used for construction of monitoring well surface completions;
- hydration of bentonite seals and/or columns, as necessary; and
- decontamination of drilling and sampling equipment.

The water source used for the project will be identified by the Fort Stewart Directorate of Public Works and will be free of contaminants. The water source used for the project also will comply with other requirements defined in Section 3-8, Subsection b, Items #1a through #1f of USACE Procedure EM 1110-1-4000 (USACE 1994) and will be approved by the USACE, Savannah District, Project Manager before use. Field personnel will be responsible for transportation and storage of the approved water required for investigation needs in a manner that will avoid chemical contamination or degradation of the approved water once obtained.

4.2.3.5 Delivery, storage, and handling of materials

All monitoring well construction materials will be supplied and delivered by the subcontracted drilling company. Upon their delivery to the site, the SAIC Field Manager will inspect all of the materials to ensure that the required types of materials have been delivered and that the materials have not been damaged or contaminated during transport to the site. During this inspection the SAIC Field Manager will collect and file any material certification documentation attached to or accompanying the materials. All material certification documentation will be maintained on-site until completion of the project, at which time the documentation will be transferred to the project file. All materials will be stored in a dry and secure location until they are used for monitoring well construction.

All well screens and well casings used for monitoring well construction will be free of foreign matter (e.g., adhesive tape, labels, soil, grease) and will be washed with approved water before use. If, however, the materials have been packaged by the manufacturer and have their packaging intact up to the time of installation, no prewashing will be conducted. Pipe nomenclature stamped or stenciled directly on well screens or solid casing to be located within and below the bentonite seal will be removed by sanding, unless removable by approved water washing. Washed screens and casings will be stored in plastic sheeting until immediately before insertion into the borehole. All well screens and casings used for construction will be free of unsecured couplings, ruptures, and other physical breakage or defects.

All protective casing materials will be cleaned before placement; free of extraneous openings; and devoid of any asphaltic, bituminous, encrusting, and/or coating materials (with the exception of black paint or primer applied by the manufacturer). Washed protective casing materials will be stored in plastic sheeting until immediately before placement around monitoring well casings.

4.2.3.6 Well identification

For each monitoring well installed, the well designation information will be engraved on a metal tag bearing the following information: contractor's name, registration number, well identification number, top of casing elevation (mean sea level), total depth, and date installed. The tag will be permanently attached to the protective casing or well casing. In addition, all wells will be permanently labeled "MONITORING WELL — NOT FOR WATER SUPPLY." Also, a placard labeled with the monitoring well identification number will be attached to the protective casing in such a manner as to be readable from a road or trail.

Additional wells installed during the investigation will be numbered consecutively beginning with MW-29. Boreholes drilled for monitoring well installation that are subsequently abandoned also will be numbered consecutively.

4.2.3.7 Well development

The development of monitoring wells installed during the project will be initiated no sooner than 48 hours after internal mortar collar placement or the final grouting of the wells.

Pump and surge-block usage. Development of monitoring wells will be accomplished using a surge block in combination with a downhole pump. During development operations the pump will be alternately started and stopped during groundwater removal, allowing the well to equilibrate and creating a surging action. The surge block will be used (as required) to agitate and mobilize particulates around the well screen by rapidly surging the well.

Development criteria. Development of each monitoring well will proceed until the following criteria are achieved:

- the well water is clear to the unaided eye;
- the sediment thickness remaining within the well is less than 0.1 foot; and
- a minimum removal of five times the standing water volume in the well (to include the well screen and casing plus saturated annulus, assuming 30-percent annular porosity) has been achieved.

The following field measurements will be recorded at the completion of well development: pH, specific conductance, and temperature. In the event that the development criteria noted above cannot be achieved after 6 consecutive hours, the SAIC Field Manager will notify the USACE, Savannah District, and request guidance.

Development water sample. For each monitoring well developed, a 1-L sample of the last water removed during development will be placed into a clear glass jar and labeled with the well number and date. Each sample will be individually agitated and immediately photographed close up with a 35-mm camera loaded with color print film, using a back-lit setup to show water clarity. These photographs, minimally 3 inches by 4 inches in size and individually identified with project name, well number, and photograph date, will be in the well development record provided to the USACE, Savannah District, at project close out. After the development water samples have been photographed, the samples will be disposed of in the same manner as the other water removed from the monitoring wells during the development operations.

Monitoring well washing. As part of each monitoring well development operation, the entire well cap and the interior of the well casing between the water table and the ground surface will be washed using water from the well. The purpose of this activity will be to remove extraneous materials (e.g., grout, bentonite, sand) from the interior of the well. The monitoring well washing activity will be conducted during the overall development operation.

4.2.3.8 Well survey

Coordinates and elevations shall be established for each soil borehole and monitoring well. The coordinates shall be to the closest 1 foot and referenced to the State Plane Coordinate System. If the State Plane Coordinate System is not readily available, an existing local grid system shall be established. A permanent survey mark (control point) shall be scribed on the top of each monitoring well riser casing. Ground elevations to the closest 0.1 foot and an elevation on the top of each well riser casing to the closest 0.01 foot shall be determined. Elevations shall be referenced to the National Geodetic Vertical Datum of 1983.

4.2.3.9 Well abandonment

Abandonment of soil boreholes for the installation of monitoring wells (if required) during the project will be conducted in a manner precluding any current or subsequent fluid media from entering or migrating within the subsurface environment along the axis or from the endpoint of the borehole or well. Abandonment will be accomplished by filling the entire volume of the borehole or well with grout composed of Type I Portland cement; 3 pounds of dry, powdered bentonite per 94-pound sack of dry cement; and a maximum of 7 gallons of approved water per sack of cement. In the event that abandonment of a completed monitoring well is required, all abovegrade and subsurface well materials will be removed prior to completion of abandonment.

Each borehole or well located in grass/gravel-covered areas will be sealed by grouting from the bottom of the borehole or well to the ground surface. For boreholes or wells located in concrete-covered areas, grout will be poured to the interface between the overlying concrete pad and underlying gravel/soil base. All grouting will be accomplished by placing a tremie pipe to the bottom of the borehole (i.e., to the maximum depth drilled) and pumping grout through this pipe until undiluted grout is present at the ground surface or the base of the surrounding concrete cover. After a 24-hour period, the abandoned site will be checked for grout settlement. At that time any settlement depression will be filled with grout. Additional grout will be added using a tremie pipe inserted to the top of the firm grout, unless the depth of the unfilled portion of the well or borehole is less than 10 feet and this portion is dry. This process will be repeated until firm grout remains at the ground surface.

The USACE, Savannah District, Project Manager will be contacted by telephone if closure of any borehole or well not scheduled for abandonment under this project is required. At that time the USACE, Savannah District, Project Manager will be informed of the borehole or well in question, current status (e.g., depth, contents of hole, stratigraphy, water level), and proposed reason for abandonment. Based on this information, the USACE, Savannah District, Project Manager will either approve the abandonment or will determine some other action to be taken.

For each abandoned borehole or well, a record will be prepared to include the following information:

- project and borehole or well designation;
- location with respect to the replacement borehole or well (if any);
- open depth of the borehole or well before grouting;
- casing or items left in borehole by depth, description, composition, and size (if applicable);
- copy of the borehole log;
- copy of construction diagram for the abandoned well (if applicable);
- reason for abandonment;
- description and total quantity of grout initially used;
- description and daily quantities of grout used to compensate for settlement;
- dates of grouting; and
- water or mud level prior to grouting and date measured.

All depths reported in the borehole or abandonment record will be designated in feet bgs.

4.2.4 Field Measurements

Groundwater field measurements performed during the project will include measurement of water level, pH, specific conductance, temperature, ORP, DO, and ferrous iron. Descriptions of each field instrument, associated calibration requirements, and performance checks for field measurements are presented in Table 4-3. A summary of the procedures and criteria to be used for the measurement of field parameters of groundwater samples is presented in Section 4.1.2. If sample temperatures are not compatible with requirements for measuring key parameters, samples will be placed in a location at which they will be allowed to stabilize to the ambient temperature appropriate for the required tests to be performed.

4.2.5 Groundwater (Performance) Monitoring

Performance monitoring refers to pre-, during, and post-test analyses of groundwater samples collected within and adjacent to the treatment area, for VOCs, to evaluate overall treatment effectiveness. The performance monitoring recommended in the CAP consisted of sampling seven shallow (i.e., MW02, MW03, MW05, MW1-22, MW1-24, MW26, and MW27) and three deep wells (i.e., MW10, MW11, and MW28) during a baseline sampling event, a sampling event following chemical injection, and a confirmation sampling event 6 months following chemical injection. The baseline sampling event for PCE was conducted in August 2000.

As part of the treatment design, GCI has requested that SAIC sample half (i.e., 15) of the injectors being installed for VOCs to help establish true pre-injection baseline numbers and to assist GCI in better defining the distribution of the contamination across the treatment zone. This additional information will assist GCI in determining the quantity of hydrogen peroxide to be injected into each injector and what the best possible picture for hydrogen peroxide needs will be for each area.

SAIC will conduct post-treatment performance monitoring in accordance with the timeline provided in the Injection Work Plan (Attachment B). Following completion of injection activities, an initial round of groundwater samples will be collected from seven shallow monitoring wells (MW02, MW03, MW05, MW1-22, MW1-24, MW26, and MW27) and three deep monitoring wells (MW10, MW11, and MW28) approximately 7 days after injection operations cease. An additional round of groundwater samples will be collected from seven shallow monitoring wells (MW02, MW03, MW05, MW1-22, MW1-24, MW26, and MW27) and three deep monitoring wells (MW10, MW11, and MW28) approximately 30 days after the end of injection. The purpose of these sampling rounds is to monitor effectiveness and potential rebound to determine if the treatment is successful. Typically, groundwater samples collected within 7 days of the end of treatment will yield elevated petroleum hydrocarbon concentrations if the treatment is incomplete (i.e., polishing is necessary). The 30-day round provides a longer period for the aquifer to return to an ambient condition and for contaminant rebound (if rebound occurs).

Collection of groundwater samples from monitoring wells will be accomplished in three general steps: (1) measurement of field parameters, (2) well purging, and (3) groundwater sample collection. Purging and sampling of monitoring wells will be accomplished using a decontaminated, nondedicated, low-flow downhole pump, bailer, or similar equipment. Procedures for groundwater sampling are described in Section 4.1.3.

4.2.5.1 Sample analysis

Samples will be analyzed at an off-site laboratory for PCE. A summary of the number of groundwater samples and analytical parameters to be collected from the monitoring wells is presented in Table 4-2.

Purging and sampling for groundwater from monitoring wells will be performed with a low-flow, nondedicated downhole pump or bailer. Field measurements of pH, specific conductance, temperature, ORP, and DO will be conducted during purging and sampling. Groundwater samples will be collected immediately after completion of purging.

4.2.5.2 Quality control/quality assurance samples

Three different types of QC samples will be collected during performance of groundwater sampling activities. These sample types will be duplicates, rinsate blanks, and trip blanks. The different of QC samples are described in Section 4.1.4.

4.2.6 Remediation system (process) monitoring

Groundwater and off-gas monitoring will be performed to monitor and control the subsurface conditions during the injection of the reagent chemicals into the subsurface. The injection of reagent chemicals into the subsurface will be performed during a 10-hour day for approximately 9 days. The rate of reagent chemical injection is determined and controlled by evaluating in situ measurements. Typically, the reagent chemicals are injected continuously over the 10-hour day.

Groundwater. During injection GCI routinely monitors pH, total iron, and hydrogen peroxide in groundwater. During each day of injection and prior to initiating the injection process, water level measurements will be taken and water samples collected for routine water quality measurements from each monitoring well within the treatment area. The measurements performed will include groundwater pH, alkalinity, dissolved iron, and hydrogen peroxide concentration. Measurements will be performed with field test kits. In addition, the same suite of measurements will be conducted at the end of each day prior to concluding the injection. Additional samples may be measured for any of these parameters throughout the course of the day, but not at prescribed intervals.

Injection well off-gas. Concurrent with the injection program, carbon dioxide and oxygen produced as by-products of the chemical oxidation process will be measured from the headspace in the injectors and monitoring wells adjacent to the treatment area. Routine sweeps of all injectors and monitoring wells will be conducted at approximately 2-hour intervals throughout the course of the day, resulting in a minimum of six measurements over a 10-hour day. A photoionization detector (PID) for organic vapors (equipped with an 10.2-eV lamp) will be used to screen the injector and monitoring well headspaces.

4.3 DOCUMENTATION

4.3.1 Boring logs

Each borehole log generated for soil sample collection or the installation of a monitoring well during the project will fully describe the subsurface environment and the procedures used to gain that description. All boreholes will be recorded in the field by the site geologist on Engineer Forms 5056-R and 5056A-R (Figure 4-2). A scale of 1 inch equals 1 foot will be used during borehole log preparation. Each original borehole log will be submitted by SAIC to the USACE, Savannah District, Project Manager. Original borehole logs will be of sufficient legibility and contrast so as to provide comparable quality in reproduction and will be recorded directly in the field without transcribing from a field logbook or other document.

All borehole logs generated during the project will routinely contain the information listed below.

- Unique borehole number and location denoted on a sketch map as part of the log.
- Depths or heights recorded in feet and decimal fractions thereof (in 0.1-foot increments).
- Field estimates of soil classification in accordance with ASTM D2488 prepared in the field at the time of sampling by the site geologist.
- Full description of each soil sample collected, including the parameters noted in Table 4-3.
- Visual numeric estimates of secondary soil constituents and quantitative definitions of descriptive terms (e.g., trace, some, several) recorded on the log.
- Description of disturbed samples (if used to supplement subsurface description) in terms of the appropriate soil parameters, to the extent practical. At a minimum, classification along with a description of drill action for the corresponding depth will be recorded. Notations will be made on the log that these descriptions are based on observations of disturbed material rather than intact samples.
- Description of drilling equipment, including such information as auger size (inner and outer diameter), bit types, compressor type, rig manufacturer, and model.
- Sequence of drilling activities.
- Any special problems encountered during drilling and their resolutions.
- Dates and times for the start and completion of the borehole, along with notation by depth for drill-crew shifts and individual days.
- Each sequential boundary between various soil types and individual lithologies.

HTRW DRILLING LOG	DISTRICT	HOLE NUMBER
1. COMPANY NAME	2. DRILL SUBCONTRACTOR	SHEET SHEETS OF

3. PROJECT	4. LOCATION
5. NAME OF DRILLER	6. MANUFACTURERS DESIGNATION OF DRILL
7. SIZES AND TYPES OF DRILLING	8. HOLE LOCATION
	9. SURFACE ELEVATION
	10. DATE STARTED / 11. DATE COMPLETED
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED
13. DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		

LOCATION SKETCH/COMMENTS SCALE:

PROJECT	HOLE NO.

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

Figure 4-2. HTRW Drilling Log

SHEET OF SHEETS				
ELEV. (A)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)

Figure 4-2. HTRW Drilling Log (continued)

Table 4-3. Soil Parameters Associated with Borehole Logging

Soil Parameters
Classification
Depositional environment and formation, if known
ASTM D2488 group symbol
Secondary components and estimated percentages
Color (using Munsell Soil or GSA Rock Color Chart); give both narrative and numerical descriptions and note which chart was used
Plasticity
Consistency (cohesive soil)
Density (noncohesive soil)
Moisture content in relative terms
Structure and orientation
Grain angularity

- Depth of first-encountered free water along with the method of determination.
- Interval by depth for each sample collected, including the length of sampled interval, length of sample recovery, and sampler type and size (diameter and length).
- Total depth of drilling and sampling.
- Results of soil sample organic vapor headspace readings. Notation will include interval sampled, corresponding vapor readings, and key to the specific instrument used to obtain readings. A general note will be made on the log indicating the manufacturer, model, serial number, and calibration information for each instrument used.
- Definition of any special abbreviations used at the first occurrence of their usage.

4.3.2 Well installation diagrams

Each monitoring well installed during the project will be depicted in an as-built well construction diagram. Each diagram will be attached to the original borehole log for that installation and will graphically denote, by depth from the ground surface, the following information:

- location of borehole bottom and borehole diameter(s);
- location of well screen;
- location of any joints;
- location of granular filter pack;
- location of bentonite seal;
- location of grout;
- location of centralizers;
- height of riser (stickup), without cap/plug, above the ground surface;
- height of protective casing, without cap/cover, above the ground surface;
- depth of protective casing base below the ground surface;
- location and size of drainage port;
- location of internal mortar collar;
- sloped concrete pad height and diameter;

- protective post configuration; and
- water level 24 hours after completion of installation, with date and time of measurement.

Additional information to be described on each as-built well construction diagram will include the following:

- actual quantity and composition of the grout, bentonite seal, and granular filter pack used for construction of the monitoring well;

- screen slot size in inches, slot configuration, total open area per foot of screen, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer;

- type of material located between the bottom of the borehole and the bottom of the screen;

- outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer of the well casing;

- joint design and composition;

- design and composition of centralizers;

- depth and description of any permanent pump or sampling device installed within the monitoring well;

- composition and nominal inside diameter of protective casing;

- any special problems encountered during well construction and their resolutions;

- dates and times for the start and completion of monitoring well installation; and

- definition of any special abbreviations used at the first occurrence of their usage.

4.3.3 Development records

For each monitoring well developed during the project, a record will be prepared to include the following information:

- project name and location;

- well designation and location;

- date(s) and time(s) of monitoring well installation;

- date(s) and time(s) of monitoring well development;

- static water level from top of well casing before and 24 hours after completion of well development, with dates and times of measurements;

- quantity of water lost during drilling, removed before well insertion, and added during granular filter placement;

- quantity of standing water contained within the well, and contained within the saturated annulus (assuming 30-percent porosity), before well development;

- field readings of pH, specific conductance, turbidity, and temperature measured before, twice during, and after completion of well development using appropriate devices and methods (see Section 4.3.5 of this plan for the field measurement parameters and procedures to be used for field measurements);

- depth from top of well casing to bottom of well;

- length of well screen;

- depth from top of well casing to top of sediment inside the well, both before and after development, as measured directly at the time of development;

- physical character of the removed water, including changes during development in clarity, color, particulates, and any noted odor;

- type and size/capacity of the bailer or pump used for development;

- description of the surge technique used during development;

- height of the well casing above the ground surface as measured directly at the time of development;

- estimated recharge rate at the time of development;

- quantity of water removed from the well during the development operation and the time for removal (presented as both incremental and total values); and

- photograph of the last water removed during monitoring well development.

4.3.4 Photographs

For each photograph taken during the project, the following items will be noted in the field logbook:

- date and time,
- photographer (name and signature),
- site name,
- aspect and description of the subject taken, and
- film roll number and sequential number of the photograph.

Photographs taken to document sampling points will include two or more permanent reference points within the photograph to facilitate relocating the point at a later date. In addition to the information recorded in the field logbook, one or more site photograph reference maps will be prepared as required.

4.4 EQUIPMENT DECONTAMINATION

Decontamination of equipment used for the development and purging of monitoring wells and collection of groundwater samples will be conducted between samples. The decontamination area will be designed so that all decontamination liquids are contained and can be recovered for disposal as IDW. Nondedicated equipment will be decontaminated after each use. The procedure for decontamination of this type equipment will be as follows:

1. Wash with approved water and phosphate-free detergent using various types of brushes required to remove particulate matter and surface films.

2. Rinse thoroughly with approved potable water.

3. Rinse thoroughly with ASTM Type I or equivalent water.

4. Rinse thoroughly with isopropyl alcohol.

5. Rinse thoroughly with ASTM Type I or equivalent water.

6. Place smaller items of equipment on aluminum foil if immediate use is anticipated, or wrap in aluminum foil to prevent contamination if longer-term storage is required. Plastic wrap will be used for only larger items such as augers.

In addition to the sampling equipment, field measurement instruments also will be decontaminated between uses. Only those portions of each instrument that come into contact with potentially contaminated environmental media will be decontaminated. Because of the delicate nature of these instruments, the decontamination procedure will involve only initial rinsing of the instrument probes with approved water, followed by a final rinse using ASTM Type I or equivalent water.

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5. SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

5.1 FIELD LOGBOOKS

Information pertinent to sampling activities, including field instrument calibration data, will be recorded in field logbooks in accordance with SAIC Field Technical Procedure (FTP)–125, "Use of Field Logbooks." The logbooks will be bound, and the pages will be consecutively numbered. Entries in the logbooks will be made in black, waterproof ink and will include, at a minimum, a description of all activities, needs of individuals involved in sampling activities, date and time of sampling, weather conditions, any problems encountered, and all field measurements. Lot numbers, manufacturer name, and expiration dates of standard solutions used for field instrument calibration will be recorded in the field logbooks. A summary of each day's activities also will be recorded in the logbooks.

Sufficient information will be recorded in the logbooks to permit reconstruction of all sampling activities conducted. Information recorded on other project documents will not be repeated in the logbooks, except in summary form when deemed necessary. All field logbooks will be kept in the possession of field personnel responsible for completing the logbooks, or in a secure place when not being used during fieldwork. Upon completion of the field activities, all logbooks will become part of the final project evidence file. The title page of each logbook will be labeled with the following information:

- logbook title,
- project name,
- USACE, Savannah District, contract number and project delivery order number,
- start date for field activities recorded in the logbook, and
- end date for field activities recorded in the logbook.

Entries recorded in logbooks will include, but not be limited to, the following information:

- name and title of author, date, and times of arrival at and departure from the work site;
- purpose of the sampling activity;
- name(s) and address(es) of the field contact(s);
- names and responsibilities of field crew members;
- names and titles of any site visitors;
- type, matrix, and containerization method for IDW generated;
- sample collection method;
- number and volume of sample(s) collected;
- references for all maps of the sampling site(s);

- information regarding sampling changes, scheduling modifications, and change orders;
- information regarding access agreements, if applicable;
- details of the sampling location, including a sketch map illustrating the sampling location;
- date and time of sample collection and name of collector;
- field observations;
- exposure monitoring;
- types of field instruments used and purpose(s) of use, including calibration methods and results;
- any field measurements made (e.g., pH, specific conductance, temperature, static groundwater level);
- sample identification number(s);
- information from containers, labels of reagents used, deionized and organic-free water used, etc.;
- sampling type and methodology (e.g., grab or composite samples);
- sample preservation methods;
- sample distribution and transportation (e.g., name and address of the laboratory and courier);
- sample documentation information including:
  - COC record numbers and
  - description of the number of shipping containers packaged (including contained COC records) and the shipping method employed (noting applicable tracking numbers);
- decontamination procedures;
- IDW documentation information including:
  - types of containers/drums,
  - contents, type, and approximate volume of waste, and
  - type of contamination and predicted level of contamination based on available information;
- summary of daily tasks (including costs, where appropriate) and documentation on any cost or scope of work changes required by field conditions; and
- signature and date entered by personnel responsible for observations recorded.

5.2 SAMPLE NUMBERING SYSTEM

A unique sample numbering scheme will be used to identify each sample designated for laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be used on all sample labels or tags, field data sheets and/or logbooks, COC records, and all other applicable documentation used during the project.

The sample numbering scheme used for field samples will also be used for duplicate samples so that these types of samples will not be discernible by the laboratory. Other types of field QC samples, however, will be numbered so that they can be readily identified from different sample types. A summary of the sample numbering scheme to be used for the project is presented in Table 5-1.

Table 5-1. Sample Numbering Scheme for the Remedial Action at the PDO Yard, HAAF, Georgia

Sample Identification: XX##NT			
XX = Area Designator	Example		
	AP	=	PDO Yard
## = Monitoring Well/Sampling Location	Examples		
	01	=	monitoring well MW-01
N = Sample Number or Depth	Sample number will be a sequential number		
	1	=	First sample interval
	2	=	Second sample interval
	3	=	Third sample interval
T = Sample Type	Examples		
	1	=	soil sample
	2	=	groundwater sample
	3	=	soil duplicate
	4	=	groundwater duplicate
	5	=	rinsate blank (soil equipment)
	6	=	rinsate blank (groundwater equipment)
	7	=	soil QA split
	8	=	groundwater QA split
	9	=	surface water sample
	0	=	sediment sample
All trip blank samples used during the project will be consecutively identified as follows: TB001, TB002, TB003, etc.			

5.3 SAMPLE DOCUMENTATION

5.3.1 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- contractor name,
- sample identification number,
- sample type (discrete or composite),

- site name and sampling station number,
- analysis to be performed,
- type of chemical preservative present in container,
- date and time of sample collection, and
- sampler's name and initials.

5.3.2 Sample Field Logbook

The logbooks will be completed by the field personnel during sampling or other field activities. The sample log will contain the following information:

- project name or identification,
- names and affiliations of sample collectors,
- instrument measurements,
- sample identification numbers,
- date(s) and time(s) of sample collection,
- methods of sample collection and deviations from the sampling procedure, and
- analyses required.

The sample log will also act as the field COC form for each sample collected until the samples are transferred to the laboratory COC form for shipment.

5.3.3 Chain-of-custody Records

COC procedures implemented for the project will be in accordance with SAIC FTP-625, "Chain of Custody," and will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The COC form serves as a legal record of possession of the sample. A sample is considered to be under custody if one or more of the following criteria are met:

1. the sample is in the sampler's possession,

2. the sample is in the sampler's view after being in his/her possession,

3. the sample was in the sampler's possession and then was placed into a locked area to prevent tampering, or

4. the sample is in a designated secure area.

Custody will be documented throughout the project field sampling activities by the COC form initiated for each day during which samples are collected. This record will accompany the samples from the site to the laboratory and will be returned to SAIC with the final analytical report. All personnel with sample custody responsibilities will be required to sign, date, and note the time on the COC form when relinquishing samples from their immediate custody (except in the case in which samples are placed into designated secure areas for temporary storage prior to shipment). Bills of lading or airbills will be used as custody documentation during times when the samples are being shipped from the site to the laboratory and will be retained as part of the permanent sample custody documentation.

COC forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfers between personnel, shipment, and receipt by the laboratory, COC forms will be completed for sample sets as deemed appropriate during the course of fieldwork. An example of the COC form to be used for the project is provided in Figure 5-1. The following information will be recorded on all COC forms:

- sample number (for each sample in shipment);
- collection date and time (for each sample in shipment);
- number of containers for each sample;
- sample description (i.e., environmental medium);
- analyses required for each sample;
- sample preservation technique(s);
- COC or shipment number;
- shipping address of the laboratory;
- date, time, method of shipment, courier, and airbill number; and
- spaces to be signed as custody is transferred between individuals.

The individual responsible for shipping of the samples from the field to the laboratory will be responsible for completing the COC form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. In addition, this individual will be responsible for determining the shipping classification for samples under U.S. Department of Transportation (DOT) HM126F. After the form has been inspected and determined to be satisfactorily complete, the responsible individual will sign, date, and note the time of transfer on the form. When a commercial carrier is used, the COC form will be placed in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached. When using a laboratory carrier, the COC form will be placed in a sealable bag on the outside of the cooler. The field copy will be detached after the laboratory carrier has signed for the samples. The field copy of the form will be appropriately filed and kept at the site for the duration of the site activities.

In addition to the COC form, COC seals also will be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers in such a manner that if the cooler is opened, the seals will be broken. The COC seals will be used to ensure that no sample tampering occurs between the time that the samples are placed into the coolers and the time that the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the COC form contained within the cooler.

5.3.4 Cooler Receipt Checklist

The condition of shipping coolers and enclosed sample containers will be documented upon receipt at the analytical laboratory, using the cooler receipt checklist presented in Figure 5-2. One of these checklists will be placed either into each shipping cooler along with the completed COC form or provided to the laboratory at the start of the project. A copy of the checklist will be faxed to the SAIC Project Manager immediately after it has been completed at the laboratory. The original, completed checklist will be transmitted with the final analytical results from the laboratory.

800 Oak Ridge Turnpike, Oak Ridge, TN (423) 481-4800

CHAIN OF CUSTODY RECORD

COC NO:

PROJECT NAME:	**LABORATORY NAME:**
PROJECT NUMBER:	**LABORATORY ADDRESS:**
PROJECT MANAGER:	**PHONE NO:**
Sampler (Signature) (Printed Name)	

Sample ID	Date Collected	Time Collected	Matrix	REQUESTED PARAMETERS												No. of Bottles/Vials:	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS,

RELINQUISHED BY:	Date/Time	RECEIVED BY:	Date/Time	TOTAL NUMBER OF CONTAINERS:	Cooler Temperature:
COMPANY NAME:		COMPANY NAME:		Cooler ID:	
RECEIVED BY:	Date/Time	RELINQUISHED BY:	Date/Time		
COMPANY NAME:		COMPANY NAME:			
RELINQUISHED BY:	Date/Time	RECEIVED BY:	Date/Time		
COMPANY NAME:		COMPANY NAME:			

Figure 5-1. Example Chain-of-custody Form

COOLER RECEIPT CHECKLIST

LIMS number ____________________ Chain-of-Custody No.
Project: ____________________ Date received: ____________________
A. Preliminary Examination Phase Date cooler(s) opened: ____________________
by (print) ____________________ (signature) ____________________

Circle response below as appropriate

1. Did cooler(s) come with a shipping slip (airbill, etc.)? .... Yes No NA

If YES, enter courier name & airbill number here: ____________________

2. Were custody seals on outside of cooler(s)? Yes No NA

How many & where: ________ Seal date: ________ Seal name: ____________________

3. Were custody seals unbroken and intact at the date and time of arrival? .... Yes No NA
4. Did you screen samples for radioactivity using a Geiger Counter? .... Yes No NA
5. Were custody papers sealed in a plastic bag & taped inside the cooler lid? .... Yes No NA
6. Were custody papers filled out properly (ink, signed, etc.)? .... Yes No NA
7. Did you sign custody papers in the appropriate place for acceptance of custody? .... Yes No NA
8. Was project identifiable from custody papers? .... Yes No NA
9. If required, was enough ice present in the cooler(s)? .... Yes No NA

Identify type of ice used in cooler and temperature reading upon receipt: ____________________
Source of temperature reading (check one): Temperature Vial ( ) Sample Material ( )

10. Initial and date this form to acknowledge receipt of cooler(s): (initial) ________ (date) ________

B. Log-In-Phase Date samples were logged in: ____________________

by (print) ____________________ (signature) ____________________

11. Describe type of packing in cooler(s): ____________________
12. Were all bottles sealed in separate plastic bags? .... Yes No NA
13. Did all bottles arrive unbroken & were labels in good condition? .... Yes No NA
14. Was all required bottle label information complete? .... Yes No NA
15. Did all bottle labels agree with custody papers? .... Yes No NA
16. Were correct containers used for the analyses indicated: .... Yes No NA
17. Were correct preservatives placed into the sample containers? .... Yes No NA
18. Was a sufficient amount of sample sent for the analyses required? .... Yes No NA
19. Were bubbles absent in VOA vials? .... Yes No NA

If no, list by sample number: ____________________

20. Has a copy of this Cooler Receipt Checklist been faxed to the SAIC Laboratory Coordinator? .... Yes No NA

Figure 5-2. Cooler Receipt Checklist

5.4 DOCUMENTATION PROCEDURES

The tracking procedure to be used for documentation of all samples collected during the project will involve the following series of steps:

1. collection and placement of samples into laboratory sample containers;
2. completion of sample container label information;
3. placement of sample containers into an ice-filled cooler;
4. completion of sample documentation information in the field logbook;
5. completion of project and sampling information sections of the COC form(s) for all samples to be transported in a single cooler;
6. completion of the airbill for the cooler to be shipped;
7. performance of a completeness and accuracy check of the COC form(s);
8. completion of the sample relinquishment section of the COC form(s) and placement of the form(s) into or onto the cooler;
9. placement of COC seals on the exterior of the cooler;
10. packaging and shipment of the cooler to the laboratory;
11. receipt of cooler at the laboratory, inspection of contents, and transmittal via fax of contained COC form(s); and
12. transmittal of original COC form(s) with final analytical results from the laboratory.

5.5 CORRECTIONS TO DOCUMENTATION

All original information and data in field logbooks, on sample labels, on COC forms, and on any other project-related documentation will be recorded in black, waterproof ink and in a completely legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. Any error discovered on a document will be corrected by the individual responsible for the entry. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and all corrections will be initialed and dated by the individual responsible for the entry.

6. SAMPLE PACKAGING AND SHIPPING

6.1 SAMPLE PACKAGING

Sample containers will be packaged in thermally insulated, Styrofoam™ coolers that will be sealed and placed into heavy cardboard shipping boxes or thermally insulated, rigid-body coolers. Sample packaging and shipping will be conducted in accordance with applicable DOT specifications. Packaging and shipping procedures to be used for environmental samples collected during the project will include those listed below.

- Sample containers will be adequately identified with sample labels placed onto each container.
- All bottles, except those containing samples designated for volatile organic analyses, will be taped shut with electrical tape.
- Each sample bottle will be placed into a separate plastic bag that will then be sealed. For groundwater samples, each volatile organic analyte vial will be wrapped in a paper towel, and the vials will be then placed into one plastic bag. Trip blank containers also will be wrapped and placed in the bag with the volatile organic analyte vials. As much air as possible will be squeezed from the sample-container bags prior to sealing.
- All of the sample containers will be placed upright in the shipping coolers, along with wet ice or chemical ice in double plastic bags that will be placed around, among, and on top of the sample containers. A laboratory-provided courier may not require that the ice be contained in double plastic bags. Before initial placement of samples into a rigid-body cooler, the cooler's drain plug will be taped shut from both the inside and outside, and the cooler will be lined with a large plastic bag.
- Inert packing material will be placed into the cooler, if required to prevent shifting of the sample containers during transport.
- All required laboratory paperwork, including the COC form(s), will be placed inside a plastic bag and taped to the inside of the cooler lid. If a laboratory-provided courier is used, the paperwork may be attached to the outside of the cooler.
- Upon completion of the packing process, the cooler lid will be closed, and two signed and dated custody seals will be placed on the cooler, one across the front and one across the side.
- The Styrofoam™ coolers will be placed into heavy cardboard shipping boxes that will be sealed with strapping tape. Rigid-body coolers will be sealed by applying strapping tape directly to the cooler body.
- The airbill for the shipment will be completed and attached to the top of the shipping box or cooler, which will then be transferred to the courier for delivery to the laboratory.

The checklist presented in Figure 6-1 will be used by the individual responsible for packaging environmental samples to verify completeness of sample shipment preparations. In addition, the laboratory will document the condition of the environmental samples upon receipt.

SAMPLE PACKAGING CHECKLIST

ATTENTION: Failure to properly handle or document the project sample could jeopardize the usability of the sample results and ultimately the project objectives. Prior to sending this cooler to the analytical laboratory at the address indicated on the chain-of-custody form, please check the following items:

- Is the project clearly identified on the chain-of-custody form (including the USACE delivery order number)?
- Are all enclosed sample containers clearly labeled with waterproof (permanent) ink?
- Are the required analyses indicated on the bottle labels and chain-of-custody form, and are the metals to be analyzed individually noted on the chain-of-custody form?
- Does the information on the chain-of-custody form match the information on the sample container labels?
- Has the chain-of-custody form been placed into a plastic bag and attached to the inside of the cooler lid?
- Have the samples been properly preserved (acid or base and cooling to 4°C)?
- Is the client information, including point of contact and telephone number, complete on the chain-of-custody form?
- Is there sufficient ice (double-bagged in sealable plastic bags) in the cooler to ensure preservation of the samples during shipment?

Figure 6-1. Sample Packaging Checklist

6.2 SAMPLE SHIPPING

All environmental samples collected during the project will be shipped no later than 48 hours to 72 hours after the time of collection, except for the sediment volatile organic analyte sample, which requires shipment within 24 hours. The extended time of 72 hours may be necessary if the samples are collected on a Friday and have to be shipped on a Monday via commercial courier. During the time period between collection and shipment, all samples will be stored in ice-filled coolers or refrigerated and kept in a secure area. All coolers containing environmental samples will then be shipped overnight to the laboratory by Federal Express, a similar courier, or a laboratory-provided courier. Due to holding time limitations, SAIC will discourage the shipping of samples on Fridays unless it is absolutely necessary, and the laboratory has assured SAIC that personnel will be present on Saturdays to receive and effect any necessary processing within the holding time.

6.3 ANALYTICAL LABORATORIES

The analytical laboratory to be used by SAIC for the project will be General Engineering Laboratories, 2040 Savage Road, Charleston, South Carolina 29414 (telephone: 803-556-8171). This laboratory is currently approved by the USACE, Center of Expertise, to perform the analytical methods required for

ATTENTION: Failure to properly handle or document the project sample could jeopardize the usability of the sample results and ultimately the project objectives. Prior to sending this cooler to the analytical laboratory at the address indicated on the chain-of-custody form, please check the following items:

- Is the project clearly identified on the chain-of-custody form (including the USACE delivery order number)?
- Are all enclosed sample containers clearly labeled with waterproof (permanent) ink?
- Are the required analyses indicated on the bottle labels and chain-of-custody form, and are the metals to be analyzed individually noted on the chain-of-custody form?
- Does the information on the chain-of-custody form match the information on the sample container labels?
- Has the chain-of-custody form been placed into a plastic bag and attached to the inside of the cooler lid?
- Have the samples been properly preserved (acid or base and cooling to 4°C)?
- Is the client information, including point of contact and telephone number, complete on the chain-of-custody form?
- Is there sufficient ice (double-bagged in sealable plastic bags) in the cooler to ensure preservation of the samples during shipment?

6.2 SAMPLE SHIPPING

All environmental samples collected during the project will be shipped no later than 48 hours to 72 hours after the time of collection, except for the sediment volatile organic analyte sample, which requires shipment within 24 hours. The extended time of 72 hours may be necessary if the samples are collected on a Friday and have to be shipped on a Monday via commercial courier. During the time period between collection and shipment, all samples will be stored in ice-filled coolers or refrigerated and kept in a secure area. All coolers containing environmental samples will then be shipped overnight to the laboratory by Federal Express, a similar courier, or a laboratory-provided courier. Due to holding time limitations, SAIC will discourage the shipping of samples on Fridays unless it is absolutely necessary, and the laboratory has assured SAIC that personnel will be present on Saturdays to receive and effect any necessary processing within the holding time.

6.3 ANALYTICAL LABORATORIES

The analytical laboratory to be used by SAIC for the project will be General Engineering Laboratories, 2040 Savage Road, Charleston, South Carolina 29414 (telephone: 803-556-8171). This laboratory is currently approved by the USACE, Center of Expertise, to perform the analytical methods required for the project. Environmental samples collected during the project investigations will be submitted to General Engineering Laboratories, for chemical testing. A summary of the specific chemical analyses and associated testing methods for each sample type to be collected is presented in the Data Management Plan in Appendix C.