Fort Stewart, Georgia

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SWMU 39
RCRA Facility Investigation Work Plan

Direct Support Maintenance Facility

Fort Stewart, Georgia

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Revision 1 – June 2010

Original Report – December 2009

ARCADIS

Infrastructure, environment, buildings

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ARCADIS

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SWMU 39 RCRA Facility Investigation Work Plan

Direct Support Maintenance Facility

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Our Ref.:
GP08HAFS.F39A.DA0WP

Date:
December 9, 2009

GEORGIA REGISTERED PROFESSIONAL ENGINEERING CERTIFICATION

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

Name: Charles A. Bertz, P.E.

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Expiration Date: December 31, 2010

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12.09.2009

Date

Tables

Figures

Appendices

Acronyms

amsl	Above Mean Sea Level
ARCADIS	ARCADIS U.S. Inc.
BERA	Baseline ERA
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAP	Corrective Action Plan
cis-1,2-DCE	cis-1,2-dichloroethene
COPC	Constituent of Potential Concern
COPEC	Constituent of Potential Ecological Concern
CSM	Conceptual Site Model
1,1-DCE	1,1-dichloroethene
DOT	U. S. Department of Transportation
DPT	Direct Push Technology
DSMF	Direct Support Maintenance Facility
ELCR	Excess Lifetime Cancer Risk
ERA	Ecological Risk Assessment
EU	Exposure Unit
ft	Feet
ft bgs	feet below ground surface
GA EPD	Georgia Environmental Protection Division
HHRA	Human Health Risk Assessment
HOT	Heating Oil Tank
IDW	Investigation Derived Waste
IRA	Interim Remedial Action
IWQS	In-Stream Water Quality Standards
LNAPL	light non-aqueous phase liquid
MCL	Maximum Contaminant Limit
µg/L	micrograms per Liter
MTBE	Methyl tert butyl ether
ORC®	Oxygen Release Compound®
PAH	Polyaromatic Hydrocarbon
PBC	Performance Based Contract
PCE	Tetrachloroethene
PID	Photo Ionization Detector

PPE	Personal protective equipment
PVC	Polyvinyl chloride
RCRA	Resource Conservation Recovery Act
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
SLERA	Screening Level ERA
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TPH DRO	Total Petroleum Hydrocarbons – Diesel Range Organics
TPH GRO	Total Petroleum Hydrocarbons – Gasoline Range Organics
trans-1,2-DCE	trans-1,2-dichlroethene
USAEC	United States Army Environmental Command
USEPA	U. S. Environmental Protection Agency
UST	Underground Storage Tank
95UCL	95 Percent Upper Confidence Level
VC	Vinyl chloride
VOC	Volatile Organic Compound

1. Introduction

ARCADIS U.S. Inc. (ARCADIS) has been retained by the United States Army Environmental Command (USAEC) to perform investigation and remediation activities at Fort Stewart in accordance with the requirements of the Performance Based Contract (PBC) number W91ZLK-05-D-0015. Fort Stewart, originally known as Camp Stewart, was established in June 1940 as an anti-aircraft artillery training center. The current primary mission for Fort Stewart is a training and maneuver area, providing tank, field artillery, helicopter gunnery, and small arms training for regular Army and National Guard units. The 24th Infantry Division, which was reflagged as the 3rd Infantry Division in May 1996, was permanently stationed at Fort Stewart in 1975.

Fort Stewart is located in portions of Liberty, Bryan, Long, Tattnall, and Evans Counties, Georgia, approximately 40 miles west-southwest of Savannah, Georgia (Figure 1-1). The cantonment, or garrison area, is located within the Liberty County portion on the southern boundary of the reservation. Hinesville, Georgia, is the nearest city to the garrison area and is located immediately outside of the reservation boundary.

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Work Plan describes proposed soil and groundwater investigation activities at Solid Waste Management Unit (SWMU) 39. SWMU 39 refers to the Direct Support Maintenance Facility (DSMF) or Building 1160 as referenced in the Georgia Environmental Protection Division (GA EPD) Facility Permit #HW-045(S&T). For the purpose of this investigation, SWMU 39 includes the DSMF fenced area and groundwater impacts identified to the south and east of the fenced area (Figure 1-2).

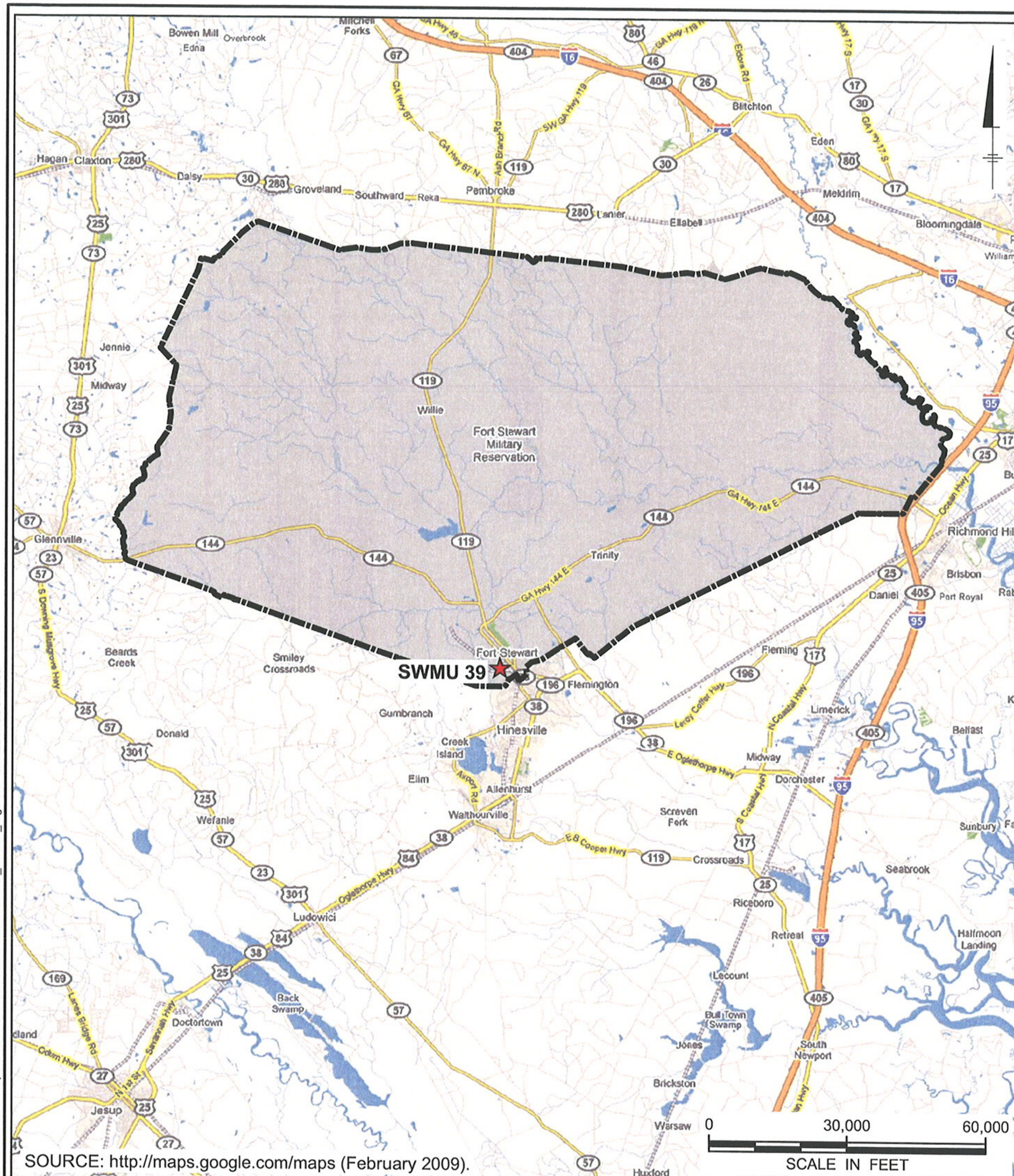
1.1 Site Background

The DSMF is a fenced facility with controlled access covering an area of approximately 10 acres. Historically the area was used as a vehicle wash/service rack. Two former underground storage tanks (USTs), USTs 59 and 60, and their associated heating oil tanks (HOTs) were west of Building 1160, at the tracked vehicle maintenance platform. The HOTs provided fuel oil to a high-pressure washer at the platform. USTs 59 and 60 were non-regulated, flow through vessels associated with the M60 maintenance platforms. The USTs were rarely used. An additional 500 gallon UST (UST 61) was located immediately southeast of the tracked vehicle maintenance platform (Building 1161) and was used for the storage of used oil. All of USTs have been removed from the site.

Investigations of the soil, groundwater, surface water, and sediment have been ongoing at this facility since 2001. During the investigations, a light non-aqueous phase liquid (LNAPL) believed to be waste oil was detected near Building 1161 and former UST 61. Excavations were conducted in 2006 and 2007 to remove the LNAPL and any impacts to soil. In April 2008, LNAPL was detected in an additional monitoring well near Building 1161.

Groundwater investigations have indicated a diffuse chlorinated volatile organic compound (VOC) plume, consisting primarily of trichloroethene (TCE). The source of the TCE is unknown. The TCE concentrations are low with a maximum detection of 27 micrograms per liter (µg/L) in April 2008. Previous investigations have not fully delineated extent of the impacts or identified the source.

The objectives of the proposed investigation at SWMU 39 includes delineation of impacted soil and groundwater, evaluation of potential impacts to sediment and surface water, investigation of potential source areas, and evaluation of potential risks to human health and ecological receptors. The investigation will be conducted in phases. The first phase of investigation includes background soil sampling for risk characterization; sediment and surface water sampling; direct push technology (DPT) soil and groundwater investigation; and LNAPL delineation. The second phase of investigation includes additional delineation if needed; installation and sampling of permanent monitoring wells including background and sentinel wells; and aquifer testing. The investigation data will be used to refine the conceptual site model (CSM), and finalize the RFI.



FORT STEWART MILITARY RESERVATION, GEORGIA

SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY RFI WORK PLAN

SWMU 39 Location Map

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FIGURE **1-1**

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBONS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F1-1 SWMU39_RFIWP_reg.mxd SAVED: 16OCT2009

LEGEND

- Fence
- Rail Spur
- Surface Water Drainage
- National Wetlands
- Excavation Area
- Monitor Well (shallow aquifer)
- Monitor Well (abandoned)
- Boring (groundwater sample)

REFERENCE: NRCS, LIBERTY COUNTY, GEORGIA (NAIP 2007).

FORT STEWART MILITARY RESERVATION, GEORGIA
SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY
RFI WORK PLAN

SWMU 39 Monitor Well Locations

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FIGURE
1-2

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F1-2 SWMU39_RFIWP_site.mxd SAVED: 8DEC2009

2. Environmental Setting

2.1 Topography

Surface elevations at Fort Stewart range from approximately 20 to 100 feet (ft) above mean sea level (amsl), generally decreasing from northwest to southeast across the reservation. The topography is dominated by terraces dissected by surface water drainage. The terraces are remnants of sea level fluctuations. The four terraces within Fort Stewart are the Wicomico, Penholoway, Talbot, and Pamlico (Metcalf & Eddy 1996). The garrison area of Fort Stewart is located within the Penholoway Terrace and has an average elevation of approximately 40 ft amsl.

2.2 Regional Geology/Hydrogeology

Fort Stewart is located on the lower coastal plain physiographic province, which is typified by very low relief that slopes toward the Atlantic Ocean. The geology is composed of a seaward thickening sequence of unconsolidated sediments. Previous regional investigations suggest that there has been minor structural deformation in the Savannah, Georgia, area during deposition of the sediments starting in the early Cretaceous Period. The sediments form a thickening wedge into the Atlantic Ocean deposited from sediment erosion of the Blue Ridge Mountains. The total thickness of the sediments in the Savannah, Georgia, area is over 2,000 feet.

The most important water supply aquifer in the lower coastal plain of Georgia and Florida is the Floridan Aquifer. The Floridan Aquifer is a regionally extensive aquifer that is approximately 800 feet thick at Savannah. The top of the Floridan Aquifer at Fort Stewart is approximately 200 feet below ground surface (ft bgs). It is composed primarily of Oligocene age and Eocene age porous limestones. The Floridan Aquifer is the principal water supply aquifer throughout coastal Georgia and most of Florida.

This investigation focuses on groundwater quality in the uppermost aquifer system only. The uppermost aquifer system at and surrounding Savannah, Georgia, is underlain by two continuous clay units, which are effective confining units that preclude downward groundwater migration of shallow groundwater to the deeper Floridan water supply aquifer. These two clay units are named the Coosawhatchie Formation and Berryville Clay member of the Hawthorne Group. Lithologic samples and fossils suggest that these two units were deposited during the Middle Miocene Period in a low energy open marine environment over a wide area. The open ocean depositional environment resulted in the widespread and continuous nature of these clay units. A deep test well in Savannah (GGS-3139) shows that the clay units extend from approximately 45 ft bgs to 167 ft bgs near Fort Stewart. Due to the thick confining unit that separates the uppermost aquifer system from the underlying Floridan Aquifer, there is minimal potential for shallow groundwater to impact deeper groundwater quality in the underlying Floridan Aquifer.

After deposition of the Hawthorne Clays, there was no preserved deposition of sediments at the study area until the late Pleistocene Period. The sediments overlying the Hawthorne Group clays to land surface are composed of a sequence of near shore to shoreface (barrier island) sediments that prograde over the Hawthorne Group marine clays. Published investigations have identified nine sets of overlapping relict beach ridges of Pleistocene age to Holocene age on the lower coastal plain that prograde towards the Atlantic Ocean. Each barrier sequence forms a ridge (also termed terrace) that is progressively lower and closer to the modern barrier island. The ancient beaches formed during higher sea levels and are parallel to the modern beach. Each barrier system is at a consistent elevation above sea level with about 20 feet relief above surrounding land.

2.3 SWMU 39 Local Geology/Hydrogeology

Lithologic logs from the shallow monitor wells at SWMU 39 suggest that the shallow sediments are dominated by fine to medium soft sands with minor interstitial clay. The homogeneous nature of the sand and lack of distinctive clay beds suggest that SWMU 39 is composed of fine to medium well sorted quartz sand. This beach will probably be a massive sand that is reworked by the constant wave action and migration of tidal inlets. There should be very little clay deposited in this highest energy depositional system.

This investigation will focus on groundwater quality in the uppermost aquifer system only. The uppermost aquifer system at and surrounding Savannah, Georgia is underlain by two continuous clay units of the Hawthorne group, which are effective confining units that preclude downward groundwater migration of shallow groundwater to the deeper Floridan water supply aquifer.

3. Previous Investigations

A summary of previous investigations is provided in the Final Resource and Recovery Act Facility Investigation and Interim Actions Report for Solid Waste Management Unit 39, Fort Stewart, Georgia (SES 2008). A brief summary is provided below.

3.1 UST 61 Investigations

UST 61 was a 500 gallon used oil tank located within the fenced portion of SWMU 39 near Building 1161. The tank was excavated and removed from the site in August 1995. In 1996 and 2000, Corrective Action Plans (CAPs) Part A and Part B were completed to investigate petroleum impacts to soil and groundwater. The CAP Part B recommended annual sampling for benzene, toluene, ethylbenzene, and xylenes (BTEX) to ensure benzene concentrations remained below the Georgia In Stream Water Quality Standards (IWQSs) of 71.28 µg/L (SES 2008). During the second annual monitoring event, LNAPL was detected in monitor well 22-07. Monitor well 22-07 was removed in 2006 along with free product and impacted soil around the well. Prior to backfilling, Oxygen Release Compound® (ORC®) was applied to the floor and sidewalls of the excavation. Monitor well 22-07R was installed to replace 22-07. The excavation was backfilled using an aggregate stone to provide a porous media to promote infiltration of the groundwater and any free product into 22-07R. No additional LNAPL has been detected in 22-07R. Subsequent monitoring events confirmed benzene concentrations in groundwater near the former UST 61 are below the IWQS. UST 61 was closed out under the Georgia UST program. Any additional monitoring near the former UST 61 will be performed as part of the investigations for SWMU 39.

3.2 UST Closure – 1997

In December 1997, field activities were conducted at 14 USTs at Fort Stewart including the two HOTs associated with USTs 59 and 60 at SWMU 39 (HAZWRAP and Earth Tech 1998). The two HOTs were associated with wash racks located at the tactical equipment motor pool area and reportedly contained heating oil to fuel high-pressure washers.

3.3 UST and HOT Investigations – 2001

In 2001, investigations were initiated at SWMU 39 to determine if there had been a historical release related to the USTs and HOTs. The investigation included DPT, installation of eight monitor wells, and groundwater sampling in the vicinity of USTs 59 and 60 and their associated HOTs. The soil sample results indicated polyaromatic hydrocarbons (PAH) and VOC detections in soil. All of the concentrations were below available soil threshold values listed in the Georgia Petroleum Threshold Levels Table A (Georgia EPD 2001; SES 2008).

Following installation of the monitor wells, 1.21 feet of LNAPL was detected in monitor well G4MW007. Groundwater samples were collected from the remaining wells for VOC and PAH analysis. With the exception of TCE, all of the groundwater sample results were below the maximum contaminant levels (MCLs) and IWQSs. Based on the results of the investigation, Fort Stewart recommended removal of the LNAPL from G4MW007 and delineation of the TCE impacts (SES 2008).

3.4 RCRA Facility Investigation – 2002

In November 2002, an RFI was initiated to delineate the extent of TCE impacts. The investigation included additional soil borings, installation of five monitor wells, and two discrete groundwater vertical profile borings. The soil and groundwater samples were analyzed for VOCs and semi volatile organic compounds (SVOCs). LNAPL was detected in monitoring wells G4MW002 and G4MW007. No samples were collected from these wells. The groundwater sample results indicated exceedances of the MCL for TCE. A baseline human health risk evaluation was performed using the results of the 2001 and 2002 investigations. The evaluation did not indicate a potential risk to human health due to exposure to the soil or groundwater. Based on the investigation, further action to remove the LNAPL, inspection and removal of the non-regulated flow-through vessels from service, and additional investigation to delineate the extent of TCE impacts was recommended.

3.5 RCRA Facility Investigation and Interim Actions – 2004

In April 2004, an RFI was initiated to delineate the extent of impacts in the subsurface soil and groundwater, an interim action was performed to remove LNAPL, and a corrective measure study was conducted to determine the best corrective action. The investigation was performed in three phases and included collection of soil, surface water, sediment, and groundwater samples, installation of twelve additional monitor wells, LANPL removal, and isolation of the two concrete flow through vaults and their associated oil water separator. During the investigation, LNAPL was detected in monitor wells G4MW002, G4MW007, and G4MW013. The results of the groundwater sample analysis reported benzene, TCE, and PCE detections in select wells above MCLs. The risk assessment was revised based on the 2004 sample results. Based on the evaluation, exposure to surface water was identified as a potential risk to human health.

Interim remedial actions were conducted including isolation of the non-regulated flow-through vaults and LNAPL recovery using multi-phase extraction. The flow-through vaults were isolated by filling the vaults with concrete and plugging the underground pipes with fuel-resistant caulking. The isolation activities did identify a potential pathway for petroleum release to the subsurface.

The multi-phase extraction was successful in removing all measureable LNAPL in wells G4MW002, G4MW007, and G4MW013. Prior to the initiating the removal action, LNAPL was measured at 0.2 feet, 2 feet, and 0.01 feet in the wells, respectively. Following the multi-phase extraction activities, additional remedial actions were recommended including excavation and replacement of monitor wells G4MW007 and G4MW013 along with the surrounding soils so that larger diameter (2 inch) wells could be installed for improved LNAPL recovery.

3.6 Interim Remedial Actions and Groundwater Sampling – 2007

An interim remedial action (IRA) was conducted at SWMU 39 in March and April 2007 to remove and replace monitor wells G4MW007 and G4MW013 with pre-packed 2-inch diameter monitor wells and excavate surrounding impacted soils and groundwater. Soil samples collected from the excavation sidewalls and bottom were analyzed for BTEX, methyl tert butyl ether (MTBE), PAHs, total petroleum hydrocarbons diesel range organics (TPH DRO), and total petroleum hydrocarbons gasoline range organics (TPH GRO). PAHs and TPH DRO constituents were detected in the excavation samples. Following sample collection and well installation, a solution of Oxygen Release Compound® was applied to the bottom and sidewalls of the excavation.

In October 2007, groundwater samples were collected from all existing wells for analysis of BTEX and MTBE. None of the constituents were detected above MCLs.

3.7 Additional Investigation – 2008

Following review of the 2004 RFI Report, GAEPD requested further delineation of TCE impacts in groundwater. In February 2008, a Geoprobe® investigation was conducted to collect discrete groundwater samples for on-site screening using a mobile laboratory. The samples were analyzed for tetrachloroethene (PCE), TCE, 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-

dichloroethene (trans-1,2-DCE), and vinyl chloride (VC). Screening samples were collected from 19 locations around SWMU 39. At each sample location, groundwater samples were collected from multiple depths starting at the water table and then every 5 ft bgs. The screening sample results indicated PCE and TCE to be present in groundwater above the MCL at depths up to 30 ft bgs. Table 3-1 summarizes the screening sample results. The TCE and PCE sample results are presented on Figure 3-1. The maximum TCE and PCE concentrations were detected in sample 1B at 18 and 23 ft bgs respectively. The majority of existing monitor wells were screened from 2 to 12 ft bgs and 5 to 15 ft bgs with the deepest well screened from 6 to 16 ft bgs.

Based on the screening results, seven additional monitor wells were installed (G4MW026 through G4MW032) in March 2008. The new wells were screened from about 10 to 20 ft bgs with one well screened from 35 to 45 ft bgs. Since the screening results indicate impacts to groundwater up to 30 ft bgs, additional investigation is required to delineate the vertical extent of impacts to groundwater.

In March and April 2008, groundwater samples were collected from the new and existing site monitoring wells. Prior to the sampling event, groundwater level measurements were collected from all the wells. The groundwater elevations are summarized in Table 3-2. A potentiometric map is provided as Figure 3-2. As shown in Figure 3-2, the general groundwater flow direction is east to west. A total of 32 monitor wells were sampled during the event. The samples were shipped to Empirical Laboratories in Nashville, Tennessee for analysis of VOC by USEPA Method 8260. The sample results are summarized in Table 3-3. During the monitoring event, 4 inches of LNAPL was detected in monitoring well G4MW002. Consequently, no sample was collected from this well. The estimated extent of LNAPL is shown on Figure 3-3. Additional investigation is required to delineate the extent of LNAPL near G4MW002.

The 2008 sample results indicate detections of PCE and TCE south of the fenced area near Building 1143. The TCE and PCE sample results are shown on Figure 3-4. As shown in the potentiometric map on Figure 3-2, Building 1143 is located side gradient to the fenced area. Additional delineation is required to evaluate the source and extent of TCE and PCE groundwater impacts near Building 1143 and to determine how they relate to the impacts reported within the fenced area. Additional investigation is planned to confirm the historical sample results, delineate the horizontal and vertical extent of impacts, and complete the human health and ecological risk assessments. The following sections outline the proposed investigations.

Table 3-1
Groundwater Screening Results, 2008
SWMU 39
Fort Stewart, Georgia

Location ID	Sample Depth (ft bgs)	Sample Date	Vinyl chloride	1,1-Dichloroethene	trans-1,2-Dichloroethene	cis-1,2-Dichloroethene	Trichloroethene	Tetrachloroethene
		Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
		Groundwater MCL[1]	*2*	*7*	*100*	*70*	*5*	*5*
SWMU-39-1A	12	2/7/2008	< 1	< 1	1.1	5	17.8	< 1
SWMU-39-1A	17	2/7/2008	< 1	< 1	< 1	2.9	13.5	< 1
SWMU-39-1A	22	2/7/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-1A	27	2/7/2008	< 1	< 1	< 1	9	29.7	13.3
SWMU-39-1A	30	2/7/2008	< 1	< 1	< 1	2.2	3.9	1
SWMU-39-1B	8	2/7/2008	< 1	1	1.1	8.8	7.6	1.8
SWMU-39-1B	13	2/7/2008	< 1	< 1	< 1	12.4	18.4	3.7
SWMU-39-1B	18	2/7/2008	< 1	< 1	< 1	13.2	46.8	27.4
SWMU-39-1B	23	2/7/2008	< 1	< 1	< 1	9.8	44.3	29.1
SWMU-39-1B	28	2/7/2008	< 1	< 1	< 1	3.5	7.1	3.4
SWMU-39-1C	8	2/8/2008	< 1	< 1	3.1	24.6	15.6	< 1
SWMU-39-1C	13	2/8/2008	< 1	< 1	5	26.6	24.6	< 1
SWMU-39-1C	18	2/8/2008	< 1	< 1	7.4	35.8	24.8	< 1
SWMU-39-1C	23	2/8/2008	< 1	< 1	11	54	8.5	< 1
SWMU-39-1D	7	2/8/2008	< 1	< 1	< 1	1	< 1	< 1
SWMU-39-1D	12	2/8/2008	< 1	< 1	< 1	< 1	2.4	< 1
SWMU-39-1D	18	2/8/2008	< 1	< 1	< 1	< 1	5.6	< 1
SWMU-39-1E	8	2/8/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-1E	13	2/8/2008	< 1	< 1	< 1	< 1	1.6	< 1
SWMU-39-1E	18	2/8/2008	< 1	< 1	< 1	< 1	3.9	< 1
SWMU-39-1E	23	2/8/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-1F	7	2/9/2008	< 1	< 1	< 1	2.3	2	< 1
SWMU-39-1F	12	2/9/2008	< 1	< 1	< 1	1.5	2.5	< 1
SWMU-39-1F	17	2/9/2008	< 1	< 1	< 1	1.1	2	< 1
SWMU-39-1F	23	2/9/2008	< 1	< 1	< 1	1	1.4	< 1
SWMU-39-1G	12	2/9/2008	< 1	< 1	< 1	1.4	1	< 1
SWMU-39-1G	17	2/9/2008	< 1	< 1	< 1	2.3	2.4	< 1
SWMU-39-1H	8	2/9/2008	< 1	< 1	< 1	2.9	< 1	< 1
SWMU-39-1H	13	2/9/2008	< 1	< 1	3.6	27	1.3	< 1
SWMU-39-1H	18	2/9/2008	< 1	1	6.4	24.3	9.8	< 1
SWMU-39-1LR	18	2/14/2008	< 2	< 2	< 2	4.3	6.1	< 2
SWMU-39-1LR	23	2/14/2008	< 1	1.3	3.8	11.6	25.3	1.2
SWMU-39-2B	8	2/9/2008	< 1	< 1	< 1	10.6	32.9	4.2
SWMU-39-2B	13	2/9/2008	< 1	< 1	1.4	10.9	32.2	1.5
SWMU-39-2C	8	2/10/2008	< 1	2.4	1.4	9.1	14.6	< 1
SWMU-39-2C	13	2/10/2008	< 1	< 1	5	26.4	23.3	< 1
SWMU-39-2C	18	2/10/2008	< 1	< 1	5.1	23.1	19.2	< 1

Table 3-1
Groundwater Screening Results, 2008
SWMU 39
Fort Stewart, Georgia

Location ID	Sample Depth (ft bgs)	Sample Date	Vinyl chloride	1,1-Dichloroethene	trans-1,2-Dichloroethene	cis-1,2-Dichloroethene	Trichloroethene	Tetrachloroethene
		Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
		Groundwater MCL[1]	*2*	*7*	*100*	*70*	*5*	*5*
SWMU-39-2D	8	2/10/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-2D	13	2/10/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-2D	18	2/10/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-2D	23	2/10/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-2D	28	2/10/2008	< 1	< 1	< 1	1.3	6.7	< 1
SWMU-39-2D	30	2/10/2008	< 1	< 1	< 1	1.4	10.1	< 1
SWMU-39-2E	10	2/10/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-2E	15	2/10/2008	< 1	< 1	< 1	< 1	3.2	< 1
SWMU-39-2E	20	2/10/2008	< 1	< 1	< 1	< 1	3.1	< 1
SWMU-39-3A	10	2/14/2008	< 1	< 1	< 1	4	27.8	6.2
SWMU-39-3A	15	2/14/2008	< 1	< 1	< 1	4	21.1	4.8
SWMU-39-3A	20	2/14/2008	< 1	< 1	< 1	3	11.5	2.4
SWMU-39-3B	8	2/10/2008	< 1	< 1	1.7	12.1	27.1	< 1
SWMU-39-3B	13	2/10/2008	< 1	< 1	1.3	12.3	34.8	1.3
SWMU-39-3C	8	2/10/2008	< 1	1	< 1	5.4	7.1	< 1
SWMU-39-3C	13	2/10/2008	< 1	1.2	1.4	9.8	8.7	< 1
SWMU-39-3D	8	2/12/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-3D	13	2/12/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-3D	18	2/12/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-3D	23	2/12/2008	< 2	< 2	< 2	< 2	< 2	< 2
SWMU-39-3D	28	2/12/2008	< 1	< 1	< 1	< 1	3.1	< 1
SWMU-39-3D	30	2/12/2008	< 1	< 1	< 1	< 1	2.5	< 1
SWMU-39-3H	13	2/14/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-3H	18	2/14/2008	< 1	1.6	5.1	15	8.9	< 1
SWMU-39-3H	23	2/14/2008	< 1	1.5	4.5	15	5.8	< 1
SWMU-39-3H	28	2/14/2008	< 1	3	4.3	13.2	1	< 1
SWMU-39-4A	10	2/14/2008	< 1	< 1	< 1	1	5	< 1
SWMU-39-4A	15	2/14/2008	< 2	< 2	< 2	< 2	14	9.2
SWMU-39-4A	20	2/14/2008	< 2	< 2	< 2	2.2	12	5.2
SWMU-39-4A	25	2/14/2008	< 1	< 1	< 1	6.8	40.6	23.6
SWMU-39-4A	30	2/14/2008	< 1	< 1	< 1	1.7	7.2	2.5
SWMU-39-4B	8	2/13/2008	< 1	< 1	2.3	10.4	32.6	6.7
SWMU-39-4C	8	2/13/2008	< 1	< 1	< 1	< 1	1	1
SWMU-39-4C	13	2/13/2008	< 1	< 1	< 1	3.4	23.6	11.1
SWMU-39-4C	18	2/13/2008	< 1	< 1	< 1	6	38.5	12.2
SWMU-39-4C	23	2/13/2008	< 1	< 1	< 1	4.9	35.6	18.5
SWMU-39-4D	8	2/13/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-4D	18	2/13/2008	< 1	< 1	< 1	< 1	< 1	< 1
SWMU-39-4D	30	2/13/2008	< 1	< 1	< 1	1.8	9.4	< 1

[1] - Remedial levels for groundwater in accordance with Georgia Rule 391-3-5-.18, *Primary Maximum Contaminant Levels for Drinking Water.*

Indicates sample results exceed the MCL.

MCL - Maximum Contaminant Level
ft bgs - feet below ground surface
µg/L - microgram per liter

Table 3-2
Groundwater Elevation Data, 2008
SWMU 39
Fort Stewart, Georgia

Well Number	Date Measured	Top of Casing Elevation (ft)	Depth of Screened Interval (ft BTOC)	Depth to Free Product (ft BTOC)	Water Depth (ft BTOC)	Product Thickness (ft)	Specific Gravity Adjustment	Potentiometric Elevation (ft)
G4MW001	3/31/2008	74.82	6-16	N/A	4.88	N/A	N/A	69.94
G4MW002	3/30/2008	74.33	5-15	4.11	4.44	0.33	0.88	70.18
G4MW003	3/30/2008	74.57	5-15	N/A	4.14	N/A	N/A	70.43
G4MW004	3/30/2008	74.51	5-15	N/A	4.00	N/A	N/A	70.51
G4MW005	3/31/2008	74.29	5-15	N/A	4.45	N/A	N/A	69.84
G4MW006	3/31/2008	74.38	5-15	N/A	4.68	N/A	N/A	69.70
G4MW007	3/31/2008	74.74	5-15	N/A	5.18	N/A	N/A	69.56
G4MW008	3/31/2008	74.36	5-15	N/A	4.96	N/A	N/A	69.40
G4MW009	3/31/2008	74.75	4-14	N/A	4.61	N/A	N/A	70.14
G4MW010	3/30/2008	74.23	5-15	N/A	4.39	N/A	N/A	69.84
G4MW011	3/31/2008	74.08	5-15	N/A	4.89	N/A	N/A	69.19
G4MW012	3/31/2008	74.27	5-15	N/A	4.80	N/A	N/A	69.47
G4MW013	3/31/2008	74.70	4-14	N/A	5.14	N/A	N/A	69.56
G4MW0l4	3/30/2008	74.96	2-12	N/A	3.70	N/A	N/A	71.26
G4MW015	3/30/2008	74.82	2-12	N/A	3.74	N/A	N/A	71.08
G4MW016	3/31/2008	72.28	3-13	N/A	3.40	N/A	N/A	68.88
G4MW017	3/31/2008	71.84	2-12	N/A	3.61	N/A	N/A	68.23
G4MW018	3/30/2008	74.27	2-12	N/A	3.99	N/A	N/A	70.28
G4MW019	3/30/2008	74.76	2-12	N/A	3.79	N/A	N/A	70.97
G4MW020	3/30/2008	74.64	2-12	N/A	3.68	N/A	N/A	70.96
G4MW021	3/30/2008	74.18	2-12	N/A	3.97	N/A	N/A	70.21
G4MW022	4/1/2008	72.59	3-13	N/A	5.00	N/A	N/A	67.59
G4MW023	4/1/2008	75.58	5-15	N/A	6.67	N/A	N/A	68.91
G4MW024	3/30/2008	74.41	5-15	N/A	4.99	N/A	N/A	69.42
G4MW025	3/30/2008	74.52	3-13	N/A	2.72	N/A	N/A	71.80
G4MW026	4/1/2008	76.01	9-19	N/A	8.90	N/A	N/A	67.11
G4MW027	4/1/2008	76.50	10-20	N/A	4.35	N/A	N/A	72.15
G4MW028	4/1/2008	82.91	9-19	N/A	3.94	N/A	N/A	78.97
G4MW029	4/1/2008	84.07	5-15	N/A	5.95	N/A	N/A	78.12
G4MW030	4/1/2008	67.64	10-20	N/A	6.21	N/A	N/A	61.43
G4MW031	4/1/2008	78.96	10-20	N/A	4.61	N/A	N/A	74.35
G4MW032	4/1/2008	74.27	35-45	N/A	2.00	N/A	N/A	72.27

Notes:
ft - feet
ft BTOC - feet below top of casing
NA - not applicable

Table 3-3
Groundwater Monitor Well Sample Results, 2008
SWMU 39
Fort Stewart, Georgia

Location ID	Sample ID	Sample Date	Vinyl chloride	1,1-Dichloroethene	Carbon disulfide	trans-1,2-Dichloroethene	1,1-Dichloroethane	cis-1,2-Dichloroethene	Benzene	Trichloroethene	Tetrachloroethene	Xylenes (total)	Acetone	tert-Butyl methyl ether (MTBE)	Chloroform	Benzene, 1-methylethyl (Isopropyl benzene)	Methylcyclohexane	2-Butanone	4-Methyl-2-pentanone	Chloromethane
		Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
		Groundwater MCL[1]	2	7	NA	100	NA	70	5	*5*	*5*	*10,000*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
G4MW001	G4MW001(033108)	3/31/2008	ND	1.3	ND	7.1	0.3 J	21	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MA002	Well not sampled due to the presence of free product																			
G4MW003	G4MW003(033008)	3/30/2008	ND	1.1	ND	7.2	ND	22	ND	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW004	G4MW004(033008)	3/30/2008	ND	1.1	ND	7.4	0.32 J	22	ND	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW005	G4MW005(033108)	3/31/2008	ND	1	ND	4.9	0.28 J	18	0.14 J	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW006	G4MW006(033108)	3/31/2008	ND	1.2	ND	5.1	0.26 J	18	0.14 J	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW007R	G4MW007R(033108)	3/31/2008	ND	0.53 J	ND	3.6	ND	14	ND	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW008	G4MW008(033108)	3/31/2008	ND	0.94 J	ND	6.5	0.32 J	19	ND	9.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW009	G4MW009(033108)	3/31/2008	ND	0.77 J	ND	5.4	0.29 J	18	ND	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW009	G4MW009-DUP(033108)	3/31/2008	ND	0.73 J	ND	5.4	ND	18	ND	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW010	G4MW010(033008)	3/30/2008	2.1	ND	0.2 J	1.8	ND	4.5 J	0.22 J	1.5 J	ND	ND	5.9 J	ND	ND	ND	ND	ND	ND	ND
G4MW011	G4MW010-DUP(033008)	3/30/2008	2	ND	ND	2.4	ND	6.6 J	0.2 J	2.6 J	ND	ND	7.6 J	ND	ND	ND	ND	ND	ND	ND
G4MW011	G4MW011(033108)	3/31/2008	ND	0.83 J	ND	5.3	0.27 J	19	ND	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW012	G4MW012(033108)	3/31/2008	ND	1	ND	7	ND	22	ND	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW013R	G4MW013R(033108)	3/31/2008	ND	1.1	ND	5.2	0.29 J	17	ND	9.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW014	G4MW014(033008)	3/30/2008	ND	ND	ND	ND	ND	0.85 J	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW015	G4MW015(033008)	3/30/2008	ND	ND	ND	ND	ND	1.4	ND	1.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW016	G4MW016(033108)	3/31/2008	ND	0.24 J	ND	0.54 J	ND	3.2	0.36 J	27	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW017	G4MW017(033108)	3/31/2008	ND	0.23 J	ND	0.71 J	ND	2.5	0.15 J	10	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW018	G4MW018(033008)	3/30/2008	0.2 J	0.82 J	ND	3.6	ND	13	ND	9.4	0.37 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW019	G4MW019(033008)	3/30/2008	ND	0.95 J	0.66 J	6.4	ND	18	0.13 J	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW020	G4MW020(033008)	3/30/2008	ND	ND	ND	1.6	ND	13	0.21 J	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW021	G4MW021(033008)	3/30/2008	ND	ND	ND	0.7 J	ND	2	0.28 J	0.38 J	ND	0.33 J	5.5 J	0.54 J	ND	ND	ND	ND	ND	ND
G4MW022	G4MW022(040108)	4/1/2008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW023	G4MW023(040108)	4/1/2008	ND	ND	ND	ND	ND	0.34 J	ND	1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW023	G4MW023-DUP(040108)	4/1/2008	ND	ND	ND	ND	ND	0.49 J	ND	1.8 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW024	G4MW024(033008)	3/30/2008	ND	0.65 J	ND	3.1	ND	9.8	0.13 J	2.3	ND	ND	6.1 J	ND	ND	ND	ND	ND	ND	ND
G4MW025	G4MW025(033008)	3/30/2008	ND	0.64 J	ND	3.2	0.32 J	11	ND	7.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW026	G4MW026(040108)	4/1/2008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.21 J	ND	ND	ND	ND	ND
G4MW027	G4MW027(040108)	4/1/2008	ND	ND	ND	ND	ND	1	ND	8.9	1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW028	G4MW028(040108)	4/1/2008	ND	ND	ND	ND	ND	ND	0.18 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW029	G4MW029(040108)	4/1/2008	ND	ND	ND	ND	ND	0.43 J	0.17 J	0.24 J	ND	ND	ND	ND	0.59 J	ND	ND	2.1 J	0.54 J	ND
G4MW030	G4MW030(040108)	4/1/2008	ND	ND	ND	ND	ND	0.3 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW031	G4MW031(040108)	4/1/2008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW031	G4MW031-DUP(040108)	4/1/2008	ND	ND	0.19 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G4MW032	G4MW032(040108)	4/1/2008	ND	ND	ND	ND	ND	0.34	ND	0.55 J	2.4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
22-08	22-08(040108)	4/1/2008	ND	ND	0.15 J	0.45 J	ND	2.1	3.6	0.82 J	0.25 J	ND	ND	0.19 J	ND	0.57 J	0.3 J	ND	ND	0.47 J

[1] - Remedial levels for groundwater in accordance with Georgia Rule 391-3-5-.18, *Primary Maximum Contaminant Levels for Drinking Water.*

(shaded) - Indicates the sample result exceeds the remedial level[1] for groundwater

MCL - maximum contaminant level

ft bgs - feet below ground surface

µg/L - microgram per liter

NA - no criteria

J - sample result is estimated

3H	PCE	TCE
13	ND	ND
18	ND	**8.9**
23	ND	**5.8**
28	ND	1.0

1G	PCE	TCE
12	ND	1.0
17	ND	2.4

1F	PCE	TCE
7	ND	2.0
12	ND	2.5
17	ND	2.0
23	ND	1.4

2E	PCE	TCE
10	ND	ND
15	ND	3.2
20	ND	3.1

1H	PCE	TCE
8	ND	ND
13	ND	1.3
18	ND	**9.8**

1E	PCE	TCE
8	ND	ND
13	ND	1.6
18	ND	3.9
23	ND	ND

1D	PCE	TCE
7	ND	ND
12	ND	2.4
18	ND	**5.6**

2D	PCE	TCE
8	ND	ND
13	ND	ND
18	ND	ND
23	ND	ND
28	ND	**6.7**
30	ND	**10.1**

3D	PCE	TCE
8	ND	ND
13	ND	ND
18	ND	ND
23	ND	ND
28	ND	3.1
30	ND	2.5

4D	PCE	TCE
8	ND	ND
18	ND	ND
30	ND	**9.4**

1C	PCE	TCE
8	ND	**15.6**
13	ND	**24.6**
18	ND	**24.8**
23	ND	**8.5**

2C	PCE	TCE
8	ND	**14.6**
13	ND	**23.3**
18	ND	**19.2**

1B	PCE	TCE
8	1.8	**7.6**
13	3.7	**18.4**
18	**27.4**	**46.8**
23	**29.1**	**44.3**
28	3.4	**7.1**

1LR	PCE	TCE
18	ND	**6.1**
23	1.2	**25.3**

3C	PCE	TCE
8	ND	**7.1**
13	ND	**8.7**

2B	PCE	TCE
8	4.2	**32.9**
13	1.5	**32.2**

1A	PCE	TCE
12	ND	**17.8**
17	ND	**13.5**
22	ND	ND
27	**13.3**	**29.7**
30	1	3.9

4B	PCE	TCE
8	**6.7**	**32.6**

4C	PCE	TCE
8	1.0	1.0
13	**11.1**	**23.6**
18	**12.2**	**38.5**
23	**18.5**	**35.6**

3B	PCE	TCE
8	ND	**27.1**
13	1.3	**34.8**

3A	PCE	TCE
10	**6.2**	**27.8**
15	4.8	**21.1**
20	2.4	**11.5**

4A	PCE	TCE
10	ND	5.0
15	**9.2**	**14**
20	**5.2**	**12**
25	**23.6**	**40.6**
30	2.5	**7.2**

LEGEND

- —x— Fence
- Rail Spur
- Surface Water Drainage
- ▲ Boring (Groundwater Sample)

NOTES:
1) Samples collected by SES (February 7-14, 2008).
2) All groundwater concentrations reported in micrograms per liter (µg/L).
3) **BOLD** concentrations exceed Georgia MCL of 5 µg/L.

Boring ID

3B	PCE	TCE
8	ND	**27.1**
13	1.3	**34.8**

Sample Depth (ft bgs)

PCE - Tetrachloroethene
TCE - Trichloroethene
ND - Not Detected
ft bgs - feet below ground surface

REFERENCE: SES (2008).

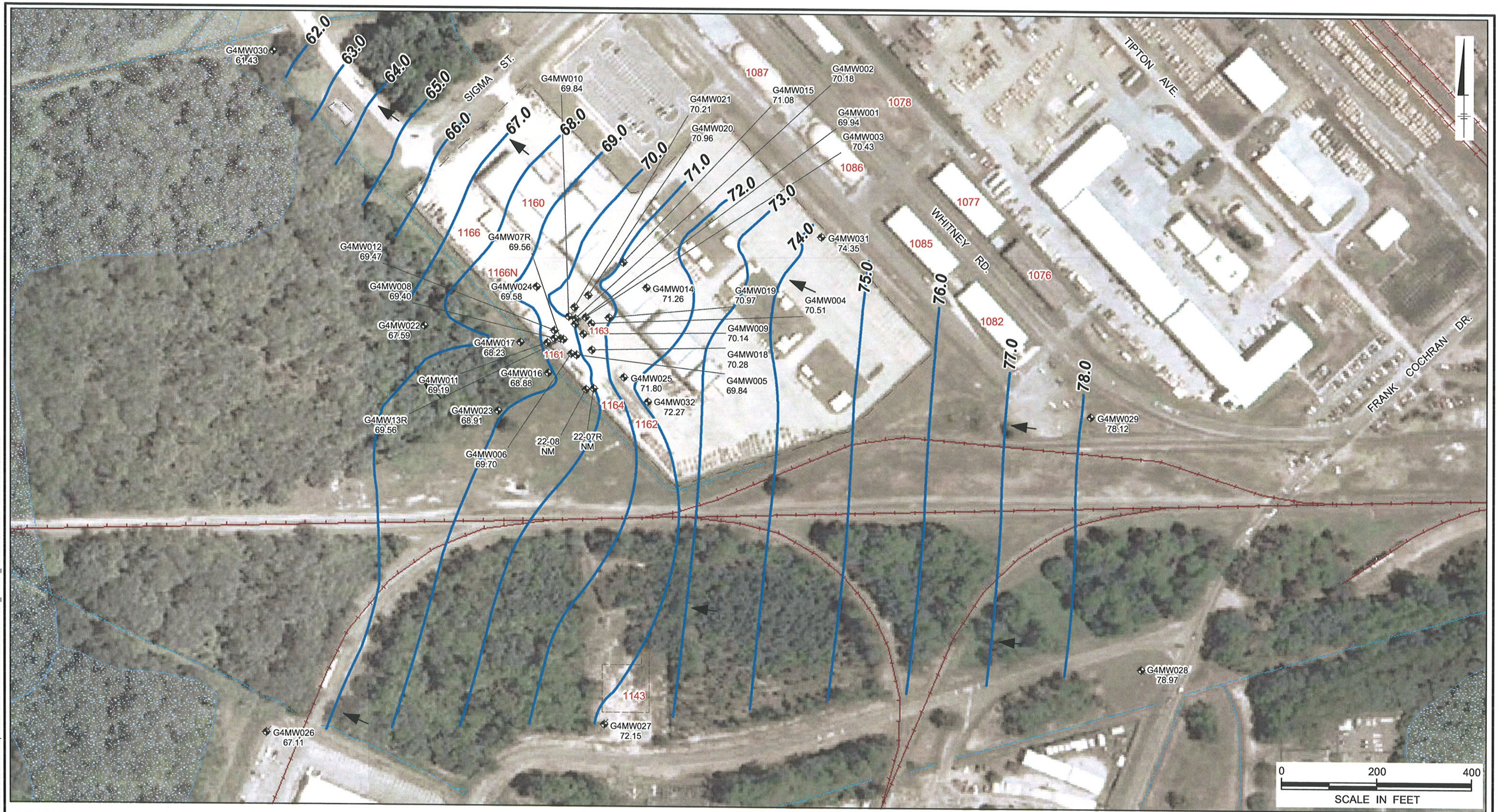
FORT STEWART MILITARY RESERVATION, GEORGIA
SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY
RFI WORK PLAN

TCE and PCE in Groundwater Analytical Screening Results (February 2008)

ARCADIS

FIGURE
3-1

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F3-1 SWMU39_RFIWP_GW_200802.mxd SAVED: 16OCT2009



LEGEND

- Fence
- Rail Spur
- Surface Water Drainage
- National Wetlands
- Monitor Well (shallow aquifer)
- Groundwater Contour Line (ft, msl)
- Groundwater Flow Direction

REFERENCES:
1) NRCS, LIBERTY COUNTY, GEORGIA (NAIP 2007).
2) SES (2008).

FORT STEWART MILITARY RESERVATION, GEORGIA

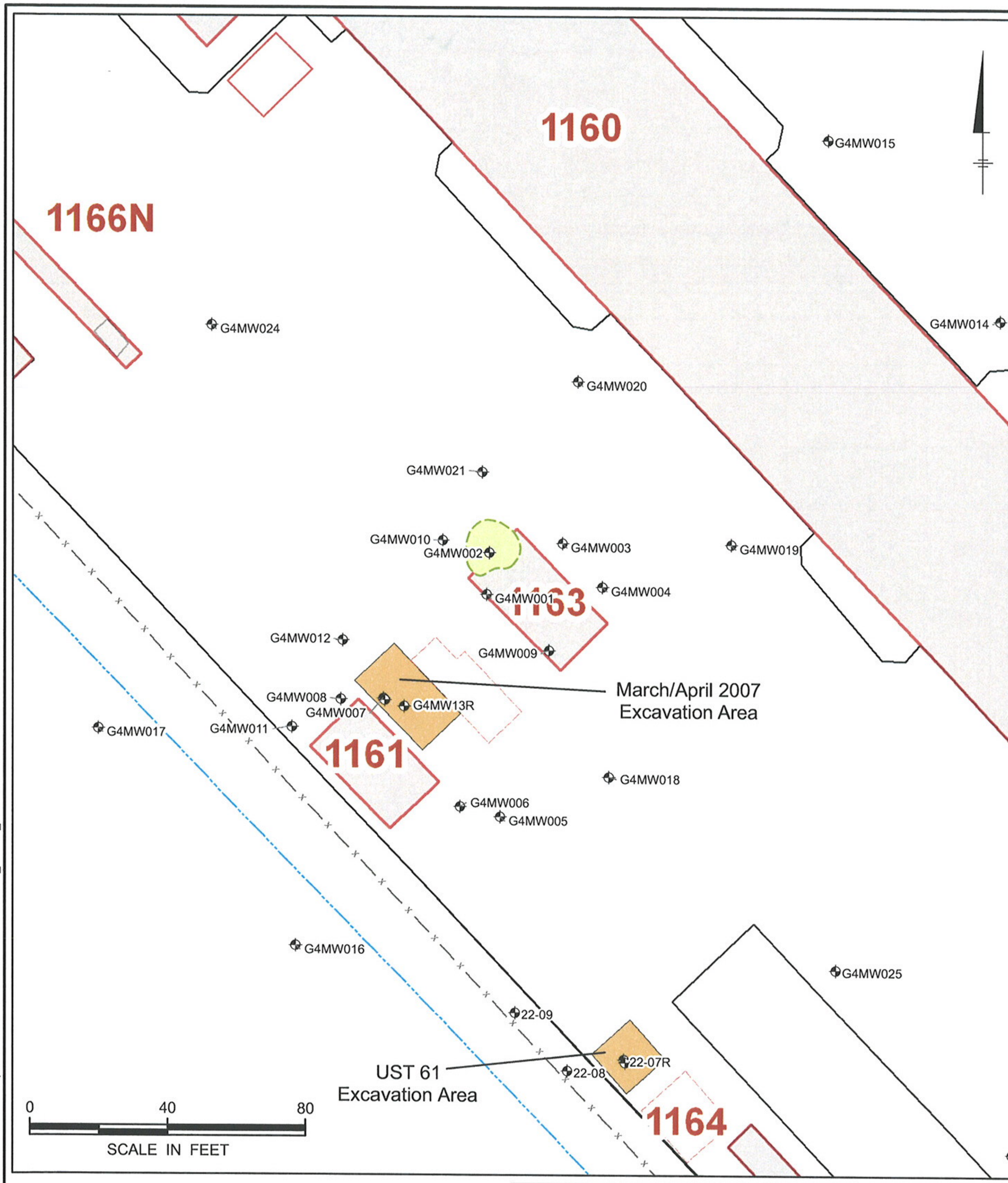
SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY RFI WORK PLAN

Potentiometric Surface Map (March/April 2008)

ARCADIS

FIGURE **3-2**

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F3-2 SWMU39_RFIWP_POT200804.mxd SAVED: 9DEC2009



LEGEND

- — x — Fence
- Rail Spur
- Surface Water Drainage
- Excavation Area
- Estimated Extent of Free Product

REFERENCE: SES (2008).

FORT STEWART MILITARY RESERVATION, GEORGIA

SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY
RFI WORK PLAN

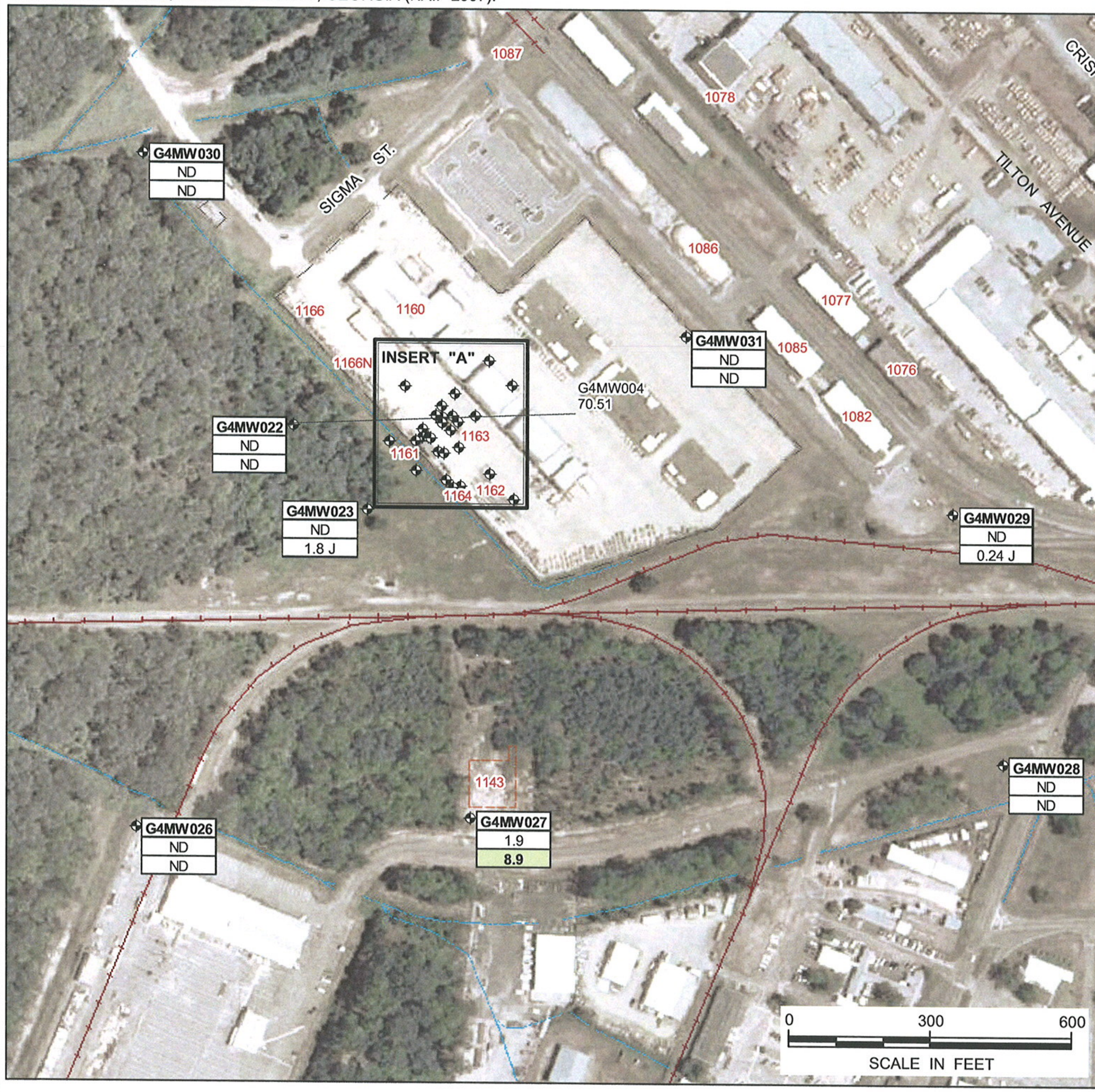
Estimated Extent of Free-Product

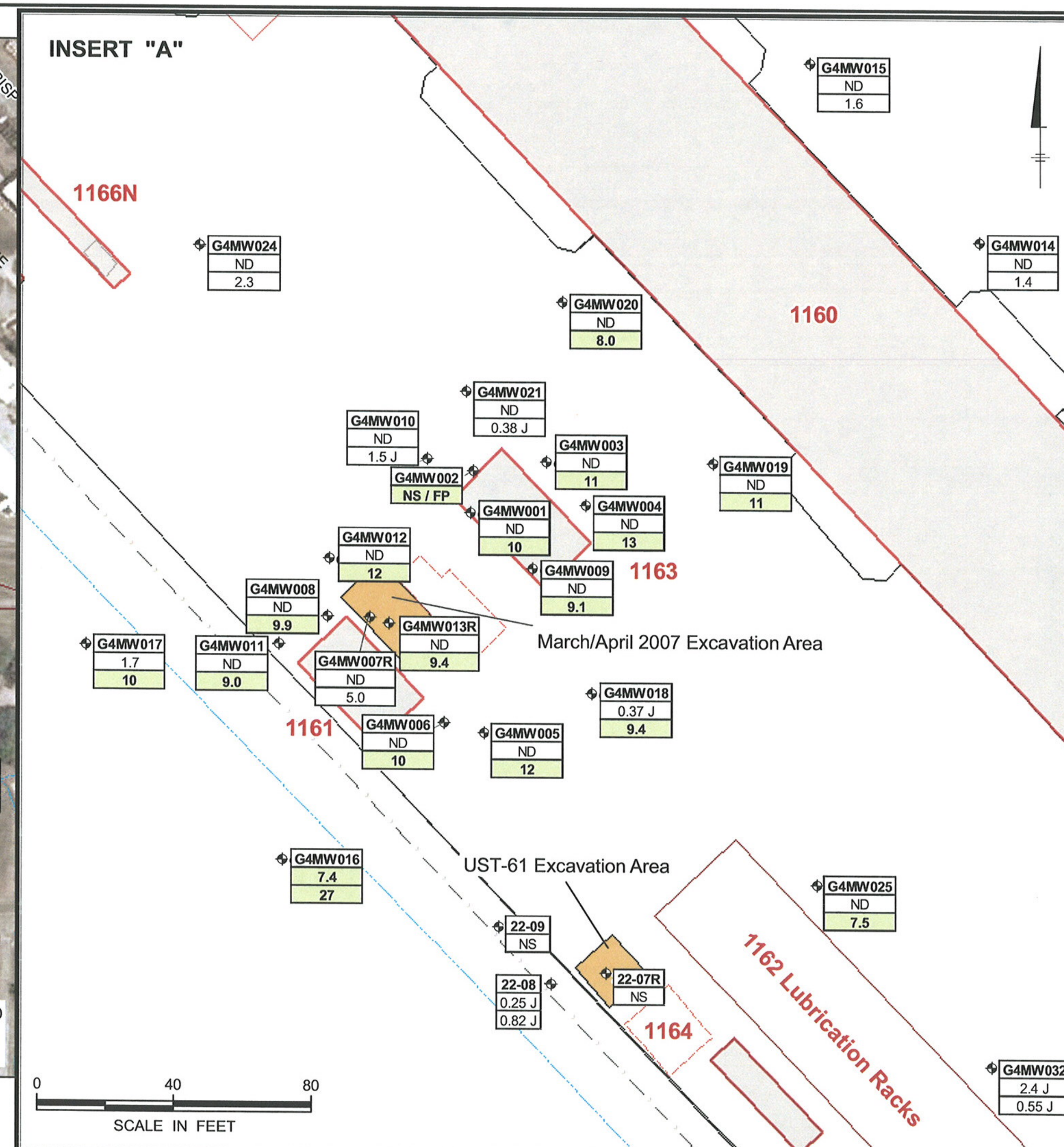
ARCADIS

FIGURE
3-3

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F3-3 SWMU39_RFIWP_FP.mxd SAVED: 16OCT2009

REFERENCE: NRCS, LIBERTY COUNTY, GEORGIA (NAIP 2007).





LEGEND

- Fence
- Rail Spur
- Surface Water Drainage
- Monitor Well (shallow aquifer)
- ND Not Detected
- NS Not Sampled
- FP Free Product
- J Estimated Value

NOTES:

1) Samples collected by SES (March 30 through April 1, 2008).
2) All groundwater concentrations reported in micrograms per liter (µg/L).
3) **BOLD** concentrations exceed Georgia MCL of 5 µg/L.

G4MW016	Well Number
7.4	Tetrachloroethene (PCE) Concentration (µg/L)
27	Trichloroethene (TCE) Concentration (µg/L)

FORT STEWART MILITARY RESERVATION, GEORGIA
SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY
RFI WORK PLAN

TCE and PCE Concentrations in Groundwater Monitor Wells (March/April 2008)

ARCADIS

FIGURE
3-4

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F3-4 SWMU39_RFIWP_PCE_TCE.mxd SAVED: 9DEC2009

4. Preliminary Conceptual Site Model and Proposed Investigation

4.1 Preliminary Conceptual Site Model

As discussed in Section 3, investigations at SWMU 39 began in 1995. The information collected during the previous investigations has been used to develop a preliminary conceptual site model and identify potential data gaps for the proposed investigations.

SWMU 39 is located in the southwest portion of the Fort Stewart Garrison Area near Building 1160 (Direct Support Maintenance Facility) near the intersection of Stephen's Road and West 4th Street. A section of SWMU 39 is surrounded by a fence with controlled access. The area within the fence is almost entirely covered with concrete. Outside the fence, along the east and southern sides of the Site, there is an undeveloped area that is grassy with some shrub vegetation and pine trees. A drainage ditch runs along the northwest portion of the fence. The ditch is around 3 feet wide and varies in depth from approximately 3 to 7 feet, with the deeper end near the northwest portion of SWMU 39. The water in the ditch is less than one foot deep with very little flow.

Historical soil boring logs indicate the geology at SWMU 39 consists primarily of fine- to medium-grained well-sorted sands with minor clay lenses. Regionally, these unconsolidated sands are underlain by two continuous clay units; the Coosawhatchie Formation and Berryville Clay member of the Hawthorne Group. The water table is approximately 5 ft bgs. Based on the regionally extensive clay layers of the Coosawhatchie Formation and Berryville Clay member, groundwater from the uppermost aquifer is not anticipated to migrate downward to the regional Floridan aquifer. The hydraulic gradient in the upper aquifer indicates overall groundwater flow is primarily to the west. Groundwater appears to partially discharge to a drainage ditch that runs northwest along the fenced area at SWMU 39.

Groundwater investigations have identified chlorinated solvents, primarily TCE, in shallow groundwater up to a maximum concentration of 50 µg/L. Groundwater impacts are both within and outside of the fenced area. The highest concentration of chlorinated solvents is in the southern portion of the site between 18 and 23 feet bgs; however, there is no apparent pattern to the distribution of concentrations. The distribution and magnitude of concentrations suggest an offsite source. Additional investigation is required to evaluate the horizontal and vertical extent of groundwater impacts and identify potential source areas.

Soil investigations identified LNAPL in monitor wells G4MW002, G4MW007, and G4MW013. Several recovery events were conducted. In 2007, monitor wells G4MW007 and G4MW013 were removed, the areas around them were excavated, lined with ORC, and backfilled, and new 2" diameter replacement wells were installed to allow easier LNAPL recovery. In 2008, 4 inches of LNAPL was identified in monitor well G4MW002. No LNAPL was detected in replacement monitor wells G4MW07R or G4MW013R. Further investigation is required to delineate the extent of LNAPL near G4MW002. Historical surface water and sediment samples collected from the drainage ditch indicate low levels of chlorinated solvents.

The current site use is industrial. Residential use of the property is not likely to occur; however, since land use could change sometime in the future, both residential and industrial land uses are evaluated for potential exposure pathways. Potential exposure pathways would involve exposure to impacted soil, groundwater, surface water and/or sediment for a site worker, construction/maintenance worker, trespassers, and/or future child and adult residents. The area of known impact to soil is covered by concrete which would have to be removed or drilled through to complete the exposure pathway. Groundwater is not currently used as a potable water source at Fort Stewart. Potential exposure pathways for groundwater would require a change in water usage or digging to depths greater than the water table. Following collection of additional data to fill the remaining data gaps, a risk assessment will be performed to evaluate the potential exposure pathways and potential risk to human health and the environment.

4.2 Summary of Proposed Investigation Activities

As discussed in Section 4.1, additional investigation is required to fill data gaps identified during the 2008 RFI. Additional investigations are required to evaluate the extent of LNAPL near G4MW002, further characterize soils in the vicinity of Buildings 1161 and 1163, delineate the horizontal and vertical extent of TCE and PCE impacts in groundwater including daughter products cis-1,2-DCE, trans-1,2-DCE, and VC, and identify the potential source for the TCE groundwater impacts south and east of the DSMF.

The investigation activities will be conducted in two phases. Phase one of the investigation will include:

- DPT investigation to evaluate the extent of LNAPL near G4MW002. Additional borings will be installed around Buildings 1161 and 1163 to further characterize soils.

- Groundwater DPT Investigation to further delineate PCE and TCE as well as the daughter products cis-1,2-DCE, trans-1,2-DCE, and VC. Investigation will include multi-level groundwater samples for vertical groundwater profiling.
- Collection of surface water and sediment samples.
- Installation of two deep and two shallow monitor wells to evaluate groundwater/surface water flow near the drainage canal. One pair of shallow and deep monitor wells will be nested to evaluate the vertical gradients between the shallow and deep groundwater.
- Collection of a full round of water level measurements from existing and proposed monitor wells.

The groundwater DPT investigation will be used to delineate the horizontal and vertical extent of PCE, TCE, and daughter products in groundwater, and to investigate a potential source for the TCE impacts near Building 1143. The results of the Phase 1 investigation will be used to scope the Phase 2 investigation and to determine the optimal locations for additional monitor wells. Phase 2 of the investigation will include:

- Installation of additional soil borings as necessary.
- Collection of background surface and/or subsurface soil samples, if necessary.
- Installation of additional monitor wells.
- Collection of water level measurements from new and existing monitor wells associated with SWMU 39.
- Collection of groundwater samples from new and existing monitor wells.
- Slug tests in select wells to determine hydraulic conductivities in the shallow aquifer.
- Collection of additional field and analytical data needed to complete a human health and ecological risk assessment.

All soil and groundwater samples collected will be submitted for analysis by a Georgia certified laboratory.

4.3 Phase I Investigation

The objective of the Phase I investigation is to delineate the vertical and horizontal extent of groundwater impacts, delineate LNAPL impacts and to better characterize shallow and subsurface soils.

4.3.1 Soil and LNAPL DPT Investigation

During the March 2008 monitoring event, LNAPL was detected in G4MW002 (0.33 feet). To evaluate the extent of the residual mass, a series of eight DPT borings will be installed near G4MW002. DPT uses a combination of hydraulic pressure and percussion to drive steel rods into subsurface soil for sample collection. The proposed boring locations are illustrated on Figure 4-1. Additional borings may be added based on field observations from the initial eight soil borings. A DPT rig will be used to collect continuous core samples from the ground surface to below the water table, a depth of approximately 6 ft bgs. Once the cores have been collected, they will be opened and immediately screened with a photoionization detector (PID). Intervals within the soil core that indicate PID readings of > 100 parts per million total detectable VOCs will undergo further evaluation using the soil-water shake test with Oil Red hydrophobic dye powder (Oil Red test) to determine the presence of NAPL. A positive test result will be indicated by the presence of a visible sheen and foam on the surface of water, a reaction between the dye and the sheen layer upon first addition of the dye powder, a bright red coating the inside of the vial (particularly above the water line), or red-dyed droplets within the soil. Soil samples will be collected from the core based on visual observations or from the interval with the highest PID reading. If no impacts to the soil are indicated, a sample will be collected just above the water table.

To further characterize and delineate soils in the vicinity of Building 1161 and 1163, a series of four additional soil borings will be advanced at the locations illustrated on Figure 4-1. Additional borings may be added based on field observations from the initial four soil borings. A DPT rig will be used to collect continuous core samples from the ground surface down to the water table, a depth of approximately 5 ft bgs. The soil cores will be screened with a PID. Soil samples will be collected from 0.5 to 1 foot and 3.0 to 3.5 feet below the base of the concrete slab. The sample depth interval may be biased based on visual observations or PID field screening results.

Shallow and subsurface soil samples will be placed in laboratory-supplied containers and stored in sealed ice filled coolers. All samples will be shipped via overnight carrier (FedEx) to Shealy Environmental, a Georgia certified laboratory, under appropriate preservation and chain-of-custody procedures. A copy of Shealy's certification information is included as Appendix A. The samples will be analyzed for VOCs by USEPA Method 8260, SVOCs by USEPA Method 8270 and metals by USEPA Method 6010.

Following completion of the DPT borings, the boring locations will be properly abandoned using a neat cement grout from the base of the boring to ground surface. Once the boring has been properly abandoned, the exact location will be documented using a global positioning system (GPS) device.

4.3.2 Groundwater DPT Investigation

The initial groundwater investigation will be conducted using DPT. A total of 12 borings/temporary wells are proposed to be installed at the locations depicted on Figure 4-1. At each boring, the 0 to 5 ft interval will be cleared for utilities using a decontaminated stainless steel hand auger. From 5 ft bgs to refusal depth, a continuous soil core will be collected using a macro-core sampler. The lithology will be logged at each location in accordance with the Soil Description Standard Operating Procedure, which is included as Appendix B. The core samples will be field screened to determine the presence of volatile organic vapors with a photo-ionization detector (PID). All work conducted during the DPT investigation will be completed by a Georgia certified driller.

Vertical groundwater profiling will be performed at each of the proposed locations using temporary wells. Prior to collecting groundwater samples, continuous macro core samples will be collected from ground surface to the top of the confining unit, which is anticipated to be at 45 ft bgs. Once the lithology has been characterized, groundwater samples will be collected from temporary wells installed immediately adjacent to the lithology boring locations. These temporary wells will be used to provide a vertical profile of the groundwater quality throughout the shallow aquifer unit. To complete the vertical profile, groundwater samples will be collected every 10-feet from the water table surface to the top of the confining unit.

The temporary wells installed will be screen point samplers, which will be driven to a predetermined depth by DPT. Once the sampler is at the correct depth the screen will be released and the rods will be retracted 4 to 5 feet to expose the screen, which will allow a depth specific sample to be collected. The temporary well will be purged to remove visual sediment to the extent possible using a peristaltic pump. If depths to water in the deeper intervals are greater than 20 ft below the top of casing, low density polyethylene tubing with a check valve will be used to purge the well. Once the well has been adequately purged, the groundwater sample will be collected.

Groundwater samples will be collected in laboratory-supplied containers and stored in sealed ice filled coolers. All samples will be shipped via overnight carrier (FedEx) to a Shealy Environmental, a Georgia certified laboratory (Appendix A), under appropriate preservation and chain-of-custody procedures. Groundwater samples will be analyzed for VOCs by USEPA Method 8260 and SVOCs by USEPA Method 8270. After the sample has been collected, the screen point will be removed and the borehole will be abandoned. This process will be completed for each depth interval until all samples have been collected.

4.3.3 Sediment and Surface Water Sampling

Sediment and surface water samples will be collected to evaluate potential impacts in the drainage ditch. Eight paired surface water and sediment samples are proposed (Figure 4-1). Surface water samples will only be collected if adequate water is present. The surface water samples will be collected directly into the sample containers. If necessary, a stainless steel scoop may be used to collect surface water from the ditch, which will then be transferred to the sample bottles. The samples will be collected while facing in the upstream direction to avoid disturbance of the water, and will be collected in such a way that the preservative from the sample vials is not displaced while the bottles are being filled. Field parameters, including pH, specific conductance, temperature, dissolved oxygen and oxidation reduction potential will be collected at each location. Samples will be collected from down stream to upstream to avoid disturbing the sediment.

Once the surface water samples have been collected, the sediment samples will be collected at a location directly below the location of the surface water sample. The sediment samples will be collected using a stainless steel scoop or spoon. The scoop or spoon will be run along the surface of the streambed in a downstream to upstream direction. Excess water will be removed from the sediment; however, some water will have to be retained to assure the silt and clay sized particles are included with the sample. The sediment from the scoop will be placed in to a stainless steel bowl and the process will be repeated until enough sediment has been collected to fill the sample jars. Once the sampling is completed, each surface water and sediment sample location will be recorded using a GPS survey instrument.

Surface water and sediment samples will be placed in laboratory-supplied containers and stored in sealed ice filled coolers. All samples will be shipped via overnight carrier (FedEx) to Shealy Environmental, a Georgia certified laboratory (Appendix A), under appropriate preservation and chain-of-custody procedures. The samples will be analyzed for VOCs by USEPA Method 8260, SVOCs by USEPA Method 8270, and metals by USEPA Method 6010.

4.3.4 Monitor Well Installation

The interaction between shallow and deep groundwater and between the groundwater and surface water in the vicinity of the drainage ditch, are not fully understood. To better understand the hydraulic gradients between the shallow and deep zones, a shallow monitor well will be installed next to existing deep monitor well G4MW032 and a deep monitor well will be installed next to existing shallow monitor well G4MW029. To determine if groundwater is discharging to the surface water in the drainage ditch, a shallow and deep monitor well pair will be installed next to the drainage ditch. The proposed monitor well locations are shown on Figure 4-1.

The proposed monitor wells will be installed using hollow stem auger drilling technology. The wells will be constructed of 2-inch-diameter schedule 40 polyvinyl chloride (PVC). The shallow monitor wells will be drilled to approximately 16 ft bgs and the deep monitor wells will be drilled to approximately 40 ft bgs. The screen will be composed of 2-inch diameter 10-slot, schedule 40 PVC. A 10 foot screen will be used for the shallow monitor wells and a 5 foot screen will be used for the deep monitor wells. From the top of the screen, 10-foot sections of Sch. 40 PVC riser will be used to extend the wells to either approximately 6 inches bgs or approximately 3 ft above ground surface, depending on the surface completion.

The annular space between the well casing and the borehole wall will be filled with a 20/40 gradation quartz sand filter that extends from the base of the well to at least 1 foot above the top of the screen. An approximate two-foot layer of bentonite pellets will be placed on top of the sand filter to serve as a seal. The remaining annular space will be filled with a Portland cement-based grout mixture. The grout mixture will be pumped into the annular space using a tremie pipe method to ensure no gaps or hollow spaces are present between the bentonite seal and surface completion. Wells installed around buildings or in populated areas will be completed flush with the ground surface. Flush mount wells will be installed flush with the ground surface within steel well vaults painted to FS/HAAF standards. Wells installed in wooded or open areas will be completed with an above ground surface completions. The above ground surface completion will consist of a 4-inch steel completion protective cover which will be secured in a 2-foot square by 6-inch thick concrete pad. Each of the wells will be fitted with a water tight cap and the protective steel casing for above ground surface completions will be outfitted with a pad lock. A schematic of the proposed monitor well construction is included as Figure 4-2. Once the wells have been completed, they will be developed using the pumping/overpumping method. All drilling activities will be completed by a Georgia certified driller. The monitor wells will be surveyed for location and elevation by a land surveyor registered in the state of Georgia.

4.3.5 Groundwater Level Measurements and Sampling

A complete set of water-level measurements will be collected from existing monitor wells installed at SWMU 39. The water-level measurements will be taken to provide a comprehensive view of vertical and horizontal gradients in the area.

4.3.6 Groundwater Monitoring

The four new monitor wells will be sampled following installation. Groundwater sampling will be performed using low-flow, or micropurge, procedures in accordance with Groundwater Sampling Operating Procedure, Number SESDPROC-301-R1 (USEPA 2007). The monitor wells will be sampled for analysis of VOCs by USEPA Method 8260, SVOCs by USEPA Method 8270, and metals by USEPA Methods 6010.

4.4 Phase II Delineation Investigation

The intention of the Phase II investigation is to perform additional delineation as needed, install permanent monitor wells, sample all existing and new monitor wells, and perform hydraulic testing. Phase II investigation activities will be discussed informally with the GA EPD prior to implementation.

4.4.1 Additional delineation

If data gaps are identified following the completion of the Phase 1 investigation, additional soil, groundwater, sediment, or surface water samples may be collected. The sample plan for any additional delineation will be submitted to GAEPD informally prior to mobilization.

Additionally, based on the Phase 1 soil investigation metals analysis results, background soil samples may be collected. Background samples will be collected well outside the known extent of impacts. Surface and/or subsurface background soil samples will be collected as necessary. Subsurface soils will be collected using a hand auger or DPT. A sufficient number of samples will be collected for statistical analysis. Background soil samples will be placed in laboratory-supplied containers and stored in sealed ice filled coolers. All samples will be shipped via overnight carrier to Shealy Environmental, a Georgia certified laboratory (Appendix A), under appropriate preservation and chain-of-custody procedures. The samples will be analyzed for VOCs by USEPA Method 8260, SVOCs by USEPA Method 8270, and metals by USEPA Method 6010. The samples will be analyzed for VOCs and SVOCs to confirm that they are representative of background conditions.

4.4.2 Groundwater Monitor Wells

Additional shallow and deep monitor wells will be installed as necessary to define the extent of TCE and PCE impacts to groundwater. The number and locations of monitor wells will be based on the results of the Phase 1 soil and groundwater investigations. The additional shallow and deep monitor wells will be installed as described above in Section 4.1.4. The monitor wells will be surveyed for location and elevation by a land surveyor registered in the state of Georgia.

All existing and new monitor wells will be sampled following installation of the new wells. Groundwater sampling will be performed using low-flow, or micropurge, procedures in accordance with Groundwater Sampling Operating Procedure, Number SESDPROC-301-R1 (USEPA 2007). All existing and new monitor wells will be sampled for analysis of VOCs by USEPA Method 8260, SVOCs by USEPA Method 8270, and metals by USEPA Methods 6010.

4.4.3 Slug Tests

Limited data has been collected to characterize the site specific hydrogeology. To better understand the site specific flow characteristics and characterize the aquifer, slug tests will be performed in select shallow and deep monitor wells. Slug tests will be conducted in a minimum of five groundwater monitor wells to represent conditions across the site. Rising head and falling head slug tests will be conducted at each location. For monitor wells where the screen brackets the water table, only falling head slug test data will be used for the calculations. The results of the slug tests will be used to determine the hydraulic conductivity of the shallow aquifer. The hydraulic conductivity will be used to calculate the groundwater flow velocity.

The slug test will be conducted as follows:

- The static water level will be measured from the top of casing in the well.
- A pressure transducer will be installed within the water column below the level of the slug test activity.

- After the water has stabilized from emplacement of the pressure transducer the water level will be measured again. The test should not start until the water level is stable. Barometric pressure, as well as other water level changing effects will be noted and taken into account during calculations.
- The pressure transducer and data logger will be set to measure water level at a specified interval, typically every second to half-second.
- Once the pressure transducer is set in the well and a baseline reading is established, a bailer or a PVC slug will be inserted in to the well. The water level will be allowed to return to within 5-percent of static water level. When a static condition has been reached, the bailer or PVC slug will be quickly removed from the water and the subsequent response will be recorded. Once the water level has recovered to at least 90-percent of the initial water level, the test is completed.
- Because of the small displacement that is being used to account for the short water columns, multiple (two minimum) tests may be conducted at each well and the resulting hydraulic conductivities values averaged.
- The data will be retrieved from the transducer's data logger and the aquifer's hydraulic conductivity will be calculated with the use of applicable calculation methods (i.e, Hvorslev, Bouwer-Rice).
- The equipment will be removed and decontaminated using a laboratory grade detergent wash and double water rinse between each monitoring well location. Sampling personnel will wear new disposable latex gloves when handling any down-hole equipment. Gloves will be changed out between each monitor well location.

4.5 Human Health and Ecological Risk Assessments

Both a human health risk assessment (HHRA) and an ecological risk assessment (ERA) will be conducted following the GAEPD Guidance for Selecting Media Remediation Levels at Resource Conservation and Recovery Act Solid Waste Management Units (GAEPD 1996) and applicable USEPA guidance for risk assessments (USEPA 1989, 1991, 1992, 1997a,b,c, 1998, 1999, 2000a,b, 2004, 2009c).

4.5.1 Data Evaluation

Initially, risk assessment datasets will be prepared for each medium at the Site (soil, groundwater, surface water, and sediment). The risk assessments will use data collected during the currently proposed investigation as well as data collected previously for the Site.

The groundwater, surface water and sediment data will be grouped by medium. The soil data may be subdivided into several datasets based on spatial distribution if several exposure units (EUs) are identified. Additionally, the soil data will be subdivided into surface soil (0 to 1 ft bgs), subsurface soil (1 ft to groundwater), and combined surface and subsurface soil (0 to groundwater) based on potential exposure scenarios.

Data summary tables will be prepared for each dataset. A data summary table will be prepared for each dataset which will include all detected constituents and the frequency of detection, the range of detection limits, and the range of detected values.

4.5.2 Human Health Risk Assessment

The HHRA will evaluate potential exposures and risks to site-related constituents (e.g., metals and organic compounds) detected in the soil, groundwater, surface water, and/or sediments at the Site. The HHRA will consist of several elements: selection of constituents of potential concern (COPCs), exposure assessment, toxicity assessment, risk characterization, development of risk-based remediation levels (if necessary), and uncertainty analysis.

COPCs will be selected by comparison to USEPA Regional Screening Levels (RSLs; USEPA 2009a) and background levels for soil (twice the mean). All detected constituents without an RSL will be identified as a COPC. For constituents listed as noncarcinogens, the RSL value will be multiplied by 0.1 to account for cumulative effects of non-carcinogens. Toxicity values will be obtained following the USEPA hierarchy (USEPA 2003).

The exposure point concentration will be calculated for each of the receptors and will be derived based on the medium the potentially exposed population will contact. Generally, the exposure point concentration is derived following USEPA methodology and is the lower of the maximum concentration and the 95 percent upper confidence level (95UCL) on the mean (assuming a one-tailed distribution). The 95UCLs will be calculated, where possible, using the ProUCL software available from USEPA (USEPA 2009d). Receptor exposure parameters will be selected from USEPA sources (USEPA 1989, 1991, 1997c, 2004, 2008).

The receptor- and pathway- specific dose of a COPC will be quantified by combining the EPC of that COPC in the exposure media with the appropriate receptor exposure parameters for that pathway. Potential risks to human health will then be evaluated quantitatively by combining calculated exposure levels and toxicity data. Estimates of excess lifetime cancer risk (ELCR) will be compared to an ELCR of $1x10^{-6}$ following GAEPD guidance (1996). Noncancer hazards, presented as hazard indices (HIs), will be compared to an HI of one per GAEPD guidance (1996).

4.5.3 Ecological Risk Assessment

The ERA will evaluate the potential exposures and risk to terrestrial and aquatic wildlife that may be exposed to site-related constituents detected in the soil, groundwater, surface water, and/or sediments at the Site. The first step of the ERA will be a preliminary comparison of Site data to screening values (GAEPD 1996). The screening values used will include Region 4 ecological screening Levels (USEPA 2001), ambient water quality criteria (USEPA 2009b) and established background metal concentrations (twice the mean), if necessary. If the maximum detected concentration is greater than the screening level, the constituent will be identified as a constituent of potential ecological concern (COPEC) and quantitatively evaluated further in the ERA unless it is a metal present at concentrations lower than the established background level. Depending on the results of this preliminary screening, it may be followed by a screening level ERA (SLERA) through step 3a of a baseline ERA (BERA), as necessary following the USEPA ERA process (USEPA 1999, 2000a,b).

A SLERA is designed to provide a conservative estimate of the risks that may exist for wildlife and incorporates uncertainty in a precautionary manner. The purpose of a SLERA is to either indicate the need for a BERA (and to help focus that baseline risk assessment), or to indicate that there is a high probability of no adverse risks for wildlife (USEPA 1999, 2000). The SLERA/step 3a BERA will follow the USEPA protocols through Step 3a, Problem Formulation. The results of the SLERA/step 3a BERA will be used to identify the need to continue through the BERA process. The BERA uses a higher level evaluation to identify the nature and extent of ecological risks. The BERA will be conducted if the conservative SLERA does not rule out further evaluation of constituents and media that clearly do not pose an ecological risk.

4.6 Field Equipment Decontamination

A decontamination area will be established and used to steam clean the drilling and well construction equipment and materials. An impervious decontamination area will be utilized and the water used to clean the equipment will be containerized for offsite disposal.

4.6.1 Cleaning Materials

The laboratory detergent used to wash the equipment will be a standard brand of phosphate-free laboratory-grade detergent such as Micro or Liquinox. Potable water, deionized water, and stiff plastic bristled brushes will be used to clean the equipment.

4.6.2 Safety Procedures to be Utilized During Cleaning Operations

The materials used to implement the cleaning procedures outlined in this section can be dangerous if improperly handled. At a minimum, the following precautions will be taken in the field during cleaning operations:

§ Safety glasses with side shields or goggles, and latex or vinyl surgical gloves or nitrile rubber gloves will be worn during all cleaning operations;

§ All rinsing operations will be conducted in the open (never in a closed room); and

§ No eating, smoking, drinking, chewing, or any hand-to-mouth contact shall be permitted during cleaning operations.

4.6.3 Storage of Field Equipment and Sample Containers

Decontaminated field and sampling equipment will be stored in covered containers or wrapped in aluminum foil to minimize contamination. All decontaminated equipment, when not in use, will be kept in a designated storage area. Sampling equipment and sample containers will not be stored or transported with any gasoline, diesel, or other fuel containers or gasoline or diesel fuel powered equipment. Decontaminated equipment will be clearly identified by labeling the wrapping material. Field equipment and reusable sample containers requiring cleaning or repairs will not be stored with clean equipment. Instead, equipment requiring repairs will be clearly identified. Field equipment that requires cleaning will be segregated from clean equipment and will be stored on plastic sheeting pending cleaning.

4.6.4 Cleaning Procedures

4.6.4.1 Drilling and Direct Push Equipment

All drilling and direct push equipment used during completion of soil borings or installation of the monitoring wells will be steam-cleaned prior to initiating drilling or direct push activities. This will include, but is not limited to, the drill stem, augers, drill bits, direct push rods, core barrels, and tools utilized by the contractor.

The drill rig or direct push rig itself will not be decontaminated between soil boring or monitoring well locations. Augers and other drilling, direct push, or sampling equipment will be returned to the decontamination area to be cleaned after each use. Cleaning of equipment will be performed using a high-pressure steam cleaner to prevent cross-contamination of the soil borings and monitoring wells. Potable water for steam cleaning will be obtained from the installation water supply system.

Tools and equipment used to measure the depth of well completion materials and water levels (i.e., measuring tapes, electric/electronic probes, tampers, tremie pipes) also will be decontaminated by steam cleaning between well locations to avoid cross-contamination. All equipment and tools will be isolated from contact with the ground by placing them onto sheets of polyethylene plastic.

4.6.4.2 Teflon™, Stainless Steel, or Glass Field Sampling Equipment

Teflon™, stainless steel, and glass sampling equipment will be cleaned using the following procedures.

1. If the equipment is used to collect samples that contain hard to remove materials, it will initially be steam cleaned prior to proceeding with the following cleaning procedures.

2. Wash equipment thoroughly with laboratory detergent and tap water using a plastic brush to remove any particulate matter or surface film.

3. Teflon™, stainless steel, or glass sampling equipment will be rinsed thoroughly with potable water from an approved onsite source.
4. Rinse thoroughly with analyte free water.
5. Rinse thoroughly with organic/analyte free water. If organic/analyte free water is not available, equipment will be allowed to completely dry.
6. Wrap equipment completely with aluminum foil or store in Ziploc™ plastic bags to prevent contamination during storage and/or transport to the field.

If the field equipment cannot be cleaned utilizing these procedures, it will discarded.

4.6.4.3 Other Sampling Equipment

Miscellaneous sampling equipment will be washed with laboratory detergent, rinsed with potable water, followed by a thorough deionized water rinse, and dried before being stored. This procedure is not used for any equipment utilized for the collection of samples for trace organic compounds analyses.

4.6.4.4 Trace Organic Sampling Equipment

The following procedures will be used for all sampling equipment used to collect routine samples undergoing trace organic or inorganic constituent analyses:

- Clean with tap water and soap using a brush if necessary to remove particulate matter and surface films. Equipment may be steam cleaned (soap and high pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned will be placed on racks or saw horses at least two ft above the floor of the decontamination pad. PVC or plastic items will not be steam cleaned;

- Rinse thoroughly with tap water;

- Rinse thoroughly with analyte free water;

- Rinse thoroughly with organic/analyte free water. If organic/analyte free water is not available, equipment will be allowed to completely dry; and

- Remove the equipment from the decontamination area and cover with plastic. Equipment stored overnight will be wrapped in aluminum foil and covered with clean, unused plastic.

4.6.4.5 Field Analytical Equipment and Other Field Instruments

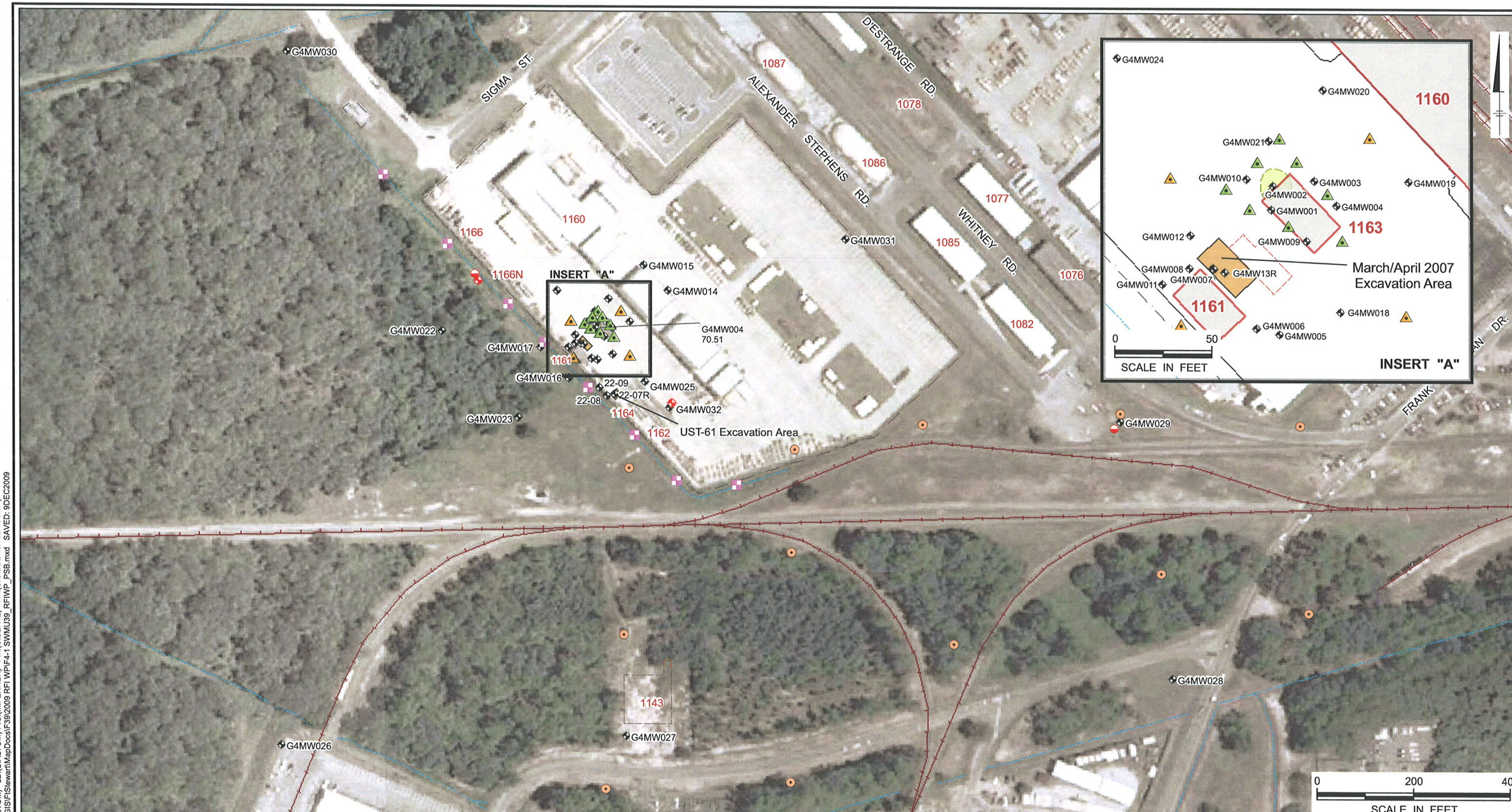
The exterior of sealed, watertight equipment will be washed with a mild detergent (for example, liquid dishwashing detergent) and rinsed with tap water before storage. The interior of such equipment may be wiped with a damp cloth if necessary. Other field instrumentation will be wiped with a clean, damp cloth. Conductivity probes, pH meter probes, etc., will be rinsed with deionized water before storage.

4.6.5 Disposable Materials

Disposable materials generated from the decontamination and sampling activities will be contained in plastic garbage bags. These materials include, but are not limited to gloves, Tyvek suits, latex booties, paper and plastic. The wastes will be disposed off-site in accordance with all applicable federal and state regulations.

4.7 IDW Characterization and Disposal

The investigation derived waste (IDW) generated during the proposed investigation activities is anticipated to consist of DPT/drill cuttings, decontamination fluids, purge water, personal protective equipment (PPE), and disposable sampling materials/general refuse (e.g. Teflon® tubing, paper, plastic, aluminum foil). The soil, drill cuttings, decontamination fluids, and purge water will be collected in U. S. Department of Transportation (DOT)-approved 55-gallon drums and samples will be collected for disposal characterization. All non-hazardous disposable PPE and sampling materials will be placed in dumpsters at Fort Stewart.



LEGEND

- Fence
- Rail Spur
- Surface Water Drainage
- Monitor Well (shallow aquifer)
- Estimated Extent of Free Product
- Excavation Area
- Proposed Soil Boring
- Proposed Soil Boring (LNAPL Delineation)
- Proposed Surface Water/Sediment Sample
- Proposed Monitor Well (shallow)
- Proposed Monitor Well (deep)
- Proposed Temporary Well (groundwater)

REFERENCE: NRCS, LIBERTY COUNTY, GEORGIA (NAIP 2007).

FORT STEWART MILITARY RESERVATION, GEORGIA

SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY RFI WORK PLAN

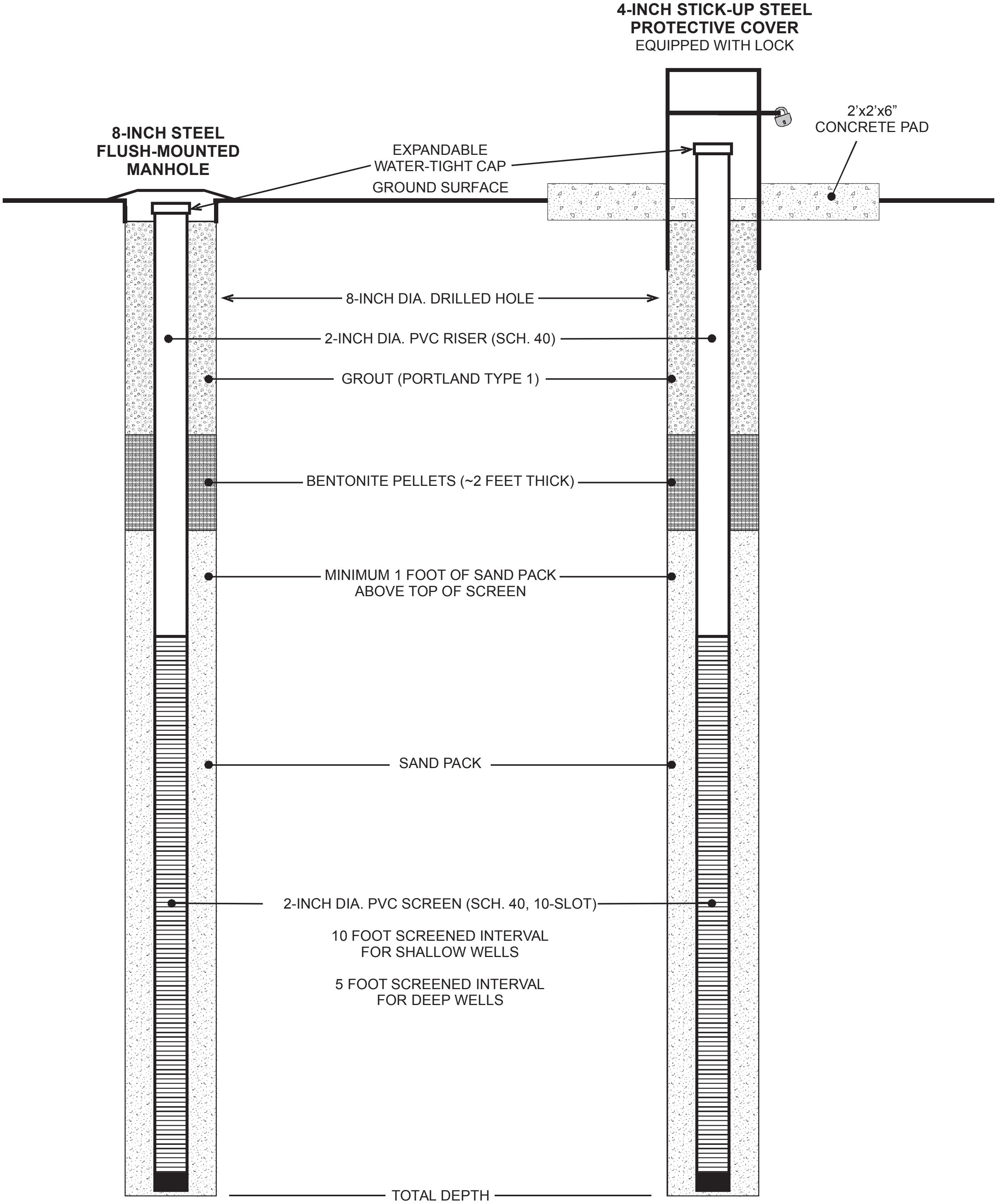
Proposed Sample Locations

ARCADIS

FIGURE

4-1

CITY:(KNOXVILLE) DIV/GROUP:(ENV) DB:(B.ALTOM) LD:(B.ALTOM) PIC:(M.FENNER) PM:(C.BERTZ) TM:(S.GIBBENS/H.ENGLISH)
PROJECT: GP08HAFS.F39A DAOWP PATH: G:\GIS\FtStewart\MapDocs\F39\2009 RFI WP\F4-1 SWMU39_RFIWP_PSB.mxd SAVED: 9DEC2009



CITY:(KNOXVILLE) DIV/GROUP:(ENV) LD:(B.ALTOM) PIC:(T.TALELE) PM:(C.BERTZ) APM:(S.GIBBONS) TM:(C.FORMAN)
PROJECT: GP09HAFS.F39A.DA0WP PATH: G:\GIS\FtStewart\MapDocs\F39\2010 RFI WP\ F4-2 F39_RFIWP_WCON.cdr SAVED: 7JUN2010

FORT STEWART MILITARY RESERVATION, GEORGIA
SWMU 39 – DIRECT SUPPORT MAINTENANCE FACILITY RFI WORK PLAN

Proposed Monitor Well Construction

ARCADIS

FIGURE
4-2

5. Conclusions

The extent of impacted soil and groundwater at SWMU 39 has not been sufficiently defined. The objective of the proposed phased investigation activities is to adequately define the extent of impacts to soil and groundwater, delineate the extent of LNAPL near G4MW002, and identify the source of TCE impacts south and east of the DSMF.

The initial phase of investigation will include a series of borings for soil sampling and LNAPL delineation, installation of temporary wells for groundwater delineation, installation of monitor wells, collection of lithologic and hydrologic data, and the collection of surface water and sediment sampling. A second phase of investigation will be conducted to fill in any remaining data gaps, install additional monitor wells, collect background soil data if determined to be necessary and perform slug tests. The results of both phases of investigation will be included in an RFI Report. A proposed project schedule is included as Figure 5-1. Copies of the 8-hour refresher certificates for the field investigation staff is included in Appendix C.

ID		Task Name	Duration	Start	Finish
0		**SWMU 39 RCRA Facility Investigation**	**238 days**	**Mon 3/8/10**	**Wed 2/2/11**
1		Phase 1 Investigation	60 edays	Mon 3/8/10	Fri 5/7/10
2		Evaluation of Phase 1 Data	45 edays	Sun 6/6/10	Wed 7/21/10
3		Disscuss Phase 1 Results with GAEPD	1 day	Wed 7/21/10	Wed 7/21/10
4		Phase 2 Investigation	60 edays	Wed 7/21/10	Sun 9/19/10
5		Evaluation of Phase 2 Data	45 edays	Tue 10/19/10	Fri 12/3/10
6		Preparation of RFI Report	60 edays	Fri 12/3/10	Tue 2/1/11
7		Submittal of RFI Report to GAEPD	1 day	Wed 2/2/11	Wed 2/2/11

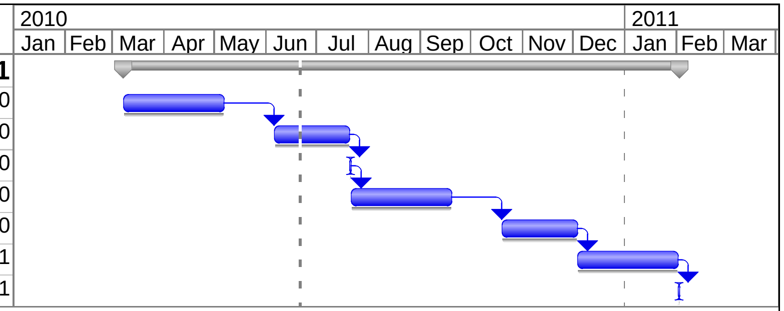
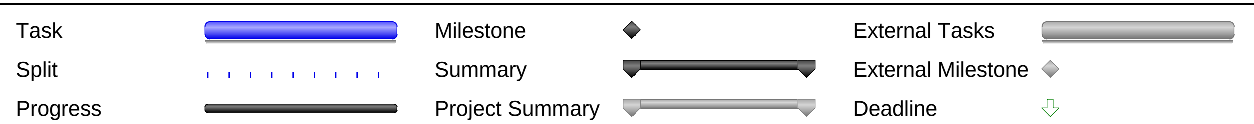


Figure 5-1
SWMU 39 RCRA Facility Investigatior



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Appendix A

Commercial Laboratory Stipulation

Commercial Laboratory Stipulation
Georgia EPD Rule 391-3-26-05(2)

Laboratory:	Shealy Environmental Services, Inc. 106 Vantage Point Drive West Columbia, SC 29172
Accreditor:	NELAP Approved State Agency (Florida)
Accreditation ID:	E87653
EPA Lab Code:	SC00162
Scope:	EPA 8260 (VOCs), EPA8270 (SVOCs), EPA 6010 (RCRA Metals)
Effective:	July 1, 2009
Expires:	June 30, 2010

ARCADIS

Appendix B

Soil Description Operating Procedure

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Soil Description

Rev. #: 0

Rev Date: May 20, 2008

Approval Signatures

Prepared by: ______________________ Date: 5/22/08

Reviewed by: ______________________ Date: 5/22/08
(Technical Expert)

Reviewed by ______________________ Date: 5/22/08
(Technical Expert)

I. Scope and Application

This ARCADIS standard operating procedure (SOP) describes proper soil description procedures. This SOP should be followed for all unconsolidated material unless there is an established client-required specific SOP or regulatory-required specific SOP. In cases where there is a required specific SOP, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-ARCADIS SOP, additional information required by this SOP should be included in field notes with client approval.

This SOP has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;

- provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This SOP incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This SOP does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other ARCADIS SOPS, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

II. Personnel Qualifications

Soil descriptions will be completed only by persons who have been trained in ARCADIS soil description procedures. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist. For sites where soil descriptions have not previously been well documented, soil descriptions should be performed only by trained persons with a degree in geology or a geology-related discipline.

III. Equipment List

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;
- field book for supplemental notes;
- this SOP for Soil Descriptions and any project-specific SOP (if required);
- field card showing Wentworth scale;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- personal protective equipment (PPE), as required by the HASP; and
- digital camera.

IV. Cautions

Drilling and drilling-related hazards including subsurface utilities are discussed in other SOPs and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

V. Health and Safety Considerations

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

VI. Procedure

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, Lexan or acetate sleeves for dual-tube direct push, etc.

2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.

3. Examine all of each individual soil sample (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:

- depth interval;
- principal component with descriptors, as appropriate;
- amount and identification of minor component(s) with descriptors as appropriate;
- moisture;
- consistency/density;
- color; and
- additional description or comments (recorded as notes).

The above is described more fully below.

DEPTH

To measure and record the depth below ground level (bgl) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.

2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).

3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.

4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Fine Sand with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the field gauge card that shows Udden-Wentworth scale or by measuring with a ruler. Use of field sieves s recommended to assist in estimating percentage of coarse grain sizes. Settling test or wash method (Appendix X4 of ASTM D2488) is recommended for determining presence and estimating percentage of clay and silt.

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Determination of actual dry weight of each Udden-Wentworth fraction requires laboratory grain-size analysis using sieve sizes corresponding to Udden-Wentworth fractions and is highly recommended to determine grain-size distributions for each hydrostratigraphic unit.

Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. Field sieve-analysis can be performed on selected samples to estimate dry weight fraction of each category using ASTM D2488 Standard Practice for Classification of Soils for Engineering Purposes as guidance, but replace required sieve sizes with the following Udden-Wentworth set: U.S. Standard sieve mesh sizes 6; 12; 20; 40; 70; 140; and 270 to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

PRINCIPAL COMPONENT

The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% pebbles would be "Pebbles"; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be "Fine to coarse Sand" or for a sample that was 40% silt and 45% clay the principal component would be "Clay and Silt".

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the ARCADIS Soil Description Field Guide.

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test below, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Description	Criteria
Nonplastic	A $^1/_8$ inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

MINOR COMPONENT(S)

The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25 % silt and clay; 15 % pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see Table on Page 5) and the same descriptors that would be used for a principal component. Plasticity should be provided as a descriptor for the silt and clay. Dilatancy should be provided for silt and silt-sand mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand. For the example above, the minor constituents with modifiers could be: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

SORTING

Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. ARCADIS prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

- Well sorted – the range of particle sizes is limited (e.g. the sample is comprised of predominantly one or two grain sizes)
- Poorly sorted – a wide range of particle sizes are present

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. For SPT blow counts the N-value is used. The N-value is the blows per foot for the 6" to 18" interval. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- **Odor** - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH "Pocket Guide to Chemical Hazards", e.g. "pungent" or "sweet" and should not indicate specific chemicals such as "phenol-like" odor or "BTEX" odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts)
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy
- Cementation
- NAPL presence/characteristics, including sheen (based on client-specific guidance)
- Reaction with HCl (typically used only for special soil conditions)
- Origin, if known (capital letters: LACUSTRINE; FILL; etc.)

EXAMPLE DESCRIPTIONS

51.4 to 54.0' Clay, some silt, medium to high plasticity; trace small to large pebbles, subround to subangular up to 2" diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0' Sand, medium to Pebbles, coarse; sub-round to sub-angular; trace silt; poorly sorted; wet; grayish brown (10YR5/2). NOTE: sedimentary, igneous and metamorphic particles.

Unlike the first example where a density of cohesive soils could be estimated, this rotosonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose Sand and Pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth

- Principal Components
  - Angularity for very coarse sand and larger particles
  - Plasticity for silt and clay
  - Dilatancy for silt and silt-sand mixtures
- Minor Components
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

VII. Waste Management

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. Two examples of standard boring logs are presented below.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

ARCADIS Page ____ of ____

Sample Log

Well/Boring ____________ Project Name and No. ____________

Site Location ____________ Drilling Started ____________ Drilling Completed ____________

Total Depth Drilled ________ feet Hole Diameter ________ inches Sampling Interval ________ feet

Length and Diameter of Sampling Device ____________ Type of Sampling Device ____________

Drilling Method ____________ Drilling Fluid Used ____________

Drilling Contractor ____________ Driller ____________ Helper ____________

Prepared By ____________ Hammer Weight ____________ Hammer Drop ________ inches

Sample Depth (feet below land surface) From	To	Sample Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 Inches	Sample Description	PID (ppm)

IX. Quality Assurance

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

X. References

ARCADIS Soil Description Field Guide, 2008 (in progress)

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder"

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48

NIOSH Pocket Guide to Chemical Hazards

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63

ARCADIS

Appendix C

Field Personnel Health and Safety Certificates

CERTIFICATE OF TRAINING

Robert Shealy

has completed: Annual 8-Hour Hazwoper Refresher

In accordance with 29 CFR 1910.120

on Thursday, July 16, 2009

ARCADIS

Patricia A. Vollertsen

Patricia A Vollertsen
Director, H&S Administration

CERTIFICATE OF TRAINING

Joshua Frizzell

has completed: Annual 8-Hour Hazwoper Refresher

In accordance with 29 CFR 1910.120

on Saturday, January 30, 2010

ARCADIS
Infrastructure, environment, facilities

Patricia A Vollertsen

Patricia A Vollertsen
Director, H&S Administration

CERTIFICATE OF TRAINING

Cecilia Bell

has completed: Annual 8-Hour Hazwoper Refresher

In accordance with 29 CFR 1910.120

on Wednesday, August 12, 2009

ARCADIS
Infrastructure, environment, facilities

Patricia A. Vollertsen

Patricia A Vollertsen
Director, H&S Administration