SITE: HAA-13 Ph1 R2, HAAF, GEORGIA

FSGA CAP-Part B R2 Submittal -	29 Aug 2000
GA EPD CAP-Part B R2 Review Comments with Milestone request -	18 Dec 2000
FSGA Response to Comments, CAP-Part B, R2 with Milestone schedule -	30 Jan 2001
GA EPD CAP-Part B R2 Review Comments -	20 Nov 2001

Contractor Change

FSGA Revised CAP-Part B sent to GA EPD -	12 Aug 2009
FSGA Revised CAP-Part B Addendum #1 sent to GA EPD -	5 Nov 2009
GA EPD CAP-Part B approval -	19 Nov 2009
GA EPD CAP-Part B Addendum #1 approval -	28 Jan 2010

Georgia Department of Natural Resources

Environmental Protection Division
Underground Storage Tank Management Program
4244 International Parkway, Suite 104, Atlanta, Georgia 30354
Chris Clark, Commissioner
F. Allen Barnes, Director
(404) 362-2687

January 28, 2010

Ms. Algeana Stevenson
U.S. Army/HQ 3d,Inf. Div (Mech)
Directorate of Public Works
Building 1137
1550 Frank Cochran Drive
Fort Stewart, Georgia 31314-4927

SUBJECT: Notice to Implement Corrective Action Plan (CAP)-Part B:
Hunter AAF, Former Pumphouse #1
Former Building 8060
Savannah, Chatham County, GA
Facility ID: 9025085*2

Dear Ms. Stevenson:

The Georgia Underground Storage Tank Management Program (USTMP) has received your consultant's letter, dated November 5, 2009, that forwarded a properly certified Revised CAP-Part B with the Fifteenth Semiannual Monitoring Only Report. The report was prepared by ARCADIS.

The technical proposal contained in the Revised CAP-Part B for further investigation, monitoring and/or remediation of the current release is hereby approved by the USTMP. As a result of your CAP-Part B being technically approved, you are authorized to begin implementation of this plan.

Please submit an updated milestone schedule by **March 31,2010**, listing specific dates, events and a timetable to complete the proposed activities. If you have any technical questions, please contact me at (404) 362-4529.

Sincerely,

William E. Logan
Geologist III
Corrective Action Unit II

WEL:
S: land/landdocs/williaml/Pend10/9025085R2A. 120
cc: Scott Bostian, P.E., ARCADIS
Lisa L. Lewis, GA EPD
File (CA): CHATHAM; 9025085

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Georgia Department of Natural Resources

Environmental Protection Division
Underground Storage Tank Management Program
4244 International Parkway, Suite 104, Atlanta, Georgia 30354
Chris Clark, Commissioner
F. Allen Barnes, Director
(404) 362-2687

RECEIVED
DEC 2 REC'D
By

November 19, 2009

Ms. Algeana Stevenson
U.S. Army/HQ 3d,Inf. Div (Mech)
Directorate of Public Works
Building 1137
1550 Frank Cochran Drive
Fort Stewart, Georgia 31314-4927

SUBJECT: Notice to Implement Corrective Action Plan (CAP)-Part B:
Hunter AAF, Former Pumphouse #1
Former Building 8060
Savannah, Chatham County, GA
Facility ID: 9025085*2

Dear Ms. Stevenson:

The Georgia Underground Storage Tank Management Program (USTMP) has received your consultant's letter, dated August 12, 2009, that forwarded a properly certified Revised CAP-Part B with the 2008 Annual Report. The report was prepared by ARCADIS.

The technical proposal contained in the Revised CAP-Part B for further investigation, monitoring and/or remediation of the current release is hereby approved by the USTMP. As a result of your CAP-Part B being technically approved, you are authorized to begin implementation of this plan.

Please submit an updated milestone schedule by **December 30, 2009**, listing specific dates, events and a timetable to complete the proposed activities. If you have any technical questions, please contact me at (404) 362-4529.

Sincerely,

William E. Logan
Advanced Geologist
Corrective Action Unit II

WEL:
S: land/landdocs/williaml/Pend09/9025085R2. 120
cc: Scott Bostian, P.E., ARCADIS
Lisa L. Lewis, GA EPD
File (CA): CHATHAM; 9025085

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, US ARMY GARRISON, FORT STEWART / HUNTER ARMY AIRFIELD
1587 FRANK COCHRAN DRIVE
FORT STEWART, GEORGIA 31314

REPLY TO
ATTENTION OF

NOV 05 2009

Office of the Directorate

CERTIFIED MAIL

Georgia Environmental Protection Division
UST Management Program
Attention: Mr. William Logan
4244 International Parkway, Suite 104
Atlanta, GA 30354

Dear Mr. Logan:

Fort Stewart is pleased to submit to the Georgia Environmental Protection Division (GA EPD) one copy of the Final Fifteenth Semiannual Monitoring Only Report With Addendum #1 to Revised Corrective Action Plan-Part B for Former Pumphouse # 1 (Release #2), Facility ID #9-025085*2, Former Building 8060, Hunter Army Airfield, Georgia, dated October 2009, for your review.

The enclosed report documents the June 2009 semiannual sampling event. In addition to the regular sampling event, supplemental data was collected to refine the design of the proposed corrective actions presented in the Revised Corrective Action Plan - Part B with 2008 Annual Report (ARCADIS 2009). Semiannual monitoring will continue in wells D-MW-05R, D-MW-06R, P1-MW-01, P1-MW-02, P1-MW-19, P1-MW-21, P1-MW-22, and P1-MW-23. The next semiannual sampling event is scheduled to be conducted in December 2009. The monitoring schedule is being conducted in accordance with the CAP - Part B Report (SAIC 2000) as approved by the GA EPD Underground Storage Tank Management Program. Termination conditions approved in the CAP - Part B Report are measured benzene concentrations in the groundwater below the approved alternate concentration level of 285 ug/L and the collection of three confirmatory soil samples to determine if the benzene and chrysene concentrations in those samples are below the GA EPD approved alternate threshold limits of 9.3 and 2.1 mg/kg, respectively.

If you have any questions or comments regarding the enclosed report, please contact Ms. Algeana Stevenson at (912)315-5144 or Ms. Tressa Rutland, Directorate of Public Works, Prevention and Compliance Branch, at (912)767-2010.

Sincerely,

Thomas C. Fry
for Robert R. Baumgardt
Director, Public Works

Enclosure

IMA

3d Inf Div (Mech)

U.S. Army Environmental Command

And

Fort Stewart Directorate of Public Works Under Contract Number W91ZLK-05-D-0015 D.O. 0003

Final Revised Corrective Action Plan – Part B with 2008 Annual Report

Former Pumphouse #1 (Release #2)
Former Building 8060
Hunter Army Airfield, Savannah, Georgia
Facility ID No. 9-025085*2

July 9, 2009

ARCADIS
Infrastructure, environment, buildings

2. Site Investigation Report

Former Underground Storage Tanks (USTs) 30 through 39 and 50 at former Pumphouse #1, Facility ID #9-025085 were located near former Building 8060 at Hunter Army Airfield (HAAF), Savannah, Georgia (Figure 2-1). Former Pumphouse #1 was an aviation-gas fuel island located along the east-west taxiway of HAAF that was used from about 1953 until the early 1970s. It consisted of ten 25,000-gallon USTs and a 50,000-gallon underground defueling tank. The pumphouse was inactive from the 1970s to 1995, when eight of the 25,000-gal USTs were removed. The 50,000-gallon defueling tank and two of the 25,000-gallon tanks remained in-place, partially under the pumphouse structure. In 1998, the pumphouse structure was removed, along with the two remaining 25,000-gallon USTs. The 50,000-gallon defueling tank was closed in-place. The piping from the boundary of the pumphouse facility to the bulk fuel farm was also drained, pigged, and grouted in-place.

Various closure activities and Corrective Action Plan (CAP)–Part A and CAP–Part B investigations were performed at the former Pumphouse #1 site between 1995 and 2000. The former Pumphouse #1 investigations covered an area south of the active taxiway. CAP–Part A and CAP–Part B investigations were conducted at the Departure/Arrival Air Control Group (DAACG) facility in 1995 and 1996, respectively. These investigations covered the active tarmac north of the active taxiway. Review of the analytical data from all of the investigations indicated that it was necessary to combine the DAACG facility data and the former Pumphouse #1 data to document the nature and extent of contamination. As a result, the former Pumphouse #1 CAP–Part B Report (SAIC 2000) combined the results of all the investigations into a single report, which was submitted to the Georgia Environmental Protection Division (GA EPD) in August 2000 and subsequently approved.

As indicated in the former Pumphouse #1 CAP–Part B Report, two distinct and separate plumes are located within the vicinity of the former Pumphouse #1 site. Release #1 is an area of soil and groundwater contamination located near the DAACG facility that is in the vicinity of former Fuel Pits 1A and 1B, located approximately 900 feet west of former Building 8060 (i.e., Pumphouse #1). Release #2 is an area of soil and groundwater contamination located near the former Pumphouse #1 facility and former Fuel Pits 1C and 1D, located approximately 200 feet north of the former Tank Pits. The CAP-Part B stated that based on proximity, a release from Former Fuel Pit 1C was apparently responsible for the contamination associated with Release #2. During the CAP–Part B investigation activities, the horizontal and vertical extent of petroleum-related contamination in soil and groundwater was determined for both areas of contamination. The corrective actions

at Release #1 and Release #2 are being addressed separately.

For the Former Pumphouse #1 tank pit area (Release #2), the CAP–Part B Report recommended semiannual monitoring of eight wells (i.e., D-MW5, D-MW6, P1-MW1, P1-MW2, P1-MW18, P1-MW19, P1-MW22, and P1-MW23) for benzene, toluene, ethylbenzene, and xylenes (BTEX). The CAP–Part B Report was approved by GA EPD in December 2000. Per the CAP-Part B, semiannual monitoring and annual reporting began in September 2001 and has continued to date. The termination goal for this monitoring is demonstrating benzene concentrations in groundwater are below the alternate concentration limit (ACL) of 285 microgram per liter (µg/L) for two consecutive sampling events. The CAP-Part B also stated that once the benzene ACL has been achieved at the Former Pumphouse #1 tank pit area, three confirmatory soil samples would be collected to confirm that soil meets the alternate threshold levels (ATLs) for benzene and chrysene of 9.3 milligram per kilogram (mg/kg) and 2.1 mg/kg, respectively.

An additional investigation was conducted in 2003 to further delineate the horizontal and vertical extent of the free product in the subsurface at Release #1 and Release #2 using cone-penetrometer-technology (CPT) equipment with laser induced fluorescence (LIF) detection. The results of the investigation were presented in the Data Summary Report for the 2003 Free Product CPT Investigation, which was also included as an appendix in the Third Annual Monitoring Only Report (SAIC 2005).

The corrective actions that were described in the CAP–Part B Addendum #1 (SAIC 2001) and Addendum #2 (SAIC 2006a) were specific to Release #1 and are not discussed further.

To address free product, absorbent socks were installed, removed and replaced on a bimonthly basis from January 2002 through March 2005. Beginning in June 2005, vacuum extraction (VE) activities were initiated on approximately 50 wells located throughout the Release #1 and Release #2 areas.

In May 2006, six injection wells were installed around the Pumphouse #1 tank pit area for the injection of oxygen-releasing compound (ORC) to enhance the degradation of the BTEX compounds. Quarterly ORC injection through the six injection wells plus six existing monitor wells and performance monitoring was conducted from July 2006 through April 2007. The results were reported in the Fifth Annual Monitoring Only Report (SAIC 2007). The report stated that site contaminant levels were not significantly reduced through the injection of ORC over the 1-year period and that there were apparently two areas that are serving as potential sources

at the site: the former Pumphouse #1 tank pit area and the area under the taxiway near the fuel pits.

Semiannual monitoring was performed in January 2008 and additional soil and groundwater samples were collected with Direct Push Technology (DPT) in January 2008. The results of these activities were included in the Sixth Annual Monitoring Only Report (SAIC 2008). Also included in the Sixth Annual Report were Enhanced Fluid Recovery (EFR) results from October 2007 and January 2008.

Semiannual sampling was conducted in July 2008 and semiannual monitoring scheduled for January 2009 was performed in December 2008. The results of the monitoring activities conducted in July and December 2008 are included in this report. Results from the January 2008 semiannual monitoring and additional investigation are also presented to provide a comprehensive overview of current site conditions.

This Revised CAP–Part B Report is being submitted to the GA EPD Underground Storage Tank Management Program (USTMP) to convey investigation and monitoring data for the 2008 Annual Monitoring Only Report and to present a proposed change to the corrective action strategy for the former Tank Pit area (Release #2).

2.1 Regional, Local, and Site Hydrogeology

A discussion of the regional, local, and site hydrogeology was presented in previous CAP–Part B Reports and is summarized below.

2.1.1 Groundwater Usage

According to the *Groundwater Pollution Susceptibility Map of Georgia* (GA EPD 1992), the former Pumphouse #1 site, Facility ID #9-025085 is located within an area of average or higher groundwater pollution susceptibility. Nine water supply wells are located within the confines of the HAAF area. These wells have the potential to provide up to 3,890 gallons per minute (gpm) of water to occupants of the HAAF installation (SAIC 2000).

2.1.2 Aquifer Description

The hydrogeology in the vicinity of HAAF is mostly influenced by two aquifer systems, the Principal Artesian (Floridan) Aquifer and the surficial aquifer (Miller

1990). The Principal Artesian Aquifer is the lowermost hydrologic unit and is regionally extensive from South Carolina to Georgia, Alabama, and most of Florida. Known elsewhere as the Floridan, this aquifer, approximately 800 feet (ft) in total thickness, is composed primarily of Tertiary-age limestone, including the Bug Island Formation, the Ocala Group, and the Suwannee Limestone. Groundwater from the Floridan is used primarily for drinking water (Arora 1984).

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

The surficial aquifer consists of widely varying amounts of sand and clay, ranging from 55 to 150 ft in thickness. This aquifer is primarily used for domestic lawn and agricultural irrigation. The top of the water table ranges from approximately 2 to 10 ft below ground surface (bgs) (Miller 1990). Groundwater in the surficial aquifer system is under unconfined, or water table, conditions. Locally, however, thin clay beds create confined or semi-confined conditions.

Groundwater encountered at HAAF Pump House #1 UST investigation sites is part of the surficial aquifer system. Based on the facts that all public and non-public water supply wells draw water from the Floridan Aquifer and that the Hawthorn confining unit separates the Floridan Aquifer from the surficial aquifer, it is concluded that there is no hydraulic interconnection between HAAF UST sites (and associated plumes) and water supply withdrawal points (SAIC 2000). Historic groundwater elevations are included in Table 2-1.

2.1.3 Surface Water

The water resources survey conducted during the CAP–Part B site investigation was presented in the CAP– Part B Report (SAIC 2000) and CAP–Part B Addendum #1 Report (SAIC 2002a). Surface water bodies at HAAF include Hallstrom Lake, Lamar Canal, Buckhalter Canal, Springfield Canal, Pond 29 located northwest of Buildings 336 and 232, and an unnamed pond located along the southeastern boundary of the HAAF installation. Several unnamed drainage canals and ditches exist throughout HAAF. Most of these canals drain southwest into the Little Ogeechee River, which is part of the Lower Ogeechee watershed. The remaining drainage canals located on the eastern side of the HAAF installation flow east and eventually drain into the Vernon River, which is located southeast of the HAAF installation. Surface water bodies at HAAF and adjacent areas are not used as public water supplies. The

ponds and lakes, as well as Lamar Canal, are perennial, whereas most of the drainage canals and ditches are intermittent. Most of the drainage canals are at least partially enclosed in culverts (SAIC 2000).

2.1.4 Site Stratigraphy

The lithology encountered at the site is predominantly a white, pale brown, or light gray, very fine to medium-grained sand, with variable silt and clay content. Generally, the samples with higher silt and clay content were within a few feet of the surface. Less silt and clay content was noted with depth. The boring log of deep well P1-MW40 indicates an increasing clay content from approximately 26 to 30 ft bgs, becoming a clayey, coarse-grained sand/gravel at 30 ft bgs. (SAIC 2000)

2.1.5 Referenced or Documented Calculations

The following referenced or documented calculations were performed to support the CAP-Part B Site Investigation and were included in the CAP-Part B (SAIC 2000).

Disturbed soil samples were collected from eight monitor wells for grain size analysis. In addition, undisturbed soil samples were collected from four monitor wells and a soil boring to determine selected engineering properties of the unsaturated zone at the site. The engineering properties that were measured included moisture content, porosity, specific gravity, bulk density and permeability.

Slug tests were conducted on two shallow and one deep well and evaluated using AQTESOLVE software. The calculated hydraulic conductivity values were 1.32×10^{-2} feet per minute (ft/min) (6.7×10^{-3} centimeters per second (cm/s)) and 1.75×10^{-2} ft/min (8.9×10^{-3} cm/s) in the shallow wells and 4.5×10^{-3} ft/min (2.3×10^{-3} cm/s) in the deep well. The average hydraulic conductivity based on slug test data is 1.17×10^{-2} ft/min (6.0×10^{-3} cm/s).

Aquifer testing (8-hour step test) was performed to determine the optimum pumping rate for the well. Pumping data yielded a transmissivity of 0.4035 ft^2/min assuming a saturated aquifer thickness of 60 ft. The recovery data produced a transmissivity of 0.089 ft^2/min assuming a saturated thickness of 60 ft. (SAIC 2000)

2.1.6 Direction of Groundwater Flow

Historical water level measurements (Table 2-1) were taken during monitoring events to evaluate the directional flow in groundwater. Groundwater in the vicinity of the

former Release #2 area was determined to flow generally to the south. Groundwater potentiometric surface measurements taken in January 2008, July 2008, and December 2008 are presented on Figures 2-2, 2-3, and 2-4, respectively.

2.2 Horizontal and Vertical Extent of Contamination

The horizontal and vertical extent of petroleum-related contamination in soil and groundwater was delineated by activities performed during the previous investigations at the former Pumphouse #1 site and the DAACG facility, which were documented in the CAP–Part B Report (SAIC 2000) and CAP–Part B Addendum #1 Report (SAIC 2002a). In September/October 2003, additional activities were performed with CPT equipment with fluorescence detection to delineate the horizontal and vertical extent of the free product at both Release #1 and Release #2. Subsequently, additional data has been obtained through semiannual sampling of monitor wells and a supplemental investigation using DPT that was conducted in January 2008. A summary of the results from these investigations is presented below.

2.2.1 Delineation of Soil Contamination

In the vicinity of the former Pumphouse #1 Tank Pit area (Release #2), the horizontal extent of petroleum-related contamination in soil was determined during the CAP-Part B site investigation and was discussed in detail in the CAP–Part B Report (SAIC 2000). Benzene, ethylbenzene, toluene, xylenes, benzo(b)fluoranthene and chrysene exceeded the applicable Georgia Underground Storage Tank (GUST) Soil Threshold Levels (STLs) (i.e., Table B, Column 1) and were identified as chemicals of potential concern (COPCs) for soil at Release #2. Only benzene and chrysene exceeded their respective ATLs.

The CAP-Part B Report stated that there was an area of contamination located 1 to 2 feet above the water table with the center of the source area located north of the Former Fuel Pit 1C. The samples with concentrations exceeding the ATLs were collected from the capillary fringe above the soil/water interface.

In January 2008, supplemental investigation activities were conducted to further delineate subsurface soil contamination at the site. Subsurface soil samples were collected from 35 direct-push borings at the site and analyzed for BTEX. One soil sample was collected from each boring at the depth interval with the highest photoionization detector (PID) reading. The soil samples were analyzed for BTEX using the U.S. Environmental Protection Agency (EPA) Method 8021B/8260B. The

analytical results from the soil sampling are presented in Table 2-2 and Figure 2-5.

The analytical results of the January 2008 supplemental investigation are summarized below (SAIC 2008).

- Benzene was detected in 8 of 35 soil samples at concentrations ranging from 0.0569J to 0.801 milligrams per kilogram (mg/kg). None of the sample concentrations or detection limits exceeded the ATL.
- Toluene was detected in 24 of 35 soil samples at concentrations ranging from 0.0312J to 125J mg/kg. None of the samples exceeded the ATL.
- Ethylbenzene was detected in 31 of 35 soil samples at concentrations ranging from 0.00301J to 66J mg/kg. None of the samples exceeded the ATL.
- Total xylenes were detected in 33 of 35 soil samples at concentrations ranging from 0.000687J to 370J mg/kg. None of the samples exceeded the ATL.

Subsurface soil sampling in January 2008 indicated that the benzene concentrations in soil were below the ATL of 9.3 mg/kg. Samples were not analyzed for polyaromatic hydrocarbons (PAHs), specifically chrysene. As previously noted, chrysene was detected in soil at concentrations exceeding the ATL during the CAP-Part B investigation.

2.2.2 Delineation of Groundwater Contamination

In the vicinity of the former Tank Pit area (Release #2), the vertical and horizontal extent of the plume was initially delineated in the CAP-Part B site investigations and was discussed in detail in the CAP–Part B Report (SAIC 2000). Benzene, ethylbenzene, toluene, benzo(a,h)anthracene, indeno(1,2,3-cd)pyrene and naphthalene were identified as COPCs for groundwater. Based on the results of fate & transport (F&T) modeling, ACLs were calculated for these constituents. An ACL of 285 micrograms/liter (µg/L) was proposed for benzene in groundwater and subsequently approved by GA EPD. Benzene was the only constituent in the Release #2 area to exceed its In-Stream Water Quality Standard (IWQS) and ACL during the site investigations.

During the semiannual sampling events from 2001 through 2007, benzene was the only COPC to exceed the IWQS or ACL. None of the other constituents were detected at concentrations that exceeded the respective ACL or IWQS. Benzene concentrations in monitor wells D-MW5, P1-MW2 and P1-MW19 have consistently exceeded the ACL of 285 µg/L. Concentrations in wells installed for ORC injection

exceeded the ACL in areas near former building 8060 and near former fuel pit 1C and the former UST 50 (SAIC 2007). During the eleventh semiannual sampling event in July 2007, the benzene concentrations in D-MW5R, P1-MW19 and CPT wells P1-CPT7, P1-CPT17, P1-CPT19, and P1-CPT22 exceeded the ACL of 285 µg/L (Figure 2-6). The CPT wells with benzene concentrations above the ACL are also in the areas previously identified as impacted. The July 2007 results are illustrated in Figure 2-6.

During the twelfth semiannual sampling event in January 2008, eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW-21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. In addition, supplemental investigation activities were conducted to delineate groundwater contamination at the site. Groundwater samples were collected from 35 direct-push borings at the site and analyzed for BTEX. Benzene was detected in 41 of 43 groundwater samples at concentrations ranging from 0.424J to 3,760 µg/L. The benzene concentrations in monitor wells D-MW5R, P1-MW2, P1-MW19, and 11 direct-push borings (P1-DB-04, P1-DB-05, P1-DB-06, P1-DB-07, P1-DB-08, P1-DB-13, P1-DB-18, P1-DB-19, P1-DB-22, P1-DB-23, and P1-DB-35) exceeded the ACL of 285 µg/L. The benzene concentrations in D-MW5R, D-MW6R, P1-MW2, P1-MW19, P1-MW23, and 16 direct-push borings exceeded the IWQS of 51 µg/L. None of the other constituents exceeded the respective ACL (SAIC 2008). The analytical results are provided in Table 2-3 and Appendix A and illustrated in Figure 2-7.

During the thirteenth semiannual sampling event in July 2008, eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. Benzene was detected in 8 of 8 groundwater samples at concentrations ranging from 2.98 to 2,090 µg/L. The benzene concentrations in D-MW5R, P1-MW2, and P1-MW19 exceeded the ACL of 285 µg/L. The benzene concentrations in D-MW5R, P1-MW2, P1-MW19, and P1-MW23 exceeded the IWQS of 51 µg/L. None of the other constituents exceeded the respective ACL. The analytical results are provided in Table 2-3 and Appendix B and illustrated in Figure 2-8.

The fourteenth semiannual sampling event was conducted in December 2008. Eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. All groundwater samples collected were analyzed by a certified laboratory as listed in the Site-Wide Quality Assurance

Project Plan (QAPP) (ARCADIS 2008). Field laboratory data included quality control samples and all data were reviewed by the project chemistry team. All data reported by Shealy Laboratory were evaluated in accordance with the Level II validation protocols set forth in the Site-Wide QAPP (ARCADIS 2008). Field parameters from each well that was sampled are provided in Table 2-4. The analytical results are provided in Table 2-3 and Appendix C and illustrated in Figure 2-9. Analytical results from the sampling event are summarized below.

- Benzene was detected in 6 of 8 groundwater samples at concentrations ranging from 29 to 1,700 µg/L. The concentrations in two samples exceeded the IWQS of 51 µg/L and in three samples exceeded the ACL of 285 µg/L.
- Toluene was detected in all eight groundwater samples at concentrations ranging from 1.2 to 16,000 µg/L. The concentrations did not exceed the ACL.
- Ethylbenzene was detected in all eight groundwater samples at concentrations ranging from 7.7 to 1,700 µg/L. The concentrations did not exceed the IWQS or ACL.
- Total xylenes were detected detected in all eight groundwater samples at concentrations ranging from 13 to 8,600 µg/L. There is no ACL or IWQS for total xylenes.

The benzene concentrations in the most contaminated wells over time are plotted on Figure 2-10.

2.2.3 Delineation of Free Product

Free product was identified at the former Fuel Pit 1A/DAACG area (Release #2) in September 2001. The free product was observed in wells D-MW5, P1-MW2, P1-MW3, and P1-MW22 at thicknesses ranging from 0.02 to 0.49 ft. The horizontal extent of the free product was bounded by existing wells at the site. Following the CAP–Part B investigation, the interim corrective action consisted of free product recovery in the wells via absorbent socks, which were first installed in November 2001. The absorbent socks were utilized from November 2001 through May 2005.

In September/October 2003, additional activities were performed with CPT equipment with fluorescence detection to delineate the horizontal and vertical extent of the free product at both Release #1 and Release #2. The Release #2 investigation concluded that the likely zones of nonaqueous-phase liquid (NAPL) contamination tend to occur between 6 and 13 ft bgs, which is in the vicinity of the water table and smear zone, at a thickness ranging from 1 to 5 ft. At three locations

there was NAPL detected below the water table at approximately 20 to 25 ft bgs (SAIC 2005).

Beginning in June 2005, VE activities were initiated on approximately 50 wells located throughout Release #1 and Release #2. The quantity of the water/product mixture varied from well to well. However, in general the amount of free product removed from each well was very small. In January 2006, the vacuum truck activities were modified from bimonthly to quarterly and focused on the wells with free product accumulation. As a result, only a few wells were pumped in January 2006, but for approximately 8 hr per well (SAIC 2006b). Measurements conducted during the vacuum extraction activities for Release #2 are presented in Table 2-5. Free product was not observed in any of the wells associated with Release #2 prior to or following the vacuum extraction activities in June 2005 through January 2006.

In July 2007, no measurable free product was observed at any of the wells associated with Release #2 and EFR activities were not conducted. In October 2007, free product was measured in one well in the Release #2 area. Well P1-MW2, had 0.01 ft of measurable product and EFR activities were performed on this well for 8 hours. In January 2008, free product was measured at two wells (P1-MW2 and P1-MW22, 0.01 ft each) and EFR activities were performed on each well for 8 hours. A summary of the vacuum activities for Release #2 is presented in Table 2-5. Prior to groundwater sampling activities on January 27, 2008, no free product was observed at the site. In July 2008, free product was observed in wells P1-MW2 and P1-MW3 at a thickness of 0.02 ft and 0.01 ft, respectively. In December 2008, no measurable free product was detected at any of the wells associated with Release #2.

The free product thickness recorded in Monitor Wells P1-MW2 and P1-MW3 versus groundwater elevation is plotted in Figures 2-12 and 2-13 respectively.

2.2.4 Delineation of Surface Water and Sediment Contamination

Results from the surface water and sediment samples collected during the CAP–Part B investigation were discussed in the CAP–Part B Report (SAIC 2000). Two surface water samples (P1-SWS-11 and P1-SWS-12) were collected in July 2007 from diffusion samplers installed within the saturated sediment of the drainage ditch located approximately 500 ft south of the source areas. The samples were analyzed for BTEX using EPA Method 8021B/8260B. Benzene was detected in P1-SW-11 and 12 at concentrations of 357 and 0.457J µg/L respectively. The benzene concentration in surface water sample P1-SWS-11 exceeded the IWQS of 51 µg/L

and the ACL of 285 µg/L. In the same sample, toluene was detected at 11,900 µg/L, ethylbenzene at 1,640 µg/L and total xylenes at 8,990 µg/L. The toluene concentration exceeded the IWQS. The analytical results are provided in Table 2-3.

Two surface water samples (P1-SWS-11 and P1-SWS-12) were collected in December 2008 from the drainage ditch located south of the site and analyzed for BTEX using EPA Method 8021B/8260B. Benzene was detected at concentrations of 2.4 and 24 µg/L, toluene at concentrations of 16 and 51 µg/L, ethylbenzene at concentrations of 26 and 33 µg/L and total xylenes at concentrations of 88 and 370 µg/L. All concentrations were below the IWQS. The analytical results are provided in Table 2-3 and illustrated in Figure 2-8.

3. Remedial Action Plan

3.1 Corrective Action Completed or in Progress

3.1.1 Recovery/Removal of Free Product

Free product was discovered at the Release #2 location in September 2001 and absorbent socks were used for product recovery from 2001 through May 2005. Free product was removed from various wells using EFR from June 2005 through July 2006 and April 2007 through January 2008. Prior to groundwater sampling activities on January 27, 2008, no free product was observed at the site. In July 2008 free product was observed in wells P1-MW2 and P1-MW3 at a thickness of 0.02 ft and 0.01 ft, respectively. In December 2008, no measurable free product was observed at any of the monitor wells associated with Release #2.

3.1.2 Remediation/Treatment of Contaminated Backfill Material and Native Soil

No contaminated backfill material or native soil associated with the former Tank Pit area (Release #2) has been excavated, remediated, or treated. Soil disposition during the tank removals in the late 1990s is unknown.

3.2 Objectives of Corrective Action

A primary objective of groundwater remedial activities is to decrease residual mass to a point where natural attenuation mechanisms, as opposed to active remedial measures, become the long-term remedial strategy. Remedy implementation will be optimized through pre-design activities to limit treatment to areas where it will be most effective based on the hydrogeology and nature/extent of hydrocarbon (i.e., benzene) impact. Plume impact on surface water in the canal will be mitigated to comply with the IWQS.

3.2.1 Remove Free Product That Exceeds One-Eighth Inch at the Former Tank Pit/Fuel Pit 1C Area (Release #2)

Free product will be addressed such that no well contains free product in excess of 1/8 inch in thickness. Free product in excess of 1/8 inch has been detected only sporadically in monitor wells and the maximum thickness measurement since April 2007 was 0.2 ft. Recovery results have indicated very little mobile (recoverable) mass. Liquid levels will be measured during future monitoring events to confirm the absence of free product at a thickness greater than one-eighth inch. Activities utilizing a vacuum truck will be invoked as the corrective action if free product is detected in recoverable quantities.

3.2.2 Remediate Groundwater Contamination at the Former Tank Pit/Fuel Pit 1C Area (Release #2)

The objectives of the corrective action for groundwater are to reduce the concentrations of the contaminants of concern to below ACLs approved in the CAP-Part B (SAIC 2000). Benzene has historically been the only COPC that exceeds ACL or IWQS concentrations.

A corrective action for groundwater was implemented in 2006, when an oxygen-releasing compound (PermeOx® Plus) was injected into the subsurface to promote aerobic conditions. Six wells located throughout the Release #2 area that were not part of the semiannual monitoring only program or quarterly free product removal were utilized as injection wells. These wells were D-CPT-4, D-CPT-20, D-CPT-2I, D-CPT-23, D-CPT-24, and D-CPT-25. Six additional injection wells (P1-J1 through P1-J6) were installed at the site in May 2006. The wells had 10 ft screens and were screened across the water table with the goal that approximately 7 ft of screen would be located below the water table. PermeOx® Plus was injected into the 12 wells on a quarterly basis for a period of 1 year. Performance monitoring of four wells (D-MW5, P1-MW2, P1-MW21, and P1-MW22) for BTEX was conducted prior to each quarterly injection (SAIC 2008). Subsequent reports stated that site contaminant levels were not significantly reduced through the injection of ORC and that the results indicated that there are two areas that are serving as potential sources in the Release #2 area: the former Pumphouse #1 tank pit area and the area under the taxiway near the Fuel Pits. The oxygen demand from this source mass and from natural sources was such that the oxygen delivery rate from a slow release oxygen compound was insufficient for a source area application.

Recent data indicate that dissolved benzene concentrations continue to exceed the ACL and that benzene is attenuating very slowly. The plume of impacted groundwater at the site is presented in Figures 2-6, 2-7, 2-8 and 2-9. The variation of benzene concentrations with time is presented on Figure 2-10. In addition, BTEX is impacting the surface water in the canal down gradient of the source.

3.2.3 Remediate Soil Contamination at the Former Tank Pit/Fuel Pit 1C (Release #2)

The objective of the corrective action is to reduce concentrations of soil contaminants exceeding ATLs approved in the CAP-Part B (SAIC 2000). Data from subsurface soil sampling in January 2008 indicated that the benzene concentrations in soil are below the ATL of 9.3 mg/kg. The other COPC that exceeded the ATL was chrysene. Samples taken in January 2008 were not analyzed for PAHs. After free product and groundwater goals are achieved, additional soil samples will be taken to determine

compliance with approved ATL goals for chrysene.

3.2.4 Provide Risk-Based Corrective Action

A risk-based approach was used in the CAP–Part B Report (SAIC 2000) to identify COPCs for soil and groundwater and to develop ATLs and ACLs for various constituents. The results of the risk screening for Release 2 were presented in the CAP–Part B Report (SAIC 2000). The ATLs and ACLs developed for the COPCs and subsequently approved by GA EPD in 2000 are listed in Table 2-6. Due to the proximity of Releases 1 and 2, the most conservative F&T modeling results were used for developing one set of ACLs and ATLs for both areas of contamination in the CAP-Part B (SAIC 2000). F&T modeling using the analytical AT123D model was revised in the Second and Fourth Annual Monitoring Only Reports but a change to the ACL for benzene was not proposed. The F&T modeling was revised as part of the Fifth Annual Monitoring Only Report (SAIC 2007). As part of this modeling, the plume was determined to be more complex than previously modeled and three dimensional numerical models MODFLOW and MT3DMS were used to simulate groundwater flow and benzene transport respectively. Based on the revised modeling results, the dilution attenuation factor (DAF) for benzene was calculated to be 37.5 at the drainage ditch. Since ATLs and ACLs were calculated using the most conservative DAF of the two separate plumes, the revised DAF was not used and the benzene ACL was not revised.

3.2.5 Conclusions and Recommendations

The following conclusions are based on the results discussed above:

- Recent thickness measurements indicate that very little mobile free product remains.
- Recent dissolved concentrations indicate that the groundwater impacted above ACLs includes the area around and north of former fuel pit 1C and east of former building 8060, the same areas previously identified in the CAP-Part B.
- Based on soil samples from January 2008, petroleum VOC concentrations in soil are below ATLs. Samples were not analyzed for PAHs to determine concentrations of chrysene, the other COPC previously detected above the ATL.

3.3 Design and Operation of Corrective Action

3.3.1 Basis for Selection

The two priorities for selection of a remediation strategy are: 1) rapidly mitigating impacts to canal surface water; and 2) reducing the source mass that could extend the remediation timeframe. The proposed remediation will be applied to two source areas and one area for mitigation of surface water impacts. The areas relative to the groundwater plume are illustrated in Figure 3-1. The source area associated with the Former Fuel Pit 1C and Defueling Tank is presented with more detail in Figure 3-2a. The source area associated with Former Building 8060 Tank Pits is presented in Figure 3-2b. The area where surface water impacts will be addressed is presented with more detail in Figure 3-2c.

3.3.1.1 Sodium Persulfate

Remedial options for source mitigation were limited because a portion of the source is located under the active tarmac. Also, addition of electron acceptors (oxygen, sulfate) was not considered favorable given the known source mass load and the demonstrated inadequacy of a slow release oxygen compound for source areas at this site. Biosparge, which likely would be effective in some areas of the site, was not selected because of the difficultly of implementation and ongoing operation and maintenance in the fuel pit area adjacent to and under the tarmac (Figure 3-2a). A substantial portion of the source mass is located in this area and not addressing the mass in that area would result in an extensive remediation timeframe. The proposed remedy for the source mass causing the groundwater impacts consists of the implementation of In-situ Chemical Oxidation (ISCO) to achieve the remedial objectives outlined in Section 3-2. EFR events may be performed to address the free product reduction requirement on an as-needed basis.

ISCO is a well-demonstrated remedial technique that uses a chemical oxidant to rapidly degrade aqueous-phase contaminants. Sodium persulfate is a strong oxidant with a demonstrated ability to oxidize benzene. It is relatively stable and therefore can be delivered at greater distances from the point of injection than other oxidants, such as catalyzed hydrogen peroxide. Persulfate salts dissociate in aqueous solutions to form the persulfate anion ($S_2O_8^{2-}$), which has an electrode potential (E_h) of 2.12 V. Persulfate's E_h is comparable to that of ozone (2.1 V) and is greater than that of hydrogen peroxide (1.8 V). Its low density and low affinity for soil sorption provides for density-driven distribution throughout the subsurface treatment area and therefore greater contact with the target contaminant and a greater percent utilization of the injected oxidant. Persulfate performance can be enhanced by activating the solution to

produce sulfate radicals ($\cdot SO_4^-$) and hydroxyl radicals ($\cdot OH$), both highly reactive and short-lived species (E_h of 2.6 V and 2.8 V, respectively). Activation can be accomplished via reaction with ferrous iron present in the formation, or by engineered activation methods such as the addition of a base, heat, or chelated metal. The remediation of BTEX should not require engineered activation of the persulfate. However, this option is available should it become necessary to increase the oxidation efficiency in target areas with high concentrations of benzene (or residual NAPL) that are found to be recalcitrant to the unactivated formulation.

The remedial design concept is presented below and will be preceded by the pre-design field data collection necessary to effectively design an appropriate and efficient oxidant delivery network.

3.3.1.2 Calcium Peroxide

Remedial options for mitigating the migration of benzene to the drainage canal surface water pending source remediation include intercepting the dissolved plume with oxygenated water to stimulate aerobic biodegradation. Aerobic conditions can be engineered via a biosparge curtain or via other chemical means to increase oxygen content within the water, such as the use of oxygen release compounds. Since the source mass will be aggressively addressed with persulfate and the timeframe for plume interception will be shortened in the down gradient portion of the plume adjacent to the canal, injection of chemicals that slowly release oxygen (e.g. magnesium peroxide, calcium peroxide, sodium percarbonate) is preferred over biosparge. These compounds can slowly release oxygen over an extended time making oxygen available over a longer period, preventing kinetic limitation. Given the relatively low flux of petroleum hydrocarbons and slow groundwater velocity expected in the downgradient portion of the plume approaching the canal, the residence times should be sufficient to allow for aerobic biodegradation as a barrier.

The most important physico-chemical properties of 3 possible slow release ORC's are listed in Table 3-1. The comparison shows that calcium peroxide releases the most oxygen. Furthermore, CaO_2 has a low solubility (in comparison with sodium percarbonate) thus being less reactive. This will enable it to release its oxygen more slowly over the course of several months. Sodium percarbonate releases its oxygen more rapidly because of its higher solubility resulting in a less efficient use of the released oxygen. Because of the higher oxygen content and its slow release characteristics, calcium peroxide is chosen to stimulate the biological breakdown.

Calcium peroxide (CaO_2) slowly releases oxygen when in contact with water according to the following reaction:

$$2\ CaO_2 + 2\ H_2O \rightarrow 2\ Ca(OH)_2 + O_2$$

The speed at which oxygen is released is determined by physical and chemical properties of the medium (e.g. pH and temperature). When CaO_2 is exposed to a lower pH, H_2O_2 can be generated according to the following reaction:

$$CaO_2 + 2\ H^+ \rightarrow Ca^{2+} + H_2O_2$$

H_2O_2 releases oxygen according to the following reaction:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Directly around the injection wells, little H_2O_2 will be generated due to the higher pH generated by the presence of calcium hydroxide and peroxide. This ensures an efficient release of oxygen. As a consequence of the low solubility in water of CaO_2 (<0.1 gram per liter (g/L) @ 20 °C), an oxygen release period of more than 6 months (Solvay) is typical.

3.3.2 Pre-Design Field Data Collection

Baseline biogeochemical sampling and analysis will be conducted. The data will be primarily focused on optimizing the application of sodium persulfate but will also be applied to aid in designing the calcium peroxide barrier. A baseline biogeochemical sampling event will be conducted consisting of samples from approximately 6 wells, 2 from each source area and 2 outside the impacted area. Samples from these wells will be analyzed for the parameters listed in Table 3-2 including total and dissolved iron, manganese, carbonate alkalinity, sulfate, total organic carbon, chemical oxygen demand, nitrate, total dissolved and suspended solids. Field parameters will consist of at a minimum dissolved oxygen, pH, oxidation reduction potential, conductivity and temperature. Baseline sampling will include obtaining samples for analysis of BTEX from the 8 wells designated for semiannual sampling plus approximately 4 wells that are proximate to source areas but have not been recently sampled.

Extensive sampling has been conducted previously to evaluate the vertical and horizontal distribution of BTEX in soil and groundwater. Numerous sampling events have confirmed the distribution of groundwater impacts and the 2003 CPT investigation and 2008 DPT investigation confirmed source mass is located north of Fuel Pit 1C and east of the former Building 8060. As is typical, the majority of the source mass is located in the smear zone. However, the 2003 investigation revealed that in two areas source mass may be located at approximately 20 ft bgs (10 ft below water level).

Impacted groundwater was identified farther to the northwest during the January 2008 investigation and an additional monitor well is proposed in this area. An additional permanent monitor well is also recommended to define the northeast extent of the plume. The locations of the additional monitor wells in Area A are shown on Figure 3-3a.

Matrix demand testing is planned for selected soil and groundwater (slurry) samples to evaluate the soil oxidant demand (SOD). Naturally occurring minerals and organic molecules in addition to the contaminants of interest that may react with persulfate will determine oxidant demand. Matrix demand tests are performed on uncontaminated samples of soil and groundwater to estimate the concentration of persulfate that will be consumed by the oxidizable components of the geological matrix and groundwater during a given treatment time. The testing will be performed at ARCADIS' laboratory in Durham, North Carolina.

Because of the well documented oxidation reaction of persulfate with BTEX, treatability testing requirements will be minimal. Samples for treatability testing will be taken from contaminated areas. The initial phase of treatability testing will include an assessment of unactivated persulfate at a concentration in the probable range of 1 percent to 5 percent to examine the treatment efficiency as a function of dose concentration. Dosing with chelated iron activation, alkaline activation, or activation with hydrogen peroxide may also be performed to evaluate suitability for the site and approximate field-scale oxidant dosing schemes.

Injection wells will be installed in the injection target areas A and B located as depicted in Figures 3-3a and 3-3b in the vicinity of the former Fuel Pit 1C and former Building 8060 respectively. The initial injection in the former Fuel Pit 1C area will be through a new injection well installed between D-MW5R and P1-CPT20 as shown on Figure 3-3a. The initial injection in the area east of the former Building 8060 will be through a new well installed between P1-J3 and P1-MW2 as shown on Figure 3-3b. Injection wells will be designed with well screens that bracket the water table (generally present at 9 to 10 ft bgs) and extend approximately 5 feet into the vadose zone areas to more efficiently address the smear zone. When possible, persulfate injections will occur during high water table conditions as the most efficient means of making contact with the smear zone relative to flooding the smear zone. The depth of the screen interval will be determined by estimated location of target mass and will typically be 15 to 20 ft bgs. Surrounding MW and CPT wells will be used as observation well locations as depicted on Figures 3-3a and 3-3b. Wells located within 10 feet of the injection well will be used as dose-response wells to verify the volume of injection solution required to achieve the target radius of injection (ROI) of 10 feet. Wells outside of the 10-foot ROI will be used to monitor (1) the movement of persulfate

outside of the injection zone, (2) treatability of BTEX using persulfate, and (3) persulfate reaction kinetics and potential secondary water quality effects in the oxidation zone.

The data from the initial injection will be utilized to verify the previously estimated relationship between injection volume and delivery radius in both targeted treatment areas (i.e., where current benzene concentrations exceed 1 milligram per liter [mg/L] or previous investigations have indicated the presence of source mass). The results of the initial injections will be evaluated to ensure adequate distribution of oxidant during remediation. The refined understanding of the optimal concentration, required volumes and viable injection flow rates will then be used to optimize the methods employed for the additional applications (e.g., injection volumes, oxidant concentrations, etc.). Distribution of persulfate will be tracked through field measurements of persulfate ions and conductivity. Movement of persulfate and conductivity will be utilized to confirm groundwater flow rates and directions. This will support evaluation of reagent migration and anticipated trends in dissolved-phase concentrations downgradient of the treatment area(s).

Temporary monitor wells will be placed if needed to refine the injection target zone. Any temporary wells will be 2-inch I.D. pre-packed wells installed using DPT and screened across the water table. The need for these wells will be determined based on initial injection results and would be installed to provide the additional data density necessary to mitigate the unnecessary injection of oxidant. Conventional well installation methods (hollow stem auger, sonic, etc.) would be used if multi-purpose wells are needed.

A permit application will be submitted to the Underground Injection Control (UIC) Division of Georgia EPD to allow the initial injection for the performance evaluation phase. The permit will be obtained before the initial injection is initiated. A copy of the UIC Permit Pilot Test Notification is included in Appendix E. After the data from the initial injection are collected and evaluated, a full UIC Permit Application will be prepared as an addendum to this CAP – Part B.

The volume of solution required to achieve breakthrough at an assumed 10-foot ROI dose-response well is estimated using the following equation:

$$V_{inj} = ROI^2 \times \pi \times h \times n_m \times \left(\frac{7.481\ gal}{ft^3}\right)$$

where:

V_{inj} = volume of injection (gal)

ROI = radius of injection (e.g., 10 feet)

h = height of injected fluid column (15 feet)

n_m = mobile porosity

The volume of solution required to achieve breakthrough at the 10-foot ROI depends on the mobile porosity of the formation. The following table shows the relationship between mobile porosity, injection volume, and amount of sodium persulfate and water required to mix injection solution containing 5 percent persulfate by weight (50 g/L) over a 15-foot screened interval with an assumed ROI of 10 feet. The persulfate concentration that will be used in the pilot study will be determined by the laboratory SOD testing, and will likely be at or below this value with the initial target concentration in the 1 to 2 percent range. A range of approximately 1 to 5 percent should also be effective for full-scale application, and will allow flexibility in the injection approach so that areas of the BTEX plume can be adaptively targeted with appropriate oxidant dosing. The initial injection will use unactivated persulfate. Depending on the outcome of the initial study, this range may be adjusted or augmented with activation chemistry suitable for the site. The actual concentration range will be defined in the UIC permit.

	$n_m = 0.05$	$n_m = 0.1$	$n_m = 0.15$	$n_m = 0.20$
Injection volume (gallons)	1,763	3,525	5,288	7,050
Mass of sodium persulfate (lb)	774	1,547	2,321	3,095

The injection rate will likely range from approximately 1 to 2 gpm under gravity-feed conditions. Injection solution will be prepared in batches immediately prior to introducing into the injection well. A stock solution of clean water will be provided in the existing 20,000-gallon tank. This water will be used to fill a 500-gallon tote, where sodium persulfate will be added and fully mixed prior to injection. The injection will continue until a concentration representing 50 percent of the initial injection solution strength (i.e., conductivity reaches half the concentration measured in the tank) and a plateau in electrical conductivity is observed in dose-response wells.

Groundwater monitoring parameters and analysis methods are detailed in Table 3-2. Monitoring will be performed according to the schedule outlined in Tables 3-3a and 3-

3b. The scope of the breakthrough and post-breakthrough monitoring includes the following:

- Electrical conductivity, pH, and persulfate sampling and field testing in all monitor wells for six months (twice for the first week, weekly for weeks 2 to 4, and biweekly for months 1 to 3).
- Vertical profile of pH and electrical conductivity within the screened intervals of all monitor wells using a hand-held water quality probe.
- Analysis of comprehensive water quality parameters in the first, second, third, and sixth months after the injection.

3.3.3 Remediation Design

Data collected from the laboratory and initial injection events will be reviewed to evaluate changes in the remedial design necessary to achieve the remedial goals. This review will include the number and construction specifications for injection wells, anticipated concentration and volume of oxidant solution, number of injection events needed to reach remedial goals, a schedule of injection events, a remediation health and safety plan, and performance monitoring requirements and schedule. All well installation, development and sampling will be conducted in accordance with the approved Sampling and Analysis Plan and Quality Assurance Project Plan (ARCADIS 2008) and GA EPD requirements.

In the event that free product is observed in monitor wells at levels that would make ISCO cost-prohibitive or where pretreatment would be effective in shortening the duration of the planned ISCO events, EFR may be utilized. EFR events use multi-phase extraction (MPE) recovery techniques. MPE is a generic term used to describe the simultaneous extraction of soil vapor and liquid from the smear zone with the goal of dewatering the smear zone to recover free product, water, and vapor. Currently, the presence of free product is rare in monitor wells. However, the extent of free product will be verified periodically during monitoring events and during remediation activities such as pre-design sampling.

3.3.3.1 Sodium Persulfate

Approximately 12 persulfate injection wells will be installed into the surficial water-bearing unit as depicted on Figures 3-3a and 3-3b. The wells would be designed with an approximate transverse spacing of 20 feet, assuming a minimum ROI of 10 feet. In the direction of groundwater flow, the downgradient injection wells would be spaced on 30-foot centers. This is based on an estimated groundwater travel time of 10 feet over a two-month duration (the time over which unactivated persulfate is assumed to remain

active) with a hydraulic gradient of 0.008 ft/ft. These wells will be installed to target benzene concentrations in the unconfined water table above 1 mg/L where source mass is indicated by historical data. Additional injection wells may be installed where necessary to achieve the remedial objectives. The injection wells will be constructed using threaded-joint materials with polyvinyl chloride (PVC) solid casing construction. Each well will be constructed consistent with the typical injection well schematic provided on Figure 3-4. Typically, the well will be fitted with a 2-inch-diameter, 5 to 15 or 5 to 20-foot-long, 0.010-inch slot size, stainless steel V-wire or PVC wire wrapped screen. The well screen length will be determined based on vertical profiling data collected during the earlier investigations at the site. The screen sections will be attached to chemically compatible riser material that extends to the ground surface. Each well will be completed in a flush-mounted, traffic-bearing vault sufficiently sized to allow attachment of pressure fittings and to accommodate gauges and related injection equipment. Well tags or markers will be fitted to each well for permanent identification.

3.3.3.2 Calcium Peroxide

In order to ensure an adequate oxygen distribution, calcium peroxide will be injected in two rows perpendicular to groundwater flow. Injection points will be 10 feet apart and the two rows will be offset by 5 feet as depicted in Figure 3-3c. Existing monitor well P1-MW19 will be used to monitor the progress of the remediation. Calcium peroxide will be injected as slurry. The slurry will be prepared by mixing approximately 65 pounds (lbs) calcium peroxide and 300 gallons of tap water. The slurry will be prepared on site. The goal for injection quantity of calcium peroxide at each injection location will adjusted based on the biogeochemical data and actual aquifer injection capacity. Additional water may be added to facilitate diluting the calcium peroxide in order to more easily inject the solution. Following delivery of calcium peroxide solution, approximately 125 gallons minimum of clean water will be injected to help is dispersing the solution away from the injection point.

3.3.3.3 Permanent Groundwater Monitor Wells

Two groundwater monitor wells will be installed to monitor plume distribution and ISCO performance as depicted on Figure 3-3a. Numerous existing wells will be utilized for characterization of groundwater quality near the injection areas and will support performance monitoring over the remediation period. Any new monitor wells will be constructed in much the same manner as illustrated on Figure 3-4, although threaded-joint, Schedule 40, PVC well casing and screen materials will be used and there will be no adaptors fitted to the well for injection connections.

Each monitor well will be fitted with a 5- to 20-foot-long, 0.010-inch, machine-slotted, PVC well screen. Well depth may vary depending on estimated contaminant distribution. The screen will be placed in the borehole with the intention to have approximately 5 feet of screen extending into the unsaturated zone to allow observation of floating layers and mounding effects of the injection events. The screen will be attached to solid PVC riser material that extends to the ground surface. Each well will be completed in a flush-mounted, traffic-bearing manhole. Watertight locking caps and well tags will be fitted to each well. Well tags or markers will be fitted to each well for permanent identification.

3.4 Implementation

ISCO implementation will occur at the injection wells shown on Figures 3-3a and 3-3b with the intent of targeting groundwater containing benzene at concentrations above 1 mg/L where source mass is indicated. The initial implementation phase will include installing all persulfate injection wells and additional monitor wells illustrated in Figures 3-3a and 3-3b. The initial implementation phase will include injection of calcium peroxide in Area C as illustrated on Figure 3-3c and injection of sodium persulfate into one well in Area A and one well in Area B as illustrated in Figures 3-3a and 3-3b. The data from the limited initial persulfate injection will be utilized to refine the plan for subsequent full scale injection. The initial injection of calcium peroxide will provide rapid mitigation of potential surface water impacts. Installation of temporary features to facilitate oxidant mixing and delivery will also be performed. An overview of the project implementation elements include:

- Obtaining a UIC Permit for injection and construction activities in the initial phase of implementation.
- Installing permanent flush-mounted wells for the purpose of persulfate injection with the screened intervals aligned to intercept the most impacted portion of the aquifer.
- Installing at least two additional monitor well for plume monitoring. The screen sections of these wells will be dependent on injection well screen intervals.
- Performing a baseline groundwater sampling event that consists of collecting samples for analysis of biogeochemical parameters and BTEX.
- If needed, performing enhanced fluid recovery extraction events to remove free product in areas where it is identified as a safety precaution prior to persulfate injection as well as a remedial objective of reducing free product thickness to less than 1/8 inch.

- Injecting slurried calcium peroxide into the water table and smear zone to effectively intercept the plume migrating to the drainage canal. Additional injection(s) may be performed depending on BTEX concentration trends from the source and dissolved oxygen concentrations.
- Constructing a mobile mixing and injection system for use in injection events. This system will be designed to be capable of injecting into multiple locations at once. Injection water will be amended with the sodium persulfate and activator (if required) and injected. This will maximize injection production and minimize the time needed to complete the injection process. At the end of each day of injections, the trailer will be moved to a secure location in accordance with HAAF direction.
- Performing an initial persulfate injection event and additional events as needed for the active phase of remediation. Anticipated concentrations of sodium persulfate solution in the 1 to 5 percent range combined with an activator (if required) will be injected on a periodic basis (anticipated to range between four months and six months apart). Focused ISCO treatment will be optimized during implementation relative to the quantities of reagents needed, volumes of solution to be injected, injection schedules, and labor requirements to administer the technology.
- Performing post-injection performance monitoring events to verify that oxidant distribution is adequate to achieve design criteria needed to meet remedial goals. This monitoring will begin following the first injection event. The periodicity of monitoring events will depend largely on the rate of oxidant consumption and associated rate at which BTEX is eliminated from the aquifer.

3.4.1 Milestone Schedule

A milestone schedule for the proposed corrective action has been prepared. A chart showing milestone activities and anticipated duration is provided in Figure 3-5. Fort Stewart will notify GA EPD USTMP of any significant changes to the schedule and will provide GA EPD USTMP with an updated chart, as necessary.

3.4.2 Progress Reporting

Performance Reports will be submitted to GA EPD that will summarize the sampling, injection and/or monitoring activities. At a minimum, the Performance Report will consist of a table summarizing the activities and analytical data and a proposal for subsequent activities. In addition, annual reports will be submitted to GA EPD that will summarize all remediation and monitoring activities for the preceding year.

Petition for permanent closure (i.e., completion report) will be submitted upon approval of the final progress report when Release #2 reaches GA EPD-approved

closure criteria. GA EPD will provide final approval for decommissioning the monitor wells. Decommissioning of the monitor wells will be completed in accordance with the U.S. Army Corps of Engineers (USACE) design manual for monitor wells. Decommissioning will comply with all applicable state and federal standards. The following certification will be submitted to GA EPD within 30 days of submittal of the final progress report:

> I hereby certify that the Corrective Action Plan–Part B, dated , 20 , for Hunter Army Airfield, Former Pumphouse #1 site (Release #2), Facility ID 9-025085*2, including any and all certified amendments/addenda thereto, has been implemented in accordance with the schedules, specifications, sampling programs, and conditions contained therein and that the plan's stated objectives have been met.
>
> _____
>
> Signature (Owner/Operator)

3.4.3 Inspection Schedule and Preventative Maintenance Program

All associated field equipment and supplies with direct application to injection activities will be inspected by field personnel prior to each use and monitored during the event to ensure proper functionality. Any suspect equipment will not be used and will be replaced. Any questionable performance issues while performing injections will be brought to the project manager's attention immediately for recommendations as to a proper course of action. Appendix F contains an excerpt from an ISCO remediation procedure and pertinent safety-related information regarding chemical handling and injection. A comprehensive health and safety plan will be maintained and utilized during the performance of this remedial project. Preventive maintenance inspection criteria include:

- Injection chemical mix tank concentrations – daily using persulfate field kit
- Injection hose and piping for leaks or notable deterioration. All process lines shall be pressure tested for leaks prior to the addition of oxidant or activator at the outset of each of the three planned full-scale injection events – daily prior to use
- Injection equipment valves, flowmeters, pressure gauges – daily for proper operation and leaks at fittings
- Containment area, delivery and storage area for adequate access, stability, and absence of impediments to level loading, emergency response equipment (personal protective equipment quantity and adequacy for use, eye wash

equipment, emergency water supply operation), site security and chemical storage area, chemical hazard communication labeling and placarding – daily

- Injection well pressure and flow – hourly during periods of injection at every injection well and manifold

3.4.4 Periodic Monitoring

Prior to initiating injections, as part of the pre-design data collection effort, a baseline groundwater sampling event will be performed as previously described. Post-injection performance monitoring events will be undertaken to verify that oxidant distribution is adequate to achieve design criteria needed to meet remedial goals. This monitoring will begin following the first injection event. The frequency of monitoring events will depend largely on the rate of oxidant consumption and associated rate at which BTEX is eliminated from the aquifer. BTEX samples will be collected from up to 15 monitor wells for each sampling event. Conventional low-flow sampling techniques will be used to collect biogeochemical parameters, such as persulfate, ferrous iron, dissolved oxygen, pH, and conductivity, during the post-injection monitoring events. Depending on the results and associated data density, the injection wells may be used for performance monitoring provided that sufficient time has elapsed from an injection event so that formation groundwater not impacted from oxidant injection is sampled. The proposed monitoring schedule during and after persulfate injection is presented in Tables 3-3a and 3-3b. Semiannual sampling events will be conducted in accordance with the schedule currently approved by EPD for the site. All sampling will conducted in accordance with the approved Sampling and Analysis Plan and Quality Assurance Project Plan (ARCADIS 2008) and GA EPD requirements.

3.4.5 Effectiveness of Corrective Action

The progress of the corrective action will be evaluated using baseline data and post-injection performance monitoring data. Oxidant distribution and consumption rate and the rate of BTEX elimination will be determined to assess the effectiveness of the corrective action. Liquid level measurements in the site monitor wells will be measured to ensure free product thickness is less than 1/8 inch. Groundwater samples from monitor well P1-MW-19 will be analyzed for BTEX and dissolved oxygen concentration and surface water samples will be analyzed for BTEX concentration to ensure that the impacts to surface water in the canal are mitigated.

3.4.6 Confirmatory Soil Sampling Program

No excavation of soil is planned. Therefore, confirmatory sampling associated with excavation of soil will not be performed. Confirmatory sampling of soil contamination

that previously exceeded the benzene ATL of 9.3 mg/kg has been completed and all concentrations were below ATLs. Confirmatory soil samples for chrysene will be taken after groundwater goals are achieved.

3.4.7 Stockpiled Bulk Soil Sampling

No stockpiled soil will be generated by this corrective action. Therefore, no soil sampling will be conducted.

3.4.8 Monitoring Only Termination Conditions

As previously stated in the CAP, the following conditions are required prior to termination of monitoring only program:

- Concentrations of benzene in groundwater must be at or below the ACL
- Concentrations of benzene and chrysene in soil must be at or below their respective ATLs prior to termination of the monitoring only program
- Product removal activities have reached a quantifiable goal agreed to by GA EPD and HAAF

Once these conditions are met, the remedial system and monitoring may be terminated regardless of the site ranking score.

3.4.9 Post-Completion Site Restoration Activities

As the remediation is currently planned, no modifications will be made to the Release #2 area because no permanent equipment or systems will be located at the site. Monitoring and injection wells will be properly abandoned in accordance with the Georgia EPD Manual for Ground Water Monitoring once a "No Further Action" notification is received from the EPD.

4. Public Notification

The former Pumphouse #1 site is located entirely within the confines of HAAF, which is part of the Fort Stewart Military Reservation, a federal facility. The U. S. Government owns all of the property contiguous to the site. The Fort Stewart DPW has complied with the public notice requirements defined by GA EPD guidance by publishing an announcement in the *Savannah Morning News* on April 1 and 8, 2001. When GA EPD and HAAF agree that the free product removal part of the corrective action has been completed, an updated public notice will be made.

5. Claim for Reimbursement

HAAF is a federally owned facility and has funded the investigation for the former Pumphouse #1 site (Release #2), Facility ID #9-025085*2 using U. S. Department of Defense Environmental Restoration Funds. Application for GUST Trust Fund reimbursement is not being pursued at this time.

6. References

ARCADIS 2008. Sampling and Analysis Plan and Quality Assurance Project Plan, *Hunter Army Airfield, Georgia*, November.

Science Applications International Corporation (SAIC) 2008. Sixth Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, September.

SAIC 2007. Fifth Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, October.

SAIC 2006b. 2004-2005 Free Product Removal Report for Former Pumphouse #1, Release #1, Building 8060, Facility ID # 9-025085*1, Hunter Army Airfield, Georgia, April.

SAIC 2006a. Corrective Action Plan-Part B Addendum #2 for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, July.

SAIC 2005. Third Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, June.

SAIC 2002b. First Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, August.

SAIC 2002a. Corrective Action Plan–Part B Addendum #1 for Former Pumphouse #1, Facility ID # 9-025085, Building 8060, Hunter Army Airfield, Georgia, September.

SAIC 2000. Corrective Action Plan–Part B for Former Pumphouse #1, Facility ID #9-025085, Building 8060, Hunter Army Airfield, Georgia, August.

Miller, James A. 1990. *Groundwater Atlas of the United States*, U. S. Department of the Interior, U. S. Geological Survey, Hydrologic Inventory Atlas 730G.

GA EPD (Georgia Environmental Protection Division) 1992. *Groundwater Pollution Susceptibility Map of Georgia.*

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

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, US ARMY GARRISON, FORT STEWART / HUNTER ARMY AIRFIELD
1587 FRANK COCHRAN DRIVE
FORT STEWART, GEORGIA 31314

REPLY TO
ATTENTION OF

AUG 1 2 2009

Office of the Directorate

CERTIFIED MAIL
7008 3230 0000 7027 5521

Georgia Environmental Protection Division
UST Management Program
Attention: Mr. William Logan
4244 International Parkway, Suite 104
Atlanta, GA 30354

Dear Mr. Logan:

Fort Stewart is pleased to submit to the Georgia Environmental Protection Division one copy of the Final Revised Corrective Action Plan (CAP)-Part B With 2008 Annual Report for Former Pumphouse # 1 (Release #2), Facility ID #9-025085*2, Former Building 8060, Hunter Army Airfield, Georgia, dated July 2009, for your review.

The enclosed report documents the delineation of soil and groundwater contamination conducted in 2008 and the semiannual sampling events conducted in January, July, and December of 2008. In July 2008, free product was observed in wells P1-MW2 AND P1-MW3 at a thickness of 0.02 feet and 0.01 feet, respectfully. No measurable free product was detected in any of the wells associated with Release #2, in December 2008. Recent thickness measurements indicate that very little mobile free product remains. Soil samples indicate that petroleum volatile organic compounds (VOC) in the soil are below their respective alternate concentration levels. Groundwater concentrations are above their respective alternate concentration levels and are located in the area around and north of former fuel pit 1C and east of former building 8060.

The corrective action selected for the source mass causing the groundwater impacts, consists of the implementation of In-situ Chemical Oxidation (ISCO) and enhanced fluid recovery events on an as needed basis to address any free product encountered. Pending source remediation, the migration of benzene migrating to the surface water of the drainage canal, will encompass intercepting the dissolved plume with oxygenated water to stimulate aerobic biodegradation. Two new groundwater monitoring wells will be installed to monitor plume distribution and ISCO performance. A baseline groundwater-sampling event will take place to determine current biogeochemical parameters and benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations. Following the first injection occurrence, post-injection groundwater monitoring events will occur to verify that oxidant distribution is adequate to achieve design criteria needed to meet remedial goals. Upon acquiring groundwater remedial goals, confirmatory soil samples for chrysene will take place.

If you have any questions or comments regarding the enclosed report, please contact Ms. Algeana Stevenson at (912)315-5144 or Ms. Tressa Rutland, Directorate of Public Works, Prevention and Compliance Branch, at (912)767-2010.

Sincerely,

for Thomas C. Fry
Robert R. Baumgardt
Director, Public Works

Enclosure

CORRECTIVE ACTION PLAN-PART B

Facility Name:	Former Pumphouse #1 (Release #2)			Street Address:	Former Building 8060, near Taxiway 3		
Facility ID:	9-025085*2	City:	Hunter Army Airfield	County:	Chatham	Zip Code:	31409
Latitude:	32° 00' 54"	Longitude:	81° 08' 26"				

Submitted by UST Owner/Operator:				Prepared by Consultant/Contractor:			
Name:	Tom Fry/ Environmental Branch			Name:	Charles Bertz		
Company:	U. S. Army/HQ 3d, Inf. Div. (Mech)			Company:	ARCADIS		
Address:	DPW ENRD ENV. Br.			Address:	801 Corporate Center Dr.		
	1550 Frank Cochran Drive, Bldg. 1137				Suite 300		
City:	Fort Stewart	State:	GA	City:	Raleigh	State:	NC
Zip Code:	31314-4927			Zip Code:	27607		
Telephone:	(912) 767-2010			Telephone:	(919) 854-1282		

I. PLAN CERTIFICATION:

A. UST OWNER/OPERATOR

I hereby certify that the information contained in this plan and in all the attachments is true, accurate, and the plan satisfies all criteria and requirements of rule 391-3-15-09 of the Georgia Rules for Underground Storage tank Management.

Name: Tom Fry
Signature: Thomas C. Fry

Date: 08/12/09

B. REGISTERED PROFESSIONAL ENGINEER OR PROFESSIONAL GEOLOGIST CERTIFICATION

I hereby certify that I have directed and supervised the fieldwork and preparation of this plan in accordance with State Rules and Regulations. As a registered professional geologist and/or professional engineer, I certify that I am a qualified groundwater professional, as defined by the Georgia State Board of Professional Geologists. All of the information and laboratory data in this plan and in all of the attachments are true, accurate, complete, and in accordance with applicable State Rules and Regulations.

Name: Scott Bostian, PE
Signature: Scott Bostian
Date: 7/09/09

GEORGIA REGISTERED PE026033 PROFESSIONAL ENGINEER CURTIS SCOTT BOSTIAN

Scott Bostian 7/9/09

Check all boxes that apply. Attach supporting documentation, i.e. narrative, figures, tables, maps, boring/well logs, etc., for all items checked. Supporting documentation should be three-hole punched and prepared in conformity with the guidance document "Underground Storage Tank (UST) Release: Corrective Action Plan-Part B (CAP-B) Content", GUST 7B.

II. SITE INVESTIGATION REPORT

[X] **Not Applicable** The extent of contamination, and the local & site hydrogeology requirements have been fulfilled under the CAP Part A, therefore additional SIR reporting is not necessary.

[ ] **Extent of Contamination:**

[ ] Soil [ ] Groundwater [ ] Free Product [ ] Surface water

[ ] **Local and Site Hydrogeology:**

- [ ] Documentation of Local Groundwater Conditions
- [ ] Stratigraphic Boring Logs
- [ ] Stratigraphic Cross Sections
- [ ] Referenced or Documented Calculations of Relevant Aquifer Parameters
- [ ] Direction of Groundwater Flow
- [ ] Table of Monitoring Well Data
- [ ] Potentiometric Map
- [ ] Flow Net Superimposed on a Base Map

III. REMEDIAL ACTION PLAN

A. Corrective Action Completed or In-Progress:

- [ ] Not Applicable
- [X] Recovery/Removal of Free Product (Non-Aqueous Phase Hydrocarbons)
- [ ] Remediation/Treatment of Contaminated Soils
- [ ] Other (specify)

_____

_____

B. Objectives of Corrective Action:

- [ ] No Further Action
- [X] Remove Free Product That Exceeds One-Eighth Inch
- [ ] Remediate Groundwater Contamination That Exceeds:
  - [ ] Maximum Contaminant Levels (MCLs)

    OR
  - [ ] In-stream Water Quality Standards

B. Objectives of Corrective Action (CONTINUED):

- [ ] Remediate Soil Contamination That Exceeds:
  - [ ] Threshold Values Listed In Table A

OR

☐ Threshold Values Listed In Table B

OR

☐ Alternate Threshold Levels (ATLs) (Reference CAP A App. I)

☒ Provide Risk-Based Corrective Action (Reference CAP B App. I):

☒ Remediate Soil and/or Groundwater Contamination That Exceeds Alternate Concentration Limits (ACLs) and Monitor Residual Contaminants

OR

☐ Monitor Soil and/or Groundwater Contamination That Exceeds Levels In Rule – 391-3-15-.09(3).

C. Design and Operation of Corrective Action Systems:

☒Soil ☒Groundwater ☒Free Product ☐Surface water ☐Not Applicable

D. Implementation (MUST INCLUDE THE FOLLOWING):

NOTE: If No Further Action is proposed and none of the following apply, a brief explanation must be provided with the signed Certificate of Completion.

- Milestone schedule for proposed site activities

- Inspection and preventive maintenance schedule for all specialized remediation equipment

AND / OR

Monitoring/sampling and reporting plan for measuring interim progress and project completion

- Plan to decommission equipment/wells and close site

IV. PUBLIC NOTICE:

☐ Not Applicable **The Corrective Action Objectives submitted and approved under the CAP-Part A have not changed.**

☐ Certified Letters to Adjacent, Potentially Affected Property Owners and Local Officials

☒ Legal Notice in Newspaper, as approved by EPD

☐ Other EPD-approved Method (specify) _____

V. CLAIM FOR REIMBURSEMENT (For GUST Trust Fund sites only)

☒ Not Applicable (specify) _____

_____

☐ GUST Trust Fund Application - (attach if applicable)

☐ Cost Proposal:

☐ A Total of All Costs Incurred To Date (MUST INCLUDE THE FOLLOWING):

- Invoices and Proofs-of-Payment For All Costs Incurred To Date
- Invoices itemized on the GUST-4D
- All Non-Eligible Costs Clearly Identified as such
- Incurred Costs Itemized per GUST-92 form or EPD provided form/specifications

☐ A Total of Estimated Costs To Complete Corrective Action

- Estimated Costs Itemized per GUST-92 form or EPD provided form or specifications

☐ Total Project Costs

☐ Proposed Schedule For Reimbursement

☐ Lump Sum Payment Upon Completion Of Corrective Action

OR

☐ Interim Payments With Final Payment Upon Completion

OR

☐ EPD Established Payment Schedule

2. Site Investigation Report

Former Underground Storage Tanks (USTs) 30 through 39 and 50 at former Pumphouse #1, Facility ID #9-025085 were located near former Building 8060 at Hunter Army Airfield (HAAF), Savannah, Georgia (Figure 2-1). Former Pumphouse #1 was an aviation-gas fuel island located along the east-west taxiway of HAAF that was used from about 1953 until the early 1970s. It consisted of ten 25,000-gallon USTs and a 50,000-gallon underground defueling tank. The pumphouse was inactive from the 1970s to 1995, when eight of the 25,000-gal USTs were removed. The 50,000-gallon defueling tank and two of the 25,000-gallon tanks remained in-place, partially under the pumphouse structure. In 1998, the pumphouse structure was removed, along with the two remaining 25,000-gallon USTs. The 50,000-gallon defueling tank was closed in-place. The piping from the boundary of the pumphouse facility to the bulk fuel farm was also drained, pigged, and grouted in-place.

Various closure activities and Corrective Action Plan (CAP)–Part A and CAP–Part B investigations were performed at the former Pumphouse #1 site between 1995 and 2000. The former Pumphouse #1 investigations covered an area south of the active taxiway. CAP–Part A and CAP–Part B investigations were conducted at the Departure/Arrival Air Control Group (DAACG) facility in 1995 and 1996, respectively. These investigations covered the active tarmac north of the active taxiway. Review of the analytical data from all of the investigations indicated that it was necessary to combine the DAACG facility data and the former Pumphouse #1 data to document the nature and extent of contamination. As a result, the former Pumphouse #1 CAP–Part B Report (SAIC 2000) combined the results of all the investigations into a single report, which was submitted to the Georgia Environmental Protection Division (GA EPD) in August 2000 and subsequently approved.

As indicated in the former Pumphouse #1 CAP–Part B Report, two distinct and separate plumes are located within the vicinity of the former Pumphouse #1 site. Release #1 is an area of soil and groundwater contamination located near the DAACG facility that is in the vicinity of former Fuel Pits 1A and 1B, located approximately 900 feet west of former Building 8060 (i.e., Pumphouse #1). Release #2 is an area of soil and groundwater contamination located near the former Pumphouse #1 facility and former Fuel Pits 1C and 1D, located approximately 200 feet north of the former Tank Pits. The CAP-Part B stated that based on proximity, a release from Former Fuel Pit 1C was apparently responsible for the contamination associated with Release #2. During the CAP–Part B investigation activities, the horizontal and vertical extent of petroleum-related contamination in soil and groundwater was determined for both areas of contamination. The corrective actions

at Release #1 and Release #2 are being addressed separately.

For the Former Pumphouse #1 tank pit area (Release #2), the CAP–Part B Report recommended semiannual monitoring of eight wells (i.e., D-MW5, D-MW6, P1-MW1, P1-MW2, P1-MW18, P1-MW19, P1-MW22, and P1-MW23) for benzene, toluene, ethylbenzene, and xylenes (BTEX). The CAP–Part B Report was approved by GA EPD in December 2000. Per the CAP-Part B, semiannual monitoring and annual reporting began in September 2001 and has continued to date. The termination goal for this monitoring is demonstrating benzene concentrations in groundwater are below the alternate concentration limit (ACL) of 285 microgram per liter (µg/L) for two consecutive sampling events. The CAP-Part B also stated that once the benzene ACL has been achieved at the Former Pumphouse #1 tank pit area, three confirmatory soil samples would be collected to confirm that soil meets the alternate threshold levels (ATLs) for benzene and chrysene of 9.3 milligram per kilogram (mg/kg) and 2.1 mg/kg, respectively.

An additional investigation was conducted in 2003 to further delineate the horizontal and vertical extent of the free product in the subsurface at Release #1 and Release #2 using cone-penetrometer-technology (CPT) equipment with laser induced fluorescence (LIF) detection. The results of the investigation were presented in the Data Summary Report for the 2003 Free Product CPT Investigation, which was also included as an appendix in the Third Annual Monitoring Only Report (SAIC 2005).

The corrective actions that were described in the CAP–Part B Addendum #1 (SAIC 2001) and Addendum #2 (SAIC 2006a) were specific to Release #1 and are not discussed further.

To address free product, absorbent socks were installed, removed and replaced on a bimonthly basis from January 2002 through March 2005. Beginning in June 2005, vacuum extraction (VE) activities were initiated on approximately 50 wells located throughout the Release #1 and Release #2 areas.

In May 2006, six injection wells were installed around the Pumphouse #1 tank pit area for the injection of oxygen-releasing compound (ORC) to enhance the degradation of the BTEX compounds. Quarterly ORC injection through the six injection wells plus six existing monitor wells and performance monitoring was conducted from July 2006 through April 2007. The results were reported in the Fifth Annual Monitoring Only Report (SAIC 2007). The report stated that site contaminant levels were not significantly reduced through the injection of ORC over the 1-year period and that there were apparently two areas that are serving as potential sources

at the site: the former Pumphouse #1 tank pit area and the area under the taxiway near the fuel pits.

Semiannual monitoring was performed in January 2008 and additional soil and groundwater samples were collected with Direct Push Technology (DPT) in January 2008. The results of these activities were included in the Sixth Annual Monitoring Only Report (SAIC 2008). Also included in the Sixth Annual Report were Enhanced Fluid Recovery (EFR) results from October 2007 and January 2008.

Semiannual sampling was conducted in July 2008 and semiannual monitoring scheduled for January 2009 was performed in December 2008. The results of the monitoring activities conducted in July and December 2008 are included in this report. Results from the January 2008 semiannual monitoring and additional investigation are also presented to provide a comprehensive overview of current site conditions.

This Revised CAP–Part B Report is being submitted to the GA EPD Underground Storage Tank Management Program (USTMP) to convey investigation and monitoring data for the 2008 Annual Monitoring Only Report and to present a proposed change to the corrective action strategy for the former Tank Pit area (Release #2).

2.1 Regional, Local, and Site Hydrogeology

A discussion of the regional, local, and site hydrogeology was presented in previous CAP–Part B Reports and is summarized below.

2.1.1 Groundwater Usage

According to the *Groundwater Pollution Susceptibility Map of Georgia* (GA EPD 1992), the former Pumphouse #1 site, Facility ID #9-025085 is located within an area of average or higher groundwater pollution susceptibility. Nine water supply wells are located within the confines of the HAAF area. These wells have the potential to provide up to 3,890 gallons per minute (gpm) of water to occupants of the HAAF installation (SAIC 2000).

2.1.2 Aquifer Description

The hydrogeology in the vicinity of HAAF is mostly influenced by two aquifer systems, the Principal Artesian (Floridan) Aquifer and the surficial aquifer (Miller

1990). The Principal Artesian Aquifer is the lowermost hydrologic unit and is regionally extensive from South Carolina to Georgia, Alabama, and most of Florida. Known elsewhere as the Floridan, this aquifer, approximately 800 feet (ft) in total thickness, is composed primarily of Tertiary-age limestone, including the Bug Island Formation, the Ocala Group, and the Suwannee Limestone. Groundwater from the Floridan is used primarily for drinking water (Arora 1984).

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

The surficial aquifer consists of widely varying amounts of sand and clay, ranging from 55 to 150 ft in thickness. This aquifer is primarily used for domestic lawn and agricultural irrigation. The top of the water table ranges from approximately 2 to 10 ft below ground surface (bgs) (Miller 1990). Groundwater in the surficial aquifer system is under unconfined, or water table, conditions. Locally, however, thin clay beds create confined or semi-confined conditions.

Groundwater encountered at HAAF Pump House #1 UST investigation sites is part of the surficial aquifer system. Based on the facts that all public and non-public water supply wells draw water from the Floridan Aquifer and that the Hawthorn confining unit separates the Floridan Aquifer from the surficial aquifer, it is concluded that there is no hydraulic interconnection between HAAF UST sites (and associated plumes) and water supply withdrawal points (SAIC 2000). Historic groundwater elevations are included in Table 2-1.

2.1.3 Surface Water

The water resources survey conducted during the CAP–Part B site investigation was presented in the CAP– Part B Report (SAIC 2000) and CAP–Part B Addendum #1 Report (SAIC 2002a). Surface water bodies at HAAF include Hallstrom Lake, Lamar Canal, Buckhalter Canal, Springfield Canal, Pond 29 located northwest of Buildings 336 and 232, and an unnamed pond located along the southeastern boundary of the HAAF installation. Several unnamed drainage canals and ditches exist throughout HAAF. Most of these canals drain southwest into the Little Ogeechee River, which is part of the Lower Ogeechee watershed. The remaining drainage canals located on the eastern side of the HAAF installation flow east and eventually drain into the Vernon River, which is located southeast of the HAAF installation. Surface water bodies at HAAF and adjacent areas are not used as public water supplies. The

ponds and lakes, as well as Lamar Canal, are perennial, whereas most of the drainage canals and ditches are intermittent. Most of the drainage canals are at least partially enclosed in culverts (SAIC 2000).

2.1.4 Site Stratigraphy

The lithology encountered at the site is predominantly a white, pale brown, or light gray, very fine to medium-grained sand, with variable silt and clay content. Generally, the samples with higher silt and clay content were within a few feet of the surface. Less silt and clay content was noted with depth. The boring log of deep well P1-MW40 indicates an increasing clay content from approximately 26 to 30 ft bgs, becoming a clayey, coarse-grained sand/gravel at 30 ft bgs. (SAIC 2000)

2.1.5 Referenced or Documented Calculations

The following referenced or documented calculations were performed to support the CAP-Part B Site Investigation and were included in the CAP-Part B (SAIC 2000).

Disturbed soil samples were collected from eight monitor wells for grain size analysis. In addition, undisturbed soil samples were collected from four monitor wells and a soil boring to determine selected engineering properties of the unsaturated zone at the site. The engineering properties that were measured included moisture content, porosity, specific gravity, bulk density and permeability.

Slug tests were conducted on two shallow and one deep well and evaluated using AQTESOLVE software. The calculated hydraulic conductivity values were 1.32×10^{-2} feet per minute (ft/min) (6.7×10^{-3} centimeters per second (cm/s)) and 1.75×10^{-2} ft/min (8.9×10^{-3} cm/s) in the shallow wells and 4.5×10^{-3} ft/min (2.3×10^{-3} cm/s) in the deep well. The average hydraulic conductivity based on slug test data is 1.17×10^{-2} ft/min (6.0×10^{-3} cm/s).

Aquifer testing (8-hour step test) was performed to determine the optimum pumping rate for the well. Pumping data yielded a transmissivity of 0.4035 ft^2/min assuming a saturated aquifer thickness of 60 ft. The recovery data produced a transmissivity of 0.089 ft^2/min assuming a saturated thickness of 60 ft. (SAIC 2000)

2.1.6 Direction of Groundwater Flow

Historical water level measurements (Table 2-1) were taken during monitoring events to evaluate the directional flow in groundwater. Groundwater in the vicinity of the

former Release #2 area was determined to flow generally to the south. Groundwater potentiometric surface measurements taken in January 2008, July 2008, and December 2008 are presented on Figures 2-2, 2-3, and 2-4, respectively.

2.2 Horizontal and Vertical Extent of Contamination

The horizontal and vertical extent of petroleum-related contamination in soil and groundwater was delineated by activities performed during the previous investigations at the former Pumphouse #1 site and the DAACG facility, which were documented in the CAP–Part B Report (SAIC 2000) and CAP–Part B Addendum #1 Report (SAIC 2002a). In September/October 2003, additional activities were performed with CPT equipment with fluorescence detection to delineate the horizontal and vertical extent of the free product at both Release #1 and Release #2. Subsequently, additional data has been obtained through semiannual sampling of monitor wells and a supplemental investigation using DPT that was conducted in January 2008. A summary of the results from these investigations is presented below.

2.2.1 Delineation of Soil Contamination

In the vicinity of the former Pumphouse #1 Tank Pit area (Release #2), the horizontal extent of petroleum-related contamination in soil was determined during the CAP-Part B site investigation and was discussed in detail in the CAP–Part B Report (SAIC 2000). Benzene, ethylbenzene, toluene, xylenes, benzo(b)fluoranthene and chrysene exceeded the applicable Georgia Underground Storage Tank (GUST) Soil Threshold Levels (STLs) (i.e., Table B, Column 1) and were identified as chemicals of potential concern (COPCs) for soil at Release #2. Only benzene and chrysene exceeded their respective ATLs.

The CAP-Part B Report stated that there was an area of contamination located 1 to 2 feet above the water table with the center of the source area located north of the Former Fuel Pit 1C. The samples with concentrations exceeding the ATLs were collected from the capillary fringe above the soil/water interface.

In January 2008, supplemental investigation activities were conducted to further delineate subsurface soil contamination at the site. Subsurface soil samples were collected from 35 direct-push borings at the site and analyzed for BTEX. One soil sample was collected from each boring at the depth interval with the highest photoionization detector (PID) reading. The soil samples were analyzed for BTEX using the U.S. Environmental Protection Agency (EPA) Method 8021B/8260B. The

analytical results from the soil sampling are presented in Table 2-2 and Figure 2-5.

The analytical results of the January 2008 supplemental investigation are summarized below (SAIC 2008).

- Benzene was detected in 8 of 35 soil samples at concentrations ranging from 0.0569J to 0.801 milligrams per kilogram (mg/kg). None of the sample concentrations or detection limits exceeded the ATL.
- Toluene was detected in 24 of 35 soil samples at concentrations ranging from 0.0312J to 125J mg/kg. None of the samples exceeded the ATL.
- Ethylbenzene was detected in 31 of 35 soil samples at concentrations ranging from 0.00301J to 66J mg/kg. None of the samples exceeded the ATL.
- Total xylenes were detected in 33 of 35 soil samples at concentrations ranging from 0.000687J to 370J mg/kg. None of the samples exceeded the ATL.

Subsurface soil sampling in January 2008 indicated that the benzene concentrations in soil were below the ATL of 9.3 mg/kg. Samples were not analyzed for polyaromatic hydrocarbons (PAHs), specifically chrysene. As previously noted, chrysene was detected in soil at concentrations exceeding the ATL during the CAP-Part B investigation.

2.2.2 Delineation of Groundwater Contamination

In the vicinity of the former Tank Pit area (Release #2), the vertical and horizontal extent of the plume was initially delineated in the CAP-Part B site investigations and was discussed in detail in the CAP–Part B Report (SAIC 2000). Benzene, ethylbenzene, toluene, benzo(a,h)anthracene, indeno(1,2,3-cd)pyrene and naphthalene were identified as COPCs for groundwater. Based on the results of fate & transport (F&T) modeling, ACLs were calculated for these constituents. An ACL of 285 micrograms/liter (µg/L) was proposed for benzene in groundwater and subsequently approved by GA EPD. Benzene was the only constituent in the Release #2 area to exceed its In-Stream Water Quality Standard (IWQS) and ACL during the site investigations.

During the semiannual sampling events from 2001 through 2007, benzene was the only COPC to exceed the IWQS or ACL. None of the other constituents were detected at concentrations that exceeded the respective ACL or IWQS. Benzene concentrations in monitor wells D-MW5, P1-MW2 and P1-MW19 have consistently exceeded the ACL of 285 µg/L. Concentrations in wells installed for ORC injection

exceeded the ACL in areas near former building 8060 and near former fuel pit 1C and the former UST 50 (SAIC 2007). During the eleventh semiannual sampling event in July 2007, the benzene concentrations in D-MW5R, P1-MW19 and CPT wells P1-CPT7, P1-CPT17, P1-CPT19, and P1-CPT22 exceeded the ACL of 285 µg/L (Figure 2-6). The CPT wells with benzene concentrations above the ACL are also in the areas previously identified as impacted. The July 2007 results are illustrated in Figure 2-6.

During the twelfth semiannual sampling event in January 2008, eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW-21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. In addition, supplemental investigation activities were conducted to delineate groundwater contamination at the site. Groundwater samples were collected from 35 direct-push borings at the site and analyzed for BTEX. Benzene was detected in 41 of 43 groundwater samples at concentrations ranging from 0.424J to 3,760 µg/L. The benzene concentrations in monitor wells D-MW5R, P1-MW2, P1-MW19, and 11 direct-push borings (P1-DB-04, P1-DB-05, P1-DB-06, P1-DB-07, P1-DB-08, P1-DB-13, P1-DB-18, P1-DB-19, P1-DB-22, P1-DB-23, and P1-DB-35) exceeded the ACL of 285 µg/L. The benzene concentrations in D-MW5R, D-MW6R, P1-MW2, P1-MW19, P1-MW23, and 16 direct-push borings exceeded the IWQS of 51 µg/L. None of the other constituents exceeded the respective ACL (SAIC 2008). The analytical results are provided in Table 2-3 and Appendix A and illustrated in Figure 2-7.

During the thirteenth semiannual sampling event in July 2008, eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. Benzene was detected in 8 of 8 groundwater samples at concentrations ranging from 2.98 to 2,090 µg/L. The benzene concentrations in D-MW5R, P1-MW2, and P1-MW19 exceeded the ACL of 285 µg/L. The benzene concentrations in D-MW5R, P1-MW2, P1-MW19, and P1-MW23 exceeded the IWQS of 51 µg/L. None of the other constituents exceeded the respective ACL. The analytical results are provided in Table 2-3 and Appendix B and illustrated in Figure 2-8.

The fourteenth semiannual sampling event was conducted in December 2008. Eight monitor wells in the semiannual monitoring program (i.e., D-MW5R, D-MW6R, P1-MW1, P1-MW2, P1-MW19, P1-MW21, P1-MW22, and P1-MW23) were sampled for analysis of BTEX using EPA Method 8021B/8260B. All groundwater samples collected were analyzed by a certified laboratory as listed in the Site-Wide Quality Assurance

Project Plan (QAPP) (ARCADIS 2008). Field laboratory data included quality control samples and all data were reviewed by the project chemistry team. All data reported by Shealy Laboratory were evaluated in accordance with the Level II validation protocols set forth in the Site-Wide QAPP (ARCADIS 2008). Field parameters from each well that was sampled are provided in Table 2-4. The analytical results are provided in Table 2-3 and Appendix C and illustrated in Figure 2-9. Analytical results from the sampling event are summarized below.

- Benzene was detected in 6 of 8 groundwater samples at concentrations ranging from 29 to 1,700 µg/L. The concentrations in two samples exceeded the IWQS of 51 µg/L and in three samples exceeded the ACL of 285 µg/L.
- Toluene was detected in all eight groundwater samples at concentrations ranging from 1.2 to 16,000 µg/L. The concentrations did not exceed the ACL.
- Ethylbenzene was detected in all eight groundwater samples at concentrations ranging from 7.7 to 1,700 µg/L. The concentrations did not exceed the IWQS or ACL.
- Total xylenes were detected detected in all eight groundwater samples at concentrations ranging from 13 to 8,600 µg/L. There is no ACL or IWQS for total xylenes.

The benzene concentrations in the most contaminated wells over time are plotted on Figure 2-10.

2.2.3 Delineation of Free Product

Free product was identified at the former Fuel Pit 1A/DAACG area (Release #2) in September 2001. The free product was observed in wells D-MW5, P1-MW2, P1-MW3, and P1-MW22 at thicknesses ranging from 0.02 to 0.49 ft. The horizontal extent of the free product was bounded by existing wells at the site. Following the CAP–Part B investigation, the interim corrective action consisted of free product recovery in the wells via absorbent socks, which were first installed in November 2001. The absorbent socks were utilized from November 2001 through May 2005.

In September/October 2003, additional activities were performed with CPT equipment with fluorescence detection to delineate the horizontal and vertical extent of the free product at both Release #1 and Release #2. The Release #2 investigation concluded that the likely zones of nonaqueous-phase liquid (NAPL) contamination tend to occur between 6 and 13 ft bgs, which is in the vicinity of the water table and smear zone, at a thickness ranging from 1 to 5 ft. At three locations

there was NAPL detected below the water table at approximately 20 to 25 ft bgs (SAIC 2005).

Beginning in June 2005, VE activities were initiated on approximately 50 wells located throughout Release #1 and Release #2. The quantity of the water/product mixture varied from well to well. However, in general the amount of free product removed from each well was very small. In January 2006, the vacuum truck activities were modified from bimonthly to quarterly and focused on the wells with free product accumulation. As a result, only a few wells were pumped in January 2006, but for approximately 8 hr per well (SAIC 2006b). Measurements conducted during the vacuum extraction activities for Release #2 are presented in Table 2-5. Free product was not observed in any of the wells associated with Release #2 prior to or following the vacuum extraction activities in June 2005 through January 2006.

In July 2007, no measurable free product was observed at any of the wells associated with Release #2 and EFR activities were not conducted. In October 2007, free product was measured in one well in the Release #2 area. Well P1-MW2, had 0.01 ft of measurable product and EFR activities were performed on this well for 8 hours. In January 2008, free product was measured at two wells (P1-MW2 and P1-MW22, 0.01 ft each) and EFR activities were performed on each well for 8 hours. A summary of the vacuum activities for Release #2 is presented in Table 2-5. Prior to groundwater sampling activities on January 27, 2008, no free product was observed at the site. In July 2008, free product was observed in wells P1-MW2 and P1-MW3 at a thickness of 0.02 ft and 0.01 ft, respectively. In December 2008, no measurable free product was detected at any of the wells associated with Release #2.

The free product thickness recorded in Monitor Wells P1-MW2 and P1-MW3 versus groundwater elevation is plotted in Figures 2-12 and 2-13 respectively.

2.2.4 Delineation of Surface Water and Sediment Contamination

Results from the surface water and sediment samples collected during the CAP–Part B investigation were discussed in the CAP–Part B Report (SAIC 2000). Two surface water samples (P1-SWS-11 and P1-SWS-12) were collected in July 2007 from diffusion samplers installed within the saturated sediment of the drainage ditch located approximately 500 ft south of the source areas. The samples were analyzed for BTEX using EPA Method 8021B/8260B. Benzene was detected in P1-SW-11 and 12 at concentrations of 357 and 0.457J µg/L respectively. The benzene concentration in surface water sample P1-SWS-11 exceeded the IWQS of 51 µg/L

and the ACL of 285 µg/L. In the same sample, toluene was detected at 11,900 µg/L, ethylbenzene at 1,640 µg/L and total xylenes at 8,990 µg/L. The toluene concentration exceeded the IWQS. The analytical results are provided in Table 2-3.

Two surface water samples (P1-SWS-11 and P1-SWS-12) were collected in December 2008 from the drainage ditch located south of the site and analyzed for BTEX using EPA Method 8021B/8260B. Benzene was detected at concentrations of 2.4 and 24 µg/L, toluene at concentrations of 16 and 51 µg/L, ethylbenzene at concentrations of 26 and 33 µg/L and total xylenes at concentrations of 88 and 370 µg/L. All concentrations were below the IWQS. The analytical results are provided in Table 2-3 and illustrated in Figure 2-8.

3. Remedial Action Plan

3.1 Corrective Action Completed or in Progress

3.1.1 Recovery/Removal of Free Product

Free product was discovered at the Release #2 location in September 2001 and absorbent socks were used for product recovery from 2001 through May 2005. Free product was removed from various wells using EFR from June 2005 through July 2006 and April 2007 through January 2008. Prior to groundwater sampling activities on January 27, 2008, no free product was observed at the site. In July 2008 free product was observed in wells P1-MW2 and P1-MW3 at a thickness of 0.02 ft and 0.01 ft, respectively. In December 2008, no measurable free product was observed at any of the monitor wells associated with Release #2.

3.1.2 Remediation/Treatment of Contaminated Backfill Material and Native Soil

No contaminated backfill material or native soil associated with the former Tank Pit area (Release #2) has been excavated, remediated, or treated. Soil disposition during the tank removals in the late 1990s is unknown.

3.2 Objectives of Corrective Action

A primary objective of groundwater remedial activities is to decrease residual mass to a point where natural attenuation mechanisms, as opposed to active remedial measures, become the long-term remedial strategy. Remedy implementation will be optimized through pre-design activities to limit treatment to areas where it will be most effective based on the hydrogeology and nature/extent of hydrocarbon (i.e., benzene) impact. Plume impact on surface water in the canal will be mitigated to comply with the IWQS.

3.2.1 Remove Free Product That Exceeds One-Eighth Inch at the Former Tank Pit/Fuel Pit 1C Area (Release #2)

Free product will be addressed such that no well contains free product in excess of 1/8 inch in thickness. Free product in excess of 1/8 inch has been detected only sporadically in monitor wells and the maximum thickness measurement since April 2007 was 0.2 ft. Recovery results have indicated very little mobile (recoverable) mass. Liquid levels will be measured during future monitoring events to confirm the absence of free product at a thickness greater than one-eighth inch. Activities utilizing a vacuum truck will be invoked as the corrective action if free product is detected in recoverable quantities.

3.2.2 Remediate Groundwater Contamination at the Former Tank Pit/Fuel Pit 1C Area (Release #2)

The objectives of the corrective action for groundwater are to reduce the concentrations of the contaminants of concern to below ACLs approved in the CAP-Part B (SAIC 2000). Benzene has historically been the only COPC that exceeds ACL or IWQS concentrations.

A corrective action for groundwater was implemented in 2006, when an oxygen-releasing compound (PermeOx® Plus) was injected into the subsurface to promote aerobic conditions. Six wells located throughout the Release #2 area that were not part of the semiannual monitoring only program or quarterly free product removal were utilized as injection wells. These wells were D-CPT-4, D-CPT-20, D-CPT-2I, D-CPT-23, D-CPT-24, and D-CPT-25. Six additional injection wells (P1-J1 through P1-J6) were installed at the site in May 2006. The wells had 10 ft screens and were screened across the water table with the goal that approximately 7 ft of screen would be located below the water table. PermeOx® Plus was injected into the 12 wells on a quarterly basis for a period of 1 year. Performance monitoring of four wells (D-MW5, P1-MW2, P1-MW21, and P1-MW22) for BTEX was conducted prior to each quarterly injection (SAIC 2008). Subsequent reports stated that site contaminant levels were not significantly reduced through the injection of ORC and that the results indicated that there are two areas that are serving as potential sources in the Release #2 area: the former Pumphouse #1 tank pit area and the area under the taxiway near the Fuel Pits. The oxygen demand from this source mass and from natural sources was such that the oxygen delivery rate from a slow release oxygen compound was insufficient for a source area application.

Recent data indicate that dissolved benzene concentrations continue to exceed the ACL and that benzene is attenuating very slowly. The plume of impacted groundwater at the site is presented in Figures 2-6, 2-7, 2-8 and 2-9. The variation of benzene concentrations with time is presented on Figure 2-10. In addition, BTEX is impacting the surface water in the canal down gradient of the source.

3.2.3 Remediate Soil Contamination at the Former Tank Pit/Fuel Pit 1C (Release #2)

The objective of the corrective action is to reduce concentrations of soil contaminants exceeding ATLs approved in the CAP-Part B (SAIC 2000). Data from subsurface soil sampling in January 2008 indicated that the benzene concentrations in soil are below the ATL of 9.3 mg/kg. The other COPC that exceeded the ATL was chrysene. Samples taken in January 2008 were not analyzed for PAHs. After free product and groundwater goals are achieved, additional soil samples will be taken to determine

compliance with approved ATL goals for chrysene.

3.2.4 Provide Risk-Based Corrective Action

A risk-based approach was used in the CAP–Part B Report (SAIC 2000) to identify COPCs for soil and groundwater and to develop ATLs and ACLs for various constituents. The results of the risk screening for Release 2 were presented in the CAP–Part B Report (SAIC 2000). The ATLs and ACLs developed for the COPCs and subsequently approved by GA EPD in 2000 are listed in Table 2-6. Due to the proximity of Releases 1 and 2, the most conservative F&T modeling results were used for developing one set of ACLs and ATLs for both areas of contamination in the CAP-Part B (SAIC 2000). F&T modeling using the analytical AT123D model was revised in the Second and Fourth Annual Monitoring Only Reports but a change to the ACL for benzene was not proposed. The F&T modeling was revised as part of the Fifth Annual Monitoring Only Report (SAIC 2007). As part of this modeling, the plume was determined to be more complex than previously modeled and three dimensional numerical models MODFLOW and MT3DMS were used to simulate groundwater flow and benzene transport respectively. Based on the revised modeling results, the dilution attenuation factor (DAF) for benzene was calculated to be 37.5 at the drainage ditch. Since ATLs and ACLs were calculated using the most conservative DAF of the two separate plumes, the revised DAF was not used and the benzene ACL was not revised.

3.2.5 Conclusions and Recommendations

The following conclusions are based on the results discussed above:

- Recent thickness measurements indicate that very little mobile free product remains.
- Recent dissolved concentrations indicate that the groundwater impacted above ACLs includes the area around and north of former fuel pit 1C and east of former building 8060, the same areas previously identified in the CAP-Part B.
- Based on soil samples from January 2008, petroleum VOC concentrations in soil are below ATLs. Samples were not analyzed for PAHs to determine concentrations of chrysene, the other COPC previously detected above the ATL.

3.3 Design and Operation of Corrective Action

3.3.1 Basis for Selection

The two priorities for selection of a remediation strategy are: 1) rapidly mitigating impacts to canal surface water; and 2) reducing the source mass that could extend the remediation timeframe. The proposed remediation will be applied to two source areas and one area for mitigation of surface water impacts. The areas relative to the groundwater plume are illustrated in Figure 3-1. The source area associated with the Former Fuel Pit 1C and Defueling Tank is presented with more detail in Figure 3-2a. The source area associated with Former Building 8060 Tank Pits is presented in Figure 3-2b. The area where surface water impacts will be addressed is presented with more detail in Figure 3-2c.

3.3.1.1 Sodium Persulfate

Remedial options for source mitigation were limited because a portion of the source is located under the active tarmac. Also, addition of electron acceptors (oxygen, sulfate) was not considered favorable given the known source mass load and the demonstrated inadequacy of a slow release oxygen compound for source areas at this site. Biosparge, which likely would be effective in some areas of the site, was not selected because of the difficultly of implementation and ongoing operation and maintenance in the fuel pit area adjacent to and under the tarmac (Figure 3-2a). A substantial portion of the source mass is located in this area and not addressing the mass in that area would result in an extensive remediation timeframe. The proposed remedy for the source mass causing the groundwater impacts consists of the implementation of In-situ Chemical Oxidation (ISCO) to achieve the remedial objectives outlined in Section 3-2. EFR events may be performed to address the free product reduction requirement on an as-needed basis.

ISCO is a well-demonstrated remedial technique that uses a chemical oxidant to rapidly degrade aqueous-phase contaminants. Sodium persulfate is a strong oxidant with a demonstrated ability to oxidize benzene. It is relatively stable and therefore can be delivered at greater distances from the point of injection than other oxidants, such as catalyzed hydrogen peroxide. Persulfate salts dissociate in aqueous solutions to form the persulfate anion ($S_2O_8^{2-}$), which has an electrode potential (E_h) of 2.12 V. Persulfate's E_h is comparable to that of ozone (2.1 V) and is greater than that of hydrogen peroxide (1.8 V). Its low density and low affinity for soil sorption provides for density-driven distribution throughout the subsurface treatment area and therefore greater contact with the target contaminant and a greater percent utilization of the injected oxidant. Persulfate performance can be enhanced by activating the solution to

produce sulfate radicals ($\cdot SO_4^-$) and hydroxyl radicals ($\cdot OH$), both highly reactive and short-lived species (E_h of 2.6 V and 2.8 V, respectively). Activation can be accomplished via reaction with ferrous iron present in the formation, or by engineered activation methods such as the addition of a base, heat, or chelated metal. The remediation of BTEX should not require engineered activation of the persulfate. However, this option is available should it become necessary to increase the oxidation efficiency in target areas with high concentrations of benzene (or residual NAPL) that are found to be recalcitrant to the unactivated formulation.

The remedial design concept is presented below and will be preceded by the pre-design field data collection necessary to effectively design an appropriate and efficient oxidant delivery network.

3.3.1.2 Calcium Peroxide

Remedial options for mitigating the migration of benzene to the drainage canal surface water pending source remediation include intercepting the dissolved plume with oxygenated water to stimulate aerobic biodegradation. Aerobic conditions can be engineered via a biosparge curtain or via other chemical means to increase oxygen content within the water, such as the use of oxygen release compounds. Since the source mass will be aggressively addressed with persulfate and the timeframe for plume interception will be shortened in the down gradient portion of the plume adjacent to the canal, injection of chemicals that slowly release oxygen (e.g. magnesium peroxide, calcium peroxide, sodium percarbonate) is preferred over biosparge. These compounds can slowly release oxygen over an extended time making oxygen available over a longer period, preventing kinetic limitation. Given the relatively low flux of petroleum hydrocarbons and slow groundwater velocity expected in the downgradient portion of the plume approaching the canal, the residence times should be sufficient to allow for aerobic biodegradation as a barrier.

The most important physico-chemical properties of 3 possible slow release ORC's are listed in Table 3-1. The comparison shows that calcium peroxide releases the most oxygen. Furthermore, CaO_2 has a low solubility (in comparison with sodium percarbonate) thus being less reactive. This will enable it to release its oxygen more slowly over the course of several months. Sodium percarbonate releases its oxygen more rapidly because of its higher solubility resulting in a less efficient use of the released oxygen. Because of the higher oxygen content and its slow release characteristics, calcium peroxide is chosen to stimulate the biological breakdown.

Calcium peroxide (CaO_2) slowly releases oxygen when in contact with water according to the following reaction:

$$2\ CaO_2 + 2\ H_2O \rightarrow 2\ Ca(OH)_2 + O_2$$

The speed at which oxygen is released is determined by physical and chemical properties of the medium (e.g. pH and temperature). When CaO_2 is exposed to a lower pH, H_2O_2 can be generated according to the following reaction:

$$CaO_2 + 2\ H^+ \rightarrow Ca^{2+} + H_2O_2$$

H_2O_2 releases oxygen according to the following reaction:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Directly around the injection wells, little H_2O_2 will be generated due to the higher pH generated by the presence of calcium hydroxide and peroxide. This ensures an efficient release of oxygen. As a consequence of the low solubility in water of CaO_2 (<0.1 gram per liter (g/L) @ 20 °C), an oxygen release period of more than 6 months (Solvay) is typical.

3.3.2 Pre-Design Field Data Collection

Baseline biogeochemical sampling and analysis will be conducted. The data will be primarily focused on optimizing the application of sodium persulfate but will also be applied to aid in designing the calcium peroxide barrier. A baseline biogeochemical sampling event will be conducted consisting of samples from approximately 6 wells, 2 from each source area and 2 outside the impacted area. Samples from these wells will be analyzed for the parameters listed in Table 3-2 including total and dissolved iron, manganese, carbonate alkalinity, sulfate, total organic carbon, chemical oxygen demand, nitrate, total dissolved and suspended solids. Field parameters will consist of at a minimum dissolved oxygen, pH, oxidation reduction potential, conductivity and temperature. Baseline sampling will include obtaining samples for analysis of BTEX from the 8 wells designated for semiannual sampling plus approximately 4 wells that are proximate to source areas but have not been recently sampled.

Extensive sampling has been conducted previously to evaluate the vertical and horizontal distribution of BTEX in soil and groundwater. Numerous sampling events have confirmed the distribution of groundwater impacts and the 2003 CPT investigation and 2008 DPT investigation confirmed source mass is located north of Fuel Pit 1C and east of the former Building 8060. As is typical, the majority of the source mass is located in the smear zone. However, the 2003 investigation revealed that in two areas source mass may be located at approximately 20 ft bgs (10 ft below water level).

Impacted groundwater was identified farther to the northwest during the January 2008 investigation and an additional monitor well is proposed in this area. An additional permanent monitor well is also recommended to define the northeast extent of the plume. The locations of the additional monitor wells in Area A are shown on Figure 3-3a.

Matrix demand testing is planned for selected soil and groundwater (slurry) samples to evaluate the soil oxidant demand (SOD). Naturally occurring minerals and organic molecules in addition to the contaminants of interest that may react with persulfate will determine oxidant demand. Matrix demand tests are performed on uncontaminated samples of soil and groundwater to estimate the concentration of persulfate that will be consumed by the oxidizable components of the geological matrix and groundwater during a given treatment time. The testing will be performed at ARCADIS' laboratory in Durham, North Carolina.

Because of the well documented oxidation reaction of persulfate with BTEX, treatability testing requirements will be minimal. Samples for treatability testing will be taken from contaminated areas. The initial phase of treatability testing will include an assessment of unactivated persulfate at a concentration in the probable range of 1 percent to 5 percent to examine the treatment efficiency as a function of dose concentration. Dosing with chelated iron activation, alkaline activation, or activation with hydrogen peroxide may also be performed to evaluate suitability for the site and approximate field-scale oxidant dosing schemes.

Injection wells will be installed in the injection target areas A and B located as depicted in Figures 3-3a and 3-3b in the vicinity of the former Fuel Pit 1C and former Building 8060 respectively. The initial injection in the former Fuel Pit 1C area will be through a new injection well installed between D-MW5R and P1-CPT20 as shown on Figure 3-3a. The initial injection in the area east of the former Building 8060 will be through a new well installed between P1-J3 and P1-MW2 as shown on Figure 3-3b. Injection wells will be designed with well screens that bracket the water table (generally present at 9 to 10 ft bgs) and extend approximately 5 feet into the vadose zone areas to more efficiently address the smear zone. When possible, persulfate injections will occur during high water table conditions as the most efficient means of making contact with the smear zone relative to flooding the smear zone. The depth of the screen interval will be determined by estimated location of target mass and will typically be 15 to 20 ft bgs. Surrounding MW and CPT wells will be used as observation well locations as depicted on Figures 3-3a and 3-3b. Wells located within 10 feet of the injection well will be used as dose-response wells to verify the volume of injection solution required to achieve the target radius of injection (ROI) of 10 feet. Wells outside of the 10-foot ROI will be used to monitor (1) the movement of persulfate

outside of the injection zone, (2) treatability of BTEX using persulfate, and (3) persulfate reaction kinetics and potential secondary water quality effects in the oxidation zone.

The data from the initial injection will be utilized to verify the previously estimated relationship between injection volume and delivery radius in both targeted treatment areas (i.e., where current benzene concentrations exceed 1 milligram per liter [mg/L] or previous investigations have indicated the presence of source mass). The results of the initial injections will be evaluated to ensure adequate distribution of oxidant during remediation. The refined understanding of the optimal concentration, required volumes and viable injection flow rates will then be used to optimize the methods employed for the additional applications (e.g., injection volumes, oxidant concentrations, etc.). Distribution of persulfate will be tracked through field measurements of persulfate ions and conductivity. Movement of persulfate and conductivity will be utilized to confirm groundwater flow rates and directions. This will support evaluation of reagent migration and anticipated trends in dissolved-phase concentrations downgradient of the treatment area(s).

Temporary monitor wells will be placed if needed to refine the injection target zone. Any temporary wells will be 2-inch I.D. pre-packed wells installed using DPT and screened across the water table. The need for these wells will be determined based on initial injection results and would be installed to provide the additional data density necessary to mitigate the unnecessary injection of oxidant. Conventional well installation methods (hollow stem auger, sonic, etc.) would be used if multi-purpose wells are needed.

A permit application will be submitted to the Underground Injection Control (UIC) Division of Georgia EPD to allow the initial injection for the performance evaluation phase. The permit will be obtained before the initial injection is initiated. A copy of the UIC Permit Pilot Test Notification is included in Appendix E. After the data from the initial injection are collected and evaluated, a full UIC Permit Application will be prepared as an addendum to this CAP – Part B.

The volume of solution required to achieve breakthrough at an assumed 10-foot ROI dose-response well is estimated using the following equation:

$$V_{inj} = ROI^2 \times \pi \times h \times n_m \times \left(\frac{7.481\ gal}{ft^3}\right)$$

where:

V_{inj} = volume of injection (gal)

ROI = radius of injection (e.g., 10 feet)

h = height of injected fluid column (15 feet)

n_m = mobile porosity

The volume of solution required to achieve breakthrough at the 10-foot ROI depends on the mobile porosity of the formation. The following table shows the relationship between mobile porosity, injection volume, and amount of sodium persulfate and water required to mix injection solution containing 5 percent persulfate by weight (50 g/L) over a 15-foot screened interval with an assumed ROI of 10 feet. The persulfate concentration that will be used in the pilot study will be determined by the laboratory SOD testing, and will likely be at or below this value with the initial target concentration in the 1 to 2 percent range. A range of approximately 1 to 5 percent should also be effective for full-scale application, and will allow flexibility in the injection approach so that areas of the BTEX plume can be adaptively targeted with appropriate oxidant dosing. The initial injection will use unactivated persulfate. Depending on the outcome of the initial study, this range may be adjusted or augmented with activation chemistry suitable for the site. The actual concentration range will be defined in the UIC permit.

	$n_m = 0.05$	$n_m = 0.1$	$n_m = 0.15$	$n_m = 0.20$
Injection volume (gallons)	1,763	3,525	5,288	7,050
Mass of sodium persulfate (lb)	774	1,547	2,321	3,095

The injection rate will likely range from approximately 1 to 2 gpm under gravity-feed conditions. Injection solution will be prepared in batches immediately prior to introducing into the injection well. A stock solution of clean water will be provided in the existing 20,000-gallon tank. This water will be used to fill a 500-gallon tote, where sodium persulfate will be added and fully mixed prior to injection. The injection will continue until a concentration representing 50 percent of the initial injection solution strength (i.e., conductivity reaches half the concentration measured in the tank) and a plateau in electrical conductivity is observed in dose-response wells.

Groundwater monitoring parameters and analysis methods are detailed in Table 3-2. Monitoring will be performed according to the schedule outlined in Tables 3-3a and 3-

3b. The scope of the breakthrough and post-breakthrough monitoring includes the following:

- Electrical conductivity, pH, and persulfate sampling and field testing in all monitor wells for six months (twice for the first week, weekly for weeks 2 to 4, and biweekly for months 1 to 3).
- Vertical profile of pH and electrical conductivity within the screened intervals of all monitor wells using a hand-held water quality probe.
- Analysis of comprehensive water quality parameters in the first, second, third, and sixth months after the injection.

3.3.3 Remediation Design

Data collected from the laboratory and initial injection events will be reviewed to evaluate changes in the remedial design necessary to achieve the remedial goals. This review will include the number and construction specifications for injection wells, anticipated concentration and volume of oxidant solution, number of injection events needed to reach remedial goals, a schedule of injection events, a remediation health and safety plan, and performance monitoring requirements and schedule. All well installation, development and sampling will be conducted in accordance with the approved Sampling and Analysis Plan and Quality Assurance Project Plan (ARCADIS 2008) and GA EPD requirements.

In the event that free product is observed in monitor wells at levels that would make ISCO cost-prohibitive or where pretreatment would be effective in shortening the duration of the planned ISCO events, EFR may be utilized. EFR events use multi-phase extraction (MPE) recovery techniques. MPE is a generic term used to describe the simultaneous extraction of soil vapor and liquid from the smear zone with the goal of dewatering the smear zone to recover free product, water, and vapor. Currently, the presence of free product is rare in monitor wells. However, the extent of free product will be verified periodically during monitoring events and during remediation activities such as pre-design sampling.

3.3.3.1 Sodium Persulfate

Approximately 12 persulfate injection wells will be installed into the surficial water-bearing unit as depicted on Figures 3-3a and 3-3b. The wells would be designed with an approximate transverse spacing of 20 feet, assuming a minimum ROI of 10 feet. In the direction of groundwater flow, the downgradient injection wells would be spaced on 30-foot centers. This is based on an estimated groundwater travel time of 10 feet over a two-month duration (the time over which unactivated persulfate is assumed to remain

active) with a hydraulic gradient of 0.008 ft/ft. These wells will be installed to target benzene concentrations in the unconfined water table above 1 mg/L where source mass is indicated by historical data. Additional injection wells may be installed where necessary to achieve the remedial objectives. The injection wells will be constructed using threaded-joint materials with polyvinyl chloride (PVC) solid casing construction. Each well will be constructed consistent with the typical injection well schematic provided on Figure 3-4. Typically, the well will be fitted with a 2-inch-diameter, 5 to 15 or 5 to 20-foot-long, 0.010-inch slot size, stainless steel V-wire or PVC wire wrapped screen. The well screen length will be determined based on vertical profiling data collected during the earlier investigations at the site. The screen sections will be attached to chemically compatible riser material that extends to the ground surface. Each well will be completed in a flush-mounted, traffic-bearing vault sufficiently sized to allow attachment of pressure fittings and to accommodate gauges and related injection equipment. Well tags or markers will be fitted to each well for permanent identification.

3.3.3.2 Calcium Peroxide

In order to ensure an adequate oxygen distribution, calcium peroxide will be injected in two rows perpendicular to groundwater flow. Injection points will be 10 feet apart and the two rows will be offset by 5 feet as depicted in Figure 3-3c. Existing monitor well P1-MW19 will be used to monitor the progress of the remediation. Calcium peroxide will be injected as slurry. The slurry will be prepared by mixing approximately 65 pounds (lbs) calcium peroxide and 300 gallons of tap water. The slurry will be prepared on site. The goal for injection quantity of calcium peroxide at each injection location will adjusted based on the biogeochemical data and actual aquifer injection capacity. Additional water may be added to facilitate diluting the calcium peroxide in order to more easily inject the solution. Following delivery of calcium peroxide solution, approximately 125 gallons minimum of clean water will be injected to help is dispersing the solution away from the injection point.

3.3.3.3 Permanent Groundwater Monitor Wells

Two groundwater monitor wells will be installed to monitor plume distribution and ISCO performance as depicted on Figure 3-3a. Numerous existing wells will be utilized for characterization of groundwater quality near the injection areas and will support performance monitoring over the remediation period. Any new monitor wells will be constructed in much the same manner as illustrated on Figure 3-4, although threaded-joint, Schedule 40, PVC well casing and screen materials will be used and there will be no adaptors fitted to the well for injection connections.

Each monitor well will be fitted with a 5- to 20-foot-long, 0.010-inch, machine-slotted, PVC well screen. Well depth may vary depending on estimated contaminant distribution. The screen will be placed in the borehole with the intention to have approximately 5 feet of screen extending into the unsaturated zone to allow observation of floating layers and mounding effects of the injection events. The screen will be attached to solid PVC riser material that extends to the ground surface. Each well will be completed in a flush-mounted, traffic-bearing manhole. Watertight locking caps and well tags will be fitted to each well. Well tags or markers will be fitted to each well for permanent identification.

3.4 Implementation

ISCO implementation will occur at the injection wells shown on Figures 3-3a and 3-3b with the intent of targeting groundwater containing benzene at concentrations above 1 mg/L where source mass is indicated. The initial implementation phase will include installing all persulfate injection wells and additional monitor wells illustrated in Figures 3-3a and 3-3b. The initial implementation phase will include injection of calcium peroxide in Area C as illustrated on Figure 3-3c and injection of sodium persulfate into one well in Area A and one well in Area B as illustrated in Figures 3-3a and 3-3b. The data from the limited initial persulfate injection will be utilized to refine the plan for subsequent full scale injection. The initial injection of calcium peroxide will provide rapid mitigation of potential surface water impacts. Installation of temporary features to facilitate oxidant mixing and delivery will also be performed. An overview of the project implementation elements include:

- Obtaining a UIC Permit for injection and construction activities in the initial phase of implementation.
- Installing permanent flush-mounted wells for the purpose of persulfate injection with the screened intervals aligned to intercept the most impacted portion of the aquifer.
- Installing at least two additional monitor well for plume monitoring. The screen sections of these wells will be dependent on injection well screen intervals.
- Performing a baseline groundwater sampling event that consists of collecting samples for analysis of biogeochemical parameters and BTEX.
- If needed, performing enhanced fluid recovery extraction events to remove free product in areas where it is identified as a safety precaution prior to persulfate injection as well as a remedial objective of reducing free product thickness to less than 1/8 inch.

- Injecting slurried calcium peroxide into the water table and smear zone to effectively intercept the plume migrating to the drainage canal. Additional injection(s) may be performed depending on BTEX concentration trends from the source and dissolved oxygen concentrations.
- Constructing a mobile mixing and injection system for use in injection events. This system will be designed to be capable of injecting into multiple locations at once. Injection water will be amended with the sodium persulfate and activator (if required) and injected. This will maximize injection production and minimize the time needed to complete the injection process. At the end of each day of injections, the trailer will be moved to a secure location in accordance with HAAF direction.
- Performing an initial persulfate injection event and additional events as needed for the active phase of remediation. Anticipated concentrations of sodium persulfate solution in the 1 to 5 percent range combined with an activator (if required) will be injected on a periodic basis (anticipated to range between four months and six months apart). Focused ISCO treatment will be optimized during implementation relative to the quantities of reagents needed, volumes of solution to be injected, injection schedules, and labor requirements to administer the technology.
- Performing post-injection performance monitoring events to verify that oxidant distribution is adequate to achieve design criteria needed to meet remedial goals. This monitoring will begin following the first injection event. The periodicity of monitoring events will depend largely on the rate of oxidant consumption and associated rate at which BTEX is eliminated from the aquifer.

3.4.1 Milestone Schedule

A milestone schedule for the proposed corrective action has been prepared. A chart showing milestone activities and anticipated duration is provided in Figure 3-5. Fort Stewart will notify GA EPD USTMP of any significant changes to the schedule and will provide GA EPD USTMP with an updated chart, as necessary.

3.4.2 Progress Reporting

Performance Reports will be submitted to GA EPD that will summarize the sampling, injection and/or monitoring activities. At a minimum, the Performance Report will consist of a table summarizing the activities and analytical data and a proposal for subsequent activities. In addition, annual reports will be submitted to GA EPD that will summarize all remediation and monitoring activities for the preceding year.

Petition for permanent closure (i.e., completion report) will be submitted upon approval of the final progress report when Release #2 reaches GA EPD-approved

closure criteria. GA EPD will provide final approval for decommissioning the monitor wells. Decommissioning of the monitor wells will be completed in accordance with the U.S. Army Corps of Engineers (USACE) design manual for monitor wells. Decommissioning will comply with all applicable state and federal standards. The following certification will be submitted to GA EPD within 30 days of submittal of the final progress report:

> I hereby certify that the Corrective Action Plan–Part B, dated , 20 , for Hunter Army Airfield, Former Pumphouse #1 site (Release #2), Facility ID 9-025085*2, including any and all certified amendments/addenda thereto, has been implemented in accordance with the schedules, specifications, sampling programs, and conditions contained therein and that the plan's stated objectives have been met.
>
> _____
>
> Signature (Owner/Operator)

3.4.3 Inspection Schedule and Preventative Maintenance Program

All associated field equipment and supplies with direct application to injection activities will be inspected by field personnel prior to each use and monitored during the event to ensure proper functionality. Any suspect equipment will not be used and will be replaced. Any questionable performance issues while performing injections will be brought to the project manager's attention immediately for recommendations as to a proper course of action. Appendix F contains an excerpt from an ISCO remediation procedure and pertinent safety-related information regarding chemical handling and injection. A comprehensive health and safety plan will be maintained and utilized during the performance of this remedial project. Preventive maintenance inspection criteria include:

- Injection chemical mix tank concentrations – daily using persulfate field kit
- Injection hose and piping for leaks or notable deterioration. All process lines shall be pressure tested for leaks prior to the addition of oxidant or activator at the outset of each of the three planned full-scale injection events – daily prior to use
- Injection equipment valves, flowmeters, pressure gauges – daily for proper operation and leaks at fittings
- Containment area, delivery and storage area for adequate access, stability, and absence of impediments to level loading, emergency response equipment (personal protective equipment quantity and adequacy for use, eye wash

equipment, emergency water supply operation), site security and chemical storage area, chemical hazard communication labeling and placarding – daily

- Injection well pressure and flow – hourly during periods of injection at every injection well and manifold

3.4.4 Periodic Monitoring

Prior to initiating injections, as part of the pre-design data collection effort, a baseline groundwater sampling event will be performed as previously described. Post-injection performance monitoring events will be undertaken to verify that oxidant distribution is adequate to achieve design criteria needed to meet remedial goals. This monitoring will begin following the first injection event. The frequency of monitoring events will depend largely on the rate of oxidant consumption and associated rate at which BTEX is eliminated from the aquifer. BTEX samples will be collected from up to 15 monitor wells for each sampling event. Conventional low-flow sampling techniques will be used to collect biogeochemical parameters, such as persulfate, ferrous iron, dissolved oxygen, pH, and conductivity, during the post-injection monitoring events. Depending on the results and associated data density, the injection wells may be used for performance monitoring provided that sufficient time has elapsed from an injection event so that formation groundwater not impacted from oxidant injection is sampled. The proposed monitoring schedule during and after persulfate injection is presented in Tables 3-3a and 3-3b. Semiannual sampling events will be conducted in accordance with the schedule currently approved by EPD for the site. All sampling will conducted in accordance with the approved Sampling and Analysis Plan and Quality Assurance Project Plan (ARCADIS 2008) and GA EPD requirements.

3.4.5 Effectiveness of Corrective Action

The progress of the corrective action will be evaluated using baseline data and post-injection performance monitoring data. Oxidant distribution and consumption rate and the rate of BTEX elimination will be determined to assess the effectiveness of the corrective action. Liquid level measurements in the site monitor wells will be measured to ensure free product thickness is less than 1/8 inch. Groundwater samples from monitor well P1-MW-19 will be analyzed for BTEX and dissolved oxygen concentration and surface water samples will be analyzed for BTEX concentration to ensure that the impacts to surface water in the canal are mitigated.

3.4.6 Confirmatory Soil Sampling Program

No excavation of soil is planned. Therefore, confirmatory sampling associated with excavation of soil will not be performed. Confirmatory sampling of soil contamination

that previously exceeded the benzene ATL of 9.3 mg/kg has been completed and all concentrations were below ATLs. Confirmatory soil samples for chrysene will be taken after groundwater goals are achieved.

3.4.7 Stockpiled Bulk Soil Sampling

No stockpiled soil will be generated by this corrective action. Therefore, no soil sampling will be conducted.

3.4.8 Monitoring Only Termination Conditions

As previously stated in the CAP, the following conditions are required prior to termination of monitoring only program:

- Concentrations of benzene in groundwater must be at or below the ACL
- Concentrations of benzene and chrysene in soil must be at or below their respective ATLs prior to termination of the monitoring only program
- Product removal activities have reached a quantifiable goal agreed to by GA EPD and HAAF

Once these conditions are met, the remedial system and monitoring may be terminated regardless of the site ranking score.

3.4.9 Post-Completion Site Restoration Activities

As the remediation is currently planned, no modifications will be made to the Release #2 area because no permanent equipment or systems will be located at the site. Monitoring and injection wells will be properly abandoned in accordance with the Georgia EPD Manual for Ground Water Monitoring once a "No Further Action" notification is received from the EPD.

4. Public Notification

The former Pumphouse #1 site is located entirely within the confines of HAAF, which is part of the Fort Stewart Military Reservation, a federal facility. The U. S. Government owns all of the property contiguous to the site. The Fort Stewart DPW has complied with the public notice requirements defined by GA EPD guidance by publishing an announcement in the *Savannah Morning News* on April 1 and 8, 2001. When GA EPD and HAAF agree that the free product removal part of the corrective action has been completed, an updated public notice will be made.

5. Claim for Reimbursement

HAAF is a federally owned facility and has funded the investigation for the former Pumphouse #1 site (Release #2), Facility ID #9-025085*2 using U. S. Department of Defense Environmental Restoration Funds. Application for GUST Trust Fund reimbursement is not being pursued at this time.

6. References

ARCADIS 2008. Sampling and Analysis Plan and Quality Assurance Project Plan, *Hunter Army Airfield, Georgia*, November.

Science Applications International Corporation (SAIC) 2008. Sixth Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, September.

SAIC 2007. Fifth Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, October.

SAIC 2006b. 2004-2005 Free Product Removal Report for Former Pumphouse #1, Release #1, Building 8060, Facility ID # 9-025085*1, Hunter Army Airfield, Georgia, April.

SAIC 2006a. Corrective Action Plan-Part B Addendum #2 for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, July.

SAIC 2005. Third Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, June.

SAIC 2002b. First Annual Monitoring Only Report for Former Pumphouse #1, Building 8060, Facility ID # 9-025085, Hunter Army Airfield, Georgia, August.

SAIC 2002a. Corrective Action Plan–Part B Addendum #1 for Former Pumphouse #1, Facility ID # 9-025085, Building 8060, Hunter Army Airfield, Georgia, September.

SAIC 2000. Corrective Action Plan–Part B for Former Pumphouse #1, Facility ID #9-025085, Building 8060, Hunter Army Airfield, Georgia, August.

Miller, James A. 1990. *Groundwater Atlas of the United States*, U. S. Department of the Interior, U. S. Geological Survey, Hydrologic Inventory Atlas 730G.

GA EPD (Georgia Environmental Protection Division) 1992. *Groundwater Pollution Susceptibility Map of Georgia.*

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

6. Conclusions/Recommendations

The monitoring schedule is being conducted in accordance with the CAP–Part B Report (SAIC 2000) as approved by the GA EPD Underground Storage Tank Management Program (USTMP). Termination conditions approved in the CAP–Part B Report were measured benzene concentrations in groundwater below the ACL of 285 µg/L and collection of three confirmatory soil samples to determine if the benzene and chrysene concentrations in those soil samples were below the GA EPD-approved alternate threshold limits (ATL) of 9.3 and 2.1 mg/kg, respectively. Subsurface soil sampling in January 2008 indicated that the benzene concentrations in soil are below the ATL of 9.3 mg/kg. Semiannual monitoring will continue in wells D-MW-05R, D-MW-06R, P1-MW-01, P1-MW-02, P1-MW-19, P1-MW-21, P1-MW-22, and P1-MW-23. The next semiannual sampling event will be conducted in December 2009. The samples will be shipped to an approved laboratory for BTEX analysis using USEPA Method 8021B/8260B. An active remediation strategy to achieve remedial goals within a shorter timeframe and prevent discharges to the canal was proposed in the Revised CAP–Part B submitted to GAEPD USTMP in July 2009. The proposed remedy will be implemented upon approval from GAEPD USTMP. A project schedule was previously provided in the Revised CAP-Part B and GAEPD USTMP will be notified if revisions are required.

Georgia Department of Natural Resources

Environmental Protection Division
Underground Storage Tank Management Program
4244 International Parkway, Suite 104, Atlanta, Georgia 30354
Lonice Barrett, Commissioner
Harold F. Reheis, Director
(404)362-2687

November 20, 2001

Colonel Gregory V. Stanley
Director, Public Works
U.S. Army/HQ3d Inf. Div. (Mech.)
1550 Frank Cochran Drive
Ft. Stewart, GA 31314-4927

SUBJECT: **Corrective Action Plan (CAP) -Part B Addendum #1 Review Comments:**
Hunter AAF, Former Fuel Pit #1 and Former Pumphouse #1
Former Building 8060
Savannah, Chatham County, GA
Facility ID: 9025085*1 and *2

Dear Colonel Stanley:

The Georgia Underground Storage Tank Management Program (USTMP) has received your letter, dated October 9, 2001, that forwarded a properly certified CAP-Part B. The report was prepared by SAIC.

We have conducted a technical review of the CAP-Part B. The basis for this review is the Georgia Rules for Underground Storage Tank Management (GUST Rules, revised 1996). Our comments are outlined in the enclosure. Please amend the CAP-Part B to address these by **December 31, 2001.**

Unless one of the outlined EPD Comments requests otherwise, you are required to submit only your responses to these comments. Resubmittal of a complete CAP-Part B is not necessary.

If you have any questions, please contact me at (404) 362-2687.

Sincerely,

William E. Logan
Senior Geologist
Corrective Action Unit II

WEL:
s:/land/landdocs/williaml/pending01/9025085.15
Enclosure
cc with EPD comments: Patricia Stroll, SAIC
Lisa L. Lewis, GA EPD
Larry Rogers, EPD Coastal District
File (CA): Chatham, 9025085

EPD Review Comments

Corrective Action Plan (CAP)-Part B Addendum #1:
Hunter AAF, Former Fuel Pit #1 and Former Pumphouse #2
Former Building 8060
Savannah, Chatham County, GA
Facility ID: 9025085*1 and *2

November 20, 2001

01. Laboratory reports and chain of custody documentation are not originals. Please provide original laboratory report and chain of custody documentation for soil and groundwater samples analyzed.
02. The quantitation limit and analytical method used for sample analysis were not provided. Please provide the quantitation limit and analytical method used for all constituents and for all samples analyzed.
03. Please provide copy of the plan for public viewing at the local library, courthouse, city hall or other public facility. Please provide date and location of placement of the plan for public viewing.
04. The corrective action objectives state that free product will be recovered until free product recovery had reached a "diminishing return". This statement is very vague. The EPD CAP-Part B guidelines state free product recovery should continue until free product is less than 1/8" thickness. Please amend the CAP-B to provide a more defined objective.

DEPARTMENT OF THE ARMY
HEADQUARTERS, 3D INFANTRY DIVISION (MECHANIZED) AND FORT STEWART
DIRECTORATE OF PUBLIC WORKS
1550 FRANK COCHRAN DRIVE
FORT STEWART, GEORGIA 31314-4927

REPLY TO
ATTENTION OF

30 JAN 2001

Office of the Directorate

CERTIFIED MAIL

7099 3400 0010
5449 3848

Georgia Department of Natural Resources
Underground Storage Tank Management Program
Attention: Mr. William E. Logan
4244 International Parkway, Suite 104
Atlanta, Georgia 30354

Dear Mr. Logan:

Fort Stewart is pleased to receive the Georgia Environmental Protection Division's (GA EPD's) correspondence dated December 18, 2000, approving the technical proposal contained in the Corrective Action Plan (CAP)-Part B, submitted for Hunter Army Airfield's former underground storage tanks (USTs) #30-#39 and #50 (Pumphouse #1), former Building 8060, Facility Identification Number 9-025085*1 and *2.

As requested, an updated milestone schedule which adheres to the GANTT Chart provided as Figure 25 in the August 2000 CAP-Part B is provided for your use and convenience. If you have any questions or comments regarding this matter, please contact Ms. Melanie Little or Ms. Tressa Rutland, Directorate of Public Works Environmental Branch, at (405) 364-8461 or (912) 767-2010, respectively.

Sincerely,

Thomas C. Fry
for Gregory V. Stanley
Colonel, U.S. Army
Director, Public Works

Enclosure

MILESTONE SCHEDULE
(January 2001)

USTs #30 through #39 and #50, FACILITY ID. NO. 9-025085*1 and *2
PUMPHOUSE #1, FORMER BUILDING 8060

PROJECTED DATE	EVENT
December 18, 2000	CAP-Part B approved by GA EPD, USTMP.
January 2001	Procure contractor for installation of additional wells at PH#1, Release #1, site per Section III.C.1.a of the CAP-Part B report.
February-March 2001	Install required wells.
April-June 2001	Perform free-phase product thickness evaluation(s) in 3 of the 10 wells having the most measurable product.
July 2001	Conduct first semiannual sampling event at Release #2 (see Section III.C.a.1 of CAP-Part B report).
September 2001	Submit CAP-Part B Addendum to GA EPD, USTMP summarizing additional information obtained for Release #1 and recommending a course of action for Release #1.
January 2002	Conduct second semiannual sampling event at Release #2 (see Section III.C.a.1 of CAP-Part B report).
May 2002	Installation submits 1st Annual Monitoring Only Report for Release #2 to GA EPD, USTMP.

Georgia Department of Natural Resources

Environmental Protection Division
Underground Storage Tank Management Program
4244 International Parkway, Suite 104, Atlanta, Georgia 30354
Lonice C. Barrett, Commissioner
Harold F. Reheis, Director
(404)362-2687

December 18, 2000

Colonel Gregory V. Stanley
Director, Public Works
U.S. Army/HQ3d Inf. Div. (Mech.)
1550 Frank Cochran Drive
Ft. Stewart, GA 31314-4927

29 Dec 00

SUBJECT: **Notice to Implement CAP-Part B Report:**
Hunter AAF, Former Pumphouse #1
Former Building 8060
Savannah, Chatham County, GA
Facility ID: 9025085*1 and *2

Dear Colonel Stanley:

The Georgia Underground Storage Tank Management Program has received your letter, dated August 29, 2000, that forwarded a CAP-Part B Report, for our review. The report was prepared by SAIC.

The technical proposal contained in the CAP-Part B Report for further investigation, monitoring and/or remediation of the current release is hereby approved by the USTMP. As a result of your CAP-Part B Report being technically approved, you are authorized to begin implementation of this plan.

Please submit an updated milestone schedule by **January 18, 2001**, listing specific dates, events and a timetable to complete the proposed activities and submit the CAP-B Addendum. If you have any technical questions, please contact me at (404)362-2687.

Sincerely,

William E. Logan
Senior Geologist
Corrective Action Unit II

WEL;
s:\landdocs\williaml\pending00\9025085.120

cc: Patricia Stoll, P.E., SAIC
Lisa L. Lewis, GA EPD
Larry Rogers, EPD Coastal District

File (CA): Chatham; 9025085

DEPARTMENT OF THE ARMY
HEADQUARTERS, 3D INFANTRY DIVISION (MECHANIZED) AND FORT STEWART
DIRECTORATE OF PUBLIC WORKS
1550 FRANK COCHRAN DRIVE
FORT STEWART, GEORGIA 31314-4927

REPLY TO
ATTENTION OF

29 August 2000

Office of the Directorate

CERTIFIED MAIL

Georgia Department of Natural Resources
Underground Storage Tank Management Program
Attention: Mr. William Logan
4244 International Parkway, Suite 104
Atlanta, Georgia 30354

Dear Mr. Logan:

Fort Stewart/Hunter Army Airfield is pleased to submit the Corrective Action Plan (CAP)-Part B for former underground storage tanks #30 through #39 and #51, former Building 8060 (Pumphouse #1), Facility Identification Number 9-025085, Hunter Army Airfield, Georgia.

This site is located less than 500 feet from a surface water body, and the area is considered to be of average or higher groundwater pollution susceptibility. As approved by Georgia Department of Natural Resources Environmental Protection Division (GA EPD), the soil threshold levels (STLs) for this site were taken from Chapter 391-3-15, Table B, Column 1, and the In-Stream Water Quality Standards (IWQS) were used for comparison to groundwater analytical data (see bottom of page 7 of the enclosed plan).

Based on the information contained in the enclosed CAP-Part B report, the site has been sub-divided into two distinct areas:

- Release #1 (an area of soil and groundwater contamination near the Departure/Arrival Air Control Group [DAACG] that is in the vicinity of Former Fuel Pits 1A and 1B), and
- Release #2 (an area of soil and groundwater contamination near the former Pumphouse #1 facility and Fuel Pits 1C and 1D, located approximately 200 feet north of the former tank pit).

As noted on the Site Ranking Form, enclosed in Appendix X (page X-5 of the enclosed plan), Release #1 scored a 53,500 using the worst soil contamination from both the CAP-Part A and CAP-Part B investigations, and the 1996 groundwater concentration from D-MW205. However, the extent of free product associated with Release #1 has not been determined. Thus, Fort Stewart proposes additional site investigation as described in Section III.C.1.a of the plan with all additional information to be submitted to GA EPD, USTMP in a CAP-Part B Addendum (page 38).

As noted on the Site Ranking Form, enclosed in Appendix X (page X-9), Release #2 scored a 25,750 using the worst soil contamination from both the CAP-Part A and CAP-Part B investigations and the 2000 groundwater concentration from D-MW5. Thus, Fort Stewart recommends a "Monitoring Only" plan for Release #2 as described in Section III.C.1.a (page 38) and Section III.D.

We appreciate your consideration of these recommendations, and if you have any questions or comments, please contact Ms. Melanie Little or Ms. Tressa Rutland, Directorate of Public Works, Environmental Branch, at (405) 364-8461 or (912) 767-7919, respectively.

Sincerely,

for Thomas C. Fry
Gregory V. Stanley
Colonel, U.S. Army
Director, Public Works

Enclosure

FINAL

CORRECTIVE ACTION PLAN
PART B
FORMER PUMPHOUSE #1
FACILITY IDENTIFICATION NUMBER #9-025085
FORMER BUILDING 8060
HUNTER ARMY AIRFIELD, GEORGIA

Prepared for:
U.S. Army Corps of Engineers
Savannah District
Under Contract Number DACA21-95-D-0022
Delivery Order Number 0061

Prepared by:
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

August 2000

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List of Acronyms

AT123D	Analytical Transient 1-, 2-, 3-Dimensional Model
ACE	Anderson Columbia Environmental, Inc.
ACL	alternate concentration limit
ARAR	applicable or relevant and appropriate requirement
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
ATL	alternate threshold level
BGS	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
COPC	chemical of potential concern
DAACG	Departure/Arrival Air Control Group
DAF	dilution attenuation factor
DO	dissolved oxygen
DPW	Directorate of Public Works
DRO	diesel-range organic
EPA	U.S. Environmental Protection Agency
GA EPD	Georgia Environmental Protection Division
gpm	gallons per minute
GRO	gasoline-range organic
GUST	Georgia Underground Storage Tank Management Program
HAAF	Hunter Army Airfield
IWQS	In-stream Water Quality Standard
M&E	Metcalf & Eddy
MCL	maximum contaminant level
MTBE	methyl tert-butyl ether
NCO	noncommissioned officer
NPDES	National Pollutant Discharge Elimination System
NRC	no regulatory criteria
ORP	oxygen reduction potential
PAH	polynuclear aromatic hydrocarbon
PVC	polyvinyl chloride
RBCA	risk-based corrective action
SAIC	Science Applications International Corporation
SI	Site Investigation
STL	soil threshold level
SVE	soil vapor extraction
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UST	underground storage tank
USTMP	Underground Storage Tank Management Program
VOC	volatile organic compound

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I. CORRECTIVE ACTION PLAN CERTIFICATION - PART B

(Form and certification follow this page.)

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Georgia Department of Natural Resources
Environmental Protection Division
Land Protection Branch
Underground Storage Tank Management Program
4244 International Parkway, Suite 104
Atlanta, Georgia 30354
Phone (404) 362-2687
FAX (404) 362-2654

CORRECTIVE ACTION PLAN
PART B

Facility Name: Former Pumphouse #1 Site

Street Address: Former Building 8060, near Taxiway 3

City: Hunter Army Airfield **County:** Chatham

Facility ID #: 9-025085

Submitted by UST Owner/Operator:

Name: Thomas C. Fry/Environmental Branch
Company: US Army/HQ 3d Inf. Div (Mech)
Address: Directorate of Public Works, Bldg 1137
1550 Frank Cochran Drive
City: Fort Stewart State: GA
Zip Code: 31314-4927

Prepared by:

Name: Patricia Stoll
Company: Science Applications International Corp.
Address: P.O. Box 2502
City: Oak Ridge State: TN
Zip Code: 37831

I. PLAN CERTIFICATION

A. UST Owner/Operator

I hereby certify that the information contained in this plan and in all the attachments is true, accurate, and complete, and the plan satisfies all criteria and requirements of Rule 391-3-15-.09 of the Georgia Rules for Underground Storage Tank Management.

Name: Thomas C. Fry

Signature: Thomas C. Fry Date: 08/29/00

B. Professional Engineer or Professional Geologist

Name: Patricia Stoll

Signature: Patricia A. Stoll

Date: 8/22/00

GEORGIA REGISTERED 22851 PROFESSIONAL ENGINEER P. A. STOLL

Georgia Stamp or Seal

Check all boxes below that apply. Attach supporting documentation, i.e., narrative, figures, tables, maps, boring/well logs, etc., for all items checked. Supporting documentation should be three-hole punched and prepared in conformity with the guidance document "Underground Storage Tank (UST) Release: Corrective Action Plan – Part B (CAP-B) Content", GUST-7B.

II. SITE INVESTIGATION REPORT

A. Horizontal and Vertical Extent of Contamination:

- ☒ Soil (Section II.A.1)
- ☒ Groundwater (Section II.A.2)
- ☒ Free Product (Section II.A.3)
- ☒ Surface Water (Section II.A.4)

B. Local and Site Hydrogeology

- ☒ Documentation of Local Groundwater Conditions (Section II.B.1)
- ☒ Stratigraphic Boring Logs (Section II.B.2)
- ☒ Stratigraphic Cross Sections (Section II.B.3)
- ☒ Referenced or Documented Calculations of Relevant Aquifer Parameters (Section II.B.4)
- ☒ Direction of Groundwater Flow (Section II.B.5)
  - ☒ Table of Monitoring Well Data (Table 8)
  - ☒ Potentiometric Map (Figures 19 and 20)
  - ☒ Flow Net Superimposed on a Base Map (Figure 21)

III. REMEDIAL ACTION PLAN:

A. Corrective Action Completed or In-Progress:

- ☒ Recovery/Removal of Free-Product (Non-aqueous Phase Hydrocarbons)
- ☐ Remediation/Treatment of Contaminated Backfill Material & Native Soils
- ☐ Other (specify)_____

B. Objective of Corrective Action:

- ☒ Remove Free Product That Exceeds One-Eighth Inch
- ☐ Remediate Groundwater Contamination That Exceeds:
  - ☐ Maximum Contaminant Levels (MCLs)

    OR
  - ☐ In-stream Water Quality Standards

B. Objective of Corrective Action (continued):

☐ Remediate Soil Contamination That Exceeds:

☐ Threshold Values Listed in Table A

OR

☐ Threshold Values Listed in Table B

OR

☐ Alternate Threshold Levels (ATLs)

☒ Provide Risk Based Corrective Action (Reference CAP B App. VI) (Section III.B.4)

☒ Remediate Soil and/or Groundwater Contamination That Exceeds Alternate Concentration Limits (ACLs) and Monitor Residual Contaminants

OR

☐ Monitor Soil and/or Groundwater Contamination That Exceeds Levels in Rule -.09 (3) But Is Less Than ACLs

OR

☐ No Further Action Required - Soil and/or Groundwater Contamination is Below Levels in Rule -.09 (3)

C. Design Operation of Corrective Action Systems

☒ Soil ☒ Groundwater ☒ Free Product ☐ Surface Water ☐ Not Applicable

D. Implementation (Section III.D)

Includes, as a minimum, the following:

- Milestone schedule for site remediation
- Inspection and preventive maintenance schedule for all specialized remediation equipment
- Monitoring/sampling and reporting plan for measuring interim progress and project completion
- Plan to decommission equipment/wells and close site

IV. PUBLIC NOTICE

☐ Certified Letters to Adjacent, and Potentially Affected Property Owners and Local Officials

☒ Legal Notice in Newspaper, as approved by EPD (Section III.E)

☐ Other EPD-approved Method (specify)_____

V. **CLAIM FOR REIMBURSEMENT:** (For GUST Trust Fund sites only)

- ☐ GUST Trust Fund Application (GUST-36), must be attached if applicable
- ☐ Cost Proposal
  - ☐ Non-Reimbursable Costs

    OR
  - ☐ Reimbursable Costs
    - ☐ Total Project Costs
      - ☐ Costs incurred to date, per GUST-92
      - ☐ Estimated costs to complete corrective action, per GUST-92
    - ☐ Invoices and Proofs-of-Payment for Costs Incurred to Date
- ☐ Proposed Schedule For Reimbursement
  - ☐ Lump Sum Payment Upon Completion Of Corrective Action

    OR
  - ☐ Interim Payments With Final Payment Upon Completion
- ☒ Not Applicable

II. SITE INVESTIGATION REPORT

This document represents the Site Investigation (SI) Report for the Former Pumphouse #1, Facility ID #9-025085, Former Building 8060, at Hunter Army Airfield (HAAF), Georgia. This Corrective Action Plan (CAP)-Part B report follows the guidance published by Georgia Environmental Protection Division (GA EPD) in February 1995; however, the organization of the appendices for this report mirrors the appendices listed in the CAP-Part A template issued by GA EPD in May 1998. Report figures and tables are located in Appendices I and II, respectively.

The Former Pumphouse #1 site is located along the east-west taxiway of HAAF, as illustrated in Figure 1. The Former Pumphouse #1 site is located within an average or higher groundwater pollution susceptibility area and is greater than 500 feet from a withdrawal point and less than 500 feet from a surface water body. As defined in Georgia Underground Storage Tank (GUST) Management Rule 391-5-15.09, the appropriate soil threshold levels (STLs) are those presented in Table B, Column 1 of Gust Rules 391-5-15 because a surface water body is located less than 500 feet from the site.

According to the operational information provided by the HAAF Directorate of Public Works (DPW), Former Pumphouse #1 was an aviation gas fuel island that was used from about 1953 until the early 1970s and consisted of ten 25,000-gallon underground storage tanks (USTs) and a 50,000-gallon underground defueling tank. The pumphouse was inactive from the 1970s to 1995.

In 1995, eight of the 25,000-gallon USTs were removed by Anderson Columbia Environmental, Inc. (ACE). The 50,000-gallon defueling tank and two of the 25,000-gallon tanks remained in place, partially under the pumphouse structure. The 8-inch cast-iron piping internal to the Former Pumphouse #1 facility was removed prior to the tank removal exercise. During UST closure activities, benzene, toluene, ethylbenzene, and xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons (TPH) were detected in the soil samples. Samples of the groundwater seeping into the excavation also contained the presence of BTEX and PAH constituents in the groundwater at the site. Free product was not observed during tank removal activities.

In 1996, Metcalf & Eddy (M&E) conducted a CAP-Part A investigation. The CAP-Part A Report for Pumphouse #1 (M&E 1997) was submitted to GA EPD in May 1997 and describes the results of the CAP-Part A SI. As outlined in the CAP-Part A Report, a CAP-Part B SI was determined to be necessary to

- delineate the horizontal and vertical extent of petroleum contamination in soil and groundwater to concentrations below the applicable STL or In-Stream Water Quality Standards (IWQS), and

- assess the potential impact of petroleum contaminants to surface water and sediment in the drainage ditch located south (downgradient) of the site.

Based on the findings of the CAP-Part A, a CAP-Part B SI was conducted by M&E in May 1997 to determine the nature and extent of petroleum contamination. On January 27, 1999, representatives from GA EPD Underground Storage Tank Management Program (USTMP), U.S. Army Corps of Engineers (USACE), Fort Stewart DPW, and M&E met to discuss issues regarding the completion of the CAP-Part B Report. Representatives of GA EPD USTMP confirmed that the surface water drainage feature located south of the Former Pumphouse #1 constitutes a surface water body regulated by the State of Georgia under the IWQS and, as such, should be considered as the most likely receptor. In addition, representatives of GA EPD USTMP concurred that Georgia Rule, Chapter 391-3-15, Table B, Column 1, STLs are the appropriate soil screening criteria for the site. As a result of the meeting, additional surface water sampling locations were determined to be necessary downgradient of the groundwater plume

emanating from the former tank pit area. In addition, it was determined that installing monitoring wells on the south side of the drainage ditch was necessary prior to submitting the CAP-Part B Report to GA EPD. M&E performed the additional work in February and November 1999.

In 1998, Earth Tech, Inc., removed the remaining two 25,000-gallon USTs, closed the 50,000-gallon defueling tank, and removed the pumphouse structure. Soil and groundwater samples were not collected during the 1998 tank removal activities because the tanks were being removed from an area of known soil contamination that was determined during the CAP-Part A investigation. GA EPD approved the request to not conduct soil sampling at the site in correspondence dated June 17, 1998 (White 1998). The piping from the boundary of the pumphouse facility to the bulk fuel farm was also drained, pigged, and grouted in-place.

CAP-Part A and CAP-Part B investigations were conducted at the DAACG Facility in 1995 and 1996, respectively. These investigations covered the active tarmac north of the active taxiway. Various closure activities, CAP-Part A, and CAP-Part B investigations at the Former Pumphouse #1 site were performed between 1995 and 2000. The Former Pumphouse #1 investigations covered an area south of the active taxiway. Review of the analytical data from all of the investigations indicated that it was necessary to combine the DAACG Facility data and the Former Pumphouse #1 data into a single report to document that the nature and extent of contamination has been determined. In order to distinguish well and boring locations between the DAACG Facility and Former Pumphouse #1 investigations, the well/boring identifiers are prefixed with a "D" or "P1," respectively. In some areas of this document, including the boring logs and well construction diagrams, the DAACG Facility wells or borings may be prefixed with "H833," which is the building number associated with the DAACG Facility.

As indicated in correspondence to GA EPD USTMP, which was dated February 29, 2000 (Perez 2000), there are two distinct and separate plumes located within the vicinity of the Former Pumphouse #1 site. Release #1 is an area of soil and groundwater contamination located near the Departure/Arrival Air Control Group (DAACG) Facility that is in the vicinity of Former Fuel Pits 1A and 1B, located approximately 900 feet west of former Building 8060 (i.e., Pumphouse #1). Throughout this document, Release #1 will be referred to as the Former Fuel Pit 1A/DAACG area. Release #2 is an area of soil and groundwater contamination located near the Former Pumphouse #1 facility and Former Fuel Pits 1C and 1D, located approximately 200 feet north of the former tank pits. Throughout this document Release #2 will be referred to as the Former Pumphouse #1 tank pit area. Based on the proximity of the various former fuel pits to the areas of contamination, it appears that a release from Former Fuel Pit 1A is responsible for the contamination associated with Release #1 and that a release from Former Fuel Pit 1C is responsible for the contamination associated with Release #2.

Science Applications International Corporation (SAIC) used the data collected by M&E in 1997 and 1999 to prepare this CAP-Part B Report for the Fort Stewart DPW, Environmental Branch, through the USACE, Savannah District, under contract DACA21-95-D-0022, delivery order 0061. In addition, in 2000, SAIC performed selected groundwater sampling to fill data gaps.

II.A. HORIZONTAL AND VERTICAL EXTENT OF CONTAMINATION

The horizontal and vertical extent of petroleum contamination in soil and groundwater has been delineated by activities performed during the UST Closure, CAP-Part A SI, and CAP-Part B SI. The activities associated with each investigation are summarized below.

Pumphouse #1 UST Closure (conducted in 1995 by ACE.)

- Removed eight 25,000-gallon USTs (USTs 32 – 39).

- Collected three soil samples from the side walls of the excavation for BTEX, PAH, and TPH analyses.
- Collected eight groundwater samples from water seeping into the excavation for BTEX and PAH analysis.

Pumphouse #1 CAP-Part A SI (conducted in 1996 by M&E)

- Conducted a soil vapor survey.
- Installed 14 soil borings (P1-SB01 through P1-SB08 and P1-SB19 through P1-SB24) and five well borings (P1-MW01, P1-MW02, P1-MW03, P1-MW11, and P1-MW12) to collect soil samples for BTEX, PAHs, TPH-diesel-range organics (DRO), TPH-gasoline-range organics (GRO), and volatile organic compound (VOC) headspace analyses.
- Installed five monitoring wells (P1-MW01, P1-MW02, P1-MW03, P1-MW11, and P1-MW12) to collect groundwater samples for BTEX and PAH analyses.
- Collected four surface water samples for BTEX and PAH analyses.
- Collected four sediment samples for BTEX, PAHs, TPH-DRO, and TPH-GRO analyses.

Pumphouse #1 CAP-Part B SI (conducted in 1997 by M&E)

- Drilled 17 soil borings (P1-SB25 through P1-SB41) and 12 well borings (P1-MW13 through P1-MW24) to collect soil samples for BTEX, PAHs, TPH-DRO, TPH-GRO, VOC headspace, and geotechnical analyses.
- Installed 12 monitoring wells (P1-MW13 through P1-MW24) to collect groundwater samples for BTEX, PAHs, and water quality analyses.
- Collected a comprehensive round of site water level measurements.

Additional Pumphouse #1 UST Closure Activities (conducted in 1998 by Earth Tech)

- Removed two 25,000-gallon USTs (i.e., USTs 30 & 31).
- Closed in-place one 50,000-gallon underground defueling tank (i.e., UST 50).
- Demolished Pumphouse #1 (Building 8060).
- With GA EPD concurrence, no soil or groundwater samples were collected during these removal activities.

Additional Former Pumphouse #1 CAP-Part B Activities (conducted in 1999 by M&E)

- Collected five surface water samples for BTEX and PAHs from a man-made drainage ditch located downgradient of the site and installed five stream gauges, as requested by GA EPD.
- Installed one monitoring well (P1-MW36) on the south side of the drainage ditch to collect a groundwater sample, as requested by GA EPD.

- Installed one monitoring well (P1-MW42) west (i.e., downgradient) of the Former Fuel Pit 1A/DAACG area of contamination to collect a groundwater sample.
- Installed one 4-inch monitoring well (P1-MW40) to perform an aquifer test.
- Collected 14 groundwater samples for BTEX, PAH, and natural attenuation parameters.
- Collected geochemical information to evaluate natural attenuation of petroleum hydrocarbons at the site.

Data Gap Groundwater Sampling (conducted in 2000 by SAIC)

- Collected groundwater samples from D-MW01, D-MW05, D-MW08, D-MW11, D-MW13, D-MW17, P1-MW11, and P1-MW13.

The CAP-Part A and Part B SI soil/sediment and groundwater/surface water analytical laboratory results are included in Appendices V and VIII, respectively, of this document.

II.A.1. Delineation of Soil Contamination

Petroleum-related contaminants detected in soil at the Former Pumphouse #1 site during the UST closure, CAP-Part A SI, CAP-Part B SI, and the DAACG Facility CAP-Part A and CAP-Part B SI included BTEX, TPH-DRO, TPH-GRO, and numerous PAH compounds. Specifics regarding the concentrations are discussed for each investigation in the following sections.

Results from the various investigations indicate that there were two separate areas of soil contamination. These areas consist of the area in the vicinity of the former tank pits near the former pumphouse and in the vicinity around Former Fuel Pit 1A/DAACG area.

II.A.1.a. Contaminant concentrations

II.A.1.a.1. Former Pumphouse #1 UST Closure (1995)

During the UST closure conducted in 1995, three soil samples were collected from the sidewalls of the excavation. The analytical results are presented in Tables 1a and 1b. BTEX, PAH constituents, and TPH were detected in all three soil samples. The detection limit for benzene in two samples exceeds the STL of 0.017 mg/kg. The concentration of benzo(a)pyrene in one sample exceeded the STL of 0.660 mg/kg. None of the other constituents exceeded their respective STLs.

II.A.1.a.2. DAACG Facility CAP-Part A Site Investigation (March 1995)

The DAACG CAP-Part A SI was initiated after contaminated groundwater was observed during the geotechnical investigation associated with the design of the foundation for the new DAACG building that was to be constructed. The investigation was limited to an area around the current DAACG building. During the CAP-Part A SI, 21 soil samples were collected from 10 soil borings. Low concentrations of toluene, below the STL of 6 mg/kg, were detected in five of the soil samples. All other BTEX, PAH, TPH-DRO, and TPH-GRO constituents were below the detection limits.

II.A.1.a.3. DAACG Facility CAP-Part B Site Investigation (May 1996)

During the CAP-Part B SI, 184 soil samples were collected from 50 soil borings and 32 monitoring wells scattered throughout the DAACG Facility investigation area as presented in Figure 2. This investigation

covered the active area of the tarmac located north of the Former Pumphouses #1 and #2 and west of Pumphouses #3, #4, and #5. The area of this investigation covers more than the areas of contamination associated with the Former Pumphouse #1 tank pit area and Former Fuel Pit 1A/DAACG area. The analytical results were provided in the CAP-Part B Report (M&E 1996) and are summarized in tabular format in Appendix V (beginning on page V-219). The data are presented in Figures 3a through 3e of this report with the Former Pumphouse #1 CAP-Part A and CAP-Part B data. BTEX, acenaphthylene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, TPH-DRO, and TPH-GRO were detected in soil samples throughout the investigation area. Results from the CAP-Part B SI at the DAACG Facility indicate that the extent of soil contamination to the south was not determined, but would be investigated as part of the CAP-Part A and CAP-Part B investigations associated with Former Pumphouse #1.

In the vicinity of the Former Fuel Pit 1A/DAACG area, concentrations of benzene, toluene, ethylbenzene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd) exceeded the applicable GUST STLs (i.e., Table B, Column 1) during the CAP-Part B SI.

In the vicinity of the Former Pumphouse #1 tank pit area, concentrations of benzene and ethylbenzene exceeded the applicable GUST STLs (i.e., Table B, Column 1) during the CAP-Part B SI.

II.A.1.a.4. Former Pumphouse #1 CAP-Part A Site Investigation (November 1996)

During the CAP-Part A SI, 38 soil samples were collected from 19 soil borings and monitoring wells (P1-SB01 through P1-SB08, P1-SB19 through P1-SB24, P1-MW01, P1-MW02, P1-MW03, P1-MW11, and P1-MW12) as presented in Figure 2. The analytical results are presented in Tables 2a and 2b and Figures 3a and 3b. The results of soil samples collected during the CAP-Part A investigation are summarized below.

- Benzene was detected in 11 of the 38 soil samples at concentrations ranging from 0.16J mg/kg to 5.5J mg/kg; however, there were 7 samples with detection limits above the benzene STL of 0.017 mg/kg.
- Toluene was detected in 21 of the 38 soil samples at concentrations ranging from 0.0041J mg/kg to 160 mg/kg. Only one of the concentrations exceeded the toluene STL of 115 mg/kg.
- Ethylbenzene was detected in 23 of the 38 soil samples at concentrations ranging from 0.0067 mg/kg to 96J mg/kg. Only four of the concentrations exceeded the ethylbenzene STL of 18 mg/kg.
- Xylenes were detected in 34 of the 38 soil samples at concentrations ranging from 0.0015J mg/kg to 260J mg/kg. These concentrations did not exceed the xylenes STL of 700 mg/kg.
- Twelve PAH compounds were detected in 16 of the 38 soil samples with concentrations of benzo(a)pyrene, benzo(b)fluoranthene, and chrysene exceeding the STL of 0.660 mg/kg.
- TPH-DRO was detected in 29 of the 38 soil samples at concentrations ranging from 4.2 mg/kg to 550 mg/kg.
- TPH-GRO was detected in 28 of the 38 soil samples at concentrations ranging from 0.51 mg/kg to 21,000J mg/kg.

Results from the CAP-Part A SI indicate that there were two areas of soil contamination where concentrations of benzene, toluene, ethylbenzene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene, exceeded the applicable GUST STLs (i.e., Table B, Column 1) during the CAP-Part A SI. These areas consist of the

area in the vicinity of the Former Pumphouse #1 tank pit and the vicinity around the Former Fuel Pit 1A/DAACG area. The areas of soil contamination are shown in Figures 3b through 3e.

II.A.1.a.5. Former Pumphouse #1 CAP-Part B Site Investigation (May 1997 and November 1999)

During the CAP-Part B SI, 58 soil samples were collected for geochemical analysis from 29 soil borings and monitoring wells (P1-SB25 through P1-SB41, and P1-MW13 through P1-MW24) installed in May 1997, as presented in Figure 2. Three additional monitoring wells (P1-MW36, P1-MW40, and P1-MW42) were installed in September 1999. Well P1-MW36 was installed to determine the extent of groundwater contamination on the south side of the drainage ditch, and with GA EPD concurrence, no soil samples were collected from this boring. Well P1-MW40 was installed to be used for aquifer testing, and two soil samples were collected from this well. Well P1-MW42 was installed west of the area of contamination in the vicinity of Former Fuel Pit 1A/DAACG to determine the extent of groundwater contamination west of this area, and with GA EPD concurrence, no soil samples were collected from this boring. Analytical results are presented in Tables 2a and 2b. Sample locations and analytical results are presented in Figures 3a and 3b. Fourteen of the 32 soil borings were converted to shallow monitoring wells to delineate the extent of contamination, and one of the soil borings was converted to a deep monitoring well (P1-MW24). Field screening methods were used during drilling to select soil samples for geochemical analysis.

Analytical results for soil sampling are summarized in Tables 2a and 2b and presented in the plan view in Figure 3a. The results exceeding applicable GUST STLs are presented in the cross-sections in Figure 3b. The results of soil samples collected during the CAP-Part B investigation are summarized below.

- Benzene was detected in 5 of the 60 soil samples at concentrations ranging from 0.0014 mg/kg to 5.1J mg/kg; however, there were 13 samples with detection limits above the benzene STL of 0.017 mg/kg.

- Toluene was detected in 25 of the 60 soil samples at concentrations ranging from 0.0078 mg/kg to 180 mg/kg, and there were 9 samples with detection limits above the reporting limit. Only two of the concentrations exceeded the toluene STL of 115 mg/kg. None of the elevated detection limits exceeded the STL.

- Ethylbenzene was detected in 26 of the 60 soil samples at concentrations ranging from 0.0062 mg/kg to 82J mg/kg, and there were 5 samples with detection limits above the reporting limit. Only six of the concentrations exceeded the ethylbenzene STL of 18 mg/kg. None of the elevated detection limits exceeded the STL.

- Xylenes were detected in 35 of the 60 soil samples at concentrations ranging from 0.0062 mg/kg to 530 mg/kg. These concentrations did not exceed the xylenes STL of 700 mg/kg.

- Fourteen PAH compounds were detected in 32 of the 60 soil samples with concentrations of chrysene exceeding the STL of 0.660 mg/kg.

- TPH-DRO was detected in 31 of the 60 soil samples at concentrations ranging from 11 mg/kg to 390 mg/kg.

- TPH-GRO was detected in 31 of the 60 soil samples at concentrations ranging from 0.24 mg/kg to 9900 mg/kg.

Concentrations of benzene, ethylbenzene, and chrysene exceeded the applicable GUST STLs (i.e., Table B, Column 1) in the vicinity of the Former Pumphouse #1 tank pit area and the Fuel Pit 1A/DAACG area during the CAP-Part B SI.

II.A.1.b. Field screening results

Field screening through VOC headspace was performed on all soil samples collected from above the saturated zone during the various investigations. For each 2-foot-length soil sample collected, VOC headspace readings were measured with an organic vapor analyzer. The field screening results for the various site investigations are presented on each boring log presented in Appendix IV.

II.A.1.c. Conclusions of the Site Soil Contamination

In the vicinity of the Former Fuel Pit 1A/DAACG area (Release #1), benzene, toluene, ethylbenzene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene exceeded the applicable GUST STLs (i.e., Table B, Column 1) and benzene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene exceeded their respective alternate threshold levels (ATLs).

In the vicinity of the Former Pumphouse #1 tank pit area (Release #2), benzene, toluene, ethylbenzene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene exceeded the applicable GUST STLs (i.e., Table B, Column 1), and benzene and chrysene exceeded their respective ATLs.

II.A.2. Delineation of Groundwater Contamination

Petroleum-related contaminants detected in groundwater at the Former Pumphouse #1 site during the previous investigations, CAP-Part A SI, and CAP-Part B SI included BTEX and numerous PAH compounds.

Results from the various investigations indicate that there are two separate areas of groundwater contamination. These areas consist of the area in the vicinity of the former tank pits near the former pumphouse and the vicinity around Former Fuel Pit 1A/DAACG.

II.A.2.a. Horizontal extent of groundwater contamination

II.A.2.a.1. UST Closure (1995)

During the 1995 UST closure activities, eight groundwater samples were collected from each of the UST tank pits as groundwater seeped into the excavation. The analytical results are presented in Tables 1c and 1d. BTEX and numerous PAH compounds were detected in all of the groundwater samples. The benzene concentrations exceeded the IWQS of 71.28 µg/L in all of the samples. Concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, and indeno(1,2,3-cd)pyrene exceeded their respective IWQS.

II.A.1.a.2. DAACG Facility CAP-Part A Site Investigation (March 1995)

The DAACG CAP-Part A SI was initiated after contaminated groundwater was observed during the geotechnical investigation associated with the design of the foundation for the new DAACG building that was to be constructed. The investigation was limited to an area around the current DAACG building. During the CAP-Part A SI, two groundwater samples were collected from two piezometers. BTEX constituents and naphthalene were detected in both groundwater samples. As a result, a site investigation plan for a CAP-Part B investigation was developed.

II.A.2.a.3. DAACG Facility CAP-Part B Site Investigation (May 1996)

During the CAP-Part B SI, 31 groundwater samples were collected from 32 monitoring wells scattered throughout the DAACG Facility investigation area as presented in Figure 2. The wells associated with this investigation have a D prefix. This investigation covered the active area of the tarmac located north of the Former Pumphouses #1 and #2 and west of Pumphouses #3, #4, and #5. The analytical results were provided in the CAP-Part B Report (M&E 1996) and are summarized in tabular format in Appendix VIII (page VIII-147). The data are presented in Figures 4 through 8 of this report with the Former Pumphouse #1 CAP-Part A and CAP-Part B data. BTEX, 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, fluorene, and naphthalene were detected in groundwater samples throughout the investigation area. Results from the 1996 CAP-Part B SI at the DAACG Facility indicated that the extent of groundwater contamination to the south of the tarmac was not determined, but would be investigated as part of the CAP-Part A and CAP-Part B investigations associated with Former Pumphouse #1.

In the vicinity of the Former Fuel Pit 1A/DAACG area, concentrations of benzene exceeded the applicable IWQS during the 1996 DAACG CAP-Part B SI.

In the vicinity of the Former Pumphouse #1 tank pit area, concentrations of benzene exceeded the applicable IWQS during the 1996 DAACG CAP-Part B SI.

II.A.2.a.4. Former Pumphouse #1 CAP-Part A & Part B Site Investigation (December 1996 and May 1997)

During the Former Pumphouse #1 CAP-Part A SI in December 1996, five groundwater samples were collected for chemical analysis from five monitoring wells, as presented in Tables 3a and 3b, to determine the horizontal extent of groundwater contamination at the site. To delineate the dissolved benzene contamination plume, a CAP-Part B SI was conducted in May 1997. Twelve wells were installed during the Former Pumphouse #1 CAP-Part B SI in 1997, and 12 groundwater samples were collected. Because these two sampling events were conducted within six months of each other, they have been combined to provide sufficient aerial coverage for plume delineation. The results of the 1999 and 2000 CAP-Part B SI sampling events are discussed in Section II.A.2.a.4.

Benzene was identified in 10 groundwater samples, including a detection limit above the reporting limit, during the 1996 and 1997 investigations. Benzene concentrations ranged from 4.2J µg/L to 1100 µg/L, as illustrated in Figure 4. The concentrations in seven samples exceed the Georgia IWQS of 71.28 µg/L. The concentrations in nine samples exceed the federal maximum contaminant level (MCL) of 5 µg/L. The concentrations in 10 samples exceed the risk-based screening level of 0.36 µg/L. The concentrations in three samples were above the site alternate concentration limit (ACL) for benzene of 285 µg/L (Appendix VI). The analytical detection limit for benzene was 2.2 µg/L in all samples except for sample HT4-MW01 from well P1-MW01.

Toluene was identified in 11 groundwater samples during the 1996 and 1997 investigations at concentrations ranging from 40 µg/L to 25,000 µg/L, as illustrated in Figure 5. The concentrations did not exceed the Georgia IWQS of 200,000 µg/L; however, five of the concentrations exceeded the federal MCL of 1,000 µg/L and the risk-based screening level of 750 µg/L. None of the concentrations was above the site ACL for toluene of 800,000 µg/L (Appendix VI). The analytical detection limit for toluene was 1 µg/L in all samples.

Ethylbenzene was identified in 12 groundwater samples during the 1996 and 1997 investigations. Ethylbenzene concentrations ranged from 2.3 µg/L to 2000 µg/L, as illustrated in Figure 6. The

concentrations did not exceed the Georgia IWQS of 28,718 µg/L; however, five of the concentrations exceeded the federal MCL of 700 µg/L, and three of the concentrations exceeded the risk-based screening level of 1,300 µg/L. None of the concentrations was above the site ACL for ethylbenzene of 114,800 µg/L (Appendix VI). The analytical detection limit for ethylbenzene was 1 µg/L in all samples.

Total xylenes were identified in 11 groundwater samples during the 1996 and 1997 investigations. Total xylene concentrations ranged from 110 µg/L to 9500 µg/L, as illustrated in Figure 7. There is no Georgia IWQS for xylenes. The concentrations did not exceed the federal MCL of 10,000 µg/L or the risk-based screening level of 12,000 µg/L; thus, an ACL was not necessary. The analytical detection limit for total xylenes was 1 µg/L in all samples.

During the 1996 and 1997 investigations, several PAH compounds were estimated or detected at concentrations at or below 10 µg/L in several groundwater samples. The compounds include acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i,)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. Concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene exceeded their IWQS of 0.0311 µg/L for all compounds. None of the PAH compounds exceeded their respective ACLs (Appendix VI).

Naphthalene was identified in eight groundwater samples during the 1996 and 1997 investigations. Naphthalene concentrations ranged from 1.5 µg/L to 16 µg/L, as illustrated in Figure 8. This compound does not have a Georgia IWQS or federal MCL; however, the concentrations in six samples are above the current risk-based screening level of 6.5 µg/L. None of the concentrations was above the site ACL for naphthalene of 260 µg/L (Appendix VI).

II.A.2.a.5. Former Pumphouse #1 CAP-Part B Site Investigation (September 1999 and February 2000)

As a result of the January 1999 meeting with GA EPD, three additional monitoring wells were installed in September 1999 to determine the vertical and horizontal extent of the dissolved benzene contamination plume that was not determined in 1997. Groundwater samples were collected from selected wells within the Former Pumphouse #1 tank pit area in November 1999. In February 2000, groundwater samples were collected from selected wells within the Former Fuel Pit 1A/DAACG Area. Twenty-two groundwater samples were collected for geochemical analysis, as presented in Tables 3a and 3b. Monitoring well locations are presented in Figure 2.

Benzene was identified in 14 groundwater samples during the 1999 and 2000 investigations. Benzene concentrations ranged from 50.3 µg/L to 4580 µg/L, as illustrated in Figure 9. The concentrations in 13 samples exceed the Georgia IWQS of 71.28 µg/L. The concentrations in 14 samples exceed the federal MCL of 5 µg/L and the risk-based screening level of 0.36 µg/L. The concentrations in nine samples were above the site ACL for benzene of 285 µg/L (Appendix VI). With the exception of two samples, the analytical detection limit for benzene was less than 1 µg/L.

Toluene was identified in 16 groundwater samples during the 1999 and 2000 investigations. Toluene concentrations ranged from 31 µg/L to 19,000 µg/L, as illustrated in Figure 10. The concentrations did not exceed the Georgia IWQS of 200,000 µg/L. However, the concentrations in seven samples exceeded the federal MCL of 1,000 µg/L and the risk-based screening level of 750 µg/L. None of the concentrations was above the site ACL for toluene of 800,000 µg/L (Appendix VI). The analytical detection limit for toluene was less than 1 µg/L.

Ethylbenzene was identified in 19 groundwater samples during the 1999 and 2000 investigations. Ethylbenzene concentrations ranged from 100 µg/L to 1800 µg/L, as illustrated in Figure 11. The concentrations did not exceed the Georgia IWQS of 28,718 µg/L. The concentrations in 6 samples exceeded the risk-based screening level of 1,300 µg/L, and the concentrations in 11 samples exceeded the MCL of 700 µg/L. None of the concentrations was above the site ACL for ethylbenzene of 114,800 µg/L (Appendix VI). The analytical detection limit for ethylbenzene was less than 1 µg/L.

Total xylenes were identified in 19 groundwater samples during the 1999 and 2000 investigations. Total xylene concentrations ranged from 404 µg/L to 10,000 µg/L, as illustrated in Figure 12. There is no Georgia IWQS for xylenes. The concentrations did not exceed the federal MCL of 10,000 µg/L or the risk-based screening level of 12,000 µg/L; thus an ACL was not necessary. The analytical detection limit for total xylenes was less than 2 µg/L.

During the 1999 and 2000 investigations, PAHs were only analyzed from the groundwater samples associated with the three wells installed in September 1999. Naphthalene was the only PAH compound detected at a concentration of 2.1 µg/L in well P1-MW40. This compound does not have a Georgia IWQS or federal MCL; however, the concentration in the sample was below the current risk-based screening level of 6.5 µg/L and the site ACL for naphthalene of 260 µg/L (Appendix VI).

II.A.2.a.6. Conclusions of the Horizontal Extent of Site Groundwater Contamination

Figures 4 through 12 demonstrate that the horizontal and vertical extent of petroleum contaminants in groundwater has been delineated to the appropriate analytical detection. Petroleum contaminants identified in groundwater at the Former Pumphouse #1 site include BTEX constituents as well as PAH constituents. The results of the CAP-Part B SI indicate that there are two separate plumes related to the operation of the Former Pumphouse #1 that are known as the Former Fuel Pit 1A/DAACG area (Release #1) and the Former Pumphouse #1 tank pit area (Release #2).

The Former Pumphouse #1 tank pit area plume is located in the vicinity of Former Fuel Pits 1C and 1D and the former tank pits located at former Building 8060. The horizontal extent of this plume was defined during the CAP-Part B SI. The groundwater is migrating toward the drainage ditch located to the south of the former tank pits; however, the dissolved plume does not migrate beyond the drainage ditch to the south. Several PAH compounds exceeded their respective IWQS or risk-based screening criteria, but the concentrations did not exceed their respective ACLs. Benzene was the only contaminant to exceed its IWQS and ACL during the various investigations.

Another plume of groundwater contamination is located in the vicinity of the Former Fuel Pit 1A/DAACG area. The horizontal extent of this plume was defined during the CAP-Part B SI. The groundwater is migrating toward the underground storm drain located to the northwest of the Former Fuel Pit 1A. The dissolved plume appears to migrate beyond the storm drain to the northwest. Several PAH compounds exceeded their respective IWQS or risk-based screening criteria, but the concentrations did not exceed their respective ACLs. Benzene was the only contaminant to exceed its IWQS and ACL during the various investigations.

II.A.2.b. Vertical extent of groundwater contamination

In the Former Pumphouse #1 tank pit area, the vertical extent of groundwater contamination was delineated through soil sampling at P1-MW40 and D-SB23. Soil samples were collected from 2-foot intervals to the total boring depth, and VOC headspace readings were measured for each interval. Boring D-SB23 was drilled to 20.0 feet below ground surface (BGS) and soil samples were collected from 1.5 – 3.5, 8.0 – 10.0, 13.0 – 15.0, and 18.0 – 20.0 feet BGS; the results are presented in Appendix V (page V-238).

The sample collected at 8.0 – 10.0 feet contained the highest concentrations of BTEX compounds, and benzene was detected at 0.091 mg/kg in the 18.0 – 20.0 foot sample, which is above the STL. Well P1-MW40 was drilled to 60.0 feet BGS and soil samples were collected from 8.0 – 10.0 and 48.0 – 50.0 feet BGS. The results are presented in Table 2a. The sample collected at 10.0 – 12.0 feet contained concentrations of BTEX, PAHs, TPH-DRO, and TPH-GRO. No BTEX, PAHs, TPH-DRO, or TPH-GRO constituents were detected in the 48.0 – 50.0 feet BGS sample interval, but the interval did contain a benzene detection limit of 0.029 mg/kg that is slightly above the STL. Since there was no estimated concentration of benzene below the elevated detection limit, benzene is probably not present above the STL at that depth. Thus, the vertical extent of groundwater contamination has been delineated and is confined to the Surficial Aquifer (i.e., less than 50.0 feet BGS). In addition, well P1-MW24 was installed near the downgradient perimeter of the plume and screened from 29.5 – 34.5 feet BGS. BTEX and PAH constituents were not detected in the groundwater sample from this well.

Within the Former Fuel Pit 1A/DAACG area, the vertical extent of groundwater contamination was delineated through soil sampling at D-SB02, D-SB06, and D-SB10. Soil samples were collected from 2-foot intervals to the total boring depth and VOC headspace readings were measured for each interval. Each boring was drilled to 20.0 feet BGS and soil samples were collected from 1.5 – 3.5, 8.0 – 10.0, 13.0 – 15.0, and 18.0 – 20.0 feet BGS; the results are presented in Appendix V (pages V-230, V-231, V-232, and V-233, respectively). In boring D-SB02, no BTEX compounds were detected in any of the samples; however, several PAH compounds were detected at the 8.0 – 10.0-foot interval. In boring D-SB06, BTEX compounds were detected at the 8.0 – 10.0-foot interval and no PAH compounds were detected in any of the samples. In boring D-SB10, BTEX compounds were detected in the three lower samples with the highest concentrations at the 8.0 – 10.0 foot interval. Benzene was present in the 18.0 – 20.0-foot interval at a concentration of 0.22 mg/kg. The vertical extent of groundwater contamination has been delineated to 20 feet BGS within the Surficial Aquifer at the Former Fuel Pit 1A/DAACG area; however, there may be some minor contamination below 20 feet BGS.

II.A.3. Delineation of Free Product Plume

Free product was identified at the Former Fuel Pit 1A/DAACG area in February 2000. The free product was observed in wells D-MW1, D-MW2, D-MW6, D-MW8, D-MW11, D-MW13, and D-MW17 at thicknesses ranging from a sheen to 0.88 feet, as shown in Figure 13 and Table 8.

Interim corrective action consisted of free product recovery in the wells via absorbent socks, which were installed on February 22, 2000. The absorbent socks were removed and replaced on May 24, 2000, and July 24, 2000.

II.A.4. Delineation of Surface Water and Sediment Contamination

II.A.4.a. CAP-Part A Investigation (December 1996)

Surface water and sediment samples were collected from four locations around the Former Pumphouse #1 site (Figure 14 and Tables 4 and 5). The sampling points were located in the drainage ditch that is approximately 300 feet south of the former tank pits of the Former Pumphouse #1 site. Surface water flow is to the west toward Lamar Canal.

BTEX constituents were detected in three of the four surface water samples and no PAH constituents were detected in any of the surface water samples. At location P1-SWE07, located 325 feet southwest of the former tank pits, benzene was detected at 19J µg/L, toluene was detected at 230J µg/L, ethylbenzene was detected at 30J µg/L, and xylenes were detected at 270 µg/L. At location P1-SWE08, located 500 feet southwest of the former tank pits, benzene was detected at 5.2J µg/L, toluene was detected at 50J µg/L,

ethylbenzene was detected at 3.8J µg/L, and xylenes were detected at 55 µg/L. At location P1-SWE09, located 1900 feet west of the former tank pits, toluene was detected at 1.8J µg/L and xylenes were detected at 3.1J µg/L. Each of these concentrations was below its respective IWQS.

No BTEX constituents were detected in any of the four sediment samples although P1-SWE07 had a benzene detection limit of 0.62 mg/kg. At P1-SWE07, TPH-GRO was detected at 130J mg/kg and total PAHs were 0.6 mg/kg. At P1-SWE09, TPH-DRO was detected at 24 mg/kg and total PAHs were 12.3 mg/kg. At P1-SWE10, TPH-GRO was detected at 0.98J mg/kg and total PAHs were 15.7 mg/kg. Elevated TPH-DRO detection limits above 10 mg/kg were observed in sediment samples from P1-SWE07, P1-SWE08, and P1-SWE10. These sediment locations are southwest of the site.

II.A.4.b. CAP-Part B Investigation (February 1999)

As a result of the January 1999 meeting with GA EPD, five additional surface water samples were collected at locations east of P1-SWE08, which were more directly downgradient of the Former Pumphouse #1 tank pit area (Figure 15 and Table 4) than the CAP-Part A locations and more likely to intercept the dissolved groundwater plume. GA EPD approved the surface water sample locations during the January 1999 meeting. No BTEX or PAH constituents were detected at locations P1-SW5 and PW-SW6. Benzene was detected at 11.1 µg/L at P1-SW7, 9 µg/L at P1-SW8, and 8.5 µg/L at P1-SW9. Toluene was detected at 96 µg/L at P1-SW7, 144 µg/L at P1-SW8, and 185 µg/L at P1-SW9. Ethylbenzene was detected at 36.4 µg/L at P1-SW7, 5.4 µg/L at P1-SW8, and 32 µg/L at P1-SW9. Total xylenes were detected at 76.8 µg/L at P1-SW7, 133.8 µg/L at P1-SW8, and 182.5 µg/L at P1-SW9. No PAH constituents were detected in any of the surface water samples. Each of these concentrations was below its respective IWQS. As a result of this surface water sampling, it appears that the dissolved groundwater plume emanating from Former Pumphouse #1 tank pit area is impacting the drainage ditch, but at concentrations below the respective IWQS.

With GA EPD concurrence, sediment samples were not collected in February 1999.

II.B. REGIONAL, LOCAL, AND SITE HYDROGEOLOGY

Discussion of the regional, local, and site hydrogeology is based on field observations and other investigative activities performed, including a water resource survey, during the CAP-Part A and CAP-Part B investigations of the Former Pumphouse #1 site.

II.B.1. Documentation of Local Groundwater Conditions

II.B.1.a. Groundwater usage

According to the Fort Stewart DPW, nine water supply wells are located within the confines of the HAAF area (Figures 16 and 17). These wells have the potential to provide up to 3,890 gallons per minute (gpm) of water to occupants of the HAAF installation. The Fort Stewart DPW was unable to provide documentation listing the companies responsible for well installation and drillers' logs showing as-built information and subsurface geologic data. Information concerning such documentation was requested from several water well drilling companies in the Chatham County area; however, data procurement met with very limited success. The Fort Stewart DPW provided well locations, pump rates, treatments, casing depths, and total depths for eight of the nine wells located at HAAF. Because of the lack of data, documentation of subsurface geology based on HAAF drill logs remains extremely limited. Therefore, other references containing deep-well information were used to document the subsurface geology and aquifer characteristics underlying HAAF and the vicinity.

Wells 1 and 2, both public water supply wells located in the cantonment area of HAAF, constitute the main water supply system at HAAF (Figure 17). Well 1, located at Building 711 on the corner of Moore Road and Douglas Street, is a 12-inch-diameter well with a 100-hp turbine pump serving a 100,000-gallon elevated storage tank (Tank 1) through 10-inch lines. Water from Well 1 is injected with hydrofluosilic acid and chlorine gas solution at the well house. Well 2, located at Building 1205 on the corner of Neal Street and Lightning Drive, is a 12-inch-diameter well with a 100-hp turbine pump serving a 200,000-gallon elevated tank (Tank 2) through 10-inch lines. Water from Well 2 is also injected with hydrofluosilic acid and chlorine gas solution at the well house. Wells 1 and 2 provide water to a 500,000-gallon elevated storage tank (Tank 3) located on Middleground Road behind noncommissioned officer (NCO) family housing. This tank provides potable water to 694 service connections, which are used by an average of at least 5,000 individuals year-round.

Wells 3, 4A, and 7 are public supply wells located outside the cantonment area of HAAF. Well 3, located at Building 8455, is a 4.0-inch-diameter well with a 1.0-hp electric submersible pump serving a 1,000-gallon hydropneumatic storage tank through 1.5-inch galvanized steel lines. Water from Well 3 is treated with calcium hypochlorite solution and is consumed by approximately 25 people during daytime hours, year-round. Well 4A, located at Building 8581 at the 117th Air National Guard Facility, is a 4.0-inch-diameter well. Pumpage is accomplished with a 0.75-hp turbine pump with 80-gpm capacity. Well 4A provides water for approximately 50 people per day year-round. Well 7 is located at Building 8703 on the Forest River, west of Rio Road. Well 7 is a 4.0-inch diameter well with a 3.0-hp submersible pump serving a 5,000-gallon hydropneumatic tank through 2.0-inch galvanized steel lines. Well 7 serves approximately 500 people on a part-time basis. Sanitary protection for Wells 3, 4A, and 7 is provided by a pump motor block, concrete slab, sealed well head, and screened casing vent.

Based on the GA EPD criteria of serving potable water to less than 25 occupants per day and having less than 15 service connections, Wells 5, 8, and 9 are classified as non-public supply wells.

Well 10 is a non-potable water source and the water is used for cleaning military equipment at a wash-rack facility. Additional information, including capacity, borehole depth, and casing depth, is not available.
The locations of supply wells found outside the boundary of HAAF are shown on Figure 17. These wells include #1, 42, 13, 25, 15, 27, 14, 23, 6, and 9. The City of Savannah Bureau of Water Operations was unable to provide drilling logs or as-built well information.

The Former Pumphouse #1 site is located approximately 4,200 feet southwest (downgradient) of HAAF Well 2, which is located at Building 1205 on Lightning Road. Well 3, which is located at Building 8455, is approximately 6,700 feet southwest (downgradient) of the Former Pumphouse #1 site. Therefore, the Former Pumphouse #1 site is classified as being greater than 500 feet to a withdrawal point. Well 2 is part of the main public water supply system at HAAF. This system supplies water to approximately 7,500 people through 525 service connections.

II.B.1.b. Aquifer description

The hydrogeology in the vicinity of HAAF is mostly influenced by two aquifer systems. These are referred to as the Principal (Floridan) Aquifer and the Surficial Aquifer (Miller 1990). The Principal Aquifer is the lowermost hydrologic unit and is regionally extensive from South Carolina to Georgia, Alabama, and most of Florida. Known elsewhere as the Floridan, this aquifer, approximately 800 feet in total thickness, is composed primarily of Tertiary-age limestone, including the Bug Island Formation, the Ocala Group, and the Suwannee Limestone. Groundwater from the Floridan is used primarily for drinking water (Arora 1984). According to Miller (1990), one of the largest cones of depression produced in the Floridan Aquifer exists directly beneath Savannah, Georgia. According to 1980 estimates, more than

500 million gallons of water per day were withdrawn from the Floridan Aquifer for public and industrial use in southeast Georgia, more than any other region (Miller 1990).

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

The Surficial Aquifer consists of widely varying amounts of sand and clay, ranging from 55 to 150 feet in thickness, and is composed primarily of the Satilla and Cypresshead Formations in the Savannah vicinity (Arora 1984). This aquifer is primarily used for domestic lawn and agricultural irrigation. The top of the water table ranges from approximately 2 to 10 feet BGS (Miller 1990). Groundwater in the Surficial Aquifer system is under unconfined, or water table, conditions. However, locally, thin clay beds create confined or semiconfined conditions.

Groundwater encountered at HAAF UST investigation sites is part of the Surficial Aquifer system. Based on the fact that all public and non-public water supply wells draw water from the Floridan Aquifer, and that the Hawthorn confining unit separates the Floridan Aquifer from the Surficial Aquifer, it is concluded that there is no hydraulic interconnection between HAAF UST sites (and associated plumes) and water supply withdrawal points.

II.B.1.c. Surface water

The water resources survey conducted during the CAP-Part B SI is presented in Appendix III. Surface water bodies at HAAF include Hallstrom Lake, Lamar Canal, Buckhalter Canal, Springfield Canal, Pond 29 located northwest of Buildings 336 and 232, and an unnamed pond located along the southeast boundary of the HAAF installation (Figure 18). Several unnamed drainage canals and ditches exist throughout HAAF. Most of these canals drain southwest into the Little Ogeechee River, which is part of the Lower Ogeechee watershed. The remaining drainage canals located on the east side of the HAAF installation flow east and eventually drain into the Vernon River, which is located southeast of the HAAF installation. Surface water bodies at HAAF and adjacent areas are not used as public water supplies. The ponds and lakes, as well as Lamar Canal, are perennial, whereas most of the drainage canals and ditches are intermittent. Most of the drainage canals are at least partially enclosed in culverts.

There is a groundwater divide at the Former Fuel Pit 1A/DAACG area with groundwater flowing to the south-southwest and to the northwest. To the southwest, there is an underground storm drain located 510 feet south-southwest of D-MW2, which is connected to a drainage ditch located south of the former tank pit area. To the northwest, there is an underground storm drain located 450 feet northwest of D-MW2 and a drainage ditch located 1000 feet northwest of D-MW2. At the Former Pumphouse #1 tank pit area, a drainage ditch is located approximately 300 feet south of the former tank pits and may receive some of the groundwater from the site. Based on the surface water features discussed in Appendix III, the Former Pumphouse #1 site, Facility ID #9-025085, is classified as being located less than 500 feet to a surface water body.

There are numerous underground water, electrical, and abandoned fuel lines that connect the former fuel pits located at the edge of the taxiway north of the former tank pits. These underground lines are located upgradient of the area of contamination around the former tank pits and are located within the area of contamination near the Former Fuel Pit 1A/DAACG area. The invert depth of the former fuel transfer line in the vicinity of Fuel Pit 1A is approximately 6.4 feet BGS. There are two monitoring wells that are located in the vicinity of Fuel Pit 1A, and in November 1999, the depths to groundwater in these wells were 8.74 feet in P1-MW11and 9.22 feet in P1-MW13. Thus, the invert depth of the former fuel transfer line is

located approximately 2.0 feet above the water table. The water and electrical lines run adjacent to the former fuel transfer line. It is estimated that the invert depths of these utilities are no more than 5 feet BGS.

The invert depth of the former fuel transfer line in the vicinity of Fuel Pit 1C, which is located north of the former tank pit area, is approximately 7.6 feet BGS. There are two monitoring wells that are located in the vicinity of Fuel Pit 1C, and in November 1999, the depths to groundwater in these wells were 8.71 feet in P1-MW3 and 8.83 feet in P1-MW22. Thus, the invert depth of the former fuel transfer line is located approximately 1.0 feet above the water table. The water and electrical lines run adjacent to the former fuel transfer line. It is estimated that the invert depths of these utilities are no more than 5 feet BGS.

II.B.2. Stratigraphic Boring Logs

The local stratigraphy of HAAF and the vicinity is presented in Section II.B.2.a, and the site stratigraphy from the CAP-Part A and CAP-Part B SIs is presented in Section II.B.2.b.

II.B.2.a. Local stratigraphy

HAAF is located within the Barrier Island Sequence District of the Coastal Plain Physiographic Province of the Southeast United States (Clark and Zisa 1976). The Barrier Island Sequence District in Chatham and Bryan Counties is characterized by the existence of several marine terraces (step-like topographic surfaces that decrease in elevation toward the coast). These marine terraces, and their associated deposits, are the result of sea level fluctuations that occurred during the Pleistocene Epoch. The surficial (Quaternary) deposits in Chatham and Bryan Counties, in decreasing elevation and age, are part of the Okefenokee, Wicomico, Penholoway, Pamlico, and Silver Bluff terrace complexes.

HAAF, as well as most of Chatham County, is underlain by the Pleistocene Pamlico Terrace. The Pleistocene Satilla Formation (formerly known as the Pamlico Formation) consists of deposits of the Pamlico Terrace complex and other terrace complexes in the region. The Satilla Formation is a lithologically heterogeneous unit that consists of variably bedded to non-bedded sand and variably bedded silty to sandy clay. During the Pleistocene, these sand and clay deposits were formed in offshore and inner continental shelf, barrier island, and marsh/lagoonal-type environments. According to the Geologic Map of Georgia, clay beds of marsh origin, which were deposited on the northwest side of the former Pamlico Barrier Island complex, exist in the western quarter of HAAF. Very fine- to coarse-grained sand deposits of barrier island origin are more common throughout the remaining areas of HAAF.

II.B.2.b. Site stratigraphy

As determined from soil borings drilled during the CAP-Part B SI, the lithologies present within 15 feet of the surface at the site appear to correlate with the regional stratigraphic section. CAP-Part A and CAP-Part B soil boring logs are located in Appendix IV. The lithology encountered is predominantly a white, pale brown, or light gray, very fine to medium-grained sand, with variable silt and clay content. Generally, the samples with higher silt and clay content were within a few feet of the surface. Less silt and clay content was noted with depth. The boring log of the deep well P1-MW40 indicates an increasing clay content from approximately 26 feet BGS to 30 feet BGS, becoming a clayey, coarse grained sand/gravel at 30 feet BGS.

II.B.3. Stratigraphic Cross-Sections

Stratigraphic cross-sections have been developed based on the CAP-Part B SI soil boring logs. Cross-sections A-A' (west/east from Former Fuel Pit 1A to the former tank pit area), B-B' (north/south through the former tank pit area), and C-C' (southeast/northeast through the Former Fuel Pit 1A/DAACG area), presented in Figure 3a, show the site geology as determined by drilling and sampling activities.

II.B.4. Referenced or Documented Calculations

Referenced or documented calculations performed to support the CAP-Part B SI include those used in developing and interpreting the results of geotechnical analysis and groundwater slug testing.

II.B.4.a. Geotechnical Analysis

Disturbed soil samples were collected from wells P1-MW13, P1-MW14, P1-MW17, P1-MW18, P1-MW19, P1-MW20, P1-MW23, and P1-MW24 for grain size analysis. In addition, undisturbed soil samples were collected from wells P1-MW15, P1-MW16, P1-MW21, and P1-MW22 and soil boring P1-SB33 in order to determine selected engineering properties of the saturated zone underlying the Former Pumphouse #1 site. The engineering properties measured included moisture content, porosity, specific gravity, bulk density, and permeability, as presented in Table 6 and Attachment A. Geotechnical samples were not collected from the five additional well borings drilled in 1999.

II.B.4.b. Slug Testing

Slug-out tests were conducted on shallow wells P1-MW01, P1-MW02, and P1-MW24 (i.e., deep well) on November 2, 1999. The slug test data were evaluated using the Bouwer and Rice method in the AQTESOLVE Professional v.4.5 (1999) software. Calculated hydraulic conductivity values are 1.32×10^{-2} ft/min (6.7×10^{-3} cm/s), 1.75×10^{-2} ft/min (8.9×10^{-3} cm/s), and 4.5×10^{-3} ft/min (2.3×10^{-3} cm/s), respectively. The average hydraulic conductivity of the surficial aquifer near Former Pumphouse #1, based on slug test data, is 1.17×10^{-2} ft/min (6.0×10^{-3} cm/s). Calculations for determining the hydraulic conductivity and transmissivity from the slug test data are presented in Attachment A.

II.B.4.c. Aquifer Testing

Aquifer testing was performed at the Former Pumphouse #1 site on November 2-5, 1999. An 8-hour step test was performed using well P1-MW40 to determine the optimum pumping rate for this well, which turned out to be 3 gallons per minute (gpm). Static water levels and barometric pressure was monitored for a 24-hour period (steady state) before the 24-hour aquifer test was conducted. The 24-hour aquifer test was conducted with P1-MW40 as the pumping well and wells P1-MW02, P1-MW03, P1-MW22, P1-MW23, and D-MW5 as observation wells. Water levels were also recorded during the recovery period after pumping stopped. Water levels and barometric pressure were measured using electronic data loggers. All aquifer test data and methodologies are discussed in Attachment A.

Discharge water generated during the step drawdown and 24-hour aquifer pumping tests was containerized in an above ground, 21,000-gallon-capacity frac tank. Two samples of the water in the tank were used to characterize the liquid for proper disposal. A total of 5,678 gallons of waste water was generated from well pumping activities. All fluids were removed from the frac tank on December 9, 1999, and were transported to Industrial Water Services, Inc., in Jacksonville, Florida, for recycling. A manifest documenting the proper disposal of all fluids generated at the site in November is provided in Attachment A (page A-60).

The drawdown data were corrected for barometric influence. Both drawdown data and the pumping well recovery data were then evaluated using AQTESOLVE Professional v.4.5 (1999) groundwater test data analysis software for unconfined aquifers. After correcting for barometric influences, only the data from P1-MW03 yielded sufficient response to enable evaluation with the software. Figure 18 provides a summary of water level and barometric measurements over the pumping period. As illustrated, water level measurements from wells P1-MW02 and P1-MW22 changed so little over the testing period that evidence of pumping influence could not be accurately determined. Therefore, data from these wells

were not evaluated quantitatively. In addition to the aquifer withdrawal data analysis, the recovery data for P1-MW40 (the pumping well) were also evaluated quantitatively. Details of calculations performed on the data are provided in Attachment A.

The computer program generated a match line for P1-MW03 using the Neuman solution yielding a transmissivity (T) of 0.4035 ft^2/min (6.25 cm^2/s) assuming a saturated aquifer thickness of 60 feet. A hand-picked visual straight line in the Theis recovery solution was selected to match the last portion of the recovery data for MW40, which would be representative of the aquifer and not the sand pack. This straight-line solution produced a transmissivity of 0.089 ft^2/min (1.38 cm^2/s), assuming a saturated aquifer thickness of 60 feet.

II.B.5. Direction of Groundwater Flow

II.B.5.a. Well construction details

Each monitoring well casing consisted of 2-inch inside diameter schedule 40 flush-thread polyvinyl chloride (PVC) risers with a 10-foot screen set across the water table. The well screen slot size was 0.010 inches. Exceptions to the typical monitoring well construction were P2-MW24, which is a 2-inch well screened from 29.5 – 34.5 feet to determine groundwater quality at depth, and P2-MW40, which is a 4-inch well screened from 3.8 – 33.8 in order to conduct aquifer testing. Table 7 summarizes construction details for all monitoring wells. Well construction diagrams are presented in Appendix VII. Following installation of the well casing, filter pack sand was poured while the augers were gradually removed to ensure a complete and even distribution of the filter pack. The filter pack extended to a measured level at least 2 feet above the top of the well screen.

Well seals were composed of bentonite pellets and allowed to hydrate before filling the annular space above the seal. The well seal extended to a measured level of at least 2.0 feet above the top of the filter pack.

Above the well seal, the remaining annular space was completed with a 1.0-foot-long flush-mount sheet steel protective casing that was grouted in place with a concrete pad. Well casings were capped with expandable locking caps. Protective casings were covered with bolted cast-iron manhole covers. Inscribed monitoring well identification plates were placed inside of each manhole cover.

II.B.5.b. Potentiometric mapping

Water level measurements were collected from existing monitoring wells during the CAP-Part A SI and from the new monitoring wells installed during the CAP-Part B SI. Data obtained from these measurements are presented in Table 8. During the CAP-Part A SI in December 1996, there was a groundwater divide at the site with groundwater flowing to the south-southwest and the northwest with an average gradient of 0.004 ft/ft.

Water level measurements were collected during the CAP-Part B SI in May 1997, November 1999, and February 2000. Data obtained from these measurements are presented in Table 8. Figure 19 shows the potentiometric surface at the site in November 1999. Groundwater in the study area is under water table conditions and is encountered between 6.06 to 12.29 feet BGS, averaging 9.21 feet BGS. Groundwater flow at the Former Pumphouse #1 tank pit area is generally to the southwest with the man-made ditches affecting localized flow, and the flow gradient is approximately 0.012 ft/ft. At the far western edge of the site near the Former Fuel Pit 1A/DAACG area, the groundwater flow changes to a more northwest direction at a gradient of approximately 0.0086 ft/ft. Figure 20 shows the potentiometric surface at the site in February 2000, and the flow in the former tank pit area is to the southwest with an average gradient of

0.0067 ft/ft. At the far western edge of the site near the Former Fuel Pit 1A/DAACG area, the groundwater flow changes to a more northwest direction at a gradient of approximately 0.0067 ft/ft.

II.B.5.c. Equipotential flow net

An equipotential flow net based on the February 2000 water level measurements and the contoured potentiometric surface is presented in Figure 21.

III. REMEDIAL ACTION PLAN

III.A. CORRECTIVE ACTION COMPLETED OR IN PROGRESS

III.A.1. Recovery/Removal of Free Product

The contractor responsible for investigating the site from 1996 through 1999 did not use a product probe for free product measurements and, as a result, the presence of free product was not identified during this time period. During sampling activities in February 2000, free product was measured in wells D-MW1, D-MW2, D-MW8, D-MW11, D-MW13, and D-MW17 at a thickness of 0.01 feet, 0.88 feet, 0.15 feet, 0.74 feet, 0.15 feet, and a sheen, respectively. Absorbent socks were placed in each well following these measurements on February 24, 2000. The free product covered an area of approximately 400 feet × 500 feet at the Former Fuel Pit 1A/DAACG area (Release #1). GA EPD was notified of the free product in correspondence dated March 8, 2000 (Stanley 2000). The absorbent socks were removed and replaced in May and July 2000.

III.A.2. Remediation/Treatment of Contaminated Backfill Material and Native Soils

During UST closure activities in 1995, all contaminated soil removed during the project was tested in accordance with disposal facility requirements and transported to Kedesh, Inc., Highway 84, Ludowici, GA 31316. The Closure Report for Former Pumphouse #1 was not submitted to GA EPD in 1995 because review of the closure analytical data indicated that a CAP-Part A would be required (i.e., per requirements of GUST-9, Item 15, page 12, dated August 1995). However, the analytical data presented in the closure report is summarized in Table 1 of this CAP-Part B Report. Approximately 913 cubic yards of contaminated soil were excavated from the site.

During the UST closure activities in 1998, the excavated soil was returned to the tank pit with the concurrence of GA EPD. The 1998 Closure Report for Former Pumphouse #1 (Earth Tech 1998) was not submitted to GA EPD because the CAP-Part A Report, which incorporated the area of the removal activities, had already been submitted to GA EPD.

III.B. OBJECTIVES OF CORRECTIVE ACTION

III.B.1. Remove Free Product that Exceeds One-Eighth Inch

Former Fuel Pit 1A/DAACG Area (Release #1)

During the CAP-Part A and Part B investigations in 1996 through 1999, free product was not observed in the wells at the Former Fuel Pit 1A/DAACG area (Release #1) since a oil/water interface probe was not used during water level measurements. However, additional sampling and product/water level measurements conducted in February 2000 indicated free product, exceeding 1/8 inch in thickness, exists at the site. Removal of the free product is recommended; however, the amount of recoverable free product and the best method for removal are not known. Thus, additional investigation activities are necessary to determine this information.

Former Pumphouse #1 Tank Pit Area (Release #2)

The previous investigations, CAP-Part A SI, and CAP-Part B SI determined that there is no evidence of free product at the Former Pumphouse #1 tank pit area (Release #2) that exceeds an eighth of an inch;

therefore, no recovery/removal of free product has been performed, nor was it required based on known site conditions.

III.B.2. Remediate Groundwater Contamination

Former Fuel Pit 1A/DAACG Area (Release #1)

The CAP-Part A and CAP-Part B investigations documented groundwater contamination that exceeded IWQS. In May 1996, the maximum benzene concentration at the site was 700 µg/L in well D-MW2, located north of the Former Fuel Pit 1A. This concentration was the maximum concentration observed for Release #1 during the CAP-Part A and CAP-Part B investigations. Well D-MW2 was not sampled in February 2000; however, other wells in the vicinity had similar concentrations in 2000 as they had in 1996, which indicates that the free product is providing a continuous source for contamination in the groundwater. The dissolved benzene plume appears to be impacting an underground storm drain, which is located approximately 450 feet northwest of well D-MW2. This is evidenced by low concentrations of benzene in well D-MW18 located on the northwest side of the storm drain.

Groundwater in the vicinity of the Former Fuel Pit 1A/DAACG area is generally flowing to the northwest, but groundwater in the southern portion of the plume is flowing to the south-southwest. The man-made drainage ditches are affecting the localized flow. Conservative fate and transport modeling using the Analytical Transient 1-, 2-, 3-Dimensional Model (AT123D) (Attachment B) predicts that benzene (the most conservative representative compound) should be exceeding its IWQS at the underground storm drain located 450 feet northwest of well D-MW2. The model results for this compound indicate that there is minimal groundwater impact at a distance of 1,000 feet from the center of the Former Fuel Pit 1A/DAACG area of contamination. Concentrations of benzene in the vicinity of the Former Fuel Pit 1A/DAACG area exceed the benzene ACL of 285 µg/L. Therefore, corrective action consisting of remediation or monitored natural attenuation of the groundwater plume in the vicinity of the Former Fuel Pit 1A/DAACG area should be considered once the free product has been removed.

Former Pumphouse #1 Tank Pit Area (Release #2)

The CAP-Part A and CAP-Part B investigations documented groundwater contamination that exceeded IWQS. In February 2000, the maximum benzene concentration at the site was 4850 µg/L in well D-MW2, located 250 feet north of the former tank pit area near Fuel Pit 1C. This concentration was the maximum concentration observed during the CAP-Part A and CAP-Part B investigations. As with the Former Fuel Pit 1A/DAACG area, the concentrations in 2000 are similar to those observed in 1996, indicating that residual contamination in the soil is acting as a source. The dissolved benzene appears to be impacting a man-made drainage ditch, which is located approximately 300 feet southeast of the former tank pits. This is evidenced by low concentrations of benzene in the drainage ditch surface water and a lack of benzene in the monitoring wells located on the south and southeast side (i.e., downgradient) of the drainage ditch.

Groundwater in the vicinity of the former tank pits is generally flowing to the southwest with a man-made drainage ditch affecting the localized flow. Conservative fate and transport modeling using the AT123D (Attachment B) predicts that benzene (the most conservative representative compound) should be exceeding its IWQS at the drainage ditch located 300 feet southeast of the site. The model results for this compound indicate that there is minimal groundwater impact at a distance of 1,000 feet from the former tank pits. Concentrations of benzene in the vicinity of the former tank pit exceed the benzene ACL of 285 µg/L. Therefore, corrective action consisting of remediation or monitored natural attenuation of the groundwater plume in the vicinity of the former tank pits is recommended.

III.B.3. Remediate Soil Contamination

Former Fuel Pit 1A/DAACG Area (Release #1)

The results from the various CAP-Part A and CAP-Part B investigations for the DAACG Facility and Former Pumphouse #1 indicate that 20 soil samples exceeded the GUST STL (i.e., 0.017 mg/kg) for benzene, 1 soil sample exceeded the GUST STL (i.e., 115 mg/kg) for toluene, and 5 soil samples exceeded the GUST STL (i.e., 18 mg/kg) for ethylbenzene. As discussed in Section III.B.4, the toluene concentrations were below the risk-based screening level (i.e., 408,800 mg/kg) that is protective of soil exposure during industrial land use and below the ATL for toluene of 479 mg/kg that was developed based on fate and transport modeling (Appendix VI). The ethylbenzene concentrations were below the risk-based screening level (i.e., 204,400 mg/kg) that is protective of soil exposure during industrial land use and below the ATL for ethylbenzene of 187 mg/kg that was developed based on fate and transport modeling (Appendix VI).

As discussed in Section III.B.4, the benzene concentrations are below the risk-based screening criteria (i.e., 197.4 mg/kg) that is protective of soil exposure during industrial land use in all but two samples that were collected from well D-MW17 and boring D-SB10. The benzene concentrations exceed the ATL of 9.3 mg/kg, which was developed based on fate and transport modeling, in six boring locations. These soil samples are located above the soil/water interface near the area of free product; thus, corrective action consisting of remediation or monitored natural attenuation for leaching of soil contaminants to groundwater is recommended for this area.

Former Pumphouse #1 Tank Pit Area (Release #2)

The results from the various CAP-Part A and CAP-Part B investigations for the DAACG Facility and Former Pumphouse #1 indicate that 26 soil samples exceeded the GUST STL (i.e., 0.017 mg/kg) for benzene, 3 soil samples exceeded the GUST STL (i.e., 115 mg/kg) for toluene, and 5 soil samples exceeded the GUST STL (i.e., 18 mg/kg) for ethylbenzene. As discussed in Section III.B.4, the toluene concentrations were below the risk-based screening level (i.e., 408,800 mg/kg) that is protective of soil exposure during industrial land use and below the ATL for toluene of 479 mg/kg that was developed based on fate and transport modeling (Appendix VI). The ethylbenzene concentrations were below the risk-based screening level (i.e., 204,400 mg/kg) that is protective of soil exposure during industrial land use and below the ATL for ethylbenzene of 187 mg/kg that was developed based on fate and transport modeling (Appendix VI).

As discussed in Section III.B.4, the benzene concentrations are below the risk-based screening criteria (i.e., 197.4 mg/kg) that is protective of soil exposure during industrial land use in all of the samples. The benzene concentrations exceed the ATL of 9.3 mg/kg, which was developed based on fate and transport modeling, in two boring locations. These soil samples are located above the soil/water interface north of Former Fuel Pit 1C; thus, corrective action consisting of remediation or monitored natural attenuation for leaching of soil contaminants to groundwater is recommended for this area.

III.B.4. Provide Risk-based Corrective Action

A risk-based approach was used to determine the need for further action at the Former Pumphouse #1 site. Due to the nature of the contamination (petroleum hydrocarbon contamination of soil and groundwater), the risk-based approach was limited to human health concerns. Ecological risk concerns are minimal because of the land use surrounding the Former Pumphouse #1 site. The site is located within an active airfield at HAAF, and the primary purpose of the drainage ditch located south is to collect and divert storm water away from the airfield.

The methods for assessing human health concerns for the site were derived from GUST CAP-Part B guidance (GA EPD 1995) and recent GA EPD guidance (GA EPD 1996). These were supplemented by the additional guidance documents on risk assessment methods referenced in this section. In general, the risk-based corrective action (RBCA) approach is performed in two steps:

1. Results are screened against readily available regulatory levels and risk-based screening levels to identify chemicals of potential concern (COPCs).

2. Site-specific ACLs are developed for COPCs using the results of the fate and transport modeling and identified receptor locations.

The following sections present the conceptual model of the exposure setting and potential receptors as well as the general methodology employed to perform the screening for COPCs and the development of ACLs.

III.B.4.a. Potential receptor survey

The exposure assessment identifies any potentially complete pathways between the contaminant source and potential receptors. This involves identifying potential current and future receptors, release mechanisms through which contamination might come into contact with the receptors, and routes of exposure through which receptors might be exposed. Figure 22 presents potentially complete and incomplete pathways for contaminant sources at the Former Pumphouse #1 site.

The Former Pumphouse #1 site is located within an active military installation and within an access-controlled fence of an active airfield. The land use at the site is currently military industrial. Installation housing areas are located more than 0.5 miles to the northeast. A man-made drainage ditch is located approximately 300 feet southeast of the former tank pits. The man-made surface water drainage feature eventually empties into Springfield Canal, which flows southwest and joins the Little Ogeechee River more than 3.8 miles downstream of the site. The drainage ditch is located adjacent to the flight line and aircraft taxiway and access to the area is restricted; thus the drainage ditch is not used for recreational purposes.

No connection between site contamination and current off-site receptors has been identified. Site contamination has migrated to the Surficial Aquifer. The Hawthorn Group, which is approximately 90 feet of clay, separates the Surficial Aquifer from the deep drinking water aquifer, the Floridan Aquifer. There appears to be no vertical migration from the Surficial Aquifer to the Floridan Aquifer. One of the HAAF's current water supply wells (i.e., Well 3) is located approximately 6,700 feet downgradient of the Former Pumphouse #1 site.

Current on-site receptors have not been identified for the site. Potential future on-site receptors might include industrial workers and military residents.

Potential future on-site industrial receptors may come in direct contact with site soil contamination during construction or excavation activities. Due to the restricted access to the site, no near-term, on-site receptors are likely to come into contact with groundwater even though the Surficial Aquifer discharges into the drainage ditch.

III.B.4.b. Screening for chemicals of potential concern

III.B.4.b.1. Screening Methodology

The purpose of a risk evaluation screening is to identify the COPCs and areas of concern at a site, and possibly to identify sites for which no further action is needed. The first step in the risk process uses

screening levels that are readily obtainable and that, due to their conservative nature, can be used with a high degree of confidence to indicate sites for which no further action is required.
An American Society for Testing and Materials (ASTM) (1995) Tier 1-type risk evaluation process has been applied to the data collected for the Former Pumphouse #1 site to identify any COPCs and media for which no further action is needed. The risk evaluation screen involves the steps listed below:

- identify potential migration and exposure pathways associated with the site, and identify potential exposure scenarios that should be used to select screening levels;
- identify risk-based screening levels and regulatory-based screening levels for each contaminant;
- compare site-related concentrations to screening levels to determine if any COPCs exist at the site; and
- compare detection limits to screening levels to identify potential false-negative screening results.

The screening levels for the Former Pumphouse #1 site data have been taken from the following sources based on GA EPD guidance (GA EPD 1996):

- Georgia IWQS (GA EPD 1998b),
- GUST STLs (i.e., Table B, column 1),
- soil screening levels developed by the U.S. Environmental Protection Agency (EPA) (1996), and
- soil and groundwater risk-based concentrations developed by EPA Region 3 (EPA 1999).

These values reflect screening levels based on a combination of regulatory screening levels (i.e., IWQS and GUST STLs), and calculated risk-based values (i.e., EPA Region 3 risk-based concentrations).

Screening levels inherently incorporate assumptions about land use. In identifying COPCs, it is generally accepted that screening levels will reflect any potential future land uses and, thus, they usually reflect a conservative residential use scenario (EPA 1991; EPA 1996; EPA 1999; ASTM 1995). Based on GA EPD guidance, risk-based screening levels reflect residential land use for groundwater and industrial land use for surface and subsurface soils (i.e., > 2 feet BGS) (GA EPD 1996).

Default residential exposure scenarios for groundwater assume that use of the land could someday be residential and that the following exposures could occur:

- ingestion of groundwater, and
- inhalation of volatiles during showering.

The default industrial exposure assumptions for surface and subsurface soils assume that the following exposures could occur:

- incidental ingestion of soil, and
- inhalation of volatiles and dust.

EPA's *Soil Screening Guidance* (EPA 1996) provides two options for selecting soil values that address protection of groundwater. One value assumes no contaminant dilution or attenuation would occur between the soil and groundwater; a second value assumes a 20-fold dilution attenuation factor (DAF). A DAF of 20 was used to develop soil screening values protective of groundwater at the Former Pumphouse #1 site.

If applicable or relevant and appropriate requirement (ARAR)- or risk-based values are not available, it generally means that (1) the constituent is not considered to be toxic except perhaps at extremely high

concentrations (e.g., aluminum, sodium); (2) the dose-response data do not indicate a toxic effect; or (3) EPA is currently reviewing toxicity information, and no reference dose or cancer slope factor is currently available.

III.B.4.b.2. Screening Results

The risk screening process is a systematic screening of sample results to identify site-related COPCs. Constituent concentrations below risk- or regulatory-based screening levels are not considered COPCs and are not evaluated further. Analytical results for the DAACG Facility and Former Pumphouse #1 investigations were combined based on the location of the sample with respect to the two separate releases. Tables 9 and 10 present the results of the risk-based screening for the Former Fuel Pit 1A/DAACG Area (Release #1), soil and groundwater, respectively. Tables 11 through 14 present the results of the risk-based screening for the Former Pumphouse #1 Tank Pit Area (Release #2) soil, sediment, groundwater, and surface water, respectively.

Former Fuel Pit 1A/DAACG Area (Release #1)

In the vicinity of the Former Fuel Pit 1A/DAACG Area, 138 soil samples were collected from 66 borehole locations between 1996 and 1999. Benzene, ethylbenzene, toluene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were detected in soil at concentrations above their respective STLs. BTEX, benzo(a)pyrene, and benzo(b)fluoranthene were detected in soil at concentrations above their respective leaching to groundwater screening. Benzene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene were detected in soil at concentrations above the risk-based screening criteria. BTEX and several PAHs were detected at concentrations below their respective screening values. As a result, BTEX, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were identified as COPCs for soil at the Former Fuel Pit 1A/DAACG Area (Release #1) site.

The detection limits for the benzene, toluene, and/or several PAHs exceeded STLs and/or risk-based screening levels in several samples during the various investigations. Many results were estimated due to detections below the detection limits. The results for several PAHs were rejected (R qualified) based on low surrogate recoveries in one sample (H833-SB0301 from boring D-SB03). No COPCs for soils were selected for the site based on the detection limit screening or qualifier screening.

In the vicinity of the Former Fuel Pit 1A/DAACG Area, 38 groundwater samples were collected from 30 monitoring wells between 1996 and 2000. Benzene, benzo(a)pyrene, and chrysene were detected in groundwater at concentrations above their respective IWQS. Benzene, ethylbenzene, toluene, and naphthalene were detected in groundwater at concentrations above their risk-based screening levels. BTEX and several PAHs were detected at concentrations below their respective screening values. As a results, benzene, ethylbenzene, toluene, benzo(a)pyrene, chrysene, and naphthalene were identified as COPCs for groundwater at the Former Fuel Pit 1A/DAACG Area (Release #1) site.

The groundwater detection limit for benzene exceeded the risk-based screening level during the various investigations. The detection limit for benzene exceeded the IWQS in one sample. Detection limits achieved for several PAHs during the various investigations exceeded their respective IWQS and/or risk-based screening levels for the groundwater data. For these constituents, screening levels represent values below analytically achievable levels. No groundwater data were rejected. No additional COPCs were selected for groundwater based on the detection limit or qualifier screening.

Former Pumphouse #1 Tank Pit Area (Release #2)

In the vicinity of the Former Pumphouse #1 Tank Pit Area, 92 soil samples were collected from 45 borehole locations between 1996 and 1999. Benzene, ethylbenzene, toluene, benzo(b)fluoranthene, and chrysene were detected in soil at concentrations above their respective STLs. Benzene, ethylbenzene, toluene, and xylenes were detected in soil at concentrations above their respective leaching to groundwater screening. Toluene, ethylbenzene, xylenes, and several PAHs were detected at concentrations below their respective screening values. As a result, benzene, ethylbenzene, toluene, xylenes, benzo(b)fluoranthene, and chrysene, were identified as COPCs for soil at the Former Pumphouse #1 Tank Pit Area (Release #2) site.

The detection limits for the benzene, toluene, and/or several PAHs exceeded STLs and/or risk-based screening levels in several samples during the various investigations. Many results were estimated due to detections below the detection limits. No soil data were rejected. No COPCs for soils were selected for the site based on the detection limit screening or qualifier screening.

In the vicinity of the Former Pumphouse #1 Tank Pit Area, 29 groundwater samples were collected from 17 monitoring wells between 1996 and 1999. Benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected in groundwater at concentrations above their respective IWQS. Benzene, ethylbenzene, toluene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene were detected in groundwater at concentrations above their risk-based screening levels. Toluene, ethylbenzene, xylenes, and several PAHs were detected at concentrations below their respective screening values. As a result, benzene, ethylbenzene, toluene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene were identified as COPCs for groundwater at the Former Pumphouse #1 Tank Pit Area (Release #2) site.

The groundwater detection limit for benzene exceeded the risk-based screening level during the various investigations. The detection limit for benzene exceeded the IWQS in two samples. Detection limits achieved for several PAHs during the various investigations exceeded their respective IWQS and/or risk-based screening levels for the groundwater data. For these constituents, screening levels represent values below analytically achievable levels. Acenaphthene and fluorene data were rejected in two samples (MW1701 and MW1901) based on low surrogate recoveries. No additional COPCs were selected for groundwater based on the detection limit or qualifier screening.

No constituents were detected above their respective IWQS for surface water data collected during the 1996 CAP-Part A investigation and 1999 CAP-Part B investigation. Benzene, ethylbenzene, toluene, and xylenes were detected below screening levels during both investigations. The detection limits for several PAHs exceeded their respective IWQS. These standards represent values below analytically achievable levels. No COPCs for surface water were selected for the Former Pumphouse #1 Tank Pit Area (Release #2) site.

Benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were detected in sediment at concentrations above their respective STLs during the 1996 CAP-Part A investigation. Several PAHs were detected in sediment at concentrations below their respective screening levels. Sediment data were not collected during the 1999 CAP-Part B investigation. The detection limit for benzene in sample HT4-SE07 and several PAHs in sample HT4-SE08 exceeded screening values, but no COPCs were selected based on this screen. Benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were identified as COPCs for sediments for the Former Pumphouse #1 Tank Pit Area (Release #2) site.

III.B.4.c. Site-specific levels

Detections exceeding the conservative generic screening levels are considered COPCs. ATLs and ACLs are developed, when appropriate, for the COPCs using site-specific information. ATLs and ACLs were developed from available regulatory screening levels. When regulatory screening levels were not available, ACLs were developed based on risk-based levels.

III.B.4.c.1. Alternate Threshold Levels

Benzene, ethylbenzene, toluene, xylenes, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were identified as COPCs for soil at the Former Fuel Pit 1A/DAACG Area (Release #1) site. Benzene, ethylbenzene, toluene, xylenes, benzo(b)fluoranthene, and chrysene, were identified as COPCs for soil at the Former Pumphouse #1 Tank Pit Area (Release #2) site. The COPCs for both areas of contamination are the same except for indeno(1,2,3-cd)pyrene, which is located only at the Former Fuel Pit 1A/DAACG Area (Release #1) site. Due to the close proximity of both releases to each other, the most conservative fate and transport modeling results were utilized for developing one set of ATLs for both areas of contamination. ATL calculations for the constituents are presented in Appendix VI and are based on the results of the AT123D modeling for the Former Fuel Pit 1A/DAACG Area (Release #1) site. The ATLs for soil at the Former Pumphouse #1 site, Release #1 and Release #2, were determined to be as follows:

- 9.3 mg/kg for benzene,
- 479 mg/kg for toluene,
- 187 mg/kg for ethylbenzene,
- 893 mg/kg for total xylenes,
- 1.4 mg/kg for benzo(a)pyrene,
- 5.8 mg/kg benzo(b)fluoranthene,
- 2.1 mg/kg chrysene, and
- 0.66 mg/kg indeno(1,2,3-cd)pyrene.

III.B.4.c.2. Alternate Concentration Limits

Benzene, ethylbenzene, toluene, benzo(a)pyrene, chrysene, and naphthalene were identified as COPCs for groundwater at the Former Fuel Pit 1A/DAACG Area (Release #1) site. Benzene, ethylbenzene, toluene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene were identified as COPCs for groundwater at the Former Pumphouse #1 Tank Pit Area (Release #2) site. The COPCs for both areas of contamination are the same except for benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, which are located only at the Former Pumphouse #1 tank pit area (Release #2) site.

To be conservative, the chemical properties of benzene were used to evaluate contaminant migration from each plume. Benzene was modeled to a potential downgradient location where a receptor may come in contact with migrating site contamination. The receptors were determined to be a storm drain located 230 feet downgradient of the center of the source area for the Former Fuel Pit 1A/DAACG Area (Release #1) and a drainage ditch located 325 feet downgradient of the center of the source area for the Former Pumphouse #1 Tank Pit Area (Release #2). Fate and transport modeling was used to develop a site-specific DAF between each source and the receptor location (see III.B.4.c.3 below). The modeling results estimated a DAF for benzene of 4 for the storm drain for Release #1 and a DAF for benzene of 5.25 for the drainage ditch for Release #2. As discussed in Appendix VI, the DAF for PAH constituents was estimated to be 40. Due to the close proximity of both releases to each other, the most conservative fate

and transport modeling results (i.e., Release #1) were utilized for developing one set of ACLs for both areas of contamination. Compound specific regulatory levels or risk-based screening criteria were used in conjunction with the site-specific DAF identified for the potential migration of contamination from the site to determine the ACL for each compound. The ACL calculations are presented in Appendix VI. The ACLs for both areas of contamination were determined to be as follows:

- 285 μg/L for benzene (i.e., 4 × 71.28 μg/L),
- 800,000 μg/L for toluene (i.e., 4 × 200,000 μg/L),
- 114,800 μg/L for toluene (i.e., 4 × 28,718 μg/L),
- 1.2 μg/L for benzo(a)anthracene (i.e., 40 × 0.0311 μg/L),
- 1.2 μg/L for benzo(a)pyrene (i.e., 40 × 0.0311 μg/L),
- 3.6 μg/L for benzo(b)fluoranthene (i.e., 40 × 0.092 μg/L),
- 1.2 μg/L for benzo(k)fluoranthene (i.e., 40 × 0.0311 μg/L),
- 1.2 μg/L for chrysene (i.e., 40 × 0.0311 μg/L),
- 1.2 μg/L for dibenzo(a,h)anthracene (i.e., 40 × 0.0311 μg/L),
- 1.2 μg/L for indeno(1,2,3-cd)pyrene (i.e., 40 × 0.0311 μg/L), and
- 260 μg/L for naphthalene (i.e., 40 × 6.5 μg/L).

Benzene was the only compound to exceed its respective ACL. At the Former Fuel Pit 1A/DAACG area (Release #1), the benzene concentrations exceeded the ACL in wells D-MW2, D-MW8, D-MW11, D-MW17, and D-MW19. At the Former Pumphouse #1 tank pit area (Release #2), the benzene concentrations exceeded the ACL in wells D-MW5, P1-MW2, and P1-MW3. In 1996/1997, benzene also exceeded the ACL in wells P1-MW1 and P1-MW19, but in 1999/2000, the benzene concentrations in these two wells were below the ACL.

III.B.4.c.3. Fate and Transport Model

Site-specific DAFs between the source and the receptor locations were developed. The DAF is a numerical value that represents the attempt to mathematically quantify the natural physical, chemical, and biological processes (e.g., advection-dispersion, sorption-retardation, biodegradation, and volatilization) that result in the decrease of a chemical concentration in an environmental medium. In simple terms, the DAF is the ratio of chemical concentration at the source (or the point of origin) to the concentration at the exposure point. The DAFs reflect the natural attenuation concepts outlined in the ASTM's RBCA protocol (ASTM 1995).

Fate and transport models are used as tools for developing DAFs. The application of fate and transport models at any release site must ensure that the modeling results are protective of human health and the environment. Therefore, the selection process of a predictive model at a release site must consider its performance, characteristics, and applicability to the site being considered. The following characteristics were considered before selecting an appropriate model for the Installation:

- the model provides conservative predictions,
- the model is technically sound,
- the model is a public-domain model or is readily available,
- the model has received adequate peer review,
- the model has been applied to other similar sites, and
- the model is easy to use.

The AT123D meets all of the above criteria and was selected for performing fate and transport analysis for this site. AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model. This model computes the spatial-temporal concentration distribution of chemicals in the

aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in one, two, or three dimensions in the groundwater resulting from a mass release (either continuous or instant or depleting source) over a source area (i.e., point, line, area, or volume source).

Vertical migration of the contaminant plume through the confining unit to the Principal Artesian aquifer is improbable. The confining unit has a vertical hydraulic conductivity on the order of 10^{-8} cm/sec and ranges from 15 to 90 feet in thickness. Assuming a vertical gradient of 1.0 ft/ft and an effective porosity of 0.06 (Mills et al. 1985) for the confining unit, the groundwater travel time is estimated to be 87 years. Therefore, it would take more than 400 years for the benzene contamination to migrate through the confining layer. The surficial aquifer in which the contaminant plume is located is not used as a source of drinking water.

There are two areas of soil and groundwater contamination at the Former Pumphouse #1 site. One area of contamination surrounds the former fuel pit labeled 1A, referred to as Release #1, and the former tank pits associated with the former pumphouse building, referred to as Release #2. The fate and transport modeling was conducted for both sites and the results are provided in Attachment B.

Former Fuel Pit 1A/DAACG Area (Release #1)

At the Former Fuel Pit 1A/DAACG area, there is a large area of free product and soil contamination located 1 to 2 feet above the water table. As a result, the source dimension was assumed to be the area of soil contamination, which is approximately 350 feet × 640 feet with the center of the source area located near D-SB06. The maximum soil concentration of benzene (i.e., 410 mg/kg in D-MW17 at 8.0 – 10.0 ft) in this area was above the soil/water interface. The majority of the soil contamination with the highest concentrations is located under 18 inches of concrete; thus, leaching of contaminants to groundwater will be more a result of fluctuations in the water table than percolating rainwater. In order to predict the maximum concentration in groundwater, leaching to groundwater by percolating rainwater was modeled with SESOIL to determine the predicted maximum concentration in the leachate at the water table interface. Since the predicted leachate concentration (i.e., 12,500 μg/L) was above the maximum observed groundwater concentration (i.e., 700 μg/L in D-MW2) within the source area, the steady-state model was developed by calibrating the model against the maximum predicted concentration (i.e., 12,500 μg/L). Modeling of the lateral migration to the receptor was performed using AT123D. An underground storm drain is located approximately 230 feet northwest (downgradient) from the center of the source area. This is the nearest potential preferential pathway that might encounter migrating groundwater contamination due to a possible hydraulic connection between the surficial groundwater and the storm drain.

The fate and transport modeling results are presented in Attachment B. The steady-state (i.e., continuous concentration at the source) model was developed by calibrating the model against the maximum predicted benzene concentration at the site, which occurred in well D-MW17 (i.e., 12,500 μg/L) in 1996 based on leaching of soil contamination to groundwater. In reality, the source of benzene will deplete due to biodegradation and natural attenuation. The modeling results indicate that benzene should reach the storm drain at a concentration of 3100 μg/L, which is above the state IWQS of 71.28 μg/L. Actual groundwater results indicate that the surficial groundwater contamination near the IWQS reaches the storm drain.

Based on modeling results, the Former Fuel Pit 1A/DAACG Area estimated a DAF for benzene at the drainage ditch is 4.0. Simulations were also performed to predict the maximum concentrations of benzene over a simulation period of two years in the monitoring wells at the Former Fuel Pit 1A/DAACG Area. The predicted maximum benzene concentrations are presented in Table 15.

Former Pumphouse #1 Tank Pit Area (Release #2)

At the Former Pumphouse #1 tank pit area, there is a large area of soil contamination located 1 to 2 feet above the water table. As a result, the source dimension was assumed to be the area of soil contamination, which is approximately 325 feet × 575 feet with the center of the source area located near P1-SB30. The maximum soil concentration of benzene (i.e., 160 mg/kg in D-SB22 at 7.3 – 9.3 ft) in this area was above the soil/water interface. The majority of the soil contamination with the highest concentrations is located under 18 inches of concrete; thus, leaching of contaminants to groundwater will be more a result of fluctuations in the water table than percolating rainwater. In order to predict the maximum concentration in groundwater, leaching to groundwater by percolating rainwater was modeled with SESOIL to determine the predicted maximum concentration in the leachate at the water table interface. Since the predicted leachate concentration (i.e., 5990 μg/L) was above the maximum observed groundwater concentration (i.e., 4580 μg/L) within the source area, the steady-state model was developed by calibrating the model against the maximum predicted concentration (i.e., 5990 μg/L). Modeling of the lateral migration to the receptor was performed using AT123D. A man-made drainage ditch is located approximately 375 feet southwest (downgradient) from the center of the source area. This is the nearest potential receptor that might encounter migrating groundwater contamination due to a possible hydraulic connection between the surficial groundwater and the surface water body.

The fate and transport modeling results are presented in Attachment B. The steady-state (i.e., continuous concentration at the source) model was developed by calibrating the model against the maximum predicted benzene concentration at the site, which occurred in well D-SB22 (i.e., 5990 μg/L) in 1996 based on leaching of soil contamination to groundwater. In reality, the source of benzene will deplete due to biodegradation and natural attenuation. The modeling results indicate that benzene should reach the man-made drainage ditch at a concentration of 1140 μg/L, which is above the state IWQS of 71.28 μg/L. Actual groundwater and surface water results indicate that the groundwater is discharging into the drainage ditch; however, the benzene concentrations in the surface water do not exceed the IWQS. Therefore, the surface water body adjacent to the Former Pumphouse #1 site, Facility ID #9-025085, site is being impacted from former UST operations, but at concentrations below the IWQS of 71.28 μg/L.

Based on modeling results, the estimated DAF for benzene at the drainage ditch is 5.25. Simulations were also performed to predict the maximum concentrations of benzene over a simulation period of two years in the monitoring wells at the site. The predicted maximum benzene concentrations are presented in Table 15.

ATLs and ACLs for the Former Pumphouse #1 site were calculated using the smallest DAF (i.e., most conservative) of the two separate plumes. Thus, the DAF for benzene associated with the Former Pumphouse #1 tank pit area was not used.

III.B.4.d. Conclusions and recommendations

The conclusions below are based on a review of the results of the various investigations conducted between 1996 and 2000 at the Former Pumphouse #1 site using a risk-based approach:

- Free product was detected at the Former Fuel Pit 1A/DAACG Area (Release #1) in February 2000. An oil/water interface probe was not used at either plume prior to February 2000.

- The horizontal and vertical extent of soil contamination below applicable GUST STLs was delineated during the various investigations.

- The horizontal and vertical extent of groundwater contamination associated with the former pumphouse operations (Release #1 and Release #2) was delineated to below federal MCLs during the various investigations.

- Risk-based screening results show that concentrations of benzene, ethylbenzene, toluene, xylenes, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene in soil exceeded their respective initial screening levels.

- Using the results of the fate and transport modeling, only the benzene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene concentrations in soil exceeded the site-specific ATLs of 9.3 mg/kg, 1.4 mg/kg, 2.1 mg/kg, and 0.66 mg/kg, respectively, at the Former Fuel Pit 1A/DAACG area (Release #1).

- Using the results of the fate and transport modeling, only the benzene and chrysene concentrations in soil exceeded the site-specific ATLs of 9.3 mg/kg and 2.1 mg/kg, respectively, at the Former Pumphouse #1 tank pit area (Release #2).

- Risk-based screening results show that concentrations of benzene, ethylbenzene, toluene, xylenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenze(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene in groundwater exceeded their respective initial screening levels. However, benzene was the only constituent where concentrations in groundwater exceeded its ACL of 285 µg/L .

- Contaminant concentrations detected in the surface water samples collected downgradient of the site indicate that contaminated groundwater is discharging into the man-made drainage ditch, but the concentrations do not exceed IWQS.

- Fate and transport modeling of benzene, assuming a continuous, steady-state source, indicates that contamination will exceed the state IWQS at the nearest defined downgradient receptor for each plume, the storm drain for Release #1 and the drainage ditch for Release #2. However, surface water sampling data indicates that contamination in the surface water does not exceed the respective IWQS.

- Based on the CAP-Part B data, the environmental site ranking score for the Former Pumphouse #1 tank pit area is 25,750 (Appendix X) and the environmental site ranking score for Former Fuel Pit 1A/DAACG area is 53,500 (Appendix X).

Considering the site characteristics, it is recommended that the free product, soil contamination above ATLs, and groundwater contamination above ACLs in the area around the vicinity of the Former Fuel Pit 1A/DAACG area be addressed. However, additional information is necessary to determine the amount of recoverable free product at the Former Fuel Pit 1A/DAACG area prior to proposing remediation systems for the site. For the area in the vicinity of Former Pumphouse #1 tank pit area, the soil contamination above ATLs and groundwater contamination above ACLs need to be addressed. Monitored natural attenuation is recommended for the Former Pumphouse #1 tank pit area. In addition, Fort Stewart/HAAF will evaluate "hot-spot" treatment pending a cost effective analysis and availability of funding.

III.C. DESIGN AND OPERATION OF CORRECTIVE ACTION SYSTEMS

III.C.1. System Effectiveness/Basis for Selection

The presumed remedies evaluated for aromatic hydrocarbons in soil and groundwater at this site include monitored natural attenuation, oxygen injection enhanced bioremediation, air sparging with soil vapor extraction, six-phase heating, and PHOSter® II enhanced bioremediation. A three-step screening process was used to select the preferred remedy for the Former Pumphouse #1 site. This alternative selection process is illustrated in Figure 23. At the Former Fuel Pit 1A/DAACG area, additional information on the amount of recoverable free product is necessary prior to the design and implementation of a corrective action system. At the Former Pumphouse #1 tank pit area, monitored natural attenuation is proposed. Fort Stewart/HAAF will evaluate "hot-spot" treatment pending a cost effective analysis and availability of funding.

III.C.1.a. Theory and feasibility

Former Fuel Pit 1A/DAACG Area (Release #1)

Free product was identified in several wells in the area in February 2000. The wells in this area are spaced over 200 feet apart. Ten additional 4-inch monitoring wells are proposed to delineate the free product area around the Former Fuel Pit 1A/DAACG as shown in Figure 24. Following the installation and development of these wells, free-phase product thickness evaluations will be conducted in the 3 of the 10 wells having the most measurable free product.

The free-phase product testing proposed for the three wells selected will be conducted to determine the actual amount of product on the groundwater surface in the vicinity of the wells. The procedure to be used to determine the free-phase product thickness will be the field bailout test method (Gruszczenski 1987). Free-phase product and groundwater level measurements will be taken using an oil/water interface probe, which detects product and water, by different conductivity values. The test method includes the following steps:

- Measure the static product surface level and groundwater surface to determine the thickness of a product and depth to groundwater in the well. A free-phase product level will be recorded as the interface probe is lowered into the well.

- Remove the free-phase product and groundwater from the well using a disposable top-filling bailer (or peristaltic pump). All measurable free-phase product will be extracted from the groundwater surface in each well. The interface probe will be lowered into the screened interval or near the bottom of the well to confirm the removal of the product.

- Measure the volume of product and groundwater extracted from the well and record the results.

- Measure the free-phase product surface and groundwater surface levels in each well and record the results at 10-minute intervals for the first hour and periodically thereafter while recovery from purging is occurring in the well (maximum duration of 48 hours). The extracted free-phase product and water will be placed in containers for later disposal.

The results of the free-phase product testing using the field bailout test method are similar to a rising head slug test. The results of the test yield two basic curve types, depending on the amount of free-phase product accumulation in the well. A Type I curve is associated with free-phase product accumulations of

less than 12 inches and indicates a one-to-one correspondence between the measured and actual formation free-phase product thickness. Type II curves are associated with free-phase product accumulations greater than 12 inches and result in interpretation of an inflection point prior to stabilization of water and free-phase product levels. This inflection point will be used to interpret the measured and actual formation of free-phase product thickness.

Graphs of the water/free-phase product levels versus time will be generated to observe the slope of the water/free-phase product interface and to determine inflection points. The actual product thickness is determined by measuring the difference between the product line and the water/free-phase product interface line at the inflection point. The difference between the water/free-phase product interface level at the time of inflection and the stabilized top of the free-phase product level is the sum of the actual product thickness and capillary fringe. The height of the capillary fringe is determined by subtracting this difference from the actual product thickness measured at the inflection point. Graphs will be generated with a depth measurement on the y axis and the time of the test along the x axis. The graphs will indicate the top of the free-phase product and the top of the water table. These curves will be used to generate and determine the apparent product thickness on the groundwater as a sum of the actual thickness and capillary fringe.

Using the test bailout method by Gruszczenski can result in reasonable determination of the actual free-phase product thickness in any particular formation. The procedure uses principles similar to the bailout slug test and interpretation of the groundwater surface as impacted by free-phase product accumulation. The information is used to determine the thickness of the actual free-phase product.

The results of the free-phase product testing will be combined with existing site data in order to evaluate remedial alternatives for Release #1. The corrective action recommendations will be summarized in a CAP-Part B Addendum Report that will be submitted to GA EPD USTMP for review and approval.

Former Pumphouse #1 Tank Pit Area (Release #2)

Natural attenuation is based on the premise that fuel-type hydrocarbons are readily biodegraded in most environmental systems. Biodegradation of BTEX has been documented for sites similar to the Former Pumphouse #1 tank pit area (e.g., shallow water table, permeable silty sand). In fact, the conditions at this site are similar to other sites that are ideal for biodegradation (Abou-Rizk et al. 1995). Finally, the source has been removed; therefore, subsurface conditions (dissolved oxygen, oxidation-reduction potential, background nutrient availability) will steadily improve with time.

In order to determine if natural attenuation of hydrocarbons was occurring, nine groundwater samples were collected from nine wells (P1-MW1, P1-MW2, P1-MW3, P1-MW19, P1-MW21, P1-MW22, P1-MW23, D-MW5, and D-MW6) in 1999. The groundwater samples were analyzed for BTEX, oxygen reduction potential, total organic carbon, sulfate, nitrate, ferrous iron, methane, ethane, ethene, alkalinity, dissolved oxygen, temperature, and pH. The results of the natural attenuation evaluation are presented in Attachment C. The results of the preliminary screening for aerobic and anaerobic biodgradation suggest that conditions are favorable for natural attenuation of aromatic hydrocarbons. The benzene concentrations at the downgradient perimeter of the plume decreased between 1996 and 1999. However, the benzene concentrations near the source, north of Former Fuel Pit 1C, have remained constant between 1996 and 2000.

During the 1999 and 2000 investigations, the Georgia IWQS for benzene of 71.28 µg/L was exceeded in seven monitoring wells. However, only four of the wells contained benzene concentrations that exceeded the benzene ACL of 285 µg/L. Fort Stewart proposes to implement monitored natural attenuation as a corrective action for this site. In addition, Fort Stewart/HAAF will evaluate "hot-spot" treatment

alternatives to be implemented upon availability of funding. Any future corrective action measures will be submitted in an addendum to this CAP-Part B Report.

III.D. IMPLEMENTATION

III.D.1. Milestone Schedule

A milestone schedule for the proposed corrective action and additional investigation has been prepared. A Gantt chart showing milestone activities and anticipated duration is provided in Figure 25. The actual time required to achieve the site remedial levels (i.e., ACLs) may be greater, or less, than presented in Figure 25. Therefore, Fort Stewart will notify GA EPD USTMP of any significant changes to the proposed remediation time and/or investigation time and will provide GA EPD USTMP an updated Gantt chart, as necessary.

III.D.2. Progress Reporting

For the Former Fuel Pit 1A/DAACG area (Release #1), the progress reporting requirements will be discussed in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area, annual monitoring reports will be submitted to GA EPD that will summarize all previous sampling events for that period.

III.D.3. Certificate of Completion Report

Petition for permanent closure will be submitted with the final progress report (i.e., completion report) for the first release to reach closure criteria. An addendum to the completion report will be submitted for the second release to reach the closure criteria. GA EPD will provide final approval for decommissioning the monitoring wells, which will be requested in the final completion addendum report. Decommissioning of monitoring wells will be completed according to the U.S. Army Corps of Engineers design manual for monitoring wells. Decommissioning will comply with all applicable state and federal standards.

The following certification will be submitted to EPD within 30 days of submitting the final progress report:

> I hereby certify that the Corrective Action Plan-Part B, dated _____, 20___, for Hunter Army Airfield, Former Pumphouse #1 site, Facility ID 9-025085, including any and all certified amendments/addenda thereto, has been implemented in accordance with the schedules, specifications, sampling programs, and conditions contained therein, and that the plan's stated objectives have been met.
>
> _____
> Signature (Owner/Operator)

III.D.4. Inspection Schedule and Preventative Maintenance Program

For the Former Fuel Pit 1A/DAACG area (Release #1), the inspection schedule and preventative maintenance program will be discussed in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area (Release #2), the wells will be visually inspected for changes or damage during each sampling event. Any notable observations will be recorded in the subsequent monitoring only report. Any required repairs to ensure the monitoring wells remain in conformance with GA EPD and EPA performance standards will be made as needed.

III.D.5. Periodic Monitoring

For the Former Fuel Pit 1A/DAACG area (Release #1), the periodic monitoring requirements will be discussed in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area (Release #2), groundwater samples will be collected semiannually from D-MW5, D-MW6, P1-MW1, P1-MW2, P1-MW18, P1-MW19, P1-MW22, and P1-MW23 and analyzed for BTEX. PAH compounds that were observed during the CAP-Part A and CAP-Part B investigations were detected at concentrations below their respective ACLs. Thus, it is recommended that PAH analysis not be performed during the semiannual sampling. Monitoring will continue at the site until the benzene concentrations in groundwater are below the ACL of 285 µg/L for two sampling events or until a "hot-spot" treatment is completed at the site.

During each sampling event, water levels will be measured in all monitoring wells. Specific conductivity, pH, and temperature analyses will be completed on each sample from the monitoring wells where analytical samples are collected. The samples will be shipped to an approved laboratory for BTEX analysis using EPA Method 8021B/8260B and PAH analysis using EPA Methods 8100/8270C/8310.

III.D.6. Effectiveness of Corrective Action

The corrective action to be implemented at the Former Fuel Pit 1A/DAACG area will be determined in an addendum to this CAP-Part B Report. Once the corrective action is implemented and the remedial objectives met, the corrective action will be discontinued. The objectives of the corrective action are to reduce the benzene concentrations in groundwater to below the ACL of 285 µg/L and to reduce the benzene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene to below the ATLs of 9.3 mg/kg, 4.2 mg/kg, 8.6 mg/kg, and 2.7 mg/kg, respectively.

For the Former Pumphouse #1 tank pit area (Release #2), the corrective action will be discontinued once the objectives of the monitoring only plan have been achieved. That is the benzene concentrations in groundwater will be reduced below the ACL of 285 µg/L, and the benzene and chrysene concentrations in soil will be reduced below their ATLs of 9.3 mg/kg and 2.2 mg/kg, respectively.

III.D.7. Confirmatory Soil Sampling Plan

For the Former Fuel Pit 1A/DAACG area (Release #1), the confirmatory soil sampling plan will be discussed in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area (Release #2), no excavation of soil is planned under the monitoring only plan; therefore, confirmatory sampling associated with excavation of soil will not be performed. However, since there is an area of soil contamination that exceeds the benzene ATL of 9.3 mg/kg and the chrysene ATL of 2.2 mg/kg, three confirmatory soil samples will be collected from the area of soil contamination. The soil samples will be collected once the benzene concentrations in groundwater are approaching the ACL. The soil samples will only be analyzed for benzene and chrysene.

The location of these samples will be determined during the monitoring only program and will be submitted to GA EPD in a letter or annual monitoring only report for approval.

III.D.8. Stockpiled Bulk Soil Sampling

For the Former Fuel Pit 1A/DAACG area (Release #1), stockpiled bulk soil sampling, if necessary, will be discussed in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area (Release #2), no stockpiled soil will be generated with this corrective action; therefore, no soil sampling will be conducted.

III.D.9. Corrective Action Termination Conditions

For the Former Fuel Pit 1A/DAACG area (Release #1), termination conditions will be provided in an addendum to the CAP-Part B Report that describes the corrective action to be implemented.

For the Former Pumphouse #1 tank pit area (Release #2), concentrations of benzene in groundwater must be at or below the ACL, and concentrations of benzene and chrysene in soil must be at or below their respective ATLs prior to terminating the monitoring only program. Once the benzene ACL and the benzene and chrysene ATLs are achieved, the remedial system and monitoring may be terminated regardless of the site ranking score.

III.D.10. Post-Completion Site Restoration Activities

After termination has been granted for either release, equipment and debris related to the corrective action will be removed from the site.

III.E. PUBLIC NOTIFICATION

The Former Pumphouse #1 site is located entirely within the confines of the Hunter Army Airfield, which is part of the Fort Stewart Military Reservation, a federal facility. The U.S. Government owns all of the property contiguous to the site. The Fort Stewart DPW has complied with the public notice requirements defined by GA EPD guidance by publishing an announcement in the *Savannah Morning News* on April 16 and 23, 2000. A copy of the newspaper announcement used for public notification is presented in Appendix XI of this report.

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