FINAL

FORSCOM

CORRECTIVE ACTION PLAN

for the

3d Inf Div (Mech)

FORMER FIRE TRAINING AREA (FTA) AT WRIGHT ARMY AIRFIELD (SOLID WASTE MANAGEMENT UNIT 13)
at
FORT STEWART MILITARY RESERVATION
FORT STEWART, GEORGIA

Prepared for

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

Contract No. DACA21-95-D-0022
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REGULATORY AUTHORITY
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Prepared for
U.S. Army Corps of Engineers
Savannah District
Under Contract DACA21-95-D-0022
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September 2002

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

____

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

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ACRONYMS

amsl	above mean sea level
AST	aboveground storage tank
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
bgs	below ground surface
BHHRA	baseline human health risk assessment
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CAP	Corrective Action Plan
CFR	*Code of Federal Regulations*
CMCOC	contaminant migration constituent of concern
CMCOPC	contaminant migration constituent of potential concern
COC	constituent of concern
COPC	constituent of potential concern
DAF	dilution attenuation factor
DPW	Directorate of Public Works
DPT	direct-push technology
ECOPC	ecological constituent of potential concern
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPRE	ecological preliminary risk evaluation
ESV	ecological screening value
FSMR	Fort Stewart Military Reservation
FTA	Fire Training Area
GEPD	Georgia Environmental Protection Division
GSSL	generic soil screening level
HHCOPC	human health constituent of potential concern
HHPRE	human health preliminary risk evaluation
IM	interim measure
IRA	interim removal action
JP	jet propellant
MCL	maximum contaminant level
O&M	operations and maintenance
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbon
PCT	Preliminary Cleanup Target
PRG	preliminary remediation goal
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RI	facility investigation
SAIC	Science Applications International Corporation
SESOIL	Seasonal Soil Compartment
SRC	site-related contaminant
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
UCL	upper confidence limit
VOC	volatile organic compound
WAAF	Wright Army Airfield

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EXECUTIVE SUMMARY

This report presents the Corrective Action Plan (CAP) for remediation of the former Fire Training Area (FTA) at Wright Army Airfield (WAAF), solid waste management unit (SWMU) 13, at Fort Stewart, Georgia. This CAP Report has been prepared by Science Applications International Corporation for the U.S. Army Corps of Engineers, Savannah District under Contract DACA21-95-D-0022, Delivery Order No. 0049.

Corrective action is required at SWMU 13 pursuant to Title 40, *Code of Federal Regulations*, Part 264.101(a), as referenced by the Rules of the Georgia Department of Natural Resources, Georgia Environmental Protection Division (GEPD), Chapter 391-3-11, Section 10. This CAP has been prepared in accordance with the recommendations in Section 9.5 of the revised final *Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for the FTA at WAAF (SWMU 13)* (SAIC 2000). This CAP addresses the requirements contained in the Fort Stewart Hazardous Waste Permit HW-045, as renewed August 1997.

Fort Stewart is located approximately 40 miles west-southwest of Savannah, Georgia, in portions of Liberty, Long, Bryan, Tattnall, and Evans counties and covers approximately 280,000 acres. FTA was located on the western edge of the WAAF runway system, which is in the southern portion of the Fort Stewart Military Reservation (FSMR). The FTA consisted of a 5,000-square-foot concrete pad with an integral berm that was used by fire-fighting personnel for training. An oil/water separator sump, underground piping, and an aboveground fuel [jet propellant (JP)-4] storage tank adjoined the main concrete pad and combined to make up the entire FTA. All of these structures and appurtenances were removed during an interim measure (IM) conducted in 1997 by CAPE Environmental. Also, as part of the IM, the top 4 feet of contaminated soil were excavated, removed, and replaced with clean soil. The IM was summarized in the *Final Interim Measures Report for SWMU 13*, dated May 1998, submitted to GEPD in August 1998.

Prior to the IM, three field investigations had been conducted at SWMU 13. Based on the analytical results obtained from these studies and confirmatory sampling done as part of the IM, the GEPD instructed the Fort Stewart Directorate of Public Works to conduct an RFI at the site.

Subsequent to the RFI, supplemental field investigations were performed in 2001/2002 and an interim removal action was conducted. During the interim removal action, a 20 feet by 8 feet, 8-inch-thick concrete pad was removed, along with 337 tons of soil and the groundwater monitoring well MW12.

The revised final Phase II RFI Report (SAIC 2000) concluded that surface soil was contaminated with benzo(*a*)pyrene; groundwater was contaminated with benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene; and arsenic and chromium were listed as contaminant migration constituents of concern (CMCOCs) based on their potential to migrate (leach) to groundwater. Upon evaluation of new data from the supplemental investigations, benzene was also identified as a CMCOC.

This CAP evaluates the constituents of concern (COCs) and alternatives for achieving the remedial levels presented in this report for the COCs. The feasibility of applicable remedial technologies is analyzed, and then a conceptual design and implementation plan for the selected corrective action are presented.

RESULTS OF THE RFI

The RFI field investigations were conducted at the former FTA from November 2, 1998, through January 26, 1999. Chapter 5.0 of the revised final Phase II RFI Report (SAIC 2000) summarizes the results.

Contaminant Nature and Extent

Contamination is present in both soil and groundwater at SWMU 13. Site-related constituents (SRCs) were identified by comparing inorganic chemical concentrations to reference background concentrations. All organic chemicals that were detected were considered site-related.

SRCs for surface soil are benzo(*a*)anthracene, benzo(*b*)fluoranthene, benzo(*k*)fluoranthene, benzo(*a*)pyrene, chrysene, fluoranthene, pyrene, and barium. These chemicals were identified in only one of three surface soil samples taken during the Phase II RFI sampling. The location of this sample was adjacent to an area of weathered and corroded asphalt pavement. SRCs for subsurface soil identified as part of this RFI sampling include those listed above for surface soils plus anthracene, benzo(*g,h,i*)perylene, indeno(*1,2,3-cd*)pyrene, phenanthrene, chromium, and lead. Additional subsurface soil SRCs were identified from samples taken as part of the IM confirmatory sampling. These are acenaphthene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, arsenic, and mercury. SRCs for groundwater are benzene, toluene, ethylbenzene, and total xylenes (BTEX), fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene.

The areal extent of groundwater contamination determined during the RFI was limited to approximately 1 acre, and there was evidence that contaminant biodegradation is taking place in groundwater at the site.

Contaminant Fate and Transport

SRCs identified in surface and subsurface soil were compared to their respective U.S. Environmental Protection Agency (EPA) generic soil screening levels (GSSLs) to assess their potential migration pathways and transport mechanisms (i.e., the leachability of contaminants from soil to groundwater). Based on the soil screening analysis, benzene, 4-methyl-2-pentanone, benzo(*a*)anthracene, benzo(*b*)fluoranthene, dibenzo(*a,h*)anthracene, 2-methylnaphthalene, arsenic, and chromium exceeded their respective EPA GSSLs and were indicated as contaminant migration constituents of potential concern (CMCOPCs) in soil.

Fate and transport modeling was performed to quantitatively assess the risks associated with exposure to the CMCOPCs in soil. Only groundwater modeling was performed, as surface water is not present at this site and the nearest surface water receptor is located 2,500 feet from the site.

The Seasonal Soil Compartment (SESOIL) Model was used to predict the maximum groundwater concentration of the CMCOPCs based on contaminant migration from the site soil.

The following summarizes the conclusions from the SESOIL modeling:

- The five preliminary organic CMCOPCs identified in the revised final RFI [4-methyl-2-pentanone, benzo(*a*)anthracene, benzo(*b*)fluoranthene, dibenzo(*a,h*)anthracene, and 2-methylnaphthalene] either naturally attenuate before reaching the water table or the predicted groundwater concentrations do not exceed their respective risk-based concentrations (RBCs). However, benzene, an additional preliminary CMCOPC identified based on supplemental data, is predicted to reach the water table with concentrations exceeding its maximum contaminant level (MCL)/RBC. Therefore, benzene is identified as a CMCOC.

- Arsenic and chromium were identified as CMCOCs as their maximum predicted concentrations at the surface of the groundwater table of 0.21 mg/L and 2.13 mg/L, respectively, exceeded their respective groundwater target concentrations (0.05 mg/L and 0.1 mg/L). These maximum groundwater concentrations of arsenic and chromium are predicted to be reached after 135 years and 67 years, respectively. Based on the groundwater velocity of 14 feet/year, arsenic and chromium will take over 15,000 years to migrate to the nearest potential surface water receptor (Peacock Creek).

SUPPLEMENTAL SOIL AND GROUNDWATER CHARACTERIZATION

December 2000

Based on the results of the revised final RFI report, supplemental characterization of the groundwater at the former FTA (SWMU 13) was performed in December 2000 in support of this CAP. The scope of work included sampling of the eight existing on-site monitoring wells (MW3, MW4, MW8, MW9, MW10, MW11, MW12, and MW13) and analyzing the samples for BTEX and PAHs.

The results of the supplemental groundwater investigation were as follows:

1. Benzene (9.5 μg/L in MW11 and 418 μg/L in MW12) and ethylbenzene (952 μg/L in MW12) were the only BTEX compounds that continued to exceed their respective MCLs of 5 μg/L and 700 μg/L, respectively, in the shallow aquifer near the source. The presence of benzene and the other BTEX compounds is consistent with the results of the November 1998 sampling event. The December 2000 sampling event indicated that the dissolved benzene groundwater plume covers an area of approximately 10,992 square feet, which is smaller than the 30,225-square-foot area observed in November 1998.

2. Naphthalene continued to be detected in MW11, MW12, and MW13. The naphthalene concentration of 304J μg/L in MW12 exceeded the remedial level of 149 μg/L. Other PAHs, including fluorene and phenanthrene, were also reported during the December 2000 sampling event.

April 2001

Six groundwater monitoring wells (MW14 through MW19) were installed at the former FTA in April 2001. During well installation activities, subsurface soil samples were collected from each of the six well locations and were analyzed for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). None of the VOCs or SVOCs detected exceeded EPA’s Region III Industrial or Residential risk-based criteria.

June 2002

In June 2002, SAIC sampled five groundwater monitoring wells (MW13, MW15, MW16, MW18, and MW19) to determine the current concentrations of benzene. The groundwater samples were analyzed for BTEX parameters. Benzene concentrations ranged from 3.6 μg/L at MW13 (compared to 120 μg/L detected during the RFI) to 120 μg/L at MW16, a new groundwater monitoring well.

INTERIM ACTIONS

In 1997, CAPE Environmental performed interim measures (IMs) at the former FTA (SWMU 13). The intent of the IM was to remove and properly dispose of the fire training facilities, which included the aboveground storage tank (AST), the mock aircraft with associated foundations and piping, the concrete fire training pad and cover soils, the concrete oil/water separator sump and appurtenances, and soil and sediments which exceeded the Preliminary Cleanup Targets (PCTs). Approximately 2,450 tons of contaminated soil was excavated. After removing the fire training facilities and contaminated soil [to approximately 4 feet below ground surface (bgs)] and completing the confirmatory sampling, the excavated area was backfilled with clean soil and seeded.

In December 2001/February 2002, Earth Tech, Inc., conducted an interim removal action (IRA) at SWMU 13. The purpose of the IRA was to remove an 8-inch concrete pad, which covered a 20 feet by 8 feet area. The IRA also included the removal of approximately 337 tons of soil and the removal of monitoring well MW12.

HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment performed during the Phase II RFI included a human health preliminary risk evaluation (HHPRE) and a baseline human health risk assessment (BHHRA).

The HHPRE in the revised final Phase II RFI Report (SAIC 2000) identified human health constituents of potential concern (HHCOPCs) as those constituents present at concentrations higher than their reference background criteria and higher than their respective risk-based or applicable or relevant and appropriate requirement-based screening criteria. New data have become available as a result of supplemental investigations since the RFI; therefore, the selection of HHCOPCs was conducted for this CAP using the same method and screening criteria presented in the RFI. Based on this screening, the following HHCOPCs were identified for SWMU 13:

Surface Soil COPCs	**Subsurface Soil COPCs**	**Soil CMCOPCs**	**Groundwater COPCs**
Benzo(*a*)pyrene	Arsenic Benzo(*a*)anthracene Benzo(*a*)pyrene Benzo(*b*)fluoranthene Benzo(*g,h,i*)perylene Dibenzo(*a,h*)anthracene Phenanthrene	Arsenic Chromium Benzene	Benzene Ethylbenzene Toluene Xylenes, total 2-Methylnaphthalene Naphthalene Phenanthrene

COPC = Constituent of potential concern.

A BHHRA was performed to assess the HHCOPCs in soil and groundwater and CMCOPCs in soil in the revised final Phase II RFI Report (SAIC 2000). Benzo(*a*)pyrene was identified as a COC in surface soil with a remedial level of 0.98 mg/kg. Arsenic, benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, and dibenzo(*a,h*)anthracene were identified in the revised final RFI Report as constituents of potential concern in subsurface soil; however, SESOIL modeling results indicate that most of the constituents [benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, and dibenzo(*a,h*)anthracene] will naturally attenuate before reaching the water table. Toxicity data were not available for benzo(*g,h,i*)perylene; therefore, it was not included in the BHHRA.

Of the HHCOPCs in groundwater, benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene in groundwater were identified as human health constituents of concern. The MCLs for benzene and ethylbenzene of 0.005 mg/L and 0.7 mg/L, respectively, were recommended as the remedial levels for these constituents. MCLs were not available for 2-methylnaphthalene or naphthalene; therefore, remedial levels for these constituents were recommended based on risk-based criteria (142 μg/L and 149 μg/L, respectively). (Refer to Section 7.0, of the revised final Phase II RFI report.)

Arsenic and chromium were identified as CMCOCs in the revised final RFI Report, and remedial levels for soil for protection of groundwater were developed. Based upon a review of supplemental data, benzene was added as a CMCOC, and remedial levels for soil for protection of groundwater are developed in this CAP. The remedial levels for CMCOCs were developed based on the soil concentration that was unlikely to leach into groundwater or migrate to surface water in concentrations that would present a significant threat to human health. Because there are no surface water bodies at SWMU 13, the remedial levels in soil were based on target groundwater concentrations. These target groundwater concentrations were based on MCLs or RBCs if no MCL was available. These target groundwater concentrations are the concentrations of a CMCOC in groundwater, as a result of leaching from soil, that would present a defined risk (carcinogenic and/or noncarcinogenic) to the most sensitive receptor (e.g., on-site resident or resident child). For the two metals, the preliminary remedial levels calculated were below the reference background concentrations (8.04 mg/kg for arsenic and 40.4 mg/kg for chromium); therefore, the reference background concentration for each constituent was recommended as the remedial level. The remedial level for benzene in soil (0.014 mg/kg) was back-calculated based on the groundwater MCL for benzene.

ECOLOGICAL RISK ASSESSMENT

An ecological preliminary risk evaluation was conducted during the Phase II RFI. Barium was detected above reference background criteria in surface soil at SWMU 13 but was below the ecological screening values (ESVs) and was, therefore, not retained as an ecological constituent of potential concern (ECOPC) in surface soil. Benzo(*a*)anthracene, benzo(*b*)fluoranthene, benzo(*k*)fluoranthene, chrysene, fluoranthene, and pyrene were detected in surface soil above reference background criteria. However, there is uncertainty as to whether these six polynuclear aromatic hydrocarbons (PAHs) are ECOPCs in surface soil, because toxicity data specific to these constituents were not available. These six PAHs were detected in only one surface soil sample that was adjacent to weathered and eroded asphalt. It is likely that this lone sample incorporated some of the asphalt, which resulted in the reported concentrations. All PAHs detected were at low concentrations and are unlikely to pose a risk to ecological receptors given the low concentrations relative to their proposed toxicity reference values (TRVs), which are one-tenth the TRV for benzo(*a*)pyrene. Therefore, no organic ECOPCs were identified in surface soil.

Based on preliminary risk calculations, ethylbenzene, total xylenes, and naphthalene were identified as ECOPCs in groundwater. The risk to ecological receptors from ECOPCs in groundwater at SWMU 13 are overestimated by the ESV comparison and preliminary risk calculations. The nearest surface water to SWMU 13 is Peacock Creek, which is 2,500 feet away. If dilution and degradation, before or after discharge, reduces the concentration of ECOPCs by a factor of 10, none of the maximum concentrations would exceed the ESVs for surface water. Supplemental risk calculations performed to evaluate ecological receptors exposed to ethylbenzene, total xylenes, and naphthalene in groundwater showed that these constituents are unlikely to pose a risk to wildlife receptors. The revised final Phase II RFI Report (SAIC 2000) concluded that there was no present ecological risk at SWMU 13 and that the site was unlikely to pose an ecological risk in the future.

SUPPLEMENTAL MODELING FOR EVALUATING NATURAL ATTENUATION MODELING

Fate and transport modeling was performed for the identified COCs to predict their concentration with distance from the source and also the time to achieve the remedial levels.

Benzene was selected as the surrogate chemical from the COCs benzene and ethylbenzene in groundwater because benzene has a slower degradation rate and higher mobility than ethylbenzene. The results of this modeling indicate that the benzene concentration in groundwater does not exceed its remedial level of 5 μg/L beyond 100 feet from the source. Therefore, benzene from the SWMU 13 site is not expected to be of potential concern at the nearest receptor location [i.e., Peacock Creek (2,500 feet from the source)]. In addition, the modeling shows that benzene concentrations at the source will be reduced to less than its remedial level by natural attenuation processes within 5 years from the time of sampling (June 2002).

The modeling shows that the time frame for natural attenuation of benzene to the MCL decreases from approximately 5 years to less than 3 years if the benzene source in the groundwater is reduced to 50 μg/L.

The other groundwater COC, ethylbenzene, could be remediated by natural attenuation alone. The benzene (considered as the surrogate chemical for ethylbenzene) concentration is expected to be reduced to half of its original concentration in 2 years. If ethylbenzene were reduced to half of its maximum detected concentration of 952 μg/L, it would be below its remedial level of 700 μg/L within 2 years (from June 2002). Therefore, monitoring alone is recommended for ethylbenzene.

Modeling results for naphthalene (considered as the surrogate chemical for 2-methylnaphthalene) indicate that the concentration in groundwater is not expected to exceed its remedial level (149 μg/L) beyond 55 feet of the source. Additionally, the source will be reduced to its remedial level within 3 years from December 2000 (or 1.5 years from June 2002).

JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION

The purpose of corrective action is to (1) protect human health and the environment, (2) attain remedial levels, (3) control the source of the releases, (4) comply with any applicable waste management standards, and (5) address other factors.

COCs were identified in the revised final RFI Report for surface soil, subsurface soil, and groundwater (SAIC 2000). New data have become available as a result of supplemental investigations performed after the RFI. One new CMCOC in soil (benzene) was identified as a result of the supplemental investigations. The remedial levels presented in the RFI remain applicable; however, an additional remedial level has been derived in this CAP for the new CMCOC, benzene. The COCs and their respective remedial levels are discussed in the following paragraphs and are shown in Tables ES-1 through ES-3.

Surface Soil

Benzo(*a*)pyrene was identified as a COC for surface soil based on direct exposure. Benzo(*a*)pyrene was detected in only one sample at a concentration of 390 μg/kg. This sample was collected from an area adjacent to weathered and eroded asphalt pavement. It is reasonable to expect that some asphalt fragments eroded from the weathered pavement could have been incorporated into the sample during the collection and, thus, biased the sample results. Based on the low frequency of detection of benzo(*a*)pyrene in surface soil, the likely biased nature of the one detectable result, and the fact that the maximum detected concentration of benzo(*a*)pyrene in surface soil is less than the remedial level (Table ES-1), no remediation for surface soil is recommended.

Table ES-1. Remedial Levels for COCs in Surface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Surface Soil Remedial Level (μg/kg)	Maximum Soil Concentration (μg/kg)	Recommendation
Benzo(*a*)pyrene	980	390	No further investigation/action is required as the maximum concentration is less than the remedial level.

Subsurface Soil

Arsenic and chromium were identified as CMCOCs based on the exposure of the future on-site groundskeeper, future off-site installation worker, future on-site resident child, and future on-site resident adult being exposed to leaching from soils to groundwater.

Arsenic was detected in 43 of 64 samples ranging from 1.1 mg/kg to 10.4 mg/kg with an average result of 2.46 mg/kg. The reference background concentration of 8.04 mg/kg exceeded the RBC of 3.8 mg/kg and indicates that arsenic naturally occurs at levels greater than its RBC throughout the FSMR. None of the RFI samples had arsenic concentrations that exceeded its remedial level. From the IM data, two samples from the same borehole exceeded the remedial level [location SA-21 at 2 feet bgs (10.4 mg/kg) and at 3 feet bgs (9 mg/kg)]. At this location, soils to a depth of 2 feet bgs were excavated during the IM. Due to the ubiquitousness of arsenic at the FSMR, and the fact that none of the RFI samples exceeded the reference background concentration, remediation of subsurface soil for arsenic is not recommended.

Table ES-2. Remedial Levels for CMCOCs in Subsurface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Subsurface Soil Remedial Level (mg/kg)	Maximum Soil Concentration (mg/kg)	Recommendation
Arsenic	8.04	10.4	No further investigation/remedial action is recommended due to its ubiquitous nature at this site and the fact that none of the RFI samples had concentrations exceeding the remedial level (background concentration).
Chromium	11.6	40.4	No further investigation/remedial action is recommended due to its ubiquitous nature at this site and the fact that chromium is not expected to migrate to the nearest surface water.
Benzene	0.014	0.24	No further investigation/remedial action is recommended. Based on the modeling results, it can be concluded that the concentration of benzene in the subsurface soil will be reduced to its soil remedial level through natural attenuation before the groundwater concentration is reduced to its groundwater remedial level for benzene.

Chromium was detected in all 64 subsurface soil samples ranging from 2.7 mg/kg to 40.4 mg/kg with an average result of 13.3 mg/kg. Chromium exceeded its remedial level (reference background criteria) of 11.6 mg/kg in 31 of the 64 samples, all of which were from the IM data set. Based on the slow groundwater movement at the site (14 feet/year) and the high retardation factors, chromium and arsenic are not expected to migrate to the nearest surface water receptor, Peacock Creek, located 2,500 feet downgradient from the site. Due to the ubiquitousness of chromium at the FSMR and the fact that it is not expected to migrate to the nearest surface water receptor, remediation of subsurface soils for chromium is also not recommended.

Based on a review of data generated from supplemental investigations, benzene was also identified as a CMCOC as it is predicted to reach the water table with concentrations exceeding its respective MCL. The maximum predicted concentration of benzene based on leaching to groundwater will be reduced to its

MCL within 4 years from January 2002 (i.e., 3.5 years from June 2002). Therefore, it may be concluded that the soil concentration of benzene will be reduced to its soil remedial level before the groundwater concentration is reduced to its groundwater remedial level at the site. Based on this information, no remediation of subsurface soil for benzene is recommended.

Groundwater

Remedial levels were developed in the revised final RFI Report for four groundwater COCs. These remedial levels are based on MCLs and RBCs, which take into consideration both human health and technological limitations. No new COCs for groundwater were identified as a result of the supplemental investigations; therefore, the remedial levels derived in the revised final RFI remain applicable. These remedial levels shown in Table ES-3 are protective of direct exposure to residents by hazardous constituents in groundwater. However, it is recognized that groundwater is not used at this site as a source of drinking water and that it will take approximately 178 years for groundwater to reach the nearest receptor at Peacock Creek, which is 2,500 feet from SWMU 13. These constituents will naturally attenuate in groundwater through retardation and biodegradation before reaching Peacock Creek. As the maximum detected concentration of 2-methylnaphthalene in the RFI samples was below the recommended remedial level; no further investigation or study is required to address this constituent in groundwater.

Table ES-3. Remedial Levels for COCs in Groundwater at the Former Fire Training Area (SWMU 13)

Analyte	Groundwater Remedial Level (μg/L)	Maximum Concentration in RFI Sampling (μg/L)	Maximum Concentration in December 2000 Sampling (μg/L)	Maximum Concentration in June 2002 Sampling (μg/L)	Recommendation
Benzene	5	440	418	120	Corrective measures are recommended
Ethylbenzene	700	940	952	486	Corrective measures are recommended
2-Methylnaphthalene	142	72	NA	NA	No further investigation/remedial action is recommended as the maximum detected concentration is below the remedial level
Naphthalene	149	140	304 J	NA	Corrective measures are recommended

J = Indicates compound was positively identified; the numerical value is the approximate concentration of the compound in the sample.
COC = Constituent of concern.
NA = Not analyzed.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA facility investigation.
SWMU = Solid waste management unit.

The remedial response objectives for SWMU 13 are to reduce the present concentrations of the site COCs (benzene, ethylbenzene, and naphthalene) in groundwater to the remedial levels presented in this CAP. The corrective action is to provide the technology necessary to minimize levels of contamination and to achieve the best overall results with respect to such factors as effectiveness, implementability, and cost.

SCREENING OF CORRECTIVE ACTION ALTERNATIVES

Several technologies for remediating petroleum-related contamination in groundwater were identified and screened. Technologies applicable to general response actions (no action, institutional controls, monitored natural attenuation, and active source remediation) were identified and evaluated with respect to their suitability in meeting the remedial response objectives. Technologies were screened using three evaluation criteria: effectiveness, implementability, and cost.

The "no action" alternative was not considered to be viable due to the need to ensure that the remedial levels for the site are being met. Institutional controls were not considered further as the sole remedial alternative because they are appropriate for this site only when combined with other technologies such as monitored natural attenuation.

Each of the following alternatives for petroleum-contaminated groundwater was considered to be applicable to the site, cost-effective, and implementable; therefore, two primary evaluation factors were used in the selection of the preferred corrective action alternative: time to implement and life-cycle cost. The time required to implement the action was an important evaluation factor for this site; the alternative would remediate the COCs to below the remedial levels in a reasonable time compared to the other alternatives. Life-cycle cost estimates are budget estimates based on conceptual design and are not adjusted to present worth costs or for escalation.

The following five corrective action alternatives were evaluated for the groundwater contamination at SWMU 13:

- Alternative 1: monitored natural attenuation,
- Alternative 2: air sparging,
- Alternative 3: oxygen injection,
- Alternative 4: air sparging and monitored natural attenuation, and
- Alternative 5: oxygen injection and monitored natural attenuation.

CONCEPTUAL DESIGN AND IMPLEMENTATION PLAN

Justification of Selection

Monitored natural attenuation, has been selected as the most appropriate corrective action for the groundwater COCs at SWMU 13 based on its reasonable time frame to achieve remedial levels (less than 7 years) and cost effectiveness. Historical groundwater results at the site show that concentrations of benzene in groundwater are decreasing. The site will be monitored during the 6-year natural attenuation period to ensure that concentrations of benzene and other COCs in the groundwater meet the remedial levels.

Conceptual Design

Baseline groundwater sampling would be conducted at the start of the remediation period and would consist of sampling seven monitoring wells (MW3, MW9, MW10, MW15, MW16, MW17, MW18, and MW19). The groundwater monitoring wells will be sampled and analyzed for VOCs, SVOCs, and natural attenuation parameters (nitrate/nitrite, sulfate/sulfide, total iron, total phosphorous, carbon dioxide, and methane).

Performance monitoring will be performed annually during the natural attenuation period. Performance monitoring will involve sampling of seven existing groundwater monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19). The groundwater samples will be analyzed for VOCs, SVOCs, and natural attenuation parameters.

One year following the completion of the monitored natural attenuation period, confirmatory groundwater sampling will be conducted to verify that the remedial levels for benzene and other COCs have been met and maintained. The confirmatory groundwater sampling will be the same as the baseline groundwater sampling, and the same seven existing monitoring wells will be sampled.

The life-cycle cost to implement monitored natural attenuation is approximately $244,000. The alternative will take approximately 7 years to complete from the baseline sampling through the confirmatory sampling.

Implementation Plan

Upon approval of this CAP by GEPD, the Installation will request funding, procure a contractor to implement the corrective action, and implement the specified action. A Corrective Action Work Plan will be prepared to guide implementation of the corrective action but will not require GEPD review or approval. Any revisions required to the Operation and Maintenance Plan or the implementation schedule that become apparent during preparation of the Work Plan will be submitted to GEPD for concurrence. Substantive changes in the remediation approach or schedule will require that the public be provided with an opportunity for review and comment in accordance with the Fort Stewart Hazardous Waste Facility Permit. No other submittals will need to be provided to GEPD prior to implementation of the selected corrective action.

During the corrective action, Corrective Action Plan Progress Reports will be prepared and submitted to GEPD for review and approval. Upon completion of the corrective action, a Corrective Action Completion Report will be prepared and submitted to GEPD for review and approval.

1.0 INTRODUCTION

1.1 SCOPE OF THE CORRECTIVE ACTION PLAN

A Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) has been completed for the former Fire Training Area (FTA) at Wright Army Airfield (WAAF), solid waste management unit (SWMU) 13, at Fort Stewart, Georgia. The revised final RFI Report (SAIC 2000) submitted to the Georgia Environmental Protection Division (GEPD) on May 22, 2000, recommended submittal of a Corrective Action Plan (CAP) for this site.

The following conclusions and recommendations were made based on the results of the Phase II RFI:

1. No perennial surface water bodies are located within 2,500 feet of SWMU 13.

2. No ecological constituents of concern (COCs) were identified.

3. Benzo(*a*)pyrene was identified as a COC in surface soil with a remedial level of 0.98 mg/kg.

4. Groundwater at this site is not currently being used for any purpose, and groundwater does not discharge to any nearby surface waters. Benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene are considered to be COCs in groundwater. The maximum contaminant levels (MCLs) for benzene and ethylbenzene of 0.005 mg/L and 0.7 mg/L, respectively, were set as the remedial levels for these constituents. MCLs were not available for 2-methylnaphthalene or naphthalene; therefore, remedial levels for these constituents were recommended based on risk-based criteria (142 μg/L and 149 μg/L, respectively).

5. Remedial levels were derived for the contaminant migration constituents of concern (CMCOCs) in soil (arsenic and chromium) based on the protection of groundwater from potential leaching from soil. The remedial level for a CMCOC represents a soil concentration that is unlikely to leach into groundwater or migrate to surface water in concentrations that would present a significant threat to human health. The potential risk associated with the CMCOCs is not direct exposure to soil, but exposure to the constituents in groundwater; therefore, the soil remedial levels were based on target groundwater concentrations. Soil remedial levels for CMCOCs are derived based on the concentration of the constituents in soil that will not leach into the groundwater at unacceptable levels. The preliminary remedial levels calculated were below the reference background concentrations for these two metals (8.04 mg/kg for arsenic and 40.4 mg/kg for chromium); therefore, the reference background concentration for each constituent was recommended as the remedial level.

6. The nature and extent of groundwater contamination at this site was determined during the Phase II RFI activities, and the information gathered is sufficient for development of a CAP.

7. A CAP is required to evaluate remedial measures to mitigate the COCs at SWMU 13.

This CAP report utilizes information from the RFI and the supplemental soil and groundwater data (see Section 2.11.1) to evaluate institutional controls and various remedial actions for achieving the remedial levels proposed in the revised final RFI Report (SAIC 2000) and in this CAP. This report analyzes the feasibility of applicable remedial actions and monitored natural attenuation on a site-specific basis while addressing the requirements contained in the Fort Stewart Hazardous Waste Facility Permit (Georgia Environmental Division Permit No. HW-045), as renewed in August 1997.

This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers, Savannah District, under Contract No. DACA21-95-D-0022, Delivery Order 0049.

1.2 SITE BACKGROUND

A RCRA facility assessment (RFA) was submitted to the GEPD in June 1990 that listed 24 SWMUs, including SWMU 13, as requiring further investigation (Geraghty and Miller 1992). SWMU 13 is located in the northwest periphery of WAAF, which is in the southern portion of the Fort Stewart Military Reservation (FSMR). SWMU 13 was used as a training area for the airfield's firefighters. SWMU 13 was not included in the Final Phase I RFI Report prepared in response to the RFA. Thus, Fort Stewart contracted with Rust Environmental (now Earth Tech) to perform an RFI at SWMU 13. The RFI report was submitted to GEPD in September 1999. Comments on the RFI report were received from GEPD in correspondence dated February 4, 2000. The RFI report was revised to incorporate GEPD comments, and the revised final RFI Report was submitted to the GEPD in May 2000.

In 1997, CAPE Environmental performed interim measures (IMs) at the former FTA (SWMU 13). The intent of the IM was to remove and properly dispose of the fire training facilities, which included the aboveground storage tank (AST), the mock aircraft with associated foundations and piping, the concrete fire training pad and cover soils, the concrete oil/water separator sump and appurtenances, and soil and sediments which exceeded the Preliminary Cleanup Targets (PCTs). Approximately 2,450 tons of contaminated soil was excavated. After removing the fire training facilities and contaminated soil [to approximately 4 feet below ground surface (bgs)] and completing the confirmatory sampling, the excavated area was backfilled with clean soil and seeded. The IM is described in the *Final Interim Measures Report for SWMU 13*, dated April 1998, submitted to GEPD in August 1998 (CAPE 1998). The activities performed during the IM and the results of the sampling and analysis are summarized in Section 2.8.1.

Prior to the IM, three site investigations had been conducted at SWMU 13. Based on the analytical results obtained from these studies and the confirmatory sampling done as part of the IM, the GEPD instructed the Fort Stewart Directorate of Public Works (DPW) to conduct an RFI at the site. The objectives of the RFI for SWMU 13, as defined in the Work Plan approved by GEPD in April 1998, were as follows:

- determine the horizontal and vertical extent of contamination,
- determine whether contaminants present a threat to human health or the environment,
- determine the need for future action and/or no further action, and
- gather necessary data to support development of a CAP, if warranted.

The scope of the RFI fieldwork included the following activities:

- Collection of soil samples using direct-push technology (DPT) at 12 locations. Soil samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and RCRA metals.

- Collection of groundwater screening samples using DPT at 23 locations, including three vertical profile probes. Direct-push groundwater samples were analyzed for VOCs and SVOCs.

- Installation of six permanent groundwater monitoring wells, both cross-gradient and downgradient of the site. One soil sample was collected from each well borehole and analyzed for VOCs, SVOCs, and RCRA metals.

- Collection of groundwater samples from each of the new and existing monitoring wells for a total of 10 groundwater samples. Groundwater samples were analyzed for VOCs, SVOCs, and RCRA metals.

- Collection of surface soil samples at a total of three locations at the site for VOCs, SVOCs, and RCRA metals.

The results of the RFI fieldwork are discussed in Chapter 2.0.

Additional investigations have been conducted at SWMU 13 since the RFI was published. Supplemental groundwater sampling was conducted in December 2000, to support the development of this CAP. The scope of work for the supplemental characterization included sampling eight on-site groundwater monitoring wells (MW3, MW4, and MW8 through MW13) and analyzing the samples for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and polynuclear aromatic hydrocarbon (PAH) parameters. Results of the December 2000 sampling and analysis are presented in Section 2.7.2.1.

Additional soil sampling was conducted in April 2001 during the installation of six new groundwater monitoring wells (MW14 through MW19). During this sampling event, subsurface soil samples were collected from the six locations and analyzed for VOCs and SVOCs. Results of the April 2001 sampling and analysis are presented in Section 2.7.2.2.

In December 2001/February 2002, Earth Tech, Inc., conducted an interim removal action (IRA) at SWMU 13. The purpose of the IRA was to remove an 8-inch concrete pad, which covered a 20 feet by 8 feet area. The IRA also included the removal of approximately 337 tons of soil and the removal of monitoring well MW12. Six confirmatory samples were collected following removal activities and analyzed for VOCs and SVOCs. The IRA is described in the *Final Interim Action Report, Former Fire Training Area at WAAF (SWMU 13) at Fort Stewart, Georgia* (Earth Tech 2002) The activities performed during the IRA and the results of the sampling and analysis are summarized in Section 2.8.2.

In June 2002, SAIC sampled five groundwater monitoring wells (MW13, MW15, MW16, MW18, and MW19) to determine the current concentrations of benzene. The groundwater samples were analyzed for BTEX parameters. The results of the June 2002 sampling and analyses are presented in Section 2.7.2.3.

1.3 REGULATORY BACKGROUND

The regulatory authority governing the action at SWMU 13 is the RCRA 40 *Code of Federal Regulations* (*CFR*) 264, Title II, Subpart C, Section 3004 (42 U.S. Code 690 et seq.). With the promulgation of RCRA and the subsequent approval of the Georgia Hazardous Waste Management Act by the U.S. Environmental Protection Agency (EPA), the State was granted RCRA permitting authority. In accordance with RCRA, the State issued to Fort Stewart, in August 1987, a Hazardous Waste Facility Permit (Georgia Environmental Division Permit No. HW-045). This permit was renewed in August 1997.

The former FTA at WAAF (SWMU 13) is a listed SWMU in Fort Stewart’s Subpart B Permit and, therefore, is subject to investigation according to Title 40, *CFR* Part 264.101(c) and to corrective action (the subject of this CAP), if necessary.

1.4 REPORT ORGANIZATION

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

This report also contains five appendices. Appendix A provides the results of the supplemental sampling performed in December 2000. Appendix B contains groundwater monitoring well construction details for six wells that were installed in April 2001. Appendix C presents the detailed results of the fate and transport modeling. Appendix D contains the cost estimate summaries for the corrective action alternatives. Appendix E is an Operation and Maintenance (O&M) Plan for the selected corrective action for natural attenuation. Appendix F lists considerations for the selection of monitored natural attenuation for the groundwater contaminant plume, following the guidance of the Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P (EPA 1999a).

2.0 SITE CHARACTERIZATION

Fort Stewart (then known as Camp Stewart) was established in June 1940 as an anti-aircraft artillery training center. Between January and September 1945, the Installation operated as a prisoner-of-war camp. The Installation was deactivated in September 1945. In August 1950, Fort Stewart was reactivated to train anti-aircraft artillery units for the Korean Conflict. The training mission was expanded to include armor training in 1953. Fort Stewart was designated a permanent Army Installation in 1956, and became a flight training center in 1966. Aviation training at the Fort Stewart facilities was phased out in 1973. In January 1974, the 1st Battalion, 75th Infantry was activated at Fort Stewart. Fort Stewart then became a training and maneuver area, providing tank, field artillery, helicopter gunnery, and small arms training for regular Army and National Guard units. The 24th Infantry Division, which was reflagged as the 3rd Infantry Division in May 1996, was permanently stationed at Fort Stewart in 1975. These activities comprise the Installation's primary mission today.

The FSMR is located in portions of Liberty, Bryan, Long, Tattnall, and Evans Counties, Georgia, approximately 40 miles west–southwest of Savannah, Georgia (Figure 2-1). The cantonment, or garrison area, of the FSMR is located within the Liberty County portion of the FSMR on the southern boundary of the reservation. Hinesville, Georgia, is the nearest city to the garrison area and is located immediately outside of the reservation boundary.

2.1 SITE LOCATION AND HISTORY

WAAF is located in Liberty County, Georgia, within the confines of Fort Stewart, Georgia. The former FTA (now known as SWMU 13) is located on the northwest periphery of WAAF (see Figure 2-2), approximately 3,000 feet northwest of the control tower.

The former FTA consisted of a 5,000-square-feet concrete pad with an integral berm that was used by firefighting personnel for training. An oil/water separator sump, underground piping, and an aboveground fuel (JP-4) storage tank combined to make up the entire former FTA. All of these structures and appurtenances were removed during the IM conducted in 1997 by CAPE Environmental (Figure 2-3). The area is also mostly enclosed by a series of drainage swales. An asphalt roadway adjoins the former FTA to the south and east. The former FTA was used as a training area for the airfield's firefighters from its construction, prior to 1982, until 1992. During training exercises, fuel [water-contaminated jet fuel (JP-4), diesel fuel, or waste oil] was pumped onto the surface of a simulated aircraft and ignited. The fires were then extinguished with water and foam. The former FTA was constructed such that water and foam used during the training would be drained into the oil/water separator. Effluent water flowed to the western drainage swale, and the lighter-than-water portion (oil) was reportedly pumped by vacuum truck and disposed of at the Fort Stewart Industrial Wastewater Treatment Plant. Occasionally, some of the water (and fuel) would either be splashed onto adjacent soil or it would run over the concrete berm onto the adjacent soil.

During a training exercise, the fuel was pumped via a small pump brought on-site; thus, the system was not pressurized and there was no need for venting. It is suspected that the former FTA was constructed just like all others in the Army at the time (i.e., with the fuel risers); however, the fuel risers were not required for operation of the facility and were never used.

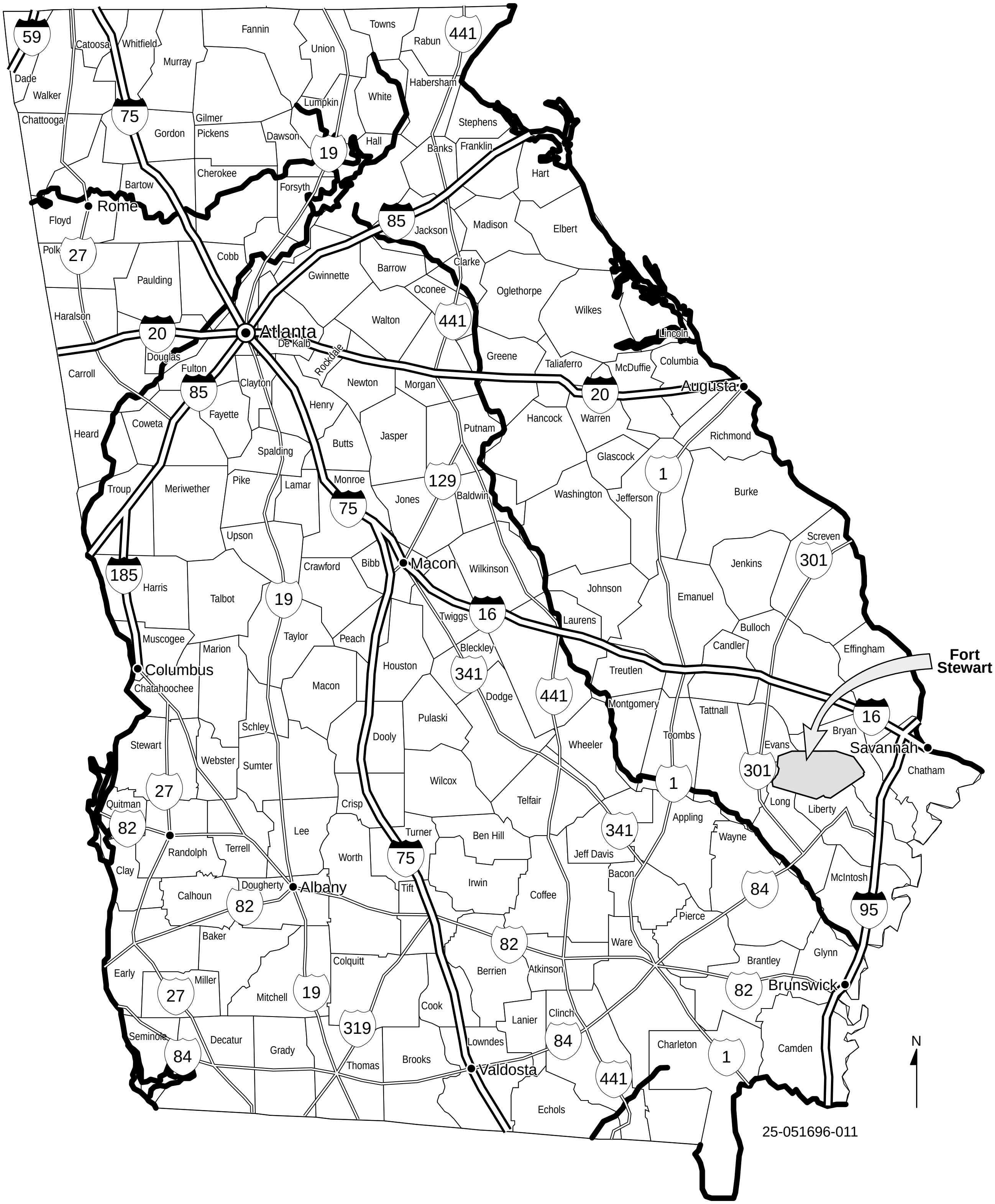
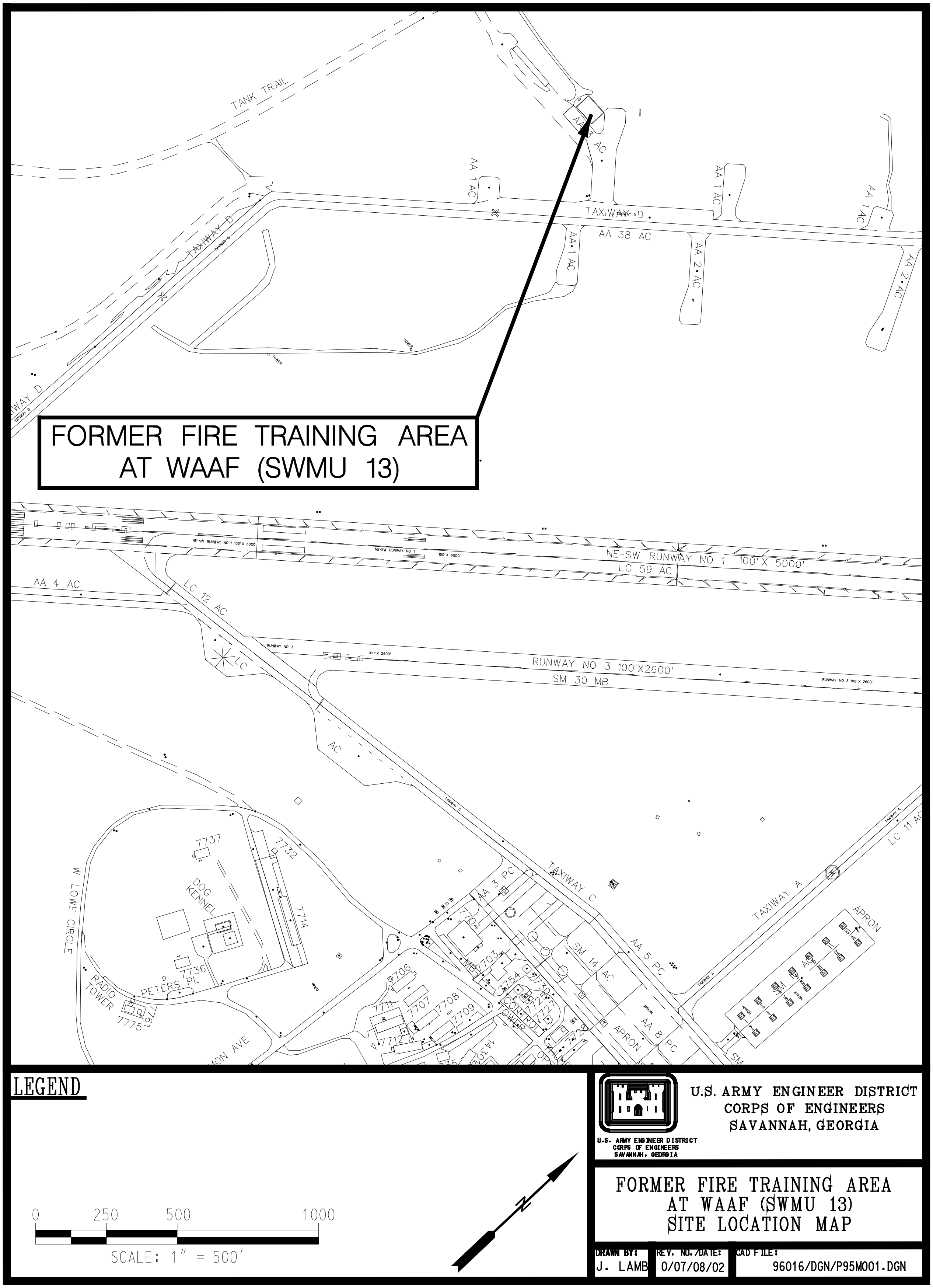


Figure 2-1. Location Map for Fort Stewart Military Reservation, Georgia



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SAVANNAH, GEORGIA

FORMER FIRE TRAINING AREA
AT WAAF (SWMU 13)
SITE LOCATION MAP

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Figure 2-2. Location of the Former Fire Training Area (SWMU 13)

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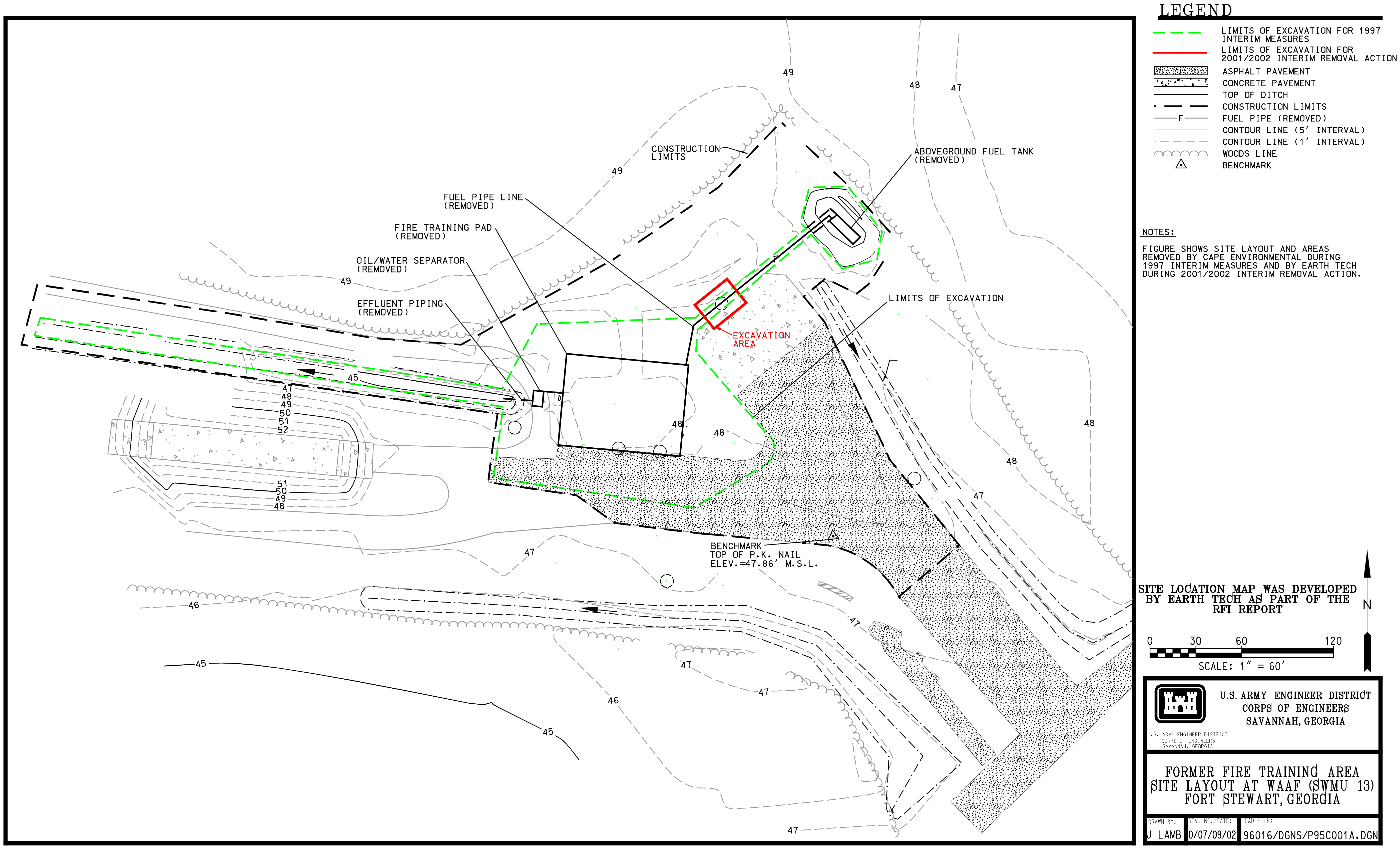


Figure 2-3. Layout of the Former Fire Training Area (SMWU 13)

2.2 TOPOGRAPHY/PHYSIOGRAPHY/CLIMATE

The FSMR occupies a low-lying, flat region in the coastal plain of Georgia. Surface elevations range from approximately 20 feet to 100 feet above mean sea level (amsl) within the FSMR and generally decrease from northeast to southeast across the Installation. Terraces dissected by surface water drainages dominate the topography. The terraces are remnants of sea level fluctuations. The four terraces present within the FSMR are the Wicomico, Penholoway, Talbot, and Pamlico (Metcalf and Eddy 1996).

The elevation of the former FTA site is approximately 45 feet amsl. The nearest surface water stream to the former FTA is Peacock Creek, which is located approximately 2,500 feet southeast (i.e., downgradient) of the site (SAIC 2000). The site has four shallow drainage swales located around it (north, south, east, and west). These swales are not connected to Peacock Creek or its tributaries. Standing water is present in these swales only after rain events, and the swales are dry during much of the year.

Fort Stewart has a humid, subtropical climate with long, hot summers. Average temperatures range from 50°F in the winter to 80°F in the summer. Average annual precipitation is 48 inches, with slightly more than half falling from June through September. Prolonged drought is rare in the area, but severe local storms (tornadoes and hurricanes) do occur. Under normal conditions wind speeds rarely exceed 5 knots, but gusty winds of more than 25 knots may occur during the summer thunderstorms (Geraghty and Miller 1992).

2.3 SITE GEOLOGY

The FSMR is located within the coastal plain physiographic province. The province is typified by nine southeastward-dipping strata that increase in thickness from zero feet at the fall line (located approximately 160 miles inland from the Atlantic coast) to approximately 4,200 feet at the coast. State geologic records describe a probable petroleum exploration well (the No. 1 Jelks-Rogers) located in the region as encountering crystalline basement rocks at a depth of 4,254 feet bgs. This well provides the most complete record for Cretaceous, Tertiary, and Quaternary sedimentary strata.

The Cretaceous section is approximately 1,970 feet in thickness and dominated by clastics. The Tertiary section is approximately 2,170 feet in thickness and dominated by limestone with a 175-foot-thick cap of dark green phosphatic clay. This clay is regionally extensive and is known as the Hawthorn Group. The interval from approximately 110 feet to the surface is Quaternary in age and composed primarily of sand with interbeds of clay or silt. This section is undifferentiated (Metcalf and Eddy 1996).

State geologic records contain information regarding a well drilled in October 1942, 1.8 miles north of Flemington at Liberty Field of Camp Stewart (now known as Fort Stewart). This well is believed to be an artesian well located approximately one-quarter mile north of the runway at WAAF within the FSMR. The log for this well describes a 410-foot section, the lowermost 110 feet of which consisted predominantly of limestone above which 245 feet of dark green phosphatic clay typical of the Hawthorn Group were encountered. The uppermost 55-foot interval was Quaternary-age interbedded sands and clays. The top 15 feet of these sediments were described as sandy clay (Metcalf and Eddy 1996).

2.4 SITE SOILS

The surficial soils at the site are generally a dark yellowish-orange to light brown silty sand interbedded with sandy clay and clayey silty sand layers up to 20 feet to 25 feet thick. A pale yellowish-orange to light brown clay layer was encountered in boreholes MW10, MW11, and MW12 at 3 feet to 7 feet bgs. A greenish-gray silty sand was encountered at 27 feet bgs in MW7 and extended to the completion depth of 55 feet bgs. Geological cross-sections of the site depicting the lithology and stratigraphy of the unconsolidated soil deposits beneath the site, as inferred from the soil boring logs, are shown in Chapter 4.0 of the revised final RFI Report (SAIC 2000). Results of geotechnical analyses indicated that the soils tested are generally non-plastic silty sands. Soil from the screened intervals in monitoring wells MW9 and MW10 are non-plastic silty sands with permeability ranging from 1.17×10^{-3} cm/sec to 6.9117×10^{-4} cm/sec. Results of aquifer (slug) tests indicated hydraulic conductivities of 1.12×10^{-3} to 4.06×10^{-5} cm/sec in MW5 and MW7, respectively (ESE 1993).

2.5 SITE HYDROLOGY

2.5.1 Groundwater Hydrology

The uppermost hydrogeologic unit is the surficial aquifer, which ranges from 55 feet to 150 feet in thickness at the FSMR. Water levels measured during the RFI field activities for well development and sampling varied from the shallowest (3 feet) at MW1, to the deepest (10 feet) at MW5 located near the center of the former FTA. Groundwater flow within the water table varies from east–southeast to southeast, ultimately discharging to Peacock Creek approximately 2,500 feet from the site. The hydraulic gradient is approximately 0.004 foot/foot at the site. The calculated groundwater flow velocity averages approximately 14 feet/year toward Peacock Creek (SAIC 2000). (See Section 2.7 and Appendix A for additional details regarding groundwater flow and direction.)

2.5.2 Surface Water Hydrology

Peacock Creek is the nearest surface water stream to SWMU 13 and is located approximately 2,500 feet southeast of the site. The site has four shallow drainage swales located around it (north, south, east, and west). These swales are not connected to Peacock Creek or its tributaries. Standing water is present in these swales only after rain events and the water most likely infiltrates into the soil or evaporates. The drainage swales are dry during much of the year.

2.6 SITE ECOLOGY

Approximately 7.8 square miles of the 436.8 square miles at FSMR comprise the garrison area. The remainder is used for ranges and training areas (approximately 11 percent) or held as non-use areas.

Eighty-four percent of the land is forested (approximately 367.2 square miles). Sixty-six percent of the forest area is pine with the major species including the slash pine, loblolly pine, and longleaf pine. Thirty-four percent of the forest is composed of river bottom lands and swamps whose major species include the tupelo, other gum trees, water oak, and bald cypress trees. The open range and training areas comprise eleven percent of the Installation and consist of grasses, shrubs, and scrub tree (oak) growth.

Aquatic habitats on FSMR include a number of natural or man-made ponds and lakes, the Canoochee River, Canoochee Creek and tributaries, and a number of bottomland swamps and pools. The Ogeechee River borders the installation along its northeast boundary. Organic detritus content is high, and dark coloring of the water is not unusual. Dense growths of aquatic vegetation are also typical, especially during the summer months.

Both terrestrial and aquatic fauna are abundant in the unimproved areas of FSMR. Major game species found on the Installation include white-tailed deer, feral hog, wild turkey, rabbit, squirrel, and bobwhite in addition to numerous other mammal, bird, reptile, and amphibian species (ESE 1982). Dominant fish include bluegill, largemouth bass, crappie, sunfish, channel catfish, minnows, and shiners. Three federally listed threatened or endangered species reside at FSMR: the American bald eagle, Eastern indigo snake, and the red-cockaded woodpecker (SAIC 2000).

2.7 CONTAMINANT NATURE AND EXTENT

Several site investigations have been conducted at SWMU 13. These investigations include a Phase I and Phase II RFI, three supplemental investigations, an IM action, and an IRA. The following sections summarize the results of these investigations and activities.

2.7.1 Summary of the RFI Results

Results of chemical analyses performed during the Phase I and Phase II RFIs indicated that the soil and groundwater at the site contain organic and metal contaminants at concentrations greater than their reference background concentrations. No surface water is present at the site.

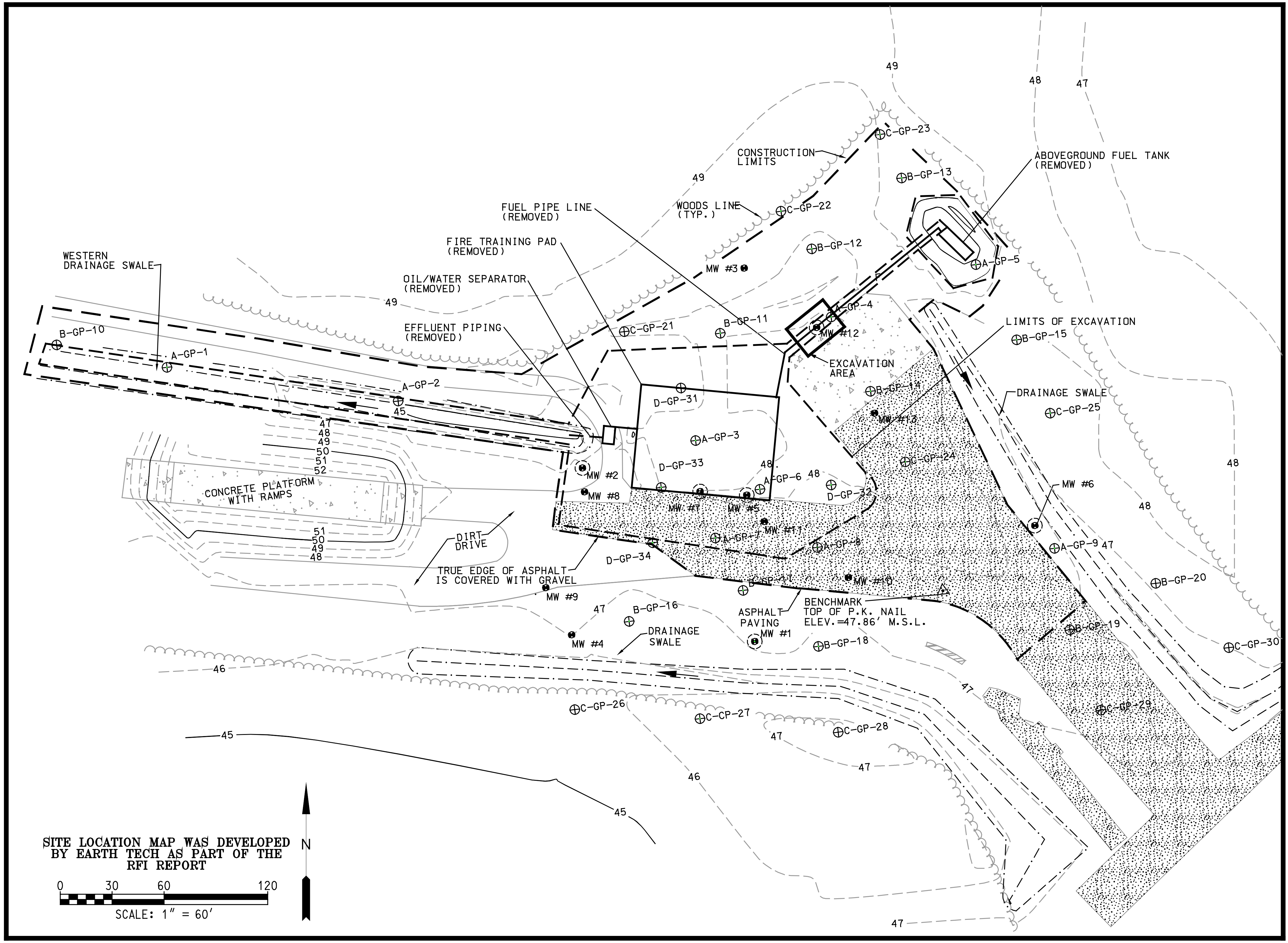
The referenced background criteria for SWMU 13 were developed based on data from background samples collected across the FSMR for SWMUs under the Phase I and/or Phase II RFIs. In general, reference background samples were collected in each medium at locations upgradient or upstream of each site so as to be representative of naturally occurring conditions at the SWMUs under investigation. In addition, soil samples collected during the Phase I RFI were included in the background data set if they were determined to come from upgradient of the site and to be of sufficient quality to be representative of natural background conditions at the FSMR. A summary of the reference background sample locations by medium at each SWMU and the source of data (Phase I and Phase II RFI analytical data) are presented in Appendix F, Table F.1 of the revised final RFI Report (SAIC 2000).

EPA Region IV methodology (EPA 1995a) was used as guidance for the development of the background data set for screening metals data. In cases in which enough samples (e.g., more than 20) are collected to define background, a background upper tolerance level can be calculated. In cases in which too few samples (e.g., fewer than 20) are collected to define background, background can be calculated as two times the mean background concentration (EPA 1995a). Given that fewer than 20 background samples were collected for the FSMR, the latter method was used for calculating reference background concentrations.

The reference background concentrations for surface soil, subsurface soil, and groundwater were calculated as two times the average concentration of all of the locations selected to be in the background data set. If a chemical was not detected at a site, then one-half the detection limit was used as the concentration when calculating the reference mean background concentration.

Appendix F of the revised final RFI Report (SAIC 2000) presents a summary of the background data as well as the two-times-mean background concentrations. Given the limited background data, the mean concentration established by the U.S. Geological Survey for soil in the eastern United States (USGS 1984) is also presented for comparative purposes. Because of the limited number of background samples, the screening value for background may be heavily skewed as a result of an outlier in the sampling data.

The nature and extent of contamination based on the Phase I and Phase II RFI data is summarized below. RFI sample locations are shown on Figure 2-4.



LEGEND

A-GP-12 ⊕	GEOPROBE SAMPLING LOCATIONS
— — —	LIMITS OF EXCAVATION
MW #2 ⊙	MONITORING WELL (DAMAGED OR NO LONGER EXISTING)
MW #4 ●	MONITORING WELL
▨	ASPHALT PAVEMENT
▨	CONCRETE PAVEMENT
———	TOP OF DITCH
· — —	CONSTRUCTION LIMITS
——F——	FUEL PIPE (REMOVED)
———	CONTOUR LINE (5' INTERVAL)
- - -	CONTOUR LINE (1' INTERVAL)
⌒⌒⌒	WOODS LINE
△	BENCHMARK

NOTES:

FIGURE SHOWS SITE LAYOUT AND AREAS REMOVED BY CAPE ENVIRONMENTAL DURING 1997 INTERIM MEASURES (IM) AND BY EARTH TECH DURING 2001/2002 INTERIM REMOVAL ACTION (IRA).

DURING THE 1997 IM, THE OIL/WATER SEPARATOR, FIRE TRAINING PAD, FUEL PIPING,ABOVE GROUND STORAGE TANK, AND 2,499 TONS OF SOIL WERE REMOVED WITHIN THE CONSTRUCTION LIMITS.

DURING THE 2001/2002 IRA,THE 8-INCH CONCRETE PAD AND 337 TONS OF SOIL WHERE REMOVED.

GEOPROBE SAMPLING LOCATIONS PREFACED WITH "A" WERE SAMPLED IN THE INITIAL ROUND OF RFI SAMPLING.THESE SAMPLES WERE ANALYZED FOR VOCs WITH A 48-HOUR TURNAROUND. SAMPLING LOCATIONS PREFACED WITH "B" WERE THEN SAMPLED BASED ON THE ANALYTICAL RESULTS OF THE "A" SAMPLES. THE "B" SAMPLES WERE ALSO ANALYZED WITH A 48-HOUR TURNAROUND TIME, AND THE RESULTS DETERMINED WHICH "C" PREFACED SAMPLING LOCATIONS WERE REQUIRED TO BE SAMPLED. "D" SAMPLES WERE FIELD-LOCATED BASED ON THE RESULTS OF "A" AND "B" SAMPLES.

VERTICAL PROFILE LOCATIONS AND PERMANENT MONITORING WELL LOCATIONS WERE DETERMINED AFTER THE ANALYTICAL RESULTS OF THE GEOPROBE BORINGS WERE EVALUATED.

CONTINUOUS SOIL SAMPLES WERE COLLECTED IN GEOPROBE BORINGS A-GP-1 THROUGH B-GP-17, EXCEPT FOR BORING LOCATIONS A-GP-3, A-GP-4, A-GP-5, A-GP-6, AND A-GP-7 SINCE THESE LOCATIONS FELL WITHIN THE BOUNDARY OF THE EXCAVATED SOIL.

SOIL SAMPLES WERE TAKEN IN THE 0-1FEET BGS INTERVAL AND WITHIN 2 FEET OF THE WATER TABLE AT A-GP-9, B-GP-15,AND B-GP-17.

MONITORING WELLS MW #2, MW #5, & MW #7 WERE ABANDONED IN OCTOBER 1997 DURING THE IM.

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SAVANNAH, GEORGIA

FORMER FIRE TRAINING AREA
RFI SAMPLING LOCATIONS
AT WAAF (SWMU 13)
FORT STEWART, GEORGIA

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Figure 2-4. RFI Sampling Locations at the Former Fire Training Area (SWMU 13) (January 1999)

2.7.1.1 Surface Soil

Contamination present in surface soil was dominated by PAH contaminants and one RCRA metal (barium). Maximum PAH concentrations reported in surface soil include benzo(*a*)anthracene (430 µg/kg), benzo(*b*)fluoranthene (560 µg/kg), benzo(*k*)fluoranthene (490 µg/kg), benzo(*a*)pyrene (390 µg/kg), chrysene (430 µg/kg), fluoranthene (720 µg/kg), and pyrene (620 µg/kg). The PAH contamination was limited to the surface soil sample (B-GP-17) located south of the former fire training pad (see Figure 2-4). Barium (20 mg/kg) at A-GP-9 (see Figure 2-4) was the only RCRA metal detected in surface soil at a concentration exceeding its reference background criteria.

2.7.1.2 Subsurface Soil

Contamination present in subsurface soils was dominated by BTEX, PAH contaminants, and RCRA metals. Maximum BTEX concentrations reported in subsurface soil include ethylbenzene (1,100 µg/kg at MW12) and total xylenes (4,100 µg/kg at MW12). BTEX contamination in soil was limited to MW12, which was located adjacent to the former fuel tank piping. Maximum PAH concentrations reported in subsurface soil include anthracene (510 µg/kg), benzo(*a*)anthracene (1,500 µg/kg), benzo(*a*)pyrene (1,100 µg/kg), benzo(*b*)fluoranthene (1,800 µg/kg), benzo(*g*,*h*,*i*)perylene (770 µg/kg), benzo(*k*)fluoranthene (1,000 µg/kg), chrysene (1,400 µg/kg), fluoranthene (4,200 µg/kg), indeno(*1*,*2*,*3*-*cd*)pyrene (730 µg/kg), phenanthrene, (2,200 µg/kg), and pyrene (2,800 µg/kg). The majority of these maximum PAH concentrations were from soil samples collected from the 6-foot to 8-foot interval at MW9. PAH compounds were also detected in soil samples from monitoring wells MW8, MW12, and MW13 and direct-push soil sample C-GP-24-6s. Barium (22 mg/kg), chromium (24 mg/kg), and lead (17 mg/kg) were detected in subsurface soil at concentrations exceeding their respective reference background criteria. Other subsurface soil samples had metal concentrations below laboratory detection limits, or below their respective reference background criteria.

2.7.1.3 Groundwater

BTEX contamination in groundwater extended to a depth of approximately 40 feet below the water table. Maximum concentrations were found at the water table in a direct-push groundwater probe (GP-4) and included benzene (400 µg/L), toluene (320 µg/L), ethylbenzene (800 µg/L), and total xylenes (4,600 µg/L). These concentrations exceeded their respective MCLs for each constituent except toluene. Acetone was detected at a maximum concentration of 330 µg/L in a direct-push groundwater sample (GP-7) at a depth of 38 feet to 39 feet (but was not found in any monitoring well sample). The maximum naphthalene (490 µg/L) and 2-methylnaphthalene (430 µg/L) concentrations were detected in a direct-push groundwater sample (GP-4) at a depth of 10 feet to 13 feet. [Direct-push groundwater samples were used for screening and were not used in determining site-related contaminants (SRCs) due to the fact that the data are not reproducible.]

Maximum contaminant concentrations found in a monitoring well (MW12) were similar and included benzene (440 µg/L), toluene (520 µg/L), ethylbenzene (940 µg/L), and total xylenes (5300 µg/L) (see Figure 2-5). Based on the RFI data, the BTEX contamination covered a plume area approximately 150 feet wide by 300 feet long, extending from the former FTA facilities to the south. Peacock Creek was noted to be more than 2,500 feet from the leading edge of the groundwater plume and is, therefore, not being impacted by the contamination.

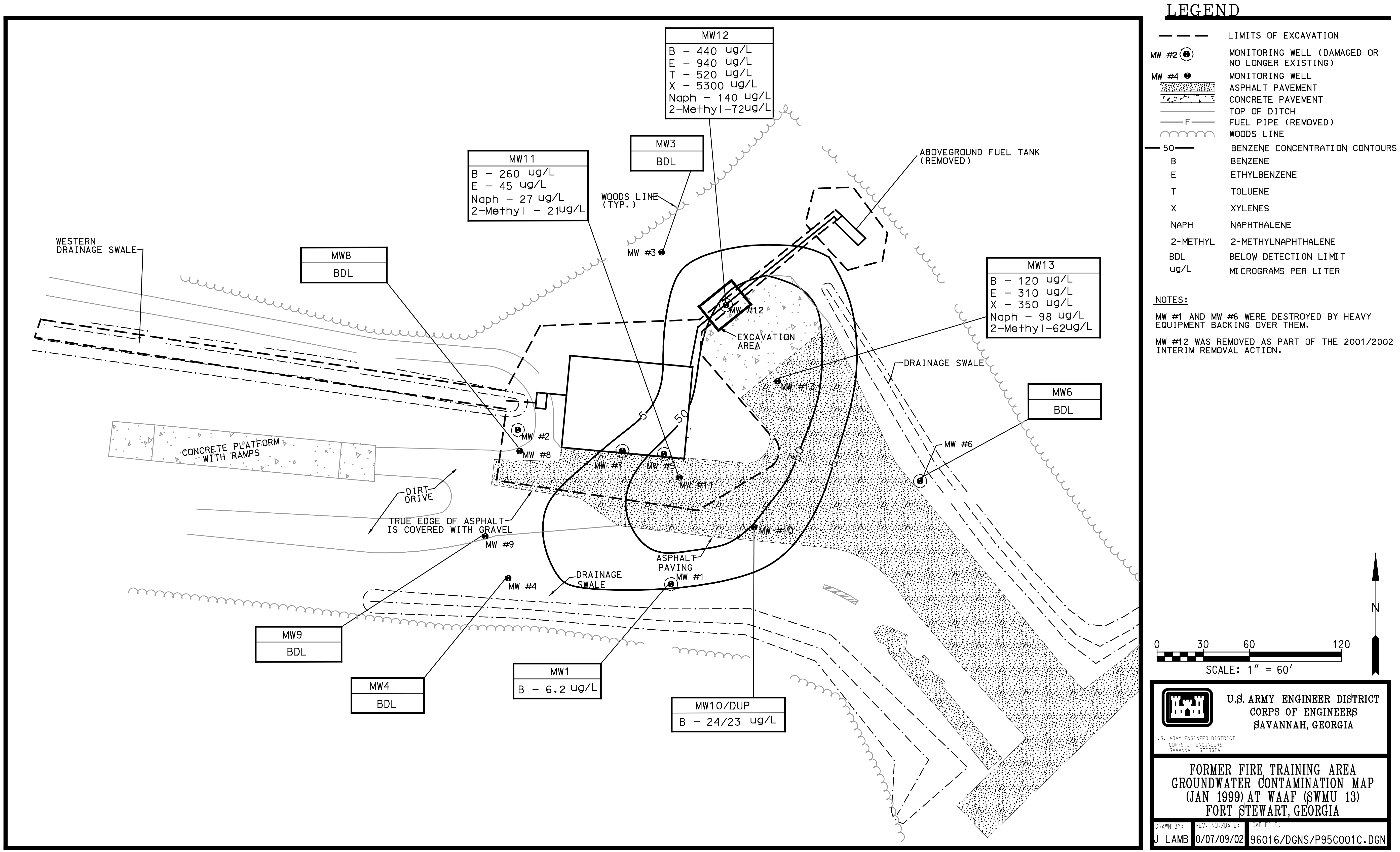


Figure 2-5. Groundwater Contamination at the Former Fire Training Are (SWMU 13) Based on January 1999 RFI Data

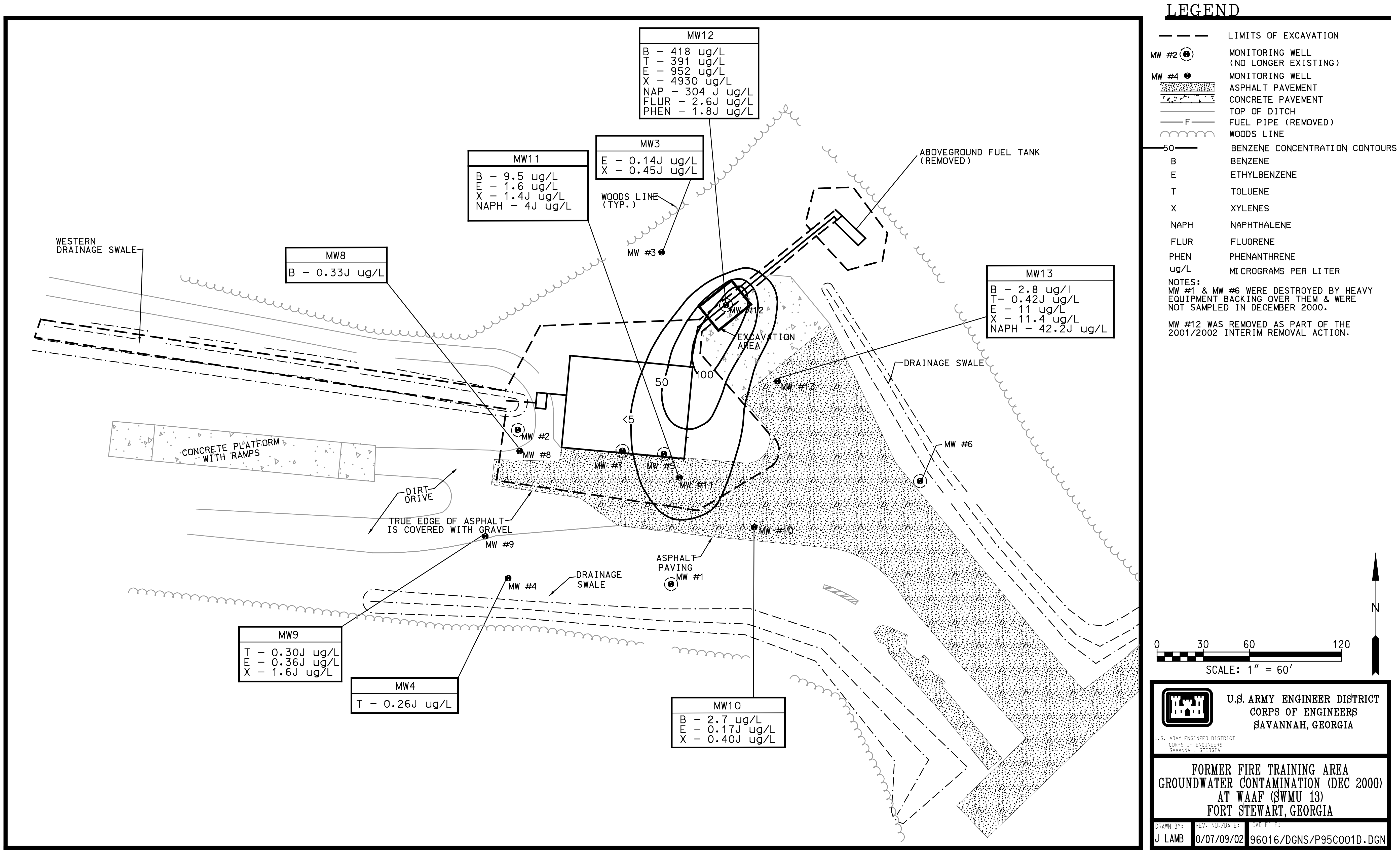


Figure 2-6. Groundwater Contamination at the Former Fire Training Area (SWMU 13) Based on December 2000 Results

2.7.2 Summary of the Results of Supplemental Investigations

2.7.2.1 December 2000 groundwater results

Groundwater samples were collected from eight on-site monitoring wells (MW3, MW4, and MW8 through MW13) in December 2000 and analyzed for BTEX and PAHs (see Table 2-1).

Benzene was detected in five of eight samples at concentrations ranging from 0.33J µg/L to 418 µg/L, with the concentrations in MW11 (9.5 µg/L) and MW12 (418 µg/L) exceeding the benzene MCL of 5 µg/L (see Figure 2-6). Toluene was detected in four of eight samples at concentrations ranging from 0.26J µg/L to 391 µg/L; however, none of the concentrations exceeded the toluene MCL of 1,000 µg/L. Ethylbenzene was detected in six of eight samples at concentrations ranging from 0.14J µg/L to 952 µg/L, with the concentration in MW12 exceeding the ethylbenzene MCL of 700 µg/L. Total xylenes were detected in six of eight samples at concentrations ranging from 0.40J µg/L to 4,930 µg/L and none of the concentrations exceeded the total xylenes MCL of 10,000 µg/L. The highest BTEX concentrations were detected in the samples collected from MW12.

Three PAH compounds were detected in groundwater. Naphthalene was detected in three of eight samples at concentrations ranging from 4.0J µg/L to 304J µg/L, with the concentration in MW12 exceeding the RFI remedial level of 149 µg/L for naphthalene.

With the exception of MW12, the PAH concentrations detected in the supplemental characterization samples were lower than the PAH concentrations detected in the RFI samples. At MW12, naphthalene exceeded its respective remedial level (149 µg/L) in one supplemental sample; however, naphthalene was below the remedial level in the RFI samples. In addition, two PAH compounds (fluorene at 2.6J µg/L and phenanthrene at 1.8J µg/L) were detected in groundwater at MW12 during the December 2000 sampling, but not during the RFI sampling event.

Additional details on the December 2000 groundwater sampling event are described in Appendix A.

2.7.2.2 April 2001 soil results

Six groundwater monitoring wells (MW14 through MW19) were installed at the former FTA in April 2001 (see Figure 2-7). The wells were constructed of ¾-inch diameter Schedule 40 polyvinyl chloride with flush threaded couplings. Well screens were constructed of factory-slotted pipe in 10-foot-long sections, with a slot size of 0.01-inches (No. 10 slot). Wells were installed to depths of approximately 15 feet bgs. Monitoring well construction details and well development information are summarized in Tables 2-2 and 2-3, respectively. Monitoring well construction diagrams are presented in Appendix B.

During well installation activities, subsurface soil samples were collected from each of the six well locations and were analyzed for VOCs and SVOCs (see Table 2-4). Detected analytes were screened against EPA's Region III Industrial and Residential risk-based criteria and against EPA's soil screening level (SSL), which is the level at which a contaminant in soil migrates to groundwater [based on a dilution attenuation factor (DAF) of 1]. Four VOCs (benzene, ethylbenzene, toluene, and total xylenes) were detected above one or more of their respective screening criteria. Benzene was detected above the EPA SSL at concentrations ranging from 0.0014 mg/kg at MW15 (10 feet to 12 feet) to 0.0211 mg/kg at MW16 (10 feet to 11 feet). Ethylbenzene was detected above the EPA SSL at concentrations ranging from 0.0107 mg/kg at MW15 (6 feet to 8 feet) to 7.44 mg/kg at MW14 (6 feet to 8 feet).

Table 2-1. Summary of Analytical Results in Groundwater at the Former Fire Training Area (SWMU 13) (December 2000)

Contaminant of Concern	Maximum Contaminant Level	MW3 FT0312 12/3/00	MW4 FT0412 12/3/00	MW8 FT0812 12/3/00	MW9 FT0912 12/3/00	MW10 FT1012 12/3/00	MW11 FT1112 12/3/00	MW12 FT1212 12/3/00	MW13 FT1312 12/3/00
Volatile Organic Compounds (μg/L)									
Benzene	5			0.33 J		2.7	**9.5**	**418**	2.8
Toluene	1,000		0.26 J		0.30 J			391	0.42 J
Ethylbenzene	700	0.14 J			0.36 J	0.17 J	1.6	**952**	11.0
Xylenes, total	10,000	0.45 J			1.6 J	0.40 J	1.4 J	4,930	11.4
Polynuclear Aromatic Hydrocarbons (μg/L)									
Naphthalene	0						4.0 J	**304 J**	42.2 J
Fluorene	0							2.6 J	
Phenanthrene	0							1.8 J	

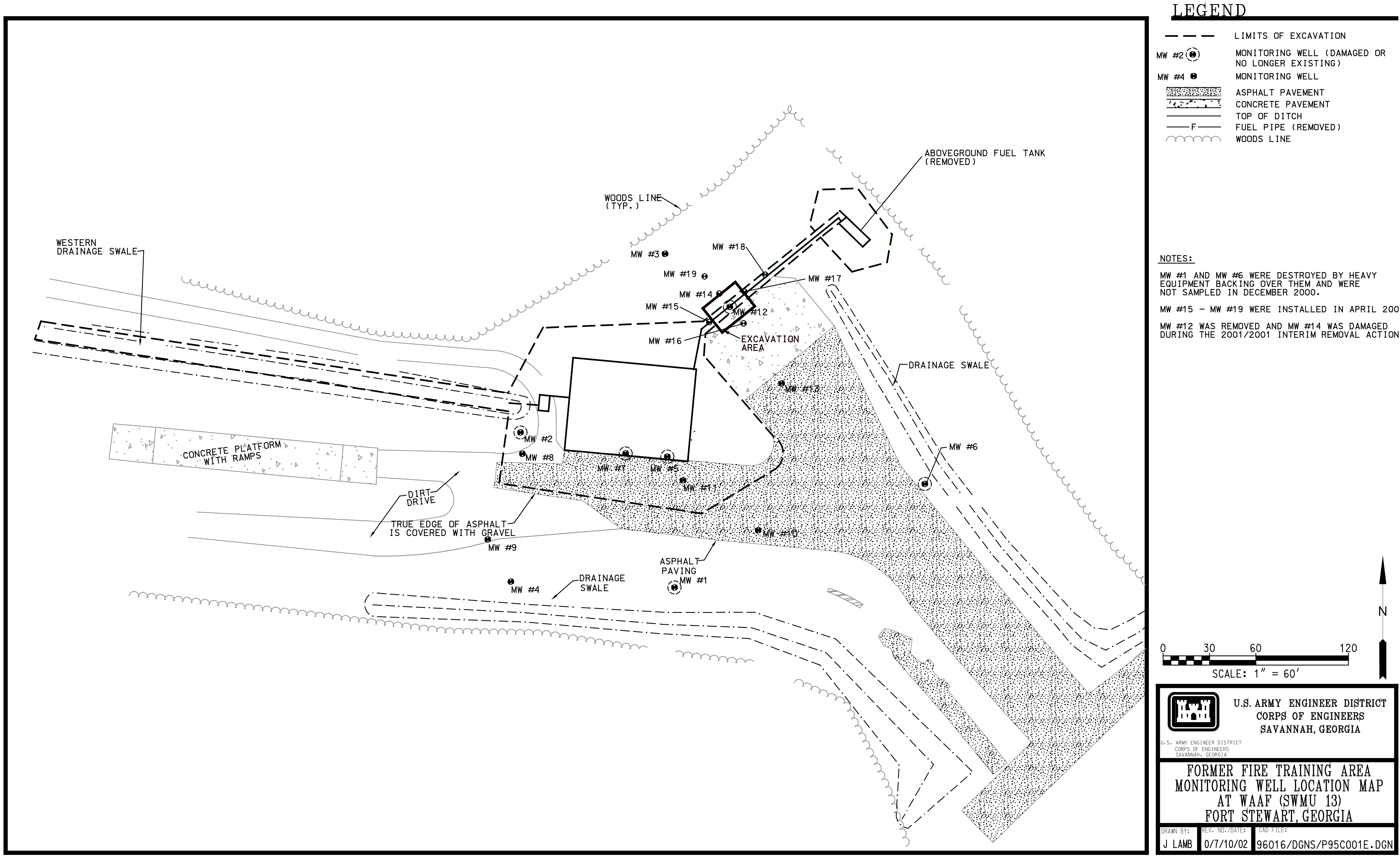
Bold type indicates concentration above the maximum contaminant level (MCL).

Blank indicates analyte not detected.

MW2, MW5, and MW7 were abandoned during the Interim Measures. MW1 and MW6 were damaged following the Resource Conservation and Recovery Act (RCRA) facility investigation activities.

J = Indicates compound was positively identified; the associated numerical value is the approximate concentration of the compound in the sample.

SWMU = Solid waste management unit.



LEGEND

- — — LIMITS OF EXCAVATION
- MW #2 ⊙ MONITORING WELL (DAMAGED OR NO LONGER EXISTING)
- MW #4 ● MONITORING WELL
- ▨ ASPHALT PAVEMENT
- ▨ CONCRETE PAVEMENT
- —— TOP OF DITCH
- —F— FUEL PIPE (REMOVED)
- ⌒⌒⌒ WOODS LINE

NOTES:

MW #1 AND MW #6 WERE DESTROYED BY HEAVY EQUIPMENT BACKING OVER THEM AND WERE NOT SAMPLED IN DECEMBER 2000.

MW #15 - MW #19 WERE INSTALLED IN APRIL 2001.

MW #12 WAS REMOVED AND MW #14 WAS DAMAGED DURING THE 2001/2001 INTERIM REMOVAL ACTION.

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FORMER FIRE TRAINING AREA
MONITORING WELL LOCATION MAP
AT WAAF (SWMU 13)
FORT STEWART, GEORGIA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
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Figure 2-7. Groundwater Monitoring Well Locations at the Former Fire Training Area (SWMU 13) (April 2001)

Table 2-2. Monitoring Well Construction Summary for the Former Fire Training Area (SWMU 13)

Well No.	Date Installed	Size/Type	Coordinates	Total Depth (feet bgs)	Screen Interval Elevation (feet bgs)	Top of Filter Pack Elevation (feet bgs)	Top of Casing Elevation (feet below sea level)
MW14	04/04/2001	3/4-inch PVC	N688436.9 E841611.9	15.0	4.5 to 14.5	3.0	46.53
MW15	04/04/2001	3/4-inch PVC	N688418.5 E841605.4	15.0	4.5 to 14.5	3.0	47.31
MW16	04/05/2001	3/4-inch PVC	N688417.5 E841627.6	14.0	3.0 to 13.0	1.5	47.39
MW17	04/04/2001	3/4-inch PVC	N688438.1 E841628.2	14.0	4.0 to 14.0	2.0	47.14
MW18	04/04/2001	3/4-inch PVC	N688449.1 E841641.5	14.0	2.6 to 12.6	1.5	46.79
MW19	04/04/2001	3/4-inch PVC	N688448.0 E841602.4	14.0	2.8 to 12.8	1.0	46.26

Note: All elevations are NAVD 1988.
Note: Groundwater monitoring well construction details are presented in Appendix B.
bgs = Below ground surface.
PVC = Polyvinyl chloride.
SWMU = Solid waste management unit.

Table 2-3. Well Development Summary for the Former Fire Training Area (SWMU 13)

Well No.	Date	Total Development Time (hours)	Total Volume Removed (gallons)	Final Turbidity Reading (NTU)
MW14	04/09/2001	0.92	9	5
MW15	04/09/2001	1.08	8.5	5
MW16	04/10/2001	5.25	8	NR
MW17	04/09/2001	1.83	9	30
MW18	04/10/2001	0.92	12	NR
MW19	04/10/2001	1.75	10	NR

NR = Not reported.
NTU = Nephelometric turbidity unit.
SWMU = Solid waste management unit.

Toluene was detected above the EPA SSL at concentrations ranging from 0.0071 mg/kg at MW19 (8 feet to 11 feet) to 0.444 mg/kg at MW 14 (6 feet to 8 feet). Total xylenes were detected above the EPA SSL at concentrations ranging from 0.0656 mg/kg at MW15 (6 feet to 8 feet) to 43.8 mg/kg at MW14 (6 feet to 8 feet). However, none of the VOCs detected exceeded the EPA Region III Residential or Industrial risk-based screening levels.

Three SVOCs (2-methylnaphthalene, naphthalene, and phenanthrene) were detected above one or more of their respective screening criteria in the subsurface soil samples collected at SWMU 13. 2-Methylnaphthalene was detected above the EPA SSL (1.11 mg/kg) at concentrations ranging from 0.639 mg/kg at MW18 to 8.85 mg/kg at MW14. Naphthalene was detected above the

Table 2-4. Summary of Analytical Results in Subsurface Soil at the Former Fire Training Area (SWMU 13) (April 2001)

Station	EPA Region III Residential (mg/kg)	EPA Region III Industrial (mg/kg)	13-MW14	13-MW14	13-MW15	13-MW15	13-MW16	13-MW16
Sample ID			**FT1411**	**FT1421**	**FT1511**	**FT1521**	**FT1611**	**FT1621**
Date			**04/04/01**	**04/04/01**	**04/04/01**	**04/04/01**	**04/05/01**	**04/05/01**
Depth (feet)			**6 - 8**	**10 - 12**	**6 - 8**	**10 - 12**	**6 - 8**	**10 - 11**
Sample Type			**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Volatile Organic Compounds (mg/kg)								
Acetone	782	20,400			0.0344			
Benzene	11.6	104		0.0128		0.0014	0.0019 J	0.0211
Carbon disulfide	782	20,400		0.0031 J		0.00071 J		
Ethylbenzene	782	20,400	7.44	0.085	0.0107	0.139	0.366	0.0969
Toluene	1,560	40,900	0.444	0.0102		0.0263		0.0174
Xylenes, total	15,600	409,000	43.8	0.566	0.0656	0.812	0.639	0.4
Semivolatile Organic Compounds (mg/kg)								
2-Methylnaphthalene	156	4,090	3.88	8.85	1.07	0.182	0.0938	0.172
Benzo(*k*)fluoranthene	8.75	78.4						
Bis(2-ethylhexyl)phthalate	45.6	409					0.0261 J	
Butyl benzyl phthalate	1,560	40,900						
Chrysene	87.5	784						
Diphenylamine	196	5,110			0.237 J			
Fluoranthene	313	8,180						
Fluorene	313	8,180	0.194		0.147	0.014 J	0.0126 J	
Naphthalene	156	4,090	2.87	6.48		0.123		0.0407
Phenanthrene			0.345	0.727	0.302	0.0278 J		
Pyrene	235	6,130	0.0402		0.0397 J			

Table 2-4. Summary of Analytical Results in Subsurface Soil at the Former Fire Training Area (SWMU 13) (April 2001) (continued)

Station	**EPA Region III Residential (mg/kg)**	**EPA Region III Industrial (mg/kg)**	**13-MW17**	**13-MW17**	**13-MW18**	**13-MW18**	**13-MW19**	**13-MW19**
Sample ID			**FT1711**	**FT1721**	**FT1811**	**FT1821**	**FT1911**	**FT1921**
Date			**04/04/01**	**04/04/01**	**04/04/01**	**04/04/01**	**04/04/01**	**04/04/01**
Depth (feet)			**6 - 8**	**8 - 11**	**8 - 11**	**11 - 12**	**6 - 8**	**8 - 11**
Sample Type			**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Volatile Organic Compounds (mg/kg)								
Acetone	782	20,400						
Benzene	11.6	104			0.0146			
Carbon disulfide	782	20,400						
Ethylbenzene	782	20,400	1.75	5.36	1.13	4.4 J	0.0162	0.0359 J
Toluene	1,560	40,900		0.2 J	0.0103			0.0071 J
Xylenes, total	15,600	409,000	4.55	30.3	5.38	13.1 J	0.0976	0.174 J
Semivolatile Organic Compounds (mg/kg)								
2-Methylnaphthalene	156	4,090	5.82	2.57	1.5	0.639	0.301	0.0627
Benzo(*k*)fluoranthene	8.75	78.4				0.0089 J		
Bis(2-ethylhexyl)phthalate	45.6	409						
Butyl benzyl phthalate	1,560	40,900						0.272 J
Chrysene	87.5	784				0.0119 J		
Diphenylamine	196	5,110	0.263 J					
Fluoranthene	313	8,180				0.0206 J		
Fluorene	313	8,180	0.253	0.133	0.0856	0.0441	0.026 J	0.0054 J
Naphthalene	156	4,090	3.71	1.7	0.793	0.309	0.0754	0.0268 J
Phenanthrene			0.45	0.234	0.151	0.0803	0.051	0.0131 J
Pyrene	235	6,130	0.0432	0.0277 J	0.0235 J	0.0235 J		

Note: Only detected constituents are included.
EPA = U.S. Environmental Protection Agency.
J = Estimated value.
U = Undetected value.
SWMU = Solid waste management unit.

EPA SSLs (0.00769 mg/kg and 0.154 mg/kg) at concentrations ranging from 0.0268J mg/kg at MW19 (8 feet to 11 feet) to 6.48 mg/kg at MW14 (10 feet to 12 feet). However, none of the SVOCs detected exceeded the EPA Region III Residential or Industrial risk-based screening levels.

2.7.2.3 June 2002 groundwater results

Groundwater samples were collected from five monitoring wells (MW13, MW15, MW16, MW18, and MW19) during June 2002 and were analyzed for BTEX constituents. Benzene was detected above EPA's Region III risk-based criteria for Tap Water (0.32 μg/L) in four of five samples at concentrations ranging from 1.9 μg/L at MW15 to 120 μg/L at MW16. Ethylbenzene was detected above EPA's Region III risk-based criteria for Tap Water (3.25 μg/L) in all five samples at concentrations ranging from 44.9 μg/L at MW13 to 486 μg/L at MW18. Toluene was detected above EPA's Region III risk-based criteria for Tap Water (74.70 μg/L) in four out of five samples at concentrations ranging from 6.4 μg/L at MW19 to 78.3 μg/L at MW16. Total xylenes were detected above EPA's Region III risk-based criteria for Tap Water (1220 μg/L) in all five samples at concentrations ranging from 11.9 μg/L at MW13 to 2,170 μg/L at MW16.

A comparison of the June 2002 groundwater results to historical groundwater results is shown in Table 2-5.

Results in Table 2-5 indicate that, in most cases, the COCs exhibit a downward trend (with the exceptions of MW12 and MW13). Naphthalene and ethylbenzene concentrations detected in MW 12 were higher in December 2000 than concentrations detected during the RFI. MW12 was removed during the 2001/2002 IRA. Based on modeling results, the current estimated concentration of benzene at MW12 is 211 μg/kg (see Appendix C). The detected concentrations in MW13 (the only monitoring well sampled during all three events) were lower in December 2000 than concentrations detected during the RFI. Concentrations detected in June 2002 were higher than the December 2000 concentrations; however, the elevated concentrations are suspected to be caused by the disturbance of the site during the IRA.

2.8 INTERIM ACTIONS

Two interim actions have been performed at the former FTA (SWMU 13) to remove suspected source materials. The removal activities conducted and results of the sampling and analysis are described below.

2.8.1 October 1997 Interim Measures

In 1997, CAPE Environmental performed an IM at SWMU 13. The intent of the IM was to remove and properly dispose of the fire training facilities, which included the AST, the mock aircraft with foundations and piping, the concrete fire training pad and cover soils, the concrete oil/water separator sump and appurtenances, and soil and sediments which exceeded the PCTs. Approximately 2,450 tons of contaminated soil was excavated. After removing the fire training facilities and contaminated soil (to approximately 4 feet bgs) and completing the confirmatory sampling, the excavated area was backfilled with clean soil and seeded.

Confirmation soil samples were collected from borings at 29 locations (SA-1.1 through SA-29.1). Of these 29 locations, seven locations were beneath the western swale, 15 locations were beneath the fire training pad area and seven locations were beneath the AST area and product piping. The soil samples were analyzed for VOCs, SVOCs, and RCRA metals. The locations of these samples are shown in Figure 2-4 in the revised final RFI (SAIC 2000).

Table 2-5. Summary of Analytical Results in Groundwater at the Former Fire Training Area (SWMU 13)

Analyte	MW1 1996	MW3 1996	MW3 Dec. 2000	MW4 1996	MW4 Dec. 2000	MW6 1996	MW8 1996	MW8 Dec. 2000	MW9 1996	MW9 Dec. 2000	MW10 1996	MW10 Dec. 2000
Volatile Organic Compounds (μg/L)												
Benzene	6.2	<5	<1 U	<5	<1 U	<5	<5	0.33 J	<5	<1 U	24	2.7
Ethylbenzene	<5	<5	0.14 J	<5	<1 U	<5	<5	<1 U	<5	0.36 J	<5	0.17 J
Toluene	<5	<5	<1 U	<5	0.26 J	<5	<5	<1 U	<5	0.3 J	<5	<1 U
Xylenes, total	<5	<5	0.45 J	<5	<3 U	<5	<5	<3 U	<5	1.6 J	<5	0.4 J
Semivolatile Organic Compounds (μg/L)												
2-Methylnaphthalene	<10	<10	NA	<10	NA	<10	<10	NA	<10	NA	<10	NA
Naphthalene	<10	<10	<0.95 U	<10	<0.95 U	<10	<10	<0.95 U	<10	<0.95 U	<10	<0.95 U
Phenanthrene	NA	NA	<0.95 U	NA	<0.95 U	NA	NA	<0.95 U	NA	<0.95 U	NA	<0.95 U

Analyte	MW11 1996	MW11 Dec. 2000	MW12 1996	MW12 Dec. 2000	MW13 1996	MW13 Dec. 2000	MW13 June 2002	MW15 June 2002	MW16 June 2002	MW18 June 2002	MW19 June 2002
Volatile Organic Compounds (μg/L)											
Benzene	260	9.5	440	418	120	2.8	3.6	1.9	120	95	<1
Ethylbenzene	45	1.6	940	952	310	11	44.9	257	385	486	201
Toluene	<25	<1 U	520	391	<25	0.42 J	<1	30.3	78.3	49.7	6.4
Xylenes, total	<25	1.4 J	5,300	4,930	350	11.4	11.9	1,380	2,170	1,840	1,040
Semivolatile Organic Compounds (μg/L)											
2-Methylnaphthalene	21	NA	72	NA	62	NA	NA	NA	NA	NA	NA
Naphthalene	27	4 J	140	304 J	98	42.2 J	NA	NA	NA	NA	NA
Phenanthrene	NA	<0.96 UJ	NA	1.8 J	NA	<0.69 UJ	NA	NA	NA	NA	NA

NA = Not analyzed.
SWMU = Solid waste management unit.
J = Estimated value.
U = Undetected value
UJ = Estimated undetected value.

The following VOCs were detected with respective maximum concentrations: 4-methyl-2-pentanone (MIBK) at 3,800 μg/L (SA-2.1); acetone at 110 μg/L (SA-18.3.5); benzene at 21 μg/L (SA-4.3); carbon disulfide at 13 μg/L (SA-10.4.5); chlorobenzene at 930 μg/L (SA-2.1); ethylbenzene at 1,600 μg/L (SA-2.1); toluene at 980 μg/L (SA-2.1); and total xylenes at 61,000 μg/L (SA-2.1). The detected VOCs were identified in the area where the aboveground fuel tank was formerly located, with some detections in the vicinity of the former fuel line from the tank.

The highest concentrations of SVOCs (with the exceptions of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene) were detected in samples taken from the swale just west of the former FTA. The following SVOCs were detected with respective maximum concentrations: acenaphthene at 4,500 μg/L (SA-1.1); anthracene at 1,100 μg/L (SA-25.1); benzo(*a*)pyrene at 3,700 μg/L (SA-25.1); benzo(*g*,*h*,*i*)perylene at 2,400 μg/L (SA-25.1); benzo(*b*)fluoranthene at 8,200 μg/L (SA-25.1); benzo(*a*)pyrene at 10,000 μg/L (SA-25.1); chrysene at 10,000 μg/L (SA-25.1); fluoranthene at 9,100 μg/L (SA-25.1); fluorene at 4,400 μg/L (SA-2.1); indeno(*1,2,3-cd*)pyrene at 4,500 μg/L (SA-25.1); dibenzo(*a*,*h*)anthracene at 4,500 μg/L (SA-25.1); phenanthrene at 1,100 μg/L (SA-25.1); pyrene at 8,100 μg/L (SA-25.1); 1-methylnaphthalene at 18,000 μg/L (SA-2.1); 2-methylnaphthalene at 24,000 μg/L (SA-2.1); and naphthalene at 1,800 μg/L (SA-5.2).

Confirmation results indicate that, in most cases, the maximum concentrations were detected in confirmation samples SA-2.1 and SA-25.1. Confirmation sample SA-2.1 was collected in the area of the AST. Confirmation sample SA-25.1 was collected from the drainage swale, just west of the former FTA. Confirmation samples SA-2.1 and SA-25.1 were collected at intervals of 0 to 6 inches below the base of the excavation.

The following RCRA metals were detected at concentrations exceeding their reference background criteria with respective maximum concentrations: arsenic at 10.4 μg/L (SA-21.2); barium at 26.6 μg/L (SA-8.2); chromium at 40.4 μg/L (SA-21.3); lead at 11.4 μg/L (SA-4.2); and mercury at 0.097 μg/L (SA-23.1).

2.8.2 December 2001/February 2001 Interim Removal Action

Based on the findings of the RFI and supplemental investigations and with the concurrence of GEPD, Fort Stewart performed an IRA at SWMU 13, from December 18, 2001 to February 15, 2002. The IRA was conducted by Earth Tech, Inc., and included the removal of an approximate 8-inch concrete pad that was an estimated 20 feet by 8 feet area, removal of approximately 337 tons of soil, and removal of monitoring well MW12 (Earth Tech 2002).

After the concrete pad was removed, an excavation area of approximately 20 feet by 27 feet was created. The site was excavated to an estimated depth of 12 feet bgs. Six confirmatory soil samples were collected; four from the side walls (FTS-SWMU13-S-1-08, FTS-SWMU13-S-2-08, FTS-SWMU13-S-3-08, and FTS-SWMU13-S-4-08) at a depth of 8 feet bgs and two from the floor (FTS-SWMU13-S-5-12 and FTS-SWMU13-S-6-12) of the excavation. Soil samples were analyzed for VOCs and SVOCs (see Figure 2-8). The site was backfilled upon completion of excavation activities. Approximately 342 cubic yards of soil and 68 tons of crush and run gravel were used to backfill the excavation.

Benzene was detected in five of six confirmatory samples at concentrations ranging from 0.005 mg/kg at FTS-SWMU13-S-1-08 to 0.24 mg/kg at FTS-SWMU13-S-2-08. Toluene was detected in all six samples with a maximum concentration of 1.8 mg/kg at FTS-SWMU13-S-2-08. Ethylbenzene was detected in all six samples at concentrations ranging from 0.047 mg/kg at FTS-SWMU13-S-2-08 to 4.4 mg/kg at FTS-SWMU13-S-5-12. Total xylenes were detected in all six samples at concentrations ranging from

1.2 mg/kg at FTS-SWMU13-S-3-08 to 41 mg/kg at FTS-SWMU13-S-2-08. None of the detected VOCs exceeded their respective EPA Region III Residential or Industrial risk-based screening levels.

Naphthalene was detected in all six samples at concentrations ranging from 0.25 mg/kg at FTS-SWMU13-S-5-12 to 9.4 mg/kg at FTS-SWMU13-S-2-08. None of the detected concentrations exceeded the EPA Region III Residential or Industrial risk-based screening levels. The results of the confirmatory sampling are presented in Table 2-6 and Figure 2-8.

2.9 CONTAMINANT FATE AND TRANSPORT

This section presents the site-specific components of the conceptual site model developed for the former FTA (SWMU 13) and describes the contaminant release mechanisms through the primary transport medium (groundwater). This section also discusses the fate and transport of contaminants at the site with respect to their leachability and natural attenuation. Additional details regarding the contaminant fate and transport evaluation is located in Chapter 6.0 and Appendix G of the revised final RFI Report (SAIC 2000).

2.9.1 Site-Related Contaminants

The soil and groundwater data from the RI and the supplemental investigations were screened to identify SRCs. Inorganics were considered to be SRCs if their concentrations were above the reference background concentration. Organics were considered to be SRCs if they were simply detected because organic constituents are considered anthropomorphic in nature. A tabular summary of SRCs by medium for SWMU 13 is presented in Table 2-7.

Based on this evaluation, four VOCs and four SVOCs were identified as SRCs in groundwater. Eleven VOCs, 22 SVOCs, and five metals were identified as SRCs in soil. These SRCs are carried through for evaluation under fate and transport (Section 2.9.3), human health preliminary risk evaluation (HHPRE) (Section 2.10.1), and ecological preliminary risk evaluation (EPRE) (Section 2.10.2).

2.9.2 Generic Soil Screening Analysis

Contaminant fate and transport analysis provided an assessment of the potential migration pathways and transport mechanisms affecting the chemicals at the site. In particular, the leachability of contaminants from soil to groundwater and their natural attenuation in groundwater were evaluated.

The site characterization identified organic and inorganic SRCs in surface and subsurface soil and in groundwater (only organic SRCs identified in groundwater). These constituents were compared to the EPA generic soil screening levels (GSSLs) (EPA 1996a) to determine if these constituents might leach from soil into groundwater at concentrations that exceed groundwater standards [i.e., concentrations that exceed the MCL or, in the absence of an MCL, the risk-based concentration (RBC) for drinking water (EPA 1996b)]. The results of the comparison to GSSLs are shown in Table 2-8.

Based on the soil screening analysis, benzene, 4-methyl-2-pentanone, benzo(*a*)anthracene, benzo(*b*)flouranthene, dibenzo(*a,h*)anthracene, 2-methylnaphthalene, naphthalene, arsenic, and chromium exceeded their respective GSSLs and were indicated as preliminary contaminant migration constituent of potential concern (CMCOPCs) in soil. Of the preliminary CMCOPCs, only benzene, naphthalene, and 2-methylnaphthalene were detected in groundwater above their reference background concentration. These inorganic and organic CMCOPCs were further evaluated using the Seasonal Soil Compartment (SESOIL) Model as discussed in the following section.

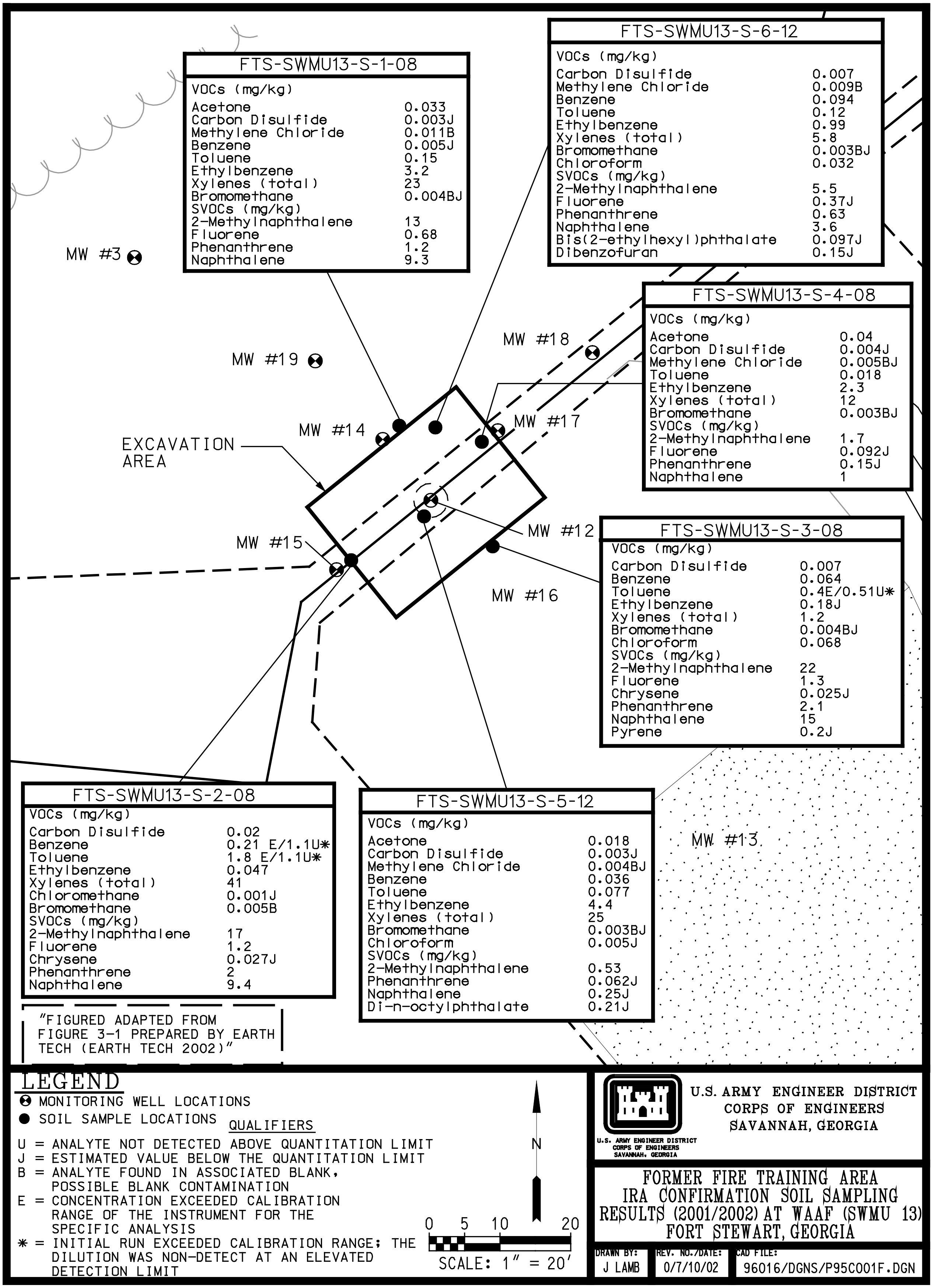
Table 2-6. IRA Confirmation Sample Results at the Former Fire Training Area (SWMU 13) for 2001/2002

Station	**EPA Region III Residential (mg/kg)**	**EPA Region III Industrial (mg/kg)**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**
Sample ID			**FTS-SWMU13-S-1-08**	**FTS-SWMU13-S-2-08**	**FTS-SWMU13-S-3-08**	**FTS-SWMU13-S-4-08**	**FTS-SWMU13-S-5-12**	**FTS-SWMU13-S-6-12**
Date			**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**
Depth (feet)			**8 - 8**	**8 - 8**	**8 - 8**	**8 - 8**	**12 - 12**	**12 - 12**
Sample Type			**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Volatile Organic Compounds (mg/kg)								
4-Methyl-2-pentanone	626	16,400						
Acetone	782	20,400	0.033			0.04	0.018	
Benzene	11.6	104	0.005 J	0.21 E	0.064		0.036	0.094
Bromomethane	11	286	0.004 BJ	0.005 B	0.004 BJ	0.003 BJ	0.003 BJ	0.003 BJ
Carbon disulfide	782	20,400	0.003 J	0.02	0.007	0.004 J	0.003	0.007
Chlorobenzene	156	4,090						
Chloroform	78.2	2,040			0.068		0.005 J	0.032
Chloromethane	49.1	440		0.001 J				
Ethylbenzene	782	20,400	3.2	0.047	0.18 J	2.3	4.4	0.99
Methylene chloride	85.2	763	0.011 B			0.005 BJ	0.004 BJ	0.009 B
Toluene	1,560	40,900	0.15	1.8	0.4 E	0.018	0.077	0.12
Xylenes, total	15,600	409,000	23	41	1.2	12	25	5.8
Semivolatile Organic Compounds (mg/kg)								
2-Methylnaphthalene	156	4,090	13	17	22	1.7	0.53	5.5
Acenaphthene	469	12,300						
Anthracene	2,350	61,300						
Benzo(*a*)anthracene	0.875	7.84						
Benzo(*a*)pyrene	0.0875	0.784						
Benzo(*b*)fluoranthene	0.875	7.84						
Benzo(*g,h,i*)perylene								
Benzo(*k*)fluoranthene	8.75	78.4						
Bis(2-ethylhexyl)phthalate	45.6	409						0.097 J
Butyl benzyl phthalate	1,560	40,900						
Chrysene	87.5	784		0.027 J	0.025 J			
Di-*N*-octylphthalate	156	4090					0.21 J	
Dibenzo(*a,h*)anthracene	0.0875	0.784						

Table 2-6. IRA Confirmation Sample Results at the Former Fire Training Area (SWMU 13) for 2001/2002 (continued)

Station	**EPA Region III Residential (mg/kg)**	**EPA Region III Industrial (mg/kg)**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**	**F-SWMU13-S**
Sample ID			**FTS-SWMU13-S-1-08**	**FTS-SWMU13-S-2-08**	**FTS-SWMU13-S-3-08**	**FTS-SWMU13-S-4-08**	**FTS-SWMU13-S-5-12**	**FTS-SWMU13-S-6-12**
Date			**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**	**01/09/02**
Depth (feet)			**8 - 8**	**8 - 8**	**8 - 8**	**8 - 8**	**12 - 12**	**12 - 12**
Sample Type			**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Dibenzofuran	31.3	818						0.15 J
Diphenylamine	196	5110	NA	NA	NA	NA	NA	NA
Fluoranthene	313	8180						
Fluorene	313	8180	0.68	1.2	1.3	0.092 J		0.37 J
Indeno(*1,2,3-cd*)pyrene	0.875	7.84						
Naphthalene	156	4090	9.3	9.4	15	1	0.25 J	3.6
Phenanthrene			1.2	2	2.1	0.15 J	0.062 J	0.63
Pyrene	235	6130			0.2 J			

Note: Non-detects not reported.
B = Analyte found in associated blank, possible blank contamination.
E = Concentration exceeded the calibration range of the instrument for the specific analysis.
EPA = U.S. Environmental Protection Agency.
FTA = Fire Training Area.
IRA = Interim removal action.
J = Estimated value below the quantitation limit.
NA = Not analyzed.
SSL = Soil screening level.
SWMU = Solid waste management unit.



FTS-SWMU13-S-1-08

VOCs (mg/kg)	
Acetone	0.033
Carbon Disulfide	0.003J
Methylene Chloride	0.011B
Benzene	0.005J
Toluene	0.15
Ethylbenzene	3.2
Xylenes (total)	23
Bromomethane	0.004BJ
SVOCs (mg/kg)	
2-Methylnaphthalene	13
Fluorene	0.68
Phenanthrene	1.2
Naphthalene	9.3

FTS-SWMU13-S-6-12

VOCs (mg/kg)	
Carbon Disulfide	0.007
Methylene Chloride	0.009B
Benzene	0.094
Toluene	0.12
Ethylbenzene	0.99
Xylenes (total)	5.8
Bromomethane	0.003BJ
Chloroform	0.032
SVOCs (mg/kg)	
2-Methylnaphthalene	5.5
Fluorene	0.37J
Phenanthrene	0.63
Naphthalene	3.6
Bis(2-ethylhexyl)phthalate	0.097J
Dibenzofuran	0.15J

FTS-SWMU13-S-4-08

VOCs (mg/kg)	
Acetone	0.04
Carbon Disulfide	0.004J
Methylene Chloride	0.005BJ
Toluene	0.018
Ethylbenzene	2.3
Xylenes (total)	12
Bromomethane	0.003BJ
SVOCs (mg/kg)	
2-Methylnaphthalene	1.7
Fluorene	0.092J
Phenanthrene	0.15J
Naphthalene	1

FTS-SWMU13-S-3-08

VOCs (mg/kg)	
Carbon Disulfide	0.007
Benzene	0.064
Toluene	0.4E/0.51U*
Ethylbenzene	0.18J
Xylenes (total)	1.2
Bromomethane	0.004BJ
Chloroform	0.068
SVOCs (mg/kg)	
2-Methylnaphthalene	22
Fluorene	1.3
Chrysene	0.025J
Phenanthrene	2.1
Naphthalene	15
Pyrene	0.2J

FTS-SWMU13-S-2-08

VOCs (mg/kg)	
Carbon Disulfide	0.02
Benzene	0.21 E/1.1U*
Toluene	1.8 E/1.1U*
Ethylbenzene	0.047
Xylenes (total)	41
Chloromethane	0.001J
Bromomethane	0.005B
SVOCs (mg/kg)	
2-Methylnaphthalene	17
Fluorene	1.2
Chrysene	0.027J
Phenanthrene	2
Naphthalene	9.4

FTS-SWMU13-S-5-12

VOCs (mg/kg)	
Acetone	0.018
Carbon Disulfide	0.003J
Methylene Chloride	0.004BJ
Benzene	0.036
Toluene	0.077
Ethylbenzene	4.4
Xylenes (total)	25
Bromomethane	0.003BJ
Chloroform	0.005J
SVOCs (mg/kg)	
2-Methylnaphthalene	0.53
Phenanthrene	0.062J
Naphthalene	0.25J
Di-n-octylphthalate	0.21J

"FIGURED ADAPTED FROM FIGURE 3-1 PREPARED BY EARTH TECH (EARTH TECH 2002)"

LEGEND

⊗ MONITORING WELL LOCATIONS
● SOIL SAMPLE LOCATIONS

QUALIFIERS

U = ANALYTE NOT DETECTED ABOVE QUANTITATION LIMIT
J = ESTIMATED VALUE BELOW THE QUANTITATION LIMIT
B = ANALYTE FOUND IN ASSOCIATED BLANK, POSSIBLE BLANK CONTAMINATION
E = CONCENTRATION EXCEEDED CALIBRATION RANGE OF THE INSTRUMENT FOR THE SPECIFIC ANALYSIS
* = INITIAL RUN EXCEEDED CALIBRATION RANGE; THE DILUTION WAS NON-DETECT AT AN ELEVATED DETECTION LIMIT

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
SAVANNAH, GEORGIA

FORMER FIRE TRAINING AREA
IRA CONFIRMATION SOIL SAMPLING
RESULTS (2001/2002) AT WAAF (SWMU 13)
FORT STEWART, GEORGIA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
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Figure 2-8. IRA Confirmation Soil Sampling Results at the Former Fire Training Area (SWMU 13) (2001/2002)

Table 2-7. Summary of Site-Related Contaminants at the Former Fire Training Area (SWMU 13)

SRCs	**Surface Soil**	**Subsurface Soil**	**Groundwater**[a]
Volatile Organic Compounds	**(μg/kg)**	**(μg/kg)**	**(μg/L)**
Acetone	NA	110	NA
Benzene	NA	240	440
Bromomethane	NA	5	NA
Carbon disulfide	NA	20	NA
Chlorobenzene	NA	930	NA
Chloroform	NA	68	NA
Chloromethane	NA	1	NA
Ethylbenzene	NA	7,440	952
4-Methyl-2-pentanone	NA	3,800	NA
Toluene	NA	1,800	520
Xylenes, total	NA	61,000	5,300
Semivolatile Organic Compounds	**(μg/kg)**	**(μg/kg)**	**(μg/L)**
Acenaphthene	NA	4,500	NA
Anthracene	NA	1,100	NA
Benzo(*a*)anthracene	430	10,000	NA
Benzo(*b*)fluoranthene	560	8,200	NA
Benzo(*k*)fluoranthene	490	8,200	NA
Benzo(*g*,*h*,*i*)perylene	NA	2,400	NA
Benzo(*a*)pyrene	390	3,700	NA
Bis(2-ethylhexyl)phthalate	NA	97	NA
Butyl benzyl phthalate	NA	272	NA
Chrysene	430	10,000	NA
Di-*N*-octylphthalate	NA	210	NA
Dibenzo(*a*,*h*)anthracene	NA	4,500	NA
Dibenzofuran	NA	150	NA
Diphenylamine	NA	263	NA
Fluoranthene	720	9,100	NA
Fluorene	NA	4,400	2.6
Indeno(*1,2,3-cd*)pyrene	NA	4,500	NA
1-Methylnaphthalene	NA	18,000	NA
2-Methylnaphthalene	NA	24,000	72
Naphthalene	NA	15,000	304
Phenanthrene	NA	2,200	1.8
Pyrene	620	8,100	NA
Metals	***(mg/kg)***	***(mg/kg)***	***(μg/kg)***
Arsenic	NA	10.4	NA
Barium	20	26.6	24
Chromium	NA	40.4	NA
Lead	NA	17	NA
Mercury	NA	0.097	NA

[a] Groundwater screening data were not used in determining SRCs due to the fact that the data are not reproducible. Groundwater SRCs were determined only from data obtained during the RFI sampling and supplemental investigation from permanent monitoring wells at the SWMU 13 site.

Numerical values represent the maximum detected concentration from the RFI, interim measures and interim removal action, and supplemental samples for the identified SRC for the indicated medium.

μg/kg = Micrograms per kilogram.
μg/L = Micrograms per liter.
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not applicable.
SRC = Site-related contaminant.
SWMU = Solid waste management unit.

Table 2-8. GSSL Screening of Site-Related Contaminants in Soil at the Former Fire Training Area (SWMU 13)

SRCs	Maximum Concentration in Surface or Subsurface Soil	GSSL[a]	Preliminary CMCOPC?
Volatile Organic Compounds	***(μg/kg)***	***(μg/kg)***	
Acetone	110	16,000	No
Benzene	240	30	Yes
Carbon disulfide	13	32,000	No
Chlorobenzene	930	1,000	No
Ethylbenzene	7,440	13,000	No
4-methyl-2-pentanone[c]	3,800	1,300	Yes
Toluene	980	12,000	No
Xylenes, total	61,000	190,000	No
Semivolatile Organic Compounds	***(μg/kg)***	***(μg/kg)***	
Acenaphthene	4,500	570,000	No
Anthracene	1,100	12,000,000	No
Benzo(*a*)anthracene	10,000	2,000	Yes
Benzo(*b*)fluoranthene	8,200	5,000	Yes
Benzo(*k*)fluoranthene	8,200	49,000	No
Benzo(*g*,*h*,*i*)perylene[b,d]	2,400	394,000	No
Benzo(*a*)pyrene	3,700	8,000	No
Dibenzo(*a*,*h*)anthracene	4,500	2,000	Yes
Chrysene	10,000	160,000	No
Fluoranthene	9,100	4,300,000	No
Fluorene	4,400	560,000	No
Indeno(*1,2,3-cd*)pyrene	4,500	14,000	No
1-Methylnaphthalene[c,e]	18,000	22,231	No
2-Methylnaphthalene[c]	24,000	22,231	Yes
Naphthalene	15,000	150	Yes
Phenanthrene[b,f]	2,200	80,400	No
Pyrene	8,100	4,200,000	No
Metals	**(mg/kg)**	**(mg/kg)**	
Arsenic	10.4	1	Yes
Barium	26.6	82	No
Chromium	40.4	2	Yes
Lead[g]	17	400	No
Mercury	0.097	0.1	No

[a] Generic soil screening level (GSSL) = U.S. Environmental Protection Agency (EPA) GSSL with a dilution attenuation factor (DAF) of 1 for inorganics and a DAF of 20 for volatile and semivolatile organics. A DAF of 1 for inorganics was used because average pH of groundwater is less than 5; unless otherwise indicated, GSSL is taken from *Soil Screening Guidance: Technical Background Document* (EPA 1996a).

[b] EPA-suggested GSSL is not available; GSSL is calculated following *Soil Screening Guidance: Technical Background Document* (EPA 1996a). GSSLs are back-calculated from maximum contaminant level, if available; otherwise, GSSLs are back-calculated based on EPA Region III risk-based concentrations (RBCs) corresponding to 10^{-6} risk or hazard quotient = 1 (SAIC 1999).

[c] GSSL taken from EPA Region III suggested soil screening level for groundwater migration (EPA 1999b).

[d] To develop GSSL, RBC is taken from benzo(*b*)fluoranthene with a TEF = 0.01.

[e] GSSL is taken from the GSSL of 2-methylnaphthalene.

[f] RBC to develop GSSL is taken from the surrogate pyrene.

[g] A screening level of 400 mg/kg is used for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA 1994b).

CMCOPC = Contaminant migration contaminant of potential concern.
μg/kg = Micrograms per kilogram.
mg/kg = Milligrams per kilogram.
SRC = Site-related contaminant.
SWMU = Solid waste management unit.

2.9.3 Fate and Transport Modeling

Fate and transport modeling was performed to quantitatively assess the risks associated with exposure to the CMCOPCs in soil. Only groundwater modeling was performed. Surface water is not present at this site and the nearest surface water receptor is located 2,500 feet from the site. Based on the estimated groundwater velocity of 14 feet/year, it would take approximately 178 years for the groundwater in the surficial aquifer to reach the nearest surface water receptor (SAIC 2000).

The SESOIL model was used to predict the maximum groundwater concentration of the CMCOPCs in the soil. A description of the SESOIL model and a summary of the results of the modeling are presented in Appendix G of the revised final RFI Report (SAIC 2000).

The following summarizes the conclusions from the SESOIL modeling:

- The five preliminary organic CMCOPCs identified in the revised final RFI [4-methyl-2-pentanone, benzo(*a*)anthracene, benzo(*b*)fluoranthene, dibenzo(*a*,*h*)anthracene, and 2-methylnaphthalene] either naturally attenuate before reaching the water table or the predicted groundwater concentrations do not exceed their respective RBCs. However, benzene, an additional preliminary CMCOPC based on the supplemental data, is predicted to reach the water table with concentrations exceeding its respective MCL/RBC. Therefore, benzene was identified as a CMCOPC (see Table 2-9).

- Arsenic and chromium were identified as CMCOPCs, as their maximum predicted concentrations at the surface of the groundwater table of 0.21 mg/L and 2.13 mg/L, respectively, exceeded their respective groundwater target concentrations (0.05 mg/L and 0.1 mg/L). (see Table 2-9) These maximum groundwater concentrations of arsenic and chromium are predicted to be reached after 135 years and 67 years, respectively. Based on the groundwater velocity of 14 feet/year, arsenic and chromium will take over 15,000 years to migrate to the nearest potential surface water receptor (Peacock Creek).

The modeled concentrations were used in the human health risk assessment to quantify risk from these constituents, unless measured groundwater concentrations were higher than the modeled concentrations.

2.10 PRELIMINARY RISK EVALUATION

2.10.1 Human Health Preliminary Risk Evaluation

The HHPRE conducted during the RFI included a Step 1 risk evaluation to determine potential human health risks associated with the contaminants present at the site. Human health constituents of potential concern (HHCOPCs) were defined as those constituents present at concentrations higher than their reference background criteria and higher than their respective EPA Region III risk-based screening criteria (SAIC 2000). Risk-based screening criteria were as follows:

- Surface soil: the most current residential preliminary remediation goals (PRGs) published by EPA Region III (available at http://www.epa.gov/reg3h/risk/index.html) using one-tenth of the noncarcinogenic PRG (equating to a screening level of 0.1) and the full carcinogenic PRG (equating to a screening level of 10^{-6}) as screening values.

Table 2-9. Summary of Leachate Modeling Results at the Former Fire Training Area (SWMU 13)

Preliminary CMCOPCs[a]	**Maximum Concentration (mg/kg)**	**Predicted $C_{leachate,max}$ Beneath the Source (mg/L)**	**Predicted T_{max} (years)**	**Predicted $C_{gw,max}$ at the Source**[b] **(mg/L)**	**Maximum Observed Groundwater Concentration (mg/L)**	**Groundwater Target Concentration (mg/L)**	**Source**[c]	**CMCOPC?**
Inorganics								
Arsenic	1.04E+01	2.50E-01	135	2.10E-01	ND	1.00E-02	M	Yes
Chromium	4.04E+01	2.53E+00	67	2.13E+00	ND	1.00E-01	M	Yes
Organics								
2-Methylnaphthalene	2.40E+01	9.10E-04	51	7.65E-04	7.20E-02	1.20E-02	R	No
4-Methyl-2-pentanone	3.80E+00	4.70E-03	< 1	3.95E-03	ND	1.40E-02	R	No
Benzene	0.24E+00	9.98E-02	1	8.38E-02	4.40E-01	5.00E-03	M	Yes
Benzo(*a*)anthracene	1.00E+01	0.00E+00	NA	0.00E+00	ND	9.20E-05	R	No
Benzo(*b*)fluoranthene	8.20E+00	0.00E+00	NA	0.00E+00	ND	9.20E-05	R	No
Dibenzo(*a*,*h*) anthracene	4.50E+00	0.00E+00	NA	0.00E+00	ND	9.20E-06	R	No
Naphthalene	0.15E+02	9.70E-02	4	8.15E-02	3.04E-01	1.49E-01	R	No

[a] These constituents were selected for Seasonal Soil Compartment (SESOIL) modeling from this site.

[b] The predicted maximum concentration in groundwater ($C_{gw,max}$) at the source was calculated by applying a dilution factor to the predicted maximum leachate concentration ($C_{leachate,max}$).

[c] M = maximum contaminant level, R = U. Environmental Protection Agency Region III suggested risk based concentration corresponding to hazard index = 0.1 or 10-6 risk (GA EPD 1999).

NA = Not applicable; constituents naturally attenuates before reaching the water table.

ND = Not detected.

SWMU = Solid waste management unit.

- Subsurface soil: the most current industrial PRGs published by EPA Region III using one-tenth of the noncarcinogenic PRG (equating to a screening level of 0.1) and the full carcinogenic PRG (equating to a screening level of 10^{-6}) as screening values.

- Groundwater: the EPA Region III Tap Water PRGs and federal drinking water MCLs. (Drinking water MCLs available at http://www.epa.gov/ost/drinking/standards/dwstandards.pdf) using one-tenth of the noncarcinogenic PRG (equating to a screening level of 0.1) and the full carcinogenic PRG (equating to a screening level of 10^{-6}) as screening values.

New data have become available as a result of supplemental investigations conducted since the revised final RFI (see Section 2.7.2); therefore, the step 1 risk evaluation is conducted for this CAP using the same method and screening criteria presented in the revised final RFI. The step 1 screening results are provided in Tables 2-10 (surface soil), 2-11 (subsurface soil), and 2-12 (groundwater).

Based on the results of the screening, one HHCOPC was identified in surface soil, seven HHCOPCs in subsurface soils, and seven HHCOPCs in groundwater.

Benzo(*a*)pyrene was detected above its RBC in surface soil at one location. This one location was adjacent to weathered asphalt, and it is likely that this lone sample incorporated some of the asphalt, which resulted in the reported concentration. To be conservative, benzo(*a*)pyrene was identified as a HHCOPC for surface soil.

In subsurface soils: six PAHs [benzo(*a*)pyrene, benzo(*a*)anthracene, benzo(*b*)flouranthene, benzo(*g*,*h*,*i*)perylene, dibenzo(*a*,*h*)anthracene, and phenanthrene] and one metal (arsenic) were detected at concentrations above their respective RBCs (or had no RBCs) and were identified as HHCOPCs for subsurface soil. Arsenic was detected in 41 of 62 samples, and its reference background concentration of 8.04 mg/kg indicates it is prevalent throughout the FSMR. The reference background concentration for arsenic exceeds its RBC of 3.8 mg/kg. None of the RFI data had arsenic concentrations that exceeded the reference background concentration. From the 1997 IM data, two samples that were from the same borehole exceeded the reference background concentration.

The HHCOPCs identified in groundwater were BTEX, naphthalene, 2-methylnaphthalene, and phenanthrene. These constituents were found to present a potential threat to human health as a result of using groundwater as a source of drinking water. Given the shallow depth of the surficial aquifer and the presence of the deeper Principal Artesian Aquifer (a common source of drinking water throughout the region), the use of the surficial aquifer at this site for drinking water is highly unlikely. However, drinking water screening values (i.e., EPA Region III tap water criteria and federal MCLs) were used in the absence of more appropriate values.

A Baseline Human Health Risk Assessment (BHHRA) was performed as part of the revised final RFI to quantitatively assess the risks associated with exposure to the HHCOPCs in the soil and groundwater. The results of the BHHRA are summarized in Section 2.11 and are presented in Appendix H of the revised final RFI Report (SAIC 2000).

2.10.2 Ecological Preliminary Risk Evaluation

The revised final RFI Report (SAIC 2000) provided an EPRE for potential terrestrial receptors at the site [see Chapter 8 of the revised final RFI Report (SAIC 2000)]. The media of concern to ecological receptors are surface soil, sediment, and surface water, because these media can be contacted directly by ecological receptors, and contaminants present in these media can accumulate in plants and animals,

Table 2-10. Selection of Chemicals of Potential Concern in Surface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Frequency of Detection	Detected Concentration		95% UCL of Mean (mg/kg)	Background Criteria[a] (mg/kg)	Maximum Detect > Background?	EPA Region III Residential PRG[b] (mg/kg)	Maximum Detect > RBC?	COPC?	Justification
		Minimum (mg/kg)	Maximum (mg/kg)							
Semivolatile Organic Compounds										
Benzo(*a*)anthracene	1/3	4.30E-01	4.30E-01	5.08E-01	NA	NA	8.75E-01	No	No	Max Detect < Risk Criterion
Benzo(*a*)pyrene	1/3	3.90E-01	3.90E-01	4.56E-01	NA	NA	8.75E-02	Yes	Yes	Max Detect > Risk Criterion
Benzo(*b*)fluoranthene	1/3	5.60E-01	5.60E-01	6.78E-01	NA	NA	8.75E-01	No	No	Max Detect < Risk Criterion
Benzo(*k*)fluoranthene	1/3	4.90E-01	4.90E-01	5.87E-01	NA	NA	8.75E+00	No	No	Max Detect < Risk Criterion
Chrysene	1/3	4.30E-01	4.30E-01	5.08E-01	NA	NA	8.75E+01	No	No	Max Detect < Risk Criterion
Fluoranthene	1/3	7.20E-01	7.20E-01	8.87E-01	NA	NA	3.13E+02	No	No	Max Detect < Risk Criterion
Pyrene	1/3	6.20E-01	6.20E-01	7.57E-01	NA	NA	2.35E+02	No	No	Max Detect < Risk Criterion
Metals										
Barium	3/3	1.00E+01	2.00E+01	2.29E+01	1.47E+01	Yes	5.48E+02	No	No	Max Detect < Risk Criterion
Chromium	3/3	2.20E+00	3.60E+00	4.50E+00	6.21E+00	No	2.35E+01	No	No	Max Detect < Background and Risk Criteria
Lead	3/3	2.90E+00	3.30E+00	3.48E+00	8.81E+00	No	4.0E+02[c]	No	No	Max Detect < Background and Risk Criteria
Mercury	1/3	1.50E-02	1.50E-02	1.81E-02	3.42E-02	No	2.35E+00	No	No	Max Detect < Background and Risk Criteria

[a] SAIC 2000.

[b] Available at http://www.epa.gov/reg3hwmd/risk/index.htm; noncarcinogenic screening values shown are one-tenth of the preliminary remedial goal.

[c] Federal standard for lead in bare soil in children's play areas (available at http://www.epa.gov/lead).

95% UCL = 95% upper confidence limit on the mean.

NA = Not applicable, background criteria are only applied to inorganic chemicals.

ND = No value is available.

RBC = Risk based criteria.

Table 2-11. Selection of Chemicals of Potential Concern in Subsurface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Frequency of Detection	Detected Concentration		95% UCL of Mean (mg/kg)	Background Criteria[a] (mg/kg)	Maximum Detect > Background?	EPA Region III Residential PRG[b] (mg/kg)	Maximum Detect > RBC?	COPC?	Justification
		Minimum (mg/kg)	Maximum (mg/kg)							
Volatile Organic Compounds										
4-Methyl-2-pentanone	2/80	6.90E-02	3.80E+00	1.65E-01	NA	NA	1.64E+04	No	No	Max Detect < Risk Criterion
Acetone	8/79	1.80E-02	1.10E-01	1.80E-01	NA	NA	2.04E+04	No	No	Max Detect < Risk Criterion
Benzene	11/80	1.40E-03	2.40E-01	2.76E-02	NA	NA	1.04E+02	No	No	Max Detect < Risk Criterion
Bromomethane	6/17	3.00E-03	5.00E-03	3.50E-02	NA	NA	2.86E+02	No	No	Max Detect < Risk Criterion
Carbon disulfide	11/79	7.10E-04	2.00E-02	4.69E-02	NA	NA	2.04E+04	No	No	Max Detect < Risk Criterion
Chlorobenzene	1/80	9.30E-01	9.30E-01	3.87E-02	NA	NA	4.09E+03	No	No	Max Detect < Risk Criterion
Chloroform	3/17	5.00E-03	6.80E-02	4.09E-02	NA	NA	2.04E+03	No	No	Max Detect < Risk Criterion
Chloromethane	1/17	1.00E-03	1.00E-03	3.46E-02	NA	NA	4.40E+02	No	No	Max Detect < Risk Criterion
Ethylbenzene	23/80	1.00E-02	7.44E+00	8.05E-01	NA	NA	2.04E+04	No	No	Max Detect < Risk Criterion
Methylene chloride	4/79	4.00E-03	1.10E-02	4.65E-02	NA	NA	7.63E+02	No	No	Max Detect < Risk Criterion
Toluene	16/80	7.10E-03	1.80E+00	1.04E-01	NA	NA	4.09E+04	No	No	Max Detect < Risk Criterion
Xylenes, total	25/80	6.40E-03	6.10E+01	5.40E+00	NA	NA	4.09E+05	No	No	Max Detect < Risk Criterion
Semivolatile Organic Compounds										
1-Methylnaphthalene	5/48	7.20E-01	1.80E+01	1.64E+00	NA	NA	4.09E+03[c]	No	No	Max Detect < Risk Criterion
2-Methylnaphthalene	21/80	6.27E-02	2.40E+01	2.38E+00	NA	NA	4.09E+03	No	No	Max Detect < Risk Criterion
Acenaphthene	2/80	2.80E+00	4.50E+00	3.70E-01	NA	NA	1.23E+04	No	No	Max Detect < Risk Criterion
Anthracene	2/80	5.10E-01	1.10E+00	2.46E-01	NA	NA	6.13E+04	No	No	Max Detect < Risk Criterion
Benzo(*a*)anthracene	5/80	4.70E-01	1.00E+01	5.95E-01	NA	NA	7.84E+00	Yes	Yes	Max Detect > Risk Criterion
Benzo(*a*)pyrene	7/80	4.40E-01	3.70E+00	3.71E-01	NA	NA	7.84E-01	Yes	Yes	Max Detect > Risk Criterion
Benzo(*b*)fluoranthene	6/80	5.50E-01	8.20E+00	5.24E-01	NA	NA	7.84E+00	Yes	Yes	Max Detect > Risk Criterion
Benzo(*g*,*h*,*i*)perylene	6/80	4.20E-01	2.40E+00	3.16E-01	NA	NA	ND	None	Yes	No Screening Criteria
Benzo(*k*)fluoranthene	5/80	8.90E-03	8.20E+00	4.95E-01	NA	NA	7.84E+01	No	No	Max Detect < Risk Criterion
Bis(2-ethylhexyl)phthalate	2/18	2.61E-02	9.70E-02	1.94E-01	NA	NA	4.09E+02	No	No	Max Detect < Risk Criterion
Butyl benzyl phthalate	1/18	2.72E-01	2.72E-01	2.07E-01	NA	NA	4.09E+04	No	No	Max Detect < Risk Criterion
Chrysene	8/80	1.19E-02	1.00E+01	5.91E-01	NA	NA	7.84E+02	No	No	Max Detect < Risk Criterion
Di-*N*-octylphthalate	1/18	2.10E-01	2.10E-01	1.98E-01	NA	NA	4.09E+03	No	No	Max Detect < Risk Criterion

Table 2-11. Selection of Chemicals of Potential Concern in Subsurface Soil at the Former Fire Training Area (SWMU 13) (continued)

Analyte	**Frequency of Detection**	**Detected Concentration**		**95% UCL of Mean (mg/kg)**	**Background Criteria[a] (mg/kg)**	**Maximum Detect > Background?**	**EPA Region III Residential PRG[b] (mg/kg)**	**Maximum Detect > RBC?**	**COPC?**	**Justification**
		Minimum (mg/kg)	**Maximum (mg/kg)**							
Dibenzo(*a*,*h*)anthracene	4/80	6.80E-01	4.50E+00	3.91E-01	NA	NA	7.84E-01	Yes	Yes	Max Detect > Risk Criterion
Dibenzofuran	1/18	1.50E-01	1.50E-01	1.97E-01	NA	NA	8.18E+02	No	No	Max Detect < Risk Criterion
Diphenylamine	2/12	2.37E-01	2.63E-01	2.17E-01	NA	NA	5.11E+03	No	No	Max Detect < Risk Criterion
Fluoranthene	10/80	2.06E-02	9.10E+00	6.71E-01	NA	NA	8.18E+03	No	No	Max Detect < Risk Criterion
Fluorene	19/80	5.40E-03	4.40E+00	4.13E-01	NA	NA	8.18E+03	No	No	Max Detect < Risk Criterion
Indeno(*1*,*2*,*3*-*cd*)pyrene	6/80	6.80E-01	4.50E+00	4.05E-01	NA	NA	7.84E+00	No	No	Max Detect < Risk Criterion
Naphthalene	17/80	2.68E-02	1.50E+01	1.31E+00	NA	NA	4.09E+03	No	No	Max Detect < Risk Criterion
Phenanthrene	21/80	1.31E-02	2.20E+00	4.13E-01	NA	NA	ND	None	Yes	No Screening Criteria
Pyrene	16/80	2.35E-02	8.10E+00	5.91E-01	NA	NA	6.13E+03	No	No	Max Detect < Risk Criterion
Metals										
Arsenic	41/62	1.10E+00	1.04E+01	2.92E+00	8.04E+00	Yes	3.82E+00	Yes	Yes	Max Detect > Risk Criterion
Barium	62/62	5.60E+00	2.66E+01	1.52E+01	1.70E+01	Yes	1.43E+04	No	No	Max Detect < Risk Criterion
Chromium	62/62	2.70E+00	4.04E+01	1.62E+01	1.16E+01	Yes	6.13E+02	No	No	Max Detect < Risk Criterion
Lead	62/62	2.20E+00	1.70E+01	7.69E+00	1.11E+01	Yes	1.2E+03[d]	No	No	Max Detect < Risk Criterion
Mercury	33/62	1.30E-02	9.70E-02	1.85E-02	4.80E-02	Yes	6.13E+01	No	No	Max Detect < Risk Criterion

[a] SAIC 2000.

[b] Available at http://www.epa.gov/reg3hwmd/risk/index.htm.

[c] Value for 2-methyl naphthalene.

[d] Federal standard for lead in bare soil in children's play areas (available at http://www.epa.gov/lead).

95% UCL = 95% upper confidence limit on the mean.

NA = Not applicable, background criteria are only applied to inorganic chemicals.

ND = No value is available.

RBC = Risk based criteria.

Table 2-12. Selection of Chemicals of Potential Concern in Groundwater at the Former Fire Training Area (SWMU 13)

		Detected Concentration										
Analyte	**Frequency of Detection**	**Minimum (µg/L)**	**Maximum (µg/L)**	**95% UCL of Mean (µg/L)**	**Bckgrnd Criteria[a] (µg/L)**	**Max. Detect > Bckgrnd?**	**EPA Region III Tap Water Criteria[b] (µg/L)**	**Max. Detect > Tap Water Criteria?**	**Max. Detect > MCL?**	**Max. Detect > MCL?**	**COPC?**	**Justification**
BTEX												
Benzene	14/23	3.30E-01	4.40E+02	1.13E+02	NA	NA	3.19E-01	Yes	5.00E+00	Yes	Yes	Max Detect > Region III Criterion and MCL
Ethylbenzene	14/23	1.40E-01	9.52E+02	2.61E+02	NA	NA	3.25E+00	Yes	7.00E+02	Yes	Yes	Max Detect > Region III Criterion and MCL
Toluene	9/23	2.60E-01	5.20E+02	9.57E+01	NA	NA	7.47E+01	Yes	1.00E+03	No	Yes	Max Detect > Region III Criterion
Xylenes, total	13/23	4.00E-01	5.30E+03	1.29E+03	NA	NA	1.22E+03	Yes	1.00E+04	No	Yes	Max Detect > Region III Criterion
Semivolatile Organic Compounds												
2-Methylnaphthalene	3/10	2.10E+01	7.20E+01	3.40E+01	NA	NA	1.22E+01	Yes	ND	None	Yes	Max Detect > Region III Criterion
Fluorene	1/8	2.60E+00	2.60E+00	1.23E+00	NA	NA	2.43E+01	No	ND	None	No	Max Detect < Risk Criteria
Naphthalene	6/18	4.00E+00	3.04E+02	6.78E+01	NA	NA	6.51E-01	Yes	ND	None	Yes	Max Detect > Region III Criterion
Phenanthrene	1/8	1.80E+00	1.80E+00	9.55E-01	NA	NA	ND	None	ND	None	Yes	No Screening Criteria
Metals												
Barium	9/10	1.50E+01	2.40E+01	2.11E+01	7.17E+01	No	2.56E+02	No	2.00E+03	No	No	Max Detect < Background and Risk Criteria
Ferric Iron	3/4	2.20E+02	7.10E+02	6.35E+02	ND	None	ND	None	ND	None	No	Essential Nutrient
Iron	4/4	5.20E+01	7.10E+02	6.35E+02	4.38E+03	No	1.10E+03	No	ND	None	No	Max Detect < Background and Risk Criteria

[a] SAIC 2000.

[b] Available at http://www.epa.gov/reg3hwmd/risk/index.htm; noncarcinogenic screening values shown are one-tenth of the preliminary remedial goal.

[c] Available at http://www.epa.gov/ost/drinking/standards/dwstandards.pdf.

95% UCL = 95% upper confidence limit on the mean.

NA = Not applicable, background criteria are only applied to inorganic chemicals.

ND = No value is available.

causing exposure to ecological receptors ingesting them. At SWMU 13, the nearest perennial surface water body, Peacock Creek, is 2,500 feet from the site and there are no other features nearby to receive groundwater discharges. Therefore, sediment and surface water samples were not collected. The media evaluated during the EPRE are surface soil and groundwater.

The EPRE provided a Phase I PRE for potential terrestrial receptors at the site. Preliminary risk calculations identified potential ecological constituents of potential concern (ECOPCs) in surface soil and groundwater, based on a comparison of detected concentrations to toxicity reference values (TRVs) for surrogate species representing ecological receptors.

Barium was detected above reference background criteria in surface soil at SWMU 13 but was below the ecological screening values (ESVs) and was, therefore, not retained as an ECOPC in surface soil. Benzo(*a*)anthracene, benzo(*b*)fluoranthene, benzo(*k*)fluoranthene, chrysene, fluoranthene, and pyrene were detected in surface soil above reference background criteria. However, there is uncertainty as to whether these six PAHs are ECOPCs in surface soil, because toxicity data specific to these constituents were not available. These six PAHs were detected in only one surface soil sample that was adjacent to weathered and eroded asphalt. It is likely that this lone sample incorporated some of the asphalt, which resulted in the reported concentrations. All PAHs detected were at low concentrations and are unlikely to pose a risk to ecological receptors given the low concentrations relative to their proposed TRVs, which are one-tenth the TRV for benzo(*a*)pyrene. Therefore, no organic ECOPCs were identified in surface soil.

Based on preliminary risk calculations, ethylbenzene, total xylenes, and naphthalene were identified as ECOPCs in groundwater. The risk to ecological receptors from ECOPCs in groundwater at SWMU 13 are overestimated by the ESV comparison and preliminary risk calculations. The nearest surface water to SWMU 13 is Peacock Creek, which is 2,500 feet away. If dilution and degradation, before or after discharge, reduces the concentration of ECOPCs by a factor of 10, none of the maximum concentrations would exceed the ESVs for surface water. Supplemental risk calculations (see Section 8.0 of the revised final RFI report) performed to evaluate ecological receptors exposed to ethylbenzene, total xylenes, and naphthalene in groundwater showed that these constituents are unlikely to pose a risk to wildlife receptors.

Based on this EPRE, no ECOPCs were identified in surface soil or groundwater at SWMU 13.

2.11 BASELINE HUMAN HEALTH RISK ASSESSMENT

A BHHRA was performed to assess HHCOPCs in soil and groundwater and CMCOPCs in soil around SWMU 13. The HHCOPCs in soil addressed in the baseline risk assessment included the following constituents: arsenic (subsurface soil), benzo(*a*)pyrene (surface and subsurface soil), benzo(*a*)anthracene (subsurface soil), benzo(*b*)fluoranthene (subsurface soil), and dibenzo(*a,h*)anthracene (subsurface soil). The HHCOPCs in groundwater that were evaluated in the BHHRA were BTEX, 2-methylnaphthalene, and naphthalene. Benzo(*g,h,i*)perylene and phenanthrene were also identified as HHCOPCs in soil and/or groundwater; however, these constituents cannot be included in the quantitative BHHRA because appropriate toxicity data are not available.

Potential groundwater concentrations resulting from leaching of the CMCOPCs benzene, naphthalene, 4-methyl-2-pentanone, benzo(*a*)anthracene, benzo(*b*)flouranthene, dibenzo(*a,h*)anthracene, 2-methylnaphthalene, arsenic, and chromium were estimated using the SESOIL leachate model (see Section 2.12). The modeled groundwater concentrations were screened using the respective groundwater screening values to determine which constituents should be evaluated further in the baseline risk assessment. The maximum modeled groundwater concentrations show that benzo(*a*)anthracene, benzo(*b*)fluoranthene, and dibenzo(*a,h*)anthracene naturally attenuate before reaching the water table, and the predicted groundwater concentrations of 2-methylnaphthalene and 4-methyl-2-pentanone do not exceed their respective RBCs. Therefore, these organic constituents are not considered to be CMCOCs and were not addressed in the BHHRA. The CMCOCs benzene, arsenic, and chromium exceeded their respective screening values; therefore, the potential risks associated with these constituents in groundwater were assessed. The results of the BHHRA are discussed below.

Benzo(*a*)pyrene in surface soil was identified as a COC based on the exposure scenario of the future on-site resident child and adult. Therefore, a remedial level was derived for benzo(*a*)pyrene. The exposure point concentration (EPC) used for surface soil exposures to benzo(*a*)pyrene in the BHHRA was the maximum detected concentration of this chemical. The maximum detected concentration of benzo(*a*)pyrene in soil did not change as a result of the supplemental investigations; therefore, the results of the BHHRA do not change and the remedial level derived in the RFI and presented in Table 2-13 remains applicable.

None of the estimated risks from exposure to constituents of potential concern (COPCs) in subsurface soil exceeded screening criteria;, therefore, no COCs were identified for this medium. The EPCs used for subsurface soil exposures in the BHHRA were the 95% upper concentration limit (UCL) of the mean concentration of each (COPC). The 95% UCL concentrations of all organic COPCs decreased as a result of the supplemental investigation. The 95% UCL concentration of arsenic increased slightly (from 2.89 mg/kg to 2.92 mg/kg), and the estimated risk results for arsenic were almost an order of magnitude below screening criteria. Therefore, no new COCs were identified as a result of the supplemental investigation.

BTEX, 2-methylnaphthalene, naphthalene, and phenanthrene were identified as HHCOPCs in groundwater. Groundwater at this site is not currently used for any purpose, and groundwater does not discharge to any nearby surface waters. Therefore, no current receptors are being exposed to HHCOPCs at this site. Potential future receptors include an on-site and off-site worker and a resident. The potential risks associated with exposure of the receptor populations to toluene and total xylenes in groundwater were below the target risk values; therefore, no adverse risks to human health are expected as a result of exposure to these constituents. Benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene are considered to be COCs in groundwater. Benzene is considered to be a COC in groundwater based on the exposure of the future on-site worker, future off-site worker, future on-site resident child, and future on-site resident adult. Ethylbenzene, 2-methylnaphthalene, and naphthalene are COCs based on the exposure scenario for the future on-site resident child. No toxicity data are available to quantitatively evaluate phenanthrene. Remedial levels were derived for benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene. The EPCs used for groundwater exposures in the BHHRA were the 95% UCL of the mean concentration of each COPC. The 95% UCL concentrations of BTEX all decreased as a result of the supplemental investigation, while the 95% UCL concentration of naphthalene rose slightly (from 58.1 µg/L to 67.8 µg/L). The 95% UCL concentration of 2-methylnaphthalene was unchanged. Therefore, no new COCs were identified as a result of the supplemental investigations and the remedial levels derived in the revised final RFI and presented in Table 2-13 remain applicable.

As discussed above, arsenic, chromium, and benzene were identified as CMCOCs.

Remedial levels were derived in the revised final RFI for benzo(*a*)pyrene in surface soil and benzene, ethylbenzene, 2-methylnaphthalene, and naphthalene in groundwater. These remedial levels remain applicable. Remedial levels for CMCOCs in soils were derived in the revised final RFI for arsenic and chromium and in this CAP for benzene based on the protection of groundwater.

Table 2-13. Remedial Levels Derived in the Revised Final RFI Report for Surface Soil and Groundwater at the Former Fire Training Area (SWMU 13)

Constituent of Concern	Environmental Medium	Units	Maximum Detected Concentration	Reference Background Concentration	Maximum Contaminant Level	Risk-Based Remedial Levels				
						Hazard Index			Incremental Lifetime Cancer Risk	
						0.1	**0.5**	**1**	**1 × 10^{-6}**	**1 × 10^{-5}**
Benzo(*a*)pyrene	Surface Soil	mg/kg	0.39	NA[c]	NA[b]	2.32E-02	1.16E-01	2.32E-01	9.8E-02	**9.8E-01**
2-Methylnaphthalene	Groundwater	mg/L	0.072	NA[c]	NA[e]	2.83E-02	**1.42E-01**	2.83E-01	NA[a]	NA[a]
Benzene	Groundwater	mg/L	0.44	NA[c]	**5.00E-03**	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Ethylbenzene	Groundwater	mg/L	0.94	NA[c]	**7.00E-01**	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Naphthalene	Groundwater	mg/L	0.304	NA[c]	NA[e]	2.98E-02	**1.49E-01**	2.98E-01	NA[a]	NA[a]

Bold indicates values that are the recommended remedial values.
NA[a] = Not applicable; constituent of concern based on systemic risk only.
NA[b] = Not applicable; maximum contaminant level is not applicable for this environmental medium.
NA[c] = Not applicable; reference background concentrations are not available for organic constituents.
NA[d] = Not applicable; this constituent has a maximum contaminant level.
NA[e] = Not applicable; a maximum contaminant level is not available for this constituent.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA facility investigation.
SWMU = Solid waste management unit.

Human Health Constituents of Concern. Remedial levels were derived in the revised final RFI report and in this CAP for the HHCOCs and CMCOCs and are shown in Tables 2-13 and 2-14. The selection of the recommended remedial levels for soil and groundwater takes into consideration regulatory levels (such as MCLs), risk-based remedial levels, and reference background concentrations of inorganics.

Table 2-14. Remedial Levels Derived in the Revised Final RFI Report and in the CAP for CMCOCs at the Former Fire Training Area (SWMU 13)

	Risk-based Remedial Levels (mg/kg)							
	Hazard Index			**ILCR**			**Soil Concentration Based on MCL**	**Reference Background Concentration (mg/kg)**
CMCOC	**0.1**	**0.5**	**1**	**1.00E-06**	**1.00E-05**	**1.00E-04**		
Arsenic	2.32E-02	1.16E-01	2.32E-01	2.80E-03	2.80E-02	2.80E-01	2.48E+00	**8.04**
Chromium	8.65E-02	4.33E-01	8.65E-01	NA	NA	NA	1.90E+00	**11.6**
Benzene							**1.40E-02**	

CMCOC = Contaminant migration constituent of concern.
ILCR = Incremental lifetime cancer risk.
MCL = Maximum contaminant level.
NA = Not applicable; a cancer slope factor is not available for this constituent.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA facility investigation.
SWMU = Solid waste management unit.
Values appearing in **bold** print are the recommended remedial levels.

Benzo(*a*)pyrene was the only COC identified in soil. The remedial level for this constituent addresses the potential risk to a hypothetical future resident (adult and child) exposed to constituents in surface soil via ingestion, inhalation, and dermal contact. The remedial level recommended for benzo(*a*)pyrene in surface soil is 0.98 mg/kg, which corresponds to a total residential cancer risk of 1×10^{-5}. This remedial level takes into account the potential contributions of carcinogens present in groundwater in addition to surface soil.

The MCLs for benzene (5 µg/L) and ethylbenzene (700 µg/L) are the recommended remedial levels for these constituents in groundwater. The remedial levels for 2-methylnaphthalene and naphthalene of 142 µg/L and 149 µg/L, respectively, were based on risk concentrations. The EPC (34 µg/L) and maximum concentrations of 2-methylnaphthalene (72 µg/L) detected in the RFI groundwater samples were below the recommended remedial level. The EPC (67.8 µg/L) of naphthalene was below the recommended remedial level. The maximum detected concentration of naphthalene (304 µg/L) was above the recommended remedial level.

Figure 2-5 presents the estimated area of groundwater contamination at SWMU 13 based on these remedial levels.

CMCOCs. Remedial levels for the CMCOCs in soils (arsenic, chromium, and benzene) were derived based on the protection of groundwater from potential leaching from soil. The remedial level for CMCOCs represents that soil concentration that is unlikely to leach into groundwater or migrate to surface water in concentrations that present a significant threat to human health. The potential risk associated with CMCOCs is not direct exposure to soil, but exposure to the constituents in groundwater; therefore, the remedial levels in soils were based upon target groundwater concentrations (see Table 2-14). These values are the concentrations of CMCOCs in groundwater, as a result of leaching from soil, that present a defined risk (carcinogenic and/or noncarcinogenic) to the most sensitive receptor (on-site resident). For SWMU 13 the potential remedial levels based on the target groundwater concentrations were below the reference background concentrations for arsenic and chromium (8.04 mg/kg and 11.6 mg/kg, respectively); therefore, the background concentration for each of these constituents was recommended as the remedial level. For the CMCOC benzene, the subsurface soil remedial level of 0.014 mg/kg was calculated based on the groundwater MCL of 0.005 mg/L.

2.12 MODELING FOR EVALUATING CONTAMINANT NATURAL ATTENUATION

Fate and transport modeling was performed to develop specific DAFs for the identified COCs (benzene, ethylbenzene, and naphthalene) and CMCOC (benzene). However, modeling was not performed for the CMCOCs arsenic and chromium, as these constituents were not expected to migrate to the nearest surface water receptor. (See discussion in Section 3.3 for additional information regarding these CMCOCs.) A general discussion of the modeling effort is presented in Chapter 6.0 and Appendix G of the revised final RFI Report (SAIC 2000), and the site-specific model parameters and results are discussed in Appendix C of this CAP. Using the measured concentrations in groundwater (as the measured concentration is greater than the predicted concentration based on leaching from contaminated soil from the site), the AT123D model was used to predict the concentration with distance from the source and also the time to achieve the remedial levels.

Benzene was selected as the surrogate chemical from the COCs benzene and ethylbenzene because benzene has a slower degradation rate and higher mobility than ethylbenzene. A steady-state AT123D model was developed by calibrating the model against observed maximum concentrations of benzene in the groundwater beneath SWMU 13. Benzene concentrations in groundwater at monitoring wells MW12, MW13, MW16, and MW18 in two different time frames (December 2000 and June 2002) were used to calibrate the model in order to simulate natural attenuation process. The results of this modeling indicate that the benzene concentration in groundwater is not expected to exceed its remedial level of 5 μg/L beyond 100 feet from the source. Therefore, benzene from the SWMU 13 site is not expected to be of potential concern at the nearest receptor location [i.e., Peacock Creek (2,500 feet from the source)], as groundwater will be completely free of benzene by the time it reaches the creek. In addition, the modeling shows that benzene concentrations at the source will be reduced to less than its remedial level by natural attenuation processes within 5 years from the time of the last sampling event (June 2002). The time period necessary to attain a concentration of 71.28 μg/L for benzene, which is the Georgia instate water quality standard, through natural attenuation is predicted to be less than 1.5 years from June 2002.

To further evaluate monitored natural attenuation as a remedial alternative, fate and transport modeling was performed in conjunction with active remediation measures. Multiple AT123D modeling runs were performed by reducing the concentration of benzene at the source. The modeling, presented in Appendix C, shows that the time frame for natural attenuation of benzene to the remedial level reduces to less than 3 years, if the benzene source in the groundwater is reduced to 50 μg/L.

To evaluate the SVOC COCs, a steady-state AT123D model was developed by calibrating the model against observed maximum concentrations of naphthalene [considered as a surrogate chemical for 2-methylnaphthalene and benzo(*a*)pyrene] in the groundwater beneath SWMU 13. During the December 2000 sampling event, a maximum concentration of naphthalene (304 μg/L) was observed in groundwater at SWMU 13. In order to simulate the natural attenuation process, the data from the December 2000 sampling event was used to calibrate the naphthalene model. Modeling results indicate that the naphthalene concentration in groundwater is not expected to exceed its remedial level after 3 years from December 2000 (less than 1.5 years from June 2002).

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3.0 JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION

3.1 PURPOSE

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

3.2 REMEDIAL RESPONSE OBJECTIVES

Due to the presence of benzene, ethylbenzene, and naphthalene in groundwater at concentrations above remedial levels, corrective action is warranted at SWMU 13. The remedial response objectives for SWMU 13 are to reduce the present concentrations of benzene, ethylbenzene, and naphthalene in groundwater to the remedial levels presented in the revised final RFI Report (SAIC 2000) and in this CAP. The selected remedy would provide the technology necessary to minimize contaminant concentrations in the groundwater and achieve the best overall result with respect to such factors as effectiveness, implementability, and cost.

3.3 IDENTIFICATION OF REMEDIAL LEVELS

COCs were identified in the revised final RFI Report for surface soil, subsurface soil, and groundwater (SAIC 2000). New data have become available as a result of supplemental investigations since the RFI. One new CMCOC in soil (benzene) was identified as a result of the supplemental investigations. The remedial level presented in the RFI remains applicable; however, an additional remedial level has been derived in this CAP for the new CMCOC, benzene. The COCs and their respective remedial levels are discussed in Sections 2.10 and 2.11, in the following paragraphs, and are shown on Tables 3-1 through 3-3.

Table 3-1. Remedial Levels for COCs in Surface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Surface Soil Remedial Level (μg/kg)	Maximum Soil Concentration (μg/kg)	Recommendation
Benzo(*a*)pyrene	980	390	No further investigation/action is required as the maximum concentration is less than the remedial level.

Surface Soil. Benzo(*a*)pyrene was identified as a COC for surface soil based on direct exposure. Benzo(*a*)pyrene was detected in only one sample at a concentration of 390 μg/kg. This sample was collected from an area adjacent to weathered and eroded asphalt pavement. It is reasonable to expect that some asphalt fragments eroded from the weathered pavement could have been incorporated into the sample during the collection and, thus, biased the sample results. Based on the low frequency of detection of benzo(*a*)pyrene in surface soil, the likely biased nature of the one detectable result, and the fact that the maximum detected concentration of benzo(*a*)pyrene in surface soil is less than the remedial level (Table 3-1), no remediation for surface soil is recommended.

Table 3-2. Remedial Levels for CMCOCs in Subsurface Soil at the Former Fire Training Area (SWMU 13)

Analyte	Subsurface Soil Remedial Level (mg/kg)	Maximum Soil Concentration (mg/kg)	Recommendation
Arsenic	8.04	10.4	No further investigation/remedial action is required due to its ubiquitous nature at this site and the fact that none of the RFI samples had concentrations exceeding the remedial level (background).
Chromium	11.6	40.4	No further investigation/remedial action is required due to its ubiquitous nature at this site and the fact that chromium is not expected to migrate to the nearest surface water.
Benzene	0.014	0.24	No further investigation/remedial action is required. Based on the modeling results (see Appendix C, Section C.5), it can be concluded that the soil concentration of benzene will be reduced to its soil remedial level through natural attenuation before the groundwater concentration is reduced to its groundwater remedial level for benzene.

CMCOC = Contaminant migration constituent of concern.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA facility investigation.

Table 3-3. Remedial Levels for COCs in Groundwater at the Former Fire Training Area (SWMU 13)

Analyte	Groundwater Remedial Level (μg/L)	Maximum Concentration in RFI Sampling (μg/L)	Maximum Concentration in December 2000 Sampling (μg/L)	Maximum Concentration in June 2002 Sampling (μg/L)	Recommendation
Benzene	5	440	418	120	Corrective action recommended.
Ethylbenzene	700	940	952	486	Corrective action recommended.
2-Methylnaphthalene	142	72	NA	NA	No further investigation/ remedial action is required as the maximum detected concentrations is below the remedial level.
Naphthalene	149	140	304 J	NA	Corrective action recommended.

J = Indicates compound was positively identified; numerical value is approximate concentration of the compound in the sample.

COC = Constituent of concern.
NA = Not analyzed.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA facility investigation.
SWMU = Solid waste management unit.

Subsurface Soil. Arsenic and chromium were identified as CMCOCs based on the exposure of the future on-site groundskeeper, future off-site installation worker, future on-site resident child, and future on-site resident adult being exposed to leaching from soils to groundwater.

Arsenic was detected in 43 of 64 samples ranging from 1.1 mg/kg to 10.4 mg/kg with an average result of 2.46 mg/kg (see Table 3-2). The reference background concentration of 8.04 mg/kg exceeded the RBC of 3.8 mg/kg and indicates that arsenic naturally occurs at levels greater than its RBC throughout the FSMR. None of the RFI samples had arsenic concentrations that exceeded its remedial level. From the IM data, two samples from the same borehole exceeded the remedial level [location SA-21 at 2 feet bgs (10.4 mg/kg) and at 3 feet bgs (9 mg/kg)]. At this location, soils to a depth of 2 feet bgs were excavated during the IM. Due to the ubiquitousness of arsenic at the FSMR, and the fact that none of the RFI samples exceeded the reference background concentration, remediation of subsurface soil for arsenic is not recommended.

Chromium was detected in all 64 subsurface soil samples ranging from 2.7 mg/kg to 40.4 mg/kg with an average result of 13.3 mg/kg. Chromium exceeded its remedial level (reference background criteria) of 11.6 mg/kg in 31 of the 64 samples, all of which were from the IM data set. Based on the slow groundwater movement at the site (14 feet/year) and the high retardation factors, chromium and arsenic are not expected to migrate to the nearest surface water receptor, Peacock Creek, located 2,500 feet downgradient from the site. Due to the ubiquitousness of chromium at the FSMR and the fact that it is not expected to migrate to the nearest surface water receptor, remediation of subsurface soils for chromium is also not recommended.

Based on a review of data generated from supplemental investigations, benzene was identified as a CMCOC as it is predicted to reach the water table with concentrations exceeding its respective MCL. Based on modeling results, the maximum predicted concentration of benzene based on leaching to groundwater will be reduced to its MCL within 4 years from January 2002 (i.e., 3.5 years from June 2002). Therefore, it may be concluded that the soil concentration of benzene will be reduced to its soil remedial level before the groundwater concentration is reduced to its groundwater remedial level at the site. Based on this information, no remediation of subsurface soil for benzene is recommended.

Groundwater. Remedial levels were developed in the revised final RFI Report for four groundwater COCs. These remedial levels are based on MCLs and RBCs, which take into consideration both human health and technological limitations. No new COCs for groundwater were identified as a result of the supplemental investigations; therefore, the remedial levels derived in the revised final RFI remain applicable. These remedial levels shown in Table 3-3 are protective of direct exposure to residents by hazardous constituents in groundwater. However, it is recognized that groundwater is not used at this site as a source of drinking water and that it will take approximately 178 years for groundwater to reach the nearest receptor at Peacock Creek, which is 2,500 feet from SWMU 13. These constituents will naturally attenuate in groundwater through retardation and biodegradation before reaching Peacock Creek. As the maximum detected concentration of 2-methylnaphthalene in the RFI samples was below the recommended remedial level; no further investigation or study is required to address this constituent in groundwater.

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4.0 SCREENING OF CORRECTIVE ACTIONS

This chapter presents the identification of technologies applicable for the remediation of the SWMU 13 site and screens the technologies with respect to effectiveness, implementability, and cost. The technologies that are retained following screening are then combined into corrective action alternatives that address the COCs at SWMU 13. These alternatives are then evaluated with respect to time implementation and total life-cycle cost.

4.1 SCREENING CRITERIA

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

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

4.1.1 Effectiveness

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

4.1.2 Implementability

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

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

Potentially applicable technologies are identified in Table 4-1.

Table 4-1. Evaluation of Corrective Actions/Technologies at the Former Fire Training Area (SWMU 13)

Action/ Technology	Description	Effectiveness	Implementability	Costs
No Action	The "No Action" alternative provides a baseline against which other actions can be compared. Under the No Action alternative, any remaining source and the groundwater would be left "as is," without implementing any removal, treatment, or other mitigating actions to reduce existing or potential future exposure.	This alternative would not meet the remedial response objectives. This alternative does not provide protection of human health or the environment because attainment of remedial levels would not be confirmed.	There is no impediment to implementation of this alternative because no action is taken.	There would be no cost associated with the No Action alternative.
Institutional Controls	Technologies associated with institutional controls would reduce potential hazards by limiting exposure of humans to contaminated groundwater. Groundwater use restrictions would prohibit the use of groundwater as a drinking water supply. Excavation permit restrictions would prohibit any construction at the site that might disturb the soil or allow contact with the groundwater.	This technology alone would not meet the remedial response objectives. Assuming compliance with groundwater use restrictions, this technology would be effective and provide reliability with respect to eliminating human exposure to contaminated groundwater within the boundaries of the site. However, use of surficial groundwater at this site for drinking water is unlikely.	Very few factors limit implementability of institutional controls. The property is not expected to be developed in the near future and will remain under federal ownership. Therefore, this alternative is readily implementable.	Low; would require establishing groundwater use and excavation restrictions.
Monitored Natural Attenuation	This action would require monitoring the contaminant levels to ensure that the mass of contamination is being reduced over time in accordance with OSWER Directive 9200.4-17P. A total of seven wells would be sampled annually for approximately 6 years (includes 1-year contingency) and analyzed for BTEX and natural attenuation parameters (e.g., methane, NO_2/NO_3). Additionally, one-time sampling events would initially be performed as a baseline and 1 year after the final annual event for confirmation sampling to determine if remedial levels were met.	Two interim actions have been conducted at this site to remove suspected source materials, and concentrations of BTEX constituents in groundwater are lower than previously observed. Therefore, natural attenuation of BTEX constituents would be effective. Remedial levels for groundwater would be achieved in 6 years (includes a 1-year contingency period).	This alternative is readily implementable and would require monitoring a total of seven wells at the site for approximately 6 years (includes a 1-year contingency period). In addition, baseline and confirmatory (1 year after the completion of annual monitoring) groundwater sampling would be required.	Low; would require annual sampling/ monitoring of seven wells for approximately 6 years (includes a 1-year contingency period). In addition, baseline and confirmatory (1 year after the completion of annual monitoring) groundwater sampling would be required.

Table 4-1. Evaluation of Corrective Actions/Technologies at the Former Fire Training Area (SWMU 13) (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Air Sparging	Air sparging involves injecting a gas, usually air, under pressure, into the subsurface to volatilize groundwater contaminants and to promote biodegradation by increasing subsurface oxygen concentrations. Groundwater sampling would be performed at the completion of the treatment to confirm that remedial levels had been achieved.	This technology has been proven to be effective for the COCs found at this site.	The equipment is readily available. Compressors and other air injection system components would be operated for up to 2 years (includes a 6-month contingency period). Up to seven injection wells would have to be installed. Monitoring and maintenance of the wells would be required. A UIC permit would be required for the injection of air.	Moderate; $20 to $50 per ton of saturated soil (EPA 1995b).
Enhanced Bioremediation (Pure Oxygen Injection)	Enhanced bioremediation is the enhancement of one aspect of natural attenuation. The activity of naturally occurring microbes is stimulated by injecting 98 percent pure oxygen to enhance in situ biological degradation of organic contaminants. Nutrients or other additives may be used to encourage the natural biodegradation processes. Groundwater sampling would be performed at the completion of the treatment to confirm that remedial levels had been achieved.	This technology has been proven to be effective for the volatile organic chemicals found at this site (benzene and ethylbenzene).	The equipment is readily available, and the treatment applicable to a small site. Up to 13 injection points would have to be installed. The bioremediation process may require continuous monitoring and maintenance to prevent plugging of injection wells by microbial growth or mineral precipitation. A UIC permit would be required for the injection of oxygen or nutrients.	Moderate; similar to air sparging based on quote from manufacturer.

Table 4-1. Evaluation of Corrective Actions/Technologies at the Former Fire Training Area (SWMU 13) (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Enhanced Bioremediation (PHOSter® II)	Similar to pure oxygen injection, the PHOSter® II technology enhances natural attenuation through injection of vapor-phase phosphorous, nitrogen, and air. Groundwater sampling would be performed at the completion of the treatment to confirm that remedial levels had been achieved.	PHOSter® II is an innovative technology that has been demonstrated in limited applications to be effective for fuels and related BTEX components. Technical performance is highly uncertain due to limited full-scale implementation.	Equipment readily available and applicable to a small site. Because this technology is innovative and relatively new, there is a high degree of uncertainty regarding the radius of influence and treatment time required. Longer-term operations may require monitoring to prevent plugging of injection wells by microbial growth or mineral precipitation.	Moderate to high; similar to air sparging; costs dependent on required treatment time.
Geo-Cleanse®	The Geo-Cleanse® Process is an aggressive, pressurized injection of concentrated hydrogen peroxide and ferrous iron catalyst (together known as Fenton's reagent) that generates a hydroxyl free radical that acts as the active oxidizing agent. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction. Groundwater sampling would be performed at the completion of the treatment to confirm that remedial levels had been achieved.	Shallow depth to groundwater at the site may limit effectiveness. Multiple applications might be required to achieve remedial levels. Chemical oxidation would temporarily destroy any natural bioremediation processes ongoing at the site.	Equipment is readily available. There is uncertainty regarding the treatment time and number of reapplications required for this site. A UIC permit would be required for the injection of hydrogen peroxide and a catalyst.	High; \$100 to \$200 per ton of saturated soil; cost would be based on bid price and number of reapplications required.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
OSWER = Office of Solid Waste and Emergency Response.
UIC = Underground Injection Permit.

4.1.3 Cost

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

4.2 EVALUATION OF CORRECTIVE ACTION TECHNOLOGIES

Four general categories of corrective actions were identified. These include (1) no action, (2) institutional controls, (3) monitored natural attenuation, and/or (4) active remediation. Various corrective action technologies were identified for the active remediation of benzene, ethylbenzene, and naphthalene in groundwater including air sparging, enhanced bioremediation (pure oxygen injection), and chemical oxidation (Geo-Cleanse®). The technologies are described in Table 4-1. The technologies were evaluated using the screening criteria of effectiveness, implementability, and cost. The results of the technology screening are also shown on Table 4-1.

The "No Action" alternative was not considered to be viable due to the need to ensure that benzene, ethylbenzene, and naphthalene concentrations reach the remedial levels. Institutional controls were not considered further since they are appropriate for this site only when combined with other technologies, such as monitored natural attenuation. Enhanced bioremediation using the PHOSter® technology was eliminated from further consideration as more conventional technologies (like pure oxygen injection) are likely to be less expensive and would result in the same effectiveness for the contaminants. In situ chemical oxidation (the Geo-Cleanse® process) was also excluded from further consideration because of its very high cost, the uncertainty of its effectiveness, and because it would likely destroy any natural biodegradation processes that have been observed at the site.

The technologies that were retained for further evaluation include monitored natural attenuation, air sparging, and oxygen injection.

4.3 CORRECTIVE ACTION ALTERNATIVES

The technologies retained following the screening step were used in various combinations to meet the remedial response objectives for groundwater. The five alternatives identified, and subsequently evaluated, for the remediation of benzene, ethylbenzene, and naphthalene in groundwater are as follows:

- Alternative 1: Monitored natural attenuation,
- Alternative 2: Air sparging,
- Alternative 3: Oxygen injection,
- Alternative 4: Air sparging and monitored natural attenuation, and
- Alternative 5: Oxygen injection and monitored natural attenuation.

4.3.1 Evaluation Factors

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

Time to Implement

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

Life-Cycle Cost

The life-cycle cost estimates are budget estimates based on conceptual designs and are to be used for comparison purposes only. Costs are estimated for capital construction and for operation and maintenance. Cost estimates are derived from current information including vendor quotes, conventional cost estimating guides (e.g., Means 1999 and ECHOS 1998), and costs associated with similar projects. The actual costs of the project would depend on labor and material costs, site conditions, competitive market conditions, final project scope, and implementation schedule at the time that the corrective action is initiated. The life-cycle cost estimates have not been adjusted to present worth costs, and no escalation factors have been applied. Appendix D presents a summary of the life-cycle cost estimates for each alternative.

4.3.2 Evaluation of Corrective Action Alternatives

The five corrective action alternatives for COCs at the site are summarized in Tables 4-2 and 4-3, along with the associated time to reach remedial levels and life-cycle costs. All of the alternatives would include the common features listed below.

- Pre-remediation baseline groundwater sampling (VOC and SVOC analysis) to confirm the present groundwater concentrations.

- The use of benzene as a surrogate parameter to track the effectiveness of the corrective action.

- Groundwater monitoring to track the effectiveness of the corrective action. As noted in the revised final RFI Report, groundwater monitoring wells MW2, MW5, and MW7 were properly abandoned during the 1997 IM activities. Groundwater monitoring wells MW1 and MW6 were destroyed following the RFI activities. During the 2001/2002 IRA, groundwater monitoring well MW12 was removed and MW14 was damaged. The monitoring well network proposed for sampling during the baseline, remediation, and confirmation sampling events consists of the following wells:

  —MW3 will monitor upgradient conditions;
  —MW9 will monitor cross-gradient/lateral conditions;
  —MW10 will monitor downgradient conditions; and
  —MW15, MW16, MW18, and MW19 will monitor conditions within the contaminated groundwater plume.

  Thus, a total of seven wells will be used to monitor the groundwater at this site.

- Post-remediation confirmatory groundwater sampling (VOC and SVOC analysis) to verify that the groundwater remedial levels have been achieved.

Table 4-2. Corrective Action Alternatives for the Former Fire Training Area (SWMU 13)

Corrective Action	Description	Time to Implement	Cost	Comments
Alternative 1. Monitored Natural Attenuation	The action would require the monitoring of contaminant levels to ensure the reduction of contaminants through biodegradation and dispersion.	The estimated time to reach the remedial level for benzene and ethylbenzene is approximately 6 years (including a 1-year contingency period) for a total implementation time of 7 years. (Naphthalene is expected to reach its remedial level in approximately 1.5 years.)	Approximately $244,000 (baseline groundwater sampling and annual monitoring of seven wells during the attenuation period, and confirmatory groundwater sampling of seven wells at 1 year after remedial action completion).	Least expensive, but longest implementation time.
Alternative 2. Air Sparging	Air sparging of ground water to below the remedial levels. Treatment using seven injection wells operated at 10 scfm each (70 scfm total).	Air sparging treatment would require approximately 23 months (including a 6-month contingency period) to reduce the estimated maximum concentration of benzene at the former location of MW12 from 210 µg/L to the remedial level of 5 µg/L. Confirmatory groundwater sampling would be performed 1 year after air sparging treatment is complete, for a total implementation time of slightly less than 3 years.	Approximately $671,000 (baseline groundwater sampling at seven wells, monthly sampling of seven wells for 4 months and bimonthly sampling thereafter during treatment, treatment, and confirmatory groundwater sampling of seven wells at 1 year after remedial action completion).	Moderately expensive to implement and moderately short time frame.
Alternative 3. Enhanced Bioremediation (Pure Oxygen Injection)	Enhanced bioremediation of groundwater to below the remedial levels. Treatment using 13 injection points operated at 0.7 scfm each (9 scfm total).	Oxygen injection treatment would require approximately 34 months (including a 6-month contingency period) to reduce the estimated maximum concentration of benzene at the former location of MW12 from 210 µg/L to the remedial level of 5 µg/L. Confirmatory groundwater sampling would be performed 1 year after oxygen injection treatment is complete, for a total implementation time of slightly less than 4 years.	Approximately $873,000 (baseline groundwater sampling at seven wells, monthly sampling of seven wells for 4 months and bimonthly sampling thereafter during treatment, treatment, and confirmatory groundwater sampling of seven wells at 1 year after remedial action completion).	More costly than Alternative 2 with longer implementation time.
Alternative 4. Air Sparging and Monitored Natural Attenuation	Air sparging of groundwater to 50 µg/L followed by monitored natural attenuation of residual contamination in groundwater. Treatment using three injection wells operated at 10 scfm each (30 scfm total).	Air sparging treatment would require approximately 10 months (including a 3-month contingency period) to reduce benzene to 50 µg/L. Natural attenuation would require an additional 3.5 years (including a 6-month contingency period) to reach the remedial level for benzene of 5 µg/L. Confirmatory groundwater sampling would be performed 1 year after the natural attenuation period, for a total implementation time of approximately 7 years.	Approximately $522,000 (baseline groundwater sampling at seven wells, monthly sampling of seven wells for 4 months and bimonthly sampling thereafter during treatment, treatment, annual monitoring of seven wells during the attenuation period, and confirmatory groundwater sampling of seven wells at 1 year after remedial action completion).	Less costly than Alternative 2 with more than twice the length of time needed to implement.

Table 4-2. Corrective Action Alternatives (continued)

Corrective Action	Description	Time to Implement	Cost	Comments
Alternative 5. Enhanced Bioremediation and Monitored Natural Attenuation	Enhanced bioremediation of groundwater to 50 µg/L followed by monitored natural attenuation of residual contamination in groundwater. Treatment using five injection points operated at 0.7 scfm each (3.5 scfm total).	Oxygen injection treatment would require approximately 13 months (including a 3-month contingency period) to reduce benzene to 50 µg/L. Natural attenuation would require an additional 3.5 years (including a 6-month contingency period) to reach the remedial level for benzene of 5 µg/L. Confirmatory groundwater sampling would be performed 1 year after the natural attenuation period, for a total implementation time of over 7 years.	Approximately $594,000 (baseline groundwater sampling at seven wells, monthly sampling of seven wells for 4 months and bimonthly sampling thereafter during treatment, treatment, annual monitoring of seven wells during the attenuation period, and confirmatory groundwater sampling of seven wells at 1 year after remedial action completion).	Less costly than Alternative 3 with over twice the length of time needed to implement.

Note: Cost estimates have been rounded to the nearest thousand dollars.
scfm = Standard cubic feet per minute.

Table 4-3. Corrective Action Alternative Design Parameters for the Former Fire Training Area (SWMU 13)

Design Parameter	Alternative 1, Monitored Natural Attenuation	Alternative 2, Air Sparging	Alternative 3, Oxygen Injection	Alternative 4, Air Sparging (to 50 μg/L) with Monitored Natural Attenuation	Alternative 5, Oxygen Injection (to 50 μg/L) with Monitored Natural Attenuation
Total remediation time period (years)[a]	7	3	4	5.5	5.5
Cost ($)	244,000	671,000	873,000	522,000	594,000
Active Remediation					
Active remediation time period (months)	0	17	28	7	10
Contingency time period (months)	NA	6	6	3	3
Number of injection wells installed	0	7	13	3	5
Number of groundwater wells sampled during active remediation period	NA	7	7	7	7
Frequency of groundwater sampling during active remediation	NA	Monthly for first 4 months and bimonthly thereafter	Monthly for first 4 months and bimonthly thereafter	Monthly for first 4 months and bimonthly thereafter	Monthly for first 4 months and bimonthly thereafter
Natural Attenuation					
Natural attenuation time period (years)	5	0	0	3	3
Contingency time period (years)	1	0	0	0.5	0.5
Number of groundwater wells sampled during natural attenuation period	7	NA	NA	7	7
Frequency of groundwater sampling during natural attenuation period	Annually	NA	NA	Annually	Annually

[a] Total remediation time periods for all alternatives includes one additional year to perform the confirmation groundwater sampling. Total remediation times are rounded to the nearest 1/2 of a year.

Note: Cost estimates have been rounded to the nearest thousand dollars.

NA = Not applicable.

The paragraphs that follow summarize the evaluation of the five corrective action alternatives with respect to the primary evaluation factors of time to implement and life-cycle cost.

Alternative 1: Monitored Natural Attenuation

Monitored natural attenuation would involve initial baseline groundwater sampling of seven monitoring wells (existing wells MW3, MW9, MW10, MW15, MW16, MW18, and MW19). Following the baseline sampling, these seven groundwater monitoring wells would be sampled annually for approximately 6 years (time period includes 1-year contingency) and the samples analyzed for VOCs, SVOCs, and natural attenuation parameters (nitrate/nitrite, sulfate/sulfide, total iron, total phosphorous, carbon dioxide, and methane). During that time, benzene concentrations in groundwater are predicted to decline below the remedial level of 5 μg/L. Annual sampling is appropriate for long-term monitoring at SWMU 13 because historical sampling events conducted since 1993 have defined baseline conditions, and an additional pre-remediation baseline sampling event would confirm those conditions still exist. Confirmatory groundwater sampling of all seven monitoring wells would be performed 1 year after the natural attenuation period to verify that the remedial levels for all COCs have been met. This is the least expensive alternative with a life-cycle cost of approximately $244,000, but it is also the longest to implement, at 7 years (5 years for natural attenuation, 1-year contingency period, and 1 year for the confirmatory sampling).

Alternative 2: Air Sparging

Initial baseline groundwater sampling would be performed to determine the present nature of the contamination and to establish parameters for the air sparging design. Baseline groundwater samples would be collected from seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19).

Approximately seven air injection wells would be installed to treat the contaminated groundwater. Treatment would continue until the concentration of benzene has declined to below its remedial level of 5 μg/L, estimated to require approximately 23 months (including a 6-month contingency period). The other COCs should not exceed their remedial levels during the remediation period. The groundwater monitoring network would be the same as that discussed under natural attenuation and would include sampling of seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19) to verify that treatment is progressing. Samples would be collected monthly for the first 4 months and bimonthly thereafter until treatment operations were completed. The groundwater samples would be analyzed for VOCs and SVOCs. This active treatment period would be followed by confirmation groundwater sampling (once after 1 year) to verify that the remedial levels for all COCs have been met and maintained. This alternative is moderately expensive, with a life-cycle cost of approximately $671,000. The total time to implement would be approximately 3 years (17 months for air sparging, a 6-month contingency period, and 1 year for confirmatory sampling).

Alternative 3: Enhanced Bioremediation (Pure Oxygen Injection)

Initial baseline groundwater sampling would be performed to determine the present nature of the contamination and to establish parameters for the oxygen injection design. Baseline groundwater samples would be collected from seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19).

Approximately 13 oxygen injection points would be installed to treat the contaminated groundwater. Treatment would consist of enhancing bioremediation by injecting 98 percent pure oxygen and would continue until the concentration of benzene has declined to below its remedial level of 5 μg/L, estimated to require approximately 28 months (includes a 6-month contingency period). The other COCs should not exceed their remedial levels during the remediation period. The groundwater monitoring network would be the same as that discussed under natural attenuation and would include sampling of seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19) to verify that treatment is progressing. Samples would be collected monthly for the first 4 months and bimonthly thereafter until treatment operations were completed. The groundwater samples would be analyzed for VOCs and SVOCs. This active treatment period would be followed by confirmation groundwater sampling (once after 1 year) to verify that the remedial levels for all COCs have been met and maintained. This alternative is more expensive than Alternative 2, with a life-cycle cost of approximately $873,000. The implementation time (approximately 4 years, which includes 28 months of oxygen injection, a 6-month contingency period, and 1 year for confirmatory sampling) is slightly longer than Alternative 2.

Alternative 4: Air Sparging and Monitored Natural Attenuation

Initial baseline groundwater sampling would be performed to determine the present nature of the contamination and to establish parameters for the air sparging design. Baseline groundwater samples would be collected from seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19).

Under this alternative, air sparging in groundwater would be shut down once benzene concentrations in groundwater declined below 50 μg/L. Three or more air injection wells would be installed. Treatment would continue for approximately 10 months (includes a 3-month contingency period). During the air sparging operations, seven monitoring wells would be sampled monthly for the first 4 months of operation, then sampled bimonthly thereafter during the active treatment period. The samples would be analyzed for VOCs and SVOCs. Following this active treatment period, benzene concentrations in groundwater would continue to decline due to natural attenuation. Monitored natural attenuation with annual groundwater sampling would be provided for approximately 3.5 years (includes a 6-month contingency period) following active treatment. Confirmatory groundwater sampling of the eight monitoring wells would be performed 1 year after the natural attenuation period to verify that the remedial levels for all COCs have been met. The estimated life-cycle cost for this alternative, $522,000, is less than Alternative 2; however, the alternative would require approximately 5.5 years to implement (7 months of active remediation, 3 years for natural attenuation, a 9-month total contingency period, and 1 year for confirmatory sampling), which is longer than twice the time needed for Alternative 2 or Alternative 3.

Alternative 5: Enhanced Bioremediation and Monitored Natural Attenuation

Initial baseline groundwater sampling would be performed to determine the present nature of the contamination and to establish parameters for the oxygen injection design. Baseline groundwater samples would be collected from seven existing monitoring wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19).

This alternative is similar to Alternative 4 in that groundwater treatment using enhanced bioremediation (pure oxygen injection) would be shut down once benzene concentrations in groundwater decline below 50 μg/L. Five or more oxygen injection points would be installed. Treatment would continue for approximately 10 months (includes a 3-month contingency period) followed by approximately 3.5 years (includes a 6-month contingency period) of monitored natural attenuation. During the oxygen injection operations, seven monitoring wells would be sampled monthly for the first 4 months of operation, then sampled bimonthly thereafter during the active treatment period. The samples would be analyzed for VOCs and SVOCs. Monitored natural attenuation with annual groundwater sampling would be provided for approximately 3.5 years following active treatment. Confirmatory groundwater sampling would be conducted 1 year later to verify that the remedial levels for all COCs have been met. The estimated life-cycle cost for this alternative, $594,000, is less than both Alternative 2 and Alternative3, but higher than Alternative 4. The alternative would require approximately 5.5 years to implement (10 months of active remediation, 3 years for natural attenuation, a 9-month total contingency period, and 1 year for confirmatory sampling), similar to Alternative 4, but longer than the time needed for Alternative 2 or Alternative 3.

5.0 CONCEPTUAL DESIGN AND IMPLEMENTATION PLAN

This section presents a conceptual design and plan for implementation of the selected corrective action alternative. Based on the available groundwater data and modeling results, a cost-effective corrective action has been selected that will reduce the COCs in groundwater to the required remedial levels. The technology evaluation presented in Chapter 4.0 considered five different corrective action alternatives for the groundwater based on the time needed to implement them and their life-cycle costs. Based on that evaluation, Alternative 1, monitored natural attenuation, has been selected for remediation of the groundwater at the former FTA because of its acceptable implementation time and cost-effectiveness. An O&M Plan for this alternative is presented in Appendix E.

5.1 SELECTED CORRECTIVE ACTION

The selected corrective action alternative for treatment of the groundwater is monitored natural attenuation. In addition, implementation of institutional controls (i.e., land use controls) would be required for the duration of the monitored natural attenuation alternative to establish the activities that are permitted at the site during the natural attenuation period (i.e., until site remedial levels have been achieved).

5.1.1 Justification for Selection of Corrective Action

Monitored natural attenuation has been selected for remediation of the groundwater because it will effectively achieve the remedial levels in a reasonable period of time and will do so cost effectively. Monitored natural attenuation is expected to achieve the groundwater remedial levels in less than 6 years (includes a 1-year contingency period); however, confirmatory groundwater sampling and analysis will be conducted 1 year after completion of the monitored attenuation period to provide additional assurance that concentrations of COCs do not exceed their remedial levels. Other corrective action alternatives evaluated would be more costly to implement.

Monitored natural attenuation is appropriate for addressing the site COCs in groundwater at SWMU 13. Appendix F lists considerations for the selection of monitored natural attenuation for the contaminated groundwater plume in accordance with the guidance of OSWER Directive 9200.4-17P (EPA 1999a).

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

Effectiveness. The selected corrective action will be effective in protecting human health and the environment. Based on the conclusions of the Phase II RFI, there is no current human health or ecological risk associated with contaminants at SWMU 13. Two interim actions have been completed at the site and the suspected sources removed (see Section 2.8). Potential exposure to groundwater is extremely unlikely because the shallow groundwater is not a viable source of drinking water, and because there is no discharge to surface water at the site. Based on modeling results, the benzene concentration in groundwater is expected to drop the MCL of 5 μg/L to within 100 feet of the source area (near former groundwater monitoring well MW12). The selected alternative will achieve the remedial level within a reasonable time frame (7 years), thereby effectively eliminating any potential future risk. The selected alternative will not require long-term O&M beyond the natural attenuation monitoring period and 1-year confirmatory sampling period; therefore, it will provide long-term reliability. Short-term risks to human health or the environment will be minimal because attenuation will occur in situ. As no active remediation will be performed, there will be no air emissions Minimal exposure could result during monitoring well sampling; however, any exposure will be minimized and kept below acceptable levels through the use of proper protective clothing and strict adherence to the project-specific health and safety plan.

The time required to achieve remedial levels has been estimated as 7 years (5 years of natural attenuation, 1 year for contingency, and 1 year for post remediation sampling). This time was determined through modeling using benzene as the primary COC and assuming a degradation half-life of 730 days.

Implementability. The selected corrective action is readily implementable. The remedial levels for the COCs will be achieved in a reasonable time period. Confirmatory sampling will be performed 1 year after the natural attenuation period, resulting in a total of 7 years to complete the alternative. The selected corrective action will use annual monitoring of COC concentrations to ensure that the remedial levels for the site are being met.

Cost. The estimated total life-cycle cost of confirmatory sampling and project reporting for the selected corrective action is $244,000. Monitored natural attenuation is the least expensive of the remediation alternatives and will require 7 years to achieve the remedial levels. Costs estimated for the active remediation alternatives are higher than those for monitored natural attenuation and range from $522,000 to $873,000.

5.2 CONCEPTUAL DESIGN

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

5.2.1 Establishment of Institutional Controls

Land-use requirements will be implemented and enforced by Fort Stewart DPW at SWMU 13 as part of the corrective action. The land-use restrictions will prohibit the following within the identified boundaries of SWMU 13:

- use of groundwater beneath the subject property except for the installation of groundwater monitoring wells and/or potentially wells required for remediation of the groundwater (i.e., extraction or injection wells);

- hunting and recreational activities; and

- all construction within the property boundaries except for those activities associated with maintenance of the facility, soil and/or groundwater sampling, implementation of the selected alternative, or potential abandonment and/or demolition of the facility.

These land-use restrictions will be enforced at SWMU 13 until remedial levels are achieved and SWMU 13 is formally closed under RCRA.

FSMR has no plans for transferring the SWMU 13 area from federal ownership; however, if in the future (i.e., prior to remedial levels being achieved) the SWMU 13 site is to be released from federal ownership, GEPD will be notified, and the CAP will be amended. Appropriate land-use controls (if any) related to the future property transfer will be evaluated and documented in the amended CAP. The purchase agreement(s) and deed recordation or lease agreement will reference this CAP and other environmental documents that contain the rationale for the restrictions. As required by the U.S. Department of Defense policy “Responsibility for

Additional Environmental Cleanup after Transfer of Property," the property disposal agent will ensure that the transfer documents for real property reflect the land-use controls. All applicable and appropriate state land-use control management systems in effect at the time of transfer will also be implemented.

5.2.2 Groundwater Monitoring During Natural Attenuation for Groundwater COCs

The conceptual design includes groundwater sampling as part of the baseline to determine the initial groundwater characteristics, annual sampling to monitor the performance of natural attenuation, and confirmatory sampling to confirm that remedial levels have been achieved in groundwater.

The baseline groundwater sampling would be conducted at the start of the remediation period and would consist of sampling seven monitoring wells. The groundwater monitoring wells would be sampled and analyzed for VOCs, SVOCs, and natural attenuation parameters (methane, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron). Field measurements to be made would include dissolved oxygen, temperature, Redox, conductivity, pH, and ferrous iron. If results of the baseline sampling indicated that benzene concentrations were less than the remedial level (5 μg/L) and that other COCs had not been detected, then monitored natural attenuation would be continued to ensure that benzene and other COCs did not leach to groundwater at concentrations above remedial levels for a minimum of two annual sampling events. GEPD would be advised by e-mail and/or facsimile of the analytical results of the baseline groundwater sampling. Any revisions to the recommendations in this CAP would be summarized in the first annual compliance monitoring progress report (see Section 5.6).

During the natural attenuation time period, seven groundwater monitoring wells would be sampled annually to verify that COC concentrations continue to decline. Samples would be analyzed at an off-site laboratory for VOCs, SVOCs, and for natural attenuation parameters (methane, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron).

Based upon the results of groundwater modeling, monitored natural attenuation period is expected to be 5 years in duration. A 1-year contingency period has been assumed for this alternative. If groundwater monitoring over two consecutive sampling periods indicates that benzene and the other COCs in groundwater are at concentrations below remedial levels or nondetect, Fort Stewart could elect to request approval from GEPD for the discontinuation of the routine sampling and for groundwater confirmatory sampling to be performed 1 year from the date of the last routine groundwater sampling. With the concurrence of GEPD, the confirmatory sampling would then be performed and the results used to determine if monitored natural attenuation had achieved the remedial levels in groundwater.

Completion Criteria. Although monitored natural attenuation would be considered complete upon attaining a maximum COC concentration in groundwater in each of the wells below the remedial levels, as measured during the routine groundwater monitoring events, monitoring might continue to ensure that the groundwater remedial levels were maintained. As discussed above, if groundwater monitoring over two consecutive sampling periods indicated that the COCs in groundwater are at concentrations below its remedial level and the other potential COCs in groundwater were nondetects, Fort Stewart could elect to request from GEPD that the routine sampling be discontinued and that groundwater confirmatory sampling be performed 1 year from the date of the last routine groundwater sampling event. With the concurrence of GEPD, the confirmatory sampling would then be performed and the results used to determine if monitored natural attenuation had achieved the remedial goals in groundwater.

5.2.3 Well Abandonment

With the concurrence of GEPD, the groundwater monitoring wells would be abandoned when the completion criteria indicated that groundwater concentrations were below remedial levels.

Upon approval by GEPD, the 10 monitoring wells would be properly abandoned. The abandonment of monitoring wells would include removal of the protective guard posts, concrete pad, and surface casing and grouting of the wells to the ground surface. The debris from the abandonment of the monitoring wells would be disposed of at the Fort Stewart Sanitary Landfill.

5.3 OPERATION AND MAINTENANCE PLAN

Appendix E presents the O&M Plan for the selected remedial alternative. O&M activities would include annual monitoring during the 6-year monitored natural attenuation period (includes a 1-year contingency period) plus one confirmatory sampling event 1 year following completion.

5.4 LIFE-CYCLE COST ESTIMATE

The total life-cycle cost estimate for the selected alternative—monitored natural attenuation alternative—is $244,000 (see Appendix D for the cost components). Table 5-1 summarizes the life-cycle costs estimated for remediation of the groundwater. Capital costs, including indirect costs, are estimated to be $32,000 and include engineering services (Work Plan, Site Safety and Health Plan, contracting/procurement, permitting, and baseline monitoring). The O&M costs, including indirect costs, are estimated to be approximately $125,000.

Table 5-1. Estimated Cost for Selected Alternative for the Former Fire Training Area (SWMU 13)

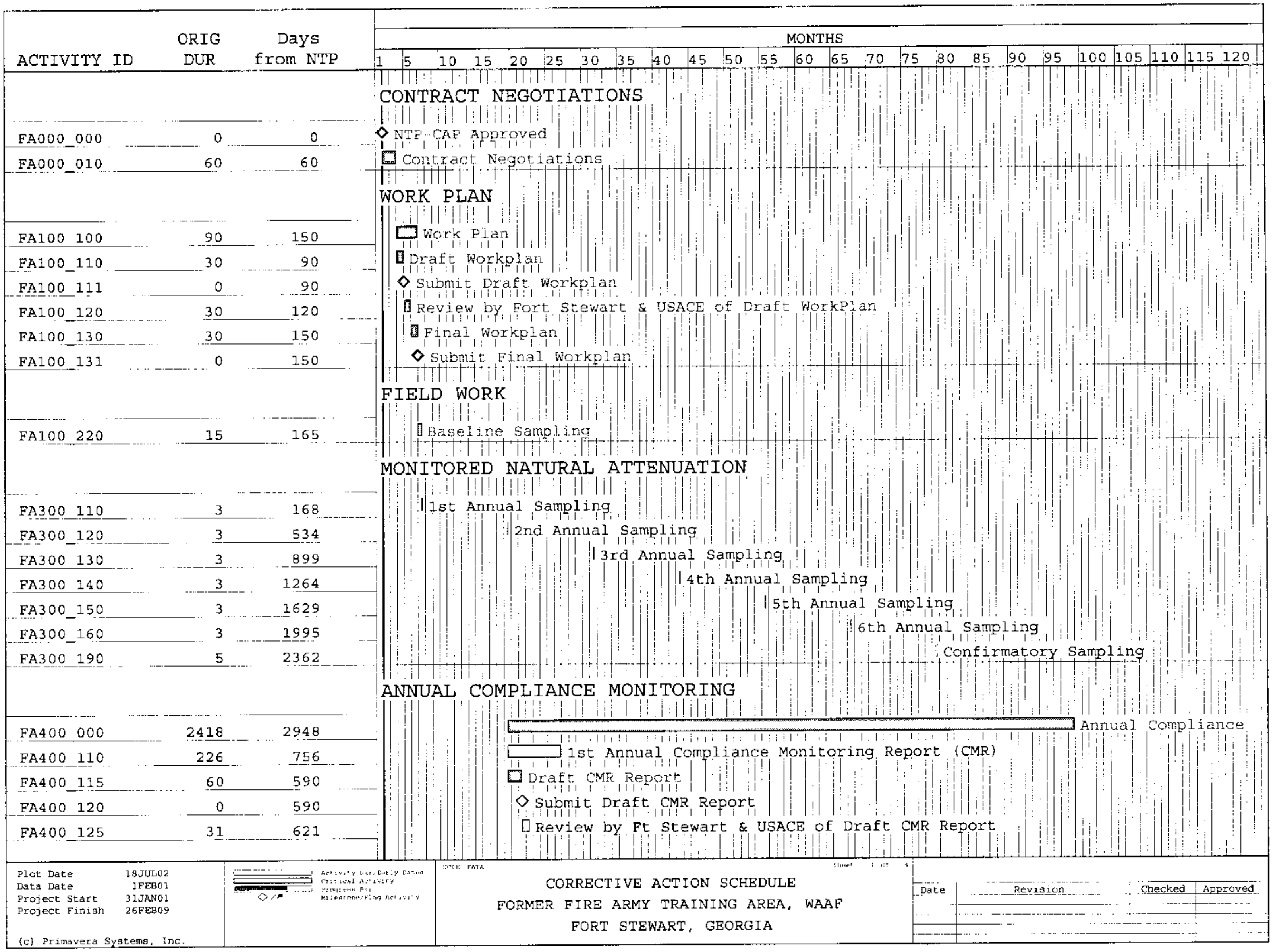
Site	Capital Costs	O&M	Other[a]	Total
SWMU 13	$32,000	$125,000	$87,000	$244,000

[a] Includes construction management, contingency, health and safety, and contractor profit.
O&M = Operations and maintenance.
SWMU = Solid waste management unit.

5.5 IMPLEMENTATION SCHEDULE

Implementation of the corrective action will begin once approval of this CAP is received from GEPD. It is anticipated that the final Corrective Action Work Plan (including appropriate reviews by the Army) will be completed within 3 months after the approval of the CAP.

Based on the groundwater modeling results presented in Appendix C, the required monitoring time for monitored natural attenuation of groundwater is expected to be approximately 6 years. Confirmatory sampling will be conducted 1 year following monitored natural attenuation to verify that remedial levels have been achieved and maintained in groundwater. Remediation should, therefore, be complete within approximately 7 years. A Corrective Action Completion Report will be prepared and submitted to GEPD for review within 4 months of the completion of the confirmatory sampling. FSMR will then abandon the monitoring wells within 90 days of GEPD approval of the Corrective Action Completion Report. The anticipated implementation schedule is presented in Figure 5-1.



ACTIVITY ID	ORIG DUR	Days from NTP	
			CONTRACT NEGOTIATIONS
FA000_000	0	0	NTP-CAP Approved
FA000_010	60	60	Contract Negotiations
			WORK PLAN
FA100_100	90	150	Work Plan
FA100_110	30	90	Draft Workplan
FA100_111	0	90	Submit Draft Workplan
FA100_120	30	120	Review by Fort Stewart & USACE of Draft WorkPlan
FA100_130	30	150	Final Workplan
FA100_131	0	150	Submit Final Workplan
			FIELD WORK
FA100_220	15	165	Baseline Sampling
			MONITORED NATURAL ATTENUATION
FA300_110	3	168	1st Annual Sampling
FA300_120	3	534	2nd Annual Sampling
FA300_130	3	899	3rd Annual Sampling
FA300_140	3	1264	4th Annual Sampling
FA300_150	3	1629	5th Annual Sampling
FA300_160	3	1995	6th Annual Sampling
FA300_190	5	2362	Confirmatory Sampling
			ANNUAL COMPLIANCE MONITORING
FA400_000	2418	2948	Annual Compliance
FA400_110	226	756	1st Annual Compliance Monitoring Report (CMR)
FA400_115	60	590	Draft CMR Report
FA400_120	0	590	Submit Draft CMR Report
FA400_125	31	621	Review by Ft Stewart & USACE of Draft CMR Report

Plot Date 18JUL02
Data Date 1FEB01
Project Start 31JAN01
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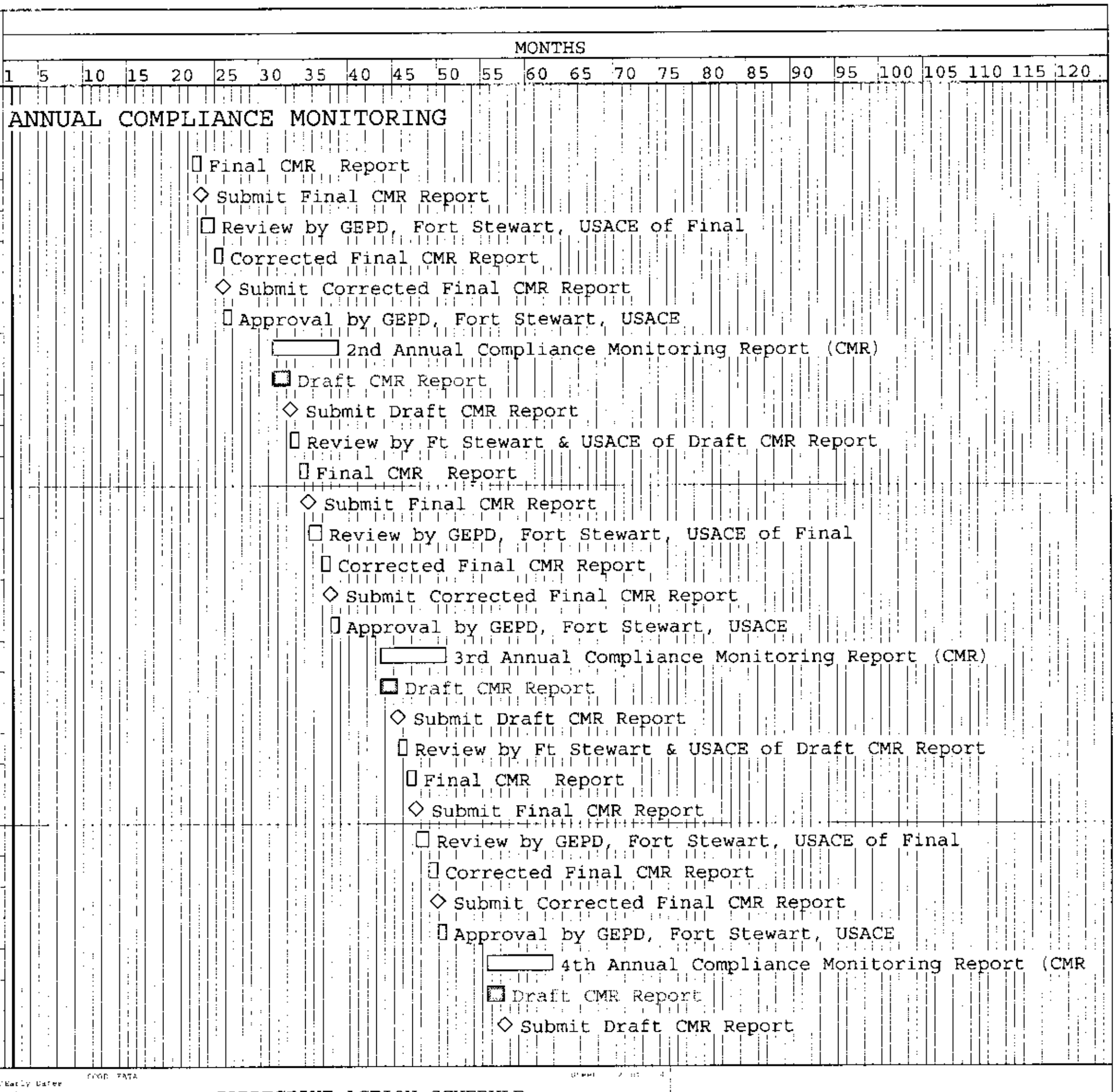
CORRECTIVE ACTION SCHEDULE
FORMER FIRE ARMY TRAINING AREA, WAAF
FORT STEWART, GEORGIA

Date	Revision	Checked	Approved

Figure 5-1. Corrective Action Schedule for the Former Fire Training Area (SWMU 13)



ANNUAL COMPLIANCE MONITORING

ACTIVITY ID	ORIG DUR	Days from NTP	
FA400_130	30	651	Final CMR Report
FA400_135	0	651	Submit Final CMR Report
FA400_140	45	696	Review by GEPD, Fort Stewart, USACE of Final
FA400_145	30	726	Corrected Final CMR Report
FA400_150	0	726	Submit Corrected Final CMR Report
FA400_155	30	756	Approval by GEPD, Fort Stewart, USACE
FA400_210	226	1121	2nd Annual Compliance Monitoring Report (CMR)
FA400_215	60	955	Draft CMR Report
FA400_220	0	955	Submit Draft CMR Report
FA400_225	31	986	Review by Ft Stewart & USACE of Draft CMR Report
FA400_230	30	1016	Final CMR Report
FA400_235	0	1016	Submit Final CMR Report
FA400_240	45	1061	Review by GEPD, Fort Stewart, USACE of Final
FA400_245	30	1091	Corrected Final CMR Report
FA400_250	0	1091	Submit Corrected Final CMR Report
FA400_255	30	1121	Approval by GEPD, Fort Stewart, USACE
FA400_310	226	1487	3rd Annual Compliance Monitoring Report (CMR)
FA400_315	60	1321	Draft CMR Report
FA400_320	0	1321	Submit Draft CMR Report
FA400_325	31	1352	Review by Ft Stewart & USACE of Draft CMR Report
FA400_330	30	1382	Final CMR Report
FA400_335	0	1382	Submit Final CMR Report
FA400_340	45	1427	Review by GEPD, Fort Stewart, USACE of Final
FA400_345	30	1457	Corrected Final CMR Report
FA400_350	0	1457	Submit Corrected Final CMR Report
FA400_355	30	1487	Approval by GEPD, Fort Stewart, USACE
FA400_410	226	1852	4th Annual Compliance Monitoring Report (CMR
FA400_415	60	1686	Draft CMR Report
FA400_420	0	1686	Submit Draft CMR Report

Plot Date	18JUL02
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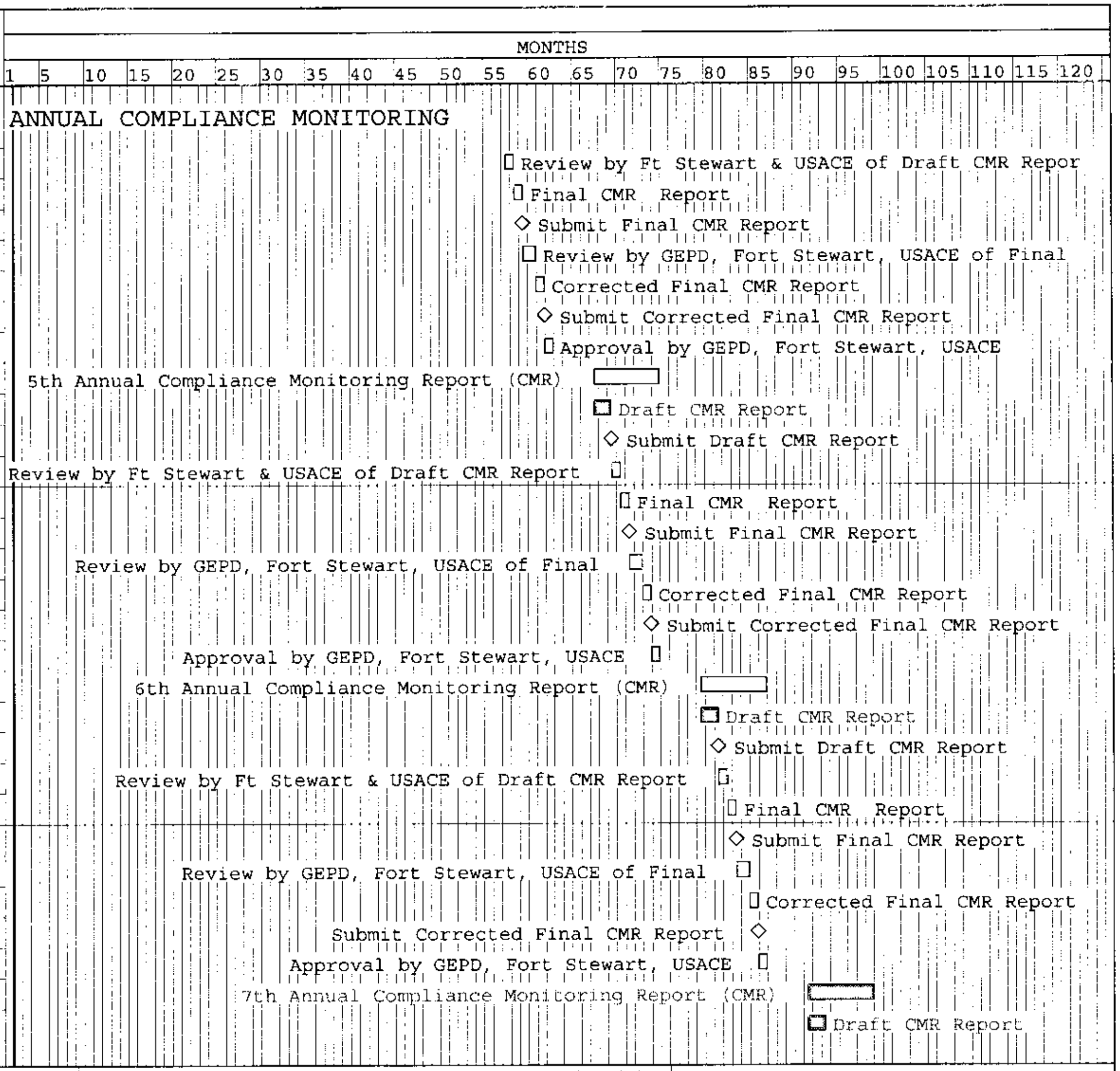
Activity Bar/Early Dates
Critical Activity
Progress Bar
◇/■ Milestone/Flag Activity

CORRECTIVE ACTION SCHEDULE
FORMER FIRE ARMY TRAINING AREA, WAAF
FORT STEWART, GEORGIA

Date	Revision	Checked	Approved

Figure 5-1. Corrective Action Schedule, SWMU 13 (continued)



ACTIVITY ID	ORIG DUR	Days from NTP	
			ANNUAL COMPLIANCE MONITORING
FA400_425	31	1717	Review by Ft Stewart & USACE of Draft CMR Repor
FA400_430	30	1747	Final CMR Report
FA400_435	0	1747	Submit Final CMR Report
FA400_440	45	1792	Review by GEPD, Fort Stewart, USACE of Final
FA400_445	30	1822	Corrected Final CMR Report
FA400_450	0	1822	Submit Corrected Final CMR Report
FA400_455	30	1852	Approval by GEPD, Fort Stewart, USACE
FA400_510	226	2217	5th Annual Compliance Monitoring Report (CMR)
FA400_515	60	2051	Draft CMR Report
FA400_520	0	2051	Submit Draft CMR Report
FA400_525	31	2082	Review by Ft Stewart & USACE of Draft CMR Report
FA400_530	30	2112	Final CMR Report
FA400_535	0	2112	Submit Final CMR Report
FA400_540	45	2157	Review by GEPD, Fort Stewart, USACE of Final
FA400_545	30	2187	Corrected Final CMR Report
FA400_550	0	2187	Submit Corrected Final CMR Report
FA400_555	30	2217	Approval by GEPD, Fort Stewart, USACE
FA400_610	226	2582	6th Annual Compliance Monitoring Report (CMR)
FA400_615	60	2416	Draft CMR Report
FA400_620	0	2416	Submit Draft CMR Report
FA400_625	31	2447	Review by Ft Stewart & USACE of Draft CMR Report
FA400_630	30	2477	Final CMR Report
FA400_635	0	2477	Submit Final CMR Report
FA400_640	45	2522	Review by GEPD, Fort Stewart, USACE of Final
FA400_645	30	2552	Corrected Final CMR Report
FA400_650	0	2552	Submit Corrected Final CMR Report
FA400_655	30	2582	Approval by GEPD, Fort Stewart, USACE
FA400_710	226	2948	7th Annual Compliance Monitoring Report (CMR)
FA400_715	60	2782	Draft CMR Report

Plot Date	18JUL02
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Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

CORRECTIVE ACTION SCHEDULE
FORMER FIRE ARMY TRAINING AREA, WAAF
FORT STEWART, GEORGIA

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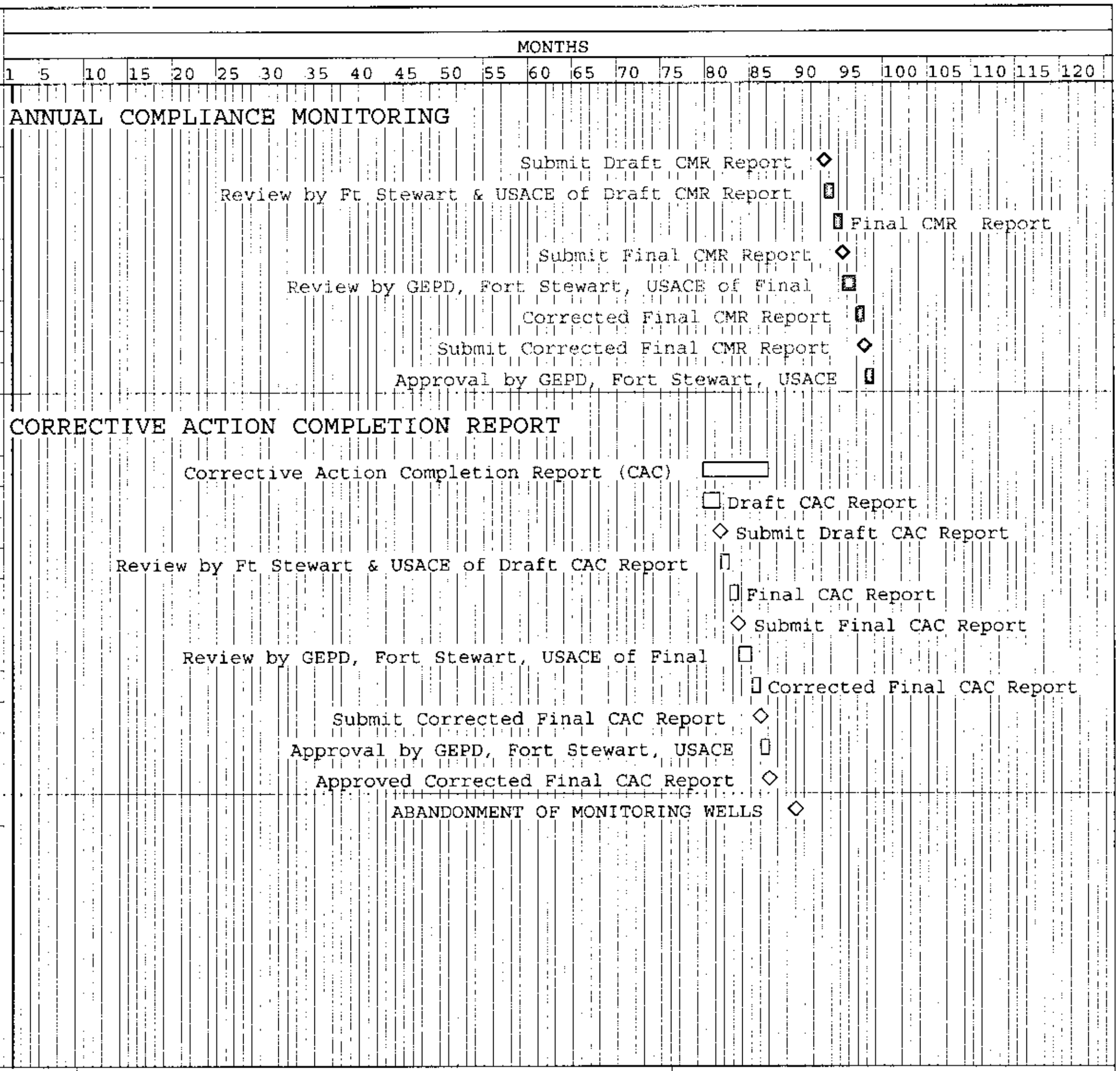
Date	Revision	Checked	Approved

Figure 5-1. Corrective Action Schedule, SWMU 13 (continued)

ACTIVITY ID	ORIG DUR	Days from NTP	
			ANNUAL COMPLIANCE MONITORING
FA400 720	0	2782	Submit Draft CMR Report
FA400 725	31	2813	Review by Ft Stewart & USACE of Draft CMR Report
FA400 730	30	2843	Final CMR Report
FA400_735	0	2843	Submit Final CMR Report
FA400 740	45	2888	Review by GEPD, Fort Stewart, USACE of Final
FA400_745	30	2918	Corrected Final CMR Report
FA400 750	0	2918	Submit Corrected Final CMR Report
FA400 755	30	2948	Approval by GEPD, Fort Stewart, USACE
			CORRECTIVE ACTION COMPLETION REPORT
FA500_800	226	2588	Corrective Action Completion Report (CAC)
FA500 810	60	2422	Draft CAC Report
FA500 811	0	2422	Submit Draft CAC Report
FA500 820	31	2453	Review by Ft Stewart & USACE of Draft CAC Report
FA500 830	30	2483	Final CAC Report
FA500 831	0	2483	Submit Final CAC Report
FA500 840	45	2528	Review by GEPD, Fort Stewart, USACE of Final
FA500 850	30	2558	Corrected Final CAC Report
FA500 851	0	2558	Submit Corrected Final CAC Report
FA500_860	30	2588	Approval by GEPD, Fort Stewart, USACE
FA500 861	0	2588	Approved Corrected Final CAC Report
FA600_000	0	2678	ABANDONMENT OF MONITORING WELLS



Plot Date 18JUL02
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Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

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CORRECTIVE ACTION SCHEDULE
FORMER FIRE ARMY TRAINING AREA, WAAF
FORT STEWART, GEORGIA

Date	Revision	Checked	Approved

Figure 5-1. Corrective Action Schedule, SWMU 13 (continued)

5.6 REPORTS

5.6.1 Corrective Action Plan Progress Report

A Corrective Action Plan Progress Report will be prepared annually during the 7-year remediation time period. These reports will summarize the sampling and analytical results of the groundwater monitoring over 1 year. The results of the baseline sampling will be presented in the first annual Corrective Action Plan Progress Report. An analysis of trends and effectiveness of the corrective action will be presented. The need for any contingent action will also be discussed, as required.

A checklist is presented in the O&M Plan (Appendix E) that summarizes the items to be addressed in each Corrective Action Plan Progress Report.

5.6.2 Corrective Action Completion Report

A final Corrective Action Completion Report will be prepared following the completion of the corrective action and confirmatory sampling (1 year after the natural attenuation period). The Corrective Action Completion Report will summarize the corrective measures taken at the site, provide a summary of sampling data, and give results of the confirmation groundwater sampling.

5.7 IMPLEMENTATION PLAN

Upon approval of this CAP by GEPD, Fort Stewart will request funding, procure a contractor for implementing the corrective actions, and implement the specified actions. A Corrective Action Work Plan will be prepared to guide implementation of the corrective action but will not require GEPD review or approval. Any revisions required to the O&M Plan (Appendix E) or the implementation schedule (Figure 5-1) that become apparent during preparation of the Work Plan will be submitted to GEPD for concurrence. Substantive changes in the remediation approach or schedule will require that the public be provided with an opportunity for review and comment, in accordance with the Fort Stewart Hazardous Waste Facility Permit. No other submittals will need to be provided to GEPD prior to implementation of the selected corrective action.

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

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6.0 REFERENCES

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APPENDIX A

DECEMBER 2000 SUPPLEMENTAL GROUNDWATER CHARACTERIZATION AT THE FORMER FIRE TRAINING AREA (SWMU 13)

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A.1. INTRODUCTION

This letter report summarizes the results of the supplemental characterization of groundwater at the former Fire Training Area (FTA) at Wright Army Airfield at Fort Stewart, Georgia. This characterization was conducted to support preparation of a Corrective Action Plan, augmenting the results of the *Revised Final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for the Fire Training Area at Wright Army Airfield [Solid Waste Management Unit (SWMU) 13]* (SAIC 2000). This report has been prepared by Science Applications International Corporation for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0049. The supplemental sampling was conducted in accordance with USACE guidance EM200-1-3 and the procedures described in the original Phase II RFI Work Plan for 16 SWMUs (SAIC 1997).

The purpose of this supplemental characterization is to provide further evidence that natural attenuation of volatile organic compounds is occurring. The scope of work included sampling of the eight existing on-site monitoring wells (MW3, MW4, MW8, MW9, MW10, MW11, MW12, and MW13) and analyzing the samples for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and polynuclear aromatic hydrocarbons (PAHs). The eight wells were previously installed during the RFI for monitoring the following aquifer units:

MW3: Shallow water table, upgradient;

MW4: Shallow water table, near southern drainage swale, cross-gradient;

MW8: Shallow water table, south of former effluent piping;

MW9: Shallow water table, south of MW8, cross-gradient;

MW10: Shallow water table, plume perimeter, downgradient;

MW11: Shallow water table, southeast corner of former fire training pad;

MW12: Shallow water table, source area near former fuel pipe line; and

MW13: Shallow water table, plume perimeter, downgradient.

A.2. SUMMARY OF INVESTIGATION ACTIVITIES

A.2.1 SAMPLING METHODOLOGY

The supplemental groundwater sampling at the FTA was conducted on December 2 and 3, 2000, using micropurging sampling techniques. Prior to installing the sampling pump, the static water level was recorded. Monitoring wells were sampled using low-flow micropurging techniques to minimize the volume of purge water and to minimize disturbance of the aquifer. Field parameters (pH, conductivity, temperature, dissolved oxygen, and oxidation-reduction potential) were monitored during micropurging. The purge rate was adjusted, as necessary, to avoid purging any well to dryness and to equal the recharge of the aquifer. Purging was considered complete when the field parameters stabilized within plus or minus 10 percent over a minimum of three readings at 5-minute intervals. Purging times varied, requiring from

10 minutes to 28 minutes to purge. Results of field parameter measurements made at the end of purging in each well are listed in Table A-1.

Sampling of each monitoring well began immediately after completion of purging, using the same micropurging pump. Groundwater samples were transferred directly into laboratory sample containers, with the portion designated for volatile organic analysis taken first. Groundwater samples were then sent off-site for laboratory analysis for BTEX and PAHs.

Table A-1. Field Parameter Measurements During Groundwater Sampling (December 2000) at the Former Fire Training Area (SWMU 13)

Well	Purging Time (min)	Volume Purged (Liters)	Temperature (°C)	Conductivity (μmho/cm)	DO (mg/L)	pH (s.u.)	Eh (MV)
MW3	15	1.5	14.91	2.00	0.17	4.72	273.1
MW4	10	1.10	13.74	3.00	2.04	4.60	226.7
MW8	20	2.0	14.58	3.00	0.55	4.33	289.7
MW9	15	1.55	15.17	4.00	0.05	4.31	331.1
MW10	15	1.5	14.86	4.00	0.13	4.29	316.3
MW11	23	4.0	13.91	2.00	0.03	4.26	319.3
MW12	28	2.8	17.68	3.00	0.08	4.70	171.1
MW13	19	1.9	20.99	2.00	0.05	4.61	261.7

DO = Dissolved oxygen.
Eh = Oxidation-reduction potential.
s.u. = Standard unit.
SWMU = Solid waste management unit.

A.2.2 DATA QUALITY ASSESSMENT

Quality assurance/quality control (QC) activities to achieve the desired data quality were as described in the Phase II RFI Work Plan for 16 SWMUs. One field QC trip blank was analyzed. The project produced acceptable results for over 99 percent of the data. The overall quality of the laboratory data meets the established project objectives and the data are acceptable for use.

A.3. SUMMARY OF INVESTIGATION RESULTS

A.3.1 POTENTIOMETRIC MAP

Water table measurements were taken in each of the eight wells on December 2, 2000, prior to sampling. Table A-2 lists the measured depth below top of casing and the corresponding water elevation. The potentiometric map is shown in Figure A-1. Water table elevations in December 2000 were approximately 2 feet deeper than those measured in January 1999. Groundwater flow is to the southeast toward Peacock Creek, with a measured gradient of 0.0026 foot/foot.

Table A-2. Water Level Measurements During Groundwater Sampling (December 2000) at the Former Fire Training Area (SWMU 13)

Well Number[a]	Date Measured	Top of Casing Elevation (feet MSL)	Depth of Screened Interval (feet BGS)	Depth of Free Product (feet BTOC)	Water Depth (feet BTOC)	Product Thickness (feet)	Groundwater Elevation (feet MSL)
MW3	12/02/2000	50.74	—	NA	12.74	0	38.00
MW4	12/02/2000	48.91	—	NA	10.82	0	38.09
MW8	12/02/2000	50.51	5.0 to 15.0	NA	12.42	0	38.09
MW9	12/02/2000	49.68	5.0 to 15.0	NA	11.54	0	38.14
MW10	12/02/2000	50.79	4.7 to 14.7	NA	13.15	0	37.64
MW11	12/02/2000	50.51	5.1 to 15.1	NA	12.68	0	37.83
MW12	12/02/2000	51.40	5.0 to 15.0	NA	13.52	0	37.88
MW13	12/02/2000	50.94	5.4 to 15.4	NA	13.22	0	37.72

[a] Wells MW2, MW5, and MW7 were abandoned in October 1997 during interim corrective measures, and wells MW1 and MW6 were destroyed after the Resource Conservation and Recovery Act (RCRA) facility investigation activities by heavy equipment backing over the wells.

BGS = Below ground surface.
BTOC = Below top of casing.
MSL = Mean sea level.
NA = Not applicable.
SWMU = Solid waste management unit.
— = Data not available.

A.3.2 RESULTS OF GROUNDWATER ANALYSES

Analytical results for groundwater samples from the eight monitoring wells are summarized in Table A-3 for those parameters detected in at least one sample. Figure A-2 shows the distribution of the detected constituents at SWMU 13 during the December 2000 sampling.

BTEX. Benzene was detected in five of eight samples at concentrations ranging from 0.33J µg/L to 418 µg/L, with the concentrations in MW11 and MW12 exceeding the benzene maximum contaminant level (MCL) of 5 µg/L. Toluene was detected in four of eight samples at concentrations ranging from 0.26J µg/L to 391 µg/L and none of the concentrations exceeding the toluene MCL of 1,000 µg/L. Ethylbenzene was detected in six of eight samples at concentrations ranging from 0.14J µg/L to 952 µg/L, with the concentration in MW12 exceeding the ethylbenzene MCL of 700 µg/L. Total xylenes were detected in six of eight samples at concentrations ranging from 0.40J µg/L to 4,930 µg/L and none of the concentrations exceeding the total xylenes MCL of 10,000 µg/L. The highest BTEX concentrations were located in well MW12.

PAHs. Three PAH compounds were detected in groundwater. Naphthalene was detected in three of eight samples at concentrations ranging from 4.0J µg/L to 304J µg/L, with the concentration in MW12 exceeding the remedial level for naphthalene of 149 µg/L. Other PAHs found at MW12 during the current sampling include fluorene (2.6J µg/L) and phenanthrene (1.8J µg/L).

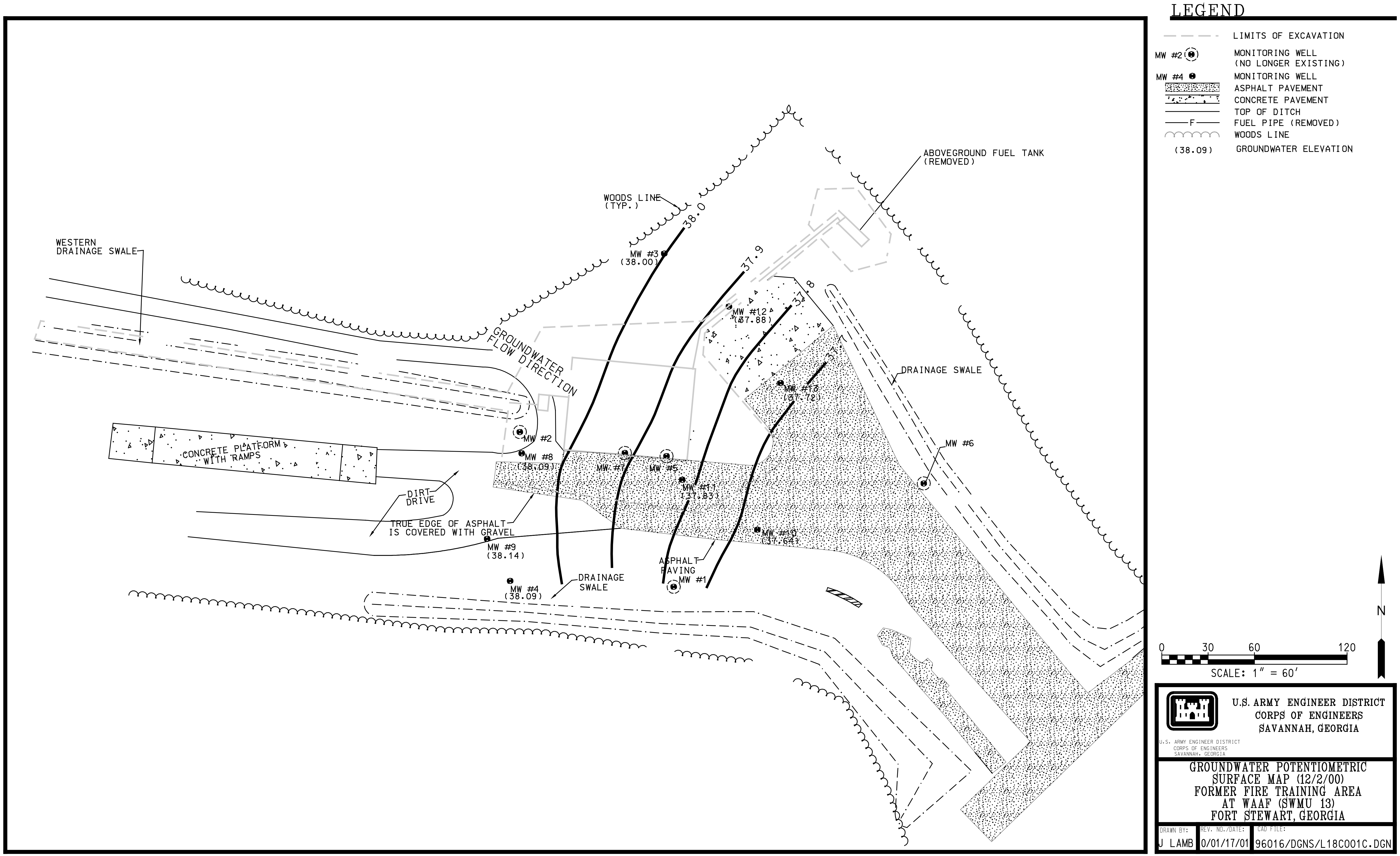

Figure A-1. Potentiometric Map (December 2000) at the Former Fire Training Area (SWMU 13)

Table A-3. Summary of Analytical Results in Groundwater (December 2000) at the Former Fire Training Area (SWMU 13)

Well **Sample ID** **Date Sampled**	**Remedial Level**	**MW3** **FT0312** **12/3/00**	**MW4** **FT0412** **12/3/00**	**MW8** **FT0812** **12/3/00**	**MW9** **FT0912** **12/3/00**	**MW10** **FT1012** **12/3/00**	**MW11** **FT1112** **12/3/00**	**MW12** **FT1212** **12/3/00**	**MW13** **FT1312** **12/3/00**
Volatile Organic Compounds (μg/L)									
Benzene	5			0.33 J		2.7	**9.5**	**418**	2.8
Toluene	[a]		0.26 J		0.30 J			391	0.42 J
Ethylbenzene	700	0.14 J			0.36 J	0.17 J	1.6	**952**	11.0
Xylenes, total	[a]	0.45 J			1.6 J	0.40 J	1.4 J	4,930	11.4
Polynuclear Aromatic Hydrocarbons (μg/L)									
Naphthalene	149						4.0 J	**304 J**	42.2 J
Fluorene	[a]							2.6 J	
Phenanthrene	[a]							1.8 J	

[a] Remedial levels were not developed for these compounds during the Resource Conservation and Recovery Act (RCRA) facility investigation report, because they were not identified as constituents of concern.

Bold type indicates concentration above the remedial level.

Blank indicates analyte not detected.

J = Indicates that the compound was positively identified; the associated numerical value is the approximate concentration of the compound in the sample.

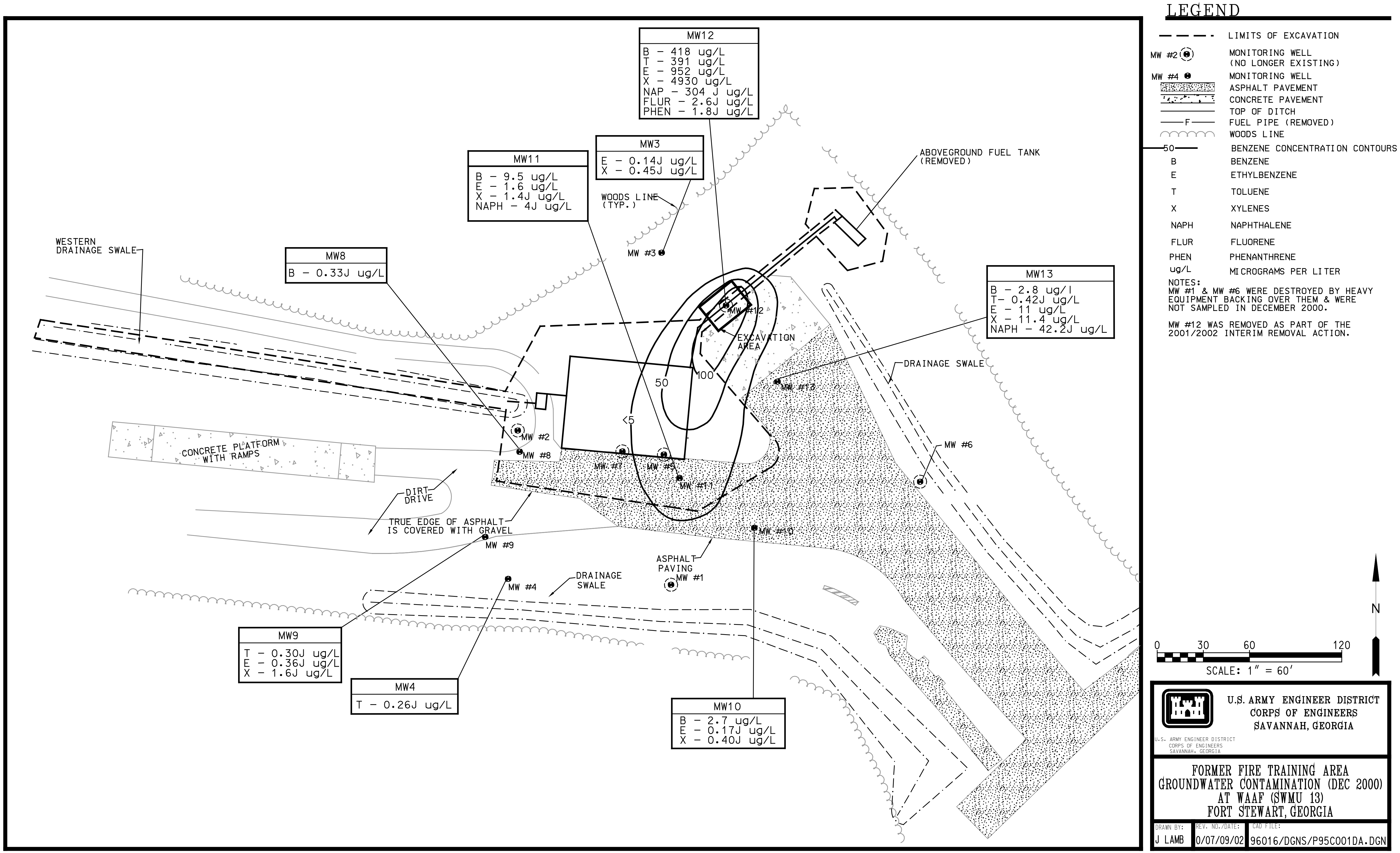

Figure A-2. Distribution of Detected Constituents During December 2000 Sampling at the Former Fire Training Area (SWMU 13)

A.4. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were made based on the results of the supplemental groundwater investigation:

1. Benzene (9.5 μg/L in MW11 and 418 μg/L in MW12) and ethylbenzene (952 μg/L in MW12) are the only BTEX compounds that continued to exceed their MCLs of 5 μg/L and 700 μg/L, respectively, in the shallow water table aquifer near the source. The presence of benzene and the other BTEX compounds is consistent with the results of the November 1998 sampling event. The December 2000 sampling event indicated that the dissolved benzene groundwater plume covered an area of approximately 30,225 square feet, which is smaller than the 10,092 square foot area observed in November 1998.

2. Naphthalene continued to be detected in MW11, MW12, and MW13. The naphthalene concentration of 304J μg/L in MW12 exceeded the remedial level of 149 μg/L. Other PAHs, including fluorene and phenanthrene, were also reported during the current sampling.

A.5. ATTACHMENTS

Attached are the chain-of-custody forms and the laboratory analytical results for the groundwater samples analyzed during the December 2000 sampling.

A.6. REFERENCES

SAIC (Science Applications International Corporation) 1997. *Sampling and Analysis Plan for the Phase II RCRA Facility Investigations of 16 Solid Waste Management Units at Fort Stewart, Georgia*, October.

SAIC 2000. *RCRA Facility Investigation Report for the Fire Training Area at Wright Army Airfield (SWMU 13), Fort Stewart, Georgia*, May.

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ATTACHMENTS

ANALYTICAL RESULTS FOR GROUNDWATER SUPPLEMENTAL SAMPLING (DECEMBER 2000) AT THE FORMER FIRE TRAINING AREA (SWMU 13)

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State of Georgia

Environmental Laboratory Accreditation

Name of Laboratory: **General Engineering Laboratories, Inc.**

Address: P.O. Box 30712
2040 Savage Road
Charleston, SC 29417

Contact: Bob Pullano or Wendy Dimmick
Telephone number: (843) 556-8171
Fax number: (843) 766-1178

#1 Accrediting Authority: **State of South Carolina**

Accreditation Number: SC-10120001

Effective Date: Extension granted while re-certification in process

Expiration Date: —

Accreditation Scope: SDWA, CWA, RCRA, CERCLA

#2 Accrediting Authority: **State of Florida**

Accreditation Number: E-87156

Effective Date: July 1, 2001

Expiration Date: June 30, 2002

Accreditation Scope: SDWA, CWA, RCRA, CERCLA

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Science Applications International Corporation — An Employee-Owned Company

800 Oak Ridge Turnpike, Oak Ridge, TN 37831 (423) 481-4600

CHAIN OF CUSTODY RECORD

COC NO.: FTA 001

PROJECT NAME: Ft. Stewart ~~USTs~~ D.O. #55 SWMU-13

PROJECT NUMBER: 01-1624-04-2352-~~200~~ -210

PROJECT MANAGER: ~~Patty Stoll~~ Debbie Browning

Sampler (Signature) Laura Lumley (Printed Name) Laura Lumley

LABORATORY NAME: General Engineering Laboratory

LABORATORY ADDRESS:
2040 Savage Raod
Charleston, SC 29417

PHONE NO: (803) 556-8171

2000120733

Sample ID	Date Collected	Time Collected	Matrix	BTEX	PAH	PAH, Lead	Dissolved Iron	TPH	TCLP BTEX	TCLP Lead	No. of Bottles/ Vials:	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
FT0312	12/3/00	1117	water		2						2	34923001	14-Day Turn *
FT0412	12/3/00	0911			2						2	002	
FT1012	12/3/00	1440			2						2	003	
FT1312	12/3/00	1346			2						2	004	
FT0812	12/3/00	1025			2						2	005	
FT0912	12/3/00	1650			2						2	006	

12/4/00

RELINQUISHED BY: Laura Lumley
COMPANY NAME: SAIC
Date/Time 12/4/00 1515

RECEIVED BY: Patricia Dover
COMPANY NAME: GEL
Date/Time 12/4/00 19:00

TOTAL NUMBER OF CONTAINERS: 12

Cooler ID: #725

Cooler Temperature:

FEDEX NUMBER:

RECEIVED BY:
COMPANY NAME:
Date/Time 12-4-00 1515

RELINQUISHED BY:
COMPANY NAME:
Date/Time

* All samples 14 Day Turn *

RELINQUISHED BY:
COMPANY NAME: GEL
Date/Time 12-4-00 1515

RECEIVED BY:
COMPANY NAME:
Date/Time

9

SAIC An Employee-Owned Company
Science Applications International Corporation

800 Oak Ridge Turnpike, Oak Ridge, TN 37831 (423) 481-4600

CHAIN OF CUSTODY RECORD

COC NO.: FTA002

PROJECT NAME: Ft. Stewart ~~USTs~~ D.O. #55 SWMU-13

PROJECT NUMBER: 01-1624-04-2352-~~200~~ -210

PROJECT MANAGER: ~~Patty Stoll~~ Debbie Browning

Sampler (Signature) (Printed Name) Laura Lumley

LABORATORY NAME: General Engineering Laboratory

LABORATORY ADDRESS:
2040 Savage Raod
Charleston, SC 29417

PHONE NO: (803) 556-8171

REQUESTED PARAMETERS

Sample ID	Date Collected	Time Collected	Matrix	BTEX	PAH	PAH, Lead	Dissolved Iron	TPH	TCLP BTEX	TCLP Lead	No. of Bottles/ Vials:	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
FT1112	12/3/00	1545	water	2	2						4	3492307	*14-Day Turn*
FT1212	12/3/00	1235		2	2						4	008	
FT0312	12/3/00	1117		2							2	009	
FT0412	12/3/00	0911		2							2	010	
FT0612	12/3/00	1025		2							2	011	
FT0912	12/3/00	1650		2							2	012	
FT1012	12/3/00	1440		2							2	013	
FT1312	12/3/00	1346		2							2	014	
TBA039	12/3/00	0750		2							2	015	

12/4/00

RELINQUISHED BY:	Date/Time 12/4/00 1515	RECEIVED BY: Patricia Dower	Date/Time 12/4/00 19:00	TOTAL NUMBER OF CONTAINERS: 22	Cooler Temperature:
COMPANY NAME: SAIC		COMPANY NAME: GEL		Cooler ID: #295	FEDEX NUMBER:
RECEIVED BY:	Date/Time 12-4-00 1515	RELINQUISHED BY:	Date/Time	* All samples - 14 Day Turn *	
COMPANY NAME: GEL		COMPANY NAME:			
RELINQUISHED BY:	Date/Time 12-4-00 1815	RECEIVED BY:	Date/Time		
COMPANY NAME: GEL		COMPANY NAME:			

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0312

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923009

Sample wt/vol: 5.000 (g/ml) ML Lab File ID: 8M342

Level: (low/med) LOW Date Received: 12/05/00

% Moisture: not dec. ________ Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm) Dilution Factor: 1.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	---------Benzene	1.0	U	U
108-88-3	--------Toluene	1.0	U	U
100-41-4	--------Ethylbenzene	0.14	J	J
1330-20-7	-------Xylenes (total)	0.45	J	J

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1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0312

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923001

Sample wt/vol: 1050 (g/mL) ML Lab File ID: 5X512

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/07/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/08/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	0.95	U	U
91-58-7	2-Chloronaphthalene	0.95	U	
208-96-8	Acenaphthylene	0.95	U	
83-32-9	Acenaphthene	0.95	U	
86-73-7	Fluorene	0.95	U	
85-01-8	Phenanthrene	0.95	U	
120-12-7	Anthracene	0.95	U	
206-44-0	Fluoranthene	0.95	U	
129-00-0	Pyrene	0.95	U	
56-55-3	Benzo(a)anthracene	0.95	U	
218-01-9	Chrysene	0.95	U	
205-99-2	Benzo(b)fluoranthene	0.95	U	
207-08-9	Benzo(k)fluoranthene	0.95	U	
50-32-8	Benzo(a)pyrene	0.95	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.95	U	
53-70-3	Dibenz(a,h)anthracene	0.95	U	
191-24-2	Benzo(g,h,i)perylene	0.95	U	↓

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1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0412

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923010

Sample wt/vol: 5.000 (g/ml) ML Lab File ID: 8M343

Level: (low/med) LOW Date Received: 12/05/00

% Moisture: not dec. ________ Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm) Dilution Factor: 1.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	---------Benzene	1.0	U	U
108-88-3	--------Toluene	0.26	J	J
100-41-4	--------Ethylbenzene	1.0	U	U
1330-20-7	-------Xylenes (total)	3.0	U	U

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SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0412

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923002

Sample wt/vol: 1050 (g/mL) ML Lab File ID: 5X513

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/07/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/08/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	0.95	U	u
91-58-7	2-Chloronaphthalene	0.95	U	
208-96-8	Acenaphthylene	0.95	U	
83-32-9	Acenaphthene	0.95	U	
86-73-7	Fluorene	0.95	U	
85-01-8	Phenanthrene	0.95	U	
120-12-7	Anthracene	0.95	U	
206-44-0	Fluoranthene	0.95	U	
129-00-0	Pyrene	0.95	U	
56-55-3	Benzo(a)anthracene	0.95	U	
218-01-9	Chrysene	0.95	U	
205-99-2	Benzo(b)fluoranthene	0.95	U	
207-08-9	Benzo(k)fluoranthene	0.95	U	
50-32-8	Benzo(a)pyrene	0.95	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.95	U	
53-70-3	Dibenz(a,h)anthracene	0.95	U	
191-24-2	Benzo(g,h,i)perylene	0.95	U	

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1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.
FT0812

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER

Lab Sample ID: 34923011

Sample wt/vol: 5.000 (g/ml) ML

Lab File ID: 8M344

Level: (low/med) LOW

Date Received: 12/05/00

% Moisture: not dec. ________

Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm)

Dilution Factor: 1.0

Soil Extract Volume: ________ (uL)

Soil Aliquot Volume: ________ (uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	---------Benzene	0.33	J	J
108-88-3	--------Toluene	1.0	U	U
100-41-4	--------Ethylbenzene	1.0	U	↓
1330-20-7	-------Xylenes (total)	3.0	U	

DATA VALIDATION
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SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0812

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923005

Sample wt/vol: 1050 (g/mL) ML Lab File ID: 5X516

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/07/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/08/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	0.95	U	U
91-58-7	2-Chloronaphthalene	0.95	U	
208-96-8	Acenaphthylene	0.95	U	
83-32-9	Acenaphthene	0.95	U	
86-73-7	Fluorene	0.95	U	
85-01-8	Phenanthrene	0.95	U	
120-12-7	Anthracene	0.95	U	
206-44-0	Fluoranthene	0.95	U	
129-00-0	Pyrene	0.95	U	
56-55-3	Benzo(a)anthracene	0.95	U	
218-01-9	Chrysene	0.95	U	
205-99-2	Benzo(b)fluoranthene	0.95	U	
207-08-9	Benzo(k)fluoranthene	0.95	U	
50-32-8	Benzo(a)pyrene	0.95	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.95	U	
53-70-3	Dibenz(a,h)anthracene	0.95	U	
191-24-2	Benzo(g,h,i)perylene	0.95	U	

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0912

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923012

Sample wt/vol: 5.000 (g/ml) ML Lab File ID: 8M345

Level: (low/med) LOW Date Received: 12/05/00

% Moisture: not dec. ________ Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm) Dilution Factor: 1.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	Benzene	1.0	U	U
108-88-3	Toluene	0.30	J	J
100-41-4	Ethylbenzene	0.36	J	J
1330-20-7	Xylenes (total)	1.6	J	J

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT0912

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923006

Sample wt/vol: 1050 (g/mL) ML Lab File ID: 5X517

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/07/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/08/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	0.95	U	U
91-58-7	2-Chloronaphthalene	0.95	U	
208-96-8	Acenaphthylene	0.95	U	
83-32-9	Acenaphthene	0.95	U	
86-73-7	Fluorene	0.95	U	
85-01-8	Phenanthrene	0.95	U	
120-12-7	Anthracene	0.95	U	
206-44-0	Fluoranthene	0.95	U	
129-00-0	Pyrene	0.95	U	
56-55-3	Benzo(a)anthracene	0.95	U	
218-01-9	Chrysene	0.95	U	
205-99-2	Benzo(b)fluoranthene	0.95	U	
207-08-9	Benzo(k)fluoranthene	0.95	U	
50-32-8	Benzo(a)pyrene	0.95	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.95	U	
53-70-3	Dibenz(a,h)anthracene	0.95	U	
191-24-2	Benzo(g,h,i)perylene	0.95	U	

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1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1012

Lab Name: GENERAL ENGINEERING LABOR   Contract: N/A

Lab Code: N/A   Case No.: N/A   SAS No.: N/A   SDG No.: 34923

Matrix: (soil/water) WATER   Lab Sample ID: 34923013

Sample wt/vol: 5.000 (g/ml) ML   Lab File ID: 8M346

Level: (low/med) LOW   Date Received: 12/05/00

% Moisture: not dec. ________   Date Analyzed: 12/07/00

GC Column: DB-624   ID: 0.25 (mm)   Dilution Factor: 1.0

Soil Extract Volume:________(uL)   Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	---------Benzene	2.7		=
108-88-3	--------Toluene	1.0	U	u
100-41-4	--------Ethylbenzene	0.17	J	J
1330-20-7	-------Xylenes (total)	0.40	J	J

EPA SAMPLE NO.

FT1012

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923003

Sample wt/vol: 1050 (g/mL) ML Lab File ID: 5X514

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/07/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/08/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	.95 ~~0.50~~	JB	U FD1,F06
91-58-7	2-Chloronaphthalene	0.95	U	u
208-96-8	Acenaphthylene	0.95	U	↓
83-32-9	Acenaphthene	0.95	U	
86-73-7	Fluorene	0.95	U	
85-01-8	Phenanthrene	0.95	U	
120-12-7	Anthracene	0.95	U	
206-44-0	Fluoranthene	0.95	U	
129-00-0	Pyrene	0.95	U	
56-55-3	Benzo(a)anthracene	0.95	U	
218-01-9	Chrysene	0.95	U	
205-99-2	Benzo(b)fluoranthene	0.95	U	
207-08-9	Benzo(k)fluoranthene	0.95	U	
50-32-8	Benzo(a)pyrene	0.95	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.95	U	
53-70-3	Dibenz(a,h)anthracene	0.95	U	
191-24-2	Benzo(g,h,i)perylene	0.95	U	

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1112

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER

Lab Sample ID: 34923007

Sample wt/vol: 5.000 (g/ml) ML

Lab File ID: 8M341

Level: (low/med) LOW

Date Received: 12/05/00

% Moisture: not dec. ________

Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm)

Dilution Factor: 1.0

Soil Extract Volume:________(uL)

Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	Benzene	9.5		=
108-88-3	Toluene	1.0	U	u
100-41-4	Ethylbenzene	1.6		=
1330-20-7	Xylenes (total)	1.4	J	J

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1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1112RE

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER

Lab Sample ID: 34923007

Sample wt/vol: 1040 (g/mL) ML

Lab File ID: 5Y315

Level: (low/med) LOW

Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___

Date Extracted:12/12/00

Concentrated Extract Volume: 1.00(mL)

Date Analyzed: 12/13/00

Injection Volume: 1.0(uL)

Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

USQ

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
91-20-3	Naphthalene	4.0		J A01
91-58-7	2-Chloronaphthalene	0.96	U	UJ A01
208-96-8	Acenaphthylene	0.96	U	
83-32-9	Acenaphthene	0.96	U	
86-73-7	Fluorene	0.96	U	
85-01-8	Phenanthrene	0.96	U	
120-12-7	Anthracene	0.96	U	
206-44-0	Fluoranthene	0.96	U	
129-00-0	Pyrene	0.96	U	
56-55-3	Benzo(a)anthracene	0.96	U	
218-01-9	Chrysene	0.96	U	
205-99-2	Benzo(b)fluoranthene	0.96	U	
207-08-9	Benzo(k)fluoranthene	0.96	U	
50-32-8	Benzo(a)pyrene	0.96	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.96	U	
53-70-3	Dibenz(a,h)anthracene	0.96	U	
191-24-2	Benzo(g,h,i)perylene	0.96	U	

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1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1212

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923008

Sample wt/vol: 5.000 (g/ml) ML Lab File ID: 8M511

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: not dec. ________ Date Analyzed: 12/08/00

GC Column: DB-624 ID: 0.25 (mm) Dilution Factor: 25.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	Benzene	418		=
108-88-3	Toluene	391		↓
100-41-4	Ethylbenzene	952		
1330-20-7	Xylenes (total)	4930		

DATA VALIDATION
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1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1212RE

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923008

Sample wt/vol: 1040 (g/mL) ML Lab File ID: 5Y316

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted: 12/12/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/13/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q	USL
91-20-3	Naphthalene	304 ~~238~~	~~E~~ D	J A01
91-58-7	2-Chloronaphthalene	0.96	U	UJ
208-96-8	Acenaphthylene	0.96	U	
83-32-9	Acenaphthene	0.96	U	
86-73-7	Fluorene	2.6		J
85-01-8	Phenanthrene	1.8		J
120-12-7	Anthracene	0.96	U	UJ
206-44-0	Fluoranthene	0.96	U	
129-00-0	Pyrene	0.96	U	
56-55-3	Benzo(a)anthracene	0.96	U	
218-01-9	Chrysene	0.96	U	
205-99-2	Benzo(b)fluoranthene	0.96	U	
207-08-9	Benzo(k)fluoranthene	0.96	U	
50-32-8	Benzo(a)pyrene	0.96	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.96	U	
53-70-3	Dibenz(a,h)anthracene	0.96	U	
191-24-2	Benzo(g,h,i)perylene	0.96	U	

DATA VAL

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VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1312

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923014

Sample wt/vol: 5.000 (g/ml) ML Lab File ID: 8M347

Level: (low/med) LOW Date Received: 12/05/00

% Moisture: not dec. ________ Date Analyzed: 12/07/00

GC Column: DB-624 ID: 0.25 (mm) Dilution Factor: 1.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q	
71-43-2	Benzene	2.8		=
108-88-3	Toluene	0.42	J	J
100-41-4	Ethylbenzene	11.0		=
1330-20-7	Xylenes (total)	11.4		=

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FT1312RE

Lab Name: GENERAL ENGINEERING LABOR Contract: N/A

Lab Code: N/A Case No.: N/A SAS No.: N/A SDG No.: 34923

Matrix: (soil/water) WATER Lab Sample ID: 34923004

Sample wt/vol: 1040 (g/mL) ML Lab File ID: 5Y314

Level: (low/med) LOW Date Received: 12/04/00

% Moisture: ______ decanted: (Y/N)___ Date Extracted:12/12/00

Concentrated Extract Volume: 1.00(mL) Date Analyzed: 12/13/00

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND		Q	
91-20-3	Naphthalene	42.2		J A01
91-58-7	2-Chloronaphthalene	0.96	U	UJ A01
208-96-8	Acenaphthylene	0.96	U	↓
83-32-9	Acenaphthene	0.96	U	↓
86-73-7	Fluorene	0.69	J	J
85-01-8	Phenanthrene	0.96	U	UJ
120-12-7	Anthracene	0.96	U	
206-44-0	Fluoranthene	0.96	U	
129-00-0	Pyrene	0.96	U	
56-55-3	Benzo(a)anthracene	0.96	U	
218-01-9	Chrysene	0.96	U	
205-99-2	Benzo(b)fluoranthene	0.96	U	
207-08-9	Benzo(k)fluoranthene	0.96	U	
50-32-8	Benzo(a)pyrene	0.96	U	
193-39-5	Indeno(1,2,3-cd)pyrene	0.96	U	
53-70-3	Dibenz(a,h)anthracene	0.96	U	
191-24-2	Benzo(g,h,i)perylene	0.96	U	↓ ↓

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Location: FIRE TRAINING (SWMU 13)
Station : FT-MW-03

FT0312 **Field Sample Type:** Grab **Matrix:** Groundwater **Collected:** 12/03/2000

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	1.0	UG/L	U	U	
REG	Ethylbenzene	.14	UG/L	J	J	
REG	Toluene	1.0	UG/L	U	U	
REG	Xylenes, Total	.45	UG/L	J	J	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	2-Chloronaphthalene	0.95	UG/L	U	U	
REG	Acenaphthene	0.95	UG/L	U	U	
REG	Acenaphthylene	0.95	UG/L	U	U	
REG	Anthracene	0.95	UG/L	U	U	
REG	Benzo(a)anthracene	0.95	UG/L	U	U	
REG	Benzo(a)pyrene	0.95	UG/L	U	U	
REG	Benzo(b)fluoranthene	0.95	UG/L	U	U	
REG	Benzo(g,h,i)perylene	0.95	UG/L	U	U	
REG	Benzo(k)fluoranthene	0.95	UG/L	U	U	
REG	Chrysene	0.95	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	0.95	UG/L	U	U	
REG	Fluoranthene	0.95	UG/L	U	U	
REG	Fluorene	0.95	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	0.95	UG/L	U	U	
REG	Naphthalene	0.95	UG/L	U	U	
REG	Phenanthrene	0.95	UG/L	U	U	
REG	Pyrene	0.95	UG/L	U	U	

Location: FIRE TRAINING (SWMU 13)
Station : FT-MW-04

FT0412 **Field Sample Type:** Grab **Matrix:** Groundwater **Collected:** 12/03/2000

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	1.0	UG/L	U	U	
REG	Ethylbenzene	1.0	UG/L	U	U	
REG	Toluene	.26	UG/L	J	J	
REG	Xylenes, Total	3.0	UG/L	U	U	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	2-Chloronaphthalene	0.95	UG/L	U	U	
REG	Acenaphthene	0.95	UG/L	U	U	
REG	Acenaphthylene	0.95	UG/L	U	U	
REG	Anthracene	0.95	UG/L	U	U	
REG	Benzo(a)anthracene	0.95	UG/L	U	U	
REG	Benzo(a)pyrene	0.95	UG/L	U	U	
REG	Benzo(b)fluoranthene	0.95	UG/L	U	U	
REG	Benzo(g,h,i)perylene	0.95	UG/L	U	U	
REG	Benzo(k)fluoranthene	0.95	UG/L	U	U	
REG	Chrysene	0.95	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	0.95	UG/L	U	U	
REG	Fluoranthene	0.95	UG/L	U	U	
REG	Fluorene	0.95	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	0.95	UG/L	U	U	
REG	Naphthalene	0.95	UG/L	U	U	
REG	Phenanthrene	0.95	UG/L	U	U	
REG	Pyrene	0.95	UG/L	U	U	

Location: FIRE TRAINING (SWMU 13)
Station : FT-MW-08

FT0812 **Field Sample Type:** Grab **Matrix:** Groundwater **Collected:** 12/03/2000

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	.33	UG/L	J	J	
REG	Ethylbenzene	1.0	UG/L	U	U	
REG	Toluene	1.0	UG/L	U	U	
REG	Xylenes, Total	3.0	UG/L	U	U	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	2-Chloronaphthalene	0.95	UG/L	U	U	
REG	Acenaphthene	0.95	UG/L	U	U	
REG	Acenaphthylene	0.95	UG/L	U	U	
REG	Anthracene	0.95	UG/L	U	U	
REG	Benzo(a)anthracene	0.95	UG/L	U	U	
REG	Benzo(a)pyrene	0.95	UG/L	U	U	
REG	Benzo(b)fluoranthene	0.95	UG/L	U	U	
REG	Benzo(g,h,i)perylene	0.95	UG/L	U	U	
REG	Benzo(k)fluoranthene	0.95	UG/L	U	U	
REG	Chrysene	0.95	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	0.95	UG/L	U	U	
REG	Fluoranthene	0.95	UG/L	U	U	
REG	Fluorene	0.95	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	0.95	UG/L	U	U	
REG	Naphthalene	0.95	UG/L	U	U	
REG	Phenanthrene	0.95	UG/L	U	U	
REG	Pyrene	0.95	UG/L	U	U	

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-09**

FT0912 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 12/03/2000**

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	1.0	UG/L	U	U	
REG	Ethylbenzene	.36	UG/L	J	J	
REG	Toluene	.3	UG/L	J	J	
REG	Xylenes, Total	1.6	UG/L	J	J	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	2-Chloronaphthalene	0.95	UG/L	U	U	
REG	Acenaphthene	0.95	UG/L	U	U	
REG	Acenaphthylene	0.95	UG/L	U	U	
REG	Anthracene	0.95	UG/L	U	U	
REG	Benzo(a)anthracene	0.95	UG/L	U	U	
REG	Benzo(a)pyrene	0.95	UG/L	U	U	
REG	Benzo(b)fluoranthene	0.95	UG/L	U	U	
REG	Benzo(g,h,i)perylene	0.95	UG/L	U	U	
REG	Benzo(k)fluoranthene	0.95	UG/L	U	U	
REG	Chrysene	0.95	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	0.95	UG/L	U	U	
REG	Fluoranthene	0.95	UG/L	U	U	
REG	Fluorene	0.95	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	0.95	UG/L	U	U	
REG	Naphthalene	0.95	UG/L	U	U	
REG	Phenanthrene	0.95	UG/L	U	U	
REG	Pyrene	0.95	UG/L	U	U	

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-10**

FT1012 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 12/03/2000**

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	2.7	UG/L		=	
REG	Ethylbenzene	.17	UG/L	J	J	
REG	Toluene	1.0	UG/L	U	U	
REG	Xylenes, Total	.4	UG/L	J	J	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	2-Chloronaphthalene	0.95	UG/L	U	U	
REG	Acenaphthene	0.95	UG/L	U	U	
REG	Acenaphthylene	0.95	UG/L	U	U	
REG	Anthracene	0.95	UG/L	U	U	
REG	Benzo(a)anthracene	0.95	UG/L	U	U	
REG	Benzo(a)pyrene	0.95	UG/L	U	U	
REG	Benzo(b)fluoranthene	0.95	UG/L	U	U	
REG	Benzo(g,h,i)perylene	0.95	UG/L	U	U	

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-10**

FT1012 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 12/03/2000**

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzo(k)fluoranthene	0.95	UG/L	U	U	
REG	Chrysene	0.95	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	0.95	UG/L	U	U	
REG	Fluoranthene	0.95	UG/L	U	U	
REG	Fluorene	0.95	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	0.95	UG/L	U	U	
REG	Naphthalene	0.95	UG/L	JB	U	F01,F06
REG	Phenanthrene	0.95	UG/L	U	U	
REG	Pyrene	0.95	UG/L	U	U	

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-11**

FT1112 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 12/03/2000**

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	9.5	UG/L		=	
REG	Ethylbenzene	1.6	UG/L		=	
REG	Toluene	1.0	UG/L	U	U	
REG	Xylenes, Total	1.4	UG/L	J	J	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REA	2-Chloronaphthalene	0.96	UG/L	U	UJ	A01
REA	Acenaphthene	0.96	UG/L	U	UJ	A01
REA	Acenaphthylene	0.96	UG/L	U	UJ	A01
REA	Anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)pyrene	0.96	UG/L	U	UJ	A01
REA	Benzo(b)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Benzo(g,h,i)perylene	0.96	UG/L	U	UJ	A01
REA	Benzo(k)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Chrysene	0.96	UG/L	U	UJ	A01
REA	Dibenzo(a,h)anthracene	0.96	UG/L	U	UJ	A01
REA	Fluoranthene	0.96	UG/L	U	UJ	A01
REA	Fluorene	0.96	UG/L	U	UJ	A01
REA	Indeno(1,2,3-cd)pyrene	0.96	UG/L	U	UJ	A01
REA	Naphthalene	4	UG/L		J	A01
REA	Phenanthrene	0.96	UG/L	U	UJ	A01
REA	Pyrene	0.96	UG/L	U	UJ	A01

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-12**

FT1212 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 12/03/2000**

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	418	UG/L		=	
REG	Ethylbenzene	952	UG/L		=	
REG	Toluene	391	UG/L		=	
REG	Xylenes, Total	4930	UG/L		=	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REA	2-Chloronaphthalene	0.96	UG/L	U	UJ	A01
REA	Acenaphthene	0.96	UG/L	U	UJ	A01
REA	Acenaphthylene	0.96	UG/L	U	UJ	A01
REA	Anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)pyrene	0.96	UG/L	U	UJ	A01
REA	Benzo(b)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Benzo(g,h,i)perylene	0.96	UG/L	U	UJ	A01
REA	Benzo(k)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Chrysene	0.96	UG/L	U	UJ	A01
REA	Dibenzo(a,h)anthracene	0.96	UG/L	U	UJ	A01

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-12**

FT1212 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected:** **12/03/2000**

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REA	Fluoranthene	0.96	UG/L	U	UJ	A01
REA	Fluorene	2.6	UG/L		J	A01
REA	Indeno(1,2,3-cd)pyrene	0.96	UG/L	U	UJ	A01
REA	Naphthalene	304	UG/L	D	J	A01
REA	Phenanthrene	1.8	UG/L		J	A01
REA	Pyrene	0.96	UG/L	U	UJ	A01

Location: **FIRE TRAINING (SWMU 13)**
Station : **FT-MW-13**

FT1312 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected:** **12/03/2000**

Sample Type	BTEX Compounds	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	2.8	UG/L		=	
REG	Ethylbenzene	11	UG/L		=	
REG	Toluene	.42	UG/L	J	J	
REG	Xylenes, Total	11.4	UG/L		=	

Sample Type	Polynuclear Aromatic Hydrocarbons	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REA	2-Chloronaphthalene	0.96	UG/L	U	UJ	A01
REA	Acenaphthene	0.96	UG/L	U	UJ	A01
REA	Acenaphthylene	0.96	UG/L	U	UJ	A01
REA	Anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)anthracene	0.96	UG/L	U	UJ	A01
REA	Benzo(a)pyrene	0.96	UG/L	U	UJ	A01
REA	Benzo(b)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Benzo(g,h,i)perylene	0.96	UG/L	U	UJ	A01
REA	Benzo(k)fluoranthene	0.96	UG/L	U	UJ	A01
REA	Chrysene	0.96	UG/L	U	UJ	A01
REA	Dibenzo(a,h)anthracene	0.96	UG/L	U	UJ	A01
REA	Fluoranthene	0.96	UG/L	U	UJ	A01
REA	Fluorene	.69	UG/L	J	UJ	A01
REA	Indeno(1,2,3-cd)pyrene	0.96	UG/L	U	UJ	A01
REA	Naphthalene	42.2	UG/L		J	A01
REA	Phenanthrene	0.96	UG/L	U	UJ	A01
REA	Pyrene	0.96	UG/L	U	UJ	A01

A. ANALYTICAL LABORATORY DATA

DEFINITIONS OF ACRONYMS AND ABBREVIATIONS

REG — Regular analysis

TCLP — Toxicity Characteristic Leachate Procedure (analytes listed in that procedure)

BGS — Below ground surface (depth in feet)

QUALIFIERS FOR ORGANIC ANALYTICAL DATA

Laboratory Flags

U — Indicates that the compound was analyzed for but not detected. The sample quantitation limit must be corrected for dilution. For a soil/sediment sample, the value must also be corrected for percent moisture.

J — Indicates an estimated value. This flag is used either when estimating a concentration for tentatively identified compounds (TICs) where a 1:1 response is assumed, or when the mass spectral data indicates the presence of a compound that meets the identification criteria but the result is less than the sample quantitation limit but greater than zero.

N — Indicates presumptive evidence of a compound. This flag is used only for TICs, where the identification is based on a mass spectral library search.

P — Used for pesticide/Aroclor target analytes when there is greater than 25 percent difference for detected concentrations between the two gas chromatography (GC) columns.

C — Applies to pesticide results where the identification has been confirmed by GC/mass spectrometry (MS). If GC/MS confirmation was attempted but was unsuccessful, do not apply this flag; instead use a laboratory-defined flag.

B — Used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag must be used for TICs as well as for positively identified target compounds.

E — Identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.

D — Identifies all compounds identified in an analysis at a secondary dilution factor. This flag alerts data users that any discrepancies between the concentrations reported may be due to dilution of the sample or extract.

A — Indicates that a TIC is a suspected aldol-condensation product.

X — Other specific flags may be required to properly define the results. If used, they must be fully described and such description must be attached to the Sample Data Summary Package and the standard delivery group narrative.

Validation Flags

U — Indicates that the compound was analyzed for, but was not detected above, the reported sample quantitation limit.

UJ — Indicates that the compound was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the compound in the sample.

J — Indicates that the compound was positively identified; the associated numerical value is the approximate concentration of the compound in the sample.

N — The analysis indicates the presence of a compound for which there is presumptive evidence to make a “tentative identification.”

NJ — Indicates that the analysis indicates the presence of a compound that has been “tentatively identified” and the associated numerical value represents its approximate concentration.

R — Indicates that the sample results for the compound are rejected or unusable due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the compound cannot be verified.

= — Indicates that the value has been validated and that the compound has been positively identified and the associated concentration value is accurate.

DATA QUALIFIER FLAGS FOR INORGANIC ANALYTICAL DATA

Laboratory Flags

B — Indicates that the reported value was obtained from a reading that was less than the Contract-Required Detection Limit (CRDL), but greater than or equal to the Instrument Detection Limit (IDL).

U — Indicates that the analyte was analyzed for but not detected.

E — Used when the reported value is estimated because of the presence of interference.

M —Indicates that the duplicate injection precision was not met.

N — Indicates that the spiked sample recovery is not within control limits.

S — Indicates that the reported value was determined by the method of standard additions (MSA).

W — Used when the post-digestion spike for furnace atomic absorption analysis is not within control limits (85 percent to 115 percent), while sample absorbance is less than 50 percent of spike absorbance.

***** — Indicates that the duplicate analysis is not within control limits.

+ — Indicates that the correlation coefficient for the MSA is less than 0.995.

Validation Flags

U — Indicates that the analyte was analyzed for, but was not detected above, the reported sample quantitation limit.

UJ — Indicates that the compound was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the compound in the sample.

J — Indicates that the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

R — Indicates that the sample results for the analyte are rejected or unusable due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

= — Indicates that the value has been validated and that the analyte has been positively identified and the associated concentration value is accurate.

DATA QUALIFIER FLAGS FOR RADIOCHEMICAL ANALYTICAL DATA

Laboratory Flags

< — The numerical value reported is less than the minimum detectable activity.

N — The sample results are flagged to denote poor spike recovery.

***** — The sample results are flagged to denote poor duplicate results.

Validation Flags

U — Indicates that the radionuclide was analyzed for, but was not detected above, the reported sample quantitation limit.

J — Indicates that the radionuclide was positively identified; the associated numerical value is the approximate concentration of the radionuclide in the sample.

N — The analysis indicates the presence of a radionuclide for which there is presumptive evidence to make a “tentative identification.”

DL — The detection limit requirements were not met. The data quality objectives may not be met.

UI — Indicates that there is uncertain identification for gamma spectroscopy. The radionuclide peaks are detected but fail to meet the positive identification criteria.

R — Indicates that the sample results for the radionuclide are rejected or unusable due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the radionuclide cannot be verified.

= — Indicates that the value has been validated and that the radionuclide has been positively identified and the associated concentration value is accurate.

ANALYTICAL DATA VALIDATION FLAGGING CODES

Holding Times

A01 Extraction holding times were exceeded.
A02 Extraction holding times were grossly exceeded.
A03 Analysis holding times were exceeded.
A04 Analysis holding times were grossly exceeded.
A05 Samples were not preserved properly.
A06 Professional judgment was used to qualify the data.

GC/MS Tuning

B01 Mass calibration was in error, even after applying expanded criteria.
B02 Mass calibration was not performed every 12 hours.
B03 Mass calibration did not meet ion abundance criteria.
B04 Professional judgment was used to qualify the data.

Initial/Continuing Calibration - Organics

C01 Initial calibration relative response factor (RRF) was <0.05.
C02 Initial calibration relative standard deviation (RSD) was >30 percent.
C03 Initial calibration sequence was not followed as required.
C04 Continuing calibration RRF was <0.05.
C05 Continuing calibration %D was >25 percent.
C06 Continuing calibration was not performed at the required frequency.
C07 Resolution criteria were not met.
C08 Relative percent difference (RPD) criteria were not met.
C09 RSD criteria were not met.
C10 Retention time of compounds was outside windows.
C11 Compounds were not adequately resolved.
C12 Breakdown of endrin or dichlorodiphenyl-trichloroethane (DDT) was >20 percent.
C13 Combined breakdown of endrin/DDT was >30 percent.
C14 Professional judgment was used to qualify the data.

Initial/Continuing Calibration - Inorganics

D01 Initial calibration verification (ICV) or continuing calibration verification (CCV) were not performed for every analyte.
D02 ICV recovery was above the upper control limit.
D03 ICV recovery was below the lower control limit.
D04 CCV recovery was above the upper control limit.
D05 CCV recovery was below the lower control limit.
D06 Standard curve was not established with the minimum number of standards.
D07 Instrument was not calibrated daily or each time the instrument was set up.
D08 Correlation coefficient was <0.995.
D09 Mid-range cyanide standard was not distilled.
D10 Professional judgment was used to qualify the data.

ICP and Furnace Requirements

E01	Interference check sample recovery was outside the control limit.
E02	Duplicate injections were outside the control limit.
E03	Post digestion spike recovery was outside the control limit.
E04	MSA was required but not performed.
E05	Correlation coefficient was <0.995.
E06	MSA spikes were not at the correct concentration.
E07	Serial dilution criteria were not met.
E08	Professional judgment was used to qualify the data.

Blanks

F01	Sample data were qualified as a result of the method blank.
F02	Sample data were qualified as a result of the field blank.
F03	Sample data were qualified as a result of the equipment rinsate.
F04	Sample data were qualified as a result of the trip blank.
F05	Gross contamination exists.
F06	Concentration of the contaminant was detected at a level below the CRQL.
F07	Concentration of the contaminant was detected at a level less than the action limit, but greater than the CRQL.
F08	Concentration of the contaminant was detected at a level that exceeds the action level.
F09	No laboratory blanks were analyzed.
F10	Blank had a negative value >2 times the IDL.
F11	Blanks were not analyzed at required frequency.
F12	Professional judgment was used to qualify the data.

Surrogate/Radiological Chemical Recovery

G01	Surrogate/radiological chemical recovery was above the upper control limit.
G02	Surrogate/radiological chemical recovery was below the lower control limit.
G03	Surrogate recovery was <10 percent.
G04	Surrogate/radiological chemical recovery was zero.
G05	Surrogate/radiological chemical recovery was not present.
G06	Professional judgment was used to qualify the data.
G07	Radiological chemical recovery was <20 percent.
G08	Radiological chemical recovery was >150 percent.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

H01	MS/MSD recovery was above the upper control limit.
H02	MS/MSD recovery was below the lower control limit.
H03	MS/MSD recovery was <10 percent.
H04	MS/MSD pairs exceed the RPD limit.
H05	No action was taken on MS/MSD results.
H06	Professional judgment was used to qualify the data.
H07	Radiological MS/MSD recovery was <20 percent.
H08	Radiological MS/MSD recovery was >160 percent.
H09	Radiological MS/MSD samples were not analyzed at the required frequency.

Matrix Spike (MS)

I01 MS recovery was above the upper control limit.
I02 MS recovery was below the lower control limit.
I03 MS recovery was <30 percent.
I04 No action was taken on MS data.
I05 Professional judgment was used to qualify the data.

Laboratory Duplicate

J01 Duplicate RPD/radiological duplicate error ration (DER) was outside the control limit.
J02 Duplicate sample results were >5 times the CRDL.
J03 Duplicate sample results were <5 times the CRDL.
J04 Professional judgment was used to qualify the data.
J05 Duplicate was not analyzed at the required frequency.

Internal Area Summary

K01 Area counts were outside the control limits.
K02 Extremely low area counts or performance was exhibited by a major drop off.
K03 Internal standard retention time varied by more than 30 seconds.
K04 Professional judgment was used to qualify the data.

Pesticide Cleanup Checks

L01 10 Percent recovery was obtained during either check.
L02 Recoveries during either check were >120 percent.
L03 Gel permeation chromatography cleanup recoveries were outside the control limits.
L04 Florisil cartridge cleanup recoveries were outside the control limits.
L05 Professional judgment was used to qualify the data.

Target Compound Identification

M01 Incorrect identifications were made.
M02 Qualitative criteria were not met.
M03 Cross-contamination occurred.
M04 Confirmatory analysis was not performed.
M05 No results were provided.
M06 Analysis occurred outside the 12-hour GC/MS window.
M07 Professional judgment was used to qualify the data.
M08 The %D between the two pesticide/polychlorinated biphenyl column checks was >25 percent.

Compound Quantitation and Reported CRQLs

N01 Quantitation limits were affected by large off-scale peaks.
N02 Method detection limits reported by the laboratory exceeded corresponding CRQLs.
N03 Professional judgment was used to qualify the data.

Tentatively Identified Compounds (TICs)

O01 Compound was suspected laboratory contaminant and was not detected in the blank.
O02 TIC result was not above 10 times the level found in the blank.
O03 Professional judgment was used to qualify analytical data.

Laboratory Control Samples (LCSs)

P01 LCS recovery was above upper control limit.
P02 LCS recovery was below lower control limit.
P03 LCS recovery was <50 percent.
P04 No action was taken on the LCS data.
P05 LCS was not analyzed at required frequency.
P06 Radiological LCS recovery was <50 percent for aqueous samples; <40 percent for solid samples.
P07 Radiological LCS recovery was >150 percent for aqueous samples; >160 percent for solid samples.
P08 Professional judgment was used to qualify the data.

Field Duplicate

Q01 No action was taken on the basis of field duplicate RPDs.
Q02 Radiological field duplicate error ratio (DER) was outside the control limit.
Q03 Duplicate sample results were >5 times the CRDL.
Q04 Duplicate sample results were <5 times the CRDL.

Radiological Calibration

R01 Efficiency calibration criteria were not met.
R02 Energy calibration criteria were not met.
R03 Resolution calibration criteria were not met
R04 Background determination criteria were not met.
R05 Quench curve criteria were not met.
R06 Absorption curve criteria were not met.
R07 Plateau curve criteria were not met.
R08 Professional judgment was used to qualify the data.

Radiological Calibration Verification

S01 Efficiency verification criteria were not met.
S02 Energy verification criteria were not met.
S03 Resolution verification criteria were not met
S04 Background verification criteria were not met.
S05 Cross-talk verification criteria were not met.
S06 Professional judgment was used to qualify the data.

Radionuclide Quantitation

T01 Detection limits were not met.
T02 Analytical uncertainties were not met and/or not reported.
T03 Inappropriate aliquot sizes were used.
T04 Professional judgment was used to qualify the data.

System Performance

V01	High background levels or a shift in the energy calibration were observed.
V02	Extraneous peaks were observed.
V03	Loss of resolution was observed.
V04	Peak-tailing or peak splitting that may result in inaccurate quantitation were observed.
V05	Professional judgment was used to qualify the data.

APPENDIX B

GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS

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3

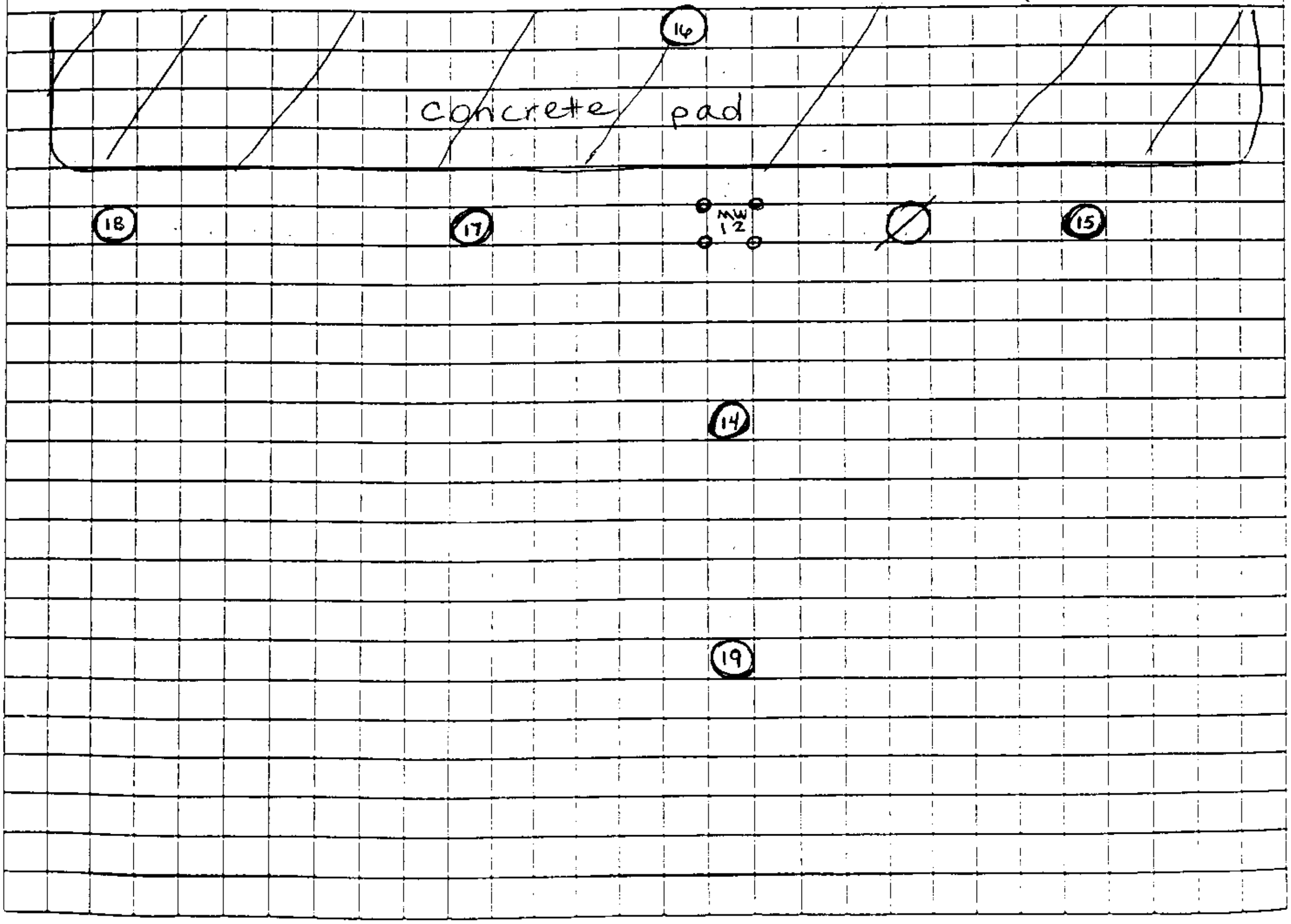
HTRW DRILLING LOG	DISTRICT USACE- Savannah	HOLE NUMBER FT-MW-14
1. COMPANY NAME: SAIC	2. DRILL SUBCONTRACTOR: NA (SAIC)	SHEET 1 OF 1

3. PROJECT: SWMU 13	4. LOCATION: Wright Army Airfield
5. NAME OF DRILLER: Al Root, SAIC	6. MANUFACTURER'S DESIGNATION OF DRILL Geoprobe 5400
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT Geoprobe 5400, 4ft, 2½" OD sampling rods.	8. HOLE LOCATION: See Sketch Below
	9. SURFACE ELEVATION
	10. DATE STARTED: 04/04/01 — 11. DATE COMPLETED: 04/04/01
12. OVERBURDEN THICKNESS NA	15. DEPTH GROUNDWATER ENCOUNTERED: 12.0' BGS
13. DEPTH DRILLED INTO ROCK NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 5.6' BGS after 20 minutes.
14. TOTAL DEPTH OF HOLE 15.0	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES NA	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES NA		
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)
	X		SVOC's		
21. TOTAL CORE RECOVERY %					
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR	
		X (¾")		Cynthia L. Abbott	

LOCATION SKETCH/COMMENTS

SCALE. 1 Square = 2 ft



* NOTE TYPE OF MONITORING (i.e., borehole cuttings, monitoring well atmosphere, soil core, breathing zone, venting compressed air, etc.)

QA CHECK BY: ____________ (Signature and Date)

HTRW DRILLING LOG

HOLE NUMBER FT MW 14 4

PROJECT: 13 SWMU's

INSPECTOR Cynthia L. Abbott

SHEET 1 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Organic debris & top soil		NA		Run: 4.0' Recover: 3.5
	1	Silty Clay. Moist. Firm. Non-plastic. 10 YR 6/8 brownish yellow	7.0ppm			
	2		8.5ppm			
	3	Clay. Hard. Dry. Crumbiosi lo plasticity. Mottled. 10R 4/4 10YR 7/1, 10YR 5/6.				
		No Recovery	NA			
	4	Clay. Hard Same as above. Mottled. 10R 4/4 Red. 10YR 7/1 Light gray. 10YR 5/6 Yellowish brown.				Run 4.0 Recover 4.0
	5		2263ppm			
	6					
	7		72500ppm		FT1411	
	8	Same as above.				
	9		72500			
	10					

HTRW DRILLING LOG

HOLE NUMBER FTMW14

PROJECT: 13 SWMU's

INSPECTOR Cynthia L. Abbott

SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
			>2500		FT1421	
	11					
	12	Same clay as above. except fully saturated.				Water encountered @ 12.0'
	13					
	14					
	15					TD=15.0' BGS
	16					
	17					
	18					
	19					
	19					

8

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13) **DELIVERY ORDER NO:** 00__

MONITORING WELL ID: FT-MW-14

INSTALLATION START: DATE: 04/04/01 TIME: 1350

INSTALLATION FINISH: DATE: 04/04/01 TIME: 1455

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: TYPE: 00 Filter Sand QUANTITY: ~8 lbs

BENTONITE SEAL: TYPE: Granular QUANTITY: ~5 lbs

GROUT: TYPE: NA QUANTITY: ______

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: NA

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: ~~3/4~~" PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: NA

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: ______ COMPOSITION: ______

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES [☒] NO [ ]

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES [☒] NO [ ]

Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? YES [ ] NO [☒] — 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: None

RECORDED BY: Cynthia L. Abbott 04/04/01 QA CHECK BY: ______
(Signature & Date) (Signature & Date)

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)

DELIVERY ORDER NO: 00__

WELL NUMBER: FT-MW-14

BEGIN: 04/04/01

END: 04/04/01

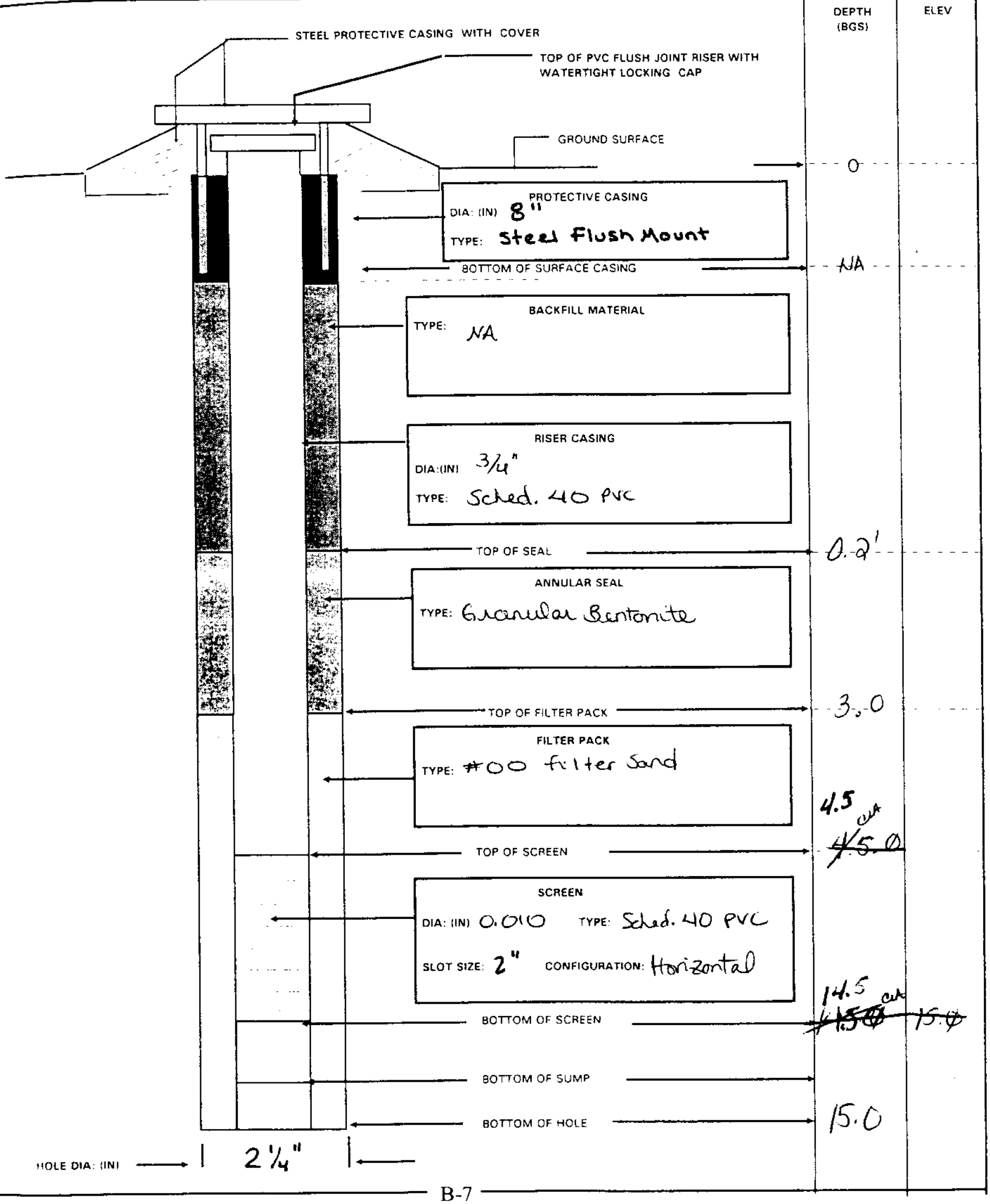
COORDINATES: N:
E:

DATUM/UNITS:

REFERENCE POINT:

ELEVATION:

DATUM/UNITS:



	DEPTH (BGS)	ELEV
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING	NA	
TOP OF SEAL	0.2'	
TOP OF FILTER PACK	3.0	
TOP OF SCREEN	4.5 cw ~~5.0~~	
BOTTOM OF SCREEN	14.5 cw ~~15.0~~ ~~15.0~~	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0	

PROTECTIVE CASING
DIA: (IN) 8"
TYPE: Steel Flush Mount

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 3/4"
TYPE: Sched. 40 PVC

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: #00 filter Sand

SCREEN
DIA: (IN) 0.010 TYPE: Sched. 40 PVC
SLOT SIZE: 2" CONFIGURATION: Horizontal

HOLE DIA: (IN) 2 1/4"

13

HTRW DRILLING LOG

DISTRICT: USACE - Savannah

HOLE NUMBER: FT-MW-15

SHEET 1 OF 1

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: NA (SAIC)

3. PROJECT: SWMU 13

4. LOCATION: See Sketch Page 3

5. NAME OF DRILLER: Al Root SAIC

6. MANUFACTURERS DESIGNATION OF DRILL: Geoprobe 5400

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Geoprobe, 4' 2¼" - OD Steel Rods, Sample Sleeves

8. HOLE LOCATION: See page 3

9. SURFACE ELEVATION:

10. DATE STARTED: 04/04/01

11. DATE COMPLETED: 04/04/01

12. OVERBURDEN THICKNESS: NA

15. DEPTH GROUNDWATER ENCOUNTERED: 12.2

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 6.11 @fter 45 min.

14. TOTAL DEPTH OF HOLE: 15'

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED		UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES NA		
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC X	METALS	OTHER (SPECIFY) SVOC's	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL X (¾")	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Cynthia L. Abbott		

LOCATION SKETCH/COMMENTS

SCALE:

See Page 3

* NOTE TYPE OF MONITORING (i.e., borehole cuttings, monitoring well atmosphere, soil core, breathing zone, venting compressed air,

QA CHECK BY: ______________ (Signature and Date)

Well Development

HTRW DRILLING LOG

HOLE NUMBER MW15

PROJECT: 13 SWMU's

INSPECTOR Cynthia L. Abbott

SHEET 1 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
	1 2 3	Silty Clay. Dry. Soft Loose. Non plastic. 10YR 5/4	9.2ppm 20.4			
	4	Clay Damp. Mod. Firm Mod. Plasticity. 10YR 5/6				
	5 6 7 8	Clay w/silt. Firm to hard. Damp. Lo plasticity. Mottled 10R 4/8 Red, 10YR 7/1 Light gray, 10YR 5/6 Yellowish brown.	40.8ppm 2285ppm		FT1511	
	9 10	Same as above	834ppm			

15

HTRW DRILLING LOG

HOLE NUMBER MW15
PROJECT:
INSPECTOR Cynthia L Abbott
SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Same Mottled Clay as before.				
	11		1835ppm		FT1521	
	12	Same As Above. Saturated throughout				
	13					∇ Water Encountered @ 12.2 - 14.5
	14					
	15	Clay and very coarse sand 10YR 7/3 Very Pale Brown. Very hard. No plasticity. Clayey sand. Very Hard. Mottled 10YR 7/3 with 10YR 6/8 Brownish Yellow				— —Well@15.0— —
	16					TD= 16.0'
	17					
	18					
	19					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13)

DELIVERY ORDER NO: 00__

MONITORING WELL ID: FT-MW-15

INSTALLATION START: DATE: 04/04/01 TIME: 1130

INSTALLATION FINISH: DATE: 04/04/01 TIME: 1300

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: TYPE: 00 QUANTITY: 8 lbs

BENTONITE SEAL: TYPE: Granular QUANTITY: 5 lbs

GROUT: TYPE: ______ QUANTITY: ______

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: Schedule 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: #00 Filter Sand

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: Schedule 40 COMPOSITION: PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: NA

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8" COMPOSITION: Steel Flush Mount

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES [X] NO [ ]

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES [X] NO [ ]

Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? YES [ ] NO [X] 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

RECORDED BY: Cynthia L. Abbott 04/04/01
(Signature & Date)

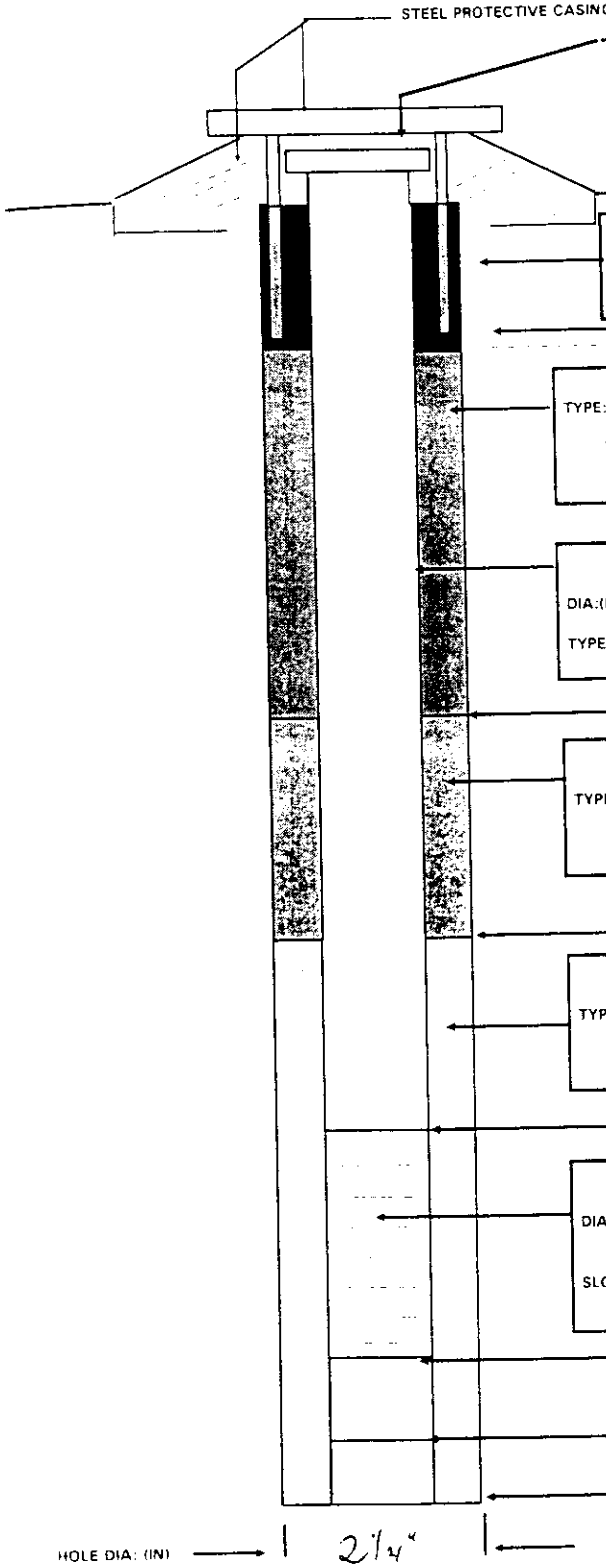
QA CHECK BY: ______
(Signature & Date)

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)

DELIVERY ORDER NO: 00__

WELL NUMBER: FT-MW-15	BEGIN: 04/04/01	END: 04/04/01
COORDINATES: N: E:	REFERENCE POINT:	ELEVATION: DATUM/UNITS:
DATUM/UNITS:		



PROTECTIVE CASING
DIA: (IN) ~~NA~~ 8"
TYPE: Steel Flush Mount

BACKFILL MATERIAL
TYPE: ~~NA~~ Quickrete

RISER CASING
DIA:(IN) 3/4"
TYPE: Sched. 40

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: 00 Filter Sand

SCREEN
DIA: (IN) 3/4" TYPE: Sched. 40
SLOT SIZE: 0.010 CONFIGURATION: Horizontal

HOLE DIA: (IN) 2 1/4"

	DEPTH (BGS)	ELEV
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	0.2'	
TOP OF FILTER PACK	3.0	
TOP OF SCREEN	4.5 ~~0~~ cla	
BOTTOM OF SCREEN	14.5 ~~0~~ cla	
BOTTOM OF SUMP	15.0	
BOTTOM OF HOLE	16.0	

3

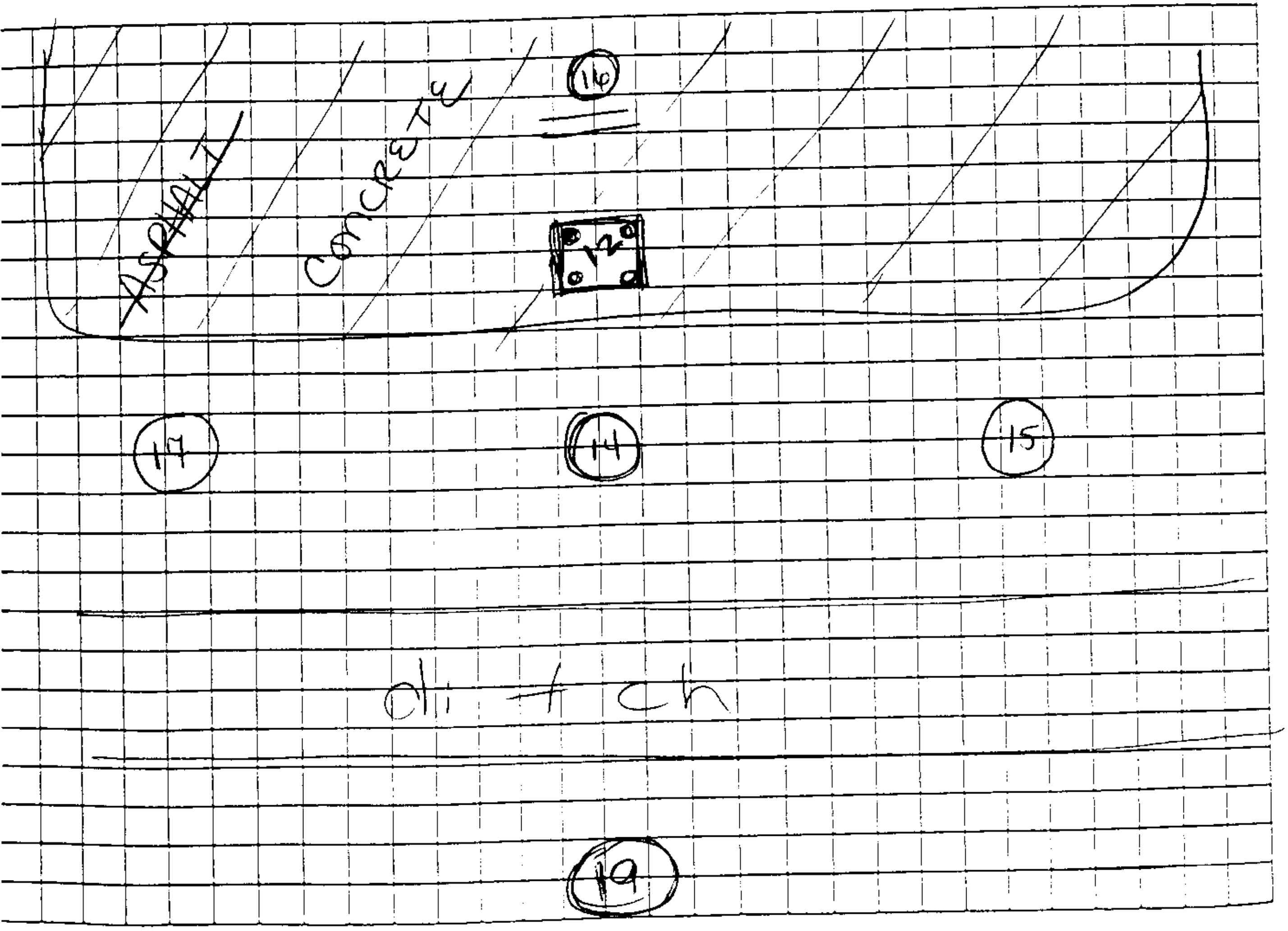
HTRW DRILLING LOG

DISTRICT USACE- Savannah		HOLE NUMBER FT-MW-16
1. COMPANY NAME: SAIC	2. DRILL SUBCONTRACTOR: NA	SHEET 1 OF 1
3. PROJECT: 13 SWMU's	4. LOCATION: See sketch below	
5. NAME OF DRILLER: Al Root, SAIC	6. MANUFACTURERS DESIGNATION OF DRILL: Geoprobe ~~[illegible]~~ 5400	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Geoprobe 5400, 4 ft, 2½ OD Samplers	8. HOLE LOCATION: See below	
	9. SURFACE ELEVATION	
	10. DATE STARTED: 04/05/01	11. DATE COMPLETED: 04/05/01
12. OVERBURDEN THICKNESS NA	15. DEPTH GROUNDWATER ENCOUNTERED: 11.5	
13. DEPTH DRILLED INTO ROCK NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 9.2' and Rising after 10 minutes	
14. TOTAL DEPTH OF HOLE 14.0	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES NA	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY 100%
	X					
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		
		X (3/4")		Cynthia L. Abbott		

LOCATION SKETCH/COMMENTS

SCALE:



* NOTE TYPE OF MONITORING (i.e., borehole cuttings, monitoring well atmosphere, soil core, breathing zone, venting compressed air.

QA CHECK BY:

4

HTRW DRILLING LOG

HOLE NUMBER FTMW16

PROJECT: 13 SWMU's

INSPECTOR Cynthia L. Abbott

SHEET 1 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Concrete		NA		Run 1: 0.5-4 Recover: 3.0
	1	Silty Clay. Soft. Damp. No plasticity.	1.1ppm			
	2					
	3		1.3ppm			
		Clay. Soft. Damp. 10YR 5/6 Yellowish Brown				
		No Recovery				
	4					Run 2 0-8 Recover 4'
	5	(CH) Fat Clay. Hard Damp. mod. to high plasticity. Highly mottled 10YR 7/1 Light Gray, 10R 4/4 Red 10 YR 5/6 Yellowish Brown.	109 ppm			
	6					
	7		783ppm		FT1611	
	8	Same As Above	325ppm			Run 3 8-11 Recover 100%
	9					
	10		↓ 42J		↓ FT1621	

HTRW DRILLING LOG

HOLE NUMBER FT MW 16

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Same (CH) as above	425ppm		FT1621	
	11	Same (CH) clay as above, however color change to 10 R 4/4 Red.				Water @ ~11.5
	12					
	13	coarse grained QTZ Sand.				Well @ 13.0
	14					TD = 14.0
	15					
	16					
	17					
	18					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13) **DELIVERY ORDER NO:** 00__

MONITORING WELL ID: FT-MW16

INSTALLATION START: DATE: 04/05/01 TIME: 1800

INSTALLATION FINISH: DATE: 04/05/01 TIME: 1840

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	TYPE: #00 Sand	QUANTITY: 5 lbs
BENTONITE SEAL:	TYPE: Granular	QUANTITY: 2 cups
GROUT:	TYPE:	QUANTITY:

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: Schedule 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: NA

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: NA

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8" COMPOSITION: Steel Flush Mount

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES ☒ NO ☐

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES ☒ NO ☐

Was deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and removal of a 1.0-inch bailer throughout the entire length of the completed well? YES ☐ NO ☒ 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: None

RECORDED BY: Cynthia Abbott 04/05/01 QA CHECK BY:
(Signature & Date) (Signature & Date)

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)
DELIVERY ORDER NO: 00__
WELL NUMBER: FT-MW-16
BEGIN: 04/05/01
END: 04/05/01
COORDINATES: N:
E:
DATUM/UNITS:
REFERENCE POINT:
ELEVATION:
DATUM/UNITS:

STEEL PROTECTIVE CASING WITH COVER

TOP OF PVC FLUSH JOINT RISER WITH WATERTIGHT LOCKING CAP

PROTECTIVE CASING
DIA: (IN) NA
TYPE:

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA:(IN) 3/4"
TYPE: Schedule 40 PVC

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: #00 Sand

SCREEN
DIA: (IN) 3/4" TYPE: Sched. 40
SLOT SIZE: 0.010 CONFIGURATION: Horizontal

HOLE DIA: (IN)

	DEPTH (BGS)	ELEV
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING	0.5	
TOP OF SEAL	0.5	
TOP OF FILTER PACK	1.5	
TOP OF SCREEN	3.0	
BOTTOM OF SCREEN	13.0	
BOTTOM OF SUMP	13.2	
BOTTOM OF HOLE	14.0	

23

HTRW DRILLING LOG

DISTRICT: USACE- Savannah

HOLE NUMBER: FT-MW-17

SHEET 1 OF 1

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: NA (SAIC)

3. PROJECT: 13 SWMU's

4. LOCATION: Ft Stewart GA

5. NAME OF DRILLER: ~~Miller~~ Al Root, SAIC

6. MANUFACTURERS DESIGNATION OF DRILL:

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:

8. HOLE LOCATION: See Page 3

9. SURFACE ELEVATION:

10. DATE STARTED: 04/04/01

11. DATE COMPLETED: 04/04/01

12. OVERBURDEN THICKNESS: NA

13. DEPTH DRILLED INTO ROCK: NA

14. TOTAL DEPTH OF HOLE: 14.0

15. DEPTH GROUNDWATER ENCOUNTERED: 12.0

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 7.5' after 20 minutes

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
	2 - X	2 - X				
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		
		X 3/4"		Cynthia L Abbott		

LOCATION SKETCH/COMMENTS

SCALE:

See Page 3

* NOTE TYPE OF MONITORING (i.e., borehole cuttings, monitoring well atmosphere, soil core, breathing zone, venting compressed air, etc.)

QA CHECK BY: ____________________ (Signature and Date)

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HTRW DRILLING LOG

HOLE NUMBER AW17

SHEET 1 OF 2

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Organic Debris				Run 4' Recover 4'
		Silty Clay. Damp. 10YR 5/4 yellowish brown. soft. no plasticity.				
	1		10.0ppm			
	2		29.0ppm			
	3					
		(Clay)(Brown). Damp. Moderate Firmness.				
	4	Lo to mod. plasticity. 10YR 5/3 Brown.				Run 4' Recover ~~4~~ 4.0'
	5		1353ppm			
		Clay. Firm. Moist. (CH) Mod. Plasticity. Mottled 10R 4/4 Red, 10YR 7/1 Light gray				
	6					
	7		>2500ppm			
	8	Same as above				Run 4' Recover 3'
	9		>2500		F11711	
	10					

HTRW DRILLING LOG		HOLE NUMBER MW17
PROJECT: 13 SWMU's	INSPECTOR Cynthia L Abbott	SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Same CH clay as above.	>2500ppm		FT1721	Run # 3 (4.0') Recover 3.0'
	11	No Recovery	NA			
	12					Water level @ 12.0' BGS
	13					
		Very Coarse Sand. Dense. Moist. 10				
	14					TD = 14.0'
	15					
	16					
	17					
	18					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13) **DELIVERY ORDER NO:** 00__

MONITORING WELL ID: FT-MW-17

INSTALLATION START: DATE: 04/04/01 TIME: 1530

INSTALLATION FINISH: DATE: 04/04/01 TIME: 1640

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: TYPE: #00 QUANTITY: 8lbs

BENTONITE SEAL: TYPE: Granular QUANTITY: 3lbs

GROUT: TYPE: ______ QUANTITY: ______

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: NA

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: NA

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8 COMPOSITION: Steel Flushmount

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES ☒ NO ☐

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES ☒ NO ☐

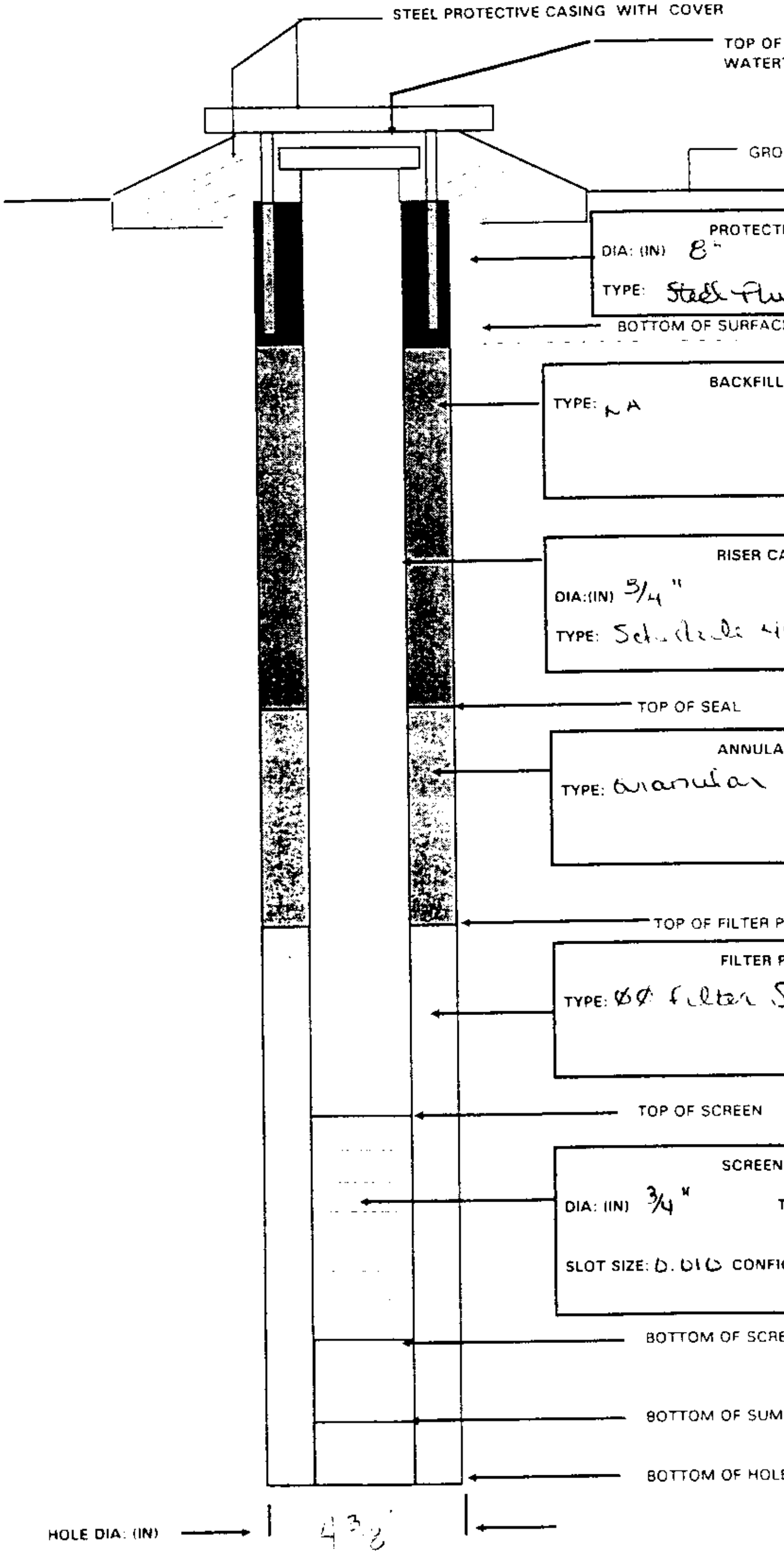
Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? YES ☐ NO ☒ 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

RECORDED BY: Cynthia L. Abbott 04/04/01 QA CHECK BY: ______
(Signature & Date) (Signature & Date)

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)
DELIVERY ORDER NO: 00__
WELL NUMBER: FT-MW-17
BEGIN: 04/04/01
END: 04/04/01
COORDINATES: N:
E:
DATUM/UNITS:
REFERENCE POINT:
ELEVATION:
DATUM/UNITS:



STEEL PROTECTIVE CASING WITH COVER

TOP OF PVC FLUSH JOINT RISER WITH WATERTIGHT LOCKING CAP

PROTECTIVE CASING
DIA: (IN) 8"
TYPE: Steel Flushmount

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 3/4"
TYPE: Schedule 40 PVC

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: 00 Filter Sand

SCREEN
DIA: (IN) 3/4"
TYPE: Sched. 40 PVC
SLOT SIZE: 0.010
CONFIGURATION: Horizontal

	DEPTH (BGS)	ELEV
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING	0.5	
TOP OF SEAL	0.2'	
TOP OF FILTER PACK	2.0	
TOP OF SCREEN	4.0	
BOTTOM OF SCREEN	14.0	
BOTTOM OF SUMP	14.4	
BOTTOM OF HOLE	14.4	

HOLE DIA: (IN) 4 3/8"

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HTRW DRILLING LOG

DISTRICT: USACE - Savannah

HOLE NUMBER: FTMW18

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: NA (SAIC)

SHEET 1 OF 1

3. PROJECT: 13 Sw.MW's

4. LOCATION: Ft.Stewart GA

5. NAME OF DRILLER: Al Root

6. MANUFACTURERS DESIGNATION OF DRILL: Geoprobe 5400

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Geoprobe 5400, 4 ft, 2"OD hollow samplers.

8. HOLE LOCATION: See Page 3

9. SURFACE ELEVATION:

10. DATE STARTED: 04/04/01

11. DATE COMPLETED: 04/04/01

12. OVERBURDEN THICKNESS: NA

15. DEPTH GROUNDWATER ENCOUNTERED: 12'

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: NA

14. TOTAL DEPTH OF HOLE: 14.0

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): NA

18. GEOTECHNICAL SAMPLES: NA | DISTURBED | UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES: NA

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	2 X	2 X				100%

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X (3/4")		Cynthia L Abbott

LOCATION SKETCH/COMMENTS

SCALE:

See Page 3

Well atmosphere, soil core, breathing zone, venting compressed air, etc.)

(Signature and Date)

QA CHECK BY:

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HTRW DRILLING LOG

HOLE NUMBER FT MW18

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

SHEET 1 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Organic debris/topsoil				Run 1: 0-4 Recover: 4'
	1	Silty clay. Soft. Damp. Non-plastic. 10 YR 5/4 Yellowish brown with occassional mottling of 10 YR 5/8 Yellowish brown.	32.8ppm			
	2					
	3		111.0ppm			
		Clay. Damp. Firm. moderate plasticity. 10 YR 5/8 Yellowish brown.				
	4	(CH) CLAY. Hard. Damp. Moderate to high plasticity. Mottled with 10 R 4/4 Red, 10 YR 7/1 Light Gray 10 YR 5/6 Yellowish Brown				Run 2: 4-8 Recover: 4.0'
	5		785ppm			
	6					
	7		1382ppm			
	8	Same as above				Run 3: 8-11
	9		2355ppm		FT1811	
	10					

HTRW DRILLING LOG

HOLE NUMBER FTMW1

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
			2355ppm		FT1811	
	11	Same as above	1382ppm		FT1821	Run: 3 • 11-14 Recovery: 3'
	12					
	13	Very coarse Sand & clay				
	14					TD = 14.0'
	15					
	16					
	17			CA		
	18					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13) **DELIVERY ORDER NO:** 00__

MONITORING WELL ID: FT MW18

INSTALLATION START: DATE: 04/04/01 TIME: 1635

INSTALLATION FINISH: DATE: 04/04/01 TIME: 1715

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: TYPE: ~~bentonite~~ 00 Sand QUANTITY: 6 ics

BENTONITE SEAL: TYPE: Granular bentonite QUANTITY: 2 ics

GROUT: TYPE: N/A QUANTITY: ______

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: #00 Filter Sand

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: ______

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8" COMPOSITION: Steel Flush Mount.

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES ☒ NO ☐

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES ☒ NO ☐

Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? YES ☐ NO ☒ 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

RECORDED BY: Cynthia Abbott 04/04/01
(Signature & Date)

QA CHECK BY: ______
(Signature & Date)

34

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)

DELIVERY ORDER NO: 00__

WELL NUMBER: FT-MW-18

BEGIN: 04/04/01

END: 04/04/01

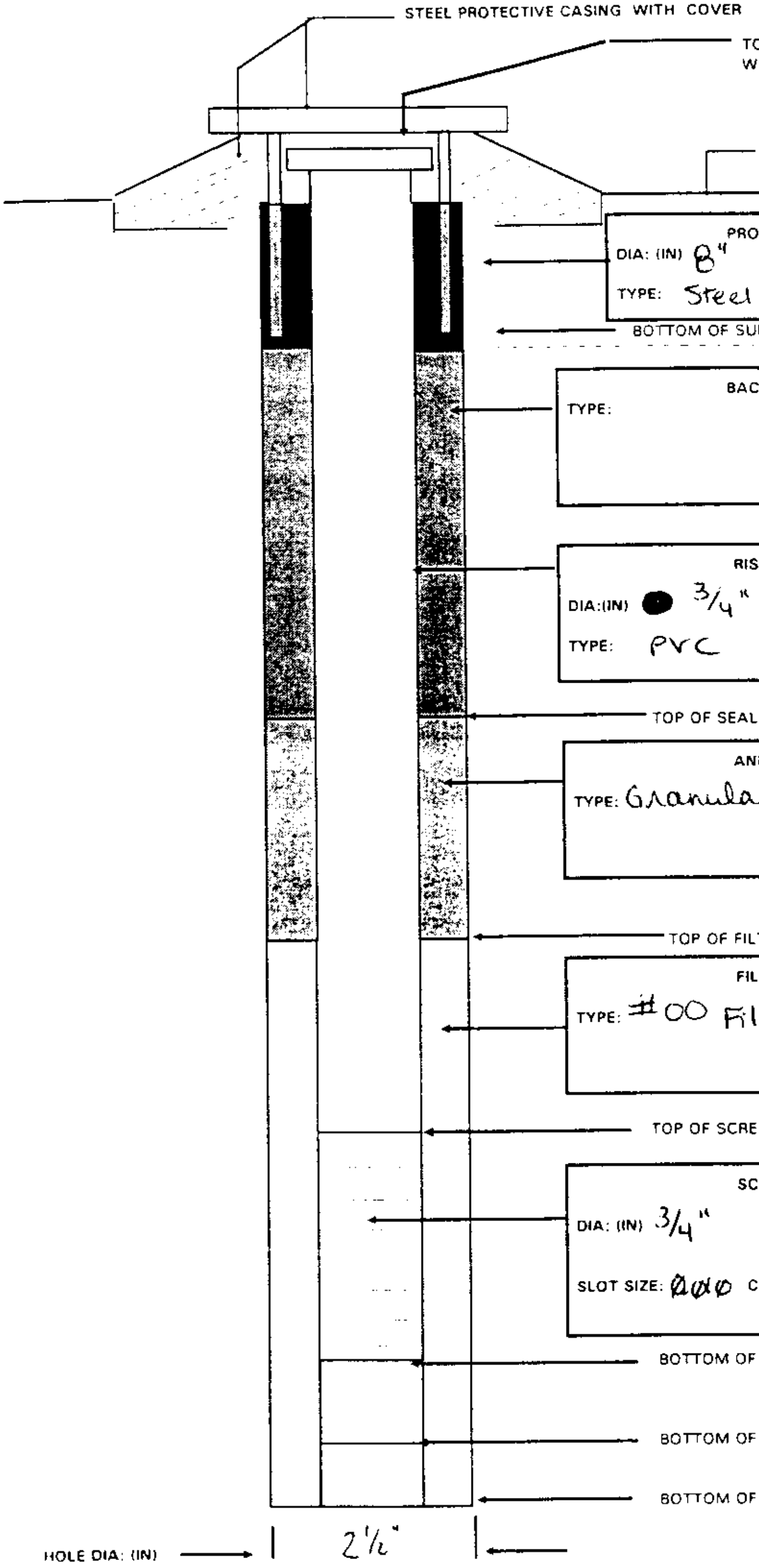
COORDINATES: N:
E:

DATUM/UNITS:

REFERENCE POINT:

ELEVATION:

DATUM/UNITS:



PROTECTIVE CASING
DIA: (IN) 8"
TYPE: Steel flush Mount

BACKFILL MATERIAL
TYPE:

RISER CASING
DIA:(IN) ● 3/4"
TYPE: PVC

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: #00 Filter Sand

SCREEN
DIA: (IN) 3/4"
TYPE: PVC
SLOT SIZE: 010
CONFIGURATION: Horizontal

	DEPTH (BGS)	ELEV
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL		
TOP OF FILTER PACK	1.5	
TOP OF SCREEN	2.6 ~~3.0~~ cn	
BOTTOM OF SCREEN	12.6 ~~13.0~~ cn	
BOTTOM OF SUMP	13.0	
BOTTOM OF HOLE	14.0	

HOLE DIA: (IN) 2½"

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HTRW DRILLING LOG

DISTRICT USACE - Savannah

HOLE NUMBER FTMW19

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: NA (SAIC)

SHEET 1 OF 1

3. PROJECT: 13 SWMU's

4. LOCATION: Fire Training, Ft. Stewart, GA

5. NAME OF DRILLER: Al Root, SAIC

6. MANUFACTURERS DESIGNATION OF DRILL: Geoprobe 5400

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Geoprobe 5400, 4'-2¼" OD Steel rods, teflon sample sleeves.

8. HOLE LOCATION: See page 3

9. SURFACE ELEVATION:

10. DATE STARTED: 04/04/01

11. DATE COMPLETED: 04/04/01

12. OVERBURDEN THICKNESS: NA

15. DEPTH GROUNDWATER ENCOUNTERED: 11.5

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

14. TOTAL DEPTH OF HOLE: 14.0

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 7.3' BGS @ 1840

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
	X (2)		SVOCs (2)			

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		X (3/4")		Cynthia L. Abbott

LOCATION SKETCH/COMMENTS

SCALE:

See page 3

well atmosphere, soil core, breathing zone, venting compressed air, etc.)

QA CHECK BY: (Signature and Date)

44

HTRW DRILLING LOG

HOLE NUMBER FTmw19

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

SHEET 1 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Organic				Run 1 0-4 Recover 3.5
		Silty Clay	25.3ppm			
	1					
		Clay				
	2	10YR 5/4				
			21.0ppm			
	3					
		No Recovery				
	4	Same Clay as above				Run 2 4-8 Recover 4
	5	(CH) Clay. Hard. Damp. Moderate to high plasticity. Mottled: 10R 4/4 Red, 10YR 7/1 light gray, 10YR 5/6 yellowish brown.	331ppm			
	6					
	7		562ppm		FT1911	
	8	Same as above with absence of mottling.				Run 3 = 8-11 Recover 100%
	9		835ppm			
	10					

HTRW DRILLING LOG

HOLE NUMBER FTmw19

PROJECT: 13 SWMU's

INSPECTOR Cynthia L Abbott

SHEET 2 OF 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
			335ppm		FT1921	Run 3 8-11' Recover 100%
	11	Saturated throughout Same red clay as above				
	12	Coarse Sand				
	13					Well set to 13.0' BGS
	14					TD = 14.0 ft
	15					
	16			cla		
	17					
	18					
	19					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: Fire Training Area (SWMU 13) **DELIVERY ORDER NO:** 00__

MONITORING WELL ID: FT-MW-19

INSTALLATION START: DATE: 04/04/01 TIME: 1750

INSTALLATION FINISH: DATE: 04/04/01 TIME: 1815

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: TYPE: #00 Filter Sand QUANTITY: 5 lbs

BENTONITE SEAL: TYPE: Granular QUANTITY: 1 lb

GROUT: TYPE: ______ QUANTITY: ______

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.010 SLOT CONFIGURATION: Horizontal

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: NA

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 7/8" NOMINAL INSIDE DIAMETER: 3/4"

SCHEDULE/THICKNESS: 40 COMPOSITION: PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded

CENTRALIZERS DESIGN AND COMPOSITION: NA

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8" COMPOSITION: Steel-Flush Mount

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? YES ☒ NO ☐

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? YES ☒ NO ☐

Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? YES ☐ NO ☒ 3/4" well

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

RECORDED BY: Cynthia L Abbott 04/04/01 QA CHECK BY: ______
(Signature & Date) (Signature & Date)

49

MONITORING WELL

PROJECT: Fire Training Area (SWMU 13)

DELIVERY ORDER NO: 00_

WELL NUMBER: FT-MW-19

BEGIN: 04/04/01

END: 04/04/01

COORDINATES: N:

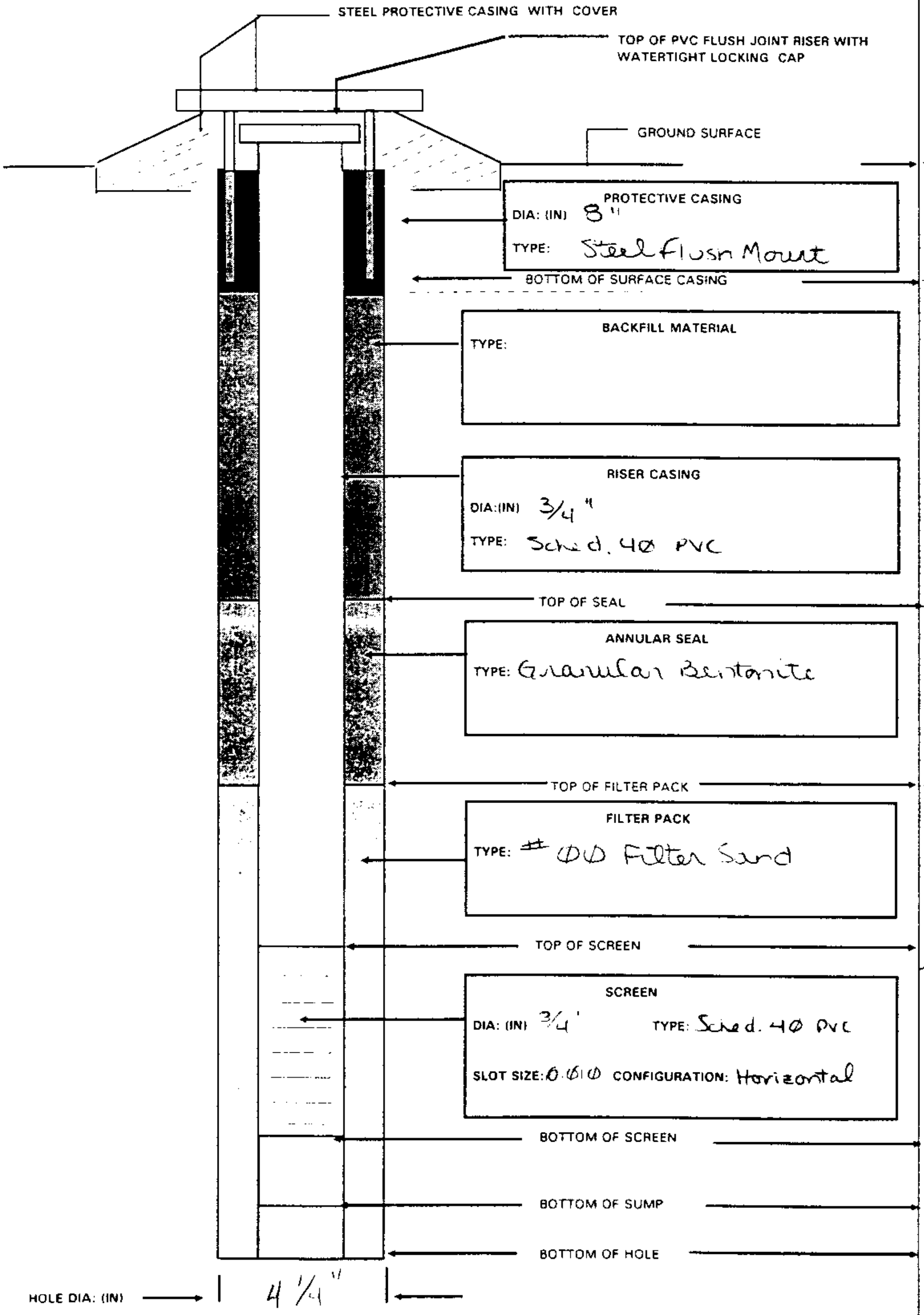
E:

DATUM/UNITS:

REFERENCE POINT:

ELEVATION:

DATUM/UNITS:



PROTECTIVE CASING
DIA: (IN) 8"
TYPE: Steel Flush Mount

BACKFILL MATERIAL
TYPE:

RISER CASING
DIA: (IN) 3/4"
TYPE: Sched. 40 PVC

ANNULAR SEAL
TYPE: Granular Bentonite

FILTER PACK
TYPE: #00 Filter Sand

SCREEN
DIA: (IN) 3/4' TYPE: Sched. 40 PVC
SLOT SIZE: 0.010 CONFIGURATION: Horizontal

HOLE DIA: (IN) 4 1/4"

DEPTH (BGS)	ELEV
0	
0.0'	
1.0'	
2.8' ~~3.0'~~ cua	
12.8' ~~13.0'~~ cua	
13.0'	

APPENDIX C

FATE AND TRANSPORT MODELING AT THE FORMER FIRE TRAINING AREA (SWMU 13)

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C.1. INTRODUCTION

Monitored natural attenuation is an appropriate remedial approach only if it can be demonstrated that a site's remedial objectives can be reached within a reasonable time frame. Fate and transport modeling is performed for a given site to show whether contaminants present in soils and groundwater can be effectively remediated by natural attenuation processes. The following sections summarize the modeling performed in order to evaluate natural attenuation as a remedial action for the Corrective Action Plan for the former Fire Training Area at Wright Army Airfield [solid waste management unit (SWMU) 13], Fort Stewart, Georgia.

C.2. MODELING APPROACH

A brief summary of the modeling approach is presented below:

1. Develop the conceptual model for each distinct flow path, which includes the contaminated soils and groundwater plume, the flow path direction and characteristics, and the receptor location.

2. Identify the constituents of concern (COCs) and select a surrogate chemical to represent the chemical group with conservatism.

3. Perform leachate modeling using the Seasonal Soil (SESOIL) Compartment Model (if there is a source of COCs in soils), and calculate the soil to leachate dilution attenuation factor (DAF) [i.e., $DAF_{S-L} = C_S/C_L$, where C_S is the maximum soil concentration at the source and C_L is the predicted maximum leachate concentration].

4. Perform steady-state saturated flow and contaminant transport modeling using the Analytical Transient 1-,2-,3-Dimensional (AT123D) Model to predict the maximum concentration at the receptor location of the surrogate chemical representing the COCs, using either the existing groundwater plume (if $C_{GWS,O} > C_{GWS,P}$) or the predicted concentration at the source (if $C_{GWS,O} < C_{GWS,P}$), and calculate the lateral flow and transport DAF [e.g., $DAF_{GWS-GWR} = C_{GWS}/C_{GWR}$, where C_{GWS} is the observed ($C_{GWS,O}$) or predicted ($C_{GWS,P}$) concentration of groundwater at the source and C_{GWR} is the predicted maximum concentration at the receptor location].

5. Perform saturated flow and contaminant transport modeling using AT123D to predict the maximum concentration over time in conjunction with source remediation in order to identify a reasonable timeframe for the monitored natural attenuation alternative.

C.3. MODELS SELECTED

C.3.1 SESOIL

SESOIL is an acronym for Seasonal Soil Compartment Model and is a one-dimensional, vertical transport code for the unsaturated soil zone designed to simultaneously model water transport and pollutant fate. The program was originally developed by the U.S. Environmental Protection Agency (EPA 1984) and has been extensively modified to enhance its capabilities (Hetrick et al. 1989, Hetrick et al. 1986, and Hetrick and Travis 1988).

The SESOIL Model defines the "soil compartment" as a soil column extending from the ground surface through the unsaturated zone to the water table. Processes will be simulated in SESOIL in both the hydrologic cycle and the pollutant cycle, each of which is a separate sub-module in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure).

SESOIL is well recognized and accepted by the scientific community utilizing soil-chemical fate models. Some of the attributes of SESOIL that make it particularly attractive and suitable for the vadose zone soil leaching at this site are as follows:

- SESOIL has been extensively validated and shown to work under a number of scenarios. It has also been used for similar applications in other parts of the country and is capable of providing the information required from this study (Bonazountas, Wagner, and Goodwin 1982; Hetrick 1984; Watson and Brown 1985; Hetrick et al. 1986; Melancol, Pollard, and Hern 1986; Hetrick and Travis 1988; Hetrick et al. 1989; Hetrick, Luxmoore, and Tharp 1993).

- SESOIL has the advantage of fewer input requirements and faster run times than more complex unsaturated zone models, while still maintaining considerable resolution of the pollutant front in both time and space.

The model can be divided into as few as two layers and as many as four layers, with as many as 10 sub-layers in each of the layers. This compartmental nature of the model allows for user-specified tailoring to suit a particular site.

C.3.2 AT123D

The AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model. This model was developed by Yeh (1981) and has since been updated by General Sciences Corporation (1996). The model computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in 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).

C.4. PARAMETERS

The hydrologic parameters used in the modeling are based on findings from previous investigations. The parameters are selected such that they are representative values and account for the variability in the hydraulic system and the most likely conditions within that variability. Time-varying model runs are performed using the representative values. The chemical-specific model parameters include solubility in water, organic carbon partition coefficient, Henry's Law constant, soil-water distribution coefficient, diffusion coefficients in air and water, and first-order decay constant. These are literature-based parameters, and a conservative approach was utilized for selecting the values of these parameters. The chemical parameters used in the modeling were presented in Table 6-2 of the SWMU 13 revised final Phase II RFI Report (SAIC 2000). The input parameters for a sample AT123D file are presented in the attachment to this appendix.

C.5. MODEL APPLICATION AND RESULTS

SESOIL was used to simulate the vertical transport of leachate from the source areas down through the vadose zone to the shallow groundwater (water table). Benzene, among the volatile organic COCs (e.g., benzene and ethylbenzene), and naphthalene, among the semivolatile organic COCs (2-methylnaphthalene and naphthalene), were selected as the surrogate chemicals for natural attenuation modeling using SESOIL and AT123D. Because benzene has a slower degradation rate and higher mobility than ethylbenzene, natural attenuation modeling results for benzene can be used for ethylbenzene with conservatism. Similarly, natural attenuation modeling results for naphthalene can be applied to the remaining semivolatile organic COCs with conservatism. SESOIL modeling results (Figures C-1 and C-2) based on soil data from the supplemental investigation indicated that the predicted maximum leachate concentrations of both benzene and naphthalene are below their respective, observed maximum groundwater concentrations. Therefore, saturated flow and contaminant transport modeling, using the AT123D Model to predict the maximum concentration at the receptor location, was performed based on the existing groundwater plume.

A steady-state AT123D Model was developed by calibrating the model against observed maximum concentrations of benzene in the groundwater beneath the site. Benzene concentrations in groundwater at monitoring wells MW12, MW13, MW16, and MW18, in two different time frames (December 2000 and June 2002), were used to calibrate the model, in order to simulate the natural attenuation process. MW12 had the highest concentration based on the December 2000 sampling event. However, this well was destroyed during the interim removal action before the June 2002 sampling event. Therefore, for June 2002, the maximum concentration of 211 μg/L at this location (MW12) was predicted by the calibrated AT123D model. Modeling results presented in Figure C-3 indicate that the benzene concentration in groundwater is not expected to exceed its remedial level [also the maximum contaminant level (MCL)] of 5 μg/L beyond 100 feet from the source. Benzene from the SWMU 13 site is not expected to be of potential concern at the nearest receptor location [i.e., Peacock Creek (2,500 feet from the source)] as groundwater will be completely free of benzene by the time it reaches the creek. Figure C-4 indicates that the concentration of benzene at the source will be reduced to less than its remedial level by natural attenuation processes within 5 years from the time of the last sampling event (June 2002). However, the time period necessary to attain a benzene concentration of 71.28 μg/L, which is the Georgia In-stream Water Quality Standard through natural attenuation, is predicted to be less than 1.5 years from June 2002. Figure C-4 also presents benzene concentrations over time at distances 10 meters and 15 meters from the source, respectively. Table C-1 presents the predicted concentrations of benzene in the monitoring wells for 2 years in the future, since June 2002, by 6-month intervals.

It should be noted that the SESOIL predicted maximum concentration of benzene based on leaching to groundwater will be reduced to its MCL within 4 years from January 2002 (i.e., 3.5 years from June 2002). Therefore, it may be concluded that the soil concentration of benzene will be reduced to its soil remedial level before the groundwater concentration is reduced to its groundwater remedial level at the site.

Site-specific DAFs between the source and the receptor locations were developed. 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 receptor (exposure point). The DAFs reflect the natural attenuation concepts outlined in the American Society for Testing and Material's risk-based corrective action protocol (ASTM 1995). Based on modeling results, the estimated DAF for benzene at Peacock Creek (2,500 feet from the source) is infinite. There is no downgradient water supply well that is screened in the surficial groundwater (above the Hawthorn Layer) near SWMU 13. However, a deep water supply well is located more than 2,500 feet southeast from SWMU 13. The well is approximately 450 feet deep and draws groundwater from the Principal Artesian (also known as the Floridian) aquifer. The modeling results indicate that the DAF (Table C-2) of benzene within 500 feet of the well (2,000 feet from the source) is infinite. The confining layer for the Principal Artesian aquifer is phosphatic clay of the upper Hawthorn group with a very low permeability (10^{-8} cm/sec). The confining layer ranges from 60 feet to 80 feet in thickness at Fort Stewart. It is improbable that benzene would reach the Principal Artesian aquifer from SWMU 13. The DAFs developed for benzene (Table C-2) can be used for the other COC (ethylbenzene), conservatively, since benzene has a higher mobility and a slower degradation rate than ethylbenzene.

To further investigate time frames for monitored natural attenuation as a corrective action, fate and transport modeling was performed in conjunction with active remediation measures. Multiple AT123D modeling runs were performed by reducing the concentration of benzene at the source. Figure C-5 represents concentration versus time plots at different distances from the source when the source concentration is reduced to 100 μg/L. As shown in Figure C-5, the time frame for monitored natural attenuation decreases from 5 years (Figure C-4) to less than 4 years (Figure C-5) based on source reduction to 100 μg/L. Figure C-6 represents concentration versus time plots at different distances from the source when the source concentration is reduced to 50 μg/L. The time for natural attenuation of benzene to the remedial level reduces to less than 3 years (Figure C-6), if the benzene source in groundwater is reduced to 50 μg/L. In summary, if an active remediation technique is used to reduce the source concentration to 100 μg/L, the monitored natural attenuation time frame is reduced by 1 year (i.e., from 5 years to 4 years), and if an active remediation technique is used to reduce the source concentration to 50 μg/L, the monitored natural time frame is reduced by 2 years (i.e., from 5 years to 3 years).

To evaluate naphthalene, a steady-state AT123D Model was developed by calibrating the model against observed maximum concentrations of naphthalene in the groundwater beneath the site. Because the maximum naphthalene concentration in groundwater (304 μg/L) was observed in the December 2000 sampling event, the data from this sampling event were used to calibrate the naphthalene model, to simulate the natural attenuation process. Modeling results presented in Figure C-7 indicate that the naphthalene concentration in groundwater is not expected to exceed its remedial level (149 μg/L) beyond 55 feet from the source, and the source will be reduced to its remedial level within 3 years from December 2000 (i.e., in less than 1.5 years from now). Because benzene is more mobile than naphthalene, and because the natural attenuation time predicted for naphthalene is significantly less than that of benzene, the DAFs (Table C-2) developed for benzene also can be used for the semivolatile organic COCs (e.g., 2-methylnaphthalene and naphthalene), conservatively.

C.5.1 DISCUSSION

Fate and transport modeling results indicate that monitored natural attenuation without active remediation could be used as an option for the remediation of the COCs in groundwater at SWMU 13. As shown in Figure C-4, the benzene (considered as the surrogate chemical for ethylbenzene) concentration is expected to be reduced to its remedial level within 5 years from June 2002, and also from Figure C-7, naphthalene (considered as the surrogate chemical for 2-methylnaphthalene) concentration in groundwater is expected to be reduced to its remedial level within 3 years from December 2000 or 1.5 years from June 2002.

C.6. LIMITATIONS/ASSUMPTIONS

Based upon the data available, a conservative approach was used that may overestimate the contaminant concentration in the groundwater. Listed below are important assumptions used in this analysis.

- The use of a distribution co-efficient (K_d) to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid- and solution-phase concentrations and that the relationship is linear and reversible.
- The most conservative biodegradation rates for benzene and naphthalene from available literature were used.
- Flow and transport in the vadose zone are one-dimensional (i.e., only in the vertical direction).
- Initial condition is disregarded in the vadose zone modeling.
- Flow and transport are not affected by density variations.
- Liquid-phase dispersion in the vadose zone is neglected.
- The aquifer is homogenous and isotropic.
- Areal distribution of soil contamination in the vadose zone is not considered; instead, the maximum concentration is used throughout the soil column.
- During the contaminant loading period, a steady-state source was assumed for lateral transport.

The inherent uncertainties associated with using these assumptions must be recognized. It is also important to note that the major geochemistry of the plume will change over time and be affected by multiple solutes that are present at the site. Projected organic concentrations in the aquifer are expected to be highly conservative due to the use of a steady-state source and a conservative literature-based decay rate.

C.7. REFERENCES

ASTM (American Society for Testing and Materials) 1995. *Standard Guide for Risk-based Corrective Action Applied at Petroleum Release Sites*, ASTM E-1739-95, Philadelphia, Pennsylvania.

Bonazountas, M., J. Wagner, and B. Goodwin. 1982. *Evaluation of Seasonal Soil/Groundwater Pollutant Pathways*, prepared for the U.S. Environmental Protection Agency, Contract No. 68-01-5949(9), Arthur D. Little, Inc., Cambridge, Massachusetts.

EPA (U.S. Environmental Protection Agency) 1984. *SESOIL: A Seasonal Soil Compartment Model*, developed by Bonazountas, M. and J. Wagner of Arthur D. Little, Inc., Cambridge, MA, prepared for EPA, Office of Toxic Substances.

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Hetrick, D. M., C. C. Travis, S. K. Leonard, and R. S. Kinerson 1989. *Qualitative Validation of Pollutant Transport Components of an Unsaturated Soil Zone Model (SESOIL)*, ORNL/TM-10672, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Hetrick, D. M., R. J. Luxmoore, and M. L. Tharp 1993. "Latin Hypercube Sampling with the SESOIL Model," *Proceedings, Eighth Annual Conference on Contaminated Soils*, University of Massachusetts at Amherst, September.

Melancol, S. M., J. E. Pollard, and S. C. Hern 1986. "Evaluation of SESOIL, PRZM, and PESTAN in a Laboratory Column Leaching Experiment," *Environ. Toxicol. Chem.* **5**(10): 865–878.

SAIC (Science Applications International Corporation) 2000. *Revised Final RCRA Facility Investigation Report for the Fire Training Area at Wright Army Airfield (SWMU 13), Fort Stewart, Georgia*, prepared by SAIC and Earth Tech, May.

Watson, D. B., and S. M. Brown. 1985. *Testing and Evaluation of the SESOIL Model*, Anderson-Nichols and Co., Inc., Palo Alto, California, p. 155.

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

Table C-1. Predicted Concentrations of Benzene at the Former Fire Training Area (SWMU 13)

Monitoring Wells	Observed Concentration June 2002 (μg/L)	Predicted Maximum Concentration of Benzene				MCL/RL (μg/L)
		December 2002 (μg/L)	June 2003 (μg/L)	December 2003 (μg/L)	June 2004 (μg/L)	
MW3	–	0.1	0.07	0.05	0.03	5
MW4	–	0	0	0	0	5
MW8	–	0	0	0	0	5
MW9	–	0	0	0	0	5
MW10	–	0.01	0.01	0.008	0.007	5
MW11	–	0.9	1.1	1.3	1.4	5
MW12	211[a]	72.6	48.4	32.6	22.1	5
MW13	3.6	0.63	0.46	0.33	0.23	5
MW14	–	22.1	14.8	10	6.8	5
MW15	1.9	23.6	16.2	11.2	7.7	5
MW16	120	92.6	62.7	42.6	29.2	5
MW17	–	125	81.7	54.4	26.6	5
MW18	95	60	40.2	27.1	18.4	5
MW19	–	1.1	0.75	0.54	0.36	5

[a] MW12, where the maximum concentration of benzene (440 uμg/L) was observed in the past, was removed as part of the 2001/2002 interim removal action. Based on the calibrated model, the concentration of benzene at this location is predicted to be 211 μg/L for the June 2002 sampling event.

MCL = Maximum contaminant level.
RL = Remedial level.
SWMU = Solid waste management unit.

Table C-2. DAF Versus Distance at the Former Fire Training Area (SWMU 13)

Distance to Receptor (feet)	Predicted Maximum Concentration of Benzene in Groundwater (μg/L)	DAF
0.0	211	1.00
3.3	212	1.00
6.6	211	1.00
9.8	206	1.02
13.1	197	1.07
23.0	165	1.28
32.8	122	1.73
36.1	107	1.97
39.4	93.7	2.25
42.6	80	2.64
45.9	69.1	3.05
49.2	58.4	3.61
55.8	42.4	4.98
65.6	26.2	8.05
72.2	19.4	10.88
82.0	12.2	17.30
88.6	9	23.44
91.9	7.7	27.40
95.1	6	35.17
98.4	5.7	37.02
101.7	4.88	43.24
105.0	4.2	50.24
121.4	2	105.50
137.8	0.94	224.47
170.6	0.218	967.89
334.6	4.90E-05	>1E+06
1647.0	0	>1E+06
2000.0	0	>1E+06
2500.0	0	>1E+06

Note: Predicted concentrations represent the maximum concentrations since June 2002 predicted by the model.

DAF = Dilution attenuation factor.
SWMU = Solid waste management unit.

Figure C-1. SESOIL Predicted Concentration of Benzene in Leachate
Based on Contaminant Migration from SWMU 13
(Time 0 = January 2002)

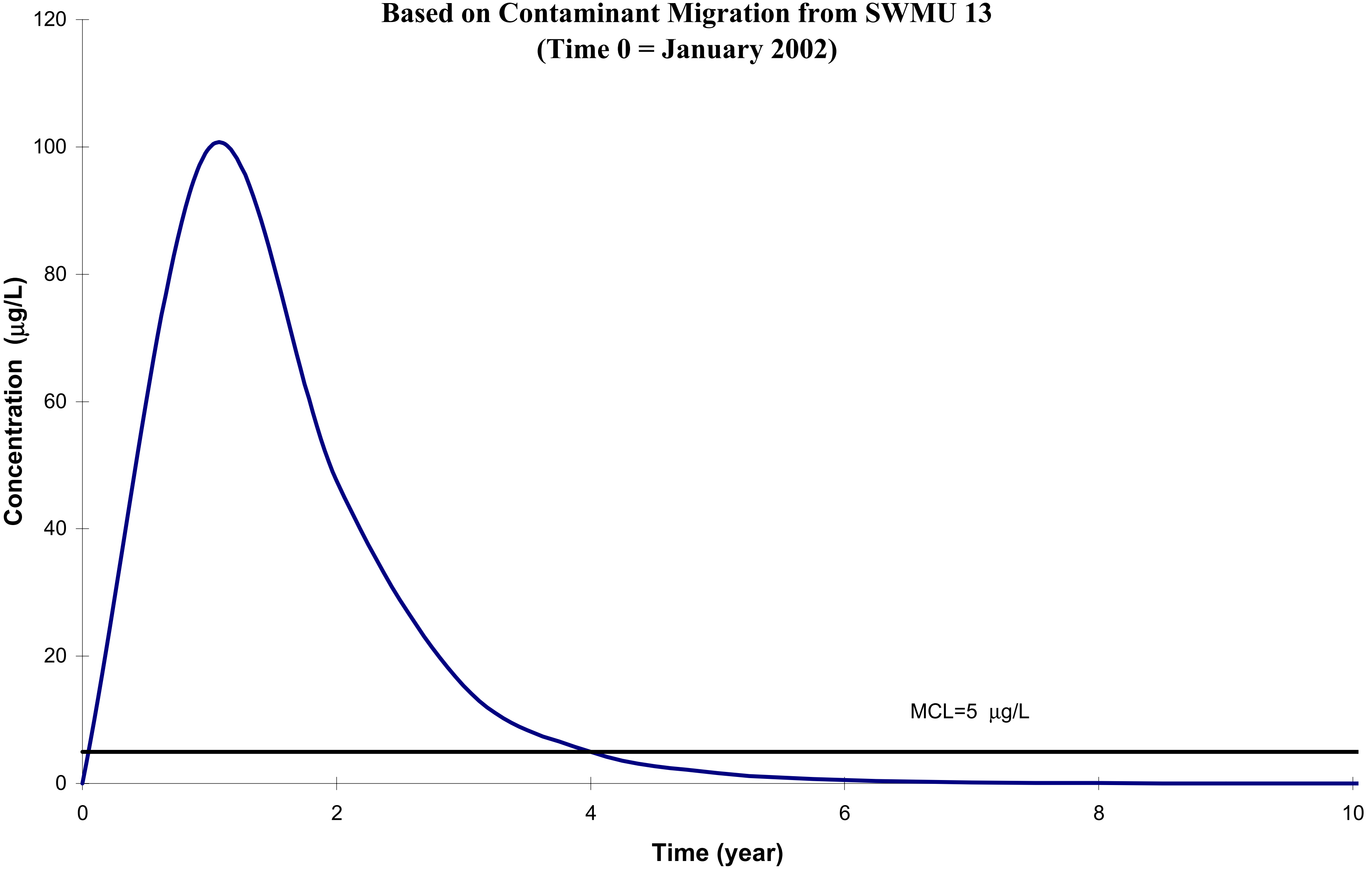


Figure C-2. Predicted Concentration of Naphthalene in Leachate Based on Contaminant Migration from SWMU 13

(Time 0 = January 2002)

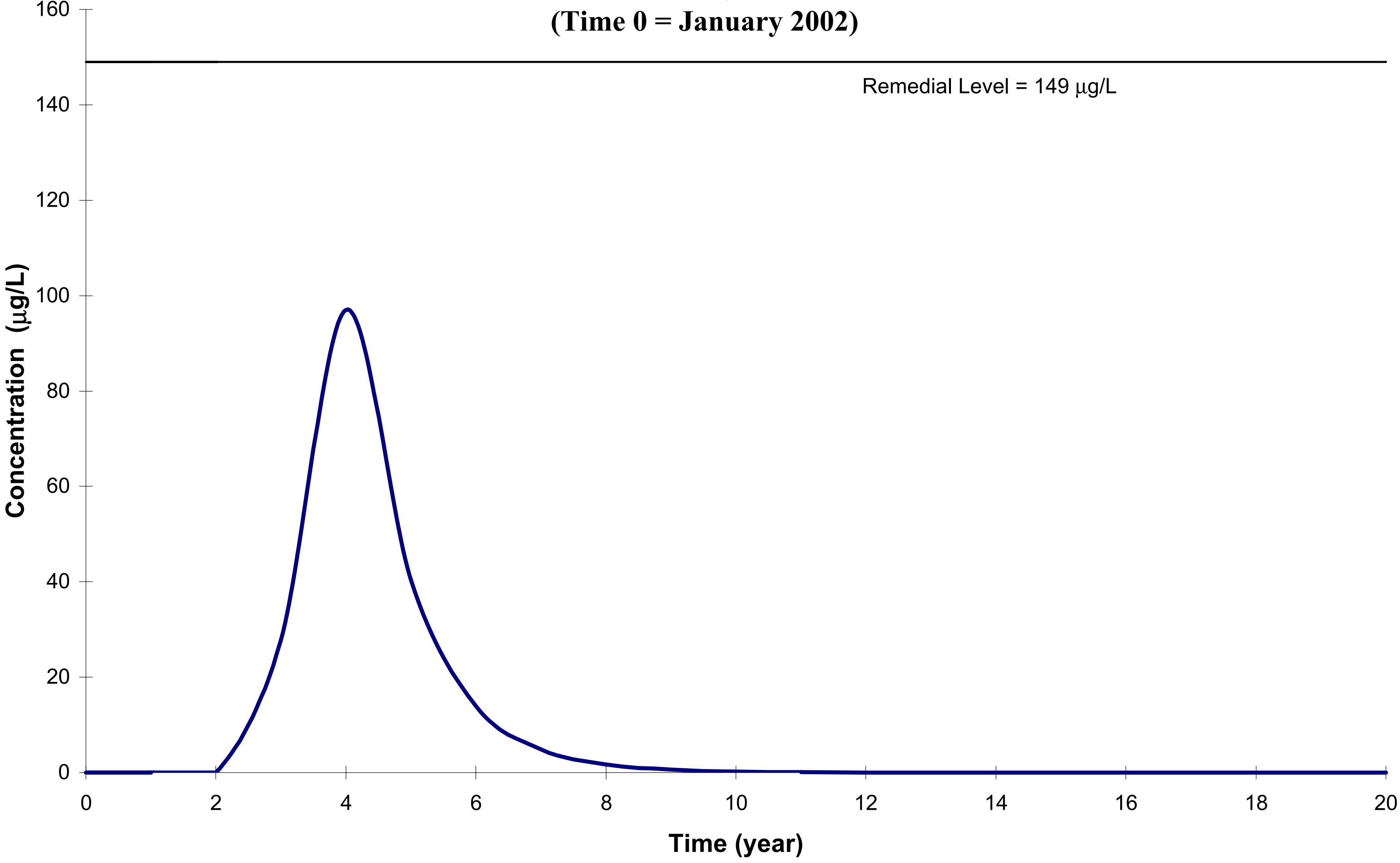


Figure C-3. AT123D Modeled Maximum Concentration of Benzene in the Groundwater Versus Downgradient Distance from the Source, SWMU 13

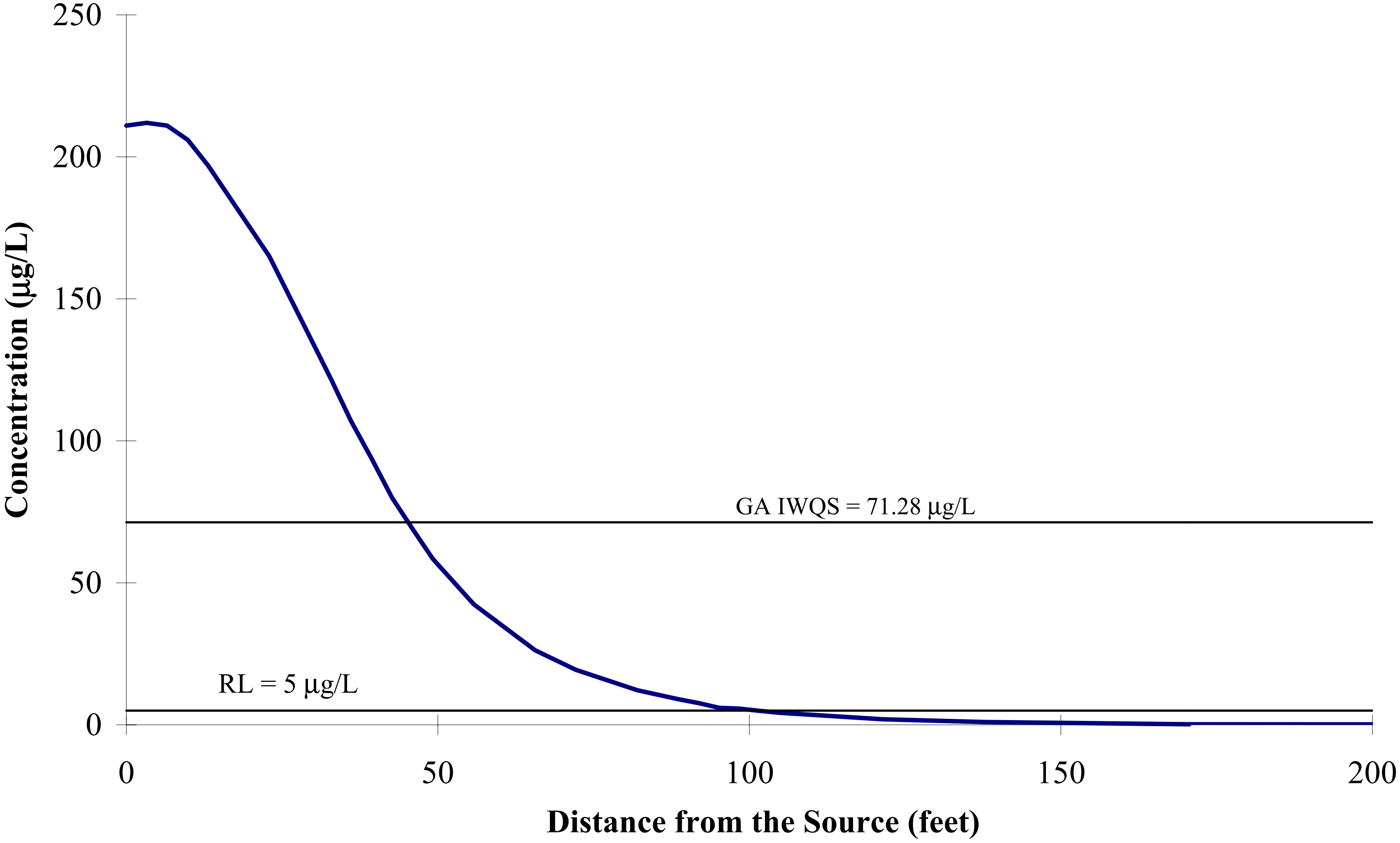


Figure C-4. AT123D Modeled Maximum Concentration of Benzene in the Groundwater Without Any Source Reduction, SWMU 13 (Time 0 = June 2002)

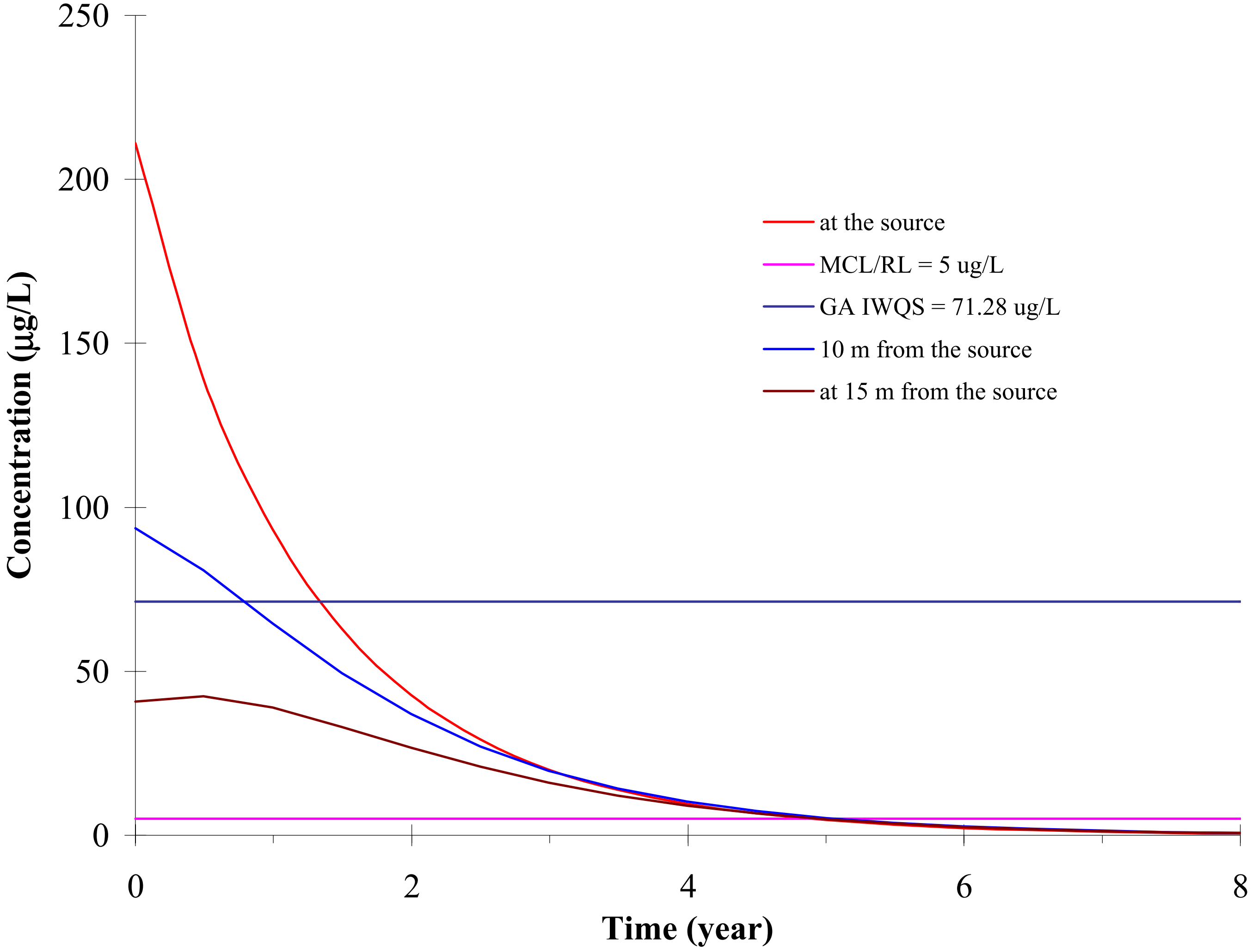


Figure C-5. AT123D Modeled Maximum Concentration of Benzene in the Groundwater for Source Reduced to 100 µg/L, SWMU 13

(Time 0 = June 2002)

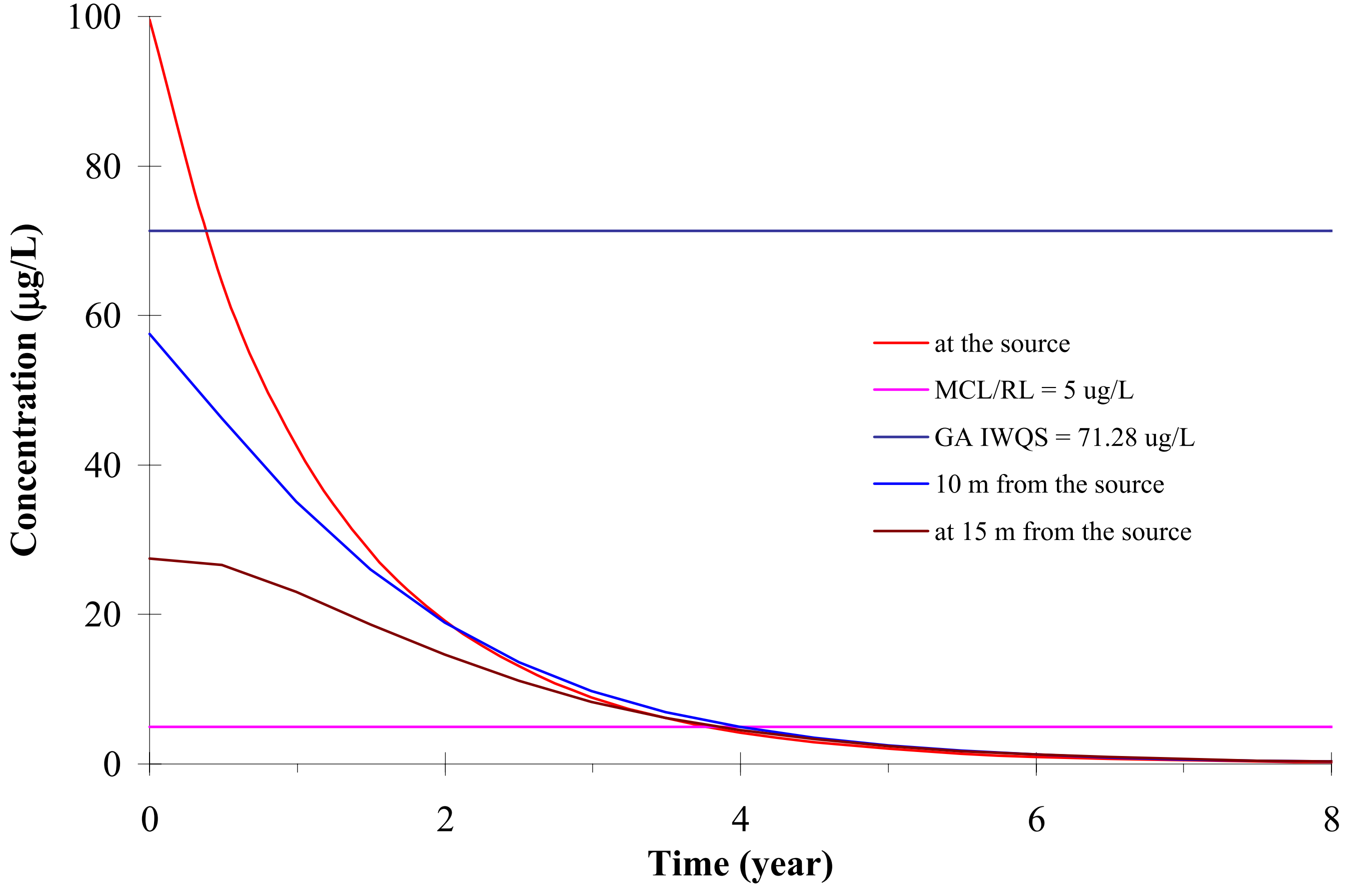


Figure C-6. AT123D Modeled Maximum Concentration of Benzene in the Groundwater for Source Reduced to 50 µg/L at SWMU 13 (Time 0 = June 2002)

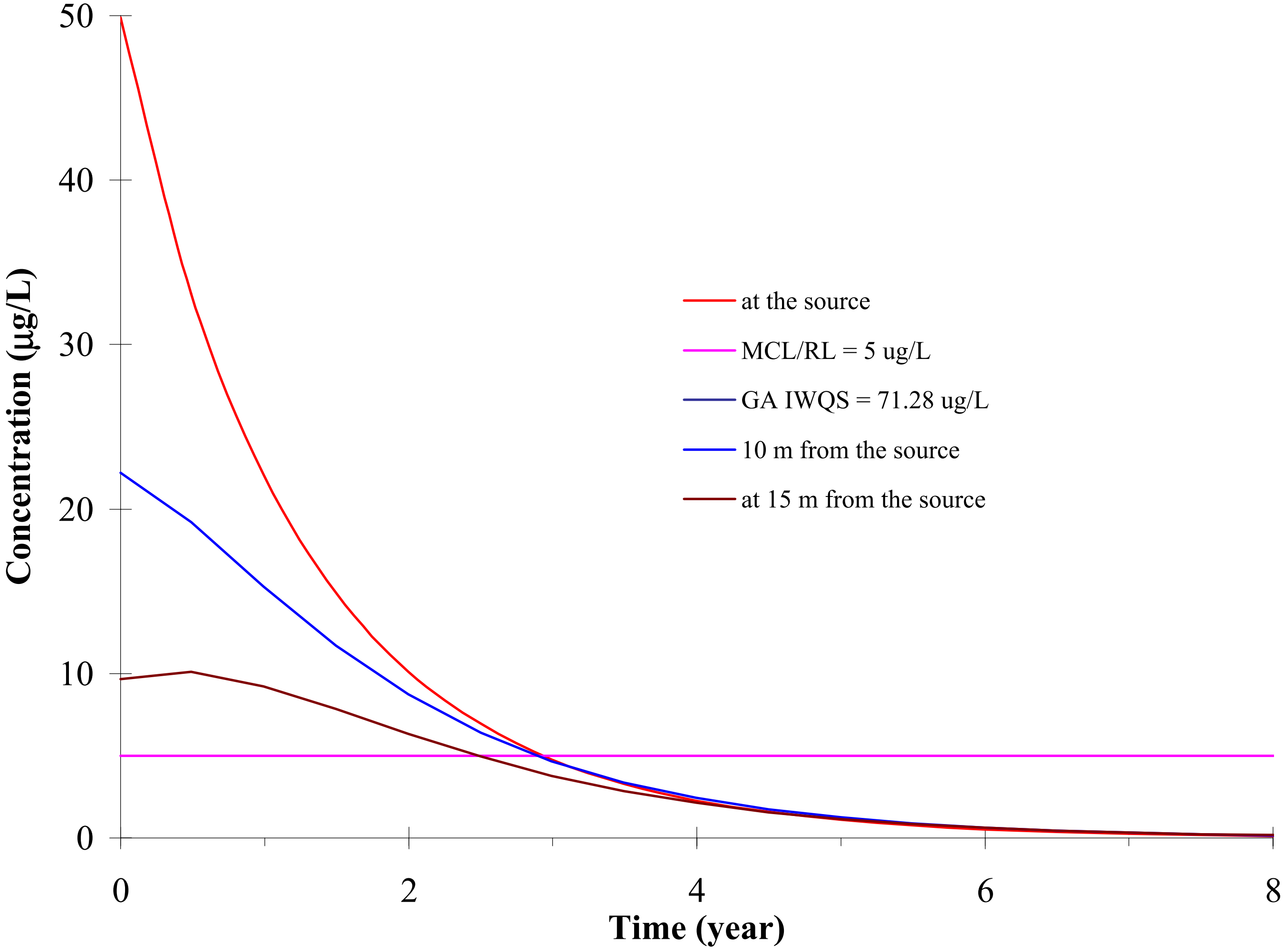
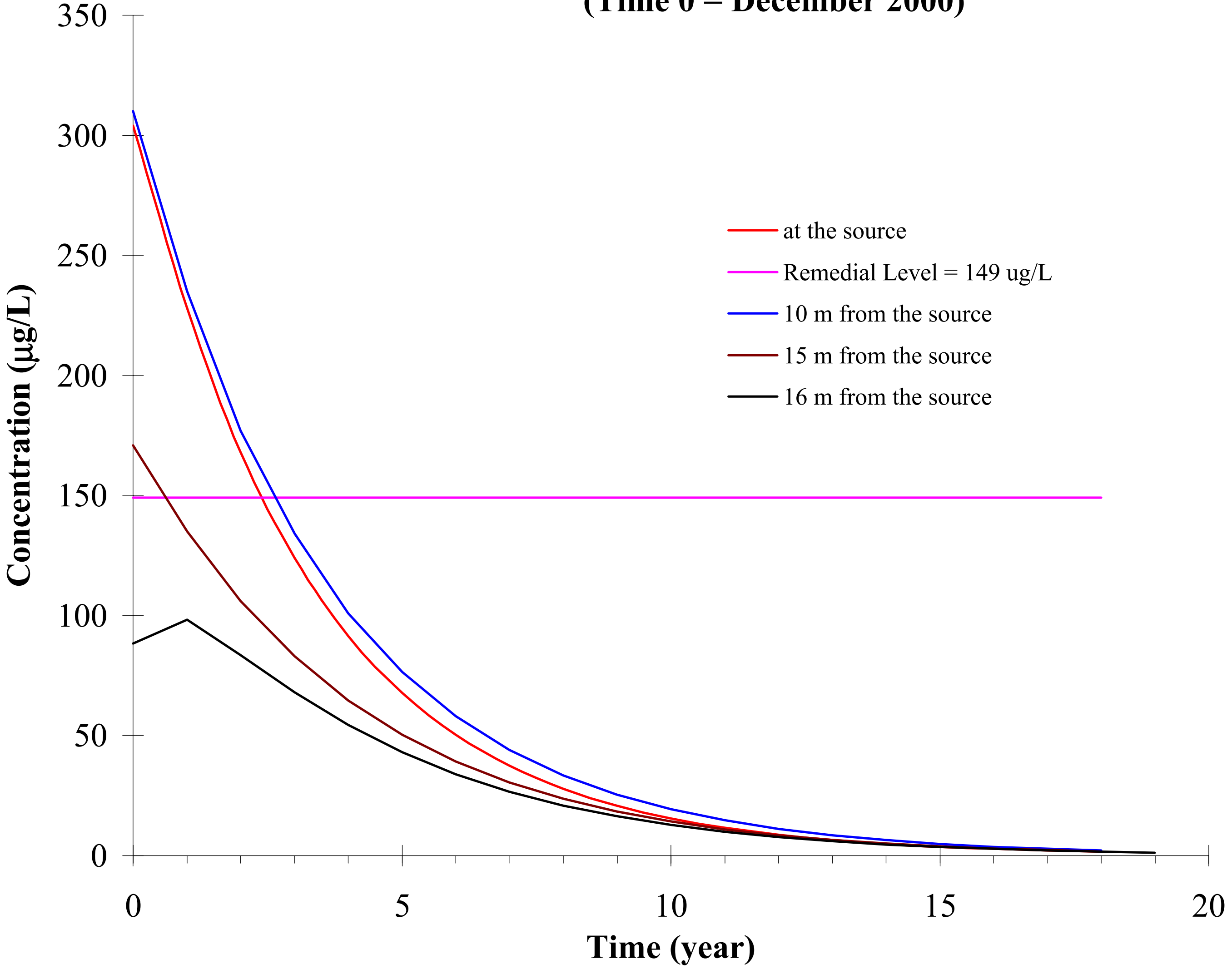


Figure C-7. AT123D Modeled Maximum Concentration of Naphthalene in the Groundwater without any Source Reduction at SWMU 13 (Time 0 = December 2000)



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AT123D OUTPUT FILE FOR SWMU 13

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SWMU-13: Benzene - CAP Modeling (rev)



NO. OF POINTS IN X-DIRECTION ......................   15
NO. OF POINTS IN Y-DIRECTION ......................    6
NO. OF POINTS IN Z-DIRECTION ......................    2
NO. OF ROOTS: NO. OF SERIES TERMS ................  400
NO. OF BEGINNING TIME STEP .......................  163
NO. OF ENDING TIME STEP ..........................  277
NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION ....    6
INSTANTANEOUS SOURCE CONTROL = 0 FOR INSTANT SOURCE    1
SOURCE CONDITION CONTROL = 0 FOR STEADY SOURCE ....    0
INTERMITTENT OUTPUT CONTROL = 0 NO SUCH OUTPUT ....    1
CASE CONTROL =1 THERMAL, = 2 FOR CHEMICAL, = 3 RAD     2


AQUIFER DEPTH, = 0.0 FOR INFINITE DEEP (METERS) ...  0.1680E+02
AQUIFER WIDTH, = 0.0 FOR INFINITE WIDE (METERS) ...  0.0000E+00
BEGIN POINT OF X-SOURCE LOCATION (METERS) ......... -0.7000E+01
END POINT OF X-SOURCE LOCATION (METERS) ........... -0.2000E+01
BEGIN POINT OF Y-SOURCE LOCATION (METERS) ......... -0.2000E+01
END POINT OF Y-SOURCE LOCATION (METERS) ...........  0.2000E+01
BEGIN POINT OF Z-SOURCE LOCATION (METERS) .........  0.0000E+00
END POINT OF Z-SOURCE LOCATION (METERS) ...........  0.0000E+00


POROSITY ..........................................  0.2000E+00
HYDRAULIC CONDUCTIVITY (METER/HOUR) ...............  0.3800E-01
HYDRAULIC GRADIENT ................................  0.4000E-02
LONGITUDINAL DISPERSIVITY (METER) .................  0.1000E+02
LATERAL DISPERSIVITY (METER) ......................  0.3000E+01
VERTICAL DISPERSIVITY (METER) .....................  0.1000E+01
DISTRIBUTION COEFFICIENT, KD (M**3/KG) ............  0.3155E-03
HEAT EXCHANGE COEFFICIENT (KCAL/HR-M**2-DEGREE C)..  0.0000E+00


MOLECULAR DIFFUSION MULTIPLY BY POROSITY (M**2/HR)   0.3530E-05
DECAY CONSTANT (PER HOUR) .........................  0.7000E-04
BULK DENSITY OF THE SOIL (KG/M**3) ................  0.1660E+04
ACCURACY TOLERANCE FOR REACHING STEADY STATE ......  0.1000E-02
DENSITY OF WATER (KG/M**3) ........................  0.1000E+04
TIME INTERVAL SIZE FOR THE DESIRED SOLUTION (HR) ..  0.7300E+03
DISCHARGE TIME (HR) ...............................  0.1051E+06
WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) .  0.8000E-05


RETARDATION FACTOR ................................  0.3619E+01
RETARDED DARCY VELOCITY (M/HR) ....................  0.2100E-03
RETARDED LONGITUDINAL DISPERSION COEF. (M**2/HR) ..  0.2105E-02
RETARDED LATERAL DISPERSION COEFFICIENT (M**2/HR) .  0.6349E-03
RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR).  0.2149E-03
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     DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.0000E+00 HRS
       (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
   2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
   0.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -5.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
 -11.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
   2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
   0.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -5.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
 -11.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
   2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
   0.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -5.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
 -11.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
0.000E+00   0.000E+00   0.000E+00   0.000E+00
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
   2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
   0.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
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  -2.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  -5.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
 -11.   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1183E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.          -1.          0.
1.          2.          5.          9.

  13.   0.581E-03   0.767E-03   0.828E-03   0.856E-03   0.883E-03   0.905E-03
0.923E-03   0.935E-03   0.942E-03   0.876E-03
   2.   0.907E-01   0.129E+00   0.137E+00   0.140E+00   0.141E+00   0.140E+00
0.138E+00   0.133E+00   0.116E+00   0.752E-01
   0.   0.136E+00   0.195E+00   0.207E+00   0.211E+00   0.212E+00   0.211E+00
0.206E+00   0.199E+00   0.170E+00   0.107E+00
  -2.   0.907E-01   0.129E+00   0.137E+00   0.140E+00   0.141E+00   0.140E+00
0.138E+00   0.133E+00   0.116E+00   0.752E-01
  -5.   0.227E-01   0.313E-01   0.336E-01   0.344E-01   0.349E-01   0.352E-01
0.350E-01   0.345E-01   0.317E-01   0.237E-01
 -11.   0.122E-02   0.161E-02   0.174E-02   0.180E-02   0.185E-02   0.189E-02
0.192E-02   0.194E-02   0.193E-02   0.174E-02
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.          55.

  13.   0.849E-03   0.675E-03   0.106E-03   0.650E-04   0.755E-05
   2.   0.662E-01   0.305E-01   0.694E-03   0.345E-03   0.239E-04
   0.   0.937E-01   0.407E-01   0.738E-03   0.363E-03   0.247E-04
  -2.   0.662E-01   0.305E-01   0.694E-03   0.345E-03   0.239E-04
  -5.   0.217E-01   0.124E-01   0.541E-03   0.281E-03   0.211E-04
 -11.   0.167E-02   0.127E-02   0.162E-03   0.961E-04   0.101E-04


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.          -1.          0.
1.          2.          5.          9.

  13.   0.481E-03   0.634E-03   0.684E-03   0.707E-03   0.730E-03   0.749E-03
0.764E-03   0.775E-03   0.783E-03   0.733E-03
   2.   0.254E-01   0.350E-01   0.376E-01   0.385E-01   0.391E-01   0.394E-01
0.392E-01   0.386E-01   0.355E-01   0.265E-01
   0.   0.311E-01   0.430E-01   0.461E-01   0.472E-01   0.479E-01   0.481E-01
0.479E-01   0.471E-01   0.430E-01   0.316E-01
  -2.   0.254E-01   0.350E-01   0.376E-01   0.385E-01   0.391E-01   0.394E-01
0.392E-01   0.386E-01   0.355E-01   0.265E-01
  -5.   0.121E-01   0.165E-01   0.178E-01   0.182E-01   0.186E-01   0.188E-01
0.189E-01   0.187E-01   0.176E-01   0.139E-01
 -11.   0.971E-03   0.129E-02   0.139E-02   0.143E-02   0.148E-02   0.151E-02
0.154E-02   0.155E-02   0.155E-02   0.141E-02
```

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                                                CONTINUE
                                                         X
   Y         10.        15.        35.        39.        55.

  13.   0.712E-03   0.572E-03   0.945E-04   0.585E-04   0.698E-05
   2.   0.243E-01   0.138E-01   0.578E-03   0.297E-03   0.219E-04
   0.   0.288E-01   0.160E-01   0.611E-03   0.312E-03   0.225E-04
  -2.   0.243E-01   0.138E-01   0.578E-03   0.297E-03   0.219E-04
  -5.   0.129E-01   0.803E-02   0.459E-03   0.244E-03   0.193E-04
 -11.   0.136E-02   0.105E-02   0.143E-03   0.859E-04   0.930E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1226E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                         X
   Y         -9.        -5.        -3.        -2.        -1.         0.
1.         2.         5.         9.

  13.   0.399E-03   0.524E-03   0.565E-03   0.585E-03   0.605E-03   0.622E-03
0.636E-03   0.647E-03   0.661E-03   0.633E-03
   2.   0.600E-01   0.829E-01   0.888E-01   0.910E-01   0.925E-01   0.931E-01
0.926E-01   0.912E-01   0.836E-01   0.617E-01
   0.   0.900E-01   0.125E+00   0.134E+00   0.137E+00   0.139E+00   0.139E+00
0.139E+00   0.136E+00   0.124E+00   0.894E-01
  -2.   0.600E-01   0.829E-01   0.888E-01   0.910E-01   0.925E-01   0.931E-01
0.926E-01   0.912E-01   0.836E-01   0.617E-01
  -5.   0.152E-01   0.206E-01   0.221E-01   0.227E-01   0.233E-01   0.236E-01
0.237E-01   0.236E-01   0.225E-01   0.183E-01
 -11.   0.832E-03   0.110E-02   0.118E-02   0.122E-02   0.126E-02   0.130E-02
0.132E-02   0.134E-02   0.136E-02   0.127E-02
                                                CONTINUE
                                                         X
   Y         10.        15.        35.        39.        55.

  13.   0.618E-03   0.514E-03   0.961E-04   0.605E-04   0.753E-05
   2.   0.561E-01   0.306E-01   0.829E-03   0.401E-03   0.264E-04
   0.   0.808E-01   0.424E-01   0.911E-03   0.429E-03   0.273E-04
  -2.   0.561E-01   0.306E-01   0.829E-03   0.401E-03   0.264E-04
  -5.   0.171E-01   0.109E-01   0.595E-03   0.309E-03   0.229E-04
 -11.   0.123E-02   0.983E-03   0.152E-03   0.922E-04   0.103E-04


                    Z =       2.00
                                                         X
   Y         -9.        -5.        -3.        -2.        -1.         0.
1.         2.         5.         9.

  13.   0.331E-03   0.433E-03   0.468E-03   0.484E-03   0.501E-03   0.515E-03
0.527E-03   0.537E-03   0.549E-03   0.529E-03
   2.   0.170E-01   0.231E-01   0.248E-01   0.255E-01   0.261E-01   0.264E-01
0.266E-01   0.265E-01   0.252E-01   0.205E-01
```

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   0.   0.208E-01   0.282E-01   0.303E-01   0.312E-01   0.318E-01   0.323E-01
0.324E-01   0.322E-01   0.306E-01   0.245E-01
  -2.   0.170E-01   0.231E-01   0.248E-01   0.255E-01   0.261E-01   0.264E-01
0.266E-01   0.265E-01   0.252E-01   0.205E-01
  -5.   0.817E-02   0.110E-01   0.118E-01   0.122E-01   0.125E-01   0.127E-01
0.128E-01   0.128E-01   0.124E-01   0.105E-01
 -11.   0.665E-03   0.875E-03   0.945E-03   0.977E-03   0.101E-02   0.104E-02
0.106E-02   0.107E-02   0.109E-02   0.103E-02
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.518E-03   0.434E-03   0.852E-04   0.541E-04   0.693E-05
   2.   0.191E-01   0.122E-01   0.641E-03   0.329E-03   0.238E-04
   0.   0.228E-01   0.143E-01   0.688E-03   0.349E-03   0.246E-04
  -2.   0.191E-01   0.122E-01   0.641E-03   0.329E-03   0.238E-04
  -5.   0.993E-02   0.677E-02   0.486E-03   0.261E-03   0.207E-04
 -11.   0.999E-03   0.809E-03   0.133E-03   0.817E-04   0.941E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1270E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.275E-03   0.359E-03   0.388E-03   0.402E-03   0.417E-03   0.429E-03
0.440E-03   0.449E-03   0.463E-03   0.455E-03
   2.   0.402E-01   0.545E-01   0.585E-01   0.602E-01   0.615E-01   0.624E-01
0.627E-01   0.624E-01   0.593E-01   0.476E-01
   0.   0.601E-01   0.817E-01   0.878E-01   0.902E-01   0.922E-01   0.933E-01
0.936E-01   0.931E-01   0.879E-01   0.696E-01
  -2.   0.402E-01   0.545E-01   0.585E-01   0.602E-01   0.615E-01   0.624E-01
0.627E-01   0.624E-01   0.593E-01   0.476E-01
  -5.   0.103E-01   0.137E-01   0.148E-01   0.152E-01   0.157E-01   0.160E-01
0.161E-01   0.162E-01   0.158E-01   0.136E-01
 -11.   0.572E-03   0.749E-03   0.809E-03   0.838E-03   0.866E-03   0.891E-03
0.912E-03   0.929E-03   0.950E-03   0.914E-03
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.447E-03   0.386E-03   0.853E-04   0.552E-04   0.742E-05
   2.   0.443E-01   0.275E-01   0.101E-02   0.480E-03   0.293E-04
   0.   0.645E-01   0.389E-01   0.117E-02   0.533E-03   0.304E-04
  -2.   0.443E-01   0.275E-01   0.101E-02   0.480E-03   0.293E-04
  -5.   0.129E-01   0.903E-02   0.644E-03   0.338E-03   0.249E-04
 -11.   0.894E-03   0.747E-03   0.139E-03   0.865E-04   0.103E-04


                    Z =       2.00
                                                            X
```

```
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.228E-03   0.297E-03   0.322E-03   0.333E-03   0.345E-03   0.356E-03
0.365E-03   0.373E-03   0.385E-03   0.380E-03
   2.   0.115E-01   0.154E-01   0.166E-01   0.171E-01   0.175E-01   0.179E-01
0.181E-01   0.182E-01   0.177E-01   0.153E-01
   0.   0.140E-01   0.188E-01   0.202E-01   0.208E-01   0.214E-01   0.218E-01
0.220E-01   0.221E-01   0.215E-01   0.184E-01
  -2.   0.115E-01   0.154E-01   0.166E-01   0.171E-01   0.175E-01   0.179E-01
0.181E-01   0.182E-01   0.177E-01   0.153E-01
  -5.   0.554E-02   0.738E-02   0.795E-02   0.821E-02   0.844E-02   0.863E-02
0.876E-02   0.883E-02   0.874E-02   0.776E-02
 -11.   0.458E-03   0.599E-03   0.647E-03   0.670E-03   0.693E-03   0.714E-03
0.731E-03   0.745E-03   0.764E-03   0.740E-03
                                                CONTINUE
                                                       X
   Y          10.         15.         35.         39.         55.

  13.   0.374E-03   0.325E-03   0.751E-04   0.490E-04   0.679E-05
   2.   0.145E-01   0.101E-01   0.701E-03   0.364E-03   0.260E-04
   0.   0.174E-01   0.120E-01   0.764E-03   0.391E-03   0.270E-04
  -2.   0.145E-01   0.101E-01   0.701E-03   0.364E-03   0.260E-04
  -5.   0.743E-02   0.545E-02   0.503E-03   0.275E-03   0.222E-04
 -11.   0.725E-03   0.612E-03   0.120E-03   0.759E-04   0.940E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1314E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                       X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.190E-03   0.248E-03   0.268E-03   0.278E-03   0.288E-03   0.297E-03
0.305E-03   0.313E-03   0.325E-03   0.325E-03
   2.   0.271E-01   0.363E-01   0.391E-01   0.403E-01   0.414E-01   0.422E-01
0.426E-01   0.428E-01   0.417E-01   0.357E-01
   0.   0.405E-01   0.544E-01   0.585E-01   0.603E-01   0.619E-01   0.630E-01
0.636E-01   0.638E-01   0.619E-01   0.523E-01
  -2.   0.271E-01   0.363E-01   0.391E-01   0.403E-01   0.414E-01   0.422E-01
0.426E-01   0.428E-01   0.417E-01   0.357E-01
  -5.   0.698E-02   0.926E-02   0.999E-02   0.103E-01   0.106E-01   0.109E-01
0.111E-01   0.112E-01   0.111E-01   0.100E-01
 -11.   0.395E-03   0.514E-03   0.556E-03   0.576E-03   0.597E-03   0.615E-03
0.631E-03   0.645E-03   0.666E-03   0.656E-03
                                                CONTINUE
                                                       X
   Y          10.         15.         35.         39.         55.

  13.   0.322E-03   0.286E-03   0.740E-04   0.493E-04   0.720E-05
   2.   0.337E-01   0.230E-01   0.121E-02   0.580E-03   0.329E-04
   0.   0.494E-01   0.330E-01   0.148E-02   0.675E-03   0.346E-04
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  -2.   0.337E-01   0.230E-01   0.121E-02   0.580E-03   0.329E-04
  -5.   0.962E-02   0.719E-02   0.675E-03   0.363E-03   0.271E-04
 -11.   0.646E-03   0.559E-03   0.124E-03   0.794E-04   0.103E-04


                    Z =       2.00
                                                          X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.158E-03   0.205E-03   0.222E-03   0.230E-03   0.239E-03   0.247E-03
0.253E-03   0.259E-03   0.270E-03   0.272E-03
   2.   0.782E-02   0.104E-01   0.112E-01   0.115E-01   0.119E-01   0.122E-01
0.124E-01   0.125E-01   0.125E-01   0.112E-01
   0.   0.953E-02   0.127E-01   0.136E-01   0.141E-01   0.145E-01   0.148E-01
0.151E-01   0.152E-01   0.151E-01   0.135E-01
  -2.   0.782E-02   0.104E-01   0.112E-01   0.115E-01   0.119E-01   0.122E-01
0.124E-01   0.125E-01   0.125E-01   0.112E-01
  -5.   0.379E-02   0.500E-02   0.539E-02   0.558E-02   0.575E-02   0.590E-02
0.601E-02   0.609E-02   0.613E-02   0.566E-02
 -11.   0.316E-03   0.412E-03   0.445E-03   0.461E-03   0.478E-03   0.493E-03
0.506E-03   0.517E-03   0.536E-03   0.530E-03
                                                  CONTINUE
                                                          X
   Y          10.         15.         35.         39.         55.

  13.   0.269E-03   0.241E-03   0.647E-04   0.435E-04   0.655E-05
   2.   0.108E-01   0.805E-02   0.740E-03   0.395E-03   0.286E-04
   0.   0.130E-01   0.958E-02   0.821E-03   0.431E-03   0.299E-04
  -2.   0.108E-01   0.805E-02   0.740E-03   0.395E-03   0.286E-04
  -5.   0.547E-02   0.426E-02   0.503E-03   0.283E-03   0.238E-04
 -11.   0.523E-03   0.457E-03   0.106E-03   0.690E-04   0.928E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1358E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                          X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.132E-03   0.171E-03   0.185E-03   0.192E-03   0.200E-03   0.206E-03
0.212E-03   0.218E-03   0.228E-03   0.232E-03
   2.   0.184E-01   0.245E-01   0.264E-01   0.272E-01   0.281E-01   0.287E-01
0.292E-01   0.294E-01   0.293E-01   0.262E-01
   0.   0.275E-01   0.366E-01   0.394E-01   0.407E-01   0.419E-01   0.428E-01
0.435E-01   0.438E-01   0.434E-01   0.386E-01
  -2.   0.184E-01   0.245E-01   0.264E-01   0.272E-01   0.281E-01   0.287E-01
0.292E-01   0.294E-01   0.293E-01   0.262E-01
  -5.   0.478E-02   0.629E-02   0.679E-02   0.702E-02   0.725E-02   0.744E-02
0.760E-02   0.771E-02   0.779E-02   0.727E-02
 -11.   0.273E-03   0.355E-03   0.384E-03   0.398E-03   0.413E-03   0.426E-03
0.438E-03   0.449E-03   0.467E-03   0.469E-03
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                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.231E-03   0.211E-03   0.629E-04   0.431E-04   0.689E-05
   2.   0.251E-01   0.185E-01   0.138E-02   0.683E-03   0.378E-04
   0.   0.369E-01   0.267E-01   0.175E-02   0.834E-03   0.405E-04
  -2.   0.251E-01   0.185E-01   0.138E-02   0.683E-03   0.378E-04
  -5.   0.705E-02   0.558E-02   0.680E-03   0.378E-03   0.296E-04
 -11.   0.464E-03   0.415E-03   0.107E-03   0.711E-04   0.101E-04


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.110E-03   0.142E-03   0.154E-03   0.160E-03   0.166E-03   0.171E-03
0.176E-03   0.181E-03   0.190E-03   0.194E-03
   2.   0.535E-02   0.705E-02   0.761E-02   0.787E-02   0.812E-02   0.834E-02
0.851E-02   0.863E-02   0.872E-02   0.814E-02
   0.   0.652E-02   0.859E-02   0.927E-02   0.959E-02   0.989E-02   0.102E-01
0.104E-01   0.105E-01   0.106E-01   0.983E-02
  -2.   0.535E-02   0.705E-02   0.761E-02   0.787E-02   0.812E-02   0.834E-02
0.851E-02   0.863E-02   0.872E-02   0.814E-02
  -5.   0.260E-02   0.341E-02   0.368E-02   0.381E-02   0.394E-02   0.405E-02
0.414E-02   0.421E-02   0.429E-02   0.408E-02
 -11.   0.219E-03   0.284E-03   0.308E-03   0.319E-03   0.331E-03   0.342E-03
0.352E-03   0.360E-03   0.376E-03   0.379E-03
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.193E-03   0.177E-03   0.547E-04   0.378E-04   0.623E-05
   2.   0.789E-02   0.624E-02   0.749E-03   0.414E-03   0.314E-04
   0.   0.952E-02   0.746E-02   0.843E-03   0.459E-03   0.331E-04
  -2.   0.789E-02   0.624E-02   0.749E-03   0.414E-03   0.314E-04
  -5.   0.398E-02   0.325E-02   0.486E-03   0.283E-03   0.254E-04
 -11.   0.376E-03   0.338E-03   0.917E-04   0.614E-04   0.902E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1402E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.920E-04   0.119E-03   0.129E-03   0.134E-03   0.139E-03   0.144E-03
0.148E-03   0.152E-03   0.160E-03   0.166E-03
   2.   0.126E-01   0.166E-01   0.179E-01   0.185E-01   0.191E-01   0.196E-01
0.200E-01   0.203E-01   0.205E-01   0.190E-01
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   0.   0.188E-01   0.248E-01   0.268E-01   0.277E-01   0.285E-01   0.293E-01
0.298E-01   0.302E-01   0.304E-01   0.280E-01
  -2.   0.126E-01   0.166E-01   0.179E-01   0.185E-01   0.191E-01   0.196E-01
0.200E-01   0.203E-01   0.205E-01   0.190E-01
  -5.   0.328E-02   0.430E-02   0.465E-02   0.481E-02   0.498E-02   0.512E-02
0.524E-02   0.534E-02   0.546E-02   0.524E-02
 -11.   0.190E-03   0.246E-03   0.266E-03   0.276E-03   0.286E-03   0.296E-03
0.305E-03   0.313E-03   0.328E-03   0.335E-03
                                                  CONTINUE
                                                            X
   Y         10.         15.         35.         39.         55.

  13.   0.165E-03   0.155E-03   0.525E-04   0.369E-04   0.648E-05
   2.   0.184E-01   0.144E-01   0.147E-02   0.767E-03   0.441E-04
   0.   0.271E-01   0.209E-01   0.193E-02   0.973E-03   0.486E-04
  -2.   0.184E-01   0.144E-01   0.147E-02   0.767E-03   0.441E-04
  -5.   0.512E-02   0.424E-02   0.656E-03   0.380E-03   0.322E-04
 -11.   0.333E-03   0.305E-03   0.914E-04   0.623E-04   0.969E-05


                    Z =       2.00
                                                            X
   Y         -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.764E-04   0.986E-04   0.107E-03   0.111E-03   0.115E-03   0.119E-03
0.123E-03   0.126E-03   0.133E-03   0.138E-03
   2.   0.368E-02   0.482E-02   0.520E-02   0.539E-02   0.557E-02   0.573E-02
0.587E-02   0.597E-02   0.611E-02   0.587E-02
   0.   0.448E-02   0.587E-02   0.634E-02   0.656E-02   0.678E-02   0.698E-02
0.714E-02   0.726E-02   0.742E-02   0.709E-02
  -2.   0.368E-02   0.482E-02   0.520E-02   0.539E-02   0.557E-02   0.573E-02
0.587E-02   0.597E-02   0.611E-02   0.587E-02
  -5.   0.179E-02   0.234E-02   0.253E-02   0.262E-02   0.271E-02   0.279E-02
0.286E-02   0.292E-02   0.301E-02   0.293E-02
 -11.   0.152E-03   0.197E-03   0.213E-03   0.221E-03   0.230E-03   0.238E-03
0.245E-03   0.251E-03   0.264E-03   0.270E-03
                                                  CONTINUE
                                                            X
   Y         10.         15.         35.         39.         55.

  13.   0.138E-03   0.130E-03   0.454E-04   0.322E-04   0.583E-05
   2.   0.573E-02   0.474E-02   0.725E-03   0.418E-03   0.344E-04
   0.   0.692E-02   0.568E-02   0.826E-03   0.470E-03   0.367E-04
  -2.   0.573E-02   0.474E-02   0.725E-03   0.418E-03   0.344E-04
  -5.   0.288E-02   0.245E-02   0.451E-03   0.273E-03   0.269E-04
 -11.   0.269E-03   0.249E-03   0.775E-04   0.534E-04   0.863E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1445E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
```

```
   Y          -9.          -5.          -3.          -2.          -1.           0.
1.          2.          5.          9.

  13.   0.641E-04   0.826E-04   0.895E-04   0.930E-04   0.967E-04   0.100E-03
0.103E-03   0.106E-03   0.113E-03   0.118E-03
   2.   0.866E-02   0.114E-01   0.123E-01   0.127E-01   0.131E-01   0.135E-01
0.138E-01   0.141E-01   0.144E-01   0.137E-01
   0.   0.129E-01   0.169E-01   0.183E-01   0.189E-01   0.196E-01   0.201E-01
0.206E-01   0.209E-01   0.213E-01   0.202E-01
  -2.   0.866E-02   0.114E-01   0.123E-01   0.127E-01   0.131E-01   0.135E-01
0.138E-01   0.141E-01   0.144E-01   0.137E-01
  -5.   0.227E-02   0.296E-02   0.319E-02   0.331E-02   0.343E-02   0.353E-02
0.363E-02   0.370E-02   0.382E-02   0.376E-02
 -11.   0.132E-03   0.170E-03   0.185E-03   0.192E-03   0.199E-03   0.206E-03
0.213E-03   0.218E-03   0.230E-03   0.239E-03
                                                  CONTINUE
                                                            X
   Y          10.          15.          35.          39.          55.

  13.   0.118E-03   0.113E-03   0.430E-04   0.311E-04   0.600E-05
   2.   0.134E-01   0.110E-01   0.148E-02   0.816E-03   0.518E-04
   0.   0.197E-01   0.160E-01   0.199E-02   0.107E-02   0.592E-04
  -2.   0.134E-01   0.110E-01   0.148E-02   0.816E-03   0.518E-04
  -5.   0.370E-02   0.318E-02   0.608E-03   0.368E-03   0.346E-04
 -11.   0.238E-03   0.223E-03   0.762E-04   0.535E-04   0.918E-05


                    Z =       2.00
                                                            X
   Y          -9.          -5.          -3.          -2.          -1.           0.
1.          2.          5.          9.

  13.   0.533E-04   0.686E-04   0.743E-04   0.772E-04   0.803E-04   0.832E-04
0.859E-04   0.884E-04   0.938E-04   0.983E-04
   2.   0.254E-02   0.331E-02   0.358E-02   0.371E-02   0.384E-02   0.396E-02
0.406E-02   0.415E-02   0.428E-02   0.421E-02
   0.   0.309E-02   0.403E-02   0.435E-02   0.451E-02   0.467E-02   0.481E-02
0.494E-02   0.504E-02   0.520E-02   0.509E-02
  -2.   0.254E-02   0.331E-02   0.358E-02   0.371E-02   0.384E-02   0.396E-02
0.406E-02   0.415E-02   0.428E-02   0.421E-02
  -5.   0.124E-02   0.161E-02   0.174E-02   0.181E-02   0.187E-02   0.193E-02
0.199E-02   0.203E-02   0.211E-02   0.210E-02
 -11.   0.106E-03   0.137E-03   0.148E-03   0.154E-03   0.160E-03   0.166E-03
0.171E-03   0.176E-03   0.185E-03   0.193E-03
                                                  CONTINUE
                                                            X
   Y          10.          15.          35.          39.          55.

  13.   0.985E-04   0.945E-04   0.371E-04   0.270E-04   0.536E-05
   2.   0.414E-02   0.356E-02   0.674E-03   0.406E-03   0.373E-04
   0.   0.500E-02   0.427E-02   0.775E-03   0.462E-03   0.402E-04
  -2.   0.414E-02   0.356E-02   0.674E-03   0.406E-03   0.373E-04
  -5.   0.207E-02   0.182E-02   0.406E-03   0.255E-03   0.280E-04
 -11.   0.192E-03   0.182E-03   0.643E-04   0.455E-04   0.811E-05
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    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1489E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.448E-04   0.576E-04   0.624E-04   0.649E-04   0.675E-04   0.700E-04
0.723E-04   0.745E-04   0.793E-04   0.839E-04
   2.   0.597E-02   0.779E-02   0.842E-02   0.873E-02   0.904E-02   0.931E-02
0.955E-02   0.975E-02   0.101E-01   0.984E-02
   0.   0.889E-02   0.116E-01   0.125E-01   0.130E-01   0.135E-01   0.139E-01
0.142E-01   0.145E-01   0.149E-01   0.145E-01
  -2.   0.597E-02   0.779E-02   0.842E-02   0.873E-02   0.904E-02   0.931E-02
0.955E-02   0.975E-02   0.101E-01   0.984E-02
  -5.   0.157E-02   0.204E-02   0.220E-02   0.229E-02   0.237E-02   0.245E-02
0.252E-02   0.258E-02   0.268E-02   0.269E-02
 -11.   0.921E-04   0.119E-03   0.128E-03   0.133E-03   0.139E-03   0.144E-03
0.149E-03   0.153E-03   0.162E-03   0.170E-03
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.842E-04   0.819E-04   0.348E-04   0.257E-04   0.546E-05
   2.   0.966E-02   0.824E-02   0.142E-02   0.822E-03   0.602E-04
   0.   0.143E-01   0.121E-01   0.194E-02   0.110E-02   0.713E-04
  -2.   0.966E-02   0.824E-02   0.142E-02   0.822E-03   0.602E-04
  -5.   0.266E-02   0.236E-02   0.545E-03   0.343E-03   0.366E-04
 -11.   0.170E-03   0.163E-03   0.625E-04   0.451E-04   0.854E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.372E-04   0.478E-04   0.518E-04   0.539E-04   0.561E-04   0.582E-04
0.601E-04   0.620E-04   0.660E-04   0.699E-04
   2.   0.176E-02   0.228E-02   0.247E-02   0.256E-02   0.265E-02   0.274E-02
0.282E-02   0.288E-02   0.300E-02   0.301E-02
   0.   0.214E-02   0.278E-02   0.300E-02   0.311E-02   0.323E-02   0.333E-02
0.342E-02   0.350E-02   0.364E-02   0.364E-02
  -2.   0.176E-02   0.228E-02   0.247E-02   0.256E-02   0.265E-02   0.274E-02
0.282E-02   0.288E-02   0.300E-02   0.301E-02
  -5.   0.859E-03   0.111E-02   0.121E-02   0.125E-02   0.130E-02   0.134E-02
0.138E-02   0.141E-02   0.148E-02   0.150E-02
 -11.   0.740E-04   0.952E-04   0.103E-03   0.107E-03   0.111E-03   0.116E-03
0.119E-03   0.123E-03   0.130E-03   0.137E-03
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.703E-04   0.686E-04   0.299E-04   0.223E-04   0.485E-05
   2.   0.297E-02   0.264E-02   0.605E-03   0.380E-03   0.396E-04
   0.   0.359E-02   0.317E-02   0.701E-03   0.436E-03   0.433E-04
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  -2.   0.297E-02   0.264E-02   0.605E-03   0.380E-03   0.396E-04
  -5.   0.149E-02   0.135E-02   0.355E-03   0.232E-03   0.286E-04
 -11.   0.137E-03   0.132E-03   0.525E-04   0.382E-04   0.749E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1533E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.314E-04   0.402E-04   0.436E-04   0.453E-04   0.472E-04   0.490E-04
0.507E-04   0.523E-04   0.559E-04   0.596E-04
   2.   0.413E-02   0.537E-02   0.581E-02   0.602E-02   0.625E-02   0.645E-02
0.663E-02   0.678E-02   0.705E-02   0.703E-02
   0.   0.615E-02   0.800E-02   0.865E-02   0.896E-02   0.929E-02   0.959E-02
0.985E-02   0.101E-01   0.105E-01   0.104E-01
  -2.   0.413E-02   0.537E-02   0.581E-02   0.602E-02   0.625E-02   0.645E-02
0.663E-02   0.678E-02   0.705E-02   0.703E-02
  -5.   0.109E-02   0.141E-02   0.153E-02   0.158E-02   0.164E-02   0.170E-02
0.175E-02   0.180E-02   0.188E-02   0.192E-02
 -11.   0.643E-04   0.827E-04   0.896E-04   0.931E-04   0.969E-04   0.101E-03
0.104E-03   0.107E-03   0.114E-03   0.121E-03
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.600E-04   0.593E-04   0.278E-04   0.210E-04   0.488E-05
   2.   0.695E-02   0.612E-02   0.130E-02   0.791E-03   0.680E-04
   0.   0.103E-01   0.898E-02   0.180E-02   0.108E-02   0.834E-04
  -2.   0.695E-02   0.612E-02   0.130E-02   0.791E-03   0.680E-04
  -5.   0.190E-02   0.174E-02   0.474E-03   0.310E-03   0.377E-04
 -11.   0.121E-03   0.118E-03   0.505E-04   0.374E-04   0.780E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.261E-04   0.334E-04   0.362E-04   0.377E-04   0.392E-04   0.407E-04
0.421E-04   0.435E-04   0.465E-04   0.497E-04
   2.   0.122E-02   0.158E-02   0.171E-02   0.177E-02   0.184E-02   0.190E-02
0.196E-02   0.201E-02   0.211E-02   0.215E-02
   0.   0.148E-02   0.192E-02   0.208E-02   0.216E-02   0.224E-02   0.231E-02
0.238E-02   0.244E-02   0.256E-02   0.260E-02
  -2.   0.122E-02   0.158E-02   0.171E-02   0.177E-02   0.184E-02   0.190E-02
0.196E-02   0.201E-02   0.211E-02   0.215E-02
  -5.   0.597E-03   0.772E-03   0.836E-03   0.868E-03   0.901E-03   0.933E-03
0.961E-03   0.987E-03   0.104E-02   0.107E-02
 -11.   0.517E-04   0.664E-04   0.720E-04   0.748E-04   0.779E-04   0.808E-04
0.835E-04   0.861E-04   0.918E-04   0.974E-04
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                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.501E-04   0.497E-04   0.238E-04   0.181E-04   0.432E-05
   2.   0.213E-02   0.194E-02   0.527E-03   0.344E-03   0.411E-04
   0.   0.258E-02   0.234E-02   0.615E-03   0.398E-03   0.454E-04
  -2.   0.213E-02   0.194E-02   0.527E-03   0.344E-03   0.411E-04
  -5.   0.106E-02   0.987E-03   0.302E-03   0.204E-03   0.285E-04
 -11.   0.979E-04   0.959E-04   0.422E-04   0.315E-04   0.680E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1577E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.220E-04   0.281E-04   0.305E-04   0.317E-04   0.330E-04   0.343E-04
0.355E-04   0.367E-04   0.394E-04   0.424E-04
   2.   0.287E-02   0.371E-02   0.402E-02   0.417E-02   0.433E-02   0.447E-02
0.461E-02   0.472E-02   0.494E-02   0.502E-02
   0.   0.426E-02   0.553E-02   0.598E-02   0.620E-02   0.644E-02   0.665E-02
0.685E-02   0.702E-02   0.733E-02   0.742E-02
  -2.   0.287E-02   0.371E-02   0.402E-02   0.417E-02   0.433E-02   0.447E-02
0.461E-02   0.472E-02   0.494E-02   0.502E-02
  -5.   0.758E-03   0.979E-03   0.106E-02   0.110E-02   0.114E-02   0.118E-02
0.122E-02   0.125E-02   0.132E-02   0.136E-02
 -11.   0.450E-04   0.578E-04   0.626E-04   0.651E-04   0.678E-04   0.704E-04
0.728E-04   0.751E-04   0.803E-04   0.858E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.428E-04   0.429E-04   0.219E-04   0.170E-04   0.430E-05
   2.   0.498E-02   0.452E-02   0.115E-02   0.732E-03   0.743E-04
   0.   0.736E-02   0.663E-02   0.161E-02   0.101E-02   0.937E-04
  -2.   0.498E-02   0.452E-02   0.115E-02   0.732E-03   0.743E-04
  -5.   0.136E-02   0.127E-02   0.402E-03   0.273E-03   0.379E-04
 -11.   0.864E-04   0.856E-04   0.403E-04   0.305E-04   0.701E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.183E-04   0.234E-04   0.254E-04   0.264E-04   0.275E-04   0.285E-04
0.296E-04   0.305E-04   0.328E-04   0.353E-04
   2.   0.849E-03   0.110E-02   0.119E-02   0.123E-02   0.128E-02   0.132E-02
0.137E-02   0.140E-02   0.148E-02   0.153E-02
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   0.   0.103E-02   0.133E-02   0.144E-02   0.150E-02   0.156E-02   0.161E-02
0.166E-02   0.170E-02   0.180E-02   0.185E-02
  -2.   0.849E-03   0.110E-02   0.119E-02   0.123E-02   0.128E-02   0.132E-02
0.137E-02   0.140E-02   0.148E-02   0.153E-02
  -5.   0.416E-03   0.537E-03   0.581E-03   0.604E-03   0.628E-03   0.650E-03
0.671E-03   0.690E-03   0.730E-03   0.760E-03
 -11.   0.362E-04   0.464E-04   0.503E-04   0.523E-04   0.545E-04   0.566E-04
0.586E-04   0.604E-04   0.647E-04   0.693E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.357E-04   0.359E-04   0.187E-04   0.146E-04   0.379E-05
   2.   0.152E-02   0.142E-02   0.448E-03   0.303E-03   0.415E-04
   0.   0.184E-02   0.171E-02   0.525E-03   0.353E-03   0.463E-04
  -2.   0.152E-02   0.142E-02   0.448E-03   0.303E-03   0.415E-04
  -5.   0.760E-03   0.721E-03   0.252E-03   0.176E-03   0.278E-04
 -11.   0.698E-04   0.694E-04   0.335E-04   0.256E-04   0.607E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1621E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.154E-04   0.197E-04   0.214E-04   0.222E-04   0.232E-04   0.241E-04
0.250E-04   0.258E-04   0.278E-04   0.301E-04
   2.   0.199E-02   0.258E-02   0.279E-02   0.290E-02   0.301E-02   0.311E-02
0.321E-02   0.330E-02   0.347E-02   0.357E-02
   0.   0.296E-02   0.383E-02   0.415E-02   0.430E-02   0.447E-02   0.463E-02
0.477E-02   0.489E-02   0.515E-02   0.529E-02
  -2.   0.199E-02   0.258E-02   0.279E-02   0.290E-02   0.301E-02   0.311E-02
0.321E-02   0.330E-02   0.347E-02   0.357E-02
  -5.   0.528E-03   0.681E-03   0.737E-03   0.766E-03   0.796E-03   0.825E-03
0.852E-03   0.877E-03   0.929E-03   0.971E-03
 -11.   0.316E-04   0.404E-04   0.438E-04   0.456E-04   0.475E-04   0.493E-04
0.511E-04   0.528E-04   0.566E-04   0.610E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.304E-04   0.309E-04   0.171E-04   0.135E-04   0.373E-05
   2.   0.356E-02   0.331E-02   0.986E-03   0.655E-03   0.782E-04
   0.   0.526E-02   0.486E-02   0.139E-02   0.912E-03   0.101E-03
  -2.   0.356E-02   0.331E-02   0.986E-03   0.655E-03   0.782E-04
  -5.   0.972E-03   0.927E-03   0.334E-03   0.234E-03   0.370E-04
 -11.   0.616E-04   0.618E-04   0.318E-04   0.246E-04   0.619E-05


                    Z =       2.00
                                                            X
```

```
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.128E-04   0.164E-04   0.178E-04   0.185E-04   0.193E-04   0.200E-04
0.208E-04   0.215E-04   0.231E-04   0.251E-04
   2.   0.592E-03   0.762E-03   0.826E-03   0.858E-03   0.892E-03   0.924E-03
0.954E-03   0.982E-03   0.104E-02   0.109E-02
   0.   0.719E-03   0.926E-03   0.100E-02   0.104E-02   0.108E-02   0.112E-02
0.116E-02   0.119E-02   0.126E-02   0.132E-02
  -2.   0.592E-03   0.762E-03   0.826E-03   0.858E-03   0.892E-03   0.924E-03
0.954E-03   0.982E-03   0.104E-02   0.109E-02
  -5.   0.291E-03   0.374E-03   0.405E-03   0.421E-03   0.438E-03   0.454E-03
0.469E-03   0.483E-03   0.514E-03   0.541E-03
 -11.   0.254E-04   0.325E-04   0.352E-04   0.366E-04   0.382E-04   0.397E-04
0.411E-04   0.425E-04   0.456E-04   0.492E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.254E-04   0.259E-04   0.146E-04   0.116E-04   0.327E-05
   2.   0.109E-02   0.104E-02   0.372E-03   0.261E-03   0.407E-04
   0.   0.132E-02   0.125E-02   0.438E-03   0.304E-03   0.458E-04
  -2.   0.109E-02   0.104E-02   0.372E-03   0.261E-03   0.407E-04
  -5.   0.542E-03   0.524E-03   0.206E-03   0.148E-03   0.264E-04
 -11.   0.497E-04   0.501E-04   0.264E-04   0.206E-04   0.533E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1664E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.108E-04   0.138E-04   0.150E-04   0.156E-04   0.163E-04   0.169E-04
0.176E-04   0.182E-04   0.196E-04   0.214E-04
   2.   0.139E-02   0.179E-02   0.194E-02   0.202E-02   0.210E-02   0.217E-02
0.224E-02   0.230E-02   0.244E-02   0.254E-02
   0.   0.206E-02   0.266E-02   0.288E-02   0.299E-02   0.311E-02   0.322E-02
0.333E-02   0.342E-02   0.362E-02   0.376E-02
  -2.   0.139E-02   0.179E-02   0.194E-02   0.202E-02   0.210E-02   0.217E-02
0.224E-02   0.230E-02   0.244E-02   0.254E-02
  -5.   0.369E-03   0.475E-03   0.514E-03   0.534E-03   0.556E-03   0.577E-03
0.596E-03   0.614E-03   0.654E-03   0.691E-03
 -11.   0.222E-04   0.283E-04   0.307E-04   0.320E-04   0.333E-04   0.346E-04
0.359E-04   0.371E-04   0.399E-04   0.433E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.217E-04   0.223E-04   0.133E-04   0.107E-04   0.319E-05
   2.   0.254E-02   0.241E-02   0.827E-03   0.569E-03   0.794E-04
   0.   0.376E-02   0.355E-02   0.117E-02   0.800E-03   0.105E-03
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  -2.   0.254E-02   0.241E-02   0.827E-03   0.569E-03   0.794E-04
  -5.   0.693E-03   0.673E-03   0.272E-03   0.197E-03   0.352E-04
 -11.   0.438E-04   0.446E-04   0.248E-04   0.196E-04   0.538E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.901E-05   0.115E-04   0.125E-04   0.130E-04   0.135E-04   0.141E-04
0.146E-04   0.151E-04   0.163E-04   0.178E-04
   2.   0.413E-03   0.531E-03   0.576E-03   0.598E-03   0.623E-03   0.646E-03
0.667E-03   0.688E-03   0.732E-03   0.773E-03
   0.   0.502E-03   0.645E-03   0.699E-03   0.727E-03   0.756E-03   0.784E-03
0.810E-03   0.834E-03   0.887E-03   0.936E-03
  -2.   0.413E-03   0.531E-03   0.576E-03   0.598E-03   0.623E-03   0.646E-03
0.667E-03   0.688E-03   0.732E-03   0.773E-03
  -5.   0.203E-03   0.261E-03   0.283E-03   0.294E-03   0.306E-03   0.318E-03
0.328E-03   0.339E-03   0.361E-03   0.385E-03
 -11.   0.178E-04   0.228E-04   0.247E-04   0.257E-04   0.268E-04   0.279E-04
0.289E-04   0.299E-04   0.322E-04   0.350E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.181E-04   0.186E-04   0.113E-04   0.912E-05   0.279E-05
   2.   0.776E-03   0.753E-03   0.304E-03   0.219E-03   0.388E-04
   0.   0.939E-03   0.909E-03   0.359E-03   0.257E-03   0.441E-04
  -2.   0.776E-03   0.753E-03   0.304E-03   0.219E-03   0.388E-04
  -5.   0.387E-03   0.380E-03   0.166E-03   0.123E-03   0.245E-04
 -11.   0.354E-04   0.361E-04   0.205E-04   0.163E-04   0.460E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1708E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.762E-05   0.972E-05   0.105E-04   0.110E-04   0.114E-04   0.119E-04
0.124E-04   0.128E-04   0.138E-04   0.152E-04
   2.   0.971E-03   0.125E-02   0.135E-02   0.141E-02   0.146E-02   0.152E-02
0.157E-02   0.161E-02   0.172E-02   0.181E-02
   0.   0.144E-02   0.185E-02   0.201E-02   0.209E-02   0.217E-02   0.225E-02
0.233E-02   0.239E-02   0.254E-02   0.268E-02
  -2.   0.971E-03   0.125E-02   0.135E-02   0.141E-02   0.146E-02   0.152E-02
0.157E-02   0.161E-02   0.172E-02   0.181E-02
  -5.   0.258E-03   0.331E-03   0.359E-03   0.373E-03   0.389E-03   0.404E-03
0.418E-03   0.431E-03   0.460E-03   0.491E-03
 -11.   0.156E-04   0.199E-04   0.216E-04   0.224E-04   0.234E-04   0.243E-04
0.252E-04   0.261E-04   0.282E-04   0.308E-04
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                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.154E-04   0.160E-04   0.102E-04   0.835E-05   0.269E-05
   2.   0.181E-02   0.175E-02   0.680E-03   0.484E-03   0.779E-04
   0.   0.268E-02   0.258E-02   0.971E-03   0.684E-03   0.104E-03
  -2.   0.181E-02   0.175E-02   0.680E-03   0.484E-03   0.779E-04
  -5.   0.494E-03   0.487E-03   0.219E-03   0.163E-03   0.327E-04
 -11.   0.312E-04   0.321E-04   0.192E-04   0.155E-04   0.460E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.634E-05   0.809E-05   0.877E-05   0.913E-05   0.952E-05   0.991E-05
0.103E-04   0.106E-04   0.115E-04   0.127E-04
   2.   0.289E-03   0.371E-03   0.402E-03   0.418E-03   0.435E-03   0.452E-03
0.468E-03   0.482E-03   0.515E-03   0.550E-03
   0.   0.351E-03   0.451E-03   0.488E-03   0.508E-03   0.528E-03   0.548E-03
0.567E-03   0.585E-03   0.625E-03   0.665E-03
  -2.   0.289E-03   0.371E-03   0.402E-03   0.418E-03   0.435E-03   0.452E-03
0.468E-03   0.482E-03   0.515E-03   0.550E-03
  -5.   0.142E-03   0.183E-03   0.198E-03   0.206E-03   0.214E-03   0.222E-03
0.230E-03   0.238E-03   0.255E-03   0.273E-03
 -11.   0.125E-04   0.160E-04   0.173E-04   0.181E-04   0.188E-04   0.196E-04
0.203E-04   0.210E-04   0.227E-04   0.249E-04
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.129E-04   0.134E-04   0.866E-05   0.712E-05   0.234E-05
   2.   0.553E-03   0.545E-03   0.244E-03   0.181E-03   0.361E-04
   0.   0.669E-03   0.658E-03   0.289E-03   0.213E-03   0.413E-04
  -2.   0.553E-03   0.545E-03   0.244E-03   0.181E-03   0.361E-04
  -5.   0.275E-03   0.275E-03   0.132E-03   0.100E-03   0.223E-04
 -11.   0.252E-04   0.260E-04   0.159E-04   0.129E-04   0.393E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1752E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.536E-05   0.683E-05   0.741E-05   0.772E-05   0.805E-05   0.838E-05
0.870E-05   0.902E-05   0.977E-05   0.108E-04
   2.   0.679E-03   0.872E-03   0.944E-03   0.982E-03   0.102E-02   0.106E-02
0.110E-02   0.113E-02   0.121E-02   0.129E-02
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   0.   0.101E-02   0.129E-02   0.140E-02   0.146E-02   0.152E-02   0.157E-02
0.163E-02   0.168E-02   0.179E-02   0.190E-02
  -2.   0.679E-03   0.872E-03   0.944E-03   0.982E-03   0.102E-02   0.106E-02
0.110E-02   0.113E-02   0.121E-02   0.129E-02
  -5.   0.181E-03   0.232E-03   0.251E-03   0.261E-03   0.272E-03   0.283E-03
0.293E-03   0.302E-03   0.324E-03   0.349E-03
 -11.   0.109E-04   0.140E-04   0.151E-04   0.158E-04   0.164E-04   0.171E-04
0.178E-04   0.184E-04   0.199E-04   0.219E-04
                                                     CONTINUE
                                                             X
   Y          10.          15.          35.          39.          55.

  13.   0.110E-04   0.115E-04   0.779E-05   0.648E-05   0.225E-05
   2.   0.129E-02   0.127E-02   0.550E-03   0.403E-03   0.741E-04
   0.   0.191E-02   0.187E-02   0.788E-03   0.572E-03   0.100E-03
  -2.   0.129E-02   0.127E-02   0.550E-03   0.403E-03   0.741E-04
  -5.   0.352E-03   0.352E-03   0.174E-03   0.132E-03   0.297E-04
 -11.   0.222E-04   0.231E-04   0.148E-04   0.121E-04   0.389E-05


                    Z =       2.00
                                                             X
   Y          -9.          -5.          -3.          -2.          -1.           0.
1.           2.           5.           9.

  13.   0.446E-05   0.569E-05   0.617E-05   0.642E-05   0.670E-05   0.698E-05
0.725E-05   0.751E-05   0.814E-05   0.901E-05
   2.   0.203E-03   0.260E-03   0.281E-03   0.293E-03   0.305E-03   0.317E-03
0.328E-03   0.339E-03   0.363E-03   0.390E-03
   0.   0.246E-03   0.315E-03   0.342E-03   0.355E-03   0.370E-03   0.384E-03
0.398E-03   0.411E-03   0.440E-03   0.473E-03
  -2.   0.203E-03   0.260E-03   0.281E-03   0.293E-03   0.305E-03   0.317E-03
0.328E-03   0.339E-03   0.363E-03   0.390E-03
  -5.   0.999E-04   0.128E-03   0.139E-03   0.144E-03   0.150E-03   0.156E-03
0.162E-03   0.167E-03   0.180E-03   0.194E-03
 -11.   0.881E-05   0.112E-04   0.122E-04   0.127E-04   0.132E-04   0.138E-04
0.143E-04   0.148E-04   0.160E-04   0.177E-04
                                                     CONTINUE
                                                             X
   Y          10.          15.          35.          39.          55.

  13.   0.916E-05   0.961E-05   0.661E-05   0.552E-05   0.195E-05
   2.   0.394E-03   0.394E-03   0.194E-03   0.147E-03   0.329E-04
   0.   0.477E-03   0.476E-03   0.230E-03   0.174E-03   0.378E-04
  -2.   0.394E-03   0.394E-03   0.194E-03   0.147E-03   0.329E-04
  -5.   0.196E-03   0.198E-03   0.104E-03   0.808E-04   0.198E-04
 -11.   0.179E-04   0.187E-04   0.122E-04   0.100E-04   0.330E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1796E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                             X
```

```
   Y         -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.378E-05   0.481E-05   0.522E-05   0.543E-05   0.567E-05   0.591E-05
0.614E-05   0.636E-05   0.691E-05   0.768E-05
   2.   0.476E-03   0.610E-03   0.661E-03   0.687E-03   0.716E-03   0.743E-03
0.769E-03   0.794E-03   0.851E-03   0.914E-03
   0.   0.706E-03   0.905E-03   0.980E-03   0.102E-02   0.106E-02   0.110E-02
0.114E-02   0.118E-02   0.126E-02   0.135E-02
  -2.   0.476E-03   0.610E-03   0.661E-03   0.687E-03   0.716E-03   0.743E-03
0.769E-03   0.794E-03   0.851E-03   0.914E-03
  -5.   0.127E-03   0.162E-03   0.176E-03   0.183E-03   0.191E-03   0.198E-03
0.206E-03   0.213E-03   0.229E-03   0.248E-03
 -11.   0.771E-05   0.982E-05   0.107E-04   0.111E-04   0.116E-04   0.121E-04
0.125E-04   0.130E-04   0.141E-04   0.155E-04
                                                  CONTINUE
                                                            X
   Y         10.         15.         35.         39.         55.

  13.   0.781E-05   0.825E-05   0.592E-05   0.500E-05   0.185E-05
   2.   0.921E-03   0.918E-03   0.438E-03   0.330E-03   0.686E-04
   0.   0.136E-02   0.135E-02   0.631E-03   0.471E-03   0.939E-04
  -2.   0.921E-03   0.918E-03   0.438E-03   0.330E-03   0.686E-04
  -5.   0.251E-03   0.254E-03   0.136E-03   0.106E-03   0.264E-04
 -11.   0.158E-04   0.166E-04   0.113E-04   0.939E-05   0.325E-05


                    Z =       2.00
                                                            X
   Y         -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.315E-05   0.400E-05   0.434E-05   0.452E-05   0.472E-05   0.492E-05
0.511E-05   0.530E-05   0.576E-05   0.640E-05
   2.   0.142E-03   0.182E-03   0.197E-03   0.205E-03   0.214E-03   0.222E-03
0.230E-03   0.238E-03   0.256E-03   0.277E-03
   0.   0.173E-03   0.221E-03   0.239E-03   0.249E-03   0.259E-03   0.270E-03
0.279E-03   0.289E-03   0.310E-03   0.336E-03
  -2.   0.142E-03   0.182E-03   0.197E-03   0.205E-03   0.214E-03   0.222E-03
0.230E-03   0.238E-03   0.256E-03   0.277E-03
  -5.   0.701E-04   0.896E-04   0.972E-04   0.101E-03   0.105E-03   0.110E-03
0.114E-03   0.118E-03   0.127E-03   0.138E-03
 -11.   0.621E-05   0.791E-05   0.858E-05   0.893E-05   0.932E-05   0.970E-05
0.101E-04   0.104E-04   0.113E-04   0.125E-04
                                                  CONTINUE
                                                            X
   Y         10.         15.         35.         39.         55.

  13.   0.652E-05   0.690E-05   0.501E-05   0.425E-05   0.160E-05
   2.   0.280E-03   0.284E-03   0.152E-03   0.118E-03   0.293E-04
   0.   0.339E-03   0.343E-03   0.181E-03   0.140E-03   0.338E-04
  -2.   0.280E-03   0.284E-03   0.152E-03   0.118E-03   0.293E-04
  -5.   0.140E-03   0.143E-03   0.812E-04   0.643E-04   0.173E-04
 -11.   0.128E-04   0.134E-04   0.929E-05   0.777E-05   0.275E-05
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     DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1840E+06 HRS
       (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                         X
   Y          -9.          -5.          -3.          -2.          -1.          0.
1.          2.          5.          9.

  13.   0.266E-05   0.339E-05   0.368E-05   0.383E-05   0.400E-05   0.417E-05
0.433E-05   0.449E-05   0.489E-05   0.545E-05
   2.   0.334E-03   0.427E-03   0.463E-03   0.481E-03   0.502E-03   0.521E-03
0.540E-03   0.558E-03   0.600E-03   0.649E-03
   0.   0.495E-03   0.633E-03   0.687E-03   0.714E-03   0.744E-03   0.773E-03
0.801E-03   0.828E-03   0.889E-03   0.960E-03
  -2.   0.334E-03   0.427E-03   0.463E-03   0.481E-03   0.502E-03   0.521E-03
0.540E-03   0.558E-03   0.600E-03   0.649E-03
  -5.   0.892E-04   0.114E-03   0.124E-03   0.129E-03   0.134E-03   0.139E-03
0.145E-03   0.150E-03   0.161E-03   0.176E-03
 -11.   0.543E-05   0.692E-05   0.750E-05   0.781E-05   0.816E-05   0.849E-05
0.882E-05   0.915E-05   0.994E-05   0.110E-04
                                                CONTINUE
                                                         X
   Y          10.          15.          35.          39.          55.

  13.   0.556E-05   0.592E-05   0.447E-05   0.383E-05   0.151E-05
   2.   0.656E-03   0.662E-03   0.346E-03   0.266E-03   0.620E-04
   0.   0.970E-03   0.977E-03   0.498E-03   0.382E-03   0.856E-04
  -2.   0.656E-03   0.662E-03   0.346E-03   0.266E-03   0.620E-04
  -5.   0.178E-03   0.183E-03   0.106E-03   0.843E-04   0.230E-04
 -11.   0.112E-04   0.119E-04   0.857E-05   0.724E-05   0.268E-05


                    Z =       2.00
                                                         X
   Y          -9.          -5.          -3.          -2.          -1.          0.
1.          2.          5.          9.

  13.   0.222E-05   0.282E-05   0.306E-05   0.319E-05   0.333E-05   0.347E-05
0.361E-05   0.374E-05   0.407E-05   0.455E-05
   2.   0.999E-04   0.128E-03   0.138E-03   0.144E-03   0.150E-03   0.156E-03
0.162E-03   0.167E-03   0.181E-03   0.197E-03
   0.   0.121E-03   0.155E-03   0.168E-03   0.175E-03   0.182E-03   0.189E-03
0.196E-03   0.203E-03   0.219E-03   0.239E-03
  -2.   0.999E-04   0.128E-03   0.138E-03   0.144E-03   0.150E-03   0.156E-03
0.162E-03   0.167E-03   0.181E-03   0.197E-03
  -5.   0.493E-04   0.629E-04   0.683E-04   0.710E-04   0.741E-04   0.771E-04
0.800E-04   0.827E-04   0.894E-04   0.980E-04
 -11.   0.438E-05   0.557E-05   0.604E-05   0.629E-05   0.657E-05   0.684E-05
0.711E-05   0.737E-05   0.801E-05   0.892E-05
                                                CONTINUE
                                                         X
   Y          10.          15.          35.          39.          55.

  13.   0.464E-05   0.495E-05   0.379E-05   0.325E-05   0.131E-05
   2.   0.200E-03   0.205E-03   0.118E-03   0.941E-04   0.256E-04
   0.   0.242E-03   0.247E-03   0.141E-03   0.112E-03   0.297E-04
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  -2.   0.200E-03   0.205E-03   0.118E-03   0.941E-04   0.256E-04
  -5.   0.994E-04   0.103E-03   0.628E-04   0.506E-04   0.149E-04
 -11.   0.908E-05   0.962E-05   0.704E-05   0.598E-05   0.226E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1883E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.188E-05   0.239E-05   0.259E-05   0.270E-05   0.282E-05   0.294E-05
0.306E-05   0.317E-05   0.346E-05   0.388E-05
   2.   0.234E-03   0.299E-03   0.325E-03   0.338E-03   0.352E-03   0.366E-03
0.380E-03   0.393E-03   0.423E-03   0.461E-03
   0.   0.347E-03   0.444E-03   0.482E-03   0.501E-03   0.522E-03   0.543E-03
0.563E-03   0.582E-03   0.627E-03   0.682E-03
  -2.   0.234E-03   0.299E-03   0.325E-03   0.338E-03   0.352E-03   0.366E-03
0.380E-03   0.393E-03   0.423E-03   0.461E-03
  -5.   0.627E-04   0.801E-04   0.868E-04   0.904E-04   0.943E-04   0.981E-04
0.102E-03   0.105E-03   0.114E-03   0.125E-03
 -11.   0.383E-05   0.487E-05   0.529E-05   0.551E-05   0.575E-05   0.599E-05
0.623E-05   0.646E-05   0.703E-05   0.785E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.396E-05   0.424E-05   0.337E-05   0.292E-05   0.123E-05
   2.   0.467E-03   0.477E-03   0.270E-03   0.212E-03   0.548E-04
   0.   0.690E-03   0.704E-03   0.390E-03   0.305E-03   0.762E-04
  -2.   0.467E-03   0.477E-03   0.270E-03   0.212E-03   0.548E-04
  -5.   0.127E-03   0.131E-03   0.818E-04   0.663E-04   0.198E-04
 -11.   0.800E-05   0.853E-05   0.647E-05   0.555E-05   0.219E-05


                    Z =       2.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.157E-05   0.199E-05   0.216E-05   0.225E-05   0.235E-05   0.245E-05
0.255E-05   0.264E-05   0.288E-05   0.323E-05
   2.   0.702E-04   0.896E-04   0.972E-04   0.101E-03   0.106E-03   0.110E-03
0.114E-03   0.118E-03   0.128E-03   0.140E-03
   0.   0.852E-04   0.109E-03   0.118E-03   0.123E-03   0.128E-03   0.133E-03
0.138E-03   0.143E-03   0.155E-03   0.170E-03
  -2.   0.702E-04   0.896E-04   0.972E-04   0.101E-03   0.106E-03   0.110E-03
0.114E-03   0.118E-03   0.128E-03   0.140E-03
  -5.   0.347E-04   0.442E-04   0.480E-04   0.500E-04   0.521E-04   0.542E-04
0.563E-04   0.583E-04   0.632E-04   0.696E-04
 -11.   0.309E-05   0.392E-05   0.426E-05   0.444E-05   0.463E-05   0.483E-05
0.502E-05   0.520E-05   0.567E-05   0.634E-05
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                                                  CONTINUE
                                                         X
   Y          10.          15.          35.          39.          55.

  13.   0.330E-05   0.355E-05   0.285E-05   0.248E-05   0.105E-05
   2.   0.142E-03   0.147E-03   0.914E-04   0.740E-04   0.220E-04
   0.   0.172E-03   0.178E-03   0.109E-03   0.879E-04   0.256E-04
  -2.   0.142E-03   0.147E-03   0.914E-04   0.740E-04   0.220E-04
  -5.   0.707E-04   0.738E-04   0.481E-04   0.395E-04   0.126E-04
 -11.   0.646E-05   0.690E-05   0.531E-05   0.457E-05   0.184E-05



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1927E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                         X
   Y          -9.          -5.          -3.          -2.          -1.          0.
1.          2.          5.          9.

  13.   0.133E-05   0.169E-05   0.183E-05   0.191E-05   0.199E-05   0.208E-05
0.216E-05   0.224E-05   0.245E-05   0.276E-05
   2.   0.165E-03   0.210E-03   0.228E-03   0.237E-03   0.247E-03   0.257E-03
0.267E-03   0.276E-03   0.299E-03   0.328E-03
   0.   0.244E-03   0.312E-03   0.338E-03   0.352E-03   0.367E-03   0.382E-03
0.396E-03   0.410E-03   0.442E-03   0.485E-03
  -2.   0.165E-03   0.210E-03   0.228E-03   0.237E-03   0.247E-03   0.257E-03
0.267E-03   0.276E-03   0.299E-03   0.328E-03
  -5.   0.442E-04   0.563E-04   0.611E-04   0.636E-04   0.663E-04   0.690E-04
0.717E-04   0.743E-04   0.805E-04   0.889E-04
 -11.   0.270E-05   0.344E-05   0.373E-05   0.388E-05   0.406E-05   0.423E-05
0.440E-05   0.456E-05   0.498E-05   0.558E-05
                                                  CONTINUE
                                                         X
   Y          10.          15.          35.          39.          55.

  13.   0.282E-05   0.304E-05   0.252E-05   0.222E-05   0.984E-06
   2.   0.332E-03   0.343E-03   0.209E-03   0.168E-03   0.476E-04
   0.   0.491E-03   0.506E-03   0.302E-03   0.242E-03   0.666E-04
  -2.   0.332E-03   0.343E-03   0.209E-03   0.168E-03   0.476E-04
  -5.   0.903E-04   0.944E-04   0.626E-04   0.516E-04   0.167E-04
 -11.   0.570E-05   0.611E-05   0.487E-05   0.423E-05   0.177E-05


                    Z =       2.00
                                                         X
   Y          -9.          -5.          -3.          -2.          -1.          0.
1.          2.          5.          9.

  13.   0.111E-05   0.140E-05   0.152E-05   0.159E-05   0.166E-05   0.173E-05
0.180E-05   0.187E-05   0.204E-05   0.230E-05
   2.   0.494E-04   0.630E-04   0.684E-04   0.712E-04   0.743E-04   0.773E-04
0.803E-04   0.831E-04   0.901E-04   0.995E-04
```

```
   0.   0.600E-04   0.764E-04   0.829E-04   0.863E-04   0.901E-04   0.937E-04
0.973E-04   0.101E-03   0.109E-03   0.120E-03
  -2.   0.494E-04   0.630E-04   0.684E-04   0.712E-04   0.743E-04   0.773E-04
0.803E-04   0.831E-04   0.901E-04   0.995E-04
  -5.   0.244E-04   0.311E-04   0.338E-04   0.352E-04   0.367E-04   0.382E-04
0.397E-04   0.411E-04   0.446E-04   0.495E-04
 -11.   0.218E-05   0.277E-05   0.300E-05   0.313E-05   0.327E-05   0.341E-05
0.354E-05   0.368E-05   0.401E-05   0.450E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.235E-05   0.254E-05   0.213E-05   0.188E-05   0.845E-06
   2.   0.101E-03   0.106E-03   0.700E-04   0.577E-04   0.186E-04
   0.   0.122E-03   0.128E-03   0.836E-04   0.687E-04   0.218E-04
  -2.   0.101E-03   0.106E-03   0.700E-04   0.577E-04   0.186E-04
  -5.   0.503E-04   0.530E-04   0.367E-04   0.306E-04   0.106E-04
 -11.   0.460E-05   0.495E-05   0.399E-05   0.348E-05   0.149E-05




    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1971E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.938E-06   0.119E-05   0.129E-05   0.135E-05   0.141E-05   0.147E-05
0.153E-05   0.159E-05   0.174E-05   0.196E-05
   2.   0.116E-03   0.148E-03   0.160E-03   0.167E-03   0.174E-03   0.181E-03
0.188E-03   0.195E-03   0.211E-03   0.233E-03
   0.   0.172E-03   0.219E-03   0.238E-03   0.247E-03   0.258E-03   0.269E-03
0.279E-03   0.289E-03   0.313E-03   0.344E-03
  -2.   0.116E-03   0.148E-03   0.160E-03   0.167E-03   0.174E-03   0.181E-03
0.188E-03   0.195E-03   0.211E-03   0.233E-03
  -5.   0.311E-04   0.396E-04   0.430E-04   0.448E-04   0.467E-04   0.486E-04
0.505E-04   0.524E-04   0.569E-04   0.631E-04
 -11.   0.191E-05   0.243E-05   0.263E-05   0.274E-05   0.286E-05   0.299E-05
0.311E-05   0.323E-05   0.352E-05   0.397E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.200E-05   0.218E-05   0.189E-05   0.167E-05   0.783E-06
   2.   0.236E-03   0.247E-03   0.160E-03   0.131E-03   0.406E-04
   0.   0.350E-03   0.364E-03   0.232E-03   0.189E-03   0.571E-04
  -2.   0.236E-03   0.247E-03   0.160E-03   0.131E-03   0.406E-04
  -5.   0.643E-04   0.678E-04   0.477E-04   0.400E-04   0.140E-04
 -11.   0.405E-05   0.438E-05   0.365E-05   0.321E-05   0.142E-05


                    Z =       2.00
                                                            X
```

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   Y          -9.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.782E-06   0.992E-06   0.108E-05   0.112E-05   0.117E-05   0.122E-05
0.127E-05   0.132E-05   0.145E-05   0.163E-05
   2.   0.348E-04   0.444E-04   0.481E-04   0.501E-04   0.523E-04   0.545E-04
0.566E-04   0.586E-04   0.637E-04   0.707E-04
   0.   0.422E-04   0.538E-04   0.584E-04   0.608E-04   0.634E-04   0.660E-04
0.686E-04   0.711E-04   0.772E-04   0.856E-04
  -2.   0.348E-04   0.444E-04   0.481E-04   0.501E-04   0.523E-04   0.545E-04
0.566E-04   0.586E-04   0.637E-04   0.707E-04
  -5.   0.172E-04   0.219E-04   0.238E-04   0.248E-04   0.259E-04   0.269E-04
0.280E-04   0.290E-04   0.316E-04   0.352E-04
 -11.   0.154E-05   0.195E-05   0.212E-05   0.221E-05   0.231E-05   0.241E-05
0.250E-05   0.260E-05   0.284E-05   0.320E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.167E-05   0.182E-05   0.159E-05   0.142E-05   0.672E-06
   2.   0.719E-04   0.759E-04   0.533E-04   0.446E-04   0.155E-04
   0.   0.871E-04   0.917E-04   0.637E-04   0.532E-04   0.182E-04
  -2.   0.719E-04   0.759E-04   0.533E-04   0.446E-04   0.155E-04
  -5.   0.358E-04   0.380E-04   0.278E-04   0.236E-04   0.873E-05
 -11.   0.327E-05   0.354E-05   0.299E-05   0.264E-05   0.119E-05

STEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINAL SIMULATING TIME



    DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.2015E+06 HRS
      (ADSORBED CHEMICAL CONC. =   0.3155E+00 * DISSOLVED CHEMICAL CONC.)


                    Z =       0.00
                                                            X
   Y      201480.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.664E-06   0.842E-06   0.914E-06   0.952E-06   0.995E-06   0.104E-05
0.108E-05   0.112E-05   0.123E-05   0.139E-05
   2.   0.817E-04   0.104E-03   0.113E-03   0.117E-03   0.123E-03   0.128E-03
0.133E-03   0.137E-03   0.149E-03   0.165E-03
   0.   0.121E-03   0.154E-03   0.167E-03   0.174E-03   0.182E-03   0.189E-03
0.196E-03   0.204E-03   0.221E-03   0.245E-03
  -2.   0.817E-04   0.104E-03   0.113E-03   0.117E-03   0.123E-03   0.128E-03
0.133E-03   0.137E-03   0.149E-03   0.165E-03
  -5.   0.219E-04   0.279E-04   0.303E-04   0.315E-04   0.329E-04   0.343E-04
0.357E-04   0.370E-04   0.402E-04   0.449E-04
 -11.   0.135E-05   0.171E-05   0.186E-05   0.194E-05   0.202E-05   0.211E-05
0.220E-05   0.228E-05   0.250E-05   0.282E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.143E-05   0.156E-05   0.140E-05   0.126E-05   0.620E-06
```

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   2.   0.168E-03   0.177E-03   0.122E-03   0.102E-03   0.341E-04
   0.   0.249E-03   0.261E-03   0.178E-03   0.147E-03   0.483E-04
  -2.   0.168E-03   0.177E-03   0.122E-03   0.102E-03   0.341E-04
  -5.   0.457E-04   0.486E-04   0.361E-04   0.307E-04   0.115E-04
 -11.   0.289E-05   0.314E-05   0.273E-05   0.242E-05   0.113E-05


                    Z =       2.00
                                                            X
   Y      201480.         -5.         -3.         -2.         -1.          0.
1.          2.          5.          9.

  13.   0.553E-06   0.701E-06   0.761E-06   0.793E-06   0.829E-06   0.865E-06
0.900E-06   0.936E-06   0.103E-05   0.116E-05
   2.   0.246E-04   0.313E-04   0.339E-04   0.353E-04   0.369E-04   0.384E-04
0.399E-04   0.414E-04   0.450E-04   0.502E-04
   0.   0.298E-04   0.379E-04   0.411E-04   0.428E-04   0.447E-04   0.466E-04
0.484E-04   0.502E-04   0.546E-04   0.608E-04
  -2.   0.246E-04   0.313E-04   0.339E-04   0.353E-04   0.369E-04   0.384E-04
0.399E-04   0.414E-04   0.450E-04   0.502E-04
  -5.   0.122E-04   0.155E-04   0.168E-04   0.175E-04   0.182E-04   0.190E-04
0.198E-04   0.205E-04   0.223E-04   0.250E-04
 -11.   0.109E-05   0.138E-05   0.150E-05   0.156E-05   0.163E-05   0.170E-05
0.177E-05   0.184E-05   0.201E-05   0.228E-05
                                                  CONTINUE
                                                            X
   Y          10.         15.         35.         39.         55.

  13.   0.119E-05   0.130E-05   0.118E-05   0.107E-05   0.530E-06
   2.   0.512E-04   0.544E-04   0.404E-04   0.343E-04   0.128E-04
   0.   0.620E-04   0.658E-04   0.483E-04   0.409E-04   0.151E-04
  -2.   0.512E-04   0.544E-04   0.404E-04   0.343E-04   0.128E-04
  -5.   0.255E-04   0.272E-04   0.210E-04   0.180E-04   0.714E-05
 -11.   0.233E-05   0.254E-05   0.223E-05   0.199E-05   0.946E-06
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APPENDIX D

COST ESTIMATE SUMMARIES FOR REMEDIAL ACTION ALTERNATIVES AT THE FORMER FIRE TRAINING AREA (SWMU 13)

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APPENDIX D

Cost Estimate Summaries for Remedial Action Alternatives at the Former Fire Training Area (SWMU 13)

		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
		Monitored Natural Attenuation	**Air Sparging**	**Oxygen Injection**	**Air Sparging (to 50 μg/L) with Monitored Natural Attenuation**	**Oxygen Injection (to 50 μg/L) with Monitored Natural Attenuation**
1.0	**Capital Costs**					
1.1	**Engineering Services**					
1.1.1	Work Plan/SSHP and Remedial Design	$8,868	$22,711	$22,711	$22,711	$21,543
1.1.2	Contracting/Procurement	$590	$915	$915	$915	$915
1.1.3	Permitting	$0	$2,582	$2,582	$2,582	$2,582
1.1.4	Construction Oversight for Monitoring Well Installation	$0	$0	$0	$0	$0
1.1.5	Construction Oversight for Extraction/ Injection Installation	$0	$14,292	$25,154	$5,740	$8,852
1.1.6	Construction Oversight for System Startup	$0	$11,365	$11,365	$11,365	$8,052
1.1	**Total Costs for Engineering Services**	**$9,458**	**$51,865**	**$62,728**	**$43,314**	**$41,943**
1.2	**System Installation**					
1.2.1	Site Preparation and Mobilization/ Demobilization					
1.2.1.1	Locate Underground Utilities	$0	$628	$628	$628	$628
1.2.1.2	Define Grid Layout	$0	$0	$2,011	$0	$2,011
1.2.1.3	Baseline Groundwater Monitoring	$15,606	$13,227	$13,227	$15,606	$15,606
1.2.1.4	Baseline Soils Letter Report	$2,262	$2,262	$2,262	$2,262	$2,262
1.2.1	**Total Costs for Site Preparation and Mobilization/Demobilization**	**$17,868**	**$16,116**	**$18,128**	**$18,496**	**$20,507**
1.2.2	Monitoring Well Installation	$0	$0	$0	$0	$0
1.2.3	Extraction/Injection and Equipment Installation	$0	$74,287	$93,880	$55,909	$72,108
1.2.4	Transport/Disposal of IDW	$0	$2,182	$2,182	$2,182	$2,182
1.2.5	Project Closeout	$4,800	$7,600	$10,000	$6,000	$6,800
1.2	**Total Costs for System Installation**	**$22,668**	**$100,185**	**$124,190**	**$82,586**	**$101,597**
1.0	**Total Capital Costs**	**$32,126**	**$152,050**	**$186,917**	**$125,900**	**$143,540**
2.0	**System Maintenance**					
2.1	Groundwater Monitoring	$109,242	$197,457	$263,033	$157,456	$0
2.2	Annual Report	$15,833	$33,929	$45,238	$24,881	$183,025
2.3	Post Remediation Soil Analysis	$0	$0	$0	$0	$29,405
2.4	Operations and Maintenance for System	$0	$47,844	$66,331	$27,644	$26,288
2.0	**Total Costs for System Maintenance**	**$125,076**	**$279,229**	**$374,602**	**$209,981**	**$238,718**
	Subtotal Project Costs	**$157,201**	**$431,279**	**$561,519**	**$335,881**	**$382,258**
	Construction Mgmt (10% of subtotal)	$15,720	$43,128	$56,152	$33,588	$38,226
	Contingency (20% of subtotal)	$31,440	$86,256	$112,304	$67,176	$76,452
	Health and Safety (7.5% of subtotal)	$11,790	$32,346	$42,114	$25,191	$28,669
	Contractor Profit (10% of subtotal)	$15,720	$43,128	$56,152	$33,588	$38,226
	Escalation (8% of Subtotal)	$12,576	$34,502	$44,922	$26,871	$30,581
	Total Project Costs	**$244,448**	**$670,639**	**$873,162**	**$522,295**	**$594,411**

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APPENDIX E

OPERATION AND MAINTENANCE PLAN FOR THE FORMER FIRE TRAINING AREA (SWMU 13)

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E.1. INTRODUCTION/PURPOSE

This plan presents preliminary procedures for the operation and maintenance (O&M) of the monitored natural attenuation system for remediation of the groundwater contamination at the former Fire Training Area at the solid waste management unit (SWMU) 13 at Fort Stewart, Georgia. This O&M Plan is based on the groundwater contaminant plume as understood at this time. If site conditions change during the O&M period, then a revised/updated O&M Plan will be submitted to the Georgia Environmental Protection Division. Substantive changes in the remediation approach or schedule will require that the public be provided with an opportunity for review and comment.

SWMU 13 contains groundwater contaminated primarily with benzene, toluene, ethylbenzene, and total xylenes and naphthalene. Corrective action is required to reduce the concentrations of contaminants to achieve the remedial levels presented in this Corrective Action Plan (CAP). The selected corrective action consists of monitored natural attenuation. A description of the selected corrective action is presented in Chapter 5.0 of the CAP.

E.2. TRAINING

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

Personnel involved in the O&M of the system will be subject to the requirements specified in this O&M Plan, the Sampling and Analysis Plan (SAP), and the project Site Safety and Health Plan (SSHP). Training will be in accordance with Science Applications International Corporation (SAIC) Quality Assurance Administrative Procedure (QAAP) 2.1, *Indoctrination and Training*. The Site Supervisor is responsible for: (1) assessing qualifications and determining skill needs of personnel; (2) assuring that appropriate training is provided to personnel and that the training (classroom, reading assignments, or on-the-job) is completed; and (3) forwarding training records for personnel to the SAIC Central Records Facility located in Oak Ridge, Tennessee. Health and safety-related documentation will also be maintained in on-site project files, in accordance with the SSHP.

E.3. WASTE MANAGEMENT PRACTICES

Wastes generated from groundwater sampling activities will be managed in accordance with Resource Conservation and Recovery Act (RCRA) requirements and the site-specific SAP, Chapter 7.0. The types of wastes anticipated to be generated are: (1) monitoring well purge waters, (2) decontamination fluids, and (3) sanitary waste (noncontaminated compactible and miscellaneous trash). Materials that can be effectively reused, recycled, or decontaminated in the field are not waste materials.

Table E-1. Training Requirements

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

CPR = Cardiopulmonary resuscitation.

O&M = Operation and maintenance.
OJT = On-the-job training.
✓ = Required training.

Decontamination and monitoring well purge waters will be stored in poly tanks. The poly tanks will be transported to a staging area for temporary storage. Analytical data gathered from grab samples collected directly from filled poly tanks will be used to characterize liquid wastes. One grab sample will be collected from each filled poly tank and submitted to an off-site laboratory for analysis of volatile organic compounds (VOCs), pH, oil and grease, and phenols. The analytical data reported for the grab samples, the quantity to be released, and the date of the release will be submitted to the Fort Stewart Directorate of Public Works (DPW) water engineer for evaluation. The water engineer will determine if the liquid waste can be released into the facility industrial wastewater treatment system on a case-by-case basis. In the event that the Fort Stewart DPW water engineer rejects release of the liquid waste into the industrial wastewater treatment system, the contents of the subject poly tank will be transferred into 44-gallon 17E closed-top drums for disposal off-site. Based upon the results of the analytical data, the material will be transported to either a permitted RCRA Subtitle D or Subtitle C facility located off the Fort Stewart Military Reservation for disposal. The material will be disposed in accordance with all applicable U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation, and State of Georgia regulations. Containerized hazardous waste will be transported off-site for disposal within 90 days of receipt of sample data indicating that the waste is hazardous.

Sanitary wastes that are noncontaminated will be bagged and placed in a sanitary waste dumpster for disposal at Fort Stewart's permitted South Central Landfill. No free liquids or hazardous substances will be placed in dumpsters.

E.4. SAMPLING AND ANALYSIS

Annual sampling of groundwater will be conducted throughout the remediation period. All information, data, and resulting decisions will be technically sound, statistically valid, and properly documented by following a QAPP. The QAPP will document all monitoring procedures, sampling, field measurements, and sample analyses performed during these activities. Appropriate quality assurance, quality control, and chain-of-custody procedures will be followed in accordance with the U.S. Army Corps of Engineers' *Requirements for the Preparation of Sampling and Analysis Plans* (EM200-1-3), EPA's *Requirements for Quality Assurance Project Plans for Environmental Data Operations* (QA/R-5), and EPA's *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (QAMS-005/80). Detailed sampling and analysis procedures will be developed in conjunction with the Corrective Action Work Plan.

E.4.1 GROUNDWATER MONITORING DURING NATURAL ATTENUATION

Seven groundwater monitoring wells will be sampled annually for approximately 6 years. Groundwater samples will be collected from each of the seven wells using low-flow sampling techniques to minimize volatilization. Samples will be analyzed at an off-site laboratory for VOCs and semivolatile organic compounds (SVOCs). In addition, groundwater samples will be analyzed for natural attenuation parameters (nitrate/nitrite, sulfate/sulfide, total iron, total phosphorous, carbon dioxide, and methane) to confirm that conditions favorable for natural attenuation are present. Field parameters will be measured at the time of sampling and will include dissolved oxygen (DO), temperature, Eh, conductivity, pH, and ferrous iron.

E.4.2 GROUNDWATER MONITORING DURING CONFIRMATION SAMPLING

Following the completion of the natural attenuation period, the monitoring wells will be sampled for all constituents of concern as defined in the CAP to confirm that groundwater remedial levels have been met for all constituents. Confirmation groundwater sampling and analysis will be conducted 1 year following the natural attenuation period to verify that corrective action is complete.

Samples will be analyzed at an off-site laboratory for VOCs and SVOCs using then-current SW-846 methods. Field parameters will be measured at the time of sampling and will include DO, temperature, Eh, conductivity, and pH.

E.5. CORRECTIVE ACTION COMPLETION CRITERIA

The purpose of the corrective action is to achieve remedial levels in the groundwater at the site. The remedial levels, as defined in Chapter 3.0 of this CAP, are shown in Table E-2:

Table E-2. Summary of Remedial Levels

Analyte	Groundwater Remedial Level (µg/L)
Benzene	5
Ethylbenzene	700
Naphthalene	149
2-Methylnaphthalene[a]	142

[a] As the maximum detected concentration of 2-methylnaphthalene in the Resource Conservation and Recovery Act (RCRA) facility investigation samples was below the recommended remedial level, no further investigation or study is required to address this constituent in groundwater.

Monitored natural attenuation will be ceased upon attaining the remedial levels shown in Table E-2. Confirmation groundwater sampling will be conducted 1 year following the monitored natural attenuation period to verify that the groundwater remedial levels have been achieved.

E.6. SYSTEM DECOMMISSIONING

Upon satisfactory completion of the confirmation groundwater sampling and acknowledgment from the regulators that the corrective action is complete, the groundwater monitoring system will be decommissioned. All above-grade completions will be removed and properly disposed of at the Fort Stewart sanitary landfill. The groundwater monitoring wells will be plugged and abandoned by filling the casings with a cement and bentonite grout mixture.

E.7. O&M SCHEDULE

The anticipated schedule for O&M is summarized in Table E-3.

Table E-3. Operations and Maintenance Schedule

O&M Activity	Frequency	Duration
Groundwater sampling during monitored natural attenuation, VOCs, SVOCs, and natural attenuation parameters	Annually	Annually throughout natural attenuation period (6 years)
Confirmatory groundwater sampling	Once after completion of remediation	After 1 year

O&M = Operation and maintenance.
SVOC = Semivolatile organic constituent.
VOC = Volatile organic constituent.

E.8. DATA MANAGEMENT AND REPORTING DOCUMENTATION

A data management system will be maintained throughout the corrective action to accumulate, archive, and control project data. The data and operational information will be used to prepare Progress Reports and the final Corrective Action Completion Report. The types of data to be maintained in the data management system include those listed below:

- Monitoring and laboratory data. Sample location, date and time of collection, chain of custody, laboratory, test method, analytical results, detection limits, and associated quality control sample results.

- Personnel, maintenance, and inspection records. Logbooks and maintenance checklists.

E.8.1 PROGRESS REPORT INFORMATION

A progress report will be prepared annually during the natural attenuation period and after the confirmatory sampling. The report will summarize the results of the groundwater sampling and analysis completed during that period. An analysis of any deviations from the required remedial levels and need for any contingent action will be discussed, as required.

A checklist is presented in Attachment 1 to this O&M Plan summarizing the items to be addressed in each Progress Report.

E.8.2 COMPLETION REPORT INFORMATION

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

ATTACHMENT 1

PROGRESS REPORT CHECKLIST
Former Fire Training Area, Solid Waste Management Unit 13, Fort Stewart, Georgia

Progress Report Section	**Baseline Groundwater Sampling System Installation and Startup**	**6-Year O&M Period**	**Annual Confirmatory Sampling**
Work Accomplished (description of significant activities)	• Baseline groundwater sampling event	• Dates of sampling, analysis, or other performance testing	• Dates of sampling and analysis
Problems Encountered	• Summary of any problems encountered • Actions taken to rectify problems	• Summary of any problems encountered • Actions taken to rectify problems	• Summary of any problems encountered • Actions taken to rectify problems
Analysis of Trends	• Comparison of results of baseline groundwater sampling and analysis to results of previous sampling events	• Comparison of groundwater analytical results to predicted performance	• Comparison of results of groundwater analysis to remedial levels • Summary of any deviations noted
Communications/Contacts	• Summaries of visitors to the site • Summaries of major contacts or communications with GEPD, the local community, or others	• Summaries of visitors to the site • Summaries of major contacts or communications with GEPD, the local community, or others	• Summaries of visitors to the site • Summaries of major contacts or communications with GEPD, the local community, or others
Conclusions and Recommendations	• Recommended changes in O&M procedures	• System shutdown if remedial levels have been met • Need for contingent action (e.g., installation of additional wells, active remediation, etc.) if remedial levels have not been met	• Need for contingent action if remedial levels exceeded

GEPD = Georgia Environmental Protection Division.
O&M = Operation and maintenance.

APPENDIX F

IMPLEMENTATION CHECKLIST FOR MONITORED NATURAL ATTENUATION FOR CONSTITUENTS OF CONCERN AT THE FORMER FIRE TRAINING AREA (SWMU 13)

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Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13)

ROLE OF MONITORED NATURAL ATTENUATION	
Source Control	Two interim removal actions (IRAs) have been performed at solid waste management unit (SWMU) 13. An interim measure (IM) was completed at SWMU 13 in 1997, which removed and properly disposed of the fire training facilities and contaminated soil to approximately 4 feet below ground surface (bgs). The second IRA was completed in 2001/2002. During the action, the concrete pad and 337 tons of soil were removed. An area of approximately 20 feet by 27 feet was excavated down to a depth of 12 feet. As a result of these two actions, the pathway of contamination leaching from the soil has been eliminated. There is no free petroleum product [nonaqueous phase liquid (NAPL)] at SWMU 13. Arsenic and chromium were identified in the revised final Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) as contaminant migration constituents of concern (CMCOCs) in soil. Arsenic and chromium are not presently identified as a human health constituent of concern (HHCOC) in groundwater. Benzene and naphthalene were also identified in the CAP as CMCOCs. Based on Seasonal Soil Compartment (SESOIL) modeling results, it is anticipated that the soil concentrations for benzene and naphthalene will be reduced to their respective soil remedial levels before the groundwater concentration is reduced to its remedial level. See discussion regarding CMCOCs presented in the Corrective Action Plan (CAP) in Chapter 3.0. There is no principal-threat waste at the SWMU 13. No other source control measures are needed to control long-term threat of release.
Restoration of Groundwater	Groundwater will be restored to “beneficial use” through reduction of constituent of concern (COC) concentrations to less than the remedial levels that were developed based on maximum contaminant levels (MCLs)/risk-based concentrations (RBCs) in the baseline human health risk assessment (BHHRA) [Appendix H of the revised final Phase II RFI Report (SAIC 2000)] and revised in Chapter 2.0 of this CAP. Based on the results of the supplemental groundwater characterization performed in December 2000, benzene, ethylbenzene, and naphthalene were detected at concentrations above these remedial levels. Based on the results of the supplemental groundwater characterization performed in June 2002, benzene and ethylbenzene were detected at concentrations above their remedial level. Groundwater at this site is not used as a source of drinking water, and exposure of a future resident is highly unlikely. Results of Analytical Transient 1,2,3-Dimensional (AT123D) modeling predict that the COC concentrations in groundwater will decline to below the remedial levels in 6 years (included a 1-year contingency period). Although this time frame is longer than that required to reduce the maximum benzene concentration to below the remedial level by active remediation, this time frame is reasonable. Further migration of the plume will be prevented. The results from December 2000 showed reductions in the COC concentrations in downgradient wells MW10, MW11, and MW13 at SWMU 13. Exposure to contaminated groundwater will be prevented through continuation of groundwater use restrictions and excavation permit restrictions at SWMU 13. Groundwater at this site is not used as a source of drinking water. Further reduction in risk will occur as contaminant concentrations in groundwater continue to decline due to biodegradation, advection, and dispersion.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

ROLE OF MONITORED NATURAL ATTENUATION (CONTINUED)	
Soil Remediation	IMs were completed at SWMU 13 in 1997 and in 2001/2002 to remove and properly dispose of the fire training facilities and contaminated soil. There is no current risk due to direct exposure to soil. The soil contamination is confined to CMCOCs (arsenic, chromium, benzene, and naphthalene).
Public Involvement	The public will be provided with an opportunity for review and comment on the CAP in accordance with the Fort Stewart Hazardous Waste Facility Permit. The public will also be provided with an opportunity for review and comment on any substantive changes in the remediation approach or schedule that may arise during implementation of the corrective action.
Protective of Human Health and the Environment	Monitored natural attenuation is protective of human health and the environment at SWMU 13. Based on the conclusions of Sections 9.4 and 9.5 of the revised final RFI Report (SAIC 2000), there is no current human health or ecological risk associated with benzene or other COCs in groundwater. Potential future exposure is unlikely because the shallow groundwater is not a viable source of drinking water in the Fort Stewart Military Reservation (FSMR). Attainment of the remedial levels will effectively eliminate any potential future risk.
Capable of Achieving Remedial Objectives	The remedial objective is to attain media cleanup standards for COCs in groundwater. Results of AT123D modeling predict that benzene (used as a surrogate parameter for modeling) concentrations in groundwater will further decline to below their remedial levels in approximately 6 years (includes a 1-year contingency period), thereby achieving remedial objectives. The other COCs in groundwater are expected to reach their respective remedial levels within 1.5 years.
Capable of Achieving Objectives in Reasonable Time Frame	Results of AT123D modeling predict that the benzene concentrations (benzene was conservatively used as the surrogate COC for modeling) in groundwater will decline to below the remedial levels in 6 years (includes a 1-year contingency period). Although this time frame is longer than that expected to be required by complete active remediation this time frame is reasonable. The results from the December 2000 groundwater sampling show that the groundwater contamination plume is shrinking in size.
Demonstrated Effectiveness	Monitored natural attenuation has been demonstrated to be effective through technical analysis of modeling (AT123D analysis) of groundwater and analysis of geochemical data. Performance monitoring for monitored natural attenuation will include annual groundwater sampling to demonstrate the effectiveness of monitored natural attenuation. Performance monitoring of surface water is not necessary at SWMU 13 as the nearest surface water is located 2,500 feet from the site. Contingency (backup) measures are identified in the Operation and Maintenance (O&M) Plan (Appendix E) to ensure attainment of remedial objectives. Contingency measures include extension of active remediation and extension of monitoring.
DEMONSTRATION OF EFFICACY	
Site-specific Characterization: Conceptual Site Model	Former releases of fuel, water, and fire-fighting chemicals at SWMU 13 during fire fighting exercises or spills during operations have resulted in contamination of groundwater. Groundwater contaminated with benzene, ethylbenzene, and naphthalene at concentrations exceeding the remedial levels extends from the former fire training pad.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

DEMONSTRATION OF EFFICACY (CONTINUED)	
Nature and Distribution of Contamination in Groundwater	Groundwater contamination is confined to an oblong-shaped plume covering an area of approximately 10,100 ft^2 (as defined by December 2000 results). Supplemental groundwater characterization performed in December 2000 showed a decrease in the COC concentrations in the downgradient wells (MW10, MW11, and MW13); however, the concentrations at MW12 are relatively unchanged from the RFI results.
Nature and Distribution of Contaminant Sources	The first 4 feet of contaminated soil were excavated and disposed as part of the IM in 1997. During the 2001/2002 IRA, a 20-feet by 27-feet area was excavated to a dept of 12 feet. Therefore, the pathway of leaching from contaminated soil has been significantly minimized or eliminated.
Potential Risk or Impacts to Receptors	There is no current human health or ecological risk associated with exposure to COCs in groundwater. Potential future exposure is unlikely because the shallow groundwater is not a viable source of drinking water at FSMR. Attainment of the remedial levels for COCs will effectively eliminate any potential future risk for all the probable scenarios, as outlined in the BHHRA. No surface water is present at the site.
Proximity of Receptors	Surficial groundwater is not used as a source of drinking water. The underlying Principal Artesian (Floridan) Aquifer is the primary source of drinking water in the vicinity of FSMR. The closest surface water body is Peacock Creek located 2,500 feet from SWMU 13.
Quantitative Understanding of Source Mass	The two interim actions conducted at the site have removed the main sources of contamination; however, limited subsurface soil contamination may still remain in this area. Any soil contamination may represent a potential risk from contaminants potentially leaching to groundwater only. The soil contamination does not represent a risk to human health (HHCOC).
Groundwater Flow	The high water table and flat terrain cause the gradient to be highly susceptible to variation as a consequence of rain events. The predominant shallow surficial groundwater direction is to the east/southeast to southeast. The hydraulic gradient was determined to be approximately 0.004 foot/foot during the RFI and 0.0026 foot/foot during the supplemental sampling performed in December 2000. Recharge is by precipitation. The aquifer consists of widely varying amounts of sand and silty sands. With the addition of the new shallow monitoring wells (MW14 through MW19), the existing monitoring well network will adequately monitor the groundwater.
Contaminant Phase Distribution and Partitioning	There is no free-phase product (NAPL) present at SWMU 13. Any contaminants determined to still be present in subsurface soils are at depths greater than 12 feet and are most likely present due to contaminant transfer between the soils and groundwater as the water table fluctuates.
Rates of Biological and Non-biological Transformation	The rates of natural attenuation of benzene and other COCs potentially in groundwater have been simulated using AT123D modeling. The model accounts for fate and transport processes of advection, dispersion, adsorption/retardation, and biological decay. Biological transformation has been simulated assuming conservative biodegradation, literature-based values. Direct measurement of the nutrients, electron donors, or microbial population present has not been made.
Variation in Factors with Time	The former Fire Training Area is not currently being used.
Site-specific Analysis: Estimated Rate of Attenuation	The rates of natural attenuation of benzene and other COCs in groundwater have been simulated using AT123D modeling. These modeling results are presented in Appendix C of this CAP.
Anticipated Time Required to Achieve Remedial Objectives	Based on the results of AT123D modeling, the benzene concentrations in groundwater are expected to decline below the remedial levels in less than 6 years (from June 2002). This time period includes a 1-year contingency period. Concentrations of the other COCs are expected to decline to below their respective remedial levels before the 6-year time period.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

DEMONSTRATION OF EFFICACY (CONTINUED)	
Lines of Evidence (Three Tiers of Information)	The efficacy of monitored natural attenuation at SWMU 13 is evidenced by monitoring trends. These monitoring trends have shown decreasing benzene concentrations in groundwater samples near the former source (MW12) and downgradient from the former source (MW10). Hydrogeologic and geochemical data have been used to simulate the rate of attenuation. Appendix C of this CAP lists the data from site-specific characterization used in the analysis. Biological transformation has been simulated assuming conservative, literature-based values for biodegradation half-lives for the COCs in groundwater. Direct measurement of the nutrients, electron donors, or microbial population present has not been made.
APPROPRIATENESS	
Whether Contaminants in Soil or Groundwater Can Be Effectively Remediated by Natural Attenuation Processes	The COCs in groundwater can be effectively remediated by natural attenuation processes. Natural attenuation processes, particularly biological degradation, are well documented at diesel fuel spill sites. The COCs may naturally degrade through microbial activity and ultimately produce nontoxic end products (e.g., carbon dioxide and water). Four feet of contaminated soil was excavated from the site in 1997 and properly disposed. An additional excavation was conducted in 2001/2002 down to a depth of 12 feet to remove suspected contaminated soil. Residual contaminated soil may continue to cause leaching to the swale or the groundwater; however, only one of the CMCOCs (benzene) has been detected in groundwater. Natural attenuation is anticipated to remediate the COCs in groundwater in less than 6 years (from June 2002). The assumptions used by the model are highly conservative, and the time required to attenuate is likely to be overestimated.
Whether the Plume Is Stable or Whether Conditions Will Change Over Time	The groundwater contamination plume at SWMU 13 is not increasing in extent but shrinking. Results of monitoring have shown that benzene concentrations are decreasing at the former source area (MW13 and MW11) and at the edges of the plume (MW10). COC concentrations at MW12 remained relatively unchanged, which may have been attributed to residual subsurface soil contamination.
Whether Receptors Will Be Adversely Impacted	There is no current human health or ecological risk associated with exposure to the COCs in groundwater at the site. Potential future exposure is unlikely because the shallow groundwater is not a viable source of drinking water at FSMR. Attainment of the remedial levels will effectively eliminate any potential future risk. The nearest surface water body, Peacock Creek, is located 2,500 feet from the site. Based on the modeling performed in the revised final RFI Report (see Chapter 6.0), it is expected to take 178 years for the site groundwater to reach the nearest potential receptor. Therefore, receptors will not be adversely impacted by implementation of monitored natural attenuation.
Whether There Is a Current or Projected Demand for the Affected Resources	Shallow groundwater is not a viable source of drinking water. The underlying Principal Artesian (Floridan) Aquifer is the primary source of drinking water in the vicinity of SWMU 13. There is no anticipated demand for the affected groundwater source within the remediation time frame.
Whether Contamination Will Exert Long-term Detrimental Impact on Water Supplies/Resources	The shallow aquifer is not a viable source of drinking water. The groundwater COCs will be remediated at all points within the aquifer to below the remedial levels in less than 6 years. There will, therefore, be no long-term detrimental impact to water resources within the vicinity of SWMU 13.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

APPROPRIATENESS (CONTINUED)	
Whether the Estimated Time Frame of Remediation Is Reasonable	Results of AT123D modeling predict that benzene (the surrogate COC used for modeling) concentrations in groundwater will decline through natural attenuation from a predicted concentration at the source (MW12) of 211 μg/kg to below its remedial level of 5 μg/L in 7 years. The other groundwater COCs (ethylbenzene and naphthalene) will reach their respective remedial levels in less time. This time frame is considered reasonable.
Whether the Sources of Contamination Can Be Adequately Controlled	Four feet of contaminated soil was excavated from the site in 1997 and properly disposed. An additional 12 feet of contaminated soil was excavated from the site in 2001/2002 and properly disposed. Residual contaminated soil may continue to cause leaching to the swale or the groundwater; however, any continued leaching is expected to be minimal. The groundwater contamination plume at SWMU 13 has been shown to be shrinking. Results of monitoring have shown that benzene concentrations are decreasing at the former source area (MW13 and MW11) and at the edges of the plume (MW10). There is no free-phase product (NAPL) present at SWMU 13.
Whether Transformation Products Present a Greater Risk	Methane is a biodegradation product of benzene and is evidence that biodegradation is occurring. Methane is an odorless, colorless gas that is physiologically inert and poses no health risk. Methane is a simple asphyxiate; at high concentrations it can supplant oxygen in the air, creating an oxygen-deficient environment. It is also flammable and has a lower explosive limit in air of 5 percent. Methane monitoring will be performed during the monitored natural attenuation period. Other transformation products formed through subsequent biodegradation of methane include carbon dioxide and water, which pose no health risk.
Whether Active Remediation Measures Will Impact the Monitored Natural Attenuation	No active remediation measures are proposed.
Whether Reliable Institutional Controls Are Available for Monitoring and Enforcement	The U.S. Government will retain ownership of the Fire Training Area to ensure that monitoring and enforcement of the monitored natural attenuation O&M Plan are completed. Other institutional controls at SWMU 13 include groundwater use restrictions and excavation permits. These controls are reliable for the short-term duration for monitored natural attenuation (6 years).
REASONABLENESS OF REMEDIATION TIME FRAME	
Comparison to Other Alternatives	The groundwater COCs are expected to be reduced to less than their respective remedial levels by the selected remedial alternative, monitored natural attenuation in less than 6 years. This time frame is longer than the time required for active remediation alone however is considered to be reasonable for this site.
Balancing of Tradeoffs: <u>Classification, Value of Resource</u>	According to the Pollution Susceptibility Map of Georgia (GDNR 1992), SWMU 13 is located in an average or higher groundwater pollution susceptibility area. Shallow groundwater is not a viable source of drinking water.
<u>Timeframe in Which Aquifer Will Be Needed</u>	Shallow groundwater is not a viable source of drinking water. The underlying Principal Artesian (Floridan) Aquifer is the primary source of drinking water in the vicinity of SWMU 13. There is no anticipated demand for the affected groundwater resource within the time frame of this remediation (less than 6 years).
<u>Plume Stability Over Time</u>	The benzene plume at the SWMU 13 is not increasing in extent but shrinking. Results of monitoring have shown that benzene concentrations are decreasing at the former source area (MW13 and MW11) and at the edges of the plume (MW10).

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

REASONABLENESS OF REMEDIATION TIME FRAME (CONTINUED)	
Detrimental Impacts	The shallow aquifer is not a viable source of drinking water. The groundwater COCs will be remediated at all points within the aquifer to below their respective remedial levels in less than 6 years (from December 2000). There will, therefore, be no long-term detrimental impact to water resources within the vicinity of SWMU 13.
Uncertainties in Mass or Time Estimates	Chemical, hydrogeologic, and geochemical data are of adequate quality and usability. Data collection and laboratory analysis have been in accordance with approved U.S. Army Corps of Engineers procedures for assessing data quality, including data validation. The lateral and vertical extent of contamination has been defined adequately to provide accurate estimates of the mass of the COCs in groundwater. Time estimates have been made based on AT123D modeling using site-specific chemical, hydrogeologic, and geochemical data and a conservative literature-based value for the biodegradation rate of benzene and other COCs. Uncertainties inherent in these estimates are, therefore, acceptable. The O&M Plan (see Appendix E) has identified contingent measures to address uncertainties.
Reliability of Monitoring and Institutional Controls	The U.S. Government will retain ownership of SWMU 13 to ensure that monitoring and enforcement of the monitored natural attenuation O&M Plan are completed. Other institutional controls at SWMU 13 include groundwater use restrictions and excavation permits. Monitoring and institutional controls can be reliably implemented during the time frame for the remediation.
Public Acceptance of Time Frame	The public will be provided with an opportunity for review and comment on the CAP in accordance with the Fort Stewart Hazardous Waste Facility Permit. The public will also be provided with an opportunity for review and comment on any substantive changes in the remediation approach or schedule that may arise during implementation of the corrective action.
Provisions for Availability of Adequate Funding	Funding is assured through the U.S. Department of Defense, Environmental Remedial Action Program.
REMEDIATION OF SOURCES	
Removal of Contaminated Soil	An IM was completed at SWMU 13 in 1997 to remove and properly dispose of the fire training facilities and contaminated soil to approximately 4 feet bgs. An IRA was also completed at the site in 2001/2002 to remove the concrete pad and contaminated soil down to a depth of 12 feet. There is no current risk due to direct exposure to soil. The soil contamination is confined to CMCOCs (arsenic, chromium, and benzene). Results of AT123D modeling predict that benzene concentrations and other COCs in groundwater will decline to below their remedial levels in less than 6 years. Modeling indicates that natural attenuation will achieve the remedial levels in groundwater.
Free-phase NAPL Removal	No free-phase product (NAPL) is present at SWMU 13.
Treatment	Interim actions were completed at SWMU 13 in 1997 and in 2001/2002 to remove and properly dispose of the fire training facilities and contaminated soil up to 12 feet bgs.
Principal-threat Waste Treatment	Not applicable. There is no principal-threat waste.
Containment	Not applicable. No active sources of contamination are known to be present. Residual soil contamination is not migrating off site. Groundwater contamination is being naturally attenuated and is not migrating off-site.
PERFORMANCE MONITORING AND EVALUATION	
Location	Seven existing wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19) will be monitored.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

PERFORMANCE MONITORING AND EVALUATION (CONTINUED)	
Frequency	The monitoring frequency will be annually during the monitored natural attenuation period (6 years). Flexibility for adjusting the monitoring duration is provided through an analysis of trends and effectiveness of the corrective action as presented in the annual progress reports. In addition, baseline sampling will be conducted at the start of the remediation period and confirmatory sampling will be conducted 1 year after the conclusion of the monitored natural attenuation period.
Type of Samples	Only groundwater samples will be collected during the monitored natural attenuation annual performance monitoring. Performance monitoring in groundwater will provide sufficient demonstration of natural attenuation for protection of the surficial aquifer. Groundwater samples will also be collected during the baseline, and confirmatory sampling.
Measurements	Analytical parameters for groundwater will include VOCs, SVOCs, methane gas, carbon dioxide, nitrate/nitrite, sulfate/sulfide, and total iron. Field parameters for groundwater will be measured at the time of sampling and will include dissolved oxygen, temperature, oxidation-reduction potential, conductivity, pH, and ferrous iron.
Design: Demonstrate That Natural Attenuation Is Occurring as Expected	Monitoring of the seven monitoring wells provides suitable measurement of contaminant trends in wells within the plume, upgradient, and laterally to the side of the plume. Declines in COCs concentrations will demonstrate that degradation is occurring as expected.
Detect Changes (Hydrogeologic, Geochemical, and Microbial)	Presence of elevated methane gas concentrations in wells within the plume will demonstrate that biodegradation is occurring. Other geochemical parameters listed under “measurements” above will detect changes in the geochemical conditions at SWMU 13.
Identify Transformation Products	Presence of elevated methane gas concentrations in wells within the plume will demonstrate that biodegradation is occurring, resulting in methane as a transformation product.
Verify That the Plume Is not Expanding	Monitoring of wells MW3, MW9, MW10, MW15, MW16,, MW18, and MW19 provides suitable measurement of contaminant trends upgradient, and laterally to the side of the plume to verify that the plume is not expanding.
Verify That There Is No Unacceptable Impact to Downgradient Receptors	There are no potential downgradient receptors. Monitoring of wells MW9 and MW10 and newly installed well MW15 located at the perimeter of the plume will provide suitable measurement of groundwater quality just prior to its going off-site.
Detect New Releases	Low levels of residual soil contamination may still remain; however, only one of the CMCOCs has been detected in the groundwater. Monitoring of well MW3 upgradient of the site provides suitable detection of any changes in upgradient groundwater conditions.
Demonstrate Effectiveness of Institutional Controls to Protect Receptors	Shallow groundwater is not used as a drinking water supply. Monitoring of wells MW9, MW10, and MW15 provides suitable measurement of groundwater quality just prior to its going off-site.
Verify Attainment of Remediation Objectives	Monitoring of the seven wells (MW3, MW9, MW10, MW15, MW16, MW18, and MW19) provides suitable measurement of contaminant concentrations in wells within the plume, upgradient, and laterally to the side of the plume to verify that remediation objectives (remedial levels) have been attained throughout the shallow aquifer.
Duration	Monitoring will be conducted throughout the monitored natural attenuation period (estimated at 6 years) or until remedial levels (remediation objectives) are met. Flexibility for adjusting the duration is provided through an analysis of trends and effectiveness of the corrective action as presented in annual progress reports. Extending (or reducing) the duration of monitoring is a contingency remedy to be evaluated as part of the annual progress reports.

Table F-1. Implementation Checklist for Monitored Natural Attenuation for COCs[a] at the Former Fire Training Area (SWMU 13) (continued)

CONTINGENCY REMEDIES	
Remedy Evaluation	Results of monitoring well sampling and analysis, in particular an analysis of trends in the rate of decline in contaminant concentrations, will be evaluated on an annual basis throughout the monitored natural attenuation period. If trends do not match predicted modeled behavior, then contingencies will be considered, including: modifying the conceptual site model and/or hydrogeologic model, revising the AT123D model to correlate to new data, extending (or reducing) the duration of monitored natural attenuation, and potentially implementing active remediation.
Triggers: Concentrations Groundwater Show Increase	If benzene or other COC concentrations in any given well increase at least 50 percent for two consecutive annual sampling events, then a contingent remedy evaluation will be implemented.
Near-source Wells Show Increase (New Release)	If benzene or other COC concentrations in MW16 and MW18 increase to a level exceeding twice their predicted maximums by modeling, then a contingent remedy evaluation will be implemented.
Contaminants Are Found Outside the Original Plume Boundary	If benzene or other COCs concentrations are detected in any individual well at a level greater than previously detected concentrations, then a contingent remedy evaluation will be implemented.
Concentrations not Decreasing Sufficiently to Meet Remediation Objectives	If benzene or other COC concentrations exceed the predicted concentration by more than 25 percent for two consecutive annual sampling events, then a contingent remedy evaluation will be implemented.
Land and/or Groundwater Use Has Changed	If land use or groundwater use changes at the SWMU 13, then a contingent remedy evaluation will be implemented.

[a] This checklist follows U.S. Environmental Protection Agency guidance as described in Office of Solid Waste and Emergency Response Directive 9200.4-17P (EPA 1999).

References:

EPA (U.S. Environmental Protection Agency) 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites,* Directive 9200.4-17P, April.

GDNR (Georgia Department of Natural Resources) 1992. *Pollution Susceptibility Map of Georgia.*

SAIC (Science Applications International Corporation) 2000. *Phase II RCRA Facility Investigation Report for the Fire Training Area at Wright Army Airfield (SWMU 13), Fort Stewart Georgia,* May.