REVISED FINAL

CORRECTIVE ACTION PLAN
FOR THE
FORMER 724th TANKER PURGING STATION (SWMU 26)
FORT STEWART, GEORGIA

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

Prepared for:

U.S. Army Corps of Engineers
Savannah District
Under Contract DACA21-95-D-0022
Delivery Order Number 0034

Prepared by:

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

January 2000

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

No. 020201
1/13/00
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Project Manager
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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

AST	aboveground storage tank
AT123D	Analytical Transient 1-, 2-, 3-Dimensional (model)
CAP	Corrective Action Plan

COC	chemical/contaminant of concern
COPC	chemical/contaminant of potential concern
DAF	dilution-attenuation factor
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ESV	ecological screening value
FSMR	Fort Stewart Military Reservation
GEPD	Georgia Environmental Protection Division
GSSL	generic soil screening level
HDPE	high-density polyethylene
JP	jet propulsion
MCL	maximum contaminant level
MOGAS	motor gasoline
O&M	operation and maintenance
PAH	polynuclear aromatic hydrocarbon
PRE	preliminary risk evaluation
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RL	remedial level
SAIC	Science Applications International Corporation
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TPS	Tanker Purging Station
TRV	toxicity reference value
VOC	volatile organic compound

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EXECUTIVE SUMMARY

This report presents the Corrective Action Plan (CAP) for remediation of the Former 724th Tanker Purging Station (TPS), Solid Waste Management Unit (SWMU) 26, at Fort Stewart, Georgia. This CAP Report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0034.

Corrective action is required at SWMU 26 pursuant to 40 *Code of Federal Regulations* (*CFR*) 264.101(a) as referenced by the Rules of the Georgia Department of Natural Resources, Environmental Protection Division (GEPD), Chapter 391-3-11 Section .10. The CAP has been prepared in accordance with the recommendations of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), approved by the GEPD on January 21, 1999. The CAP addresses the requirements contained in the Fort Stewart Hazardous Waste Facility Permit No. HW-045 (S&T), as renewed August 1997.

The Former 724th TPS was located in the western cantonment area, which is in the southern portion of the Fort Stewart Military Reservation. The TPS was an area where tanker trailers that carried diesel, jet propulsion (JP-4) fuel, and motor gasoline (MOGAS) were routinely cleaned. During August 1996, the TPS was dismantled, the underground facilities were removed, and approximately 525 cubic yards of contaminated soil were excavated and replaced with clean backfill.

Results of the Phase II RFI concluded that soil and groundwater at the Former 724th TPS site are contaminated with organic compounds, predominantly benzene. This CAP report evaluates options for achieving the Remedial Levels (RLs) required by the Phase II RFI Report. The CAP analyzes the feasibility of applicable remedial technologies, then presents a conceptual design and implementation plan for the selected corrective action.

RESULTS OF THE PHASE II RFI

Nature and Extent of Soil Contamination. Contamination present in surface and subsurface soils is dominated by fuel-related chemicals such as benzene, ethylbenzene, toluene, and total xylenes (BTEX) and secondary polynuclear aromatic hydrocarbons (PAHs), such as naphthalene. Maximum BTEX concentrations reported in soil include benzene (9,420 μg/kg), toluene (27,400 μg/kg), ethylbenzene (27,100 μg/kg), and total xylenes (124,000 μg/kg). BTEX contamination in soil extends to the water table (approximately 6 feet deep) and is greatest immediately north and east of the area where contaminated soils were removed in August 1996. The remaining soil contamination covers an area approximately 60 × 75 feet.

Nature and Extent of Groundwater Contamination. Organic compounds exceed Maximum Contaminant Levels (MCLs) in the shallow water table aquifer near the source. Contaminants of concern (COCs) include predominantly BTEX compounds, with secondary contaminants such as acetone and naphthalene. BTEX contamination in groundwater extends to a depth of approximately 20 feet below the water table, although isolated areas of BTEX were found in groundwater to depths up to 40 feet. Maximum concentrations were found at the water table in a direct-push groundwater probe (GP-1) and include benzene (8,090 μg/L), toluene (4,200 μg/L), ethylbenzene (27,100 μg/L), and total xylenes (12,100 μg/L). The BTEX contamination covers a plume area approximately 100 feet wide by 160 feet long, extending from the Former 724th TPS facilities downgradient to the north and west.

No free petroleum product was encountered in any direct-push groundwater probe or in any well during the Phase II RFI. However, during supplemental groundwater sampling in September 1998, as much as 1.9 feet of free petroleum product was encountered at well MW-2 in the center of the former facility. As a result, a Ferret® free product recovery system was installed. Operation of the Ferret® system in ongoing, although there is little volume being recovered.

There is no evidence that contamination has migrated beyond the source, despite the presence of free product being discovered. No BTEX has been encountered at downgradient well MW-3. Mill Creek is more than 1,000 feet from the leading edge of the BTEX plume and is not being impacted by the contamination. Natural attenuation of the BTEX through biodegradation has occurred and is continuing, as evidenced by the presence of higher concentrations of methane, a breakdown product of BTEX degradation, in downgradient wells.

Concentrations of metals found during the Phase II RFI and the September 1998 supplemental groundwater sampling did not exceed MCLs or U.S. Environmental Protection Agency (EPA) Region II risk-based levels. No further corrective action for metals in groundwater is warranted.

Contaminant Fate and Transport. Organic compounds were detected in surface and subsurface soils at concentrations that exceed EPA Generic Soil Screening Levels and, therefore, could migrate from soils to the water table at concentrations exceeding their respective MCLs. These organics, which include BTEX, acetone, and naphthalene, have already reached the groundwater because of their high mobility and historically higher soil concentrations. However, groundwater movement off site is very slow (3.6 feet/year) and it may take 280 years for contaminants in groundwater to reach the nearest downgradient receptor location (Mill Creek). In addition, off-site migration of contaminants will be limited due to retardation and biodegradation as well as the slow movement of groundwater.

Human Health Risk Assessment. There were no human health COCs identified in the Phase II RFI Report in surface or subsurface soil as a result of direct exposure. No constituent was found to present a significant potential risk to receptors. Acetone, BTEX, and naphthalene were identified as contaminants in subsurface soil that may leach to groundwater at concentrations that would be unacceptable in terms of using groundwater as a drinking water source.

In groundwater, BTEX, acetone, and naphthalene were identified as COCs in the Phase II RFI Report. Maximum concentrations of these chemicals exceed their respective MCLs or EPA Region III risk-based values for groundwater ingestion. Other chemicals detected previously in groundwater, including arsenic, 1,1-dichloroethane, 1,2-dichloroethane, chloroform, and chloromethane, were not detected at concentrations exceeding their MCLs or EPA Region III risk-based values during the September 1998 supplemental groundwater sampling. Therefore, no corrective action is needed for those chemicals.

Ecological Risk Assessment. There are no ecological COCs at the Former 724th TPS. Therefore, no corrective action is needed to protect ecological receptors.

SUPPLEMENTAL SAMPLING AND MODELING

March 1999 Supplemental Groundwater Sampling. Four onsite monitoring wells (MW-1 through MW-4) were sampled in March 1999 and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and water quality parameters (nitrate/nitrite, sulfate/sulfide, iron, methane, and carbon dioxide).

Seven individual VOCs were detected in groundwater samples. BTEX compounds were detected predominantly in well MW-2, which is screened at the water table in the center of the former facility (i.e., the identified source). During sampling, approximately 0.02 feet of free product were encountered in well MW-2. Benzene (792 µg/L), ethylbenzene (206 µg/L), toluene (521 µg/L), and total xylenes (1,080 µg/L) were reported in MW-2. The concentration of benzene exceeded its MCL of 5 µg/L. Toluene and total xylenes were reported in well MW-4, which is screened in the deeper portion of the aquifer at concentrations scarcely above the detection limit. No BTEX compound was found in any of the other wells.

Other VOCs detected included 1,1-dichloroethane (0.88 µg/L at MW-3) and styrene (11.2 µg/L at MW-2). Methane gas was detected at 5,960 µg/L at MW-2. The combined observations of elevated methane, carbon dioxide, and total iron in MW-2 suggests that active biodegradation is occurring within the groundwater at the source.

Four separate SVOC compounds were detected in groundwater. Naphthalene, which had been detected at MW-2 in both of the two previous sampling events, was reported at 94.6 µg/L, which is less than its EPA Region III risk-based criterion of 150 µg/L. Other SVOCs were found at MW-2 in the March 1999 sampling event, but not during previous sampling, and include 2-methylnaphthalene (160 µg/L), phenanthrene (24.5 µg/L), pyrene (5.8 µg/L), and bis(2-ethylhexyl)phthalate (6.9 µg/L).

Supplemental Modeling for Evaluating Natural Attenuation. The Analytical Transient 1-, 2-, 3-Dimensional Model (AT123D) was used to determine whether monitored natural attenuation would be appropriate as a remedial approach for achieving RLs at the site. Benzene was selected as the surrogate chemical because it has a slower degradation rate and higher mobility than the other COCs. A steady-state AT123D model was developed by calibrating it against observed maximum concentrations of benzene in the groundwater beneath the Former 724th TPS site and assuming a constant source of contamination leaching to groundwater. Results of this modeling indicate that benzene concentrations in groundwater would not be expected to exceed its MCL at a distance of approximately 320 feet from the source. In addition, benzene will degrade from its observed maximum of 8,090 µg/L (direct-push probe GP-1) at the source to a concentration less than its MCL of 5 µg/L in less than 19 years, based on a conservative benzene biodegradation half-life of 2 years.

To evaluate the impact of residual leaching of benzene from soil, <u>Se</u>asonal <u>Soil</u> compartment modeling (SESOIL) runs were performed. The results of this modeling indicate that benzene concentrations in groundwater, due to leaching from source soils that have a maximum concentration of 9,400 µg/kg, will decline to less than the benzene MCL of 5 µg/L within 6 years.

JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION

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

The remedial response objectives for the Former 724th TPS are to reduce concentrations of BTEX in vadose zone soil to prevent further release to groundwater and minimize levels of contamination in groundwater to prevent off-site migration. The corrective action is to provide the technology necessary to minimize levels of contamination and achieve the best overall results with respect to such factors as effectiveness, implementability, and cost.

RLs for soil and groundwater were presented in the approved Phase II RFI Report. Soil RLs are based on leaching from soil to groundwater at levels exceeding MCLs or EPA Region III risk-based values. Groundwater RLs are based on MCLs, which take into consideration both human health and technological limitations. In the absence of an MCL, the EPA Region III risk-based values for groundwater were used for deriving RLs.

These soil and groundwater RLs are protective of direct exposure to residents by hazardous constituents in groundwater or that may leach from the soil to groundwater. However, it is recognized that groundwater is not used at this site as a source of drinking water. It may take 280 years for groundwater to reach the nearest downgradient receptor at Mill Creek, which is 1,200 feet from the former facility. Constituents will naturally attenuate in groundwater through retardation and biodegradation before reaching Mill Creek.

SCREENING OF CORRECTIVE ACTION ALTERNATIVES

Several technologies for remediating contamination in soil and groundwater were identified and screened. Technologies applicable to general response actions (no action, institutional controls, natural attenuation and long-term monitoring, 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 nearly 20 years required to meet the MCLs for the site. Institutional controls were not considered further since they are appropriate for this site only when combined with other technologies, such as monitored natural attenuation. In situ chemical oxidation using Geo-Cleanse® is not considered an acceptable technology since the depth to contamination at the site is less than the required 5 feet and because chemical oxidation would likely destroy the natural biodegradation processes that have been observed at the site. Soil vapor extraction was not considered applicable at this site due to the shallow thickness of the vadose zone (less than 6 feet) and the likelihood for short-circuiting of any applied vacuum.

The following six corrective action alternatives were evaluated further:

Alternative 1: Monitored natural attenuation,

Alternative 2: Excavation (soil) and air sparging (groundwater),

Alternative 3: Excavation (soil) and enhanced bioremediation (groundwater),

Alternative 4: Air sparging (groundwater) and monitored natural attenuation (soil and groundwater),

Alternative 5: Enhanced bioremediation (groundwater) and monitored natural attenuation (soil and groundwater), and

Alternative 6: PHOSter® II enhanced bioremediation (groundwater and soil).

Each of these alternatives is considered applicable to the site, cost-effective, and implementable. Therefore, two primary evaluation factors were used in the selection of the preferred corrective action alternative: time to implement and life-cycle cost. Time to implement the action is an to account for this uncertainty. In addition, contingent actions are identified in the O&M Plan (Appendix D) to ensure that RLs will be met.

The conceptual design of the groundwater treatment system is to operate the injection system over 4-hour cycles: air would be injected continuously in a given well for 4 hours, then turned off for 4 hours and subsequently turned back on. Because there are six injection wells, the conceptual design is to actively inject in 3 wells at any given time. Therefore the system will operate continuously, alternating between 2 sets of 3 wells each.

Four additional shallow monitoring wells (MW-6, MW-7, MW-8, and MW-9) and one additional deep monitoring well (MW-10) will be installed within the contamination plume where benzene concentrations in direct-push groundwater samples taken during the RFI were highest. The shallow wells will be screened to bisect the water table, for a total depth of less than 20 feet. The deep well will be screened between a depth of 35 and 45 feet. The wells will be used to more accurately observe the reduction in benzene concentrations during remediation and to verify the effectiveness of treatment after remedial activities are completed.

During O&M of the groundwater treatment system, the 4 existing and 5 new groundwater monitoring wells will be sampled to verify that benzene concentrations are declining and that active biodegradation is occurring. On a monthly basis, samples will be taken and analyzed at an off-site laboratory for BTEX and for natural attenuation parameters (methane, carbon dioxide, total phosphorous, nitrate/nitrite, sulfate/sulfide, and total iron). Field measurements will be made of dissolved oxygen, temperature, oxidation-reduction potential (Eh), conductivity, pH, and ferrous iron. A simplified respiration test will be run on one of the new monitoring wells (MW-6) during the monthly groundwater sampling by shutting off air injection and monitoring dissolved oxygen and carbon dioxide concentrations in the well for approximately eight hours.

Operation of the groundwater treatment system will be ceased upon attaining a maximum benzene concentration in any of the 9 on-site wells of 5 μg/L, as measured during the monthly groundwater monitoring. Confirmation groundwater sampling will be conducted at the end of the active treatment period to verify that the groundwater RLs have been achieved for all COCs. Upon completion of the nutrient/air injection (approximately 4 months), groundwater will be monitored on a quarterly basis for 1 year. Samples will be collected from each of the 9 on-site wells and analyzed for VOCs and PAHs. Analysis for PAHs in lieu of the full suite of SVOCs is appropriate because naphthalene is the only SVOC that is a COC at the site.

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

During the corrective action, progress reports as defined in Section 5.6 of this CAP will be prepared and submitted to GEPD for review. Upon completion of the corrective action, a Corrective Action Completion Report will be prepared and submitted to GEPD for review and approval. Decommissioning of the treatment system (Appendix D) will not begin until after approval of the Corrective Action Completion Report has been received by GEPD, and will include removal of all equipment and plugging and abandonment of any below-grade wells or piping.

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1.0 INTRODUCTION

1.1 SCOPE OF THE CORRECTIVE ACTION PLAN

A Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) has been completed for the Former 724th Tanker Purging Station (TPS), Solid Waste Management Unit (SWMU) 26, at Fort Stewart, Georgia. The Revised Final Phase II RFI Report submitted to the Georgia Environmental Protection Division (GEPD) on November 24, 1998, and accepted by GEPD in correspondence dated January 21, 1999, 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 and the supplemental groundwater investigations:

1. Because there are no ecological contaminants of potential concern (COPCs) at the Former 724th TPS, an ecological risk assessment is (ERA) not warranted.

2. Concentrations of metals found in groundwater during the Phase II RFI are similar to those found during the supplemental sampling. None of the metal concentrations exceeds maximum contaminant limits (MCLs) or U.S. Environmental Protection Agency (EPA) Region III risk-based levels. No further corrective action for metals in groundwater is warranted.

3. Free petroleum product was encountered at well MW-2 in the center of the former facility during the supplemental investigation, although at a substantially reduced thickness from previous sampling. Free product recovery, which has been undertaken at the site, should be continued until a final corrective action is implemented at the site.

4. Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds exceed MCLs in the shallow water table aquifer near the source. There is no evidence that contamination has migrated beyond the source, despite the presence of free product being discovered.

5. Natural attenuation of organics through biodegradation is occurring, as suggested by the presence of higher methane, alkalinity, and sulfate in downgradient wells.

6. Aerobic biodegradation of organic contaminants in groundwater is indicated by elevated concentrations of breakdown products, methane and carbon dioxide, in MW-2. Due to the presence of free product discovered in September 1998, trends in BTEX concentrations in all the site wells are not meaningful in assessing natural attenuation. The free product provides a continuing source of contaminants to the groundwater, so contaminant concentrations would not be seen to decline, even though natural attenuation is occurring.

7. Due to the presence of free product and BTEX compounds at concentrations in groundwater exceeding MCLs, a CAP will be required to evaluate measures to mitigate the effects of these contaminants.

This CAP report utilizes information from the Phase II RFI to evaluate institutional controls and various remedial actions for achieving the remedial levels (RLs) proposed in the Revised Final Phase II RFI Report. The options analyzed for achieving the stated RLs included an evaluation of monitored natural attenuation, in accordance with published guidance documents (EPA 1994b). Institutional controls are evaluated to ensure the safety of any personnel who may come in contact with the Former 724th TPS. This report analyzes the feasibility of the applicable remedial actions, monitored natural attenuation, and institutional controls 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 (S&T)], 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 No. 0034.

1.2 SITE BACKGROUND

A RCRA Facility Assessment (RFA) was submitted to the GEPD in June 1990 that listed 24 SWMUs, including the then active 724th TPS, as requiring further investigation (Geraghty and Miller 1992). The Former 724th TPS was located in the western cantonment area, which is in the southern portion of the Fort Stewart Military Reservation (FSMR). The TPS was an area where tanker trailers that carried diesel, jet propulsion (JP-4) fuel, and motor gasoline (MOGAS) were routinely cleaned. A Phase I RFI was initiated in 1993 in response to the RFA submittal. The objective of the Phase I RFI was to determine if releases to the environment had occurred from any of the 24 identified SWMUs, including potential contamination due to fuel leakage at the Former 724th TPS site.

During a site reconnaissance performed on November 8, 1993 during the Phase I RFI, on-site workers stated that a hydrocarbon layer approximately 2.5 feet thick was present in a temporary monitoring well located at the site. Black-stained soils and vegetation were present near the swale located on the west side of the site. A yellow-to-orange floating layer (apparent oil/water emulsion layer) was observed within both the swale and the pump control manhole. A petroleum hydrocarbon odor was noted and appeared to be originating on site (Rust 1996).

A tank tightness test was completed on the underground waste oil tank at the Former 724th TPS. This tank, identified as tank 4A at facility number 1840 (facility identification number 9-089065), failed the tightness test, according to the Tracer Research Corporation report (1994).

The Phase I RFI was completed in April 1996. Analytical results from soil sampling conducted during the Phase I RFI at the Former 724th TPS indicated fuel product and solvent contamination in the soil. During August 1996, the TPS was dismantled, the underground facilities were removed, and approximately 525 cubic yards of contaminated soil were excavated and replaced with clean backfill. The site was then reseeded.

Based on the findings of the Phase I RFI, GEPD instructed the Fort Stewart Directorate of Public Works to conduct a Phase II RFI. The objectives of the Phase II RFI for the Former 724th TPS, as defined in the Work Plan approved by GEPD on June 10, 1997, 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 a CAP if warranted.

The scope of the Phase II field work included the following activities:

- Collecting direct-push soil samples using a push probe at a total of 21 locations. Direct-push soil samples were analyzed for VOCs.
- Collecting direct-push groundwater samples using a push probe at a total of 17 locations, including 5 vertical profile probes. Direct-push groundwater samples were analyzed for VOCs.
- Installing five permanent groundwater monitoring wells both upgradient and downgradient of the site. Soil samples were collected from each well borehole and analyzed for VOCs, polynuclear aromatic hydrocarbons (PAHs), and RCRA metals.
- Collecting a groundwater sample from each of the five new wells. Groundwater samples were analyzed for VOCs, PAHs, and RCRA metals.
- Completing aquifer (slug) tests in each of the newly installed wells.
- Collecting surface water and sediment samples at a total of five locations within the swale adjacent to the site and within Mill Creek.

The Revised Final Phase II RFI Report was submitted to the GEPD in November 1998 and approved in January 1999. The results of the Phase II fieldwork are discussed in Section 2.0.

1.3 REGULATORY BACKGROUND

The regulatory authority governing the action at the Former 724th TPS is the RCRA 40 *Code of Federal Regulations* 264, Title II, Subpart C, Section 3004 (42 USC 690 et seq.). With the promulgation of RCRA and the subsequent approval of the Georgia Hazardous Waste Management Act by the EPA, the State was granted RCRA permitting authority. In accordance with RCRA, the State issued to Fort Stewart, in August 1987, a Hazardous Waste Facility Permit [Georgia Environmental Division Permit No. HW-045 (S&T)]. The permit was renewed in August 1997.

1.4 REPORT ORGANIZATION

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

This report also contains four appendices. Appendix A contains the supplemental sampling results from groundwater sampling activities in March 1999. Appendix B provides the detailed results of the natural attenuation modeling. Appendix C contains a cost estimate summary for corrective action Alternatives 1 through 6. Appendix D is an operation and maintenance (O&M) plan for the selected corrective action, PHOSter® II enhanced bioremediation system.

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

The Former 724th TPS (SWMU 26) was an area where tanker trailers that carried JP-4 jet fuel, diesel, and MOGAS were routinely cleaned. The Former 724th TPS is located in the western cantonment area in the 1800 block of McFarland Avenue, at the western end of the fuel truck parking area. The former TPS occupied an area approximately 30 feet by 50 feet (Rust 1996) located between the chain-link fence at the parking area (western end) and a shallow swale approximately 25 feet to the west (Figure 2-2). The former site facilities included an underground waste oil tank and oil/water separator, an aboveground storage tank (AST) that received water after oil/water phase separation, and an underground pump with surface access and pumping controls for pumping water into the AST.

The Former 724th TPS was constructed in 1982 and taken out of service in March 1996. During August 1996 the purging station was dismantled, the underground facilities were removed, and approximately 525 cubic yards of contaminated soil were excavated and replaced with clean backfill. Soil was excavated to the water table at the former facility (approximate depth of 3 to 10 feet) and to a depth of 6 inches in the adjacent swale. All equipment, above ground and below ground, was removed from the site during removal activities.

Potentially contaminated materials used or generated at the Former 724th TPS included waste liquids from the purging of fuel tankers. These waste liquids contained assorted petroleum hydrocarbons, such as diesel, JP-4, and MOGAS (Geraghty and Miller 1992). In addition, various additives, which included Citrikleen™ (Pentebose Corp.), purging fluid MIL-F-38299B AM.2 (Exxon Chemicals America), and a petroleum distillate-based purging solution (Continental Chemicals Corp.) were added to the purging water to aid in the cleaning of the fuel tankers.

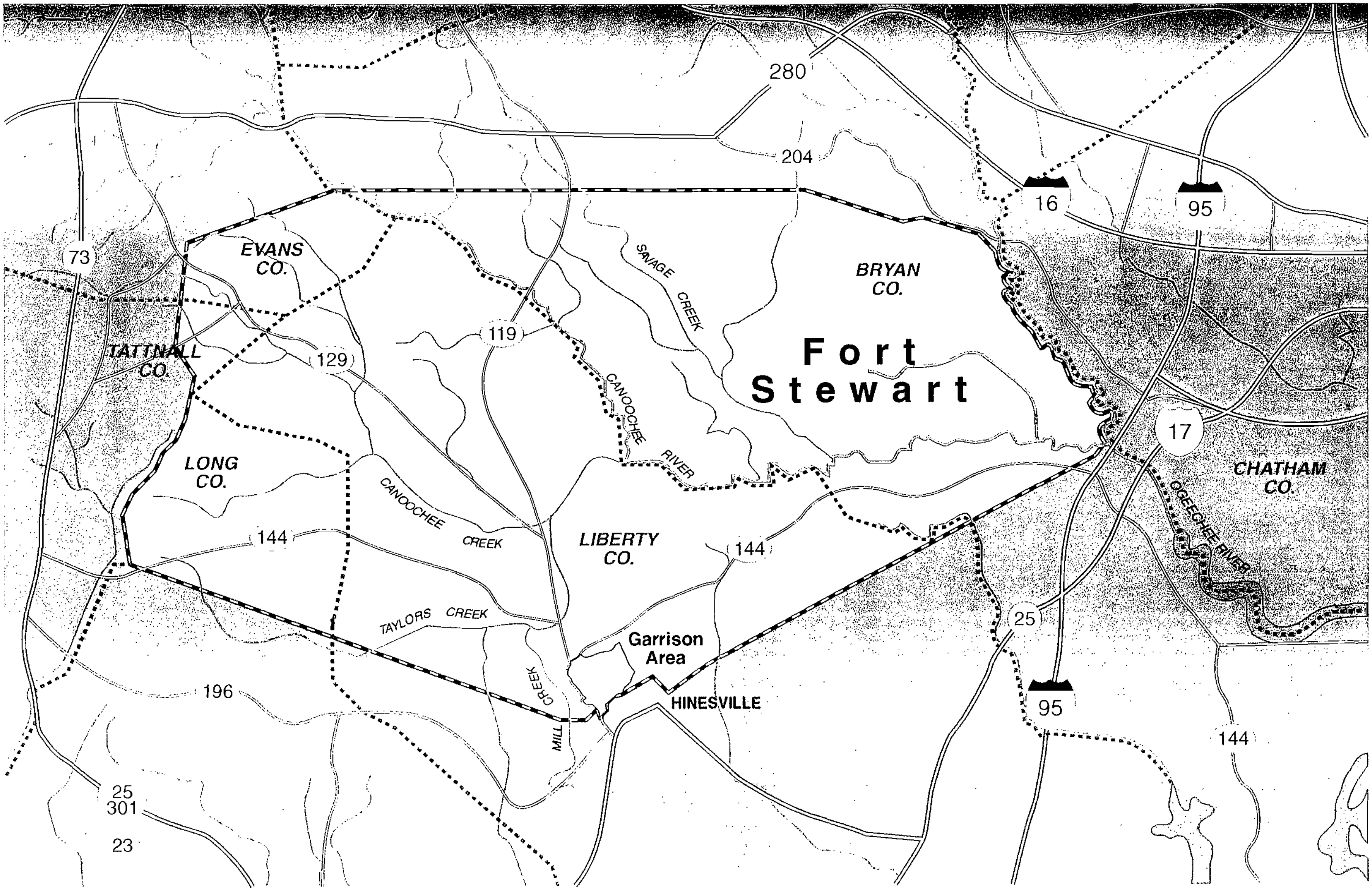

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Figure 2-1. Location Map for Fort Stewart Military Reservation, Georgia

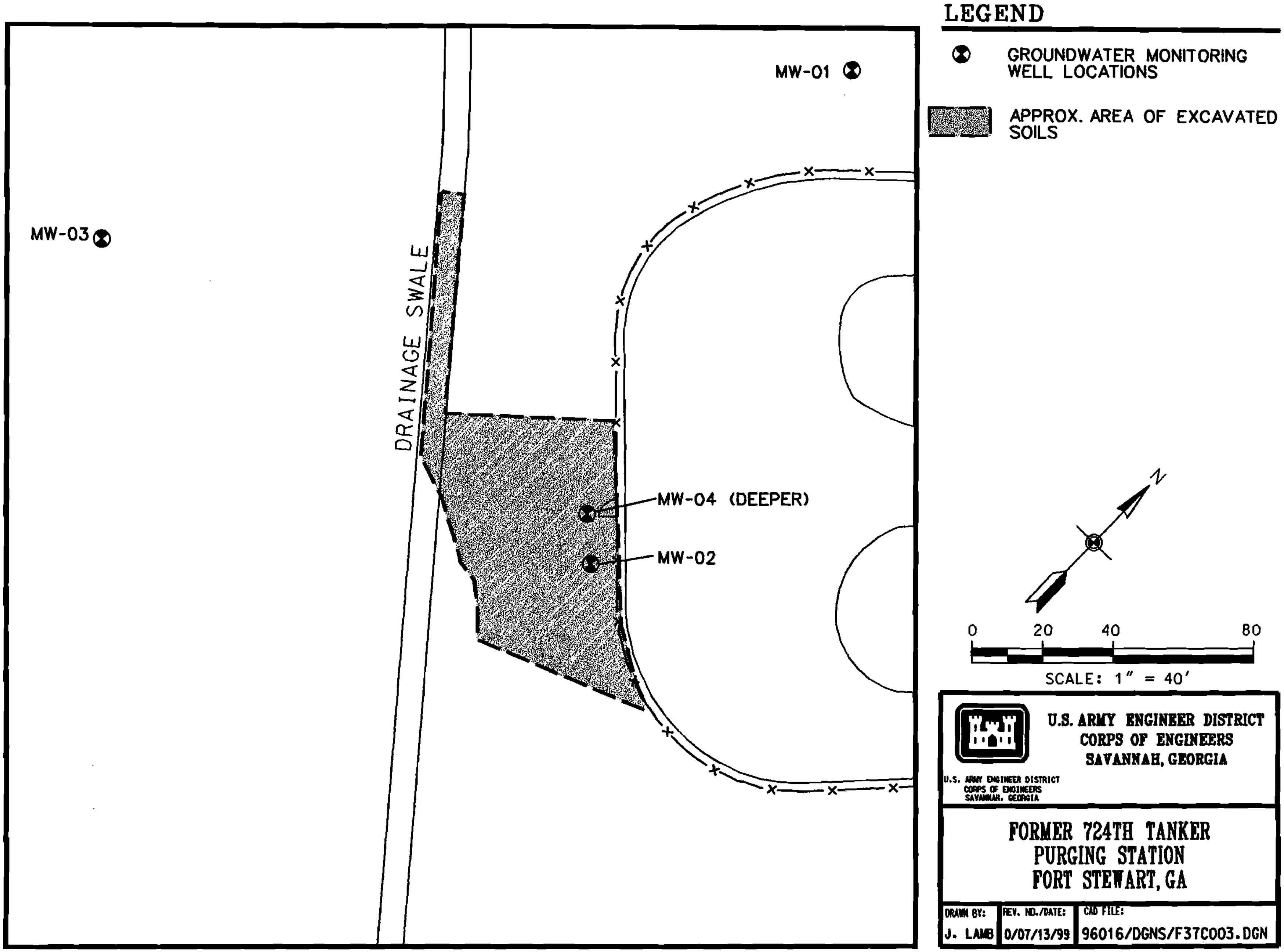

Figure 2-2. Location of the Former 724th Tanker Purging Station (SWMU 26)

2.2 PHYSICAL CHARACTERISTICS OF THE SITE

The Former 724th TPS occupied an area approximately 30 feet by 50 feet, located between a fuel truck parking area to the east and a shallow swale to the west. The topography at the site varies between 60 and 70 feet mean sea level. The drainage swale receives runoff from the site and the adjacent fuel truck parking area, but is not connected to Mill Creek or its tributaries. Mill Creek is the nearest surface water stream to the Former 724th TPS and is located approximately 1,200 feet west (i.e., downgradient) of the site (SAIC 1998).

2.3 SITE GEOLOGY

The surficial soils at the site are generally a light gray sand or silty sand up to 15 feet thick. Interbedded clayey sand and sandy clay layers generally underlie these surficial sandy layers to a depth of 15 to 25 feet. A light gray to greenish gray sand and silty sand was encountered beneath these clayey layers and varied from 5 to 15 feet thick. A dark greenish gray silty and clayey sand with shells (typical of the Hawthorn formation) was present in the lower portion of the soil profile to the maximum depth explored (51 feet). Results of geotechnical analyses indicated that the soils tested are generally non-plastic silty to clayey sands, with between 4 and 48 percent by weight fine-grained particles. One soil sample from well MW-1 located northeast of the site consisted of a clayey sand having high plasticity and a low laboratory permeability of 2×10^{-6} cm/second. Results of aquifer (slug) tests indicated hydraulic conductivities ranging from 2.0×10^{-5} to 4.0×10^{-4} cm/second for the five wells (SAIC 1998).

2.4 SITE HYDROLOGY

The uppermost hydrogeologic unit is the surficial aquifer, which ranges from 55 to 150 feet in thickness at the FMSR. Water levels measured during well development and sampling varied from the shallowest (3 feet) at MW-1, to the deepest (10 feet) at MW-5 located near Mill Creek. Groundwater flow within the water table is to the west-northwest, ultimately discharging to Mill Creek approximately 1,200 feet from the site. The horizontal gradient is approximately 0.01 feet/feet at the site, and approximately 0.0083 feet/feet between the site and Mill Creek. The calculated groundwater flow velocity averages approximately 3.6 feet/year toward Mill Creek.

Monitoring well MW-4 is screened within the surficial aquifer at a depth of 35 to 45 feet below ground surface. Water levels in MW-4 were compared to those in an adjacent well, MW-2, which is screened at the water table. Water levels in the deeper well MW-4 were 2.87 feet lower than in MW-2, indicating a downward hydraulic gradient of 0.082 feet/feet. The downward gradient may indicate that the clayey sand layers act as a semiconfining unit, restricting downward migration of groundwater (SAIC 1998).

2.5 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 11 percent of the base 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 (Environmental Science and Engineering 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 1998).

2.6 CONTAMINANT NATURE AND EXTENT

Results of chemical analyses indicate that soils, groundwater, surface water, and sediment at the site contain organic and metal contaminants at concentrations greater than their reference background concentrations. The predominant contaminants in both soil and groundwater are fuel-related chemicals such as BTEX compounds, with secondary contaminants such as acetone, 1,2-dichloroethane, and naphthalene.

2.6.1 Phase II RFI Results

Contamination present in surface and subsurface soils is dominated by BTEX and secondary PAH contaminants. Maximum BTEX concentrations reported in soil include benzene (9,420 µg/kg), toluene (27,400 µg/kg), ethylbenzene (27,100 µg/kg), and total xylenes (124,000 µg/kg). BTEX contamination in soil extends to the water table (approximately 6 feet deep) and is greatest immediately north and east of the area where contaminated soils were removed in August 1996. The remaining BTEX soil contamination covers an area approximately 60 by 75 feet.

Acetone was detected in a direct-push soil sample (S-10) at a concentration of 1,060 µg/kg, but was found at a maximum of only 27 µg/kg in any soil boring sample (MW-2). Naphthalene was detected in a subsurface soil sample from boring MW-2 at a concentration of 4,160 µg/kg.

BTEX contamination in groundwater extends to a depth of approximately 20 feet below the water table, although isolated areas of BTEX were found in groundwater to depths up to 40 feet. Maximum concentrations were found at the water table in a direct-push groundwater probe (GP-1) and include benzene (8,090 µg/L), toluene (4,200 µg/L), ethylbenzene (2,870 µg/L), and xylenes (12,100 µg/L). These concentrations exceed the respective MCLs for each chemical. Maximum concentrations found in a monitoring well (MW-2) were lower and include benzene (329 µg/L), ethylbenzene (62.3 µg/L), toluene (72.6 µg/L), and total xylenes (296 µg/L). The BTEX contamination covers a plume area approximately 100 feet wide by 160 feet long, extending from the Former 724th TPS facilities to the north and west. Mill Creek is more than

1,000 feet from the leading edge of the BTEX plume and is, therefore, not being impacted by the contamination. Biodegradation of the BTEX is likely occurring, as evidenced by the presence of methane, a breakdown product of BTEX degradation (SAIC 1998). Acetone was detected at a maximum concentration of 1,450 µg/L in a direct-push groundwater sample (GP-2 at a depth of 30 to 34 feet), but was not found in any monitoring well sample. Naphthalene was detected in the groundwater sample from well MW-2 at a concentration of 10.5 µg/L. 1,2-Dichloroethane was also found in MW-2 at a concentration of 7.6 µg/L and is considered a secondary contaminant within the primary BTEX plume.

Limited metal contamination is present at the site and in the swale immediately west of the site. In surface and subsurface soils at the site, maximum concentrations of cadmium (0.44 mg/kg), chromium (12.9 mg/kg), and mercury (0.06 mg/kg) were reported. In groundwater at the site, maximum concentrations of arsenic (3.5 µg/L), barium (99.2 µg/L), mercury (0.3 µg/L), and silver (4.1µg/L), were reported, although concentrations in the upgradient well MW-1 were generally higher than those in the downgradient wells and, therefore, may not be site related. In sediments within the swale, concentrations of barium (29.2 mg/kg), mercury (0.07 mg/kg), and silver (2.6 mg/kg) were reported at levels above reference background criteria for both sediment and soil media; chromium (4.4 mg/kg) and lead (6.6 mg/kg) were both higher than reference background criteria for sediment, but below the criteria for surface soil and, therefore, may not be site related. In surface water, concentrations of cadmium (1.7 µg/L), lead (10.8 µg/L), mercury (0.18 µg/L), and silver (1.3 µg/L) were reported at levels above reference background criteria for both surface water and groundwater; arsenic (1.8 µg/L) was higher than reference background for surface water, but below the criteria for groundwater and, therefore, may not be site related (SAIC 1998).

Constituents detected during the Phase II RFI in Mill Creek are not related to the Former 724th TPS, since neither contaminated groundwater nor runoff from the site discharge directly to the creek.

2.6.2 September 1998 Supplemental Sampling Results

Based upon the results of the original Phase II RFI at the Former 724th TPS, a supplemental characterization was conducted in September 1998 to verify concentrations of metals in groundwater and to provide further evidence that natural attenuation of VOCs is occurring. The scope of work included sampling of the four on-site monitoring wells (MW-1 through MW-4) and analyzing the samples for VOCs, PAHs, RCRA metals, and water quality parameters. Results of this supplemental investigation are summarized below (SAIC 1998).

VOCs. Seven individual VOCs were detected in groundwater samples. BTEX compounds were detected only in a single well, MW-2, which is screened at the water table and located in the center of the former facility (i.e., the identified source). During sampling, approximately 1.9 feet of free petroleum product were encountered in MW-2; no free product had been encountered in any of the direct-push groundwater samples or any of the wells during the Phase II RFI in August 1997. An absorbent sock was inserted into the well once the free product was discovered. A Ferret® system was installed on October 20, 1998, in MW-2 for recovery of the free product and to replace the absorbent sock. Operation of the Ferret® system began on November 16, 1998, when power hookup was complete, and is ongoing, although there is little volume being recovered.

Benzene (1,350 µg/L), ethylbenzene (477 µg/L), toluene (1,540 µg/L), and total xylenes (2,350 µg/L) were reported in MW-2. The concentrations of benzene and toluene exceeded their respective MCLs of 5 µg/L and 1,000 µg/L. No BTEX constituent was found in any of the other wells, confirming the Phase II RFI conclusions that contaminants have not migrated vertically or laterally from the source at the former facility.

The other VOCs that were detected included chloroform (18.7 µg/L at MW-2); 1,1-dichloroethane (1.4 µg/L at MW-3); and 2-hexanone (6.7 µg/L at MW-3). Chloroform and 2-hexanone are common laboratory contaminants and were not detected in these wells during the Phase II RFI and are, therefore, not likely a result of contaminant releases from the former facility. 1,1-Dichloroethane was detected in MW-3 during the Phase II RFI at a concentration of 2.2 µg/L and is considered a secondary contaminant within the primary BTEX plume. Acetone was not detected in any groundwater sample during the September 1998 supplemental sampling.

Samples submitted for methane, ethane, and ethene gaseous organic analysis were lost due to laboratory handling errors. Therefore, additional samples were collected in January 1999 for analysis of methane, ethane, and ethene. Methane was the only gaseous organic compound detected. Methane was detected at the background well (MW-1) at 189 µg/kg and at each of the downgradient wells (MW-2, MW-3, and MW-4) at concentrations of 2,440 µg/kg, 3,310 µg/kg, and 352 µg/kg, respectively. The elevated methane concentrations in downgradient wells indicate that biodegradation of contaminants has occurred and is continuing.

PAHs. Naphthalene was the only PAH compound detected in groundwater. Naphthalene was reported at 242 µg/L at MW-2, which exceeds its EPA Region III risk-based criterion of 150 µg/L. Naphthalene was also detected in MW-2 during the Phase II RFI. The increase in the concentration of naphthalene is likely due to the presence of the free product found during the supplemental sampling.

RCRA Metals. Four metals were detected in the groundwater samples, including arsenic, barium, chromium, and mercury. These metals were detected above the reference background criteria and in the same wells as detected during the Phase II RFI sampling in August 1997. None of the metals exceeded its respective MCL. Silver, which was detected above background in the original Phase II RFI sampling, was not detected above background in the supplemental sampling.

- Arsenic (maximum 16.4 µg/L) was found at its highest concentration in the upgradient well MW-1 and is, therefore, not considered site related.

- Barium (maximum 87.9 µg/L) and mercury (maximum 0.59 µg/L) were found at concentrations above background in well MW-4, screened at a depth of 35 to 45 feet. In other wells, barium and mercury were found at or below reference background criteria. Because these metals do not migrate readily and are only present at depth, they are not likely related to any contaminant plume emanating from the facility.

- Chromium (maximum 6.1 µg/L) was found in MW-2 at a concentration only slightly above reference background criteria and marginally higher than that found during the Phase II RFI (2.4 µg/L). Chromium was not detected in any of the other wells in the vicinity of the Former 724th TPS and was detected at a concentration well below its MCL (100 µg/L) and its EPA Region III risk-based criterion (180 µg/L). Therefore, no further action is warranted for chromium in groundwater at the facility.

Other Analytes. Alkalinity varied between 102 and 321 mg/L (lowest at the upgradient well MW-1 and highest in the deeper well MW-4). Sulfate varied between 0.18 and 11.4 mg/L (lowest at well MW-2 and highest at MW-4). These results are consistent with the results of the Phase II RFI and suggest that biodegradation is occurring, resulting in higher alkalinity and sulfate content in the downgradient wells.

2.7 CONTAMINANT FATE AND TRANSPORT

A contaminant fate and transport analysis which provided an assessment of the potential migration pathways and transport mechanisms affecting the chemical compounds found at the site was performed and presented in Section 6.0 of the Phase II RFI Report (SAIC 1998).

The following summarizes the conclusions regarding contaminant fate and transport:

- Metals are not considered contaminants of potential concern (COPCs) for contaminant migration, mainly due to their low concentrations in the soils.

- Some organics in the site soils exceed EPA Generic Soil Screening Levels (GSSLs) and are, therefore, of concern for leaching from soils to groundwater. These organics include BTEX, acetone, and naphthalene. Due to their high mobility, these organics have already reached the groundwater. However, groundwater movement offsite is very slow (3.6 feet/year) and may take 280 years to reach the nearest downgradient receptor location (i.e., Mill Creek).

The organic compounds that are currently observed above their respective MCLs in groundwater are BTEX and acetone. Based on the site conceptual model, these contaminants may have been leaching (and may continue to leach in the future) from the contaminated soils into the groundwater beneath the site with concentrations above their MCLs. However, off-site migration of these constituents will be limited due to retardation and biodegradation as well as the slow movement of groundwater. Benzene will degrade to a concentration less than its MCL in 22 years, having traveled less than 80 feet from the source. Similarly, ethylbenzene, toluene, xylene, and acetone, with higher biodegradation rates, will remain at concentrations much lower than benzene. Therefore, none of the constituents from the Former 724th TPS site are expected to be of potential concern at the nearest downgradient receptor location [i.e., Mill Creek (1,200 feet from the former facility)].

2.8 PRELIMINARY RISK EVALUATION

2.8.1 Human Health Risk Assessment

The human health risk assessment conducted during the Phase II RFI included a Step 1 risk evaluation to determine potential human health risks associated with the contaminants. COPCs were identified 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 1998).

In surface soil, no COPCs were identified for human health, because no constituent exceeded its respective risk-based screening criterion for exposure to a residential receptor.

In subsurface soil, no COPCs were identified for human health as a result of direct exposure; therefore, no constituent was found to present a significant potential risk to receptors. As discussed for fate and transport, acetone, BTEX, and naphthalene were identified as contaminants in subsurface soil that may leach into groundwater at concentrations that are unacceptable in terms of using groundwater as a drinking water source.

In groundwater, COPCs were identified initially as acetone, arsenic, 1,1-dichloroethane, 1,2-dichloroethane, chloroform, chloromethane, and BTEX. These constituents were found to present a potential threat to human health as a result of using groundwater as a source of drinking water. However, the maximum concentration of arsenic found in a downgradient well (3.5 µg/L) was below its MCL of 50 µg/L and was only slightly above its reference background concentration of 3.02 µg/L. Arsenic exceeded background in only a single downgradient well (MW-2) and was reported at an even higher concentration in the site-specific upgradient well (10.1 µg/L at MW-1). Therefore, arsenic in groundwater was not considered site related and was not identified as a COPC.

In addition, use of the surficial groundwater at this site for drinking water is highly unlikely. 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 was not considered to be a viable exposure scenario. However, drinking water screening values were used in the absence of more appropriate values.

In surface water and sediment, no human health COPCs were identified because no constituent exceeded its respective risk-based criterion for exposure to a residential receptor.

2.8.2 Ecological Risk Assessment

The ERA conducted during the Phase II RFI provided a preliminary risk evaluation (PRE) for potential terrestrial and aquatic receptors at the site. The PRE for the Former 724th TPS identified ecological COPCs in surface water, sediment, and groundwater based on a comparison of their maximum site concentrations to their EPA Region 4 ecological screening values (ESVs). Preliminary risk calculations for identified ecological COPCs in Mill Creek surface water were based on a comparison of detected concentrations to toxicity reference values (TRVs) for surrogate species representing ecological receptors (SAIC 1998). TRVs are derived from no observed adverse effect levels from laboratory toxicity studies on test species.

Chromium was the only chemical detected in surface soil at the Former 724th TPS at concentrations that exceeded both its reference background criteria and its TRV for an ecological receptor (robin). There is uncertainty about whether earthworms from the Former 724th TPS will constitute 20 percent or more of the diet of robins foraging at the site. Thus, robins are unlikely to be at risk from chromium in surface soil.

There is uncertainty about whether ethylbenzene, benzo(b)fluoranthene, and styrene are ecological COPCs in surface soil, because there are no TRVs for these substances. Benzo(b)fluoranthene and styrene were not present in surface soil at the site, but were detected in soil only at MW-5 (adjacent to Mill Creek) at concentrations near their detection limit and are, therefore, not site related. Ethylbenzene was detected in surface soil at MW-2 and is related to former releases at the site. However, ethylbenzene in surface soil is unlikely to pose a risk to ecological receptors given the low concentration (0.02 mg/kg) relative to the TRV proposed for ethylbenzene in the Phase II RFI report of 8.4 mg/kg (one-tenth the TRV for total xylenes). There are, therefore, no ecological COPCs in surface soil.

Barium and silver were identified as ecological COPCs in sediment in the drainage swale, but exposure of sediment-dwelling biota to sediment in the swale was judged to be unlikely. The swale is an ephemeral surface water body, as shown by the lack of water at SWS-3 at the time of the Phase II RFI sampling, and is unlikely to support a community of aquatic sediment-dwelling organisms. Exposure of other types of receptors (e.g., terrestrial animals) to swale sediment by direct contact and ingestion is likely to be minimal. There are, therefore, no ecological COPCs in sediment in the swale.

Cadmium, lead, and silver were detected in surface water in the drainage swale at the Former 724th TPS at concentrations that exceed reference background criteria and which also exceed EPA Region 4 ESVs for aquatic biota. However, there are no aquatic biota or other ecological receptors of concern in the man-made swale. Maximum surface water concentrations of cadmium and lead do not exceed their published TRVs for terrestrial receptors (raccoons) and are, therefore, not of concern. There is uncertainty about whether silver is of concern because there is no published TRV for silver. There are, therefore, no ecological COPCs in surface water in the swale.

According to EPA Region 4 guidance, groundwater is to be treated as surface water in the ecological PRE. Treating groundwater as surface water is realistic at the Former 724th TPS site because groundwater may discharge to the drainage swale next to the site during times of high groundwater levels.

Barium, mercury, silver, benzene, and chloromethane are present in groundwater at the Former 724th TPS at concentrations that exceed reference background criteria and which also exceed EPA Region 4 ESVs for surface water. However, there are no aquatic biota or other ecological receptors of concern in the man-made swale. Maximum groundwater concentrations of barium, mercury, and benzene do not exceed a published TRV for terrestrial receptors (raccoons) potentially ingesting groundwater as surface water; therefore, these metals are not of concern for terrestrial receptors. There is uncertainty about whether silver or chloromethane are ecological COPCs in groundwater because there are no published TRVs for them, so that they are potentially of concern for raccoons, by default. However, silver and chloromethane concentrations are higher in the upgradient well (MW-1) and are not considered site related. There are, therefore, no ecological COPCs in groundwater at the site.

In Mill Creek, mercury was identified as an ecological COPC in surface water based on comparison to EPA Region 4 ESVs. Mercury is also an ecological COPC in surface water for protection of terrestrial predators (mink, green heron) in Mill Creek based on comparison to their TRVs. In Mill Creek sediment, no ecological COPCs were identified, although there is uncertainty about barium, since there are no published values for barium, making it a COPC by default. Ecological risks in Mill Creek are not related to the Former 724th TPS for the following reasons:

- As concluded in the fate and transport evaluation, off-site migration of contaminants would be very limited because of retardation and biodegradation, as well as the slow movement of groundwater. Mill Creek is the nearest downgradient surface water stream to the Former 724th TPS and is located approximately 1,200 feet west of the site. It would take more than 280 years for any contaminant to reach Mill Creek. Therefore, migration of contaminants to Mill Creek via groundwater discharge is unlikely, and there is no complete pathway from groundwater to potential ecological receptors in Mill Creek.

- The drainage swale accepts runoff from the site and the adjacent fuel truck parking area but is not connected to Mill Creek or its tributaries. Therefore, migration of contaminants to Mill Creek via surface water runoff is also not likely, and there is no complete pathway from the Former 724th TPS to potential ecological receptors in Mill Creek.

2.9 SUPPLEMENTAL SAMPLING AND MODELING

Based upon the results of the Revised Final Phase II RFI Report for the Former 724th TPS, a second supplemental characterization was conducted in March 1999 to support the preparation of this CAP and to provide further evidence that natural attenuation of VOCs is occurring. Fate and transport modeling was then performed to develop chemical-specific dilution-attenuation factors (DAFs) for chemicals of concern at the site.

2.9.1 March 1999 Supplemental Groundwater Characterization

The scope of work for the supplemental characterization included sampling the four on-site monitoring wells (MW-1 through MW-4) and analyzing the samples for VOCs, semivolatile organic compounds (SVOCs), and water quality parameters (nitrate/nitrite, sulfate/sulfide, iron, methane, and carbon dioxide). Results of this supplemental investigation are presented in Appendix A and summarized below. Table 2-1 summarizes the supplemental sampling results in comparison to background levels and MCLs.

Table 2-1. Summary of Analytical Results in Groundwater (March 1999)
Former 724th Tanker Purging Station, Fort Stewart

Parameter	**Reference Background Criteria**	**MCL**	**Monitoring Well ID**			
			MW-1	**MW-2**	**MW-3**	**MW-4**
Volatile Organic Compounds (μg/L)						
1,1-Dichloroethane	0.0	5			**0.88**	
Benzene	0.0	5		***792***		
Ethylbenzene	0.0	700		**206**		
Methane	0.0			**5,960**		
Styrene	0.0			**11.2**		
Toluene	0.0	1,000		**521**		**0.6**
Xylenes, total	0.0	10,000		**1,080**		**0.62**
Semivolatile Organic Compounds (μg/L)						
2-Methylnaphthalene	0.0			**160**		
Naphthalene	0.0			**94.6**		
Phenanthrene	0.0			**24.5**		
Pyrene	0.0			**5.8**		
Bis(2-ethylhexyl)phthalate	0.0	6		**6.9**		
Other Analytes (mg/L)						
Nitrate	0.5	10	0	0	0	0
Sulfate	26.7		1.92	2.29	**49.2**	6.59
Carbon dioxide	–		112	337	51.6	35.1
Total dissolved solids	–		140	396	365	406
Iron (total)	–		31.4	155	29.4	4.66

Bold outlined box with ***bold italicized*** type indicates concentration above maximum contaminant level (MCL).
Bold type indicates concentration above Fort Stewart Military Reservation reference background criteria.
Blank indicates analyte not detected.

VOCs. Seven individual VOCs were detected in groundwater samples. BTEX compounds were detected predominantly in well MW-2, which is screened at the water table and located in the center of the former facility (i.e., the identified source). During sampling, approximately 0.02 foot of free petroleum product was encountered in MW-2, which is significantly less than the 1.9 feet of free product that were reported in MW-2 in September 1998.

Benzene (792 μg/L), ethylbenzene (206 μg/L), toluene (521 μg/L), and total xylenes (1,080 μg/L) were reported in MW-2. The concentration of benzene exceeded its MCL of 5 μg/L. Toluene and total xylenes were reported in well MW-4, which is screened in the deeper portion of the aquifer, at concentrations scarcely above the detection limit. No BTEX constituent was found in any of the other wells, confirming the Phase II RFI conclusions that contaminants have not migrated vertically or laterally from the source at the former facility.

The other VOCs that were detected included 1,1-dichloroethane (0.88 μg/L at MW-3) and styrene (11.2 μg/L at MW-2). 1,1-Dichloroethane was detected in MW-3 during the Phase II RFI at a concentration of 2.2 μg/L and is considered a secondary contaminant within the primary BTEX plume, as also concluded in the Phase II RFI report. Styrene had not been previously detected. Methane gas was detected at 5,960 μg/L in MW-2. This suggests that active biodegradation is occurring within the groundwater at the source, as methane is a breakdown product of benzene.

SVOCs. Five separate SVOC compounds were detected in groundwater. Naphthalene, which had been detected at MW-2 in both of the two previous sampling events, was reported at 94.6 μg/L during the current sampling, which is less than its EPA Region III risk-based criterion of 150 μg/L. Other SVOCs were found at MW-2 during the current sampling event, but not during previous sampling, and include 2-methylnapthalene (160 μg/L), phenanthrene (24.5 μg/L), bis(2-ethylhexyl)phthalate (6.9 μg/L), and pyrene (5.8 μg/L).

Other Analytes. Nitrate was not detected in any of the site wells. Sulfate varied between 1.92 and 49.2 mg/L (lowest at well MW-1 and highest at MW-3). Carbon dioxide varied between 35.1 and 337 mg/L (lowest at well MW-4 and highest at MW-2). Total iron varied from 4.66 mg/L at MW-4 to 155 mg/L at MW-2. Total dissolved solids remained relatively constant, varying between 140 mg/L at MW-1 and 406 mg/L at MW-4. These results are consistent with the results of the Phase II RFI.

The combined observations of elevated methane gas, carbon dioxide, and total iron in MW-2 indicate that aerobic biodegradation of the hydrocarbon contaminants in groundwater at this well has occurred and is continuing.

2.9.2 Supplemental Modeling for Evaluating Natural Attenuation

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

The AT123D model was used to determine whether monitored natural attenuation is appropriate as a remedial alternative for achieving the site's remedial objectives within a reasonable time frame. Benzene was selected as the surrogate chemical from the group of organic chemicals that were identified as COPCs at this site. Because benzene has a slower degradation rate and higher mobility than any of the chemicals within the group, natural attenuation modeling results for benzene can be used for the remaining constituents with conservatism. The results from the modeling of the leaching of soil contamination to the groundwater using Seasonal Soil (SESOIL) compartmental modeling performed for benzene indicated that the additional contaminant contribution to the groundwater is expected to produce concentrations in groundwater that would be lower than the maximum concentration already observed in the groundwater. To be conservative a steady-state AT123D model was developed by calibrating the model against the observed maximum concentration of benzene (8,090 μg/L) in the groundwater beneath the Former 724th TPS site. This maximum concentration was found in July 1997 during the Phase II RFI in a direct-push groundwater sample (GP-1) located approximately 40 feet downgradient from well MW-2. Results of this modeling indicate that benzene from the TPS site is not expected to be of potential concern at the nearest receptor location [i.e., Mill Creek (1,200 feet downgradient from the source)] as the concentration will be reduced to below the MCL within 200 feet of the source. Also, the concentration of benzene at the source will be reduced to less than its MCL by natural attenuation processes within 20 years.

Site-specific DAFs between the source and the receptor locations were developed. The DAF is a numerical value that represents the attempt to mathematically quantify the natural physical, chemical, and biological processes (e.g., advection-dispersion, sorption-retardation, biodegradation, and volatilization) that result in the decrease of a chemical concentration in an environmental medium. In simple terms, the DAF is the ratio of chemical concentration at the source (or the point of origin) to the concentration at the exposure point. The DAF reflects 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 Mill Creek is infinite, suggesting that contaminants will not reach Mill Creek.

To estimate a reasonable time frame for monitored natural attenuation as a remedial alternative, fate and transport modeling was performed in conjunction with active remediation measures (e.g., source reduction). Multiple AT123D modeling runs were performed by reducing the residual concentration of benzene in groundwater at the source. Concentration versus time plots, shown in Appendix B, were developed for multiple source concentrations (8090, 1000, 500, 300, 100, 50, and 30 μg/L). Figure 2-3 represents the concentration versus time plot for the maximum source concentration of 8,090 μg/L. The results of the modeling and plots indicate the estimated time frame needed for benzene concentrations to degrade to less than the MCL, during which time monitored natural attenuation would occur. The time frame for monitored natural attenuation decreases from 20 to 4.5 years based on source reduction. Figure 2-3 shows that, if the groundwater at the source were to be remediated such that benzene concentrations would not exceed 50 μg/L, then monitored natural attenuation would further reduce the benzene concentration to less than its MCL of 5 μg/L in a subsequent 6-year time frame.

To evaluate the impact of residual leaching from the soil contamination above the water table, SESOIL modeling runs were performed using different input soil concentrations. The results of this modeling, shown in Appendix B, indicate that the peak contaminant contribution to groundwater will be within 6 months from the time of sampling (July 1997) and has, therefore, already occurred. Also, the predicted maximum groundwater concentration of benzene is expected to be less than its MCL within 6 years, corresponding to a maximum input soil concentration of 9,400 μg/L (Figure 2-4). Figure 2-4 also shows that, if the vadose zone soil at the source were to be remediated (e.g., excavated) such that benzene concentrations in soil would not exceed 200 μg/kg, then monitored natural attenuation would further reduce benzene concentrations due to leaching to groundwater over a 3-year time frame. After that time, benzene concentrations in groundwater would not exceed the MCL for benzene of 5 μg/L.

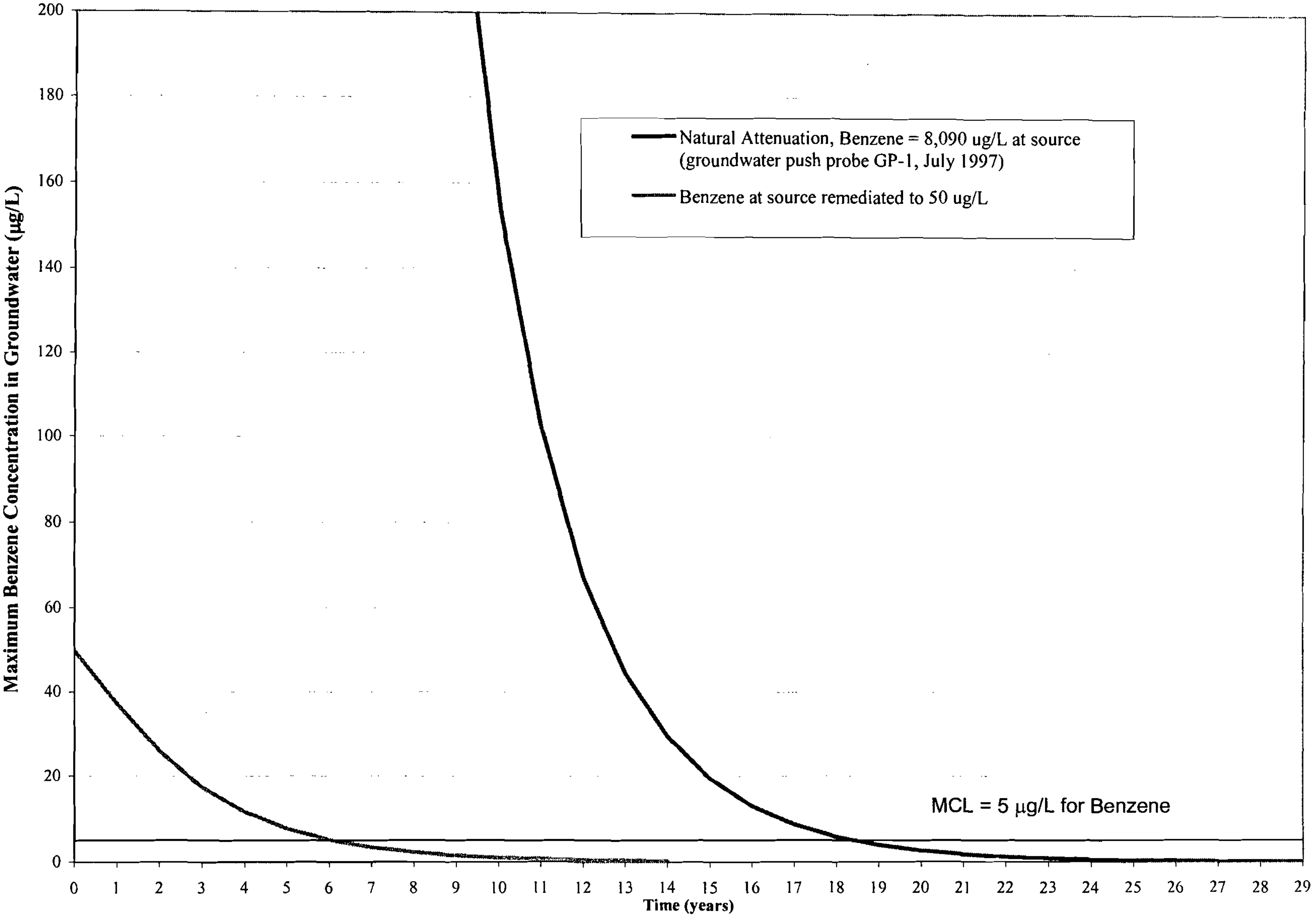

Figure 2-3. Predicted Maximum Concentration of Benzene in the Groundwater at the Source

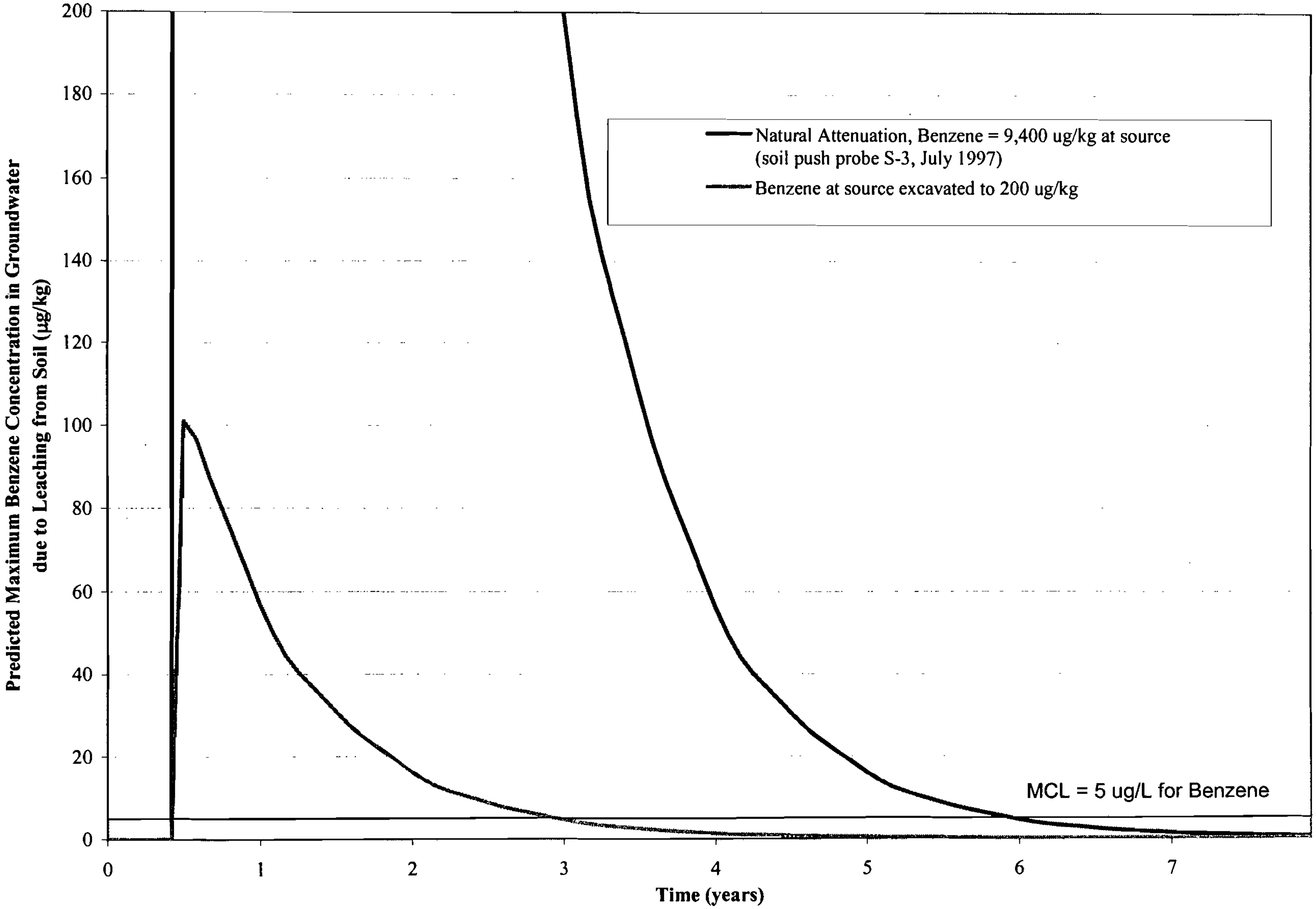

Figure 2-4. Predicted Maximum Concentration of Benzene in the Groundwater at the Source due to Leaching from Soil

3.0 JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION

3.1 PURPOSE

The EPA has established corrective action standards that reflect the major technical components that should be included with a selected remedy (EPA 1994). 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 free product and BTEX compounds at concentrations in groundwater exceeding MCLs, corrective action is warranted at the Former 724th TPS. The remedial response objectives for the Former 724th TPS are: (1) to reduce concentrations of BTEX, acetone, and naphthalene in vadose zone soils to the Remedial Levels identified in Table 3-1 so as to prevent further release of these hazardous constituents at levels which negatively impact groundwater and (2) to remediate groundwater to the Remedial Levels identified in Table 3-1 for these same hazardous constituents. The selected remedy would provide the technology necessary to minimize levels of contaminants in the groundwater and to achieve the best overall results with respect to such factors as effectiveness, implementability, and cost.

3.3 IDENTIFICATION OF REMEDIAL LEVELS

RLs were developed in the Phase II RFI and are presented in Table 3-1 for soil and groundwater (SAIC 1998). Soil RLs are based on leaching from soil to groundwater at levels exceeding MCLs or EPA Region III risk-based values. Groundwater RLs are based on MCLs, which take into consideration both human health and technological limitations. In the absence of an MCL, the EPA Region III risk-based values for groundwater were used for deriving RLs.

These soil and groundwater RLs are protective of direct exposure to residents by hazardous constituents in groundwater or leaching from the soil to groundwater. However, it is recognized that groundwater is not used at this site as a source of drinking water. It will take approximately 280 years for groundwater to reach the nearest receptor at Mill Creek, which is 1,200 feet from the former facility. Constituents will naturally attenuate in groundwater through retardation and biodegradation before reaching Mill Creek.

Table 3-1. Remedial Levels for Soil and Groundwater, Former 724th Tanker Purging Station, Fort Stewart

Analyte	Soil Remedial Level (µg/kg)	Maximum Observed Level in Soil (µg/kg)	Groundwater Remedial Level (µg/L)	Maximum Observed Level in Groundwater (µg/L)
Arsenic	–	–	–[a]	–
1,1-Dichloroethane	–	–	–[b]	–
1,2-Dichloroethane	–	–	–[b]	–
Acetone	370	1,060	370	1,450
Benzene	20	9,420	5	8,090
Chloroform	–	–	–[a]	–
Chloromethane	–	–	–[b]	–
Ethylbenzene	3,100	27,100	700	2,870
Naphthalene	600	4,160	150[c]	242
Toluene	4,200	27,400	1,000	4,200
Xylenes, total	31,700	124,000	10,000	12,100

– Indicates no remedial action needed for that analyte.

[a] No remedial action is needed for arsenic or chloroform in groundwater since the maximum concentrations for arsenic and chloroform are below their respective maximum contaminant levels (MCLs).

[b] No remedial action is needed for 1,1-dichloroethane, 1,2-dichloroethane, or chloromethane since the maximum concentrations for these analytes during the supplemental groundwater sampling did not exceed their respective MCLs or U.S. Environmental Protection Agency (EPA) Region III risk-based levels.

[c] No MCL exists for naphthalene; the remedial level for naphthalene is based on its EPA Region III risk-based level.

4.0 SCREENING OF CORRECTIVE ACTIONS

This section presents the identification of technologies applicable to remediation of the Former 724th TPS site and screening of the technologies with respect to effectiveness, implementability, and cost. The technologies that are retained following screening are then combined into corrective action alternatives that address contamination in both soil and groundwater. These alternatives are then evaluated with respect to time to implement and total life-cycle cost.

4.1 SCREENING CRITERIA

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

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

4.1.1 Effectiveness

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

4.1.2 Implementability

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

Service and material considerations include equipment and operator availability and applicability or development requirements for prospective technologies. The availability of services and materials is addressed by considering the material components of the proposed technologies and the locations and quantities of those materials. Administrative factors include ease of obtaining permits, enforcing deed restrictions, or maintaining long-term control of the site. Remedies that would require permitting under the Underground Injection Control (UIC) Program within the GEPD Geologic Survey Branch Program are identified in Table 4-1.

4.1.3 Cost

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

4.2 EVALUATION OF CORRECTIVE ACTION TECHNOLOGIES

Four general categories of corrective actions were identified. These include (1) no action, (2) institutional controls, (3) monitored natural attenuation, and/or (4) source remediation. Various corrective action technologies were identified for source remediation, including excavation of contaminated soil, air sparging, enhanced bioremediation (oxygen injection or PHOSter® II injection), and chemical oxidation (Geo-Cleanse®). Soil vapor extraction was not considered applicable at this site due to the shallow thickness of the vadose zone (less than 6 feet) and the likelihood for short-circuiting of any applied vacuum.

The corrective action technologies are described in Table 4-1. The technologies were evaluated using the screening criteria of effectiveness, implementability, and cost. Results of that screening evaluation are also shown on Table 4-1.

The "No Action" alternative was not considered to be viable due to the 20 years required to meet the MCLs for the site. Institutional controls were not considered further since they are appropriate for this site only when combined with other technologies, such as monitored natural attenuation. In situ chemical oxidation using Geo-Cleanse® is not considered an acceptable technology since the depth to contamination at the site is less than the required 5 feet and because chemical oxidation would likely destroy the natural biodegradation processes that have been observed at the site.

The remaining technologies were retained for further evaluation. These include monitored natural attenuation, excavation, air sparging, and enhanced bioremediation using either pure oxygen injection or PHOSter® II 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 soil and groundwater. Six alternatives were identified, and subsequently evaluated, that included the following:

1. Alternative 1: Monitored natural attenuation,

2. Alternative 2: Excavation (soil) and air sparging (groundwater),

3. Alternative 3: Excavation (soil) and enhanced bioremediation (groundwater),

4. Alternative 4: Air sparging (groundwater) and monitored natural attenuation (soil and groundwater),

Table 4-1. Evaluation of Corrective Actions/Technologies

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, all source units, surface water, and groundwater would be left "as is," without implementing any removal, treatment, or other mitigating actions to reduce existing or potential future exposure.	This alternative would not address remedial response objectives of the site. This alternative does not provide protection of human health or the environment.	There is no implementability involved for this alternative because no action is taken.	There would be no cost associated with the "No Action" alternative
Institutional Controls	Technologies associated with institutional controls will reduce potential hazards by limiting exposure of humans to contaminated soils, surface water, and groundwater. Land use restrictions and institutional control requirements that would be enforced include the following: deed restrictions; zoning controls; and applicable State land use control management systems in effect at the time. Deed restrictions would prohibit any construction at the site that might disturb the soil.	This technology alone would not meet the site objectives (i.e., RLs). Assuming compliance with deed restrictions, this technology should be effective and provide long-term reliability with respect to eliminating human exposure to contaminated media within the boundaries of the site. From the Phase II RFI Report, there are no COCs for human health in surface or subsurface soil due to direct contact. In addition, use of surficial groundwater at this site for drinking water is unlikely.	Very few factors limit implementability of the institutional controls. The property is not expected to be developed in the near future and will remain under Federal ownership. This alternative is readily implementable.	Low; to establish deed restrictions, approximately $6,000
Monitored Natural Attenuation	This action would require the monitoring of contaminant levels to ensure that the mass of contamination is being reduced over time. A total of 5 wells would be sampled annually for 20 years and analyzed for BTEX and natural attenuation parameters (e.g., methane).	Natural attenuation of BTEX constituents through biodegradation is known to be occurring at the site and would be effective. However, this action would require approximately 20 years to successfully meet the site objectives (i.e., RLs).	This alternative is readily implementable and would only require the installation of one new monitoring well and monitoring of a total of 5 wells at the site for approximately 20 years.	High; installation of 1 new well and annual sampling/ monitoring of 5 wells are required for approximately 20 years

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Table 4-1 (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Excavation	Excavation involves the removal of "hot spots" of soil contamination. The area of benzene soil contamination greater than 200 µg/kg would be removed to the depth of the water table (~6 feet). Approximately 10,930 cubic feet (547 tons) of soil would be removed and disposed of at a RCRA landfill.	Excavation has already proven to be effective in reducing the contamination level in soil at the site.	Excavation is a readily implementable alternative since it would only require excavation equipment, an operator, and disposal.	High; $100 to $200 per ton of unsaturated soil excavated and disposed
Air Sparging	Air sparging involves injecting a gas, usually air, under pressure, into the subsurface to volatilize groundwater contaminants and to promote biodegradation by increasing subsurface oxygen concentrations. Volatilized vapors migrate into the vadose zone where they can be extracted via vacuum, generally by a soil vapor extraction system. At this site, since the depth to groundwater is very shallow (~6 feet), a soil vapor extraction system is not necessary.	Technology proven for light petroleum products such as those present at the site. Air sparging has been used to address a broad range of volatile and semivolatile groundwater and soil contaminants including gasoline and other fuels and associated BTEX components.	Equipment readily available. Compressors and other air injection system components would need to be operated for two or more years. Approximately six injection wells would have to be installed. Monitoring and maintenance of the wells would be required. UIC permit would be required for injection of air.	Moderate; $20 to $50 per ton of saturated soil (EPA 1995)

Table 4-1 (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Enhanced Bioremediation (Pure Oxygen Injection)	Enhanced biodegradation is the enhancement of one aspect of natural attenuation. The activity of naturally occurring microbes is stimulated by injecting 98 percent pure oxygen to enhance in situ biological degradation of organic contaminants. Nutrients or other additives may be used to encourage the natural biodegradation processes.	Technology proven for site contaminants.	Equipment readily available, applicable to small site. Approximately 40 injection points would have to be installed for this alternative. Bioremediation process may require continuous monitoring and maintenance to prevent plugging of injection wells by microbial growth or mineral precipitation. UIC permit would be required for injection of oxygen or nutrients.	Moderate; similar to air sparging based on quote from manufacturer
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. In soils, enhanced bioremediation using air/nutrient injection is referred to as "bioventing."	PHOSter® II is an innovative technology that has been demonstrated at other sites 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 small site. Because this technology is innovative and relative new, there is relatively high uncertainty regarding 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. UIC permit would be required for injection of vapor-phase nutrients and air.	Moderate; similar to enhanced bioremediation using pure oxygen injection; costs dependent on required treatment time

Table 4-1 (continued)

Action/ Technology	Description	Effectiveness	Implementability	Costs
Geo-Cleanse®	The Geo-Cleanse® Process is an aggressive, pressurized injection of concentrated hydrogen peroxide and ferrous iron catalyst (together known as Fenton's reagent) that generates a hydroxyl free radical that acts as the active oxidizing agent. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction.	Expected to provide accelerated performance over air sparging. However, multiple applications may be required to achieve RLs. Chemical oxidation would temporarily destroy the natural bioremediation processes observed at the site.	Geo-Cleanse® requires that the depth to contamination be greater than 5 feet BGS. Table 5-3 in the Phase II RFI Report presents values in soil exceeding 100 μg/kg in the 4- to 6-foot interval. UIC permit would be required for injection of reagent.	High; $100 to $200 per ton of saturated soil; cost would be based on bid price and number of reapplications required

BGS = Below ground surface.
BTEX = Benzene, toluene, ethylbenzene, and total xylenes.
COC = Chemical/contaminant of concern.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA Facility Investigation.
RL = Remedial level.
UIC = Underground Injection Control (Program) (Tennessee Department of Environment and Conservation regulations).

5. Alternative 5: Enhanced bioremediation (groundwater) and monitored natural attenuation (soil and groundwater), and

6. Alternative 6: PHOSter® II enhanced bioremediation (groundwater and soil).

4.3.1 Evaluation Factors

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

Time to Implement

Time to implement the action is an important evaluation factor for this site. Preferably, the site would be remediated to meet RLs for groundwater and soil in the shortest possible time. For each alternative, an estimate was made of the duration of any active remediation system, or the duration of any natural attenuation period. For all alternatives, 1 year of quarterly groundwater sampling would be performed following the remediation/attenuation period to verify that RLs in groundwater have been met. In addition, soil samples would be taken at the end of the confirmatory groundwater sampling period (in conjunction with the fourth quarterly groundwater sampling event) to verify that RLs in soil have also been met.

Life-Cycle Cost

The life-cycle cost estimates are budget estimates based on conceptual design and are to be used for comparison purposes. Costs are estimated for capital construction and for operation and maintenance. Cost estimates are derived from current information including vendor quotes, conventional cost estimating guides (e.g., Means 1996 and ECHOS 1995), and costs associated with similar projects. The actual costs of the project would depend on labor and material costs, site conditions, competitive market conditions, final project scope, and implementation schedule at the time that the corrective action is initiated. The life-cycle cost estimates are not adjusted to present worth costs, and no escalation factors have been applied.

4.3.2 Evaluation of Corrective Action Alternatives

The six corrective action alternatives are summarized in Table 4-2 with the associated time to reach RLs and associated life-cycle costs. Figure 4-1 graphically presents the six alternatives, their time to implement, and associated costs.

All of the alternatives would include the following common features:

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

- the installation of four additional shallow monitoring wells and one additional deep monitoring well in the groundwater plume to monitor the decline in benzene concentrations in the area of hazardous constituent contamination in groundwater (detailed in Section 5.0);

Table 4-2. Corrective Action Alternatives

Corrective Action	Description	Time to Implement	Cost	Comments
Alternative 1. Monitored Natural Attenuation	The action would require the monitoring of contaminant levels to ensure the reduction of these levels through biodegradation and dispersion	The estimated time to reach the RL of 5 μg/L in groundwater is approximately 20 years.	Approximately $578,000 (installation of 5 monitoring wells, annual monitoring of 9 wells during attenuation period, quarterly post-attenuation monitoring for 1 year, and soil verification)	Least expensive, but longest implementation time
Alternative 2. Excavation and Air Sparging	Excavation of soils above 200 μg/kg followed by air sparging of groundwater to the MCL of 5 μg/L	Air sparging treatment at 60 scfm total would require approximately 32 months to reduce the maximum concentration of benzene from 8,090 μg/L to 5 μg/L. Following excavation, natural attenuation of soils <200 μg/kg would reach the 20 μg/kg RL within the groundwater remediation time frame.	Approximately $989,000 (excavation and disposal of soils, installation of 5 monitoring wells, monthly monitoring of 9 wells during treatment, treatment with 6 injection wells, post-remediation monitoring for 1 year, and soil verification)	Moderately expensive to implement and moderately short time frame
Alternative 3. Excavation and Enhanced Bioremediation (Pure Oxygen Injection)	Excavation of soils above 200 μg/kg followed by enhanced bioremediation of groundwater to MCL of 5 μg/L	Oxygen injection treatment at 28 scfm total would require approximately 35 months to reduce the maximum concentration of benzene from 8,090 μg/L to 5 μg/L. Following excavation, natural attenuation of soils <200 μg/kg would reach the 20 μg/kg RL within the groundwater remediation time frame.	Approximately $1,224,000 (excavation and disposal of soils, installation of 5 monitoring wells, monthly monitoring of 9 wells during treatment, treatment with 40 injection points, post-remediation monitoring for 1 year, and soil verification)	More costly than Alternative 2 with slightly longer implementation time
Alternative 4. Air Sparging and Monitored Natural Attenuation	Air sparging of groundwater to 50 μg/L followed by natural attenuation of residual contamination in soil and groundwater (no excavation of soil)	Air sparging treatment at 60 scfm total would require approximately 22 months to reduce benzene to 50 μg/L. Natural attenuation would then require approximately 6 years to reach the RL of 5 g/L. Natural attenuation of soils would reach the 20 μg/kg RL within the groundwater remediation time frame.	Approximately $824,000 (installation of 5 monitoring wells, monthly monitoring of 9 wells during treatment, treatment with 6 injection wells, monitored natural attenuation for 6 years, post-remediation monitoring for 1 year, and soil verification)	Less costly than Alternative 2 with twice the length of time needed to implement

Table 4-2 (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 natural attenuation of residual contamination in soil and groundwater (no excavation of soil)	Oxygen injection treatment at 28 scfm total would require approximately 24 months to reduce benzene to 50 µg/L. Natural attenuation would then require approximately 6 years to reach the RL of 5 µg/L. Natural attenuation of soils would reach the 20 µg/kg RL within the groundwater remediation time frame.	$1,020,000 (installation of 5 monitoring wells, monthly monitoring of 9 wells during treatment, treatment with 40 injection points, monitored natural attenuation for 6 years, post-remediation monitoring for 1 year, and soil verification)	Less costly than Alternative 3 with twice the length of time needed to implement
Alternative 6. PHOSter® II Enhanced Bioremediation and Bioventing	Enhanced bioremediation using the PHOSter® II system in groundwater to meet the RL of 5 µg/L, in situ bioventing in soil to meet the RL of 20 µg/kg.	PHOSter® II injection treatment at a total of 12 scfm would require an estimated 4 months to reduce benzene levels to 5 µg/L in groundwater and 20 µg/kg in vadose zone soil. Time to implement is highly uncertain due to limited full-scale implementation of the PHOSter® II technology.	$579,000 (installation of 5 monitoring wells, monthly monitoring of 9 wells during treatment, treatment with 6 injection points in groundwater, and a 100-foot-long lateral injection trench in vadose zone soil). Post-remediation monitoring for one year and soil verification.	Lower cost than air sparging or oxygen injection and shortest time to implement; however, much higher uncertainty on system effectiveness and required treatment time

RL = Remedial level.

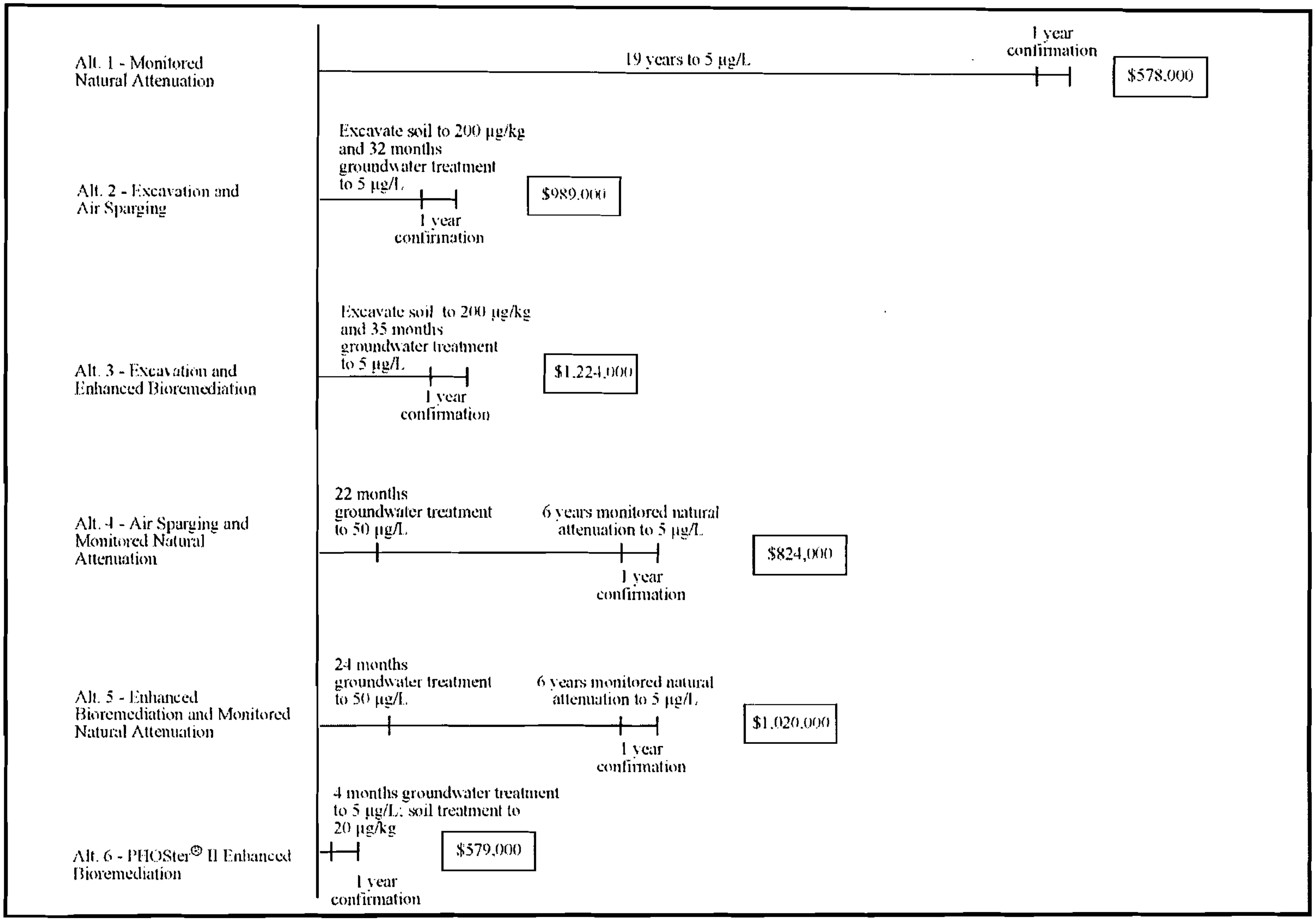


Figure 4-1. Corrective Action Alternatives, Implementation Time, and Costs

- quarterly post-remediation monitoring for 1 year to verify that the groundwater RLs for all chemicals of concern (COCs) have been achieved and maintained; and
- soil sampling upon completion of the 1-year groundwater monitoring period to verify that soil RLs for all COCs have been achieved.

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

Alternative 1: Monitored Natural Attenuation

Monitored natural attenuation would involve long-term annual monitoring of the site for approximately 19 years. During that time, benzene concentrations in groundwater are predicted to decline below the 5 µg/L MCL for benzene. Similarly, benzene concentrations in soil are predicted to decline below the 20 µg/kg RL for benzene. Annual sampling is appropriate for long-term monitoring at the Former 724th TPS site because (1) historical sampling events conducted since 1993 have clearly defined baseline conditions, (2) an additional pre-remediation baseline sampling event would confirm those conditions still exist, and (3) the duration of natural attenuation is relatively long (19 years) and conditions would not change dramatically from year to year. This monitored natural attenuation period would be followed by one year of groundwater and soil confirmation sampling to verify that RLs for all COCs have been met. This is the least expensive alternative with a life-cycle cost of approximately $578,000; but, it is also the longest to implement, at 20 years.

Alternative 2: Excavation and Air Sparging

Soil with benzene concentrations greater than 200 µg/kg would be excavated and disposed of offsite. This cleanup level was chosen based on modeling results that predict that soil with benzene concentrations less than 200 µg/kg will naturally attenuate to the target RL of 20 µg/kg within the same 32-month time frame estimated to be required for groundwater treatment. In groundwater, approximately six air sparging wells would be installed to treat the contaminated groundwater. Treatment would continue until the concentration of benzene has declined to a level below its MCL of 5 µg/L, estimated to require approximately 32 months. This active treatment period would be followed by confirmation groundwater monitoring and soil sampling to verify that RLs for all COCs have been met. The total time to implement would, therefore, be approximately 4 years. This alternative is moderately expensive, with life-cycle costs estimated at approximately $989,000.

Alternative 3: Excavation and Enhanced Bioremediation (Pure Oxygen Injection)

Similar to Alternative 2, soil with benzene concentrations greater than 200 µg/kg would be excavated and disposed offsite. Approximately 40 oxygen injection points would be installed to treat the contaminated groundwater. Treatment would consist of enhanced bioremediation using 98 percent pure oxygen injection and would continue until the concentration of benzene has declined to a level below its MCL of 5 µg/L, estimated to require approximately 35 months. This active treatment period would be followed by confirmation groundwater monitoring and soil sampling to verify that RLs for all COCs have been met. This alternative is more expensive than Alternative 2, with life-cycle costs estimated at approximately $1,224,000. Implementation time (approximately 4 years) is similar to Alternative 2, requiring only 3 months longer time to implement.

Alternative 4: Air Sparging and Monitored Natural Attenuation

Under this alternative, contamination in soil would be allowed to attenuate naturally, and air sparging in groundwater would be shut down once benzene concentrations in groundwater declined below 50 µg/L. Approximately six air sparging injection wells would be installed; treatment would continue for approximately 22 months. Following this active treatment period, benzene concentrations in both soil and groundwater would continue to decline due to natural attenuation. Monitored natural attenuation with annual groundwater sampling would be provided for approximately 6 years following active treatment. The estimated life-cycle cost for this alternative, $824,000, is less than Alternative 2; however, the alternative would require approximately 9 years to implement, nearly twice the time needed for Alternatives 2 or 3.

Alternative 5: Enhanced Bioremediation and Monitored Natural Attenuation

This alternative is similar to Alternative 4 in that contamination in soil would be allowed to attenuate naturally. Groundwater treatment using enhanced bioremediation (pure oxygen injection) would be shut down once benzene concentrations declined to below 50 µg/L. Approximately 40 oxygen injection points would be installed. Treatment would continue for approximately 27 months followed by approximately 6 years of monitored natural attenuation. The estimated life-cycle cost for this alternative, $1,020,000, is less than Alternative 3, but higher than both Alternatives 2 and 4. The alternative would require approximately 9 years to implement, similar to Alternative 4, but nearly twice the time needed for Alternatives 2 or 3.

Alternative 6: PHOSter® II Enhanced Bioremediation

This alternative is also similar to Alternatives 3 and 5 in that contaminants would be treated in situ through an innovative PHOSter® II process that injects vapor phase phosphorous, nitrogen, and air to enhance natural biodegradation. In groundwater, approximately six injection wells would be installed to treat the contaminated groundwater. Treatment would continue until the concentration of benzene has declined to a level below its MCL of 5 µg/L, estimated to require approximately 4 months. In vadose zone soil, a lateral injection well, approximately 100 feet long, would be installed in a shallow trench to treat the contaminated soil through bioventing. Treatment would continue until the concentration of benzene has declined to a level below its remedial level of 20 µg/kg, estimated to require approximately 3.2 months. The estimated life-cycle cost for this alternative, $579,000, is similar to Alternative 1, natural attenuation, but less expensive than all other alternatives. The alternative would require a total of less than 2 years to implement (including a 1-year confirmation sampling period), the shortest time to implement of any of the alternatives. Because this technology is new and innovative, there is greater uncertainty than with other alternatives as to the cost and time of treatment.

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 and soil data and modeling results, a cost-effective corrective action was selected that would reduce the COCs in groundwater and soil to the required RLs. The technology evaluation presented in Section 4.0 evaluated six different corrective action alternatives based on the time needed to implement and life-cycle cost. Based on that evaluation, Alternative 6, PHOSter® II Enhanced Bioremediation, was selected for its short implementation time and low cost.

5.1 SELECTED CORRECTIVE ACTION

The selected corrective action alternative involves in situ enhanced bioremediation using the patented PHOSter® II technology. The PHOSter® II system delivers air and nutrients to the subsurface at a controlled rate to promote biomass growth and increase degradation rates of contaminants. Nutrient delivery is accomplished through the vapor-phase addition of phosphorous, nitrogen, and air. Because the nutrients are delivered in the vapor phase, they are more readily available for use by microorganisms in their biodegradation of contaminants. The technology has been demonstrated to be effective in both soils and groundwater in reducing concentrations of BTEX and other fuel-related contaminants to nondetectable levels.

5.1.1 Justification of Selection

The PHOSter® II system has been selected because it will effectively achieve RLs in soil and groundwater in the shortest period of time and at moderately low cost. Although Monitored Natural Attenuation would be less costly, RLs would not be expected to be achieved in groundwater for nearly 19 years. The PHOSter® II system is expected to achieve RLs in as little as 4 months. Other corrective action alternatives, such as air sparging or pure oxygen injection, would provide a higher degree of reliability and less uncertainty in their effectiveness than the PHOSter® II system; however, they would probably cost more than the PHOSter® II system and would require a much longer time to achieve RLs. Justification for selection of this corrective action alternative is detailed in the following evaluations of effectiveness, implementability, and cost.

Effectiveness. The selected corrective action will be effective in protecting human health and the environment. Based on the conclusions of the Phase II RFI, there is no current human health or ecological risk associated with the contaminants at the Former 724th TPS. If no remediation was conducted, potential future risk might be associated with leaching of organic contaminants to groundwater and subsequent groundwater ingestion. This potential exposure is extremely unlikely because the shallow groundwater is not a viable source of drinking water in the Fort Stewart area. The selected alternative will achieve RLs within a relatively short time frame (4 months), thereby effectively eliminating any potential future risk. The selected alternative will not require long-term O&M beyond the 4-month treatment period and 1-year confirmatory sampling period; it therefore provides long-term reliability and no need for replacement of system components. Short-term risks to human health or the environment are minimal because treatment occurs in situ. There are no air emissions or surface water discharges associated with the selected corrective action. Potential exposure by remediation workers to contaminants is limited. Minimal exposure could result during well installation or trenching for installation of the injection lateral; any exposure will be minimized and maintained below acceptable levels with the use of proper protective clothing, monitoring of airborne VOCs in the breathing zone, and strict adherence to the project health and safety plan.

The selected corrective action will be effective in controlling contaminants at the source and preventing any future releases. The vadose-zone soils will be treated in situ using the PHOSter® II bioventing system to degrade the COCs below their respective RLs, thereby eliminating any future release. The shallow groundwater will also be treated in situ using the PHOSter® II vapor-phase nutrient injection system to eliminate any future migration from the source. The time required to achieve RLs has been estimated using benzene as the primary COC and assuming a degradation half-life of 11 days. In soil, the time required to degrade benzene from a maximum of 9,040 μg/kg to its RL of 20 μg/kg has been estimated to require 98 days (3.2 months). In groundwater, the time required to degrade benzene from a maximum of 8,090 μg/L to its MCL of 5 μg/L has been estimated to require 117 days (4 months), which is nominally the same duration as required in soil. There is uncertainty regarding the actual time required for treatment because the PHOSter® II technology is innovative and relatively new. Full-scale demonstration projects in Georgia and South Carolina using the PHOSter® II system have shown the technology to be effective for fuel constituents in both soil and groundwater for similar levels of contamination. These case studies have also shown that a benzene half-life of between 4 and 11 days is achievable. Consequently, the reliability of the PHOSter® II system, while uncertain, is considered acceptable. Contingent actions are identified in the O&M Plan (Appendix D) to ensure that RLs will be met.

Because the vadose zone is relatively shallow (less than 6 feet) and because the native surficial soils are relatively sandy, conditions within the vadose zone may be sufficiently aerated to promote natural biodegradation of contaminants. In such case, in situ bioventing using the PHOSter® II system may be unnecessary. However, the selected corrective action includes bioventing for the following reasons: (1) the PHOSter® II mobile treatment unit will already be on the site for groundwater treatment and will be available for soil treatment at little additional cost, (2) soil vapor monitoring and respiration testing during installation of the injection lateral will be used to verify whether bioventing is necessary, and (3) bioventing could be suspended at any time during O&M of the system based on results of soil vapor monitoring and respiration testing.

Implementability. The selected corrective action can be readily implemented. Construction involves conventional drilling and trenching techniques for which numerous qualified construction contractors and equipment are readily available. The action will comply with RCRA waste management standards for sampling of any contaminated soil excavated during drilling or trenching and off-site disposal at a permitted landfill. The action will require an Underground Injection Control (UIC) permit be obtained from GEPD prior to operation; such a permit is readily obtainable for air injection. The action will also require a construction permit be obtained from the Installation prior to any below-ground drilling or trenching. Electrical power is available at the site.

The implementation schedule allows for initiating and completing the remedial activities within a reasonable period of time. The RLs will be achieved in the shortest period of time of any of the corrective action alternatives (4 months after start of O&M). The selected corrective action utilizes a relatively new technology to accelerate natural biodegradation processes and thereby accelerate remediation. Because of this, there is uncertainty whether RLs can be achieved so quickly; contingent actions are therefore identified in the O&M Plan (Appendix D) and in the implementation schedule. The project implementation schedule is presented in detail in the conceptual design later in this section.

Cost. The estimated total life-cycle cost of construction, operation, maintenance, and confirmatory sampling for the selected corrective action is $579,000. Monitored natural attenuation is similar in cost ($578,000), but would require nearly 19 years to achieve RLs, compared to only 4 months for the selected PHOSter® II system. This significant savings in implementation schedule justifies the selected system. Costs estimated for the other corrective action alternatives were much higher than the selected PHOSter® II system, ranging from ($824,000 to $1,224,000).

5.2 CONCEPTUAL DESIGN

The conceptual design and cost estimate presented in this section for the Former 724th TPS are based on the subsurface stratigraphy information presented on the drilling logs, the most recent contaminant chemistry for the soil and groundwater, and SAIC's experience in designing similar remediation systems.

5.2.1 Decommissioning of Free Product Recovery System

Although operation of the Ferret® free product recovery system in MW-2 is ongoing, less than 0.02 foot of free product was encountered during the March 1999 sampling event, and little volume of product has been recovered. No free product had been encountered previously in any of the direct-push soil or groundwater probes completed during the Phase II RFI in July 1997. Therefore, operation of the Ferret® system will be discontinued when the nutrient/air injection wells are installed. Decommissioning of the free product recovery system will involve removal of the Ferret® system from MW-2 and decontamination of the equipment. If at any future date free product is discovered in a monitoring well or injection well, the Ferret® system will be reinstalled, as required.

5.2.2 Bioventing of Soils

The PHOSter® II bioventing system conceptual design is based on the results of published case studies provided by the system vendor, extrapolated to conditions at the Former 724th TPS site. Figure 5-1 indicates the location of the area that requires bioventing and the conceptual design layout. Figure 5-2 is a process flow schematic and shows the conceptual design components of the bioventing system.

Bioventing Conceptual Design Layout. The depth to the water table in the area of soil contamination is approximately 6 feet. Because of this shallow depth, vertical injection wells are not considered appropriate to address remediation of the remaining soil contamination due to the potential for short-circuiting of injected air and nutrients directly to the atmosphere and resulting limited radius of influence. A lateral injection line is therefore planned. The area of contaminated vadose-zone soil extends predominantly over an L-shaped area about 20 feet wide and 100 feet long. A 100-foot-long injection lateral running the length of this area of contamination is used for the conceptual design.

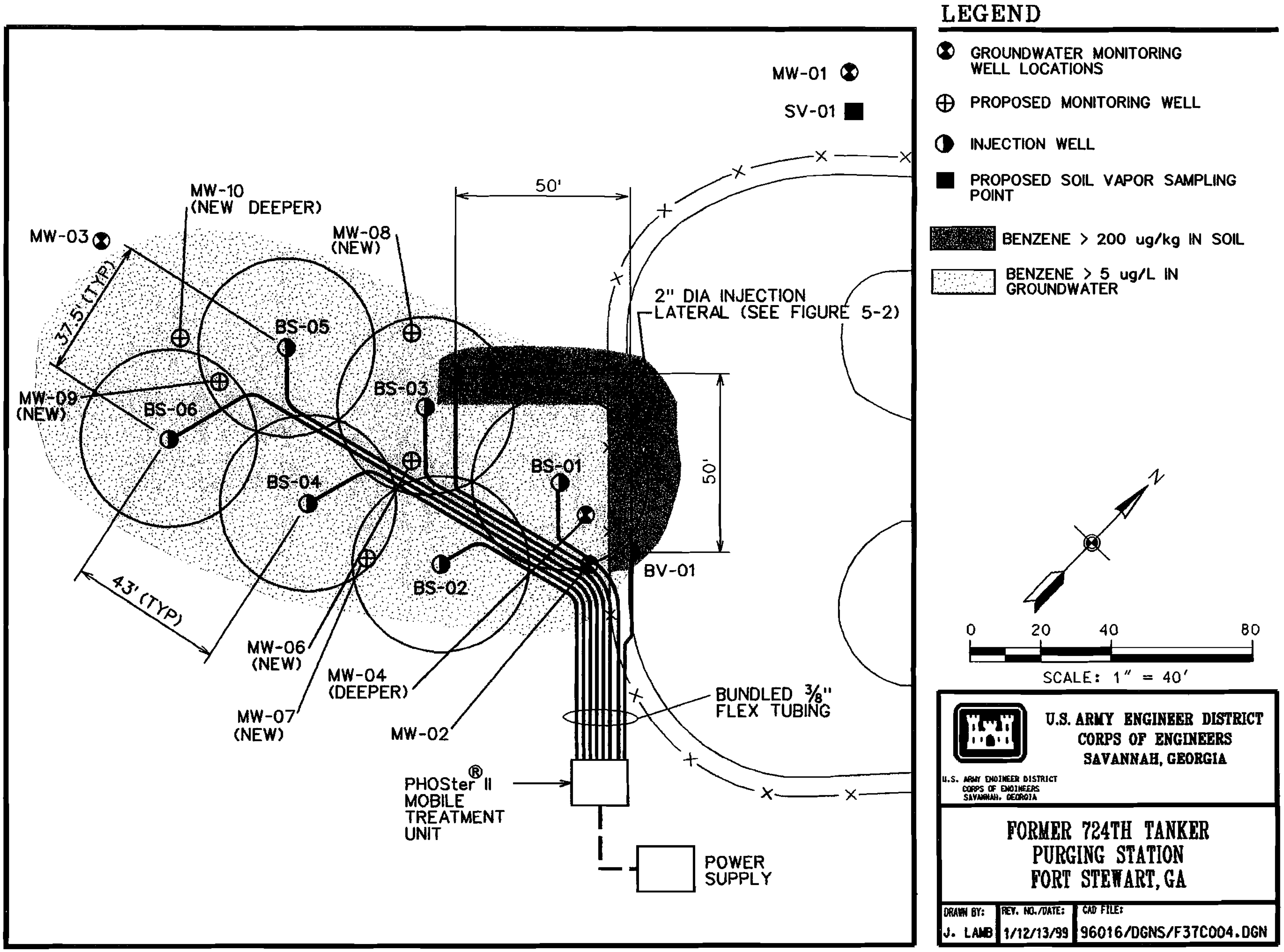
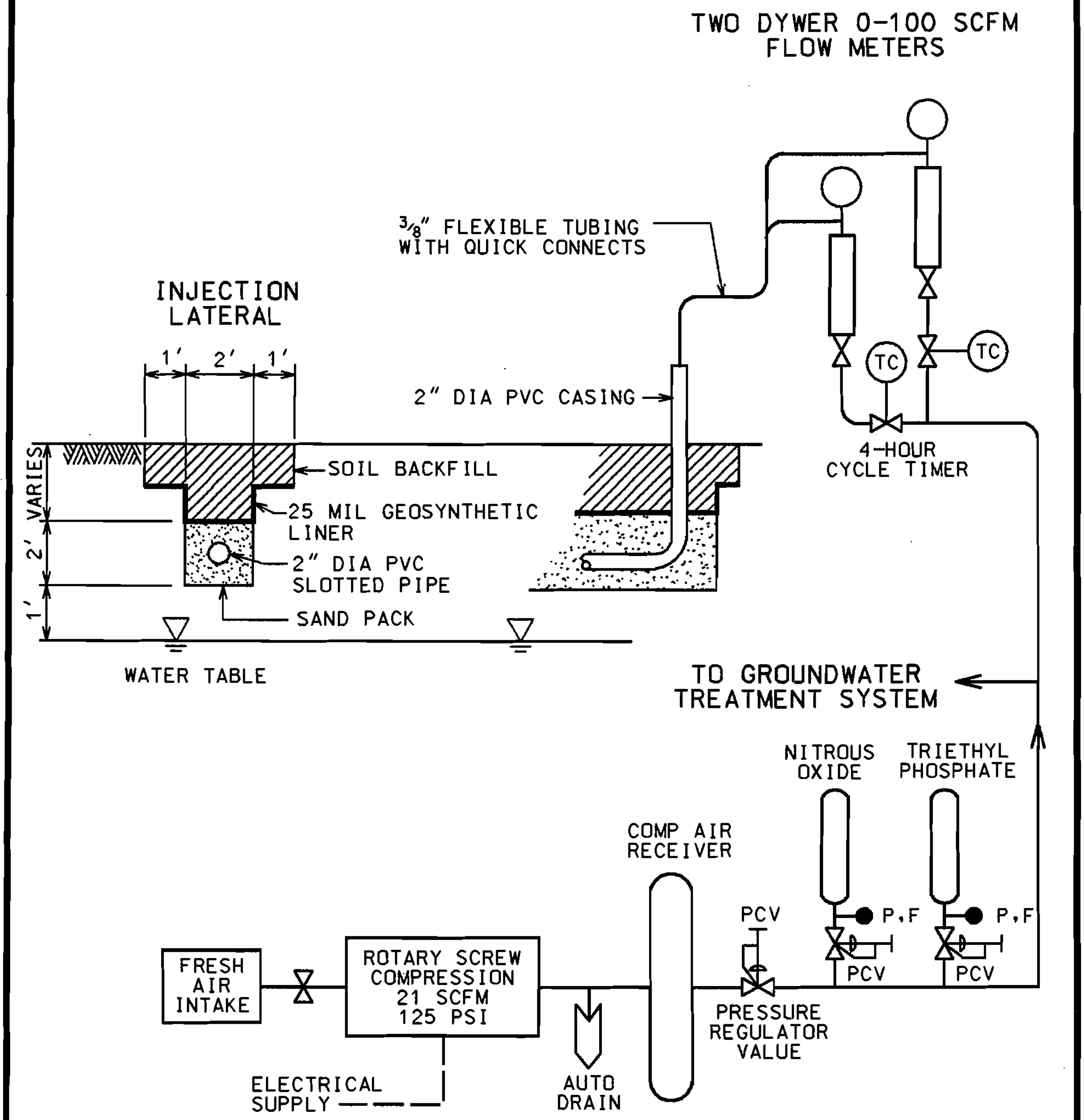


Figure 5-1. Conceptual Design Layout



LEGEND

PCV.. PRESSURE CONTROL VALVE
P.....PRESSURE METER
F.....FLOW METER
TC....TIMER CONTROL

SCALE: NONE

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

PHOSter® II SOIL BIOVENTING SYSTEM
PROCESS FLOW DIAGRAM

DRAWN BY:	REV. NO./DATE:	CAD FILE:
J. LAMB	0/07/13/99	96016/DGNS/F37C002.DGN

Figure 5-2. PHOSter® II Soil Bioventing System Process Flow Diagram

No pilot test data are available for establishing the radius of influence. Previous case studies have indicated that a radius of influence of 45 feet or more is possible in silty sands similar to those at the site. Because the area of contamination is approximately 20 feet wide, only a 10-foot radius of influence is required. Therefore, a single injection lateral is used for the conceptual design. The actual radius of influence and respiration rate will be confirmed during installation of the injection lateral. Procedures described in EPA's Bioventing Principles and Practice Manual (EPA 1995) will be followed for determining the radius of influence and respiration rate.

The injection lateral will consist of 2-inch-diameter slotted high-density polyethylene (HDPE) pipe that will be installed in a shallow trench and backfilled with a sand pack 1 foot thick all around the pipe that would serve as filter and bedding material. A 25-mil geomembrane liner will be place above the sand pack to act as a barrier to upward migration of vapors within the trench and will be anchored into the sides of the trench. A 2-inch-diameter non-slotted HDPE riser piper will be installed at the either end of the injection lateral with a top port that allows quick connection to 3/8-inch-diameter flexible tubing.

Based on a typical injection pressure of 2 to 3 pounds per square inch gauge (psig) and a typical airflow rate of 0.1 to 0.2 standard cubic feet per minute (scfm) per foot of well screen, a total operating vapor injection rate of 10 to 20 scfm is planned. The injected vapor will be supplied using a PHOSter® II mobile treatment unit, a prefabricated unit containing a compressor, nitrogen and phosphorous injection systems, control panels, and flow meters. The mobile unit is a fully-enclosed trailer-mounted unit approximately 8 feet wide by 12 feet deep.

Bioventing Operational Life Model. The time required to achieve RLs has been estimated using benzene as the primary COC and assuming a degradation half-life of 11 days. In soil, the time required to degrade benzene from a maximum of 9,040 μg/kg to its RL of 20 μg/kg has been estimated to require 98 days (3.2 months). There is uncertainty regarding the actual time required for treatment because the PHOSter® II technology is innovative and relatively new. It is therefore prudent to plan on operating the system for at least 4 more months to account for this uncertainty. In addition, contingent actions are identified in the O&M Plan (Appendix D) to ensure that RLs will be met.

Bioventing Operation and Maintenance. Bioventing systems are very simple and require a minimum of O&M. The general O&M tasks include weekly operational checks of the system pressure and airflow, checking for leaks and that system components are in working order. Appendix D presents the O&M Plan. Pulsed air injection has been shown to be more efficient than continuous operation in removing contaminant mass. The conceptual design of the bioventing system is to operate the injection system over 4-hour cycles; air would be injected continuously for 4 hours, then turned off for 4 hours, and subsequently turned back on.

Soil Monitoring. Monthly soil gas monitoring and respiratory testing will be conducted to verify that the site is sufficiently oxygenated and that active biodegradation is occurring. Soil gas concentrations of oxygen, carbon dioxide, benzene, and total hydrocarbons will be measured while the system is operating. After these measurements are collected, the bioventing system will be turned off and soil gas concentrations of oxygen and carbon dioxide will be measured hourly until oxygen levels drop below 5 percent or are no longer declining. The oxygen utilization rate will be used as an indicator that bioremediation is complete; once the oxygen utilization rate in the contaminated area is similar to that in the background (uncontaminated) area, operation of the bioventing system will be suspended (anticipated to be after 4 months of operation). A soil vapor sampling point will be installed near the upgradient monitoring well (MW-1) at the site to measure background oxygen utilization. Figure 5-3 shows the location of the soil vapor sampling

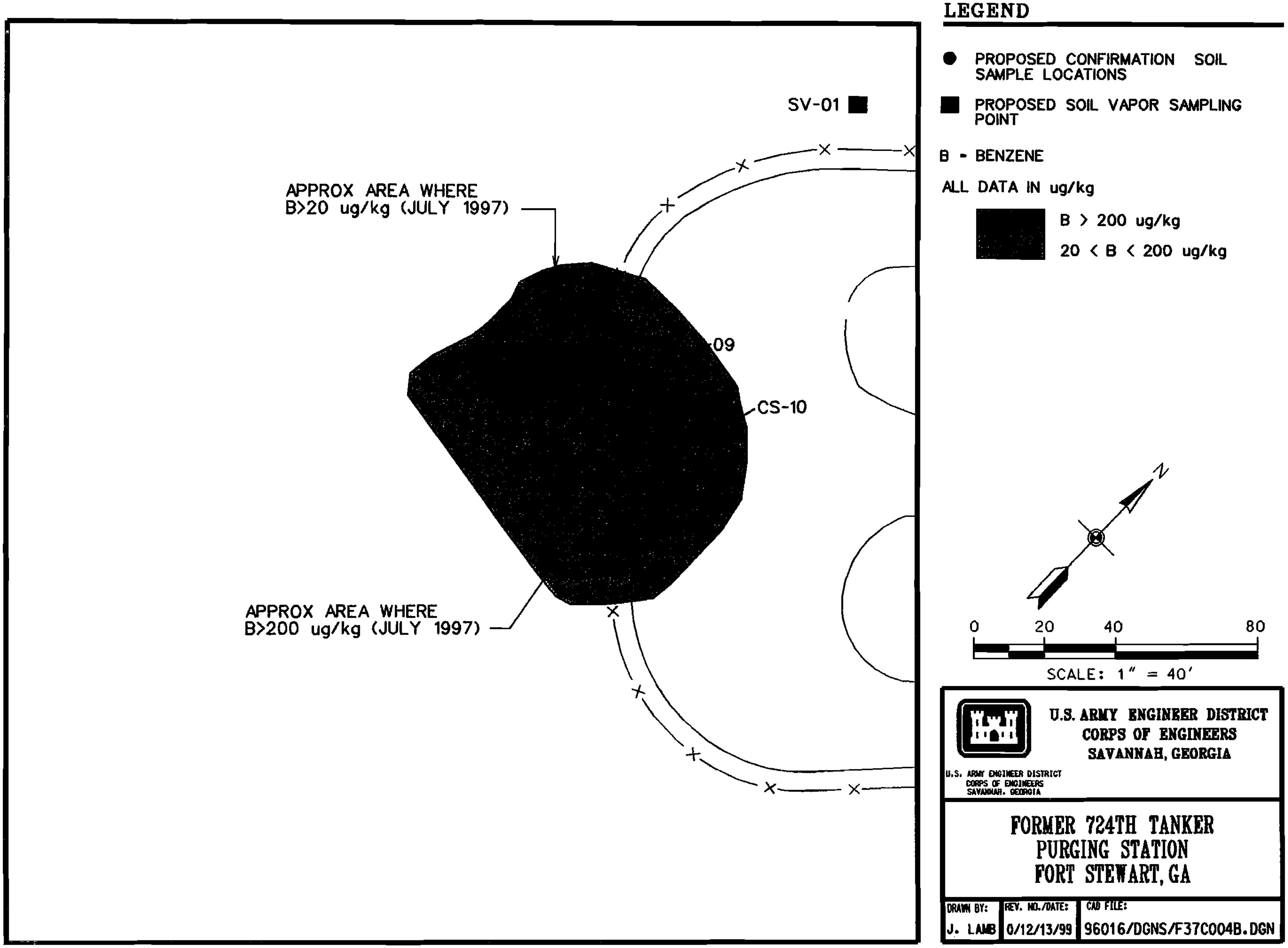


Figure 5-3. Locations of Soil Vapor Sampling Point and Confirmatory Soil Samples

point (SV-01). Soil sampling will then be conducted to verify that benzene concentrations have declined to below 20 µg/kg. A total of 10 subsurface soil samples will be collected from the locations shown on Figure 5-3, within the source area at a depth just above the water table. Samples will be analyzed at an off-site laboratory for VOCs and PAHs. Analysis for PAHs in lieu of the full suite of SVOCs is appropriate because naphthalene is the only SVOC that is a COC at the site.

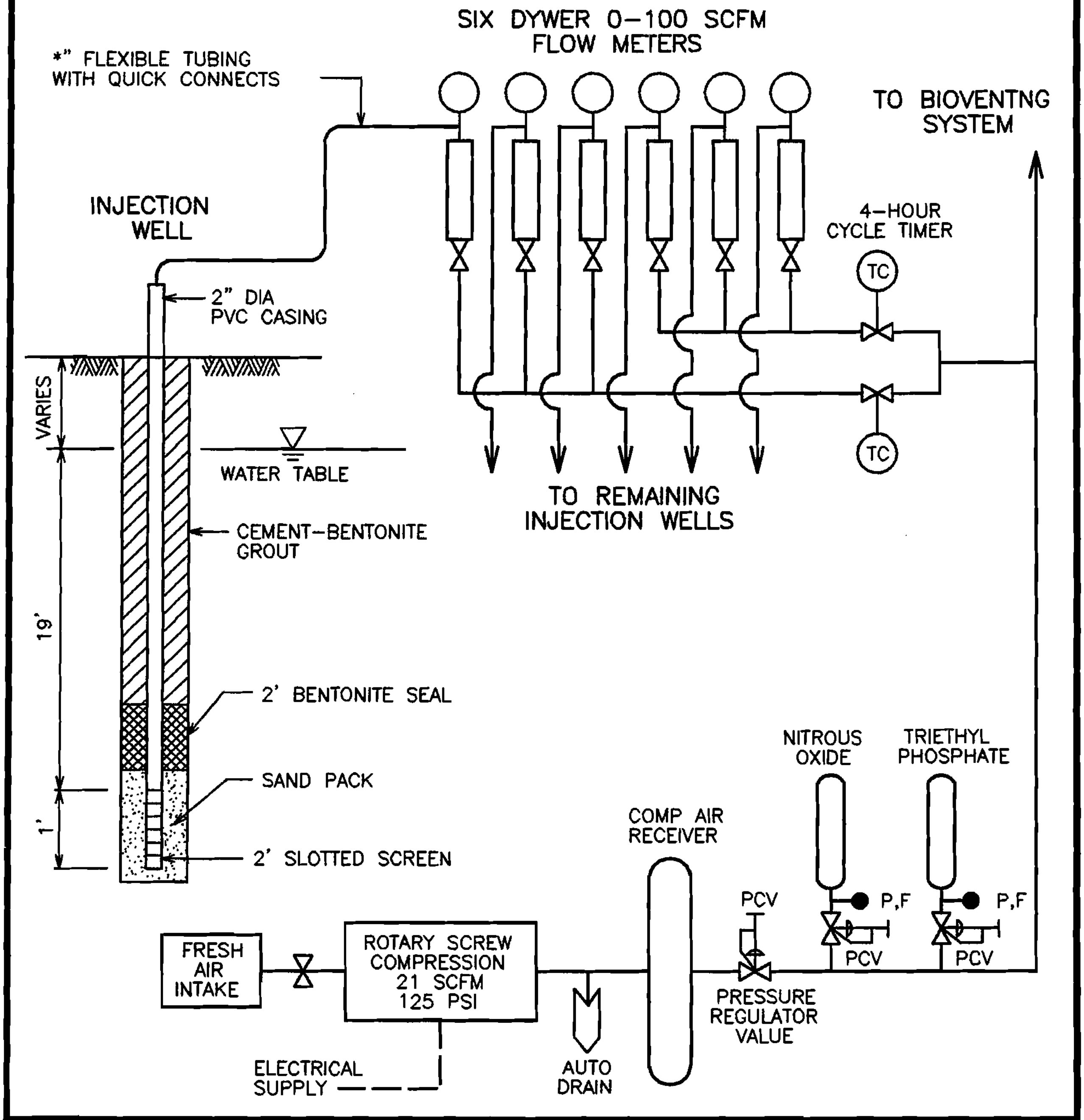
Bioventing Completion Criteria. Completion criteria are listed in the O&M Plan (Appendix D). Operation of the bioventing system will be ceased upon attaining a maximum benzene concentration in the soil of 20 µg/kg. Confirmation soil sampling will be conducted at the end of the 1-year confirmation groundwater sampling to verify that the soil RLs have been achieved for all COCs and that corrective action is complete. Up to 10 soil samples will be collected from random locations within the formerly contaminated vadose-zone soil area at a depth just above the water table. As discussed in the O&M Plan in Appendix D, sample locations will be within the area of contamination delineated in the Phase II RFI report. Figure 5-3 shows the preliminary locations of confirmatory soil samples. Samples will be analyzed for VOCs and PAHs. If results of the soil sampling conducted immediately after the 4-month O&M period indicate that RLs have been met for all COCs in soil, then a second confirmation soil sampling event will not be needed.

5.2.3 Enhanced Biodegradation of Groundwater

The PHOSter® II groundwater treatment system conceptual design is based on the results of published case studies provided by the system vendor, extrapolated to conditions at the Former 724th TPS site. Figure 5-1 indicates the location of the groundwater plume that requires corrective action and the conceptual design layout. Figure 5-4 is a process flow schematic and shows the conceptual design components of the PHOSter® II groundwater treatment system.

Groundwater Treatment Conceptual Design Layout. The contaminated groundwater plume extends over an oval-shaped area about 90 feet wide and 180 feet long. The depth of groundwater contamination is limited predominantly to the upper 20 feet of the shallow aquifer zone. The conceptual design for the nutrient/air injection system includes the installation of six vertical injection wells in this area of the groundwater plume (Figure 5-4). No pilot test data are available for establishing the radius of influence. Previous case studies have indicated that a radius of influence of 45 feet or more is possible in silty sands similar to those at the site. To be conservative, a 25-foot radius of influence is used for the conceptual design. The actual radius of influence will be confirmed during installation of the wells; if the actual radius of influence is significantly different than the 25-foot radius used in the design, the number of injection wells will be increased or decreased accordingly.

Each injection well will consist of 2-inch-diameter slotted HDPE pipe that will be screened over the interval between 19 and 20 feet below the water table. A sand pack will be placed in the annulus around the pipe to a level 1 foot above the top of the screened section. A 2-foot-thick bentonite seal will be placed above the sand pack, and the remainder of the borehole will be filled with a cement-bentonite grout to the ground surface. A 2-inch-diameter non-slotted HDPE riser piper will be completed about 3 feet above the ground surface and will be equipped with a top port that allows quick connection to 3/8-inch-diameter flexible tubing.



LEGEND

PCV.. PRESSURE CONTROL VALVE
P..... PRESSURE METER
F..... FLOW METER
TC.... TIMER CONTROL

SCALE: NONE

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

FIGURE
PHOSter® II GROUNDWATER
TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

DRAWN BY:	REV. NO./DATE:	CAD FILE:
J. LAMB	1/01/14/00	96016/DGNS/F37C001A.DGN

Figure 5-4. PHOSter® II Groundwater Treatment Process Flow Diagram

Based on a typical injection pressure of 2 to 3 psig and a typical airflow rate of 0.1 to 0.2 scfm per foot of well screen, an injection rate of 1 to 2 scfm per well is planned. Because three wells will be operated at any given time, the total operating vapor injection rate will be 3 to 6 scfm. The injected vapor will be supplied using the same PHOSter® II mobile treatment unit as used for bioventing, with separate control panels and flow meters.

Operational Life Model. As in soil treatment, the time required to achieve RLs in groundwater has been estimated using benzene as the primary COC and assuming a degradation half-life of 11 days. In groundwater, the time required to degrade benzene from a maximum of 8,090 µg/L to its MCL of 5 µg/L has been estimated to require 117 days (4 months). There is uncertainty regarding the actual time required for treatment because the PHOSter® II technology is innovative and relatively new. It is therefore prudent to plan on operating the system for at least 4 more months to account for this uncertainty. In addition, contingent actions are identified in the O&M Plan (Appendix D) to ensure that RLs will be met.

Operation and Maintenance. Air injection systems are very simple and require a minimum of O&M. The general O&M tasks include weekly operational checks of the system pressure and airflow, checking for leaks and that system components are in working order. Appendix D presents the O&M Plan. Pulsed air injection has been shown to be more efficient than continuous operation in removing contaminant mass, particularly where the soil layers have higher clay or silt content. The conceptual design of the groundwater treatment system is to operate the injection system over 4-hour cycles; air would be injected continuously in a given well for 4 hours, then turned off for 4 hours, and subsequently turned back on. Because there are six injection wells, the conceptual design is to actively inject in three wells at any given time. Therefore, the system will operate continuously, alternating between two sets of three injection wells each.

Groundwater Monitoring. The conceptual design includes the installation of four additional shallow monitoring wells and one additional deep monitoring well to augment the existing four wells (note that existing well MW-05 is located at Mill Creek and will not be sampled). The proposed wells (MW-6, MW-7, MW-8, MW-9, and MW-10) will be located as shown on Figure 5-1 within the contamination plume where benzene concentrations in direct-push groundwater samples taken during the RFI were highest (i.e., GP-1 at 8,090 µg/L). The shallow wells will be screened to bisect the water table, for a total depth of less than 20 feet. The deep well (MW-10) will be screened between a depth of 35 and 45 feet below land surface. The wells will be used to more accurately observe the reduction in benzene concentrations during remediation and to verify the effectiveness of treatment after remedial activities are completed.

During O&M of the groundwater treatment system, the nine groundwater monitoring wells will be sampled to verify that benzene concentrations are declining and that active biodegradation is occurring. On a monthly basis, samples will be taken and analyzed at an off-site laboratory for BTEX and for natural attenuation parameters (methane, carbon dioxide, total phosphorous, nitrate/nitrite, sulfate/sulfide, and total iron). Field measurements will be made of dissolved oxygen (DO), temperature, oxidation-reduction potential (Eh), conductivity, pH, and ferrous iron. A simplified respiration test will be run on one of the new monitoring wells (MW-6) during the monthly groundwater sampling by shutting off air injection and monitoring DO and carbon dioxide concentrations in the well for approximately 8 hours.

Groundwater Treatment Completion Criteria. Completion criteria are listed in the O&M Plan (Appendix D). Operation of the groundwater treatment system will be ceased upon attaining a maximum benzene concentration in each of the nine on-site wells of 5 µg/L, as measured during the monthly groundwater monitoring.

Confirmation groundwater sampling will be conducted at the end of the active treatment period to verify that the groundwater RLs have been achieved for all COCs. Upon completion of the air injection (approximately 4 months), groundwater will be monitored on a quarterly basis for 1 year. Samples will be collected from each of the nine on-site wells and analyzed for VOCs and PAHs. Analysis for PAHs in lieu of the full suite of SVOCs is appropriate because naphthalene is the only SVOC that is a COC at the site.

5.3 OPERATION AND MAINTENANCE PLAN

O&M includes weekly inspections of the equipment components and monthly monitoring of benzene contamination trends in groundwater. Appendix D presents the O&M Plan for the selected remedial alternative.

5.4 LIFE-CYCLE COST ESTIMATE

The life-cycle cost estimate for the selected PHOSter® II system alternative is $579,000 (see Appendix C for cost components). The capital costs, including indirect costs, are estimated to be $373,000 and would include engineering services (Work Plan, Site Safety and Health Plan, contracting/procurement, permitting, construction oversight for monitoring and injection well installation) and system installation (site preparation, mobilization/demobilization, monitoring and injection well installation, PHOSter® II equipment installation).

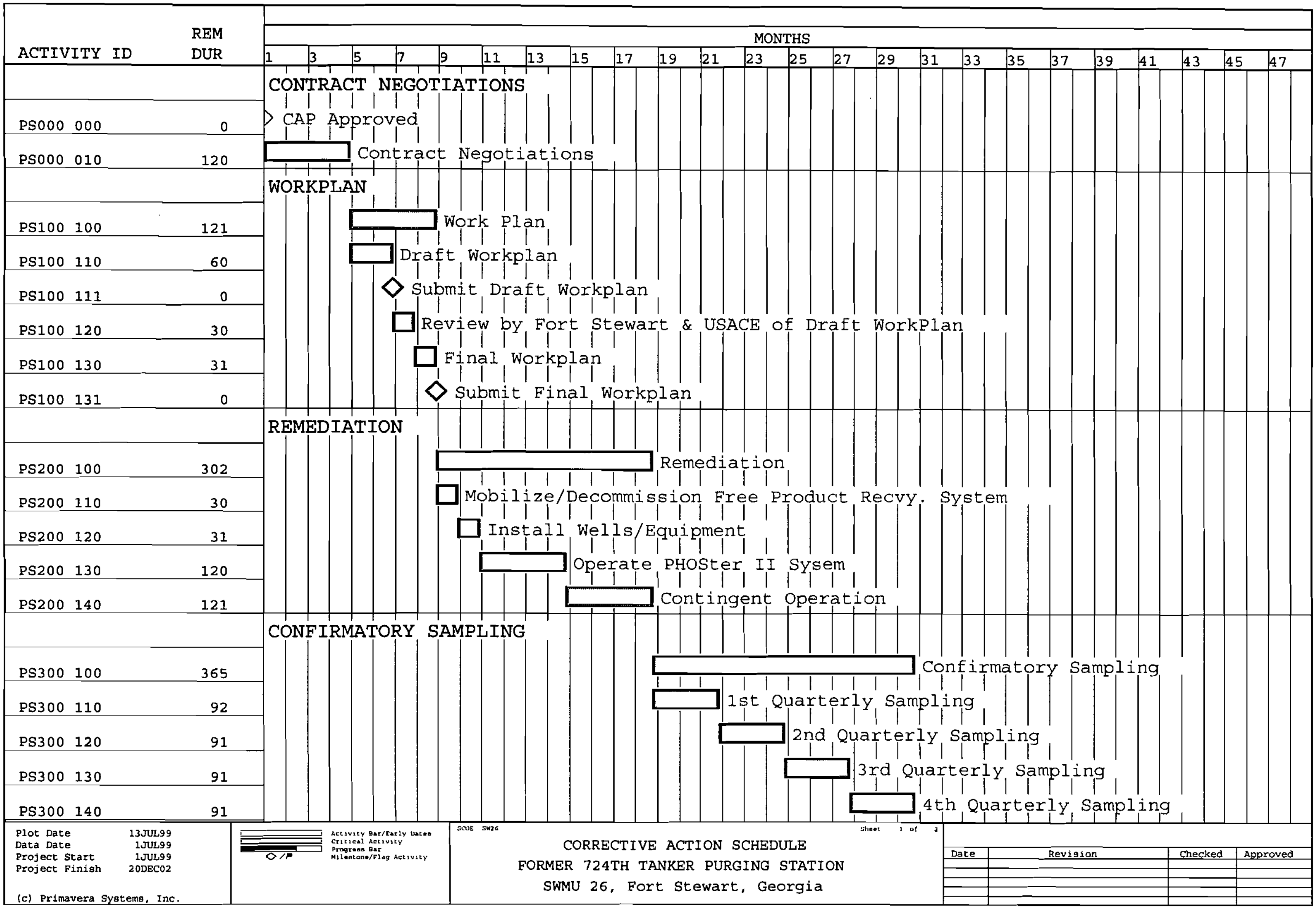
The O&M costs, including indirect costs, are estimated to be approximately $206,000 and would include groundwater monitoring, soil analysis, and O&M for the PHOSter® II system. The required monitoring time for the system is assumed to be 4 months based on the assumptions presented in Section 5.2.3. An additional year of confirmatory sampling will be required to verify that RLs have been achieved in both groundwater and soil.

5.5 IMPLEMENTATION SCHEDULE

Implementation of the corrective action will begin once approval of this CAP is received from GEPD. It is anticipated that a construction contractor can be procured within 4 months following approval of the CAP and that the final corrective action work plan (including appropriate reviews by the Army) will be completed within 4 months thereafter. Mobilization, installation, and startup of the PHOSter® II system will take an additional 2 months. Based on the estimated operational life model, remediation will be complete within an estimated 4 months, although it is prudent to allow an additional 4 months for any contingent action due to the uncertainties associated with the technology. Confirmatory sampling will continue as required for 1 year following treatment. A Corrective Action Completion Report will be prepared and submitted to GEPD for review within 4 months thereafter. The anticipated implementation schedule is presented in Figure 5-5.

5.6 PROGRESS REPORTS

A progress report will be prepared both at the end of system installation and startup and at the end of the anticipated 4-month O&M period of the PHOSter® II nutrient/air injection system. These



ACTIVITY ID	REM DUR	
		CONTRACT NEGOTIATIONS
PS000 000	0	CAP Approved
PS000 010	120	Contract Negotiations
		WORKPLAN
PS100 100	121	Work Plan
PS100 110	60	Draft Workplan
PS100 111	0	Submit Draft Workplan
PS100 120	30	Review by Fort Stewart & USACE of Draft WorkPlan
PS100 130	31	Final Workplan
PS100 131	0	Submit Final Workplan
		REMEDIATION
PS200 100	302	Remediation
PS200 110	30	Mobilize/Decommission Free Product Recvy. System
PS200 120	31	Install Wells/Equipment
PS200 130	120	Operate PHOSter II Sysem
PS200 140	121	Contingent Operation
		CONFIRMATORY SAMPLING
PS300 100	365	Confirmatory Sampling
PS300 110	92	1st Quarterly Sampling
PS300 120	91	2nd Quarterly Sampling
PS300 130	91	3rd Quarterly Sampling
PS300 140	91	4th Quarterly Sampling

Plot Date	13JUL99
Data Date	1JUL99
Project Start	1JUL99
Project Finish	20DEC02

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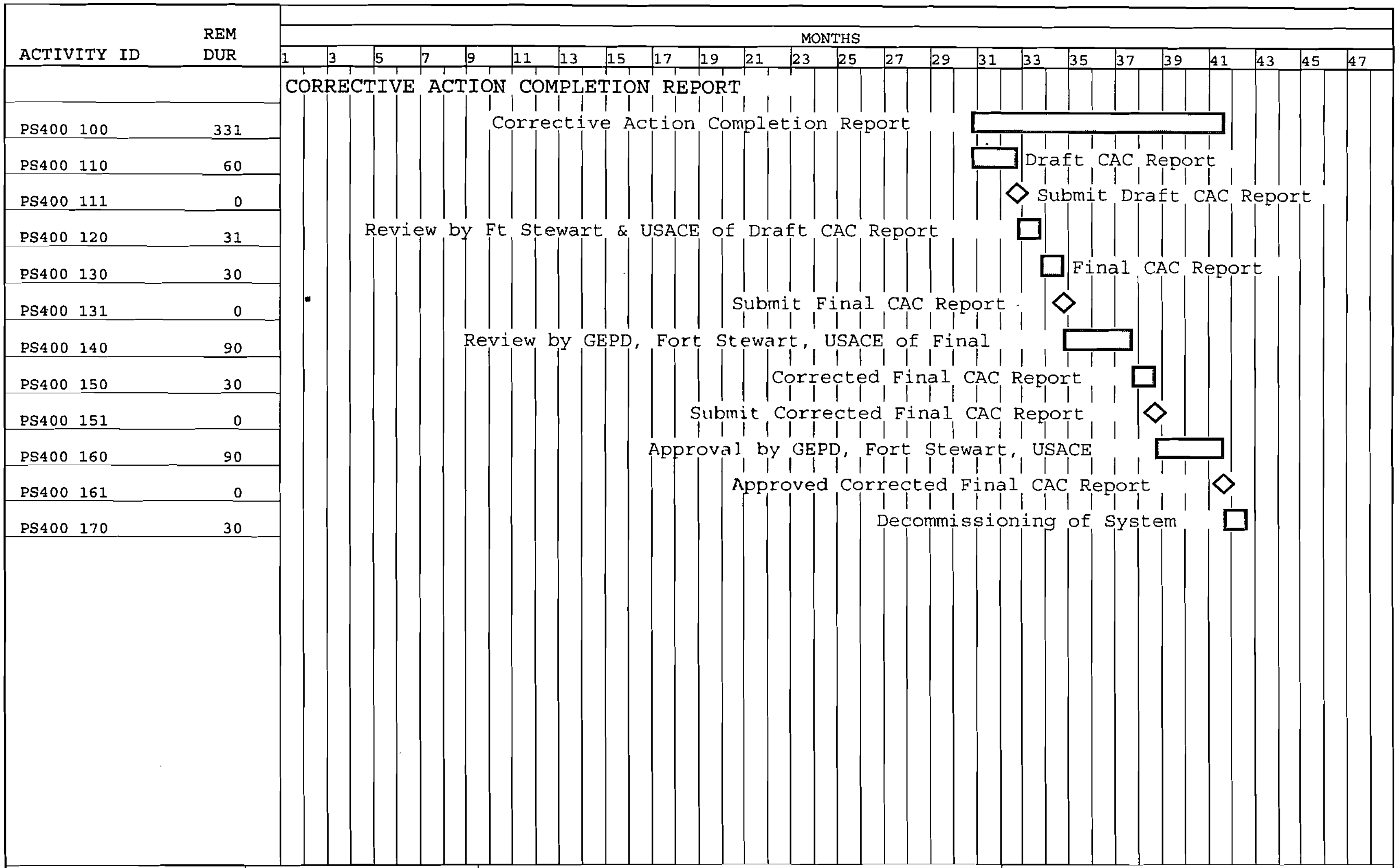
CORRECTIVE ACTION SCHEDULE
FORMER 724TH TANKER PURGING STATION
SWMU 26, Fort Stewart, Georgia

Figure 5-5. Corrective Action Implementation Schedule



ACTIVITY ID	REM DUR	
PS400 100	331	Corrective Action Completion Report
PS400 110	60	Draft CAC Report
PS400 111	0	Submit Draft CAC Report
PS400 120	31	Review by Ft Stewart & USACE of Draft CAC Report
PS400 130	30	Final CAC Report
PS400 131	0	Submit Final CAC Report
PS400 140	90	Review by GEPD, Fort Stewart, USACE of Final
PS400 150	30	Corrected Final CAC Report
PS400 151	0	Submit Corrected Final CAC Report
PS400 160	90	Approval by GEPD, Fort Stewart, USACE
PS400 161	0	Approved Corrected Final CAC Report
PS400 170	30	Decommissioning of System

Plot Date	13JUL99
Data Date	1JUL99
Project Start	1JUL99
Project Finish	20DEC02

(c) Primavera Systems, Inc.

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

SCOE SW26 Sheet 2 of 2

CORRECTIVE ACTION SCHEDULE
FORMER 724TH TANKER PURGING STATION
SWMU 26, Fort Stewart, Georgia

Date	Revision	Checked	Approved

Figure 5-5. Corrective Action Implementation Schedule (continued)

reports will summarize the installation, operation, maintenance, sampling, and analysis performed during system startup and the 4-month O&M period. An analysis of trends and effectiveness of the corrective action will be presented, as will the need for any contingent action discussed, as required.

A progress report will be prepared quarterly during the 1-year confirmatory sampling period. The report will summarize the results of the groundwater sampling and analysis completed during that quarter. An analysis of any deviations from the required RLs and the need for any contingent action will be discussed, as required.

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

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

5.7 IMPLEMENTATION PLAN

Upon approval of this CAP by GEPD, Fort Stewart will request funding, procure a contractor for implementing the corrective action, and implement the specified action. A corrective action work plan will be prepared to guide implementation of the corrective action but will not require GEPD review or approval. Any revisions needed to the O&M Plan (Appendix D) or the Implementation Schedule (Figure 5-4) 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 Public Involvement Plan. No other submittals will need to be provided prior to implementing the selected corrective action.

During the corrective action, progress reports as defined in Section 5.6 will be prepared and submitted to GEPD for review. Upon completion of the corrective action, a Corrective Action Completion Report as defined in Section 5.6 will be prepared and submitted to GEPD for review and approval. Decommissioning of the treatment system (Appendix D) will not begin until after approval of the Corrective Action Completion Report has been received by GEPD and will include removal of all equipment and plugging and abandonment of any below-grade wells or piping.

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6.0 REFERENCES

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APPENDIX A

MARCH 1999
SUPPLEMENTAL GROUNDWATER CHARACTERIZATION
AT THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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1.0 INTRODUCTION

This letter report summarizes the results of the supplemental characterization of groundwater at the Former 724th Tanker Purging Station (TPS) at Fort Stewart, Georgia. This characterization was conducted to support preparation of a Corrective Action Plan (CAP), augmenting the results of the *Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for the Former 724th Tanker Purging Station [Solid Waste Management Unit (SWMU) 26]* (SAIC 1998). This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0034. 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 (SAIC 1997).

The purpose of this supplemental characterization is to provide further evidence that natural attenuation of volatile organic compounds (VOCs) is occurring. The scope of work included sampling of the four existing on-site monitoring wells (MW-1 through MW-4) and analyzing the samples for VOCs, semivolatile organic compounds (SVOCs), and parameters that affect biodegradation of hydrocarbons (nitrate, sulfate, iron, methane, and carbon dioxide). The four wells were previously installed during the Phase II RFI for monitoring the following aquifer units:

MW-1: Shallow water table, upgradient;

MW-2: Shallow water table, center of site;

MW-3: Shallow water table, downgradient; and

MW-4: Deeper portion of the surficial aquifer (35 to 45 feet below land surface), center of site.

2.0 SUMMARY OF INVESTIGATION ACTIVITIES

2.1 SAMPLING METHODOLOGY

The supplemental groundwater sampling at the Former 724th TPS was conducted on March 7 and 8, 1999. The sampling procedures used were the same as those used during the Phase II RFI sampling in August 1997. 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 minimize disturbance of the aquifer. Field parameters [pH, conductivity, temperature, turbidity, and oxidation-reduction potential (Eh)] were monitored during micropurging. Dissolved oxygen (DO) could not be measured due to instrument problems at the time of sampling. 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 0.6 to 4.0 hours to purge. Results of field parameter measurements made at the end of purging in each well are listed in Table A-1.

Table A-1. Field Parameter Measurements During Groundwater Sampling (March 1999)
Former 724th Tanker Purging Station, Fort Stewart

Parameter	Units	Field Reading at Monitoring Well			
		MW-1	**MW-2**	**MW-3**	**MW-4**
Purging Time	Hours	4.0	1.4	0.6	2.4
Volume Purged	Liters	21.1	4.6	8.4	11.6
pH	Su	6.07	6.2	6.73	6.89
Conductivity	µmho/cm	238	474	770	617
Temperature	°C	14.79	13.95	16.47	16.68
Turbidity	NTU	34	18	9.3	11.8
DO	mg/L	na	na	na	na
Eh	MV	45	-31	-74	-92.8
Ferrous Iron	mg/L	5.9	6.1	8.4	na
Elevation TOC	Feet MSL	67.08	70.86	67.51	71.23
Depth to water[a]	Feet	5.36	8.85	6.29	11.06
Elevation water[a]	Feet MSL	61.72	62.01	61.22	60.17

DO = Dissolved oxygen.
Eh = Oxidation-reduction potential.
MSL = Mean sea level (National Geodetic Vertical Datum of 1929).
na = Not measured during sampling.
NTU = Nephelometric turbidity unit.
TOC = Top of casing.
[a] Depth to water measured on March 7, 1999, during pump installation.
[b] Elevation does not include approximately 0.02 feet of floating free product.

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. Ferrous iron was measured in the field at the time of sampling. Groundwater samples were then sent offsite for laboratory analysis for VOCs, PAHs, and water quality parameters (nitrate, sulfate, total iron, methane, and carbon dioxide).

2.2 DATA QUALITY ASSESSMENT

Quality assurance/quality control (QA/QC) activities to achieve the desired data quality were as described in the Phase II RFI Report and the Phase II RFI Work Plan. 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.

3.0 SUMMARY OF INVESTIGATION RESULTS

3.1 POTENTIOMETRIC MAP

Water table measurements were taken in each of the four wells on March 7, 1999, prior to sampling. Table A-1 lists the measured depth below top of casing and the corresponding water elevation. Because only 0.02 foot of floating free product was reported in well MW-2, a reasonably accurate potentiometric map can be drawn (Figure A-1). Water table elevations in March 1999 were generally similar to those measured in September 1998 and August 1997. Groundwater flow is to the west toward Mill Creek, with a measured gradient of 0.005. Vertical

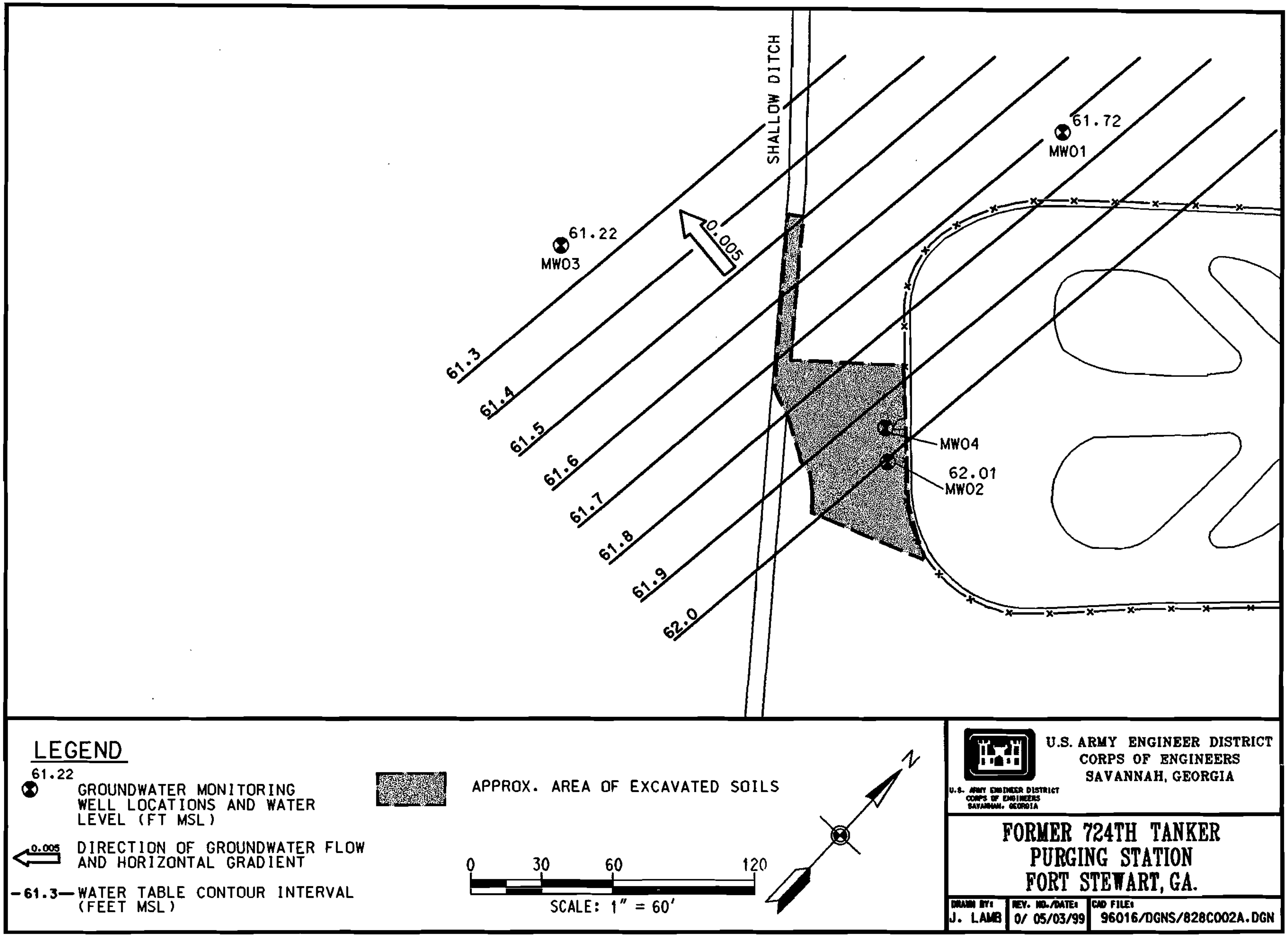

Figure A-1. Potentiometric Map (March 1999) hydraulic gradients measured between MW-4 and the shallow monitoring wells are downward, with a hydraulic head difference of up to 2 feet; this downward gradient is in contrast to previous sampling, which recorded an upward gradient at the site.

3.2 RESULTS OF GROUNDWATER ANALYSES

Analytical results for groundwater samples from the four monitoring wells are summarized in Table A-2 for those parameters detected in at least one sample. Figure A-2 shows the distribution of the detected constituents at the Former 724th TPS during the March 1999 sampling.

Table A-2. Summary of Analytical Results in Groundwater (March 1999)
Former 724th Tanker Purging Station, Fort Stewart

			Monitoring Well ID			
Parameter	**Reference Background Criteria**	**MCL**	**MW-1**	**MW-2**	**MW-3**	**MW-4**
Sample ID			264122	264222	264322	264422
Date			3/8/99	3/8/99	3/8/99	3/8/99
Volatile Organic Compounds (µg/L)						
1,1-Dichloroethane	0.0	5			**0.88**	
Benzene	0.0	5		***792***		
Ethylbenzene	0.0	700		**206**		
Methane	0.0			**5,960**		
Styrene	0.0			**11.2**		
Toluene	0.0	1,000		**521**		**0.6**
Xylenes, total	0.0	10,000		**1,080**		**0.62**
Semivolatile Organic Compounds (µg/L)						
2-Methylnaphthalene	0.0			**160**		
Naphthalene	0.0			**94.6**		
Phenanthrene	0.0			**24.5**		
Pyrene	0.0			**5.8**		
Bis(2-ethylhexyl)phthalate		6		**6.9**		
Other Analytes (mg/L)						
Nitrate	0.5	10	0	0	0	0
Sulfate	26.7		1.92	2.29	**49.2**	6.59
Carbon dioxide			112	337	51.6	35.1
Total dissolved solids			140	396	365	406
Iron (total)			31.4	155	29.4	4.66

Bold outlined box with ***bold italicized*** type indicates concentration above maximum contaminant level (MCL).
Bold type indicates concentration above Fort Stewart Military Reservation reference background criteria.
Blank indicates analyte not detected.

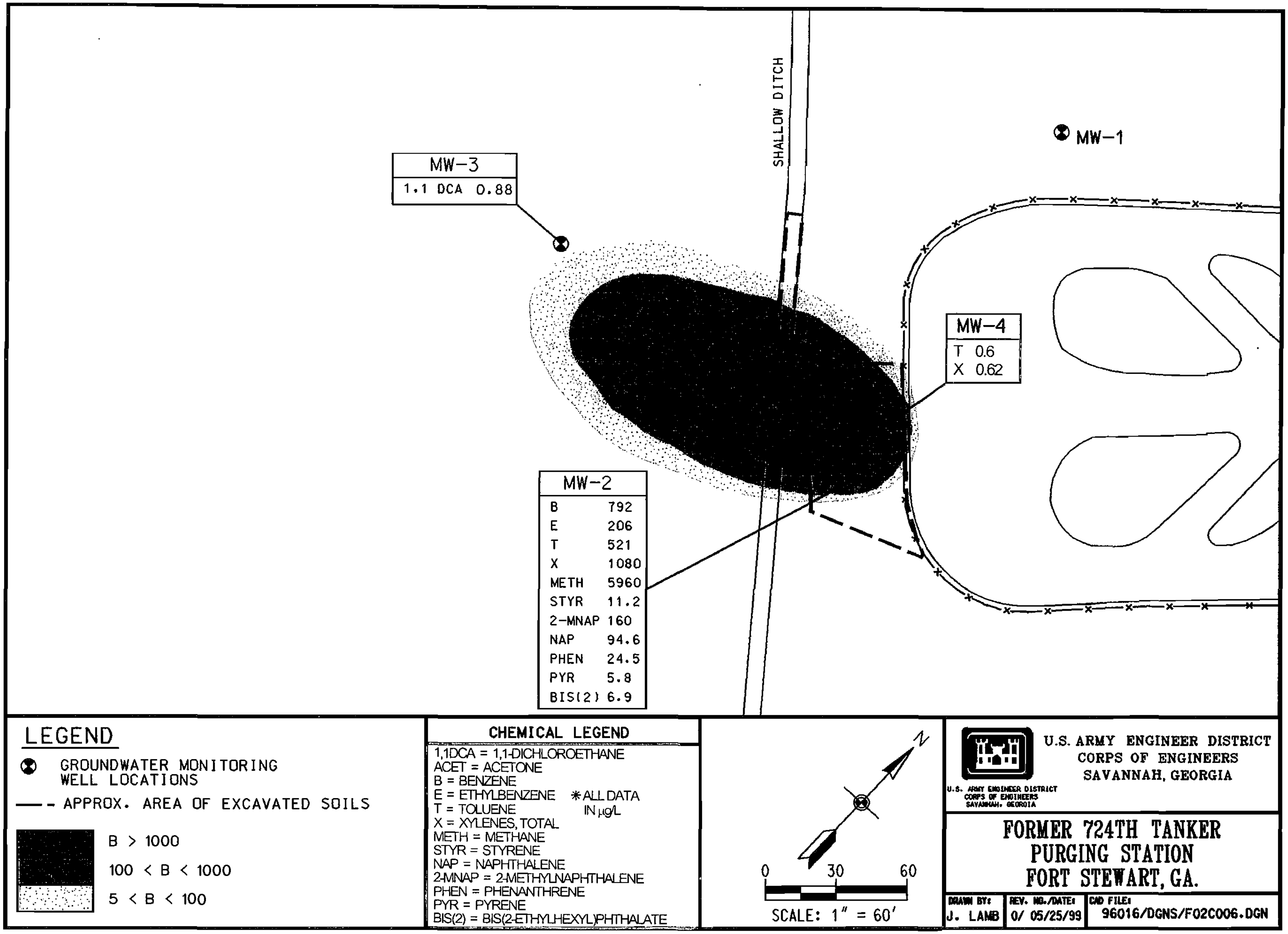

Figure A-2. Distribution of Detected Constituents During March 1999 Sampling

VOCs. Eight individual VOCs were detected in groundwater samples. Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds were detected predominantly in well MW-2, which is screened at the water table and located in the center of the former facility. During sampling, approximately 0.02 foot of free petroleum product was encountered in MW-2. No free product had been encountered in any of the direct-push groundwater samples or any of the wells during the Phase II RFI in August 1997; however, as much as 1.9 feet of free product were reported in MW-2 in September 1998. A Ferret® system was installed on October 20, 1998, in MW-2 for recovery of the free product; operation of the Ferret® system is ongoing, although there is little volume being recovered. Benzene (792 µg/L), ethylbenzene (206 µg/L), toluene (521 µg/L), and total xylenes (1,080 µg/L) were reported in MW-2. The concentration of benzene exceeded its MCL of 5 µg/L.

Toluene and total xylenes were reported in well MW-4, which is screened in the deeper portion of the aquifer, at concentrations slightly above the detection limit. No BTEX constituent was found in any of the other wells, confirming the Phase II RFI conclusions that contaminants have not migrated vertically or laterally from the source at the former facility.

The other VOCs that were detected included 1,1-dichloroethane (0.88 µg/L at MW-3) and styrene (11.2 µg/L at MW-2). 1,1-Dichloroethane was detected in MW-3 during the Phase II RFI at a concentration of 2.2 µg/L and is considered a secondary contaminant within the primary BTEX plume, as also concluded in the Phase II RFI report. Styrene has not been previously detected.

Methane gas was detected at 5,960 µg/L in MW-2. This suggests that active biodegradation is occurring within the groundwater at the source, as methane is a breakdown product of benzene.

SVOCs. Four separate SVOC compounds were detected in groundwater. Naphthalene, which had been detected at MW-2 in both of the two previous sampling events, was reported at 94.6 µg/L during the March 1999 sampling event, which is less than its U.S. Environmental Protection Agency Region III risk-based level of 150 µg/L. Other polynuclear aromatic hydrocarbons were found at MW-2 during the current sampling, but not during previous sampling events, and include 2-methlynapthalene (160 µg/L), phenanthrene (24.5 µg/L), pyrene (5.8 µg/L), and bis(2-ethylhexyl)phthalate (6.9 µg/L).

Other Analytes. Nitrate was not detected in any of the site wells. Sulfate varied between 1.92 and 49.2 mg/L (lowest at well MW-1 and highest at MW-3). Carbon dioxide varied between 35.1 and 337 mg/L (lowest at MW-4 and highest at MW-2). Total iron varied from 4.66 mg/L at MW-4 to 155 mg/L at MW-2. Total dissolved solids remained relatively constant, varying between 140 mg/L at MW-1 and 406 mg/L at MW-4. These results are consistent with the results of the Phase II RFI.

The combined observations of elevated methane gas, carbon dioxide, and total iron in MW-2 indicate that aerobic biodegradation of the hydrocarbon contaminants in groundwater at this well has occurred and is continuing.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been made based on the results of the supplemental groundwater investigation:

1. Free petroleum product was encountered at well MW-2 in the center of the former facility, although at a substantially reduced thickness from previous sampling. Free product recovery, which has been undertaken at the site, should be continued until final corrective action is implemented at the site.

2. Benzene (792 µg/L) is the only BTEX compound that continues to exceed its MCL (5 µg/L) 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 August 1997 and September 1998 sampling events. There is no evidence that contamination has migrated further beyond the source, despite the presence of free product being discovered.

3. Aerobic biodegradation of organic contaminants in groundwater is indicated by elevated concentrations of breakdown products, methane and carbon dioxide, in MW-2. Due to the presence of free product discovered in September 1998, trends in BTEX concentrations are not meaningful in assessing natural attenuation. The free product provides a continuing source of contaminants to the groundwater so that contaminant concentrations would not be seen to decline, even though natural attenuation is occurring.

4. Naphthalene, which is likely associated with the free petroleum product, continues to be detected in MW-2. Other SVOCs, including 2-methylnaphthalene, were also reported during the current sampling.

5.0 ATTACHMENTS

Attached are the laboratory analytical results for the groundwater samples analyzed during the March 1999 sampling.

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ATTACHMENTS

ANALYTICAL RESULTS
FOR
GROUNDWATER SUPPLEMENTAL SAMPLING
(MARCH 1999)
AT THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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A. ANALYTICAL LABORATORY DATA

DEFINITIONS OF ACRONYMS AND ABBREVIATIONS

REG	— Regular analysis
TCLP	— Toxicity Characteristic Leachate Procedure (analytes listed in that procedure)
BG	— 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% difference for detected concentrations between the two gas chromatography (GC) columns.

C — Applies to pesticide results where the identification has been confirmed by GC/MS (gas chromatography/mass spectrometry). 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 SDG 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, 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 - 115%), while sample absorbance is less than 50% 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 MDA.

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 RRF was <0.05.
C02	Initial calibration RSD was >30%.
C03	Initial calibration sequence was not followed as required.
C04	Continuing calibration RRF was <0.05.
C05	Continuing calibration %D was >25%.
C06	Continuing calibration was not performed at the required frequency.
C07	Resolution criteria were not met.
C08	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 DDT was >20%.
C13	Combined breakdown of endrin/DDT was >30%.
C14	Professional judgment was used to qualify the data.

Initial/Continuing Calibration - Inorganics

D01	ICV or 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 's 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%.
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%.
G08	Radiological chemical recovery was >150%.

Matrix Spike/Matrix Spike Duplicate

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%.
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%.
H08	Radiological MS/MSD recovery was >160%.
H09	Radiological MS/MSD samples were not analyzed at the required frequency.

Matrix Spike

I01	MS recovery was above the upper control limit.
I02	MS recovery was below the lower control limit.
I03	MS recovery was <30%.
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 × the CRDL.
J03	Duplicate sample results were <5 × 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	IS retention time varied by more than 30 seconds.
K04	Professional judgment was used to qualify the data.

Pesticide Cleanup Checks

L01	10% recovery was obtained during either check.
L02	Recoveries during either check were >120%.
L03	GPC 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 12 hr GC/MS window.
M07	Professional judgment was used to qualify the data.
M08	The %D between the two pesticide/PCB column checks was >25%.

Compound Quantitation and Reported CRQLs

N01	Quantitation limits were affected by large off-scale peaks.
N02	MDLs 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 × 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%.
P04	No action was taken on the LCS data.
P05	LCS was not analyzed at required frequency.
P06	Radiological LCS recovery was <50% for aqueous samples; <40% for solid samples.
P07	Radiological LCS recovery was >150% for aqueous samples; >160% 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 × the CRDL.
Q04	Duplicate sample results were <5 × 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.

Location: SWMU 26
Station : 26-MW-01

264122 | Field Sample Type: Grab | Matrix: Groundwater | Collected: 03/08/1999

Sample				Qualifiers		Validation
Type	Common Anions	Result	Units	Lab	Data	Code
REG	Nitrite	0	MG/L	U	U	
REG	Sulfate	1.92	MG/L		=	

Sample				Qualifiers		Validation
Type	General Chemistry	Result	Units	Lab	Data	Code
REG	CARBON DIOXIDE, FREE	112	MG/L		=	
REG	Total Dissolved Solids	140	MG/L		J	A03

Sample				Qualifiers		Validation
Type	Metals	Result	Units	Lab	Data	Code
REG	Iron	31400	UG/L		=	

Sample				Qualifiers		Validation
Type	Semi-Volatile Organics	Result	Units	Lab	Data	Code
REG	1,2,4-Trichlorobenzene	11.9	UG/L	U	U	
REG	1,2-Dichlorobenzene	11.9	UG/L	U	U	
REG	1,3-Dichlorobenzene	11.9	UG/L	U	U	
REG	1,4-Dichlorobenzene	11.9	UG/L	U	U	
REG	2,2'-oxybis (1-chloropropane)	11.9	UG/L	U	U	
REG	2,4,5-Trichlorophenol	11.9	UG/L	U	U	
REG	2,4,6-Trichlorophenol	11.9	UG/L	U	U	
REG	2,4-Dichlorophenol	11.9	UG/L	U	U	
REG	2,4-Dimethylphenol	11.9	UG/L	U	U	
REG	2,4-Dinitrophenol	23.8	UG/L	U	U	
REG	2,4-Dinitrotoluene	11.9	UG/L	U	U	
REG	2,6-Dinitrotoluene	11.9	UG/L	U	U	
REG	2-Chloronaphthalene	11.9	UG/L	U	U	
REG	2-Chlorophenol	11.9	UG/L	U	U	
REG	2-Methylnaphthalene	11.9	UG/L	U	U	
REG	2-Methylphenol	11.9	UG/L	U	U	
REG	2-Nitroaniline	11.9	UG/L	U	U	
REG	2-Nitrophenol	11.9	UG/L	U	U	
REG	3,3'-Dichlorobenzidine	59.5	UG/L	U	U	
REG	3-Nitroaniline	11.9	UG/L	U	U	
REG	4,6-Dinitro-o-Cresol	11.9	UG/L	U	U	
REG	4-Bromophenyl-phenyl Ether	11.9	UG/L	U	U	
REG	4-Chloroaniline	23.8	UG/L	U	U	
REG	4-Chlorophenyl-phenylether	11.9	UG/L	U	U	
REG	4-Methylphenol	11.9	UG/L	U	U	
REG	4-Nitroaniline	11.9	UG/L	U	U	
REG	4-Nitrophenol	23.8	UG/L	U	U	
REG	4-chloro-3-methylphenol	11.9	UG/L	U	U	
REG	Acenaphthene	11.9	UG/L	U	U	
REG	Acenaphthylene	11.9	UG/L	U	U	
REG	Anthracene	11.9	UG/L	U	U	
REG	Benzo(a)anthracene	11.9	UG/L	U	U	
REG	Benzo(a)pyrene	11.9	UG/L	U	U	
REG	Benzo(b)fluoranthene	11.9	UG/L	U	U	
REG	Benzo(g,h,i)perylene	11.9	UG/L	U	U	
REG	Benzo(k)fluoranthene	11.9	UG/L	U	U	
REG	Bis(2-chloroethoxy)methane	11.9	UG/L	U	U	
REG	Bis(2-chloroethyl)ether	11.9	UG/L	U	U	
REG	Bis(2-ethylhexyl)phthalate	11.9	UG/L	U	U	
REG	Butyl Benzyl Phthalate	11.9	UG/L	U	U	
REG	Carbazole	11.9	UG/L	U	U	
REG	Chrysene	11.9	UG/L	U	U	
REG	Di-n-butyl Phthalate	11.9	UG/L	U	U	
REG	Di-n-octyl Phthalate	11.9	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	11.9	UG/L	U	U	
REG	Dibenzofuran	11.9	UG/L	U	U	
REG	Diethyl Phthalate	11.9	UG/L	U	U	
REG	Dimethyl Phthalate	11.9	UG/L	U	U	
REG	Fluoranthene	11.9	UG/L	U	U	
REG	Fluorene	11.9	UG/L	U	U	
REG	Hexachlorobenzene	11.9	UG/L	U	U	
REG	Hexachlorobutadiene	11.9	UG/L	U	U	
REG	Hexachlorocyclopentadiene	11.9	UG/L	U	U	
REG	Hexachloroethane	11.9	UG/L	U	U	

Location: SWMU 26
Station : 26-MW-01

264122 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Indeno(1,2,3-cd)pyrene	11.9	UG/L	U	U	
REG	Isophorone	11.9	UG/L	U	U	
REG	N-Nitroso-di-n-propylamine	11.9	UG/L	U	U	
REG	N-Nitrosodiphenylamine	11.9	UG/L	U	U	
REG	Naphthalene	11.9	UG/L	U	U	
REG	Nitrobenzene	11.9	UG/L	U	U	
REG	Pentachlorophenol	11.9	UG/L	U	U	
REG	Phenanthrene	11.9	UG/L	U	U	
REG	Phenol	11.9	UG/L	U	U	
REG	Pyrene	11.9	UG/L	U	U	

Sample Type	Volatile Organic Gases	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Methane	5	UG/L	U	U	

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,1,1-Trichloroethane	2	UG/L	U	U	
REG	1,1,2,2-Tetrachloroethane	2	UG/L	U	U	
REG	1,1,2-Trichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloroethane	2	UG/L	U	U	
REG	1,2-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloropropane	2	UG/L	U	U	
REG	1,3-cis-Dichloropropene	2	UG/L	U	U	
REG	1,3-trans-Dichloropropene	2	UG/L	U	U	
REG	2-Butanone	5	UG/L	U	R	C01,C04
REG	2-Hexanone	5	UG/L	U	U	
REG	4-Methyl-2-pentanone	5	UG/L	U	U	
REG	Acetone	5	UG/L	J	U	F04,F06
REG	Benzene	2	UG/L	U	U	
REG	Bromodichloromethane	5	UG/L	U	U	
REG	Bromoform	2	UG/L	U	U	
REG	Bromomethane	2	UG/L	U	U	
REG	Carbon Disulfide	2	UG/L	U	U	
REG	Carbon Tetrachloride	2	UG/L	U	U	
REG	Chlorobenzene	2	UG/L	U	U	
REG	Chloroethane	2	UG/L	U	U	
REG	Chloroform	2	UG/L	U	U	
REG	Chloromethane	2	UG/L	U	U	
REG	Dibromochloromethane	2	UG/L	U	U	
REG	Ethylbenzene	2	UG/L	U	U	
REG	Methylene Chloride	2	UG/L	U	U	
REG	Styrene	2	UG/L	U	U	
REG	Tetrachloroethene	2	UG/L	U	U	
REG	Toluene	2	UG/L	U	U	
REG	Trichloroethene	2	UG/L	U	U	
REG	Vinyl Chloride	2	UG/L	U	U	
REG	Xylenes, Total	3	UG/L	U	U	

Location: SWMU 26
Station : 26-MW-02

264222 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Common Anions	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Nitrite	0	MG/L	U	U	
REG	Sulfate	2.29	MG/L		=	

Sample Type	General Chemistry	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	CARBON DIOXIDE, FREE	337	MG/L		=	
REG	Total Dissolved Solids	396	MG/L		J	A03

Ft Stewart SWMU 26 Supplemental Sampling (Mar 99)

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Iron	155000	UG/L		=	

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,2,4-Trichlorobenzene	11.2	UG/L	U	U	
REG	1,2-Dichlorobenzene	11.2	UG/L	U	U	
REG	1,3-Dichlorobenzene	11.2	UG/L	U	U	
REG	1,4-Dichlorobenzene	11.2	UG/L	U	U	
REG	2,2'-oxybis (1-chloropropane)	11.2	UG/L	U	U	
REG	2,4,5-Trichlorophenol	11.2	UG/L	U	U	
REG	2,4,6-Trichlorophenol	11.2	UG/L	U	U	
REG	2,4-Dichlorophenol	11.2	UG/L	U	U	
REG	2,4-Dimethylphenol	11.2	UG/L	U	U	
REG	2,4-Dinitrophenol	22.5	UG/L	U	U	
REG	2,4-Dinitrotoluene	11.2	UG/L	U	U	
REG	2,6-Dinitrotoluene	11.2	UG/L	U	U	
REG	2-Chloronaphthalene	11.2	UG/L	U	U	
REG	2-Chlorophenol	11.2	UG/L	U	U	
REG	2-Methylnaphthalene	160	UG/L	D	=	
REG	2-Methylphenol	11.2	UG/L	U	U	
REG	2-Nitroaniline	11.2	UG/L	U	U	
REG	2-Nitrophenol	11.2	UG/L	U	U	
REG	3,3'-Dichlorobenzidine	56.2	UG/L	U	U	
REG	3-Nitroaniline	11.2	UG/L	U	U	
REG	4,6-Dinitro-o-Cresol	11.2	UG/L	U	U	
REG	4-Bromophenyl-phenyl Ether	11.2	UG/L	U	U	
REG	4-Chloroaniline	22.5	UG/L	U	U	
REG	4-Chlorophenyl-phenylether	11.2	UG/L	U	U	
REG	4-Methylphenol	11.2	UG/L	U	U	
REG	4-Nitroaniline	11.2	UG/L	U	U	
REG	4-Nitrophenol	22.5	UG/L	U	U	
REG	4-chloro-3-methylphenol	11.2	UG/L	U	U	
REG	Acenaphthene	11.2	UG/L	U	U	
REG	Acenaphthylene	11.2	UG/L	U	U	
REG	Anthracene	11.2	UG/L	U	U	
REG	Benzo(a)anthracene	11.2	UG/L	U	U	
REG	Benzo(a)pyrene	11.2	UG/L	U	U	
REG	Benzo(b)fluoranthene	11.2	UG/L	U	U	
REG	Benzo(g,h,i)perylene	11.2	UG/L	U	U	
REG	Benzo(k)fluoranthene	11.2	UG/L	U	U	
REG	Bis(2-chloroethoxy)methane	11.2	UG/L	U	U	
REG	Bis(2-chloroethyl)ether	11.2	UG/L	U	U	
REG	Bis(2-ethylhexyl)phthalate	6.9	UG/L	J	J	
REG	Butyl Benzyl Phthalate	11.2	UG/L	U	U	
REG	Carbazole	11.2	UG/L	U	U	
REG	Chrysene	11.2	UG/L	U	U	
REG	Di-n-butyl Phthalate	11.2	UG/L	U	U	
REG	Di-n-octyl Phthalate	11.2	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	11.2	UG/L	U	U	
REG	Dibenzofuran	11.2	UG/L	U	U	
REG	Diethyl Phthalate	11.2	UG/L	U	U	
REG	Dimethyl Phthalate	11.2	UG/L	U	U	
REG	Fluoranthene	11.2	UG/L	U	U	
REG	Fluorene	11.2	UG/L	U	U	
REG	Hexachlorobenzene	11.2	UG/L	U	U	
REG	Hexachlorobutadiene	11.2	UG/L	U	U	
REG	Hexachlorocyclopentadiene	11.2	UG/L	U	U	
REG	Hexachloroethane	11.2	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	11.2	UG/L	U	U	
REG	Isophorone	11.2	UG/L	U	U	
REG	N-Nitroso-di-n-propylamine	11.2	UG/L	U	U	
REG	N-Nitrosodiphenylamine	11.2	UG/L	U	U	
REG	Naphthalene	94.6	UG/L		=	
REG	Nitrobenzene	11.2	UG/L	U	U	
REG	Pentachlorophenol	11.2	UG/L	U	U	
REG	Phenanthrene	24.5	UG/L		=	
REG	Phenol	11.2	UG/L	U	U	
REG	Pyrene	5.8	UG/L	J	J	

Sample Type	Volatile Organic Gases	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Methane	5960	UG/L		=	F04,F08

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,1,1-Trichloroethane	20	UG/L	U	U	
REG	1,1,2,2-Tetrachloroethane	20	UG/L	U	U	
REG	1,1,2-Trichloroethane	20	UG/L	U	U	
REG	1,1-Dichloroethane	20	UG/L	U	U	
REG	1,1-Dichloroethene	20	UG/L	U	U	
REG	1,2-Dichloroethane	20	UG/L	U	U	
REG	1,2-Dichloroethene	20	UG/L	U	U	
REG	1,2-Dichloropropane	20	UG/L	U	U	
REG	1,3-cis-Dichloropropene	20	UG/L	U	U	
REG	1,3-trans-Dichloropropene	20	UG/L	U	U	
REG	2-Butanone	50	UG/L	U	R	C01,C04
REG	2-Hexanone	50	UG/L	U	U	
REG	4-Methyl-2-pentanone	50	UG/L	U	U	
REG	Acetone	50	UG/L	U	U	
REG	Benzene	792	UG/L		=	
REG	Bromodichloromethane	50	UG/L	U	U	
REG	Bromoform	20	UG/L	U	U	
REG	Bromomethane	20	UG/L	U	U	
REG	Carbon Disulfide	20	UG/L	U	U	
REG	Carbon Tetrachloride	20	UG/L	U	U	
REG	Chlorobenzene	20	UG/L	U	U	
REG	Chloroethane	20	UG/L	U	U	
REG	Chloroform	20	UG/L	U	U	
REG	Chloromethane	20	UG/L	U	U	
REG	Dibromochloromethane	20	UG/L	U	U	
REG	Ethylbenzene	206	UG/L		=	
REG	Methylene Chloride	20	UG/L	U	U	
REG	Styrene	11.2	UG/L	J	J	
REG	Tetrachloroethene	20	UG/L	U	U	
REG	Toluene	521	UG/L		=	
REG	Trichloroethene	20	UG/L	U	U	
REG	Vinyl Chloride	20	UG/L	U	U	
REG	Xylenes, Total	1080	UG/L		=	

Location: **SWMU 26**
Station : **26-MW-03**

264322 **Field Sample Type: Grab** **Matrix: Groundwater** **Collected: 03/08/1999**

Sample Type	Common Anions	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Nitrite	0	MG/L	U	U	
REG	Sulfate	49.2	MG/L		=	

Sample Type	General Chemistry	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	CARBON DIOXIDE, FREE	51.6	MG/L		=	
REG	Total Dissolved Solids	365	MG/L		J	A03

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Iron	29400	UG/L		=	

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,2,4-Trichlorobenzene	10.4	UG/L	U	U	
REG	1,2-Dichlorobenzene	10.4	UG/L	U	U	
REG	1,3-Dichlorobenzene	10.4	UG/L	U	U	
REG	1,4-Dichlorobenzene	10.4	UG/L	U	U	
REG	2,2'-oxybis (1-chloropropane)	10.4	UG/L	U	U	
REG	2,4,5-Trichlorophenol	10.4	UG/L	U	U	
REG	2,4,6-Trichlorophenol	10.4	UG/L	U	U	
REG	2,4-Dichlorophenol	10.4	UG/L	U	U	
REG	2,4-Dimethylphenol	10.4	UG/L	U	U	
REG	2,4-Dinitrophenol	20.8	UG/L	U	U	
REG	2,4-Dinitrotoluene	10.4	UG/L	U	U	
REG	2,6-Dinitrotoluene	10.4	UG/L	U	U	
REG	2-Chloronaphthalene	10.4	UG/L	U	U	
REG	2-Chlorophenol	10.4	UG/L	U	U	
REG	2-Methylnaphthalene	10.4	UG/L	U	U	
REG	2-Methylphenol	10.4	UG/L	U	U	
REG	2-Nitroaniline	10.4	UG/L	U	U	

Location: SWMU 26
Station : 26-MW-03

264322 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Data	Validation Code
REG	2-Nitrophenol	10.4	UG/L	U	U	
REG	3,3'-Dichlorobenzidine	52.1	UG/L	U	U	
REG	3-Nitroaniline	10.4	UG/L	U	U	
REG	4,6-Dinitro-o-Cresol	10.4	UG/L	U	U	
REG	4-Bromophenyl-phenyl Ether	10.4	UG/L	U	U	
REG	4-Chloroaniline	20.8	UG/L	U	U	
REG	4-Chlorophenyl-phenylether	10.4	UG/L	U	U	
REG	4-Methylphenol	10.4	UG/L	U	U	
REG	4-Nitroaniline	10.4	UG/L	U	U	
REG	4-Nitrophenol	20.8	UG/L	U	U	
REG	4-chloro-3-methylphenol	10.4	UG/L	U	U	
REG	Acenaphthene	10.4	UG/L	U	U	
REG	Acenaphthylene	10.4	UG/L	U	U	
REG	Anthracene	10.4	UG/L	U	U	
REG	Benzo(a)anthracene	10.4	UG/L	U	U	
REG	Benzo(a)pyrene	10.4	UG/L	U	U	
REG	Benzo(b)fluoranthene	10.4	UG/L	U	U	
REG	Benzo(g,h,i)perylene	10.4	UG/L	U	U	
REG	Benzo(k)fluoranthene	10.4	UG/L	U	U	
REG	Bis(2-chloroethoxy)methane	10.4	UG/L	U	U	
REG	Bis(2-chloroethyl)ether	10.4	UG/L	U	U	
REG	Bis(2-ethylhexyl)phthalate	10.4	UG/L	U	U	
REG	Butyl Benzyl Phthalate	10.4	UG/L	U	U	
REG	Carbazole	10.4	UG/L	U	U	
REG	Chrysene	10.4	UG/L	U	U	
REG	Di-n-butyl Phthalate	10.4	UG/L	U	U	
REG	Di-n-octyl Phthalate	10.4	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	10.4	UG/L	U	U	
REG	Dibenzofuran	10.4	UG/L	U	U	
REG	Diethyl Phthalate	10.4	UG/L	U	U	
REG	Dimethyl Phthalate	10.4	UG/L	U	U	
REG	Fluoranthene	10.4	UG/L	U	U	
REG	Fluorene	10.4	UG/L	U	U	
REG	Hexachlorobenzene	10.4	UG/L	U	U	
REG	Hexachlorobutadiene	10.4	UG/L	U	U	
REG	Hexachlorocyclopentadiene	10.4	UG/L	U	U	
REG	Hexachloroethane	10.4	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	10.4	UG/L	U	U	
REG	Isophorone	10.4	UG/L	U	U	
REG	N-Nitroso-di-n-propylamine	10.4	UG/L	U	U	
REG	N-Nitrosodiphenylamine	10.4	UG/L	U	U	
REG	Naphthalene	10.4	UG/L	U	U	
REG	Nitrobenzene	10.4	UG/L	U	U	
REG	Pentachlorophenol	10.4	UG/L	U	U	
REG	Phenanthrene	10.4	UG/L	U	U	
REG	Phenol	10.4	UG/L	U	U	
REG	Pyrene	10.4	UG/L	U	U	

Sample Type	Volatile Organic Gases	Result	Units	Qualifiers Lab	Data	Validation Code
REG	Methane	18.6	UG/L		U	F04,F07

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Data	Validation Code
REG	1,1,1-Trichloroethane	2	UG/L	U	U	
REG	1,1,2,2-Tetrachloroethane	2	UG/L	U	U	
REG	1,1,2-Trichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethane	0.88	UG/L	J	J	
REG	1,1-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloroethane	2	UG/L	U	U	
REG	1,2-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloropropane	2	UG/L	U	U	
REG	1,3-cis-Dichloropropene	2	UG/L	U	U	
REG	1,3-trans-Dichloropropene	2	UG/L	U	U	
REG	2-Butanone	5	UG/L	U	R	C01,C04
REG	2-Hexanone	5	UG/L	U	U	
REG	4-Methyl-2-pentanone	5	UG/L	U	U	
REG	Acetone	5	UG/L	J	U	F04,F06

Location: SWMU 26
Station : 26-MW-03

264322 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Benzene	2	UG/L	U	U	
REG	Bromodichloromethane	5	UG/L	U	U	
REG	Bromoform	2	UG/L	U	U	
REG	Bromomethane	2	UG/L	U	U	
REG	Carbon Disulfide	2	UG/L	U	U	
REG	Carbon Tetrachloride	2	UG/L	U	U	
REG	Chlorobenzene	2	UG/L	U	U	
REG	Chloroethane	2	UG/L	U	U	
REG	Chloroform	2	UG/L	U	U	
REG	Chloromethane	2	UG/L	U	U	
REG	Dibromochloromethane	2	UG/L	U	U	
REG	Ethylbenzene	2	UG/L	U	U	
REG	Methylene Chloride	2	UG/L	U	U	
REG	Styrene	2	UG/L	U	U	
REG	Tetrachloroethene	2	UG/L	U	U	
REG	Toluene	2	UG/L	U	U	
REG	Trichloroethene	2	UG/L	U	U	
REG	Vinyl Chloride	2	UG/L	U	U	
REG	Xylenes, Total	3	UG/L	U	U	

Location: SWMU 26
Station : 26-MW-04

264422 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Common Anions	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Nitrite	0	MG/L	U	U	
REG	Sulfate	6.59	MG/L		=	

Sample Type	General Chemistry	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	CARBON DIOXIDE, FREE	35.1	MG/L		=	
REG	Total Dissolved Solids	406	MG/L		J	A03

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Iron	4660	UG/L		=	

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,2,4-Trichlorobenzene	11.1	UG/L	U	U	
REG	1,2-Dichlorobenzene	11.1	UG/L	U	U	
REG	1,3-Dichlorobenzene	11.1	UG/L	U	U	
REG	1,4-Dichlorobenzene	11.1	UG/L	U	U	
REG	2,2'-oxybis (1-chloropropane)	11.1	UG/L	U	U	
REG	2,4,5-Trichlorophenol	11.1	UG/L	U	U	
REG	2,4,6-Trichlorophenol	11.1	UG/L	U	U	
REG	2,4-Dichlorophenol	11.1	UG/L	U	U	
REG	2,4-Dimethylphenol	11.1	UG/L	U	U	
REG	2,4-Dinitrophenol	22.2	UG/L	U	U	
REG	2,4-Dinitrotoluene	11.1	UG/L	U	U	
REG	2,6-Dinitrotoluene	11.1	UG/L	U	U	
REG	2-Chloronaphthalene	11.1	UG/L	U	U	
REG	2-Chlorophenol	11.1	UG/L	U	U	
REG	2-Methylnaphthalene	11.1	UG/L	U	U	
REG	2-Methylphenol	11.1	UG/L	U	U	
REG	2-Nitroaniline	11.1	UG/L	U	U	
REG	2-Nitrophenol	11.1	UG/L	U	U	
REG	3,3'-Dichlorobenzidine	55.6	UG/L	U	U	
REG	3-Nitroaniline	11.1	UG/L	U	U	
REG	4,6-Dinitro-o-Cresol	11.1	UG/L	U	U	
REG	4-Bromophenyl-phenyl Ether	11.1	UG/L	U	U	
REG	4-Chloroaniline	22.2	UG/L	U	U	
REG	4-Chlorophenyl-phenylether	11.1	UG/L	U	U	
REG	4-Methylphenol	11.1	UG/L	U	U	
REG	4-Nitroaniline	11.1	UG/L	U	U	

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Location: SWMU 26
Station : 26-MW-04

264422 Field Sample Type: Grab Matrix: Groundwater Collected: 03/08/1999

Sample Type	Semi-Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	4-Nitrophenol	22.2	UG/L	U	U	
REG	4-chloro-3-methylphenol	11.1	UG/L	U	U	
REG	Acenaphthene	11.1	UG/L	U	U	
REG	Acenaphthylene	11.1	UG/L	U	U	
REG	Anthracene	11.1	UG/L	U	U	
REG	Benzo(a)anthracene	11.1	UG/L	U	U	
REG	Benzo(a)pyrene	11.1	UG/L	U	U	
REG	Benzo(b)fluoranthene	11.1	UG/L	U	U	
REG	Benzo(g,h,i)perylene	11.1	UG/L	U	U	
REG	Benzo(k)fluoranthene	11.1	UG/L	U	U	
REG	Bis(2-chloroethoxy)methane	11.1	UG/L	U	U	
REG	Bis(2-chloroethyl)ether	11.1	UG/L	U	U	
REG	Bis(2-ethylhexyl)phthalate	11.1	UG/L	U	U	
REG	Butyl Benzyl Phthalate	11.1	UG/L	U	U	
REG	Carbazole	11.1	UG/L	U	U	
REG	Chrysene	11.1	UG/L	U	U	
REG	Di-n-butyl Phthalate	11.1	UG/L	U	U	
REG	Di-n-octyl Phthalate	11.1	UG/L	U	U	
REG	Dibenzo(a,h)anthracene	11.1	UG/L	U	U	
REG	Dibenzofuran	11.1	UG/L	U	U	
REG	Diethyl Phthalate	11.1	UG/L	U	U	
REG	Dimethyl Phthalate	11.1	UG/L	U	U	
REG	Fluoranthene	11.1	UG/L	U	U	
REG	Fluorene	11.1	UG/L	U	U	
REG	Hexachlorobenzene	11.1	UG/L	U	U	
REG	Hexachlorobutadiene	11.1	UG/L	U	U	
REG	Hexachlorocyclopentadiene	11.1	UG/L	U	U	
REG	Hexachloroethane	11.1	UG/L	U	U	
REG	Indeno(1,2,3-cd)pyrene	11.1	UG/L	U	U	
REG	Isophorone	11.1	UG/L	U	U	
REG	N-Nitroso-di-n-propylamine	11.1	UG/L	U	U	
REG	N-Nitrosodiphenylamine	11.1	UG/L	U	U	
REG	Naphthalene	11.1	UG/L	U	U	
REG	Nitrobenzene	11.1	UG/L	U	U	
REG	Pentachlorophenol	11.1	UG/L	U	U	
REG	Phenanthrene	11.1	UG/L	U	U	
REG	Phenol	11.1	UG/L	U	U	
REG	Pyrene	11.1	UG/L	U	U	

Sample Type	Volatile Organic Gases	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Methane	5	UG/L	U	U	

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,1,1-Trichloroethane	2	UG/L	U	U	
REG	1,1,2,2-Tetrachloroethane	2	UG/L	U	U	
REG	1,1,2-Trichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloroethane	2	UG/L	U	U	
REG	1,2-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloropropane	2	UG/L	U	U	
REG	1,3-cis-Dichloropropene	2	UG/L	U	U	
REG	1,3-trans-Dichloropropene	2	UG/L	U	U	
REG	2-Butanone	5	UG/L	U	R	C01,C04
REG	2-Hexanone	5	UG/L	U	U	
REG	4-Methyl-2-pentanone	5	UG/L	U	U	
REG	Acetone	5	UG/L	U	U	
REG	Benzene	2	UG/L	U	U	
REG	Bromodichloromethane	5	UG/L	U	U	
REG	Bromoform	2	UG/L	U	U	
REG	Bromomethane	2	UG/L	U	U	
REG	Carbon Disulfide	2	UG/L	U	U	
REG	Carbon Tetrachloride	2	UG/L	U	U	
REG	Chlorobenzene	2	UG/L	U	U	
REG	Chloroethane	2	UG/L	U	U	
REG	Chloroform	2	UG/L	U	U	

Location: SWMU 26
Station : 26-MW-04

264422 — **Field Sample Type: Grab** — **Matrix: Groundwater** — **Collected:** 03/08/1999

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Chloromethane	2	UG/L	U	U	
REG	Dibromochloromethane	2	UG/L	U	U	
REG	Ethylbenzene	2	UG/L	U	U	
REG	Methylene Chloride	2	UG/L	U	U	
REG	Styrene	2	UG/L	U	U	
REG	Tetrachloroethene	2	UG/L	U	U	
REG	Toluene	0.6	UG/L	J	J	
REG	Trichloroethene	2	UG/L	U	U	
REG	Vinyl Chloride	2	UG/L	U	U	
REG	Xylenes, Total	0.62	UG/L	J	J	

Location: SWMU 26
Station : QC

TB2610 — **Field Sample Type: Trip Blank** — **Matrix: Quality Control** — **Collected:** 03/08/1999

Sample Type	Volatile Organics	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	1,1,1-Trichloroethane	2	UG/L	U	U	
REG	1,1,2,2-Tetrachloroethane	2	UG/L	U	U	
REG	1,1,2-Trichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethane	2	UG/L	U	U	
REG	1,1-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloroethane	2	UG/L	U	U	
REG	1,2-Dichloroethene	2	UG/L	U	U	
REG	1,2-Dichloropropane	2	UG/L	U	U	
REG	1,3-cis-Dichloropropene	2	UG/L	U	U	
REG	1,3-trans-Dichloropropene	2	UG/L	U	U	
REG	2-Butanone	5	UG/L	U	R	C01,C04
REG	2-Hexanone	5	UG/L	U	U	
REG	4-Methyl-2-pentanone	5	UG/L	U	U	
REG	Acetone	2.4	UG/L	J	J	
REG	Benzene	2	UG/L	U	U	
REG	Bromodichloromethane	5	UG/L	U	U	
REG	Bromoform	2	UG/L	U	U	
REG	Bromomethane	2	UG/L	U	U	
REG	Carbon Disulfide	2	UG/L	U	U	
REG	Carbon Tetrachloride	2	UG/L	U	U	
REG	Chlorobenzene	2	UG/L	U	U	
REG	Chloroethane	2	UG/L	U	U	
REG	Chloroform	2	UG/L	U	U	
REG	Chloromethane	2	UG/L	U	U	
REG	Dibromochloromethane	2	UG/L	U	U	
REG	Ethylbenzene	2	UG/L	U	U	
REG	Methylene Chloride	2	UG/L	U	U	
REG	Styrene	2	UG/L	U	U	
REG	Tetrachloroethene	2	UG/L	U	U	
REG	Toluene	2	UG/L	U	U	
REG	Trichloroethene	2	UG/L	U	U	
REG	Vinyl Chloride	2	UG/L	U	U	
REG	Xylenes, Total	3	UG/L	U	U	

TB2611 — **Field Sample Type: Trip Blank** — **Matrix: Quality Control** — **Collected:** 03/08/1999

Sample Type	Volatile Organic Gases	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Methane	9.04	UG/L		=	

APPENDIX B

FATE AND TRANSPORT MODELING
AT THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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1.0 INTRODUCTION

Monitored natural attenuation is appropriate as a remedial approach only where it can be demonstrated capable of achieving a site's remedial objectives within a time frame that is reasonable. In order to determine whether monitored natural attenuation is an appropriate remedy for soils and groundwater at a given site, fate and transport modeling was performed to show whether contaminants present in soils and groundwater can be effectively remediated by natural attenuation processes. The following sections summarize the modeling performed for evaluating natural attenuation as an alternative for the Corrective Action Plan (CAP) at the 724th Tanker Purging Station (TPS) at Fort Stewart, Georgia.

2.0 MODELING APPROACH

A brief summary of the modeling approach is presented as follows:

1. Develop the conceptual model for each distinct flow path including contaminated soils, groundwater plume, the flow path direction and characteristics, and receptor location.

2. Identify the chemicals 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 (because 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. Using the results from the leachate modeling, perform saturated flow and contaminant transport modeling using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model to predict the maximum groundwater concentration ($C_{GWS,P}$) at the source, and compare against the observed maximum concentration in the groundwater ($C_{GWS,O}$) beneath the source.

5. Perform steady-state saturated flow and contaminant transport modeling using AT123D to predict the maximum concentration of the surrogate chemical representing the COCs at the receptor location, 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_{GWR} is the predicted maximum concentration at the receptor location and C_{GWS} is the concentration of groundwater at the source) [i.e., either $C_{GWS,O}$ or $C_{GWS,P}$].

6. 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.

7. Perform leachate modeling using SESOIL in conjunction with source removal to estimate the minimum time required that will not cause any further leaching to groundwater with concentrations higher than maximum contaminant levels (MCLs).

3.0 MODELS SELECTED

3.1 SESOIL

The SESOIL model was used to simulate the vertical transport of contaminants from the source areas down through the vadose zone to the shallow groundwater (water table). SESOIL is a one-dimensional, vertical transport code for the unsaturated soil zone and is designed to simultaneously model water transport and pollutant fate. The program was originally developed by the U.S. Environmental Protection Agency (Bonazountas and Wagner 1981; 1984) and has been extensively modified to enhance its capabilities (Hetrick et al. 1989; Hetrick et al. 1986; 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 are simulated in SESOIL in both the hydrologic cycle and 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 the program particularly attractive and suitable for the vadose zone soil leaching at this site are:

- SESOIL has been extensively validated and shown to work under a number of scenarios. The model 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; Wagner et al. 1986; 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, compared to 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 2 layers and as many as 4 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.

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 GSC (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).

4.0 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 always utilized for selecting the values of these parameters. The input parameters are presented in the attachment to this appendix.

5.0 MODEL APPLICATION AND RESULTS

Both SESOIL, for unsaturated zone, and AT123D, for saturated zone, were applied to benzene, which was selected as the surrogate chemical from the group of organic chemicals identified as COCs at this site. Because benzene has a slower degradation rate and a higher mobility than other chemicals within the group, natural attenuation modeling results for benzene can be used for the remaining constituents with conservatism. The results from the modeling of the leaching of soil contamination to the groundwater using SESOIL indicated that the additional contaminant contribution to the groundwater is expected to produce concentrations in groundwater that would be lower than the maximum concentration already observed in the groundwater. Therefore, to be conservative, a steady-state AT123D model was developed by calibrating the model against observed maximum concentrations of benzene in the groundwater beneath the Former 724th TPS site. Results of this modeling, shown in Figure B-1, indicate that benzene from the TPS site is not expected to be of potential concern at the nearest receptor location [i.e., Mill Creek (1,200 feet from the source)]. Also, concentrations of benzene at the source will be reduced to less than their MCLs by natural attenuation processes within 20 years.

Site-specific DAFs between the source and the receptor locations were developed. The DAF is a numerical value that represents the attempt to mathematically quantify the natural physical, chemical, and biological processes (e.g., advection-dispersion, sorption-retardation, biodegradation, and volatilization) that result in the decrease of a chemical concentration in an environmental medium. In simple terms, the DAF is the ratio of chemical concentration at the source (or the point of origin) to the concentration at the exposure point. The DAFs reflect the natural attenuation concepts outlined in the American Society for Testing and Material's risk-based corrective action protocol (ASTM 1995). Based on modeling results, the estimated DAF for benzene at Mill Creek is infinite.

To estimate a reasonable time frame for monitored natural attenuation as a remedial alternative, fate and transport modeling was performed in conjunction with active remediation measures e.g., source reduction). Multiple AT123D modeling runs were performed by reducing the concentration of benzene at the source. Figures B-2 through B-8 represent concentrations

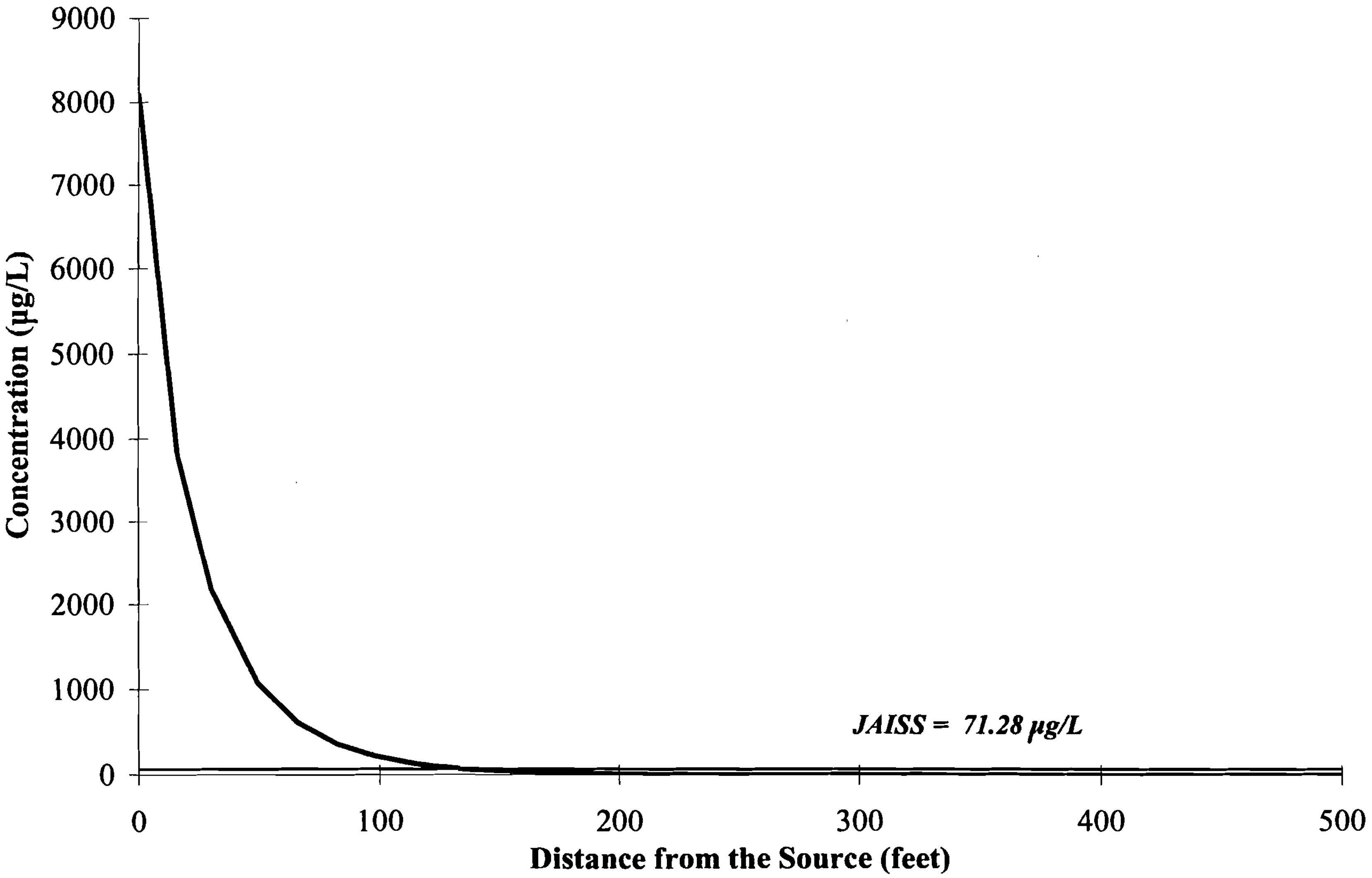

Figure B-1. AT123D Modeled Maximum Concentration of Benzene in the Groundwater Versus Downgradient Distance from the Source (SWMU 26)

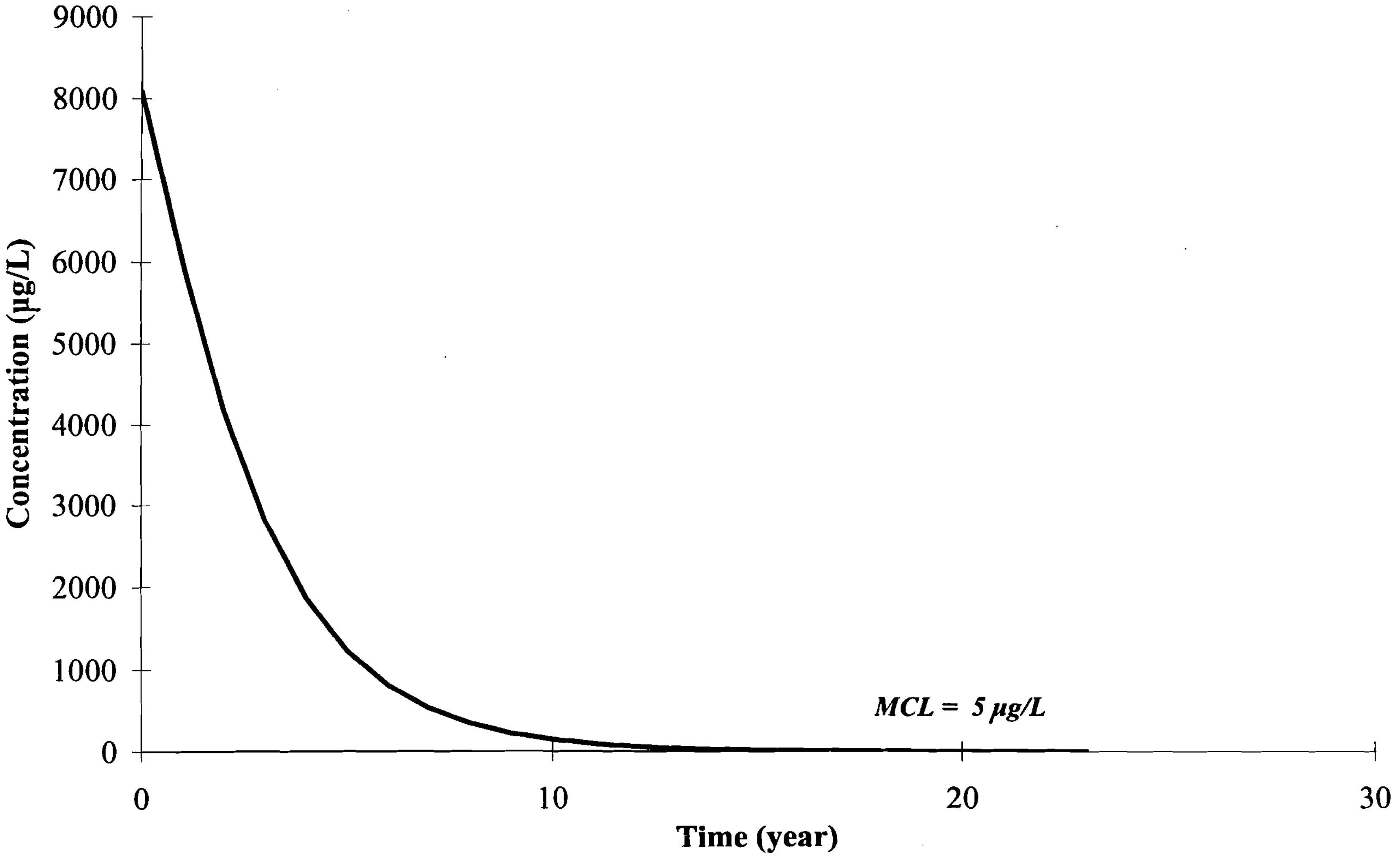

Figure B-2. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source (SWMU 26)

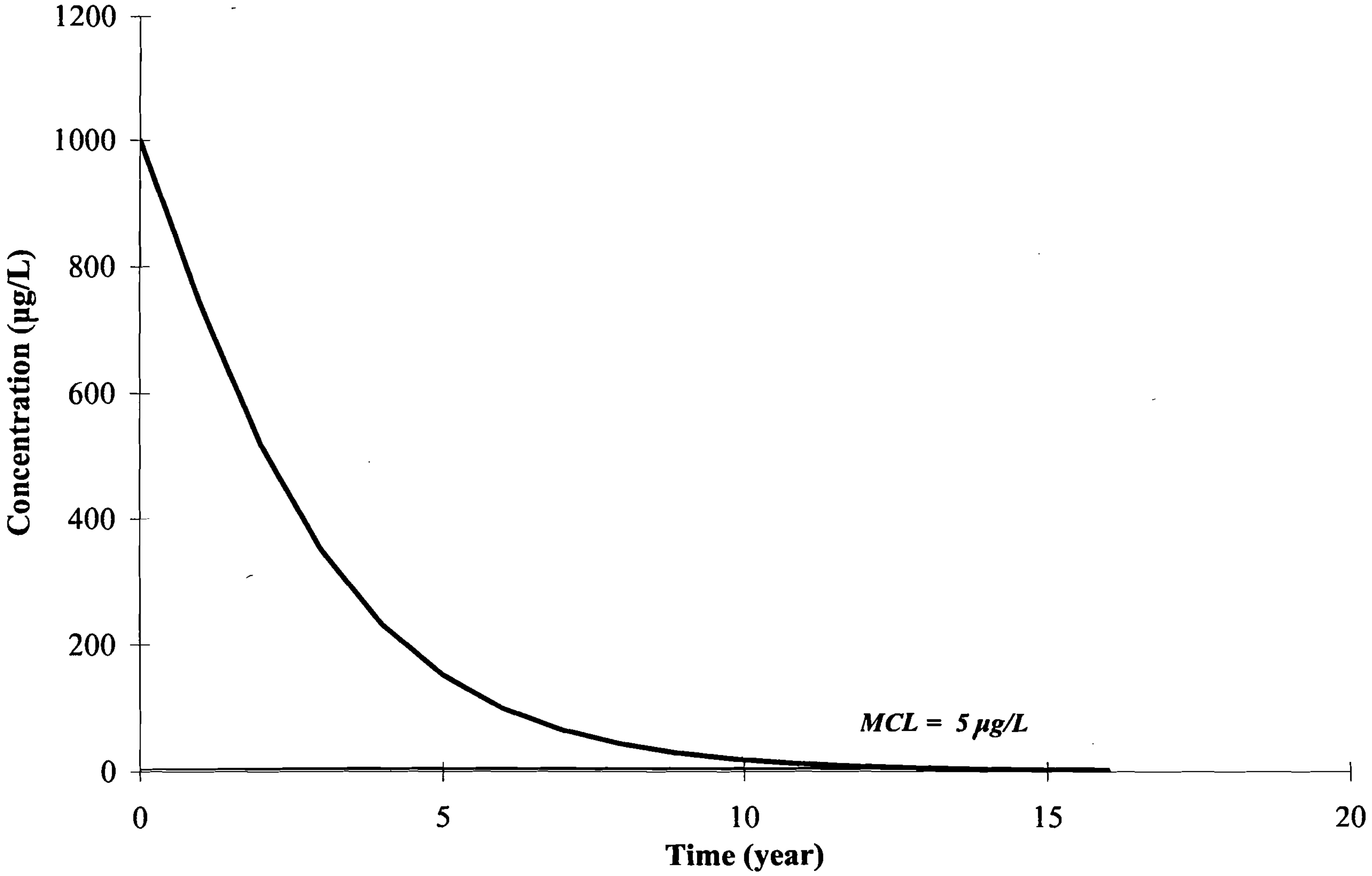

Figure B-3. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source after Source Concentration is Reduced to 1,000 ppb

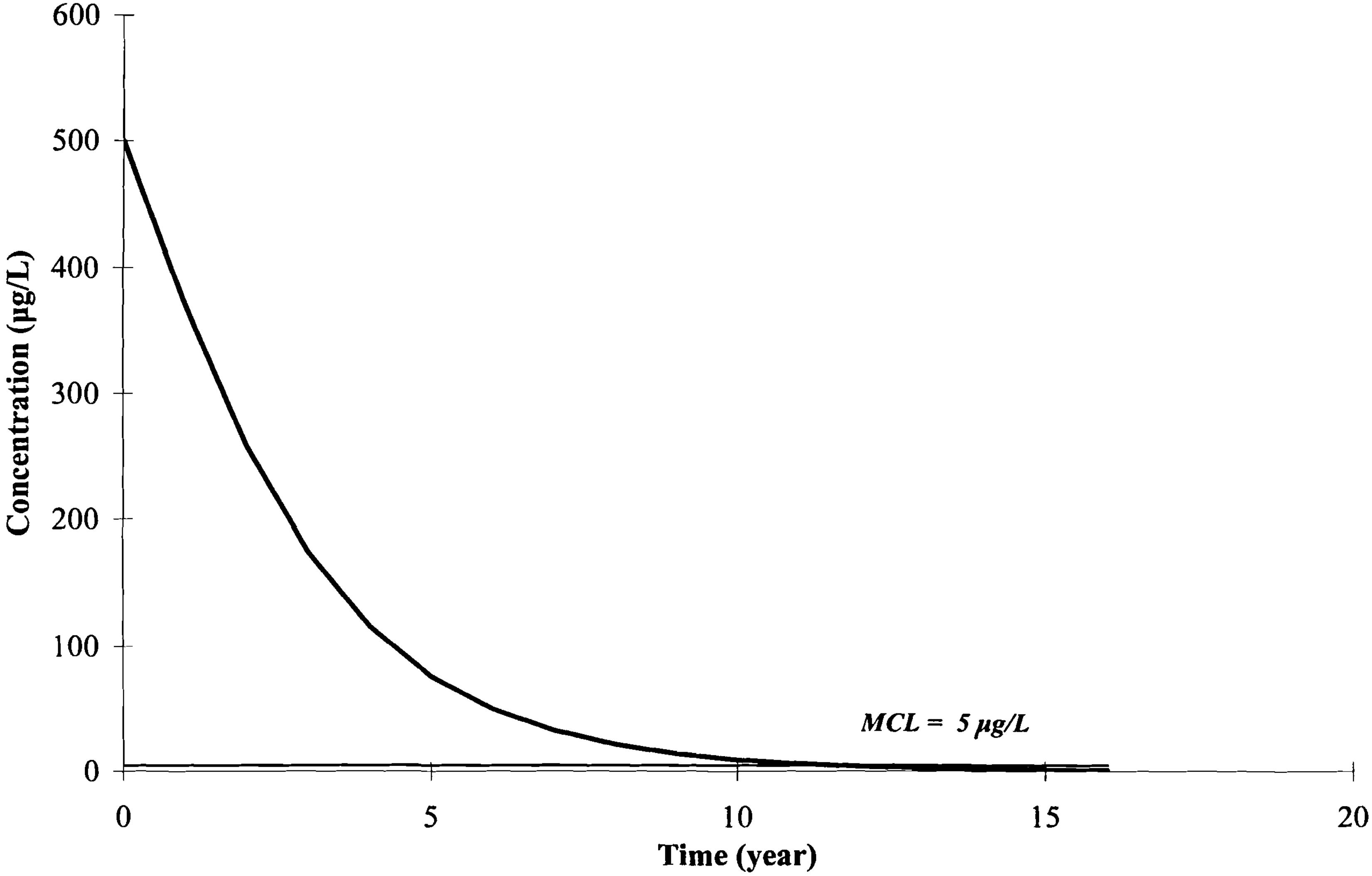

Figure B-4. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source After Source Concentration is Reduced to 500 ppb

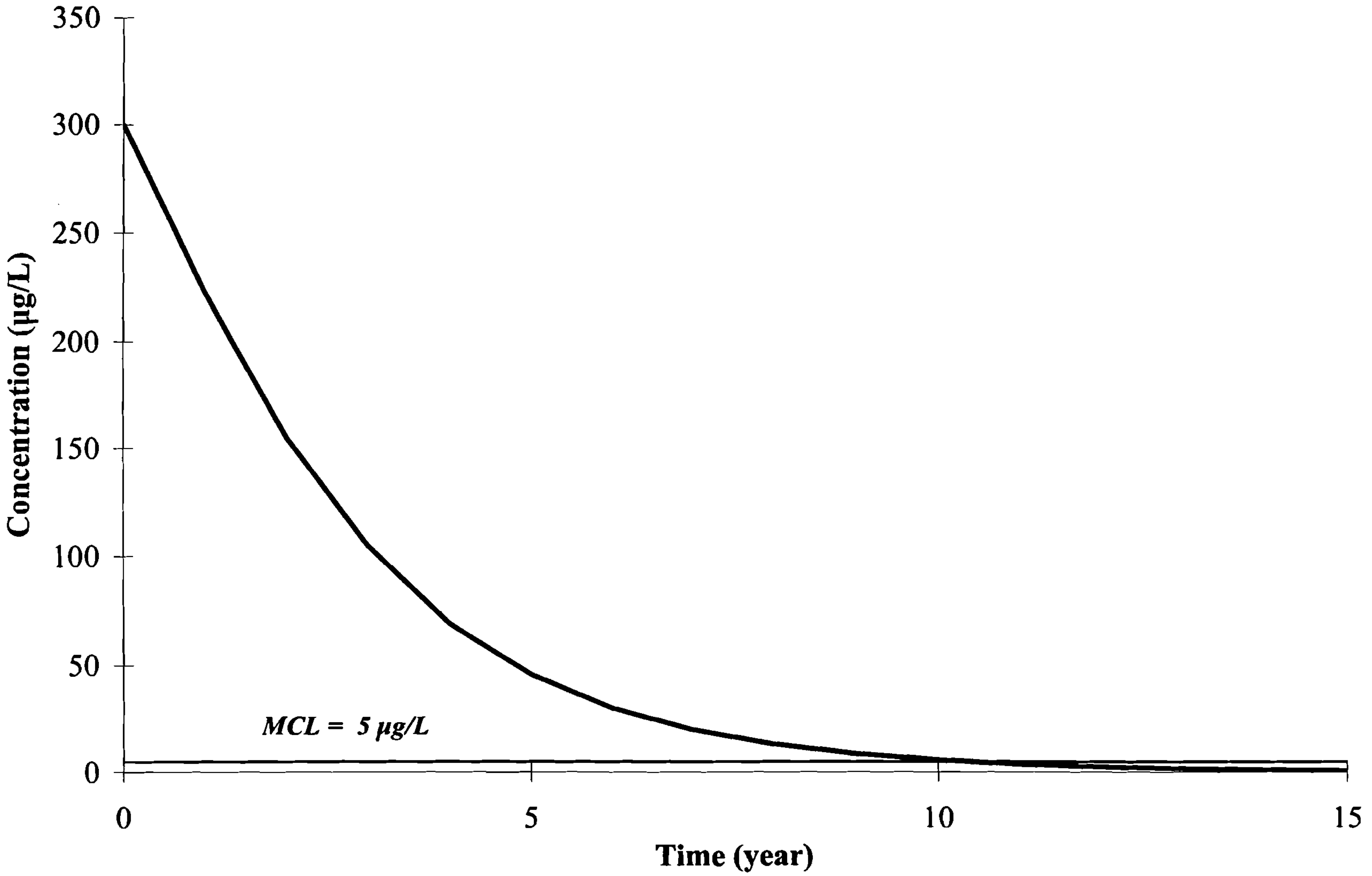

Figure B-5. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source after Source Concentration is Reduced to 300 ppb

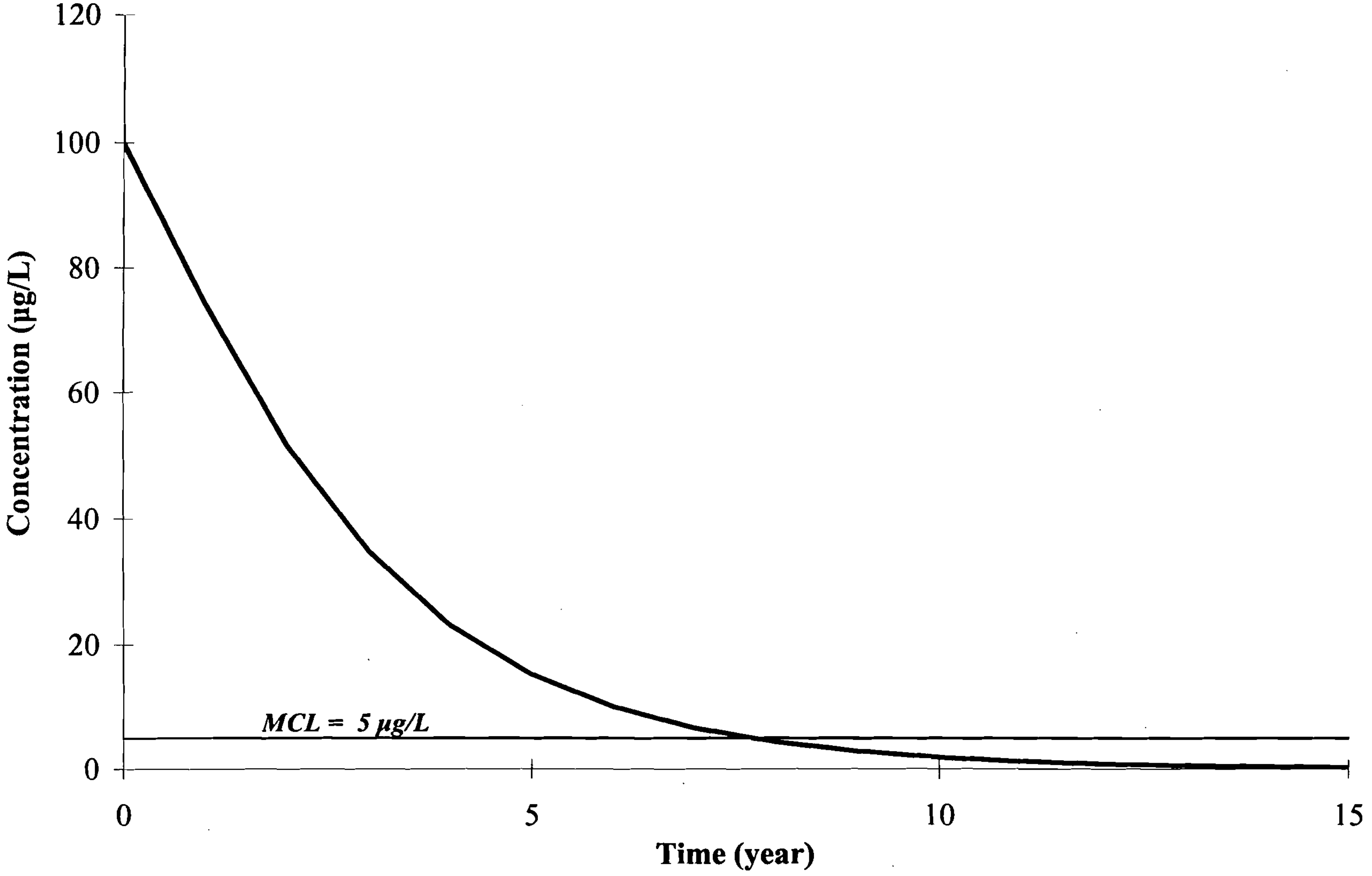

Figure B-6. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source After Source Concentration is Reduced to 100 ppb

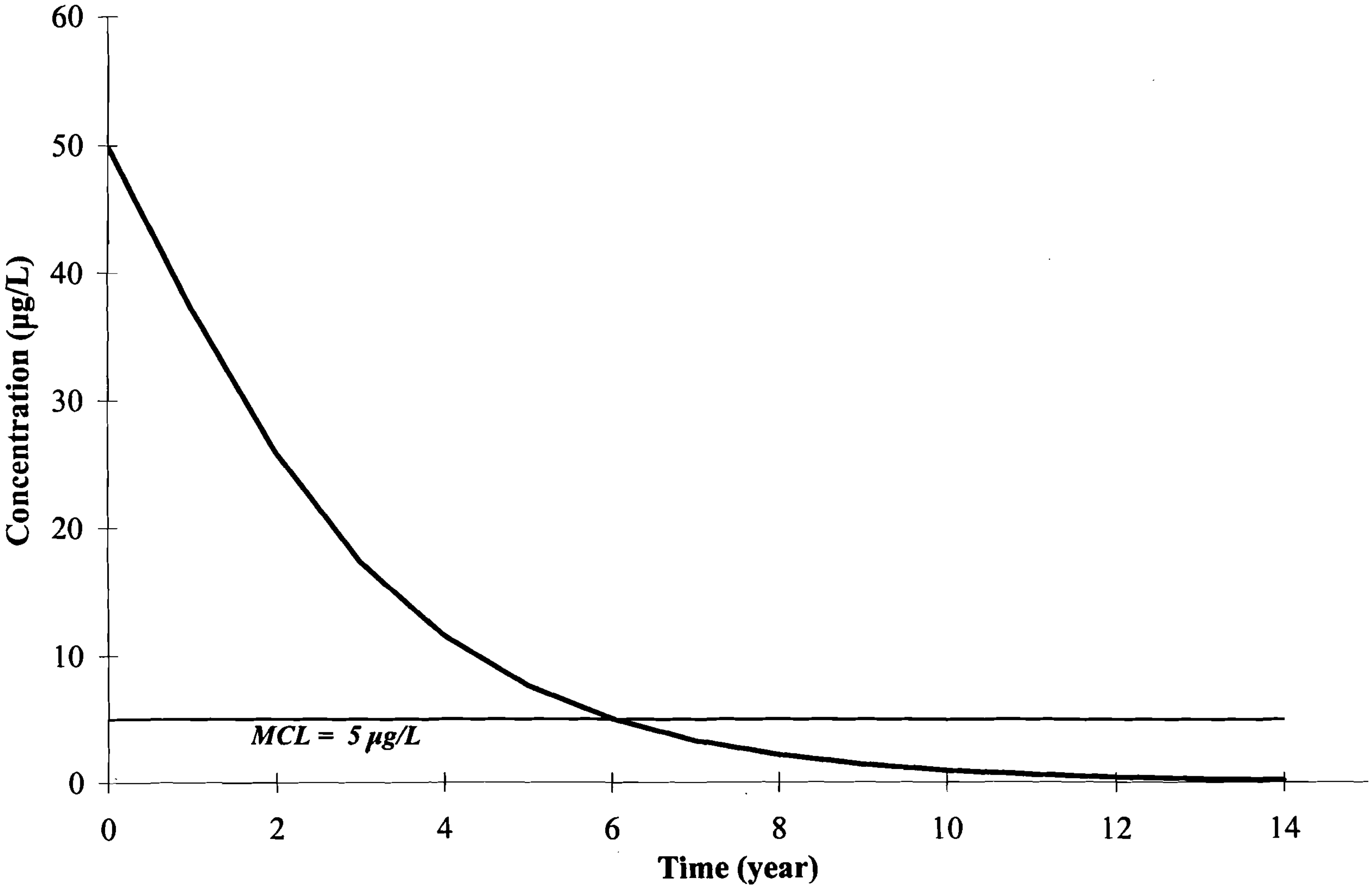

Figure B-7. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source After Source Concentration is Reduced to 50 ppb

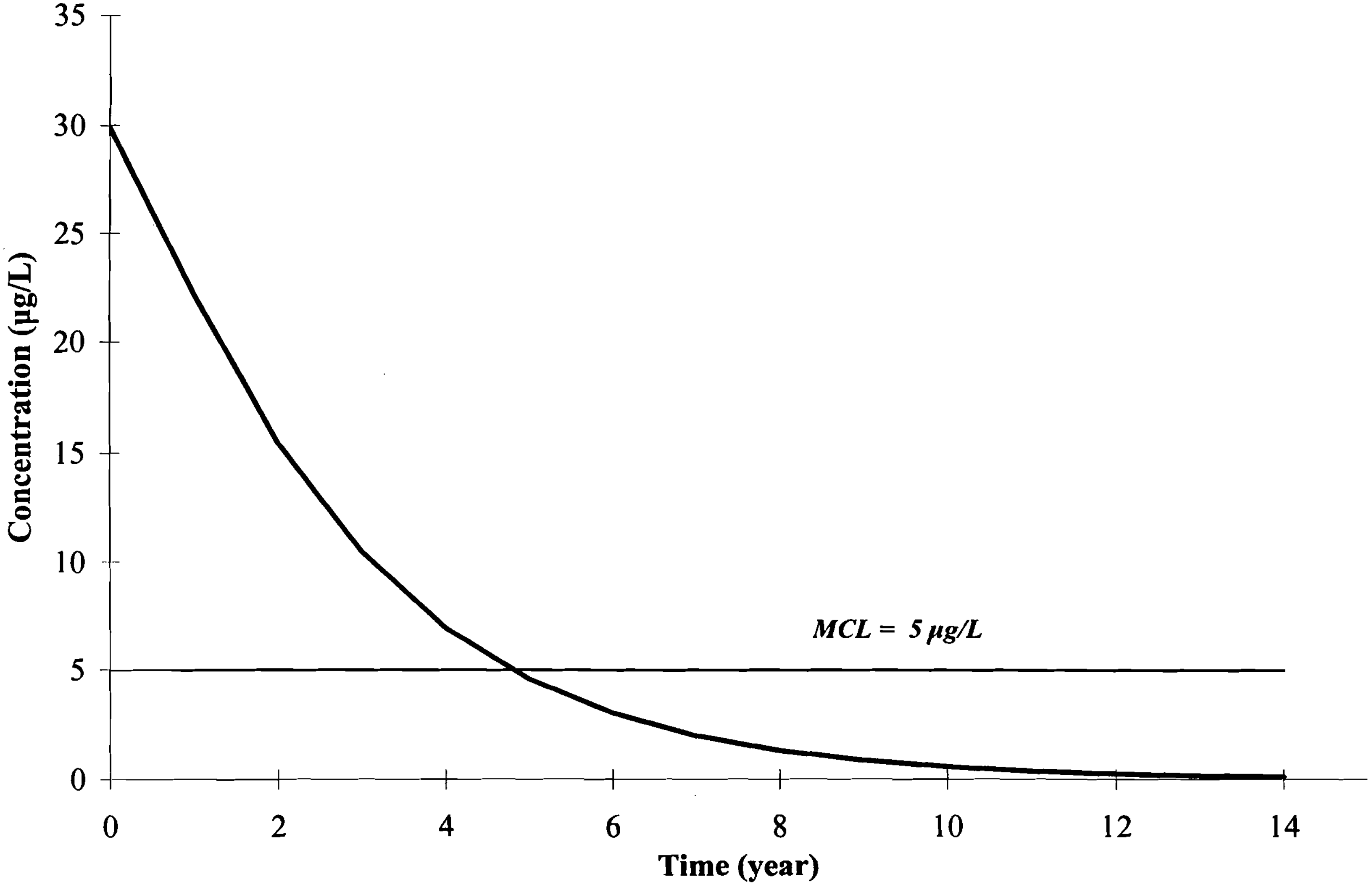

Figure B-8. AT123D Modeled Maximum Concentration of Benzene in the Groundwater at the Source After Source Concentration is Reduced to 30 ppb versus time plots for multiple source concentrations, 8,090, 1,000, 500, 300, 100, 50, and 30 parts per billion (ppb), respectively. As can be seen from these figures, the timeframe for monitored natural attenuation decreases from 20 to 4.5 years based on source reduction.

To evaluate the impact of residual leaching from the soil contamination, SESOIL modeling runs were performed using different input soil concentrations. The results of this modeling are shown in Figures B-9 through B-13. As can be seen from these figures, the peak contaminant contribution to groundwater concentration will be within 6 months. Also, predicted maximum groundwater concentrations are expected to be less than the MCLs for benzene within 6, 5, 4, 3, and 2.5 years, respectively, corresponding to input soil concentrations of 9,400, 1,000, 500, 200, and 100 ppb, respectively. Therefore, it can be concluded that, if 5 years is chosen as the time frame for monitored natural attenuation, the source soil at concentrations exceeding 1,000 ppb must be excavated or cleaned. Similarly, if 3 years is chosen as the time frame for monitored natural attenuation, the source soils at concentrations exceeding 200 ppb must be excavated.

6.0 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 K_d and R_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 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.
- A steady-state contaminant loading source to the aquifer is 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.

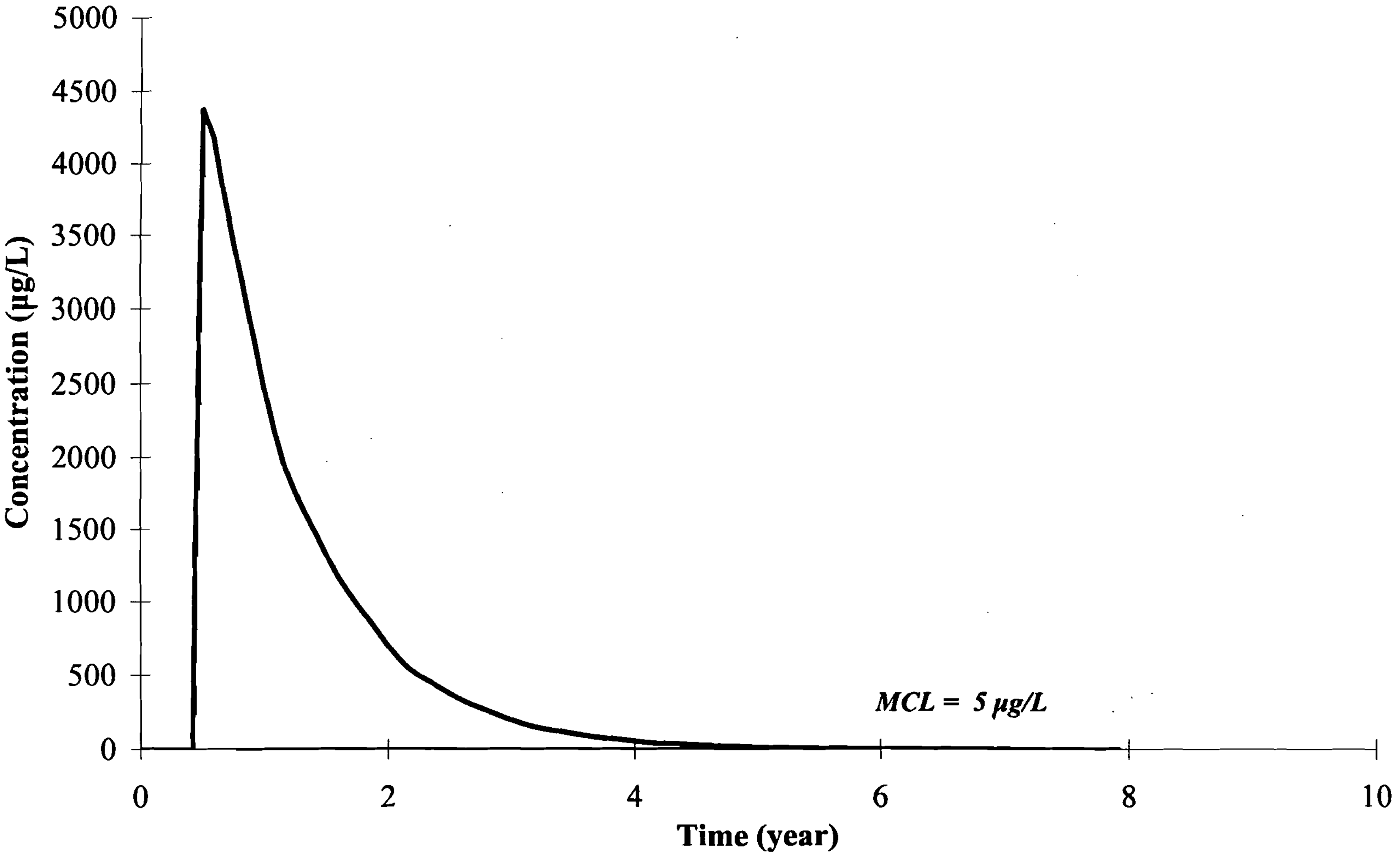

Figure B-9. Predicted Maximum Concentration of Benzene in the Groundwater due to Leaching from Soils at the Source (SWMU 26) [maximum soil concentration = 9,400 ppb]

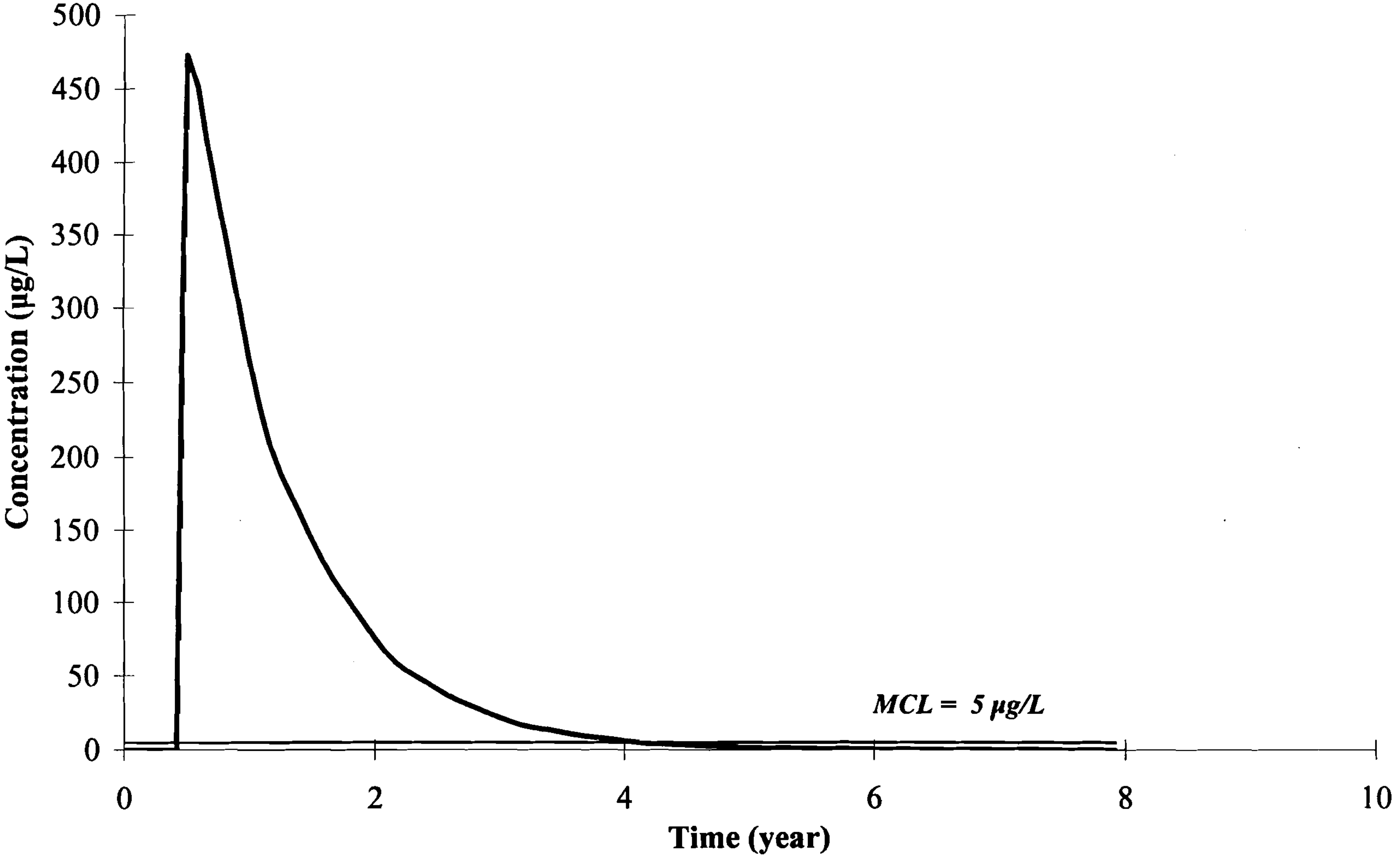

Figure B-10. Predicted Maximum Concentration of Benzene in the Groundwater due to Leaching from Soils at the Source (SWMU 26) [maximum soil concentration = 1,000 ppb]

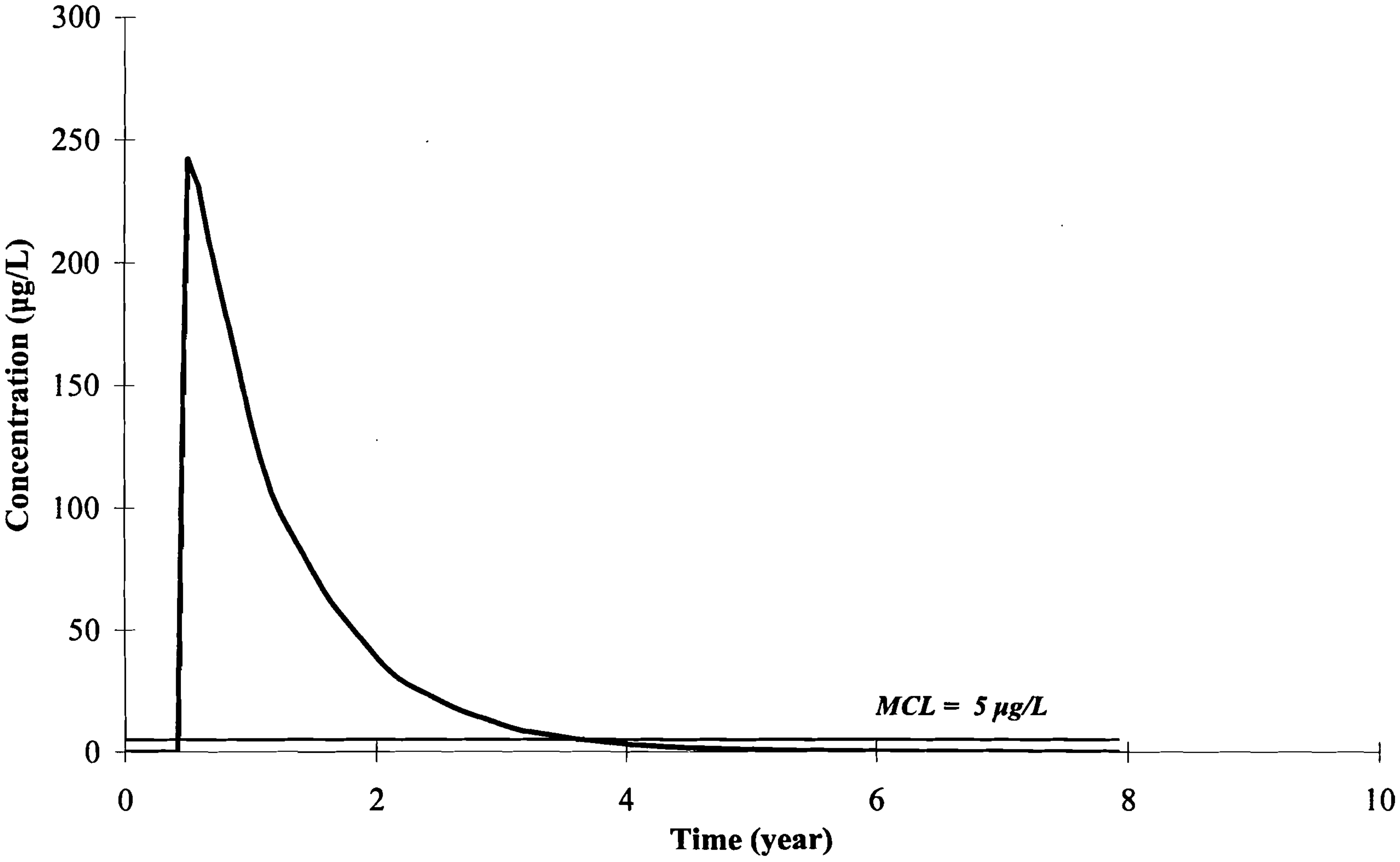

Figure B-11. Predicted Maximum Concentration of Benzene in the Groundwater due to Leaching from Soils at the Source (SWMU 26) [maximum soil concentration =500 ppb]

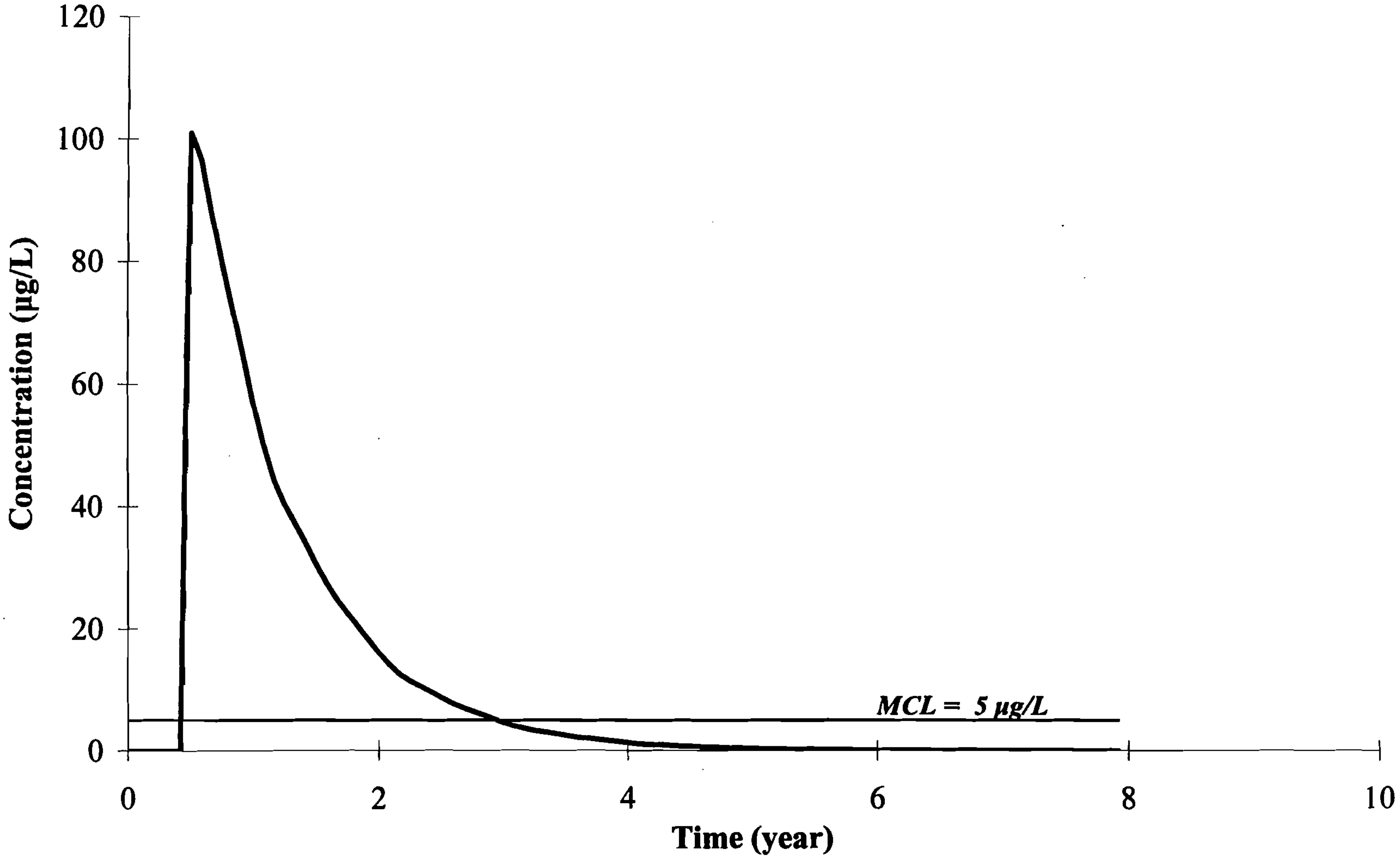

Figure B-12. Predicted Maximum Concentration of Benzene in the Groundwater due to Leaching from Soils at the Source (SWMU 26) [maximum soil concentration = 200 ppb]

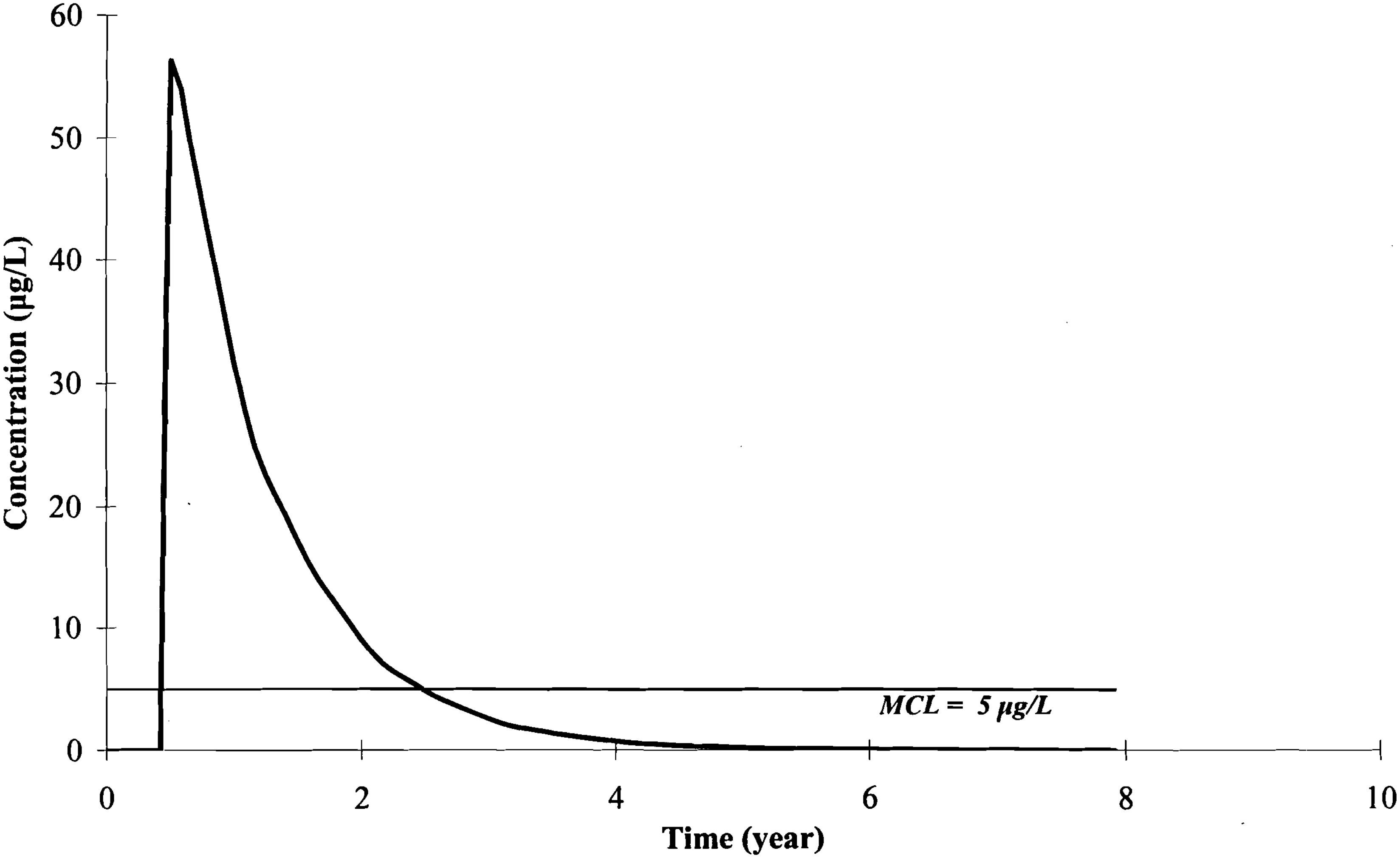

Figure B-13. Predicted Maximum Concentration of Benzene in the Groundwater due to Leaching from Soils at the Source (SWMU 26) [maximum soil concentration = 100 ppb]

7.0 REFERENCES

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ATTACHMENT

INPUT PARAMETERS
FOR
FATE AND TRANSPORT MODELING
AT THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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Former 724 TPS Benzene

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NO. OF POINTS IN X-DIRECTION .....................     9
NO. OF POINTS IN Y-DIRECTION .....................     5
NO. OF POINTS IN Z-DIRECTION .....................     1
NO. OF ROOTS: NO. OF SERIES TERMS ................   400
NO. OF BEGINNING TIME STEP .......................   109
NO. OF ENDING TIME STEP ..........................   320
NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION ....    12
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) ...  0.1676E+02
AQUIFER WIDTH, = 0.0 FOR INFINITE WIDE (METERS) ...  0.0000E+00
BEGIN POINT OF X-SOURCE LOCATION (METERS) ......... -0.2740E+02
END POINT OF X-SOURCE LOCATION (METERS) ...........  0.0000E+00
BEGIN POINT OF Y-SOURCE LOCATION (METERS) ......... -0.6900E+01
END POINT OF Y-SOURCE LOCATION (METERS) ...........  0.6900E+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) ...............  0.1440E-01
HYDRAULIC GRADIENT ................................  0.8300E-02
LONGITUDINAL DISPERSIVITY (METER) .................  0.1500E+02
LATERAL DISPERSIVITY (METER) ......................  0.5000E+01
VERTICAL DISPERSIVITY (METER) .....................  0.1500E+01
DISTRIBUTION COEFFICIENT, KD (M**3/KG) ............  0.2300E-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) .........................  0.4010E-04
BULK DENSITY OF THE SOIL (KG/M**3) ................  0.1250E+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) ...............................  0.8760E+06
WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) .  0.4390E-03


RETARDATION FACTOR ................................  0.2438E+01
RETARDED DARCY VELOCITY (M/HR) ....................  0.2452E-03
RETARDED LONGITUDINAL DISPERSION COEF. (M**2/HR) ..  0.3685E-02
RETARDED LATERAL DISPERSION COEFFICIENT (M**2/HR) .  0.1233E-02
RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR).  0.3750E-03
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 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.0000E+00 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =         0.00
                                                  X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   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
  50.   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
  20.   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.   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


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.7884E+05 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =         0.00
                                                  X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   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
  50.   0.913E-04  0.909E-04  0.875E-04  0.683E-04  0.454E-04  0.120E-04  0.258E-07  0.000E+00  0.000E+00
  20.   0.188E+00  0.164E+00  0.139E+00  0.745E-01  0.353E-01  0.547E-02  0.607E-05  0.000E+00  0.000E+00
   5.   0.657E+01  0.302E+01  0.177E+01  0.507E+00  0.173E+00  0.189E-01  0.163E-04  0.000E+00  0.000E+00
   0.   0.806E+01  0.375E+01  0.216E+01  0.587E+00  0.194E+00  0.206E-01  0.174E-04  0.000E+00  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.8760E+05 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =         0.00
                                                  X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   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
  50.   0.130E-03  0.131E-03  0.127E-03  0.103E-03  0.722E-04  0.221E-04  0.894E-07  0.000E+00  0.000E+00
  20.   0.192E+00  0.168E+00  0.143E+00  0.787E-01  0.385E-01  0.665E-02  0.134E-04  0.000E+00  0.000E+00
   5.   0.658E+01  0.303E+01  0.178E+01  0.517E+00  0.180E+00  0.217E-01  0.333E-04  0.000E+00  0.000E+00
   0.   0.807E+01  0.376E+01  0.217E+01  0.597E+00  0.201E+00  0.235E-01  0.354E-04  0.000E+00  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.9636E+05 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =         0.00
                                                  X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   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
  50.   0.169E-03  0.171E-03  0.168E-03  0.141E-03  0.102E-03  0.351E-04  0.238E-06  0.000E+00  0.000E+00
  20.   0.195E+00  0.171E+00  0.147E+00  0.816E-01  0.408E-01  0.765E-02  0.245E-04  0.000E+00  0.000E+00
   5.   0.658E+01  0.304E+01  0.178E+01  0.523E+00  0.185E+00  0.238E-01  0.574E-04  0.000E+00  0.000E+00
   0.   0.808E+01  0.377E+01  0.217E+01  0.604E+00  0.207E+00  0.258E-01  0.608E-04  0.000E+00  0.000E+00
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       DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1051E+06 HRS
          (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                          Z =        0.00
                                                           X
    Y            0.          5.          9.          20.         30.         50.         100.        200.        366.

  100.    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
   50.    0.204E-03   0.209E-03   0.206E-03   0.177E-03   0.133E-03   0.501E-04   0.518E-06   0.000E+00   0.000E+00
   20.    0.197E+00   0.173E+00   0.149E+00   0.836E-01   0.425E-01   0.846E-02   0.394E-04   0.000E+00   0.000E+00
    5.    0.659E+01   0.304E+01   0.179E+01   0.527E+00   0.188E+00   0.255E-01   0.876E-04   0.000E+00   0.000E+00
    0.    0.808E+01   0.378E+01   0.218E+01   0.608E+00   0.210E+00   0.275E-01   0.924E-04   0.000E+00   0.000E+00


       DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1139E+06 HRS
          (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                          Z =        0.00
                                                           X
    Y            0.          5.          9.          20.         30.         50.         100.        200.        366.

  100.    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
   50.    0.236E-03   0.242E-03   0.241E-03   0.211E-03   0.162E-03   0.659E-04   0.967E-06   0.000E+00   0.000E+00
   20.    0.199E+00   0.175E+00   0.150E+00   0.849E-01   0.437E-01   0.908E-02   0.571E-04   0.000E+00   0.000E+00
    5.    0.659E+01   0.305E+01   0.179E+01   0.530E+00   0.191E+00   0.267E-01   0.122E-03   0.000E+00   0.000E+00
    0.    0.808E+01   0.378E+01   0.218E+01   0.611E+00   0.213E+00   0.288E-01   0.128E-03   0.000E+00   0.000E+00


       DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1226E+06 HRS
          (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                          Z =        0.00
                                                           X
    Y            0.          5.          9.          20.         30.         50.         100.        200.        366.

  100.    0.380E-10   0.408E-10   0.424E-10   0.432E-10   0.393E-10   0.238E-10   0.109E-11   0.000E+00   0.000E+00
   50.    0.262E-03   0.270E-03   0.270E-03   0.240E-03   0.189E-03   0.815E-04   0.160E-05   0.000E+00   0.000E+00
   20.    0.199E+00   0.176E+00   0.151E+00   0.858E-01   0.445E-01   0.956E-02   0.764E-04   0.000E+00   0.000E+00
    5.    0.659E+01   0.305E+01   0.179E+01   0.532E+00   0.192E+00   0.276E-01   0.157E-03   0.000E+00   0.000E+00
    0.    0.808E+01   0.378E+01   0.218E+01   0.613E+00   0.214E+00   0.297E-01   0.165E-03   0.000E+00   0.000E+00


       DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1314E+06 HRS
          (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                          Z =        0.00
                                                           X
    Y            0.          5.          9.          20.         30.         50.         100.        200.        366.

  100.    0.202E-09   0.218E-09   0.227E-09   0.234E-09   0.217E-09   0.137E-09   0.761E-11   0.643E-18   0.000E+00
   50.    0.283E-03   0.293E-03   0.294E-03   0.265E-03   0.212E-03   0.960E-04   0.241E-05   0.542E-13   0.000E+00
   20.    0.200E+00   0.176E+00   0.152E+00   0.864E-01   0.450E-01   0.992E-02   0.962E-04   0.119E-11   0.000E+00
    5.    0.659E+01   0.305E+01   0.179E+01   0.533E+00   0.193E+00   0.282E-01   0.192E-03   0.207E-11   0.000E+00
    0.    0.809E+01   0.378E+01   0.218E+01   0.614E+00   0.215E+00   0.303E-01   0.201E-03   0.215E-11   0.000E+00
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 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1402E+06 HRS
   (ADSORBED CHEMICAL CONC. =   0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                    Z =        0.00
                                                      X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   0.530E-09  0.573E-09  0.600E-09  0.627E-09  0.590E-09  0.393E-09  0.267E-10  0.705E-16  0.000E+00
  50.   0.300E-03  0.311E-03  0.313E-03  0.285E-03  0.231E-03  0.109E-03  0.337E-05  0.329E-11  0.000E+00
  20.   0.200E+00  0.177E+00  0.152E+00  0.868E-01  0.454E-01  0.102E-01  0.115E-03  0.645E-10  0.000E+00
   5.   0.659E+01  0.305E+01  0.179E+01  0.533E+00  0.194E+00  0.286E-01  0.225E-03  0.110E-09  0.000E+00
   0.   0.809E+01  0.378E+01  0.218E+01  0.614E+00  0.216E+00  0.308E-01  0.235E-03  0.114E-09  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1489E+06 HRS
   (ADSORBED CHEMICAL CONC. =   0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                    Z =        0.00
                                                      X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   0.103E-08  0.112E-08  0.118E-08  0.125E-08  0.119E-08  0.831E-09  0.684E-10  0.523E-15  0.000E+00
  50.   0.313E-03  0.325E-03  0.327E-03  0.301E-03  0.246E-03  0.120E-03  0.442E-05  0.141E-10  0.000E+00
  20.   0.200E+00  0.177E+00  0.152E+00  0.871E-01  0.457E-01  0.104E-01  0.133E-03  0.244E-09  0.000E+00
   5.   0.659E+01  0.305E+01  0.179E+01  0.534E+00  0.194E+00  0.289E-01  0.254E-03  0.405E-09  0.000E+00
   0.   0.809E+01  0.378E+01  0.219E+01  0.615E+00  0.216E+00  0.311E-01  0.265E-03  0.419E-09  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1577E+06 HRS
   (ADSORBED CHEMICAL CONC. =   0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                    Z =        0.00
                                                      X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   0.173E-08  0.188E-08  0.198E-08  0.213E-08  0.206E-08  0.150E-08  0.147E-09  0.249E-14  0.000E+00
  50.   0.323E-03  0.336E-03  0.339E-03  0.313E-03  0.258E-03  0.129E-03  0.551E-05  0.404E-10  0.000E+00
  20.   0.201E+00  0.177E+00  0.152E+00  0.872E-01  0.459E-01  0.105E-01  0.149E-03  0.619E-09  0.000E+00
   5.   0.659E+01  0.305E+01  0.179E+01  0.534E+00  0.194E+00  0.292E-01  0.279E-03  0.101E-08  0.000E+00
   0.   0.809E+01  0.378E+01  0.219E+01  0.615E+00  0.217E+00  0.314E-01  0.291E-03  0.104E-08  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1664E+06 HRS
   (ADSORBED CHEMICAL CONC. =   0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                    Z =        0.00
                                                      X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

 100.   0.258E-08  0.282E-08  0.298E-08  0.322E-08  0.317E-08  0.238E-08  0.274E-09  0.906E-14  0.000E+00
  50.   0.330E-03  0.344E-03  0.347E-03  0.323E-03  0.268E-03  0.137E-03  0.659E-05  0.947E-10  0.000E+00
  20.   0.201E+00  0.177E+00  0.152E+00  0.874E-01  0.460E-01  0.106E-01  0.162E-03  0.130E-08  0.000E+00
   5.   0.659E+01  0.305E+01  0.180E+01  0.534E+00  0.195E+00  0.293E-01  0.300E-03  0.207E-08  0.000E+00
   0.   0.809E+01  0.378E+01  0.219E+01  0.615E+00  0.217E+00  0.315E-01  0.313E-03  0.213E-08  0.000E+00
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 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1752E+06 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                  Z =        0.00
                                                   X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.357E-08  0.390E-08  0.414E-08  0.452E-08  0.450E-08  0.350E-08  0.464E-09  0.277E-13  0.000E+00
 50.   0.335E-03  0.350E-03  0.354E-03  0.330E-03  0.275E-03  0.143E-03  0.761E-05  0.194E-09  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.874E-01  0.461E-01  0.107E-01  0.174E-03  0.238E-08  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.534E+00  0.195E+00  0.294E-01  0.318E-03  0.374E-08  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.615E+00  0.217E+00  0.316E-01  0.331E-03  0.385E-08  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1840E+06 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                  Z =        0.00
                                                   X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.465E-08  0.510E-08  0.542E-08  0.597E-08  0.601E-08  0.480E-08  0.726E-09  0.741E-13  0.000E+00
 50.   0.339E-03  0.354E-03  0.358E-03  0.335E-03  0.281E-03  0.148E-03  0.856E-05  0.358E-09  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.875E-01  0.461E-01  0.107E-01  0.183E-03  0.400E-08  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.534E+00  0.195E+00  0.295E-01  0.332E-03  0.617E-08  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.317E-01  0.346E-03  0.635E-08  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.1927E+06 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                  Z =        0.00
                                                   X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.578E-08  0.635E-08  0.677E-08  0.751E-08  0.763E-08  0.627E-08  0.106E-08  0.176E-12  0.000E+00
 50.   0.342E-03  0.357E-03  0.362E-03  0.339E-03  0.285E-03  0.152E-03  0.941E-05  0.610E-09  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.875E-01  0.461E-01  0.107E-01  0.190E-03  0.623E-08  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.535E+00  0.195E+00  0.295E-01  0.343E-03  0.947E-08  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.317E-01  0.357E-03  0.974E-08  0.000E+00


 DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.2015E+06 HRS
    (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                  Z =        0.00
                                                   X
  Y          0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.692E-08  0.762E-08  0.814E-08  0.909E-08  0.931E-08  0.784E-08  0.148E-08  0.380E-12  0.000E+00
 50.   0.344E-03  0.360E-03  0.364E-03  0.342E-03  0.288E-03  0.154E-03  0.101E-04  0.967E-09  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.876E-01  0.462E-01  0.108E-01  0.196E-03  0.913E-08  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.535E+00  0.195E+00  0.296E-01  0.352E-03  0.137E-07  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.318E-01  0.366E-03  0.140E-07  0.000E+00
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   DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.2102E+06 HRS
     (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =        0.00
                                                  X
  Y         0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.803E-08  0.886E-08  0.947E-08  0.107E-07  0.110E-07  0.945E-08  0.196E-08  0.750E-12  0.000E+00
 50.   0.345E-03  0.361E-03  0.366E-03  0.344E-03  0.290E-03  0.156E-03  0.108E-04  0.145E-08  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.876E-01  0.462E-01  0.108E-01  0.201E-03  0.127E-07  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.535E+00  0.195E+00  0.296E-01  0.358E-03  0.187E-07  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.318E-01  0.373E-03  0.192E-07  0.000E+00


   DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.2190E+06 HRS
     (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =        0.00
                                                  X
  Y         0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.908E-08  0.100E-07  0.107E-07  0.121E-07  0.126E-07  0.111E-07  0.250E-08  0.137E-11  0.000E+00
 50.   0.347E-03  0.362E-03  0.367E-03  0.345E-03  0.291E-03  0.158E-03  0.113E-04  0.205E-08  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.876E-01  0.462E-01  0.108E-01  0.205E-03  0.168E-07  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.535E+00  0.195E+00  0.296E-01  0.364E-03  0.246E-07  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.318E-01  0.378E-03  0.252E-07  0.000E+00

STEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINAL SIMULATING TIME.


   DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT  0.2278E+06 HRS
     (ADSORBED CHEMICAL CONC. =    0.2300E+00 * DISSOLVED CHEMICAL CONC.)

                 Z =        0.00
                                                  X
  Y         0.         5.         9.        20.        30.        50.       100.       200.       366.

100.   0.101E-07  0.111E-07  0.119E-07  0.135E-07  0.141E-07  0.126E-07  0.307E-08  0.234E-11  0.000E+00
 50.   0.347E-03  0.363E-03  0.368E-03  0.346E-03  0.293E-03  0.159E-03  0.117E-04  0.278E-08  0.000E+00
 20.   0.201E+00  0.177E+00  0.153E+00  0.876E-01  0.462E-01  0.108E-01  0.207E-03  0.215E-07  0.000E+00
  5.   0.659E+01  0.305E+01  0.180E+01  0.535E+00  0.195E+00  0.296E-01  0.367E-03  0.311E-07  0.000E+00
  0.   0.809E+01  0.378E+01  0.219E+01  0.616E+00  0.217E+00  0.318E-01  0.382E-03  0.318E-07  0.000E+00
```

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  1 Fort Stewart TPS 724th Benzene

 -ILYS,IYRS,AR,L,ISPILL,ISUMRS,ICONC    4.00    2.00.42E+07  33.29  0  0  1
 -D1,D2,D3,D4,NSUBL1 to NSUBL4         60.96   60.96  60.96  30.48  2  1  2 10
 -PH1,PH2,PH3,PH4                       0.00    0.00   0.00   0.00
 -K11,K12,K13,K14                       0.00    0.00   0.00   0.00
 -KDEL MULTIPLIERS                      1.00    1.00   1.00
 -KDES MULTIPLIERS                      1.00    1.00   1.00
 -OC MULTIPLIERS                        1.00    1.00   1.00
 -CEC MULTIPLIERS                       1.00    1.00   1.00
 -FRN MULTIPLIERS                       1.00    1.00   1.00
 -ADS MULTIPLIERS                       1.00    1.00   1.00


                **** LAYER 1 **  YEAR 1 ****
POLIN1   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS1   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK1    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG1     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF1    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
ISRM1    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
ASL1     0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00


                **** LAYER 2 **  YEAR 1 ****
POLIN2   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS2   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK2    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG2     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF2    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00


                **** LAYER 3 **  YEAR 1 ****
POLIN3   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS3   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK3    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG3     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF3    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00


                **** LAYER 4 **  YEAR 1 ****
POLIN4   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS4   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK4    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG4     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF4    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00


                **** LAYER 1 **  YEAR 2 ****
POLIN1   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS1   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK1    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG1     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF1    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
ISRM1    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
ASL1     0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
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              **** LAYER 2 **  YEAR 2 ****
POLIN2   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS2   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK2    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG2     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF2    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00


              **** LAYER 3 **  YEAR 2 ****
POLIN3   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS3   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK3    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG3     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF3    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00


              **** LAYER 4 **  YEAR 2 ****
POLIN4   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
TRANS4   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
SINK4    0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
LIG4     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VOLF4    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00

INITIAL CONTAMINANT CONCENTRATIONS FOLLOW
MONTH IN YEAR 1 FOR LOADING CONC.'S    1.0
CONCIN10.0018  0.00
CONCIN2 0.024
CONCIN3 11.75 11.75
CONCIN4  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
 999 END OF FILE
```

```
    1 SAVANNAH WSO AP                                      1
         ****  YEAR 1  ****
TA        20.17 14.83 11.17 10.83 11.94 15.00 19.33 23.17 26.22 27.28 27.17 24.94
NN         0.50  0.50  0.55  0.55  0.55  0.55  0.50  0.50  0.60  0.60  0.60  0.60
S          0.75  0.75  0.75  0.75  0.70  0.70  0.70  0.70  0.70  0.80  0.80  0.80
A          0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
REP        0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
MPM        7.43  6.56  9.07 10.53 11.24 12.50  8.96 10.39 11.05 13.27 12.82  9.45
MTR        0.44  0.38  0.44  0.48  0.44  0.37  0.37  0.31  0.29  0.26  0.29  0.38
MN         3.17  3.08  4.97  4.97  5.14  5.69  4.26  5.49  7.36  9.56  7.92  6.39
MT        30.40 30.40 30.40 30.40 30.40 30.40 30.40 30.40 30.40 30.40 30.40 30.40
  999 END OF FILE
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  1 Benzene
      - SL,DA,H,KOC,K               1780.00  0.0930.00555  62.00   0.00
      - MWT,VAL,KNH,KBH,KAH           78.10   0.00   0.00   0.00   0.00
      - KDEL,KDES,SK,B,MWTLIG       0.000960.00096   0.00   0.00   0.00
999 END OF FILE
```

```
  1 Silty Sand
      -  RS,K1,C,N,OC                    1.25.98E-09  10.00 0.5218   0.24
      -  CEC,FRN                         0.00   1.00
999 END OF FILE
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APPENDIX C

COST ESTIMATE SUMMARIES
FOR CORRECTIVE ACTION ALTERNATIVES
FOR THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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APPENDIX C

Cost Estimate Summaries for Corrective Action Alternatives Former 724th Tanker Purging Station (SWMU 26), Fort Stewart, Georgia

		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
		Monitored Natural Attenuation	**Excavate/ Air Sparge**	**Enhanced Biorem.[a]**	**Air Sparge/ Monitored Nat. Atten.**	**Enhanced Biorem.[a]/ Monitored Nat. Atten.**	**PHOSter® II/ Enhanced Biorem.[a]**
1.0	**Capital Costs**						
1.1	**Engineering Services**						
1.1.1	Work Plan/SSHP and Remedial Design	$7,609	$27,369	$27,369	$27,369	$27,369	$27,369
1.1.2	Contracting/Procurement	$1,342	$1,766	$1,766	$1,766	$1,766	$1,766
1.1.3	Permitting	$2,443	$2,443	$2,443	$2,443	$2,443	$2,443
1.1.4	Construction Oversight/Labor for Monitoring Well Installation	$20,329	$20,329	$20,329	$20,329	$20,329	$20,329
1.1.5	Construction Oversight/Labor for Injection Installation	$0	$5,638	$12,181	$5,638	$12,181	$5,638
1.1.6	Construction Oversight/Labor System Startup	$0	$7,203	$7,203	$7,203	$7,203	$7,203
1.1	**Total Costs for Engineering Services**	**$31,722**	**$64,747**	**$71,290**	**$64,747**	**$71,290**	**$64,747**
1.2	**System Installation**						
1.2.1	Site Preparation and Mobilization/Demobilization						
1.2.1.1	Locate Underground Utilities	$608	$608	$608	$608	$608	$608
1.2.1.2	Define Grid Layout	$1,865	$1,865	$1,865	$1,865	$1,865	$1,865
1.2.1.3	Baseline Groundwater Monitoring	$11,854	$11,854	$11,854	$11,854	$11,854	$11,854
1.2.1	**Total Costs for Site Preparation and Mob/Demob**	**$14,327**	**$14,327**	**$14,327**	**$14,327**	**$14,327**	**$14,327**
1.2.2	Monitoring Well Installation	$29,999	$29,999	$29,999	$29,999	$29,999	$29,999
1.2.3	Injection and Equipment Installation	$0	$33,237	$94,915	$33,237	$94,915	$97,366
1.2.4	Excavation and Disposal of Soil at an RCRA Landfill	$0	$57,003	$57,003	$0	$0	$34,187
1.2	**Total Costs for System Installation**	**$44,326**	**$134,565**	**$196,244**	**$77,563**	**$139,241**	**$175,879**
1.0	**Total Capital Costs**	**$76,048**	**$199,312**	**$267,533**	**$142,309**	**$210,531**	**$240,626**
2.0	**System Maintenance**						
2.1	Groundwater Monitoring	$287,221	$396,179	$476,884	$360,931	$417,615	$109,412
2.2	Soil Analysis after Excavation and Before Backfill	$0	$6,149	$6,149	$0	$0	$9,479
2.3	Post-Remediation Soil Analysis	$9,479	$9,479	$9,479	$9,479	$9,479	$9,479
2.4	Operations and Maintenance for System	$0	$27,069	$29,466	$19,079	$20,677	$4,696
2.0	**Total Costs for System Maintenance**	**$296,700**	**$438,876**	**$521,979**	**$389,489**	**$447,771**	**$133,066**
	Subtotal Project Costs	**$372,748**	**$638,188**	**$789,513**	**$531,798**	**$658,302**	**$373,692**
	Engineering Construction Management (10% of subtotal)	$37,275	$63,819	$78,951	$53,180	$65,830	$37,369
	Contingency (20% of subtotal)	$74,550	$127,638	$157,903	$106,360	$131,660	$74,738
	Health and Safety (15% of subtotal)	$55,912	$95,728	$118,427	$79,770	$98,745	$56,054
	Contractor Profit (10% of subtotal)	$37,275	$63,819	$78,951	$53,180	$65,830	$37,369
	Total Project Costs	**$577,760**	**$989,192**	**$1,223,745**	**$824,287**	**$1,020,367**	**$579,222**

RCRA = Resource Conservation and Recovery Act.

[a] Enhanced bioremediation by injection of 98% pure oxygen.

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APPENDIX D

OPERATION AND MAINTENANCE PLAN
FOR THE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

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1.0 INTRODUCTION/PURPOSE

This plan presents preliminary procedures for the operation and maintenance (O&M) of the PHOSter® II enhanced bioremediation and groundwater monitoring systems for remediation of soil and groundwater contamination at the Former 724th Tanker Purging Station (TPS) at Fort Stewart, Georgia. This O&M Plan is based on the remediation system components as understood at this time. If system components change during installation, then a revised/updated O&M Plan will be submitted to the Georgia Environmental Protection Division (GEPD). 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 Public Involvement Plan.

The Former 724th TPS unit contains soil and groundwater contaminated with volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). Corrective action is required to reduce the concentrations of contaminants at the source and to achieve the remedial levels (RLs) presented in the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report. The selected corrective action consists of enhanced bioremediation in both vadose-zone soil and groundwater using the patented PHOSter® II technology A description of the system components is presented in Section 5 of the Corrective Action Plan and includes the following:

- air compressor and associated electrical connections;
- six nutrient/air injection wells, each consisting of 2-inch high-density polyethylene (HDPE) pipe to a depth of 25 feet below land surface and screened over the bottom one foot;
- a 100-foot-long nutrient/air injection lateral within the vadose-zone soil consisting of a 2-inch HDPE slotted pipe;
- aboveground nutrient/air supply lines consisting of 3/8-inch flexible tubing with quick-connects and fittings (pressure valves and gauges) connecting the compressor to the injection wells; and
- a total of nine monitoring wells, including three existing shallow wells, one existing deep well, four additional new shallow wells, and one additional new deep well.

2.0 TRAINING

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

Subcontractor personnel involved in the installation, adjustment, startup, and initial operation of the PHOSter® II treatment system will be subject to the training requirements specified by the subcontracted system vendor, Stevenson & Palmer Engineering, Inc., who specializes in the system installation.

Personnel involved in the operation and maintenance of the system, once startup has been successfully accomplished, will be subject to the requirements specified in this O&M Plan, the Sampling and Analysis Plan (SAP), the SAP Addendum, and the project Site Safety and Health Plan (SSHP). Training will be in accordance with Science Applications International Corporation (SAIC) Quality Assurance Administrative Procedure (QAAP) 2.1, *Indoctrination and Training.* The Site Supervisor is responsible for (1) assessing qualifications and determining skill needs of personnel; (2) assuring that appropriate training is provided to personnel and that the training (classroom, reading assignments, or on-the-job) is completed; and (3) forwarding training records for personnel to the SAIC Central Records Facility located in Oak Ridge, Tennessee. Health and safety-related documentation will also be maintained in on-site project files, in accordance with the SSHP.

Table D-1. Training Requirements

Training	Type	Remediation Worker	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	OTJ	√	√	√
Safety Briefing (daily and whenever conditions or tasks change)	OTJ	√	√	√
First Aid/CPR (standard Red Cross or equivalent)	Classroom	At least 2 workers		
Quality Assurance Training				
O&M Plan	Reading	√	√	√
Sampling and Analysis Plan (with Addendum)	Reading	√	√	√
Quality Assurance Project Plan (QAPjP), including applicable QA program elements	Reading	√	√	√
General criteria, including applicable codes, standards, and regulations, and the purpose, scope, and implementation of manuals, instructions, and procedures	Reading	√	√	√
Job responsibilities and authority	Reading	√	√	√
Quality Assurance Administrative Procedures (QAAP)	Reading	√	√	√
Quality Assurance Technical Procedures (QATP) for sampling and analysis	Reading	√	√	√
Demonstration of proficiency for task-specific procedures and equipment	OTJ	√	√	√

O&M = operation and maintenance.
OTJ = on-the-job.
√ = required training.

3.0 WASTE MANAGEMENT PRACTICES

Wastes generated by installation and operation of the corrective action will be managed in accordance with RCRA requirements and the SAP, Section 7.0, Investigation-Derived Waste. The types of wastes anticipated to be generated are: (1) soil cuttings and spoil materials from trenching, (2) residual soil samples, (3) monitoring well and injection well development and purge waters, (4) decontamination fluids, and (5) sanitary waste (noncontaminated compactible and miscellaneous trash). Materials that can be effectively reused, recycled, or decontaminated in the field are not waste materials.

Soil cuttings generated during drilling of boreholes for collecting soil samples, monitoring well construction, air injection well construction, bioventing trench installation, decontamination sludge, or residual soil samples will be segregated by borehole or trench and drummed at the point of generation. The drummed wastes will then be transported to a staging area established for the project and temporarily stored until the wastes are transported for final disposal. Analytical data gathered from environmental soil samples will be used to characterize indigenous soil waste from boreholes. If analytical data are insufficient for characterization of the containerized wastes, the wastes will be sampled and analyzed for RCRA toxicity characteristic contaminants using the Toxicity Characteristic Leaching Procedure (TCLP). Analytical data will be extrapolated to reflect TCLP values (i.e., 20 × divisor rule for soils). Soil cuttings and spoil materials will be managed as nonhazardous waste pending the analytical results. 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 (FSMR) for disposal. The material will be disposed in accordance with all applicable U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation (DOT), and State of Georgia regulations. Containerized hazardous waste will be transported offsite for disposal within 90 days of receipt of sample data indicating that the waste is hazardous.

Decontamination and monitoring well development or 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 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 offsite. 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 FSMR for disposal. The material will be disposed in accordance with all applicable EPA, DOT, and State of Georgia regulations. Containerized hazardous waste will be transported offsite 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 the dumpster.

4.0 SYSTEM OPERATION

The system operation strategy is to inject nutrients and air, at a continuous rate and pressure, into the vadose zone and the shallow groundwater zone to enhance biodegradation of contaminants in the soil and groundwater and subsequent reduction in contaminant concentrations. Soil treatment equipment is to be operated until benzene concentrations, as measured in random soil samples, decrease to below 20 µg/kg. Groundwater treatment equipment is to be operated until benzene concentrations, as measured in all on-site wells, decrease to below 5 µg/L. Confirmation groundwater sampling and analysis will then be conducted quarterly for 1 year to verify that corrective action is complete.

The operational strategy is to optimize the system to achieve maximum contaminant removal rates at minimum costs as quickly as possible. The strategy involves collecting data frequently to check continuity of trends. The initial conceptual site model will be periodically updated to include results of operational data. This updated model will then be used as a basis for any system modification or change in operation.

4.1 STARTUP PROCEDURES

Operational testing during startup will include optimization of airflow to provide proper air distribution separately within the soil and groundwater. A continuous air supply, at a constant pressure, must be used to optimize or balance the system. The six injection wells will be connected separately to the air supply header using header globe valves to allow balancing of each well independently of the rest. Similarly, the injection lateral will be connected separately to allow balancing of the vadose-zone soil treatment system, independent of the groundwater treatment system.

System optimization will be achieved by the procedures below.

- Confirm that all header globe valves are in the open position. Never pressurize the header system with the air injection well or header globe valves closed. This action could cause excessive pressures within the header system, causing damage to the piping and/or valves.

- Start the compressor and adjust the pressure to that specified in the system design, allowing a few minutes for the header to build up pressure.

- Once sufficient pressure is in the header, check that each well flow meter is operational. Initially, the system may not provide enough back pressure to allow significant flow to all air injection wells.

- Begin the flow optimization process by adjusting the globe valve on each well sequentially to allow approximately half the design airflow rate into each well. Continue down the header system until each of the well flow meters registers approximately half the design airflow rate.

- Increase the pressure by adjusting the globe valve on each well sequentially to allow the full airflow rate into each well. Continue down the header system until each of the well flow meters registers the full design airflow rate. Since each well has a slightly different back pressure, each globe valve will need a different level of adjustment. Once the flow rate at each well is within ±10 percent of the set flow rate, the system will be considered balanced.

4.2 ROUTINE OPERATING PROCEDURES

The current plan is to operate the PHOSter® II system using pulsed nutrient/air injection throughout the treatment period. Pulsed injection is a mode of operation whereby the airflow is turned off for some period of time and subsequently turned back on. In diffusion-limited soils, the concentrations will tend to rebound when the system is shut off. Pulsed injection may be more efficient than continuous operation in removing contaminant mass, particularly where the soil layers have higher clay or silt content. At the Former 724th TPS site, pulsed injection is planned over 4-hour cycles; air will be injected for 4 hours, then turned off for 4 hours, and subsequently turned back on. In groundwater, air will be injected alternately between two sets of three wells each over the 4-hour cycles.

System well head pressures will be balanced to provide approximately uniform air delivery to each of the six injection wells. Routine operations will involve bi-weekly operational checks of pressure and volumetric airflow rate. In addition, dissolved oxygen, nitrate, and orthophosphate field parameters will be measured in groundwater at monitoring wells MW-2 and MW-6. If the system is shut down at any time for maintenance or repair, then the system will be restarted following the startup procedures given in Section 2.1.

5.0 SYSTEM MAINTENANCE

5.1 BI-WEEKLY MAINTENANCE

Check the system bi-weekly (i.e., once every two weeks) for operation. This will be accomplished by inspecting the system for visible damage or power cutoff. Any equipment that is found to be faulty, out of adjustment, or in disrepair will be repaired or serviced. Pertinent manufacturer's information for the compressor will be attached to the O&M Plan once the equipment is selected for purchase or lease. Checks will include operation of the compressor system and well head pressures. The inspector will fill out a bi-weekly inspection checklist (similar to that contained in Attachment 1) and record the system operating parameters as measured at the time of inspection. The required bi-weekly inspection items are listed below.

- Air supply header and injection well head. Inspect both the air injection wells and piping for evidence of tampering or damage. Check all piping and connections for any signs of leaks and proper operation of pressure gauges, airflow meters, or globe valves.

- Compressor and air supply system. Inspect the compressor for signs of improper operation, such as abnormal noise levels, excessive vibration, or overheating.

- System balance. Check the airflow rates at each well head and balance the system if required following the procedures given in Section 2.1.

5.2 ROUTINE (QUARTERLY) MAINTENANCE

In addition to weekly inspections, the PHOSter® II system will be inspected quarterly for the following:

- Check nutrient/air injection wells for silt accumulation, clogging, or biofouling.
- Check monitoring wells for silt accumulation, tampering, or other surficial damage.
- Maintain compressor per the manufacturer's recommendations.
- Clear brush or vegetative growth from around wells and headers by mowing or scythe.

6.0 SAMPLING AND ANALYSIS

Sampling of soil and groundwater will be conducted throughout the remediation period to verify effective O&M of the corrective measure. All information, data, and resulting decisions will be technically sound, statistically valid, and properly documented by following a QAPjP. The QAPjP 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.

6.1 GROUNDWATER MONITORING DURING PHOSter® II SYSTEM OPERATION

The nine on-site groundwater monitoring wells will be sampled once every month during the PHOSter® II system operation, for a total predicted duration of 4 months. The purpose of this sampling will be to evaluate trends in system effectiveness and to compare the actual rate of remediation to the predicted rate.

Prior to sampling the monitoring wells, the nutrient/air injection system will be temporarily shut down for 1 day to allow equilibrium to be reached. A simplified respiration test will be run on one of the new monitoring wells (MW-6) during this shutdown time by monitoring dissolved oxygen (DO) and carbon dioxide concentrations in the well for approximately 8 hours. After 24 hours, groundwater samples will be collected from each of the eight wells using low-flow sampling techniques to minimize volatilization. Samples will be analyzed at an off-site laboratory for benzene, toluene, ethylbenzene, and total xylenes (BTEX). 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 persist during PHOSter® II treatment. Field parameters will be measured at the time of sampling and will include DO, temperature, oxidation-reduction potential (Eh), conductivity, pH, and ferrous iron.

Due to the active nutrient/air injection and disturbance at each nutrient/air injection well, sampling of the injection wells is not required.

6.2 GROUNDWATER MONITORING DURING CONFIRMATION SAMPLING

Following the completion of groundwater remediation using the PHOSter® II treatment, the nine on-site monitoring wells will be sampled for all chemicals of concern (COCs) as defined in the Phase II RFI Report to confirm that groundwater RLs have been met for all constituents. Confirmation groundwater sampling and analysis will be conducted quarterly for 1 year to verify that corrective action is complete.

Samples will be analyzed at an off-site laboratory for VOCs and PAHs using then-current SW-846 methods. Analysis of PAHs in lieu of the full suite of SVOCs, is appropriate for this site because naphthalene is the only SVOC that is a COC. Field parameters will be measured at the time of sampling and will include DO, temperature, Eh, conductivity, and pH.

6.3 SOIL SAMPLING DURING PHOSter® II SYSTEM OPERATION

Monthly soil gas monitoring and respiratory testing will be conducted to verify that the site is sufficiently oxygenated and that active bioremediation is occurring. Soil gas concentrations of oxygen, carbon dioxide, benzene, and total hydrocarbons will be measured during system operation. After these measurements are collected, the bioventing system will be turned off and soil gas concentrations of oxygen and carbon dioxide will be measured hourly until oxygen levels drop below 5 percent or are no longer declining. The oxygen utilization rate will be used as the primary indicator that remediation is complete; once the oxygen utilization rate in the contaminated area is similar to that in the background (uncontaminated) area, operation of the bioventing system will be suspended (anticipated to be after 4 months of operation). A soil vapor sampling point (SV-01) will be installed near the upgradient monitoring well (MW-01) at the site to measure background oxygen utilization.

Soil sampling and analysis will be conducted upon completion of the 4-month treatment period to verify that benzene concentrations have declined to below 20 µg/kg. A total of 10 subsurface soil samples will be collected within the source area as delineated in the Phase II RFI Report at a depth just above the water table. Sample locations will be as shown on Figure 5-3 of the CAP. Samples will be analyzed at an off-site laboratory for VOCs and PAHs. Analysis of PAHs in lieu of the full suite of SVOCs is appropriate for this site because naphthalene is the only SVOC that is a COC.

6.4 SOIL SAMPLING DURING CONFIRMATION SAMPLING

Following remediation and concurrent with the final quarter of confirmation groundwater sampling (i.e., 1 year after shutting down the system), a total of 10 subsurface soil samples will be collected within the source area as delineated in the Phase II RFI Report to confirm that soil RLs have been met for all COCs. Confirmation soil sampling and analysis will be conducted as a single event to verify that corrective action is complete. Sample locations will be selected based on a random grid pattern within the area of contamination. Samples will be collected at a depth just above the water table. Samples will be analyzed at an off-site laboratory for VOCs and PAHs using then-current SW-846 methods. If results of the soil sampling conducted immediately after the 4-month O&M period indicate that RLs have been met for all COCs in soil, then a second confirmation soil sampling event will not be needed.

7.0 CORRECTIVE ACTION COMPLETION CRITERIA

The purpose of the corrective action is to achieve RLs in groundwater and soil at the site. The RLs, as defined in the Phase II RFI Report, are as listed in Table D-2:

Table D-2. Summary of Remedial Levels

Analyte	Soil Remedial Level (μg/kg)	Groundwater Remedial Level (μg/L)
Acetone	370	370
Benzene	20	5
Ethylbenzene	3,100	700
Naphthalene	600	150
Toluene	4,200	1,000
Xylenes, total	31,700	10,000

Operation of the PHOSter® II system will be ceased upon attaining a maximum benzene concentration in each of the eight on-site wells of 5 μg/L and a maximum benzene concentration in soil of 20 μg/kg. Confirmation groundwater sampling will be conducted quarterly for 1 year to verify that the groundwater RLs have been achieved. Confirmation soil sampling will be conducted at the end of the confirmation groundwater sampling to verify that the soil RLs have also been achieved.

8.0 SYSTEM DECOMMISSIONING

Upon satisfactory completion of the year of confirmation groundwater sampling (see Section 4.2) and acknowledgment from the regulators that the corrective action is complete, the PHOSter® II system will be decommissioned. Surficial equipment, including the aboveground piping and connections, will be removed. Reusable equipment and materials will be transported to an on-site storage area designated by the Installation. Non-salvageable equipment and materials will be properly disposed of. The nutrient/air injection wells and groundwater monitoring wells will be plugged and abandoned by filling the casings with a cement and bentonite grout mixture. Below-ground piping will be removed and the trench backfilled, or the piping will be grouted in place.

9.0 O&M CONTINGENCY PROCEDURES

In the event of a major breakdown and/or complete failure of the PHOSter® II system (including emergency situations) at Solid Waste Management Unit (SWMU) 26, Fort Stewart will orally notify GEPD within 24 hours of the event and will notify GEPD in writing within 72 hours of the event. Written notification will, at a minimum, specify what happened, what response action is being taken and/or is planned, and any potential impacts on human health and/or the environment.

Contingency procedures may be considered during the operation of the PHOSter® II system in response to observed operational malfunction or unanticipated trends in the predicted rate of remediation. Contingency actions that may be considered are listed in the following troubleshooting guide (Table D-3).

Table D-3. Troubleshooting Guide for Operational Malfunctions

Problems	Considerations	Potential Solutions
The radius of influence of injection pressures is insufficient or not as predicted	The soil may be less permeable in some locations or there may be a preferential flow path	Further subsurface investigation Readjust flows Install additional wells Check wells for clogging Check for short-circuiting
Pressures vary between wells	There may be a preferential flow path or heterogeneities	Further subsurface investigation Install additional wells Rebalance globe valves
The benzene concentrations have reduced in some but not all wells	Treatment may be completed in some areas of the site	Reduce flows to some wells Take some wells off-line Check for ongoing sources of contamination
The benzene concentrations remain consistently high	Undiscovered source of contamination or free product may be present	Further investigation Restart free product recovery Reassess PHOSter® II system effectiveness
Benzene concentrations rebound when system is shut off	Air diffusion may be limited, short-circuiting may be occurring due to preferential flow, airflow rates may be higher than necessary	Reduce airflow rates Install additional wells Adjust rates of nutrient injection
Benzene concentrations decline but do not reach completion criteria	Operation of PHOSter® II system may be nearing point of diminishing returns	Extend injection period Shut off PHOSter® II system and continue with monitored natural attenuation
System breakdown or power interruption is frequent	Operating conditions may be erratic	Redundant or emergency backup equipment
Extent of groundwater contamination is greater than anticipated	Contamination may have migrated further than previously measured	Further subsurface investigation Readjust flows Install additional wells
Rate of remediation is slower than anticipated	Soil conditions may be less porous, heterogenous, or more layered than anticipated	Extend PHOSter® II treatment period Install additional wells Adjust rates of nutrient injection Shut off PHOSter® II system and continue with monitored natural attenuation

10.0 O&M SCHEDULE

The anticipated schedule for O&M is summarized in Table D-4.

Table D-4. Operations and Maintenance Schedule

O&M Activity	Frequency	Duration
System startup	Once	Until system balanced (~1 week)
Site inspection/bi-weekly maintenance	Bi-weekly (once every two weeks)	Bi-weekly throughout nutrient/air injection operations (~4 to 8 months)
Site inspection/quarterly maintenance	Quarterly	Quarterly throughout nutrient/air injection operations (~4 to 8 months)
Groundwater sampling during PHOSter® II system operation, BTEX, and natural attenuation parameters	Monthly	Monthly throughout nutrient/air injection operations (~4 to 8 months)
Soil vapor monitoring during PHOSter® II system operation (O_2, CO_2, benzene, total petroleum hydrocarbons)	Monthly	Monthly throughout nutrient/air injection operations (~4 to 8 months)
Soil sampling during PHOSter® II system operation (BTEX)	Once after 4 months of operation	One-time event
Confirmatory groundwater sampling	Quarterly following shutdown of PHOSter® II treatment system	Quarterly for 1 year
Confirmatory subsurface soil sampling	Once at the completion of confirmatory groundwater sampling	One-time event

11.0 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.

- Records of operating parameters. Pressures, flow rates, temperatures, and other operating parameters recorded on inspection checklists.

- Personnel, maintenance, and inspection records. Logbooks, maintenance checklists, repairs, or system upgrades.

11.1 PROGRESS REPORT INFORMATION

A progress report will be prepared both at the end of system installation and startup and at the end of the anticipated 4-month O&M period of the PHOSter® II nutrient/air injection system. These reports will summarize the operation, maintenance, sampling, and analysis performed during system startup and the 4-month O&M period. In addition, an analysis of trends and effectiveness of the corrective action will be presented as will the need for any contingent action discussed, as required.

A progress report will be prepared quarterly during the 1-year confirmatory sampling period. The report will summarize the results of the groundwater sampling and analysis completed during that quarter. An analysis of any deviations from the required RLs and need for any contingent action will be discussed, as required.

A checklist is presented in Attachment 2 to this O&M Plan summarizing the items to be addressed in each Progress Report.

11.2 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 system performance and sampling data, and give results of the confirmation groundwater and soil sampling.

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ATTACHMENT 1

BI-WEEKLY INSPECTION CHECKLIST
PHOSter® II SYSTEM OPERATION AND MAINTENANCE
FORMER 724th TANKER PURGING STATION
FORT STEWART, GEORGIA

Inspector:______________________________ **Date:**__________**Time:**__________
Unit No.:______________________________ **Unit Type:**____________________

Operation Check:

System Settings		Process Control	
SV1	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________
SV2	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________
SV3	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________
SV4	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________
SV5	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________
SV6	Pressure __________ Flow:__________	Well No.	DO__________ Nitrate__________ Orthophosphate__________

Chemicals

Triethylphosphate Added______________________________________

Maintenance Check:

Injection wells show no visible damage/tampering:____________________
Supply tubing shows no visible damage/tampering:____________________
Supply tubing/connections show no visible leaks:____________________
Pressure gauges are operating properly:__________________________
Flow meters are operating properly:____________________________
Compressor is operating properly (noise, vibration, overheating):____________
Flow rates at each well head are balanced:________________________
Power service has not been uninterrupted:________________________

Unit Maintenance Performed____________________________________
____
____
____

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ATTACHMENT 2

PROGRESS REPORT CHECKLIST
Former 724th Tanker Purging Station, Fort Stewart, Georgia

Progress Report Section	System Installation and Startup	End of 4-Month O&M Period	Quarterly Confirmatory Sampling Period
Work Accomplished (description of significant activities)	• System installation (well logs, facility layout, components) • Baseline groundwater sampling event • System balancing and operating parameters • Any changes made to the system design or operation	• Dates of inspections (copies of Weekly Inspection Checklists) • System operation (hours of treatment, system operating parameters, amount of nutrients or air injected) • Any system maintenance performed • 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 system operation to design operating parameters • Comparison of groundwater and soil vapor analytical results to predicted performance	• Comparison of results of groundwater or soil 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 system design or operation	• System shutdown if remedial levels have been met • Need for contingent action (e.g., continued operation, monitored natural attenuation) if remedial levels have not been met	• Need for contingent action if remedial levels exceeded

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