REVISED FINAL

PHASE II RCRA FACILITY INVESTIGATION REPORT FOR THE BURN PITS (SWMUs 4A - 4F) FORT STEWART, GEORGIA

REGULATORY AUTHORITY
RESOURCE CONSERVATION AND RECOVERY ACT
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Prepared for:

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Savannah District
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I, the undersigned, certify that I am a qualified groundwater scientist who has received a baccalaureate or post-graduate 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, that enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or by a subordinate working under my direction.

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List of Abbreviations and Acronyms

amsl	above mean sea level
ASTM	American Society for Testing and Materials
AUF	area use factor
BAF	bioaccumulation factor
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMCOPC	contaminant migration constituent of potential concern
COC	chemical/contaminant of concern
COPC	chemical/contaminant of potential concern
CSM	conceptual site model
DAF	dilution attenuation factor
DPW	Directorate of Public Works
DQCSR	Daily Quality Control Summary Report
DQO	Data Quality Objective
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
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IDW	investigation-derived wastes
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level
NOAEL	no observed adverse effect level
PAH	polyaromatic hydrocarbon
PCE	tetrachloroethene

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PID	photoionization detection
PRE	Preliminary Risk Evaluation
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAIC	Science Applications International Corporation
SRC	site-related contaminant/constituent
SSL	Soil Screening Level
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TRV	toxicity reference value
USACE	U.S. Army Corps of Engineers
UTL	upper tolerance level
VOC	volatile organic compound

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EXECUTIVE SUMMARY

This report summarizes the results of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the Burn Pits, Solid Waste Management Units (SWMUs) 4A through 4F, at Fort Stewart, Georgia. 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. 0008. The RFI was conducted in accordance with USACE guidance EM200-1-3 and the approved Phase II RFI Work Plan.

SWMU 4 consists of a total of seven separate burn pits located in the southern portion of the Fort Stewart Military Reservation. One of these burn pits, Burn Pit G, has not been used and is, therefore, not included in this Phase II RFI. The remaining six burn pits, Burn Pits A through F, have been used in the past to burn combustible waste such as scrap lumber, timber cuttings, or construction and demolition waste, and for the disposal of ashes, concrete debris, and soil from excavations. Burning operations were not actually done in trenches, or "pits," but in surface piles that were doused with gasoline and burned. The units are, therefore, similar to "burn areas."

Potential contamination at each of the six sites was investigated during a Phase I RFI for 24 SWMUs at Fort Stewart in 1993. Analytical results from soil and groundwater sampling conducted at the former Burn Pits indicated metal and/or volatile organic contamination in both soil and groundwater at each site. Based on these findings, Georgia Environmental Protection Division (GEPD) instructed the Fort Stewart Directorate of Public Works (DPW) to conduct a Phase II RFI.

The objectives of the Phase II RFI for the Burn Pits, as defined in the Work Plan approved by GEPD on June 10, 1997 are to:

- 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 Corrective Action Plan, if warranted.

SUMMARY OF INVESTIGATION ACTIVITIES

The information provided in this report is based upon data collected previously during the Phase I RFI and data collected as part of the Phase II field sampling and analysis. The scope of the Phase II field work included the following activities:

- Redevelopment of 18 existing wells and abandonment of 6 existing wells found to be damaged or unusable.

- Drilling of 3 soil borings at each burn pit site (for a total of 18 borings) with collection of associated surface and subsurface soil samples. Surface soil samples were analyzed for semivolatile organic compounds (SVOCs) and RCRA metals; subsurface soil samples were analyzed for volatile organic compounds (VOCs) and RCRA metals.

- Installation of eight permanent groundwater monitoring wells both upgradient and downgradient of selected sites.

- Collection of groundwater samples from both new and existing wells for a total of 26 samples. Groundwater samples were analyzed for VOCs and RCRA metals

PHYSICAL CHARACTERISTICS OF THE BURN PIT SITES

The former Burn Pits range between one and four acres in size. The topography at each of the sites is relatively flat, with local relief varying by only 5 to 10 feet. There are no surface water bodies in the vicinity of any of the burn pits. Runoff is collected in ditches that discharge to different receiving streams. Burn Pits A through D are within the Mill Creek and Horse Creek subwatershed areas, Burn Pit E is located within the Canoochee River floodplain, and Burn Pit F is located in the Peacock Creek watershed, with drainage from the site into Goshen Swamp.

The surficial soils at each of the sites are generally a light gray sand or silty sand up to 20 feet thick, the maximum depth explored. Clayey sand and sandy clay layers are interbedded with this sandy material, and wood fragments and charred wood were also encountered in some of the borings. Results of geotechnical analyses indicated that the soils tested are generally non-plastic sands with silt, with only 2 to 12 percent by weight fine-grained particles. Laboratory permeability of the soils tested varied from 3.11×10^{-4} to 1.73×10^{-3} cm/second.

The uppermost hydrologic unit is the surficial aquifer, which ranges from 55 to 150 feet in thickness. Water levels measured during well development and sampling varied from the shallowest (2 to 3 feet) at Burn Pit C, to the deepest (12 to 13 feet) at Burn Pit E. Groundwater flow is generally planar toward the nearest surface stream into which the groundwater discharges. An exception to this is at Burn Pits C and F, where water levels suggest that flow may be radially away from the source area. Horizontal gradients are generally very flat, ranging from 0.001 to 0.009 foot/foot. Calculated groundwater flow velocities vary from a low of 1.2 feet/year at Burn Pit B to a high of 35 feet/year at Burn Pit A. Groundwater discharges to the receptor stream nearest to each of the sites, located at distances that vary from 1000 to 4500 feet from the site.

CONTAMINANT NATURE AND EXTENT

- SVOCs were found only in a single surface soil sample at low concentrations at Burn Pit E.

- Metals found above background in surface soils include arsenic, barium, cadmium, lead, and mercury in the northern and eastern portions of Burn Pit A; lead and mercury at Burn Pit B; barium, cadmium, lead and mercury in the center of Burn Pit C; barium and mercury at Burn Pit E; and arsenic, chromium, and mercury in the northern and northeastern portion of Burn Pit F.

- Benzene, toluene, ethylbenzene, and xylene (BTEX) compounds were found in subsurface soil at low concentrations sporadically at all six Burn Pit sites. A consistent pattern of distribution is evident only at Burn Pit B and Burn Pit C.

- Metals in subsurface soil were generally found sporadically at all six Burn Pit sites twice background and in no consistent pattern of distribution. Notable presence of metals found in subsurface soils includes lead and mercury in the central and northeastern portion of Burn Pit C, and five metals (predominantly barium, lead, and chromium) throughout the Burn Pit F site.

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- In groundwater, the highest levels of BTEX contamination were found in a single well located west (side-gradient) of the Burn Pit F site. Concentrations of BTEX were less than their respective maximum contaminant levels (MCLs) and less than reported Phase I concentrations, suggesting that natural attenuation may be occurring. The source of the BTEX contamination is unknown; BTEX compounds were not found at high concentrations in soils at Burn Pit F.

- Metals in groundwater were found at all six sites at concentrations less than their respective MCLs and much less than reported Phase I concentrations, suggesting that redevelopment of the wells and use of low-flow sampling equipment to reduce turbidity in the samples were successful.

- Metals found in groundwater include barium, mercury, and silver at Burn Pit A; barium, cadmium, chromium, selenium, and silver at Burn Pit B; barium, cadmium, and mercury at Burn Pit C; arsenic, barium, and silver at Burn Pit D; and cadmium at Burn Pits E and F.

CONTAMINANT FATE AND TRANSPORT

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

Among the metal constituents, only chromium from Burn Pit F is considered a contaminant of potential concern (COPC) for contaminant migration based on contaminant transport analysis for leaching from soil to groundwater. At Burn Pit F, chromium could reach the water table at a predicted concentration (173 µg/L) exceeding its MCL of 100 µg/L. However, offsite migration of chromium would be very limited due to its high K_d (i.e., high retardation factor), as well as the slow movement of groundwater toward Goshen Swamp, located approximately 1000 feet west of the site.

Benzene, methylene chloride, and tetrachloroethene could migrate from soils to the water table at one or more of the sites at concentrations exceeding their respective MCLs. However, offsite migration of these constituents would be very limited due to retardation and biodegradation as well as the slow movement of groundwater. Predicted maximum concentrations of these constituents at a distance of 300 feet from the source are not expected to exceed their MCLs even with the most conservative assumption for their biodegradation half-lives. None of the organic compounds that are currently observed in groundwater exceed their respective MCLs in groundwater.

HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment included a Step 1 risk evaluation to determine potential human health risks associated with the contaminants.

In surface soil, arsenic is a potential human health COPC at Burn Pits A and F, where arsenic exceeds its risk-based screening value for exposure of a residential receptor. It should be noted that the maximum concentration of arsenic at these sites (2.7 mg/kg) is below the average concentration of arsenic for soils regionally (7.4 mg/kg). In addition, a residential screening value was used, since there are no screening values for industrial land use, even though residential land use at these sites is unlikely. Therefore, arsenic in surface soil is not considered a potential threat to human health at the Burn Pits.

In subsurface soil, no constituent exceeded its respective risk-based screening value for exposure to a residential receptor.

In groundwater, arsenic is a potential human health COPC only at Burn Pit D, where the maximum concentration of arsenic in groundwater exceeded its risk-based screening value for residential use of groundwater as drinking water. However, the maximum concentration of arsenic (4.2 μg/L) was well below its MCL of 50 μg/L, and was only slightly above its reference background concentration of 3.4 μg/L. Arsenic exceeded background in only a single well at Burn Pit D (MW-6). In addition, use of the surficial groundwater at this site for drinking water is unlikely. Therefore, arsenic in groundwater is not considered a potential threat to human health at the Burn Pits.

ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment included a Phase 1 preliminary risk evaluation (PRE) for potential terrestrial and aquatic receptors at the sites.

Cadmium, chromium, and lead are present in surface soil at one or more of the former Burn Pits at concentrations that exceed the toxicity reference values (TRVs) for the robin, and in some cases, the shrew. Cadmium, chromium. and lead in surface soil at these two sites are, therefore, identified as potential ecological COPCs in the PRE. Based on the results of additional evaluations using published dietary fractions and LOAEL-based TRVs, and the uncertainties in the preliminary risk calculations, cadmium, chromium, and lead in surface soil at the burn pits are unlikely to pose a risk to ecological receptors.

According to GEPD (1996) and U.S. Environmental Protection Agency (EPA) Region 4 (1995) guidance, groundwater was screened as surface water in the ecological PRE. Barium, cadmium, lead, mercury, silver, and ethylbenzene are present in groundwater at one or more of the former burn pits at concentrations that exceed EPA Region 4 ecological screening values for surface water.

Groundwater is not evaluated further in the PRE for the Burn Pits because ecological receptors are not likely to be exposed to groundwater at these sites. There are no surface water bodies at or near the Burn Pits. Also, groundwater contaminants are not expected to migrate from the Burn Pit sites because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in soils at the sites.

SUPPLEMENTAL GROUNDWATER CHARACTERIZATION

Based upon the results of the original Phase II RFI at the Burn Pit F site, a supplemental groundwater characterization was conducted in November 1998. The purpose of this supplemental characterization is to verify (1) the groundwater contours in the vicinity of Burn Pit F and the ultimate rate and point of discharge of groundwater, (2) the presence or absence of a source of organic contamination, and (3) the natural attenuation of the BTEX compounds. The scope of work included installing eight temporary piezometers within the center of the site, in the northwestern boundary of the site, and to the north and west of the site from MW-4. Grab groundwater samples were taken from these piezometers and were analyzed for BTEX. The four

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existing on-site monitoring wells (MW-1 through MW-4) were also sampled and analyzed for VOCs and water quality parameters (methane, ethane, and ethene).

VOCs. Two BTEX (ethylbenzene at 289 μg/L and total xylenes at 1420 μg/L) compounds were detected in groundwater at MW-4. The concentrations are less than the respective MCLs for ethylbenzene (700 μg/L) and total xylenes (10,000 μg/L). In Phase I sample results, both ethylbenzene and xylenes were reported at much higher concentrations (2,800 and 15,800 μg/L, respectively). In the Phase II RFI, both ethylbenzene and total xylenes were also reported at higher concentrations of 637 and 3170 μg/L, respectively. These results indicate that the concentrations of BTEX present in groundwater at the site are attenuating naturally, either through dispersion, volatilization, or biodegradation.

Low concentrations of total xylenes (3.8 μg/L) were also found in MW-1. Total xylenes were found at a concentration only slightly above its detection limit and significantly less than its MCL of 10,000 μg/L. No VOCs were reported above the detection limit in MW-1 during Phase II groundwater sampling.

Chloroform and styrene (2.8 and 12.2 μg/L, respectively) were observed in MW-4. Styrene is considered a secondary contaminate in the primary BTEX plume. Chloroform is a common laboratory contaminant, was not detected in the Phase II RFI sampling event, and is substantially less than its MCL of 100 μg/L.

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

1. The exact source of the BTEX contamination at Burn Pit F is unknown. MW-4 is located hydraulically higher than the other wells at the Burn Pit F site and is considered side-gradient to the existing groundwater flow. BTEX compounds were not detected at significant concentrations in the soil borings within the potable source area, were not detected in the remaining downgradient wells, and were not detected in the eight additional piezometers installed around MW-4. Therefore, the source and extent of contamination is expected to be localized and confined to the immediate vicinity of MW-4.
2. BTEX compounds (ethylbenzene and total xylenes) continue to be present in groundwater at MW-4. However, the concentrations are less than their respective MCLs and less than the concentrations reported during the Phase I and II RFIs, indicating they are attenuating naturally, either through dispersion, volatilization, or biodegradation.
3. No further investigation or action is recommended for Burn Pit F. The existing wells should be retained in the event that future site monitoring is required to confirm that concentrations of ethylbenzene and total xylenes continue to decrease.

RECOMMENDATIONS

The results of the RFI and supplemental groundwater sampling, conclusions regarding nature and extent of contamination, fate and transport, human health risk, and ecological risk result in the following recommendations:

1. No further action is recommended for all six Burn Pits (i.e., SWMUs 4A, 4B, 4C, 4D, 4E, and 4F). If approved by GEPD, Fort Stewart respectfully requests that the installation's Subpart B permit be amended to reflect this change in status.

2. Due to the fact that all human health COPCs have been eliminated in site-specific evaluations, none of the Burn Pits will require a baseline risk assessment.

3. Due to the fact that all ecological COPCs have been eliminated in site-specific evaluations, none of the Burn Pits will require an ecological risk assessment.

4. If GEPD approves Fort Stewart's recommendation for No Further Action at SWMUs 4A, 4B, 4C, 4D, 4E, and 4F, the existing site monitoring wells will be properly abandoned, with the exception of the wells located at SWMU 4F. Fort Stewart proposes to retain the wells at SWMU 4F in the event that future site monitoring is required to confirm that concentrations of ethylbenzene and total xylenes continue to decrease.

1.0 INTRODUCTION

This report summarizes the results of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the Burn Pits, Solid Waste Management Units (SWMUs) 4A through 4F, at Fort Stewart, Georgia. 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. 0008. This RFI has been conducted in accordance with USACE standards EM 200-1-3 and the approved Phase II RFI Work Plan.

SWMU 4 consists of a total of seven separate burn pits located in the southern portion of the Fort Stewart Military Reservation (FSMR). One of these burn pits, Burn Pit G, has not been used and is, therefore, not included in this Phase II RFI. The remaining six burn pits, Burn Pits A through F, have been used in the past to burn combustible waste such as scrap lumber, timber cuttings, or construction and demolition waste, and for the disposal of ashes, concrete debris, and soil from excavations. Burning operations were not actually done in trenches or "pits," but in surface piles that were doused with gasoline and burned. The units are, therefore, similar to "burn areas."

Potential contamination at each of the six sites was investigated during a Phase I RFI for 24 SWMUs at Fort Stewart (Rust 1993). Analytical results from soil and groundwater sampling conducted at the former Burn Pits indicated metal and/or volatile organic contamination in both soil and groundwater at each site. Based on these findings, Georgia Environmental Protection Division (GEPD) instructed the Fort Stewart Directorate of Public Works (DPW) to conduct a Phase II RFI.

1.1 OBJECTIVES AND SCOPE OF THE INVESTIGATION

The specific objectives of the Phase II RFI for the former Burn Pits at Fort Stewart, Georgia, as defined in the Phase II RFI Work Plan (SAIC 1997) (approved by GEPD on June 10, 1997), are to:

- 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 Corrective Action Plan (CAP), if warranted.

The information provided in this report is based upon data collected previously during the Phase I RFI and data collected as part of the Phase II field sampling and analysis. The Phase II field work was conducted in accordance with the Phase II Work Plan (SAIC 1997), with the exception that the existing wells found to be damaged or unusable were abandoned. The scope of the Phase II field work included the following activities:

- Redevelopment of 18 existing wells.

- Abandonment of six existing wells found to be damaged or unusable.

- Drilling of 3 soil borings at each burn pit site (for a total of 18 borings) with collection of associated surface and subsurface soil samples.

- Installation of eight permanent groundwater monitoring wells, both upgradient and downgradient of selected sites.
- Collection of groundwater samples from both new and existing wells for a total of 26 samples.
- Surveying the position of all sample locations.

1.2 REPORT ORGANIZATION

This Phase II RFI Report consists of 16 sections. Section 1.0 describes the purpose of this investigation and summarizes the scope of work performed. Section 2.0 discusses the site history and conceptual site model (CSM) for the former Burn Pits. Section 3.0 summarizes the investigation activities and methodologies used in completing the Phase II RFI field work. Section 4.0 presents the regional setting of the FSMR, including the demographics, topography, regional geology and hydrogeology, surface drainage, soils, and ecology. Section 5.0 describes the results of the investigation, including background data analysis and summary of the nature and extent of contamination. Section 6.0 identifies considerations affecting contaminant fate and transport. Section 7.0 presents the human health risk assessment (HHRA) methodology and summary of the risk characterization. Section 8.0 presents the ecological risk assessment (ERA) methodology and summary of the risk characterization.

Sections 9.0 through 14.0 describe the results of the investigation for each of the six Burn Pit sites, respectively. These sections present the site-specific history, nature and extent of contamination, fate and transport, HHRA, and ERA. Section 15.0 summarizes the conclusions and recommendations for subsequent corrective action. The references cited in this report are listed in Section 16.0.

This revised final report also contains eight appendices. Appendices A through D contain the same information as presented in the final report (March 1998), including boring logs, monitoring well construction diagrams, Quality Control Summary Report (QCSR), and geotechnical laboratory test results. Appendix E, which contains the background data, has been substantially modified to include additional information collected in conjunction with ongoing RFIs at other SWMUs on the FSMR. Appendix F has been modified to include an explanation of acronyms and validation flags. Appendix G has been added to include a summary of the toxicity data for Human Health Chemicals of potential concern. Appendix H is a new appendix that presents the results of the November 1998 supplemental groundwater sampling.

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2.0 SITE HISTORY AND CONTAMINANTS

2.1 INSTALLATION DESCRIPTION

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 (Figures 2-1 and 2-2). 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.

2.2 SITE LOCATION AND HISTORY

A total of seven separate burn pits are located around the garrison (or cantonment) area on the FSMR (Figure 2-3), within 10 miles of the garrison area. One of these burn pits, Burn Pit G, was cleared but has not been used (Geraghty and Miller 1992) and is, therefore, not included in this Phase II RFI. The remaining six burn pits, Burn Pits A through F, have been used in the past and are included in this Phase II RFI.

The six burn pits may have been in existence since Fort Stewart operations began, and have been used at various times to burn combustible solid waste such as scrap lumber, timber cuttings, construction and demolition waste, and to dispose of ashes, concrete debris, and soil from excavations. The burn pits were not actually "pits," but surface piles of clearing and grubbing debris that may have been doused with gasoline and burned. The burn pits operations were, therefore, not in trenches, but in surface "burn areas."

Potentially contaminated materials used or generated at the former Burn Pits included flammable liquids, such as gasoline. However, the use of fuels or solvents as ignition sources at the Burn Pits has not been specifically indicated (Geraghty and Miller 1992).

2.3 PREVIOUS INVESTIGATIONS

An RCRA Facility Assessment (RFA) was submitted to the GEPD in June 1990 that listed 24 SWMUs, including the former Burn Pits, as requiring further investigation (Geraghty and Miller 1992). A Phase I RFI, completed in April 1996, was performed in response to that

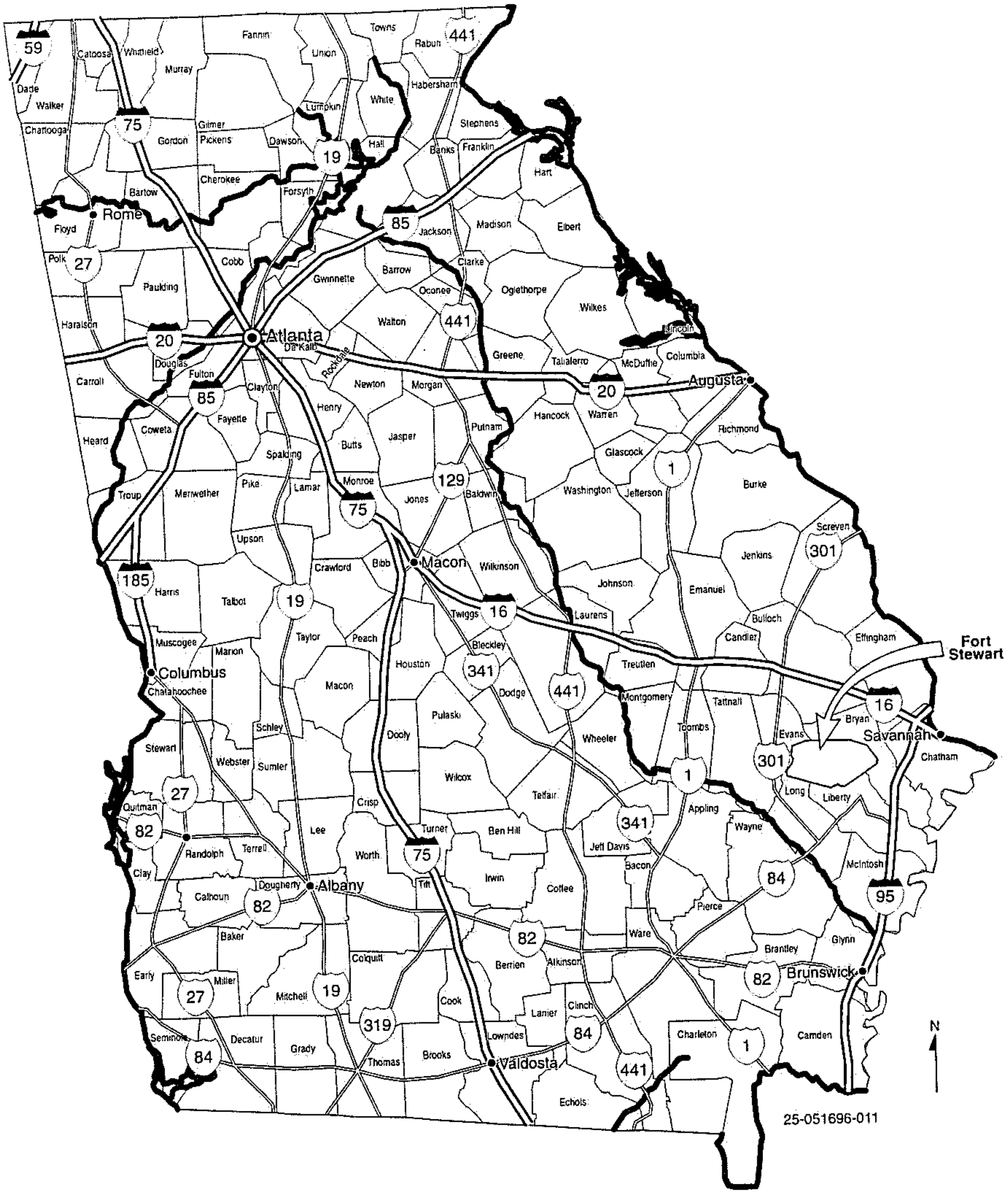

Figure 2-1. Regional Location Map for Fort Stewart Military Reservation, Georgia

submittal (Rust 1996). The objective of the Phase I RFI was to determine if releases to the environment had occurred from any of the 24 identified SWMUs.

During the Phase I RFI, site characterization activities involved the installation of four monitoring wells at each of the six burn pits, and the sampling and analysis of both soil and groundwater samples collected from these wells. Soil samples were collected during June 1993 (Geraghty and Miller 1993), and groundwater sampling took place during July, August, and November 1993 (Rust 1996). Results of that sampling are presented for each Burn Pit site in their respective site-specific characterizations (Sections 9.0 through 14.0). General trends in those results are described below.

One soil sample was collected by Geraghty and Miller (1993) during drilling of each monitoring well borehole and analyzed for volatile organic compounds (VOCs), RCRA total metals, pH, and specific conductance. Analytical results for the soil samples taken from the monitoring well boreholes were compared to then current GEPD guidelines (1993) or to site-specific background concentrations with the following results:

- **VOCs.** Benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations were reported in soil samples at levels less than 0.03 mg/kg at each of the sites. The compound tetrachlorethene (PCE) was detected in soil samples from Burn Pits A through D, with the highest value reported at Burn Pit D at 9.7 mg/kg. Methylene chloride, acetone, and carbon disulfide were detected in soil samples at levels above background; however, these compounds are common laboratory artifacts.

- **Metals.** Five RCRA metals were detected in soil samples from each of the Burn Pit sites at levels exceeding site-specific background concentrations. These metals and their corresponding maximum reported levels included arsenic (6.2 mg/kg), barium (27.0 mg/kg), chromium (15.0 mg/kg), lead (12.0 mg/kg), and mercury (0.063 mg/kg).

- **Specific Conductance.** Specific conductance in the soil samples ranged from 2.1 to 17.0.

- **pH.** Values of pH in soil ranged from 3.7 to 6.5, indicating slightly acidic, yet natural, conditions.

Groundwater samples were collected by USACE (1996) and analyzed for VOCs and RCRA total metals; pH and specific conductance were measured in the field. Analytical results for the groundwater samples were compared to Maximum Contaminant Levels (MCLs) and site-specific background concentrations with the following results:

- **VOCs.** Detection of BTEX reported in groundwater samples at two of the sites: at Burn Pit A, individual BTEX concentrations were less than 1.19 mg/L; at Burn Pit F, BTEX concentrations of 41.1 mg/L for individual constituents were reported. No chlorinated organic compound was reported in groundwater that can be associated with site contamination. Methylene chloride, acetone, and carbon disulfide were detected in groundwater; however, these compounds are common laboratory artifacts.

- **Metals.** Six RCRA metals were detected in groundwater samples from each of the Burn Pit sites at concentrations exceeding their respective MCLs and site-specific background concentrations. These metals and their corresponding maximum reported concentrations (total metal analysis) included arsenic (0.091 mg/L), chromium (1.4 mg/L), lead (0.625 mg/L), mercury (0.0062 mg/L), selenium (0.110 mg/L), and silver (0.2 mg/L).

- **Specific Conductance.** Specific conductance in the groundwater samples ranged from 0.02 to 0.5 mhos.

- **pH.** Values of pH in groundwater ranged from 4.6 to 6.5, indicating slightly acidic, yet natural, conditions.

2.4 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary CSM was developed based upon a review of the history of operations at the Burn Pits and the results of the Phase I RFI, which suggest that a release may have occurred at each of these six sites. During the Phase I RFI, soil samples from the monitoring well boreholes surrounding the suspected burn areas contained VOCs and metals at concentrations above site-specific background concentrations. Similarly, groundwater samples from the wells contained VOCs and metals at concentrations above their respective MCLs.

Chemicals of potential concern (COPCs) at this site include gasoline constituents (BTEX) and cleaning solvents (PCE), which may have been used to ignite surface piles of clearing and grubbing debris. Resulting burning residues may include hazardous constituents, primarily semivolatile organic compounds (SVOCs), in the surface soils. Although process knowledge indicates that metal contamination is not anticipated, metal constituents with concentrations greater than background were reported in soil and groundwater in the Phase I RFI and may have been present in the burning residues.

The most likely pathways for contaminant migration at the Burn Pits are via percolation vertically through the subsurface soils to groundwater, then via groundwater flow toward the nearest stream. VOCs and some metals are relatively mobile and may have migrated to subsurface soils or to groundwater. However, because VOCs are not persistent in soils due to their volatile and biodegradable nature, they are not likely to be present in surface soils. SVOCs and most metals, on the other hand, are not very mobile and are relatively persistent; therefore, they are not likely to migrate to groundwater but to remain in the soils on site. Surface water drainages are not present in the vicinity of the Burn Pits; therefore, constituents that reach groundwater are not likely to migrate to surface water. Thus, SVOCs and metals would be expected to be present predominantly in the surface soils within the burn areas; VOCs and metals would be expected in subsurface soil and groundwater localized to the sites.

Potential human receptors include on-site workers or soldiers on maneuvers who may come into contact with contaminated soils, and hypothetical future residents who may ingest groundwater. Because the surficial aquifer is not used as a source of potable water, any ingestion of groundwater by future residents would be accidental. Potential ecological receptors include terrestrial soil-dwelling animals and their predators that may ingest contaminated surface soil at the site, and aquatic biota in the respective receiving stream that may ingest contaminated groundwater discharging to that stream.

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3.0 SUMMARY OF INVESTIGATION ACTIVITIES

3.1 SAMPLING METHODOLOGIES

This section describes the Phase II RFI field investigations conducted at the Burn Pits from July 8 through August 13, 1997. The sampling methodologies and types of testing for physical and chemical characterization of each site are also described. Locations of the Phase II sampling stations are shown generally in Figure 3-1 and in greater detail in Sections 9.0 through 14.0 for Burn Pits A through F, respectively. The sampling strategy included soil and groundwater sampling at each of the six Burn Pit sites.

3.1.1 Soil Sampling

Three soil borings were drilled at each of the 6 Burn Pit sites, for a total of 18 borings. The soil borings were drilled between July 8 and 14, 1997, and surface and subsurface soil samples were collected for the following reasons:

- to identify whether chemicals occur at concentrations above background in soils at the site;
- to determine the nature of any such contamination, if present;
- to determine the extent of that contamination, together with the peripheral soil borings at monitoring wells;
- to obtain lithographic descriptions of the soil profile at each monitoring well; and
- to evaluate human health and ecological risks due to site contaminants.

Soil samples were also taken during the drilling of boreholes for the installation of monitoring wells at selected sites. A total of eight new monitoring wells were installed, one at Burn Pit A, three at Burn Pit C, two at Burn Pit D, and two at Burn Pit E. The monitoring well boreholes were drilled between July 9 and 24, 1997. The monitoring wells were installed around the periphery of the site, at both upgradient and downgradient locations. Soil samples were collected from the monitoring well boreholes for the following reasons:

- to collect relatively undisturbed samples for geotechnical testing of the screened interval;
- to obtain lithographic descriptions of the soil profile at each monitoring well; and
- to obtain background (upgradient) soil samples for characterization at Burn Pit C.

Auger-drilled soil boreholes were advanced using 4.25-inch inside diameter hollow-stem augers drilling with either a CME-55 or Ingersoll-Rand A-300 drilling rig. Total depth of the undisturbed soil samples ranged from 9.5 to 19.5 feet, and the total depth of the monitoring well boreholes ranged from 14 to 21 feet. During the drilling of each soil borehole, soil samples were collected with a split-barrel sampler continuously over 5-foot intervals from the ground surface to the water table. Two soil samples were collected for off-site chemical laboratory analysis, one from the ground surface and one from the subsurface interval having the highest VOC headspace reading.

The surface soil sample was taken from a depth of 0 to 1 foot below the ground surface and was sent offsite for analysis for SVOCs and RCRA metals. The analysis of surface soils was carried out to provide data suitable for conducting human health and ERAs. SVOCs are target

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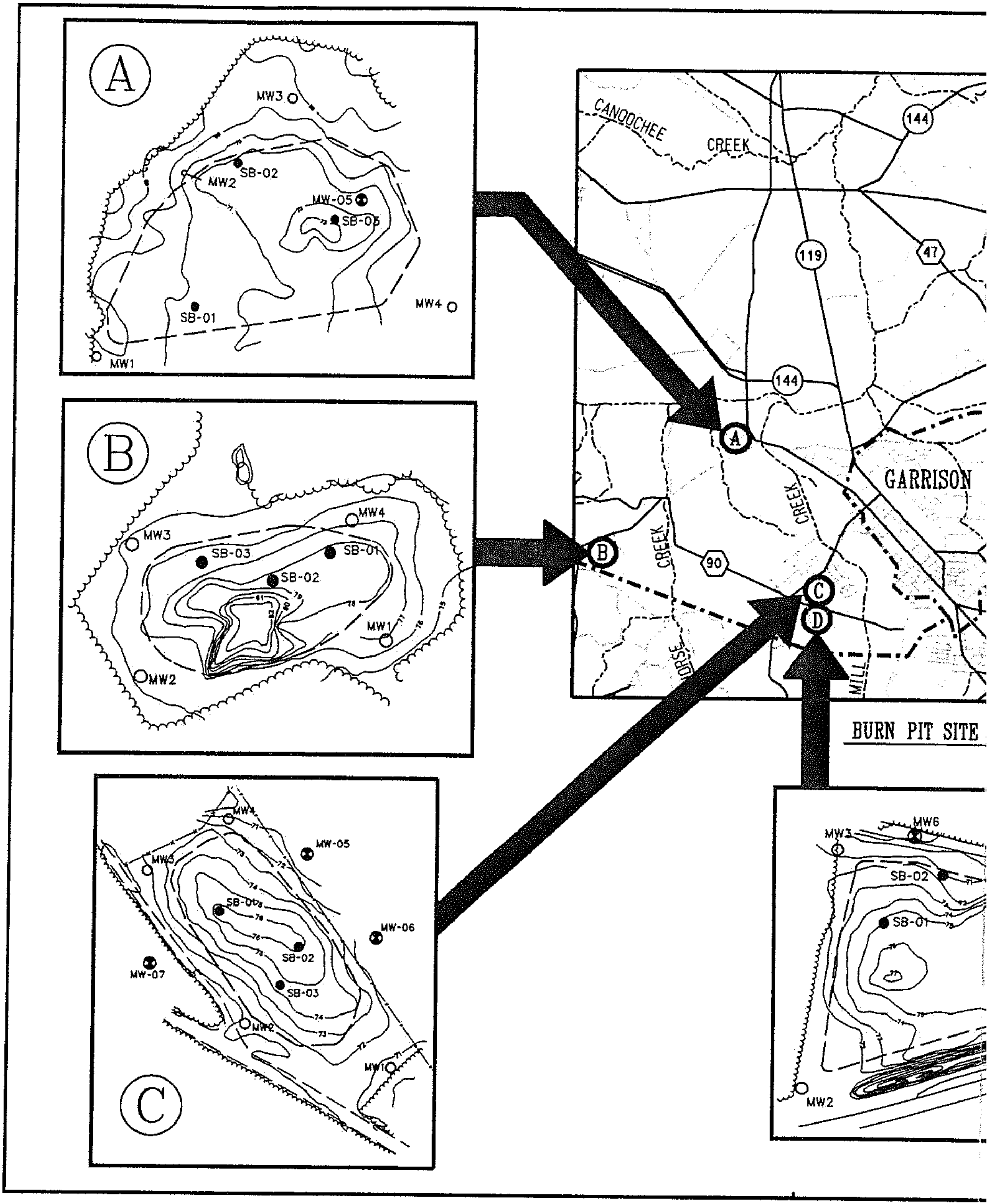

Figure 3-1. Locations of Sampling Stations at the E

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compounds in surface soils because they may occur as residuals from burning operations. RCRA metals are target chemicals because they were found at concentrations above background during the Phase I RFI in peripheral monitoring wells.

For subsurface soil samples, the 5-foot split-barrel core was split into two 2.5-foot sections. A portion of each 2.5-foot section was field tested for VOC headspace gas using a photoionization detector (PID). The borehole sample having the highest detected organic vapor concentration in the headspace gas was then sent offsite for quantitative laboratory analysis for VOCs and RCRA metals. The analysis of subsurface soils was conducted to characterize the extent of subsurface contamination and the potential for contaminants identified in the soil to leach to groundwater. VOCs are target compounds because they may have resulted from gasoline or other flammable liquids used to ignite the clearing and grubbing debris at the Burn Pits. If no VOCs were detected in the headspace gas, then the sample from the 2-foot interval directly above the water table was sent for analysis because gasoline-based contaminants of concern (COCs) float on the water table interface. In addition, one soil sample was collected from each borehole and sent offsite for laboratory analysis for total organic carbon for use in assessing fate and transport of organic constituents.

Results of the chemical analyses are presented in Sections 9.0 through 14.0. Boring logs for the drilling of both monitoring wells and soil borings are included in Appendix A.

One soil sample from the screened interval in each monitoring well borehole was analyzed for geotechnical parameters to support contaminant transport evaluation. Bulk soil samples were taken directly from the 5-foot split-barrel core and placed into jars. Bulk samples were tested for moisture content, Atterberg limits, and grain size distribution. One relatively undisturbed sample was collected from a boring at each of the six Burn Pit sites using a thin-walled (Shelby) tube sampler. The Shelby tube sampler was inserted into the hollow-stem auger string and hydraulically pushed approximately 2.0 feet. The ends of the Shelby tube sampler were sealed with wax to preserve moisture content in accordance with American Society for Testing and Materials (ASTM) D1587-83, and the tubes were shipped to an off-site laboratory for analysis. The Shelby tube samples were tested for moisture content, Atterberg limits, grain size distribution, specific gravity, soil porosity, and permeability. Geotechnical parameters were obtained to support fate and transport analysis.

Decontamination of drilling and down-hole sampling equipment was accomplished in accordance with the procedures specified in the Phase II RFI Work Plan. These procedures for sampling equipment included washing with water and phosphate-free detergent; rinsing alternately with water and isopropyl alcohol; and placing the equipment on clean plastic, or wrapping in plastic or aluminum foil, to prevent cross-contamination.

3.1.2 Groundwater Sampling

3.1.2.1 Monitoring Well Installation and Development

A total of eight new monitoring wells were installed between July 9 and 24, 1997–one at Burn Pit A, three at Burn Pit C, two at Burn Pit D, and two at Burn Pit E. The wells were constructed of 2.0-inch-diameter Schedule 40 polyvinyl chloride (PVC) casing with flush-threaded couplings. Well screens were constructed of factory-slotted pipe in 10-foot-long sections. Slot size, determined from the sieve analysis results from the soil boring and field sieve analyses, varied from 0.008 to 0.010 inches (No. 8 to No. 10 slot). Filter pack materials consisted variously of DSI Extra Fine, DSI #1, and DSI #2 Sand. Well construction diagrams are presented in Appendix B. Well construction details are summarized in Table 3-1.

Table 3-1. Phase II Monitoring Well Construction Summary
Burn Pits, Fort Stewart

Well No.	Date Installed	Size/ Type	Slot Size (inches)	Coordinates	Total Depth (feet)	Screen Interval Elevation (feet)	Filter Pack Material	Top of Filter Pack Elevation (feet)	Top of Casing Elevation (feet)
Burn Pit A									
MW-5	07-21-97	2-inch PVC	0.008	N686360.3 E814818.7	16.0	61.47 - 51.97	DSI Extra Fine Sand	62.97	70.38
Burn Pit C									
MW-5	07-10-97	2-inch PVC	0.010	N677164.6 E818074.3	16.0	69.16 - 59.56	DSI #2 Sand	70.79	75.45
MW-6	07-10-97	2-inch PVC	0.010	N677009.4 E818206.9	14.5	69.90 - 60.40	DSI #2 Sand	71.30	74.66
MW-7	07-11-97	2-inch PVC	0.010	N676959.2 E817785.4	14.5	67.49 - 57.99	DSI #2 Sand	68.69	74.26
Burn Pit D									
MW-5	07-09-97	2-inch PVC	0.010	N675893.0 E820512.8	13.8	68.24 - 58.54	DSI #2 Sand	68.94	72.34
MW-6	07-09-97	2-inch PVC	0.010	N675942.0 E820314.1	15.2	63.78 - 54.08	DSI #2 Sand	64.78	71.82
Burn Pit E									
MW-5	07-23-97	2-inch PVC	0.008	N709229.1 E847941.1	21.0	65.84 - 55.64	DSI #1 Sand	68.04	76.53
MW-6	07-24-97	2-inch PVC	0.008	N709141.5 E847932.0	21.0	65.54 - 55.34	DSI #1 Sand	67.74	76.24

Note: All elevations in National Geodetic Vertical Datum 1929 datum.
PVC = polyvinyl chloride.

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Each of the eight new wells was installed in the water table aquifer, to depths ranging from 14 to 21 feet. These wells were installed such that the screened interval bisects the water table, so that any free phase liquid floating on the water table surface could be detected in the well.

The wells were developed between July 13 and 30, 1997. Well development was accomplished using a downhole positive displacement pump. A surge block was used to agitate and mobilize particulates around the well screen by rapidly surging the block up and down. Well development continued until the well water was clear to the eye, sediment within the well was less than 0.1 foot, a minimum of five times the standing water volume in the well had been removed, and five times the volume of any water added during completion had been removed. In addition, water quality parameters [pH, conductivity, temperature, dissolved oxygen, oxidation-reduction potential (Eh), and turbidity] were measured during well development to verify that they had reached equilibrium, and development of the new wells continued until turbidity measured less than 10 nephelometric turbidity units (NTUs) if achievable. Well development is summarized in Table 3-2.

Each of the 24 existing wells at these sites was redeveloped using the same methods as for newly installed wells. The purpose of this redevelopment was to remove any accumulated sediment and to provide well water of comparable turbidity to newly installed wells. The redevelopment of existing wells is also summarized in Table 3-2. Problems were encountered attaining a turbidity reading less than 10 NTUs while redeveloping the four existing wells at Burn Pit A; therefore, discussions between Fort Stewart and GEPD were held, and a decision was made to cease redevelopment once turbidity was less than 25 NTUs. At Burn Pit D, turbidity in MW-2 could not be reduced below 54 NTUs after more than 20 hours of development; a decision was made to cease redevelopment. During sampling, turbidity in MW-2 declined to 16 NTUs.

At Burn Pit C, turbidity could not be reduced below 200 NTUs even after more than 10 hours of development. After consultation with GEPD, these four wells were abandoned by filling the wells with grout. Formal closure of these wells was approved by GEPD in telephone conversations with Ms. Melanie Little of Fort Stewart and followed up with a memorandum to Mr. Rabon of GEPD dated July 30, 1997.

Monitoring well MW-2 at Burn Pit E was discovered to have a bent or separated pipe casing, which prevented the surge block from being inserted into the well. Monitoring well MW-2 at Burn Pit E was, therefore, also abandoned by filling the well with grout, and a new well, MW-6, was constructed to replace it. Monitoring well MW-1 at Burn Pit E could not be developed or sampled, due a depth of water in the well of less than 1 foot and an extremely slow recharge rate, which resulted in the well being purged dry. Therefore, MW-1 was also abandoned by filling the well with grout.

3.1.2.2 Monitoring Well Sampling

A total of 26 monitoring wells were sampled. Groundwater sampling was not conducted until at least 14 days after well development, between July 27 and August 13, 1997. Monitoring wells were sampled using low-flow micropurging techniques to minimize the volume of purge water, minimize disturbance of the aquifer, and thereby minimize turbidity in the sample. Prior to installing the sampling pump, the static water level was recorded in each well. Field parameters (pH, conductivity, temperature, dissolved oxygen, Eh, and turbidity) were monitored during micropurging. The purge rate was adjusted, as necessary, to avoid purging any well to dryness and to equal the recharge of the aquifer. Purging was considered complete when the field

Table 3-2. Well Development Summary, Burn Pits, Fort Stewart

Well No.	New or Existing	Date Developed	Total Development Time (hours)	Total Volume Removed (gallons)	Final Turbidity Reading (NTUs)
Burn Pit A					
MW-1	Exst	7/22/97	2.5	244	25.4
MW-2	Exst	7/22/97	2.75	180	2.75
MW-3	Exst	7/22/97	4.25	372	25.8
MW-4	Exst	7/16,7/22//97	7	235	17.18
MW-5	New	7/30/97	2	156	6.52
Burn Pit B					
MW-1	Exst	7/23/97	1.75	60	7.5
MW-2	Exst	7/23/97	1.25	85	3.3
MW-3	Exst	7/23/97	1.25	109	2.1
MW-4	Exst	7/23/97	2.5	190	7.67
Burn Pit C					
MW-1*	Exst	7/11-7/12/97	21.25	825	very turbid*
MW-2*	Exst	7/11-7/12/97	14.5	135	>200*
MW-3*	Exst	7/11-7/12/97	11	65	very turbid*
MW-4*	Exst	7/12/97	3.75	18	opaque*
MW-5	New	7/15-7/16/97	14.75	142	9.74
MW-6	New	7/15/97	2.25	77	4.87
MW-7	New	7/15-7/16/97	11.25	117	5.17
Burn Pit D					
MW-1	Exst	7/9/97	5	184	1.44
MW-2	Exst	7/9-7/11/97	21.5	1,595	54
MW-3	Exst	7/10/97	2	65	3.95
MW-4	Exst	7/10/97	4.25	290	7.2
MW-5	New	7/13/97 7/28/97	6.75 1	555 55	9.25 7
MW-6	New	7/13/97 7/28/97	3 1.5	110 55	5.54 7.25
Burn Pit E					
MW-1*	Exst	7/14/97	0.5	<1	pumped dry*
MW-2*	Exst	7/14/97	PVC casing bent, well abandoned*		
MW-3	Exst	7/19/97	1.75	57	2.19
MW-4	Exst	7/14/97	3.5	16	2.1
MW-5	New	7/27/97	1.25	75	2.04
MW-6	New	7/27/97	1.75	115	1.79
Burn Pit F					
MW-1	Exst	7/14/97	4.75	47	9.96
MW-2	Exst	7/14/97	1	40	1.94
MW-3	Exst	7/28/97	3	25	0.5
MW-4	Exst	7/14/97	2	18	5.75

*Monitoring well could not be developed and was abandoned.
NTUs = nephelometric turbidity units.
PVC = polyvinyl chloride.

parameters stabilized within plus or minus 10 percent after a minimum of three readings at 5-minute intervals. Results of field parameter measurements made at the end of purging in each well are listed in Table 3-3.

Table 3-3. Field Parameter Measurement During Groundwater Sampling Burn Pits, Fort Stewart

Monitoring Well	pH (S.U.)	Conductivity (µmho/cm)	Temperature (°C)	Turbidity (NTUs)	Dissolved Oxygen (mg/L)	Eh (mV)	Total Purge Time (hours)
Burn Pit A							
MW-1	4.73	51	21.69	25.0	2.11	444.1	12
MW-2	4.63	73	22.19	22.4	1.73	417.4	4.5
MW-3	4.5	53	22.04	86.5	0.88	319.0	16
MW-4	4.37	220	24.9	9.59	1.05	430.4	2
MW-5	4.55	114	24.38	8.9	1.36	359.7	2.75
Burn Pit B							
MW-1	4.85	45	22.69	50.9	2.74	442.4	12
MW-2	4.73	20	24.12	24.1	3.12	448.9	12
MW-3	4.77	49	22.8	79.8	1.63	456.2	10
MW-4	5.68	376	28.02	6.2	1.31	81.3	4
Burn Pit C							
MW-1	Monitoring well abandoned						
MW-2	Monitoring well abandoned						
MW-3	Monitoring well abandoned						
MW-4	Monitoring well abandoned						
MW-5	6.97	613	23.30	23.9	0.51	-98.3	6.5
MW-6	4.67	296	24.56	35.8	0.99	78.5	11.75
MW-7	5.01	122	23.89	10.0	0.86	358.0	5
Burn Pit D							
MW-1	4.39	139	24.02	7.59	0.70	113.9	1
MW-2	6.19	199	26.09	16.3	8.73	18.9	3.25
MW-3	4.49	34	25.37	8.9	2.50	397.5	3.5
MW-4	4.59	84	22.90	8.4	8.27	78.4	3
MW-5	4.18	89	24.59	8.6	2.15	434.0	1.5
MW-6	4.30	116	23.85	20.6	2.54	427.3	12
Burn Pit E							
MW-1	Monitoring well abandoned						
MW-2	Monitoring well abandoned						
MW-3	4.84	30	23.06	1.8	2.59	341.6	0.5
MW-4	4.76	32	24.45	5.5	4.03	395.4	1
MW-5	5.03	46	22.87	10.0	2.07	373.2	0.3
MW-6	4.67	29	21.2	9.9	2.24	404.4	1.5
Burn Pit F							
MW-1	4.84	23	26.38	8.5	9.34	419.2	2
MW-2	4.71	35	28.84	1.7	6.23	385.1	0.3
MW-3	4.77	84	25.44	7.1	3.92	344.0	0.3
MW-4	4.91	48	26.43	4.3	4.67	357.1	0.75

NTUs = nephelometric turbidity units.

Purging times varied, requiring from 20 minutes to 16 hours per well. A turbidity less than 10 NTUs was attainable in 10 of the 26 wells that were sampled. During the field work, a field change was approved by GEPD (memorandum to Mr. Rabon from Ms. Little, dated August 8, 1997) which allowed Fort Stewart to cease purging and to collect the groundwater sample if turbidity was less than 25 NTUs after at least 3 hours of purging, or if total purging time had exceeded 10 hours. The maximum turbidity at the time of sampling was 86.5 NTUs at Burn Pit A, MW-3.

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

A filtered groundwater sample was collected from six of the wells (Burn Pit A wells MW-3 and MW-5, Burn Pit B wells MW-1 and MW-3, Burn Pit C well MW-7, and Burn Pit E well MW-6) and sent offsite for laboratory analysis of RCRA metals. Filtered samples were taken for comparison with total metals analysis to determine whether high metals concentrations in groundwater, which had been observed at a number of SWMUs across the FSMR in the Phase I RFI, were due to turbidity (soil particles) in the samples. Filtered samples were taken from three wells in particular (Burn Pit A well MW-3, and Burn Pit B wells MW-1 and MW-3) because these three wells had shown the highest turbidity readings at the end of purging (between 50.9 and 86.5 NTUs). Filtered samples were taken by attaching a 0.45-micron filter to the end of the low-flow pump sampling line.

3.1.3 Investigation-Derived Waste Management

Investigation-derived wastes (IDW) were managed in accordance with the procedures specified in the Phase II RFI Work Plan (SAIC 1997). All IDW were determined to be nonhazardous material. Solid wastes were disposed of by transporting the material to the Fort Stewart Sanitary Landfill for use as daily cover. Liquid wastes were disposed of at the Fort Stewart industrial waste water treatment system.

3.2 DATA QUALITY ASSESSMENT

Multiple activities were performed to achieve the desired data quality in this project. Data quality objectives (DQOs) were established in the Phase II RFI Work Plan to guide the implementation of the field sampling and laboratory analysis. A quality assurance (QA) program was established to standardize procedures and to document activities following the Quality Assurance Project Plan (QAPP) in the Work Plan. Upon receipt by the project team, data were subjected to a verification and validation review that identified and qualified problems related to the analysis. These review steps contributed to a final QCSR, Appendix C, which defines that data used in the investigation met the criteria and are employed appropriately.

The QA program established requirements for both field and laboratory quality control (QC) procedures. In general: field QC duplicates and QA split samples were required for each environmental sample matrix collected at sites being investigated at a frequency of ~10 percent; VOC trip blanks accompanied each cooler containing water samples for VOC determinations; and analytical laboratory QC duplicates, matrix spikes (MSs), laboratory control samples (LCSs), and method blanks were required for every 20 samples or less of each matrix and analyte. The primary goal of the QA program was to ensure that the quality of the results for all environmental measurements were appropriate for their intended use. To this end, a QAPP and standardized field procedures were compiled to guide the investigation and are described in the Work Plan. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA program.

Project data quality determines its usability. The evaluation is based on the interpretation of laboratory QC measures, field QC measures, and the project DQOs. Daily Quality Control Summary Reports (DQCSRs) and other field-generated documents, such as sampling logs, boring logs, daily health and safety summaries, daily safety inspections, equipment calibration and maintenance logs, and sample management logs, were peer reviewed on site. Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project-designated validation staff and were reviewed by the project laboratory coordinator.

A total of 108 environmental soil, groundwater, and field QC samples were collected with approximately 4700 discrete analyses (i.e., analytes), not including field measurements and field descriptions. The project produced acceptable results for over 97 percent of the sample analyses performed and successfully collected all required investigation samples, with the exception of the wells abandoned at Burn Pits C and E.

The overall quality of the Burn Pit SWMUs 4A through 4F information meets or exceeds the established project objectives listed in the Work Plan. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be acceptable for use. This rigorous QA/QC approach demonstrates that the data, as presented, have been qualified as usable but estimated when necessary. Data produced for this study can withstand scientific scrutiny; are appropriate for their intended purpose; are technically defensible; and are of known and acceptable sensitivity, precision, and accuracy. A more detailed data quality assessment (DQA) may be found in Appendix C.

Common Laboratory Contaminants. Common laboratory contaminants were detected in one or more soil samples and include acetone, 2-butanone, 2-hexanone, methylene chloride, and toluene. Results for these common laboratory contaminants are questionable when the results are less than 5 times the quantitation limit for these constituents, or when the result is less than the average concentration detected in the background samples. In such cases, the constituent is not considered a site-related contaminant (SRC), but a likely laboratory artifact. Reference values are listed in Table 3-4.

Table 3-4. Common Laboratory Contaminants (Soil)
Burn Pits, Fort Stewart

Parameter	Quantitation Limit	5 × Quantitation Limits	Average Concentration in Background
Acetone	10	50	60.21
2-Butanone	10	50	5.63
2-Hexanone	10	50	5.63
Methylene Chloride	5	25	6.19
Toluene	5	25	10.64

Note: All units in µg/kg.

Filtered vs. Unfiltered Analyses. RCRA metals analyses were conducted on both filtered and unfiltered groundwater samples from six Burn Pits wells and two wells at the Former 724th Tanker Purging Station (TPS). Results for detected analytes are listed in Table 3-5.

As discussed in Appendix C, the results indicate no significant relative percent difference (RPD) for any of the analytes. Filtered results were somewhat less than the corresponding unfiltered results in most cases, but the differences were not significant relative to the analytical precision. With few exceptions, the results were less than 5 times the quantitation limit for the analyte. At these low concentrations, the absolute differences between analytical results are not considered significant if the difference is less than 3 times the quantitation limit. Therefore, filtered and unfiltered results were comparable, indicating good correlation in results. These results demonstrate that efforts to reduce effects of turbidity in groundwater samples were successful, and that any residual turbidity (maximum 86.5 in MW-3 at Burn Pit A) did not adversely affect the groundwater sampling results.

Table 3-5. Filtered vs. Unfiltered (µg/L) Groundwater Sample Comparison
Burn Pits, Fort Stewart

Area	Station	Sample ID	Parameter	Reporting Limit	Unfiltered Result	Filtered Result
724th TPS	MW-4	264411	Barium	200	99.20 J	96.90 J
724th TPS	MW-5	264511	Barium	200	70.20 J	69.40 J
Burn Pit A	MW-3	4A4311	Barium	200	26.20 J	
Burn Pit A	MW-5	4A4511	Barium	200	66.70 J	62.80 J
Burn Pit B	MW-1	4B4111	Barium	200	21.00 J	
Burn Pit C	MW-7	4C4711	Barium	200	26.60 J	
Burn Pit A	MW-3	4A4311	Cadmium	0.5	0.36 J	
Burn Pit E	MW-6	4E4611	Cadmium	0.5	1.20	
Burn Pit B	MW-1	4B4111	Chromium	10	2.40 J	0.88 J
Burn Pit B	MW-3	4B4311	Chromium	10	3.70 J	0.88 J
Burn Pit E	MW-6	4E4611	Chromium	10	1.70 J	
Burn Pit A	MW-3	4A4311	Lead	1	1.80 J	
Burn Pit A	MW-5	4A4511	Lead	1	0.82 J	
Burn Pit B	MW-1	4B4111	Lead	1	2.00	0.84 J
Burn Pit B	MW-3	4B4311	Lead	1	2.20	1.00 J
724th TPS	MW-4	264411	Mercury	0.05	0.30	
724th TPS	MW-5	264511	Mercury	0.05	0.58	0.052=
Burn Pit A	MW-3	4A4311	Mercury	0.05	0.22	
Burn Pit B	MW-3	4B4311	Mercury	0.05		0.04 J
Burn Pit C	MW-7	4C4711	Mercury	0.05	0.28	
724th TPS	MW-4	264411	Selenium	5	0.51 J	0.79 J
724th TPS	MW-5	264511	Selenium	5	0.78 J	
Burn Pit A	MW-5	4A4511	Selenium	5	0.70 J	1.00 J
724th TPS	MW-4	264411	Silver	0.2	4.10	
Burn Pit A	MW-3	4A4311	Silver	0.2	.028	
Burn Pit B	MW-1	4B4111	Silver	0.2	0.39 J	0.19 J
Burn Pit B	MW-3	4B4311	Silver	0.2	0.14 J	0.11 J
Burn Pit C	MW-7	4C4711	Silver	0.2	0.08 J	

Note: A blank indicates that analyte was not detected.
J indicates estimated value.

An exception is mercury, where results for 4 of the 8 unfiltered samples exceeded 5 times the quantitation limit, but results for the corresponding filtered samples did not exceed the quantitation limit. Another exception is silver in one sample from MW-4 at the Former 724th TPS, where the reported unfiltered result also exceeded 5 times the quantitation limit, but was undetected in the filtered sample. This suggests that mercury and silver may be adhered to soil particles and would be less likely to be transported in the dissolved phase in the groundwater.

4.0 PHYSICAL CHARACTERISTICS OF THE SITE

4.1 DEMOGRAPHICS

The Burn Pits are located around the cantonment, or garrison, area of the FSMR, within Liberty County, Georgia (Figure 2-2). Liberty County occupies 328,768 acres and had a total population of 52,745 in 1990. Forty-one percent of the county population lives in Hinesville, the largest city in Liberty County. The total population of Fort Stewart in 1990 was 13,774, 55 percent of which were employed by the Armed Forces. Forty-one percent of the Fort Stewart population live in group quarters while the remaining population live in households (U.S. Department of Commerce 1990).

4.2 TOPOGRAPHY

The FSMR occupies a low-lying, flat region on the coastal plain of Georgia. Surface elevations range from approximately 20 to 100 feet above mean sea level (amsl) within the FSMR and generally decrease from northwest to southeast across the reservation. The topography is dominated by terraces dissected by surface water drainages. The terraces are remnants of sea level fluctuations. The four terraces present within the FSMR are the Wicomico, Penholoway, Talbot, and Pamlico (Metcalf and Eddy 1996). Burn Pits A, B, C, and D are situated west of the cantonment area in the southern portion of the FSMR and are located on the Wicomico Terrace (marsh deposits). Burn Pit E is situated north-northeast of the cantonment area on the Penholoway Terrace (barrier island deposits). Burn Pit F is located northeast of the cantonment area on the Talbot Terrace (barrier island deposits).

The elevation of most of the sites ranges between 65 and 85 feet amsl; the elevation of Burn Pit F ranges between 33 and 40 feet amsl. Each site is relatively flat, with local relief varying by only 5 to 10 feet.

4.3 SURFACE DRAINAGE

The principal surface water body accepting drainage from the FSMR is the Canoochee River, which joins the Ogeechee River (part of the northwestern boundary of the reservation). The individual Burn Pit sites are located within different subwatersheds (Figure 2-3). Burn Pits A through D are located west of the garrison area within the Taylors Creek watershed; drainage from these sites is collected by Mill Creek and Horse Creek tributaries that discharge into Taylors Creek, which in turn discharges into Canoochee Creek. Canoochee Creek is a tributary of the Canoochee River that drains much of the western portion of the FSMR. Burn Pit E is located near the Canoochee River; drainage from the site is collected in small unnamed streams or swampy areas that discharge directly to the Canoochee River. Burn Pit F is located south of Savannah Road in the Peacock Creek watershed; drainage from the site flows into Goshen Swamp, which discharges southward into Peacock Creek and ultimately into the Jerico River.

4.4 REGIONAL GEOLOGY

The FSMR is located within the coastal plain physiographic province. This province is typified by nine southeastward dipping strata that increase in thickness from 0 feet at the fall line (located approximately 350 miles inland from the Atlantic coast) to approximately 4200 feet at the coast. State geologic records describe a probable petroleum exploration well (the No. 1 Jelks-Rogers) located in the region as encountering crystalline basement rocks at a depth of 4254 feet below land surface. This well provides the most complete record for Cretaceous, Tertiary, and Quaternary sedimentary strata. Figure 4-1 presents a geologic column for the Tertiary and Quaternary section in the Fort Stewart area.

The Cretaceous section is approximately 1970 feet in thickness and dominated by clastics. The Tertiary section is approximately 2170 feet in thickness and dominated by limestone with a 175-foot-thick cap of dark green phosphatic clay. This clay is regionally extensive and is known as the Hawthorn Group. The interval from approximately 110 feet to the surface is Quaternary in age and composed primarily of sand with interbeds of clay or silt. This section is undifferentiated (Metcalf and Eddy 1996).

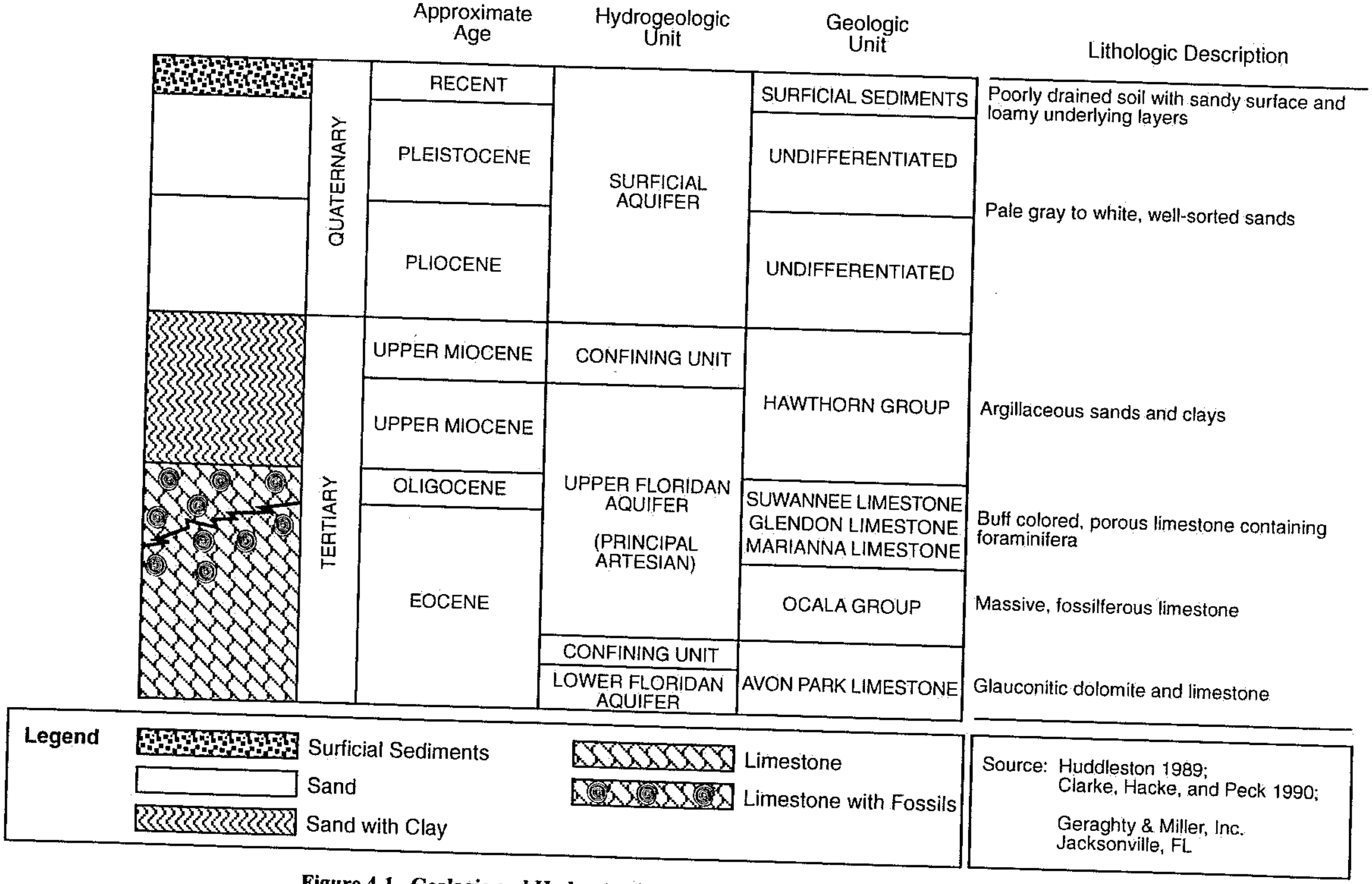
State geologic records contain information regarding a well drilled in October 1942, 1.8 miles north of Flemington at Liberty Field of Camp Stewart (now known as Fort Stewart). This well is believed to be an artesian well located approximately one-quarter mile north of the runway at Wright Army Airfield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

4.5 SOILS

Boring logs showing the types of soils encountered during the Phase II RFI at the Burn Pits in soil borings and monitoring well boreholes are given in Appendix A. Geological cross-sections of the sites are presented in Sections 9.0 through 14.0 for individual Burn Pit sites. In general, the soils are highly variable with abrupt changes in soil types occurring over relatively short distances. The surficial materials are generally a light gray sand or silty sand up to 20 feet thick. Clayey sand and sandy clay layers are interbedded with this sandy material at some boring locations. Wood fragments and charred wood were also encountered in some of the borings. The maximum depth explored in either the Phase I or Phase II RFIs was 21 feet at Burn Pit E.

Geotechnical analyses were conducted on five bulk samples plus six Shelby tube samples taken from the soil borings and monitoring well boreholes. The bulk samples were analyzed for moisture content in accordance with ASTM D2216, grain size distribution (ASTM D422), and Atterberg limits (ASTM D4318). The Shelby tube samples, which included one sample from each of the six Burn Pit sites, were analyzed for the same parameters as bulk samples, plus specific gravity (ASTM D854), porosity (EM1110-2-1906), and permeability (ASTM 5084). Results of the geotechnical analyses are summarized in Table 4-1. The geotechnical laboratory data sheets are included in Appendix D.

These results indicate that the tested soils are generally non-plastic sands with silt. The proportion of fine-grained particles varied over a relatively narrow range in the soils tested, from 2 to 12 percent by weight. The soil from the screened interval in MW-7 at Burn Pit C is a slightly silty sand, and was the only sample tested that showed some low plasticity. The permeability of the soils tested also varied over a relatively narrow range, from 3.11×10^{-4} to 1.73×10^{-3} cm/second, a range that is typical for fine to silty sands.



	Approximate Age	Hydrogeologic Unit	Geologic Unit	Lithologic Description
QUATERNARY	RECENT	SURFICIAL AQUIFER	SURFICIAL SEDIMENTS	Poorly drained soil with sandy surface and loamy underlying layers
	PLEISTOCENE		UNDIFFERENTIATED	Pale gray to white, well-sorted sands
	PLIOCENE		UNDIFFERENTIATED	
TERTIARY	UPPER MIOCENE	CONFINING UNIT	HAWTHORN GROUP	Argillaceous sands and clays
	UPPER MIOCENE	UPPER FLORIDAN AQUIFER (PRINCIPAL ARTESIAN)		
	OLIGOCENE		SUWANNEE LIMESTONE GLENDON LIMESTONE MARIANNA LIMESTONE	Buff colored, porous limestone containing foraminifera
	EOCENE		OCALA GROUP	Massive, fossilferous limestone
		CONFINING UNIT	AVON PARK LIMESTONE	Glauconitic dolomite and limestone
		LOWER FLORIDAN AQUIFER		

Legend

▩	Surficial Sediments
☐	Sand
▨	Sand with Clay
▧	Limestone
◎	Limestone with Fossils

Source: Huddleston 1989;
Clarke, Hacke, and Peck 1990;

Geraghty & Miller, Inc.
Jacksonville, FL

Figure 4-1. Geologic and Hydrostratigraphic Column for the Fort Stewart Area

Table 4-1. Summary of Geotechnical Analyses, Burn Pits, Fort Stewart

				Atterburg Limits			Grain Size Distribution					
Station	Depth (feet)	Sample No.	Moisture Content (percent)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Gravel (percent)	Sand (percent)	Fines (percent)	Specific Gravity	Soil Porosity	Permeability (cm/second)
Burn Pit A												
SB-2	9.5 - 11.5	4A1213*	19	NP	NP	NP	0	94	6	2.662	0.4209	1.73E-03
MW-5	4.5 - 6.5	4A1513	19.9	NP	NP	NP	0	96	4			
Burn Pit B												
SB-3	13 - 15	4B1313*	15.4	NP	NP	NP	0	96	4	2.672	0.3649	7.07E-04
Burn Pit C												
MW-5	7.5 - 10.0	4C1513	13.3	NP	NP	NP	1	87	12			
MW-6	12 - 14	4C1613*	16.4	NP	NP	NP	0	95	5	2.784	0.3956	1.24E-03
MW-7	10 - 12.5	4C1713	16.8	30	15	15	1	87	12			
Burn Pit D												
MW-5	10.7 - 12.5	4D1513*	20.2	NP	NP	NP	0	94	6	2.664	0.3678	9.45E-04
MW-6	12.8 - 13.8	4D1613	16.9	NP	NP	NP	1	91	8			
Burn Pit E												
MW-5	15 - 17	4E1513*	29.9	NP	NP	NP	0	96	4	2.554	0.4641	3.11E-04
MW-6	15 - 17.5	4E1613	31.6	NP	NP	NP	0	98	2			
Burn Pit F												
SB-2	19.5 - 21.5	4F1213*	23	NP	NP	NP	1	90	9	2.663	0.4078	5.81E-04

NOTE: NP = Non-plastic.
A blank indicates the sample was not tested for that parameter.
*Indicates Shelby tube sample.

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4.6 HYDROGEOLOGY

The hydrogeology in the vicinity of the FSMR is dominated by two aquifers, referred to as the Principal Artesian and the surficial, that are separated by a confining unit (Figure 4-1).

The Principal Artesian aquifer is the lowermost hydrologic unit which is regionally extensive from South Carolina through Georgia, Alabama, and most of Florida, and is regionally known as the Floridan Aquifer. This aquifer is subdivided into upper and lower hydrogeologic units. The upper hydrogeologic unit is composed primarily of Miocene-age argillaceous sands and clays and Oligocene- to Eocene-age limestones (including the Ocala Group and the Suwannee Limestone, where present) at the top. The upper hydrogeologic unit ranges in thickness from 200 to 260 feet and is most productive where it is thickest and where secondary permeability is most developed. The lower hydrologic unit is comprised of the Eocene-age Avon Park Limestone at the base. The transmissivity of the aquifer in the Savannah area ranges from about 28,000 to 33,000 square feet/day (Krause and Randolph 1989). Groundwater from this aquifer is primarily used for drinking water (Arora 1984). Thirteen groundwater production wells screened in this aquifer are used for potable water supply on the FSMR, and one additional production well is available for use in fire protection.

The confining layer for the Principal Artesian aquifer is the phosphatic clays of the upper Hawthorn Group. These sediments are regionally extensive and range from 60 to 80 feet in thickness at the FSMR. There are minor occurrences of aquifer material within the Hawthorn Group; however, they have limited utilization (Miller 1990).

The uppermost hydrologic unit is the surficial aquifer, which consists of widely varying amounts of sand, silt, and clay ranging from 55 to 150 feet in thickness. This aquifer is primarily utilized for domestic lawn and agricultural irrigation with wells typically yielding 2 to 180 gallons per minute. The top of the water table ranges from 2 to 10 feet below ground level (Geraghty and Miller 1992) but was found as deep as 13 feet in the current investigation.

Water levels were measured during well development and groundwater sampling in the monitoring wells at each of the six Burn Pits. Depth to water varied from 2 to 3 feet at Burn Pit C, to 12 to 13 feet at Burn Pit E. Water table contour maps, showing directions and rates of groundwater flow, are presented for each of the Burn Pit sites in Sections 9.0 through 14.0. Groundwater flow at each site is generally planar toward the nearest surface stream into which the groundwater discharges. An exception to this is at Burn Pits C and F, where water levels suggest that flow may be radially away from the burn area, prior to joining the direction of the general water table flow in the surrounding area.

4.7 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 bottom land 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.

4.8 METEOROLOGY

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

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5.0 CONTAMINANT NATURE AND EXTENT

This section summarizes the results of the chemical laboratory analyses of the soil and groundwater samples collected at the former Burn Pit sites. An assessment of contaminant concentrations, patterns of distribution at the six sites, and general conclusions as to the nature and extent of site-related contamination is also presented. This section provides an overview of the six sites; Sections 9.0 through 14.0 provide details specific to each of the six sites individually, including maps of contaminant distribution. Complete analytical results for the Phase II chemical data are included in Appendix F of this report. Analytical results for the Phase I chemical data were presented in Appendix U of the Phase I RFI Report (Rust 1994).

5.1 BACKGROUND DATA ANALYSIS AND SCREENING

The reference background criteria for the Burn Pits have been developed based on data from background samples collected from SWMUs across the FSMR. In general, reference background samples were collected in each medium at locations upgradient or upslope of each site so as to be representative of naturally occurring conditions at SWMUs under Phase II investigation. In addition, soil samples collected during the Phase I investigation [i.e., Burn Pits (SMWUs 4A, 4B, 4D, 4E, and 4F), Active Explosive Ordnance Disposal (EOD) Area (SWMU 12A), etc.], were included as reference background samples if they were upgradient of the site and if the data were of sufficient quality to be representative of natural background conditions at the FSMR. A summary of the sample stations, SWMUs, and the source of the data (Phase I or II RFI) is presented in Table 5-1 for each medium.

EPA Region IV methodology (EPA 1996b) was used as guidance for the development of the background data set for screening metals data. In cases where enough samples (e.g., more than 20) are collected to define background, a background upper tolerance level can be calculated. In cases where fewer samples (e.g., less than 20) are collected to define background, background can be calculated as 2 times the mean background concentration (EPA 1996b). Given that fewer than 20 background samples were collected for the FSMR, the latter method was used for calculating reference background concentrations for metals.

Appendix E presents the summary of background data and presents the two-times-mean background concentrations for metals. Given the limited number of reference background samples, the mean concentration of metals for soils in the eastern United States is also presented, for comparative purposes only. The locations of all reference background samples are also shown in Appendix E, on Figures E-1 and E-2.

The detected concentrations of organics in background samples were not used to calculate reference background criteria because all organic compounds are considered to be potentially man-made. Organic compounds were not screened against background. All detected organic compounds are considered SRCs. The following sections discuss the background data analysis for each medium.

5.1.1 Surface Soil

Surface soil samples were taken from the ground surface to a depth of 1 or 2 feet below ground surface (bgs) depending on the amount of recovery from the sampling device. Thirteen surface

Table 5-1. Background Media Summary, Burn Pits, Fort Stewart

SWMU Number	SWMU Name on Hazardous Waste Permit HW-045	Station				
		Surface Soil	**Subsurface Soil**	**Groundwater**	**Surface Water**	**Sediment**
1	South Central Landfill	SC-M17[a]	SC-M17[a]	SC-M10[a]	NA	NA
2	Camp Oliver Landfill	**MW5**[c]	**MW5**[c]	**MW5**[c]	NA	NA
3	TAC-X Landfill	**MW5**[c]	**MW5**[c]	**MW5**[c]	NA	NA
4A	Burn Pit A		**MW1**[b] (Phase I)	**MW1**[d]	NA	NA
4B	Burn Pit B		**MW3**[b] (Phase I)	**MW3**[d]	NA	NA
4C	Burn Pit C	**MW7**[d]	**MW7**[d]	**MW7**[d]	NA	NA
4D	Burn Pit D		**MW2**[b] (Phase I)	**MW2**[d]	NA	NA
4E	Burn Pit E		**MW3**[b] (Phase I)	**MW3**[d]	NA	NA
4F	Burn Pit F		**MW1**[b] (Phase I)	**MW1**[d]	NA	NA
12A	Active EOD containing Open Detonation Unit and Open Burn Pit	**MW1**[e]	**MW1**[e] (Phase I)	**MW1**[c]	NA	NA
14	Old Fire Training Area			MW8[c]	NA	NA
17	DRMO Hazardous Waste Storage Area	**MW1**[c]	**MW1**[c]	**MW1**[c]	NA	NA
18	Industrial Wastewater Treatment Plant	**MW1**[c]	**MW1**[c]	**MW1**[c]	NA	NA
26	Former 724th Tanker Purging Station	**MW1**[c]	**MW1**[c]	**MW1**[c]	SWS-1	SWS-1
29	Evans Army Heliport POL Storage Facility	**MW5**[c]	**MW5**[c]	**MW5**[c]	NA	NA
31	DEH Asphalt Tanks	**MW1**[c]	**MW1**[c]	**MW1**[c]	NA	NA
32	Supply Diesel Tank	**MW1**[c]	**MW1**[c]	**MW1**[c]	NA	NA
34	DEH Equipment Wash Rack	**MW1**[c]	**MW1**[f]	**MW1**[c]	NA	NA
35	Wright Army Airfield Bulk Fuel System	HA-05[f] (Phase I)	HA-05[f] (Phase I)	MW9[f] (Phase I)	NA	NA

DEH = Directorate of Engineering and Housing.
DRMO = Defense Reutilization and Marketing Office.
EOD = Explosive Ordnance Disposal.
NA = Not applicable; surface water and sediment background are site specific.
POL = Petroleum Oil and Lubricant.
Bold indicates background groundwater sample collected from the same borehole as sample for soil (i.e., monitoring well was constructed in the borehole).

[a] Science Applications International Corporation (SAIC), September 1998. *Phase II RCRA Facility Investigation Report for the South Central Landfill (SWMU 1), Fort Stewart, Georgia* (Final Report), U.S. Army Corps of Engineers, Savannah District, Contract No. DACA21-95-D-0022, Delivery Order 0012.

[b] Rust Environment and Infrastructure, May 1996. *Phase I RCRA Facility Investigation Report for 24 Solid Waste Management Units at Fort Stewart, Georgia, Volume I of III* (Corrected Final Report), U.S. Army Corps of Engineers, Savannah District, Contract No. DACA21-93-D-0029, Delivery Order 0005.

[c] Science Applications International Corporation (SAIC), September 1998. *Phase II RCRA Facility Investigation Report for 16 Solid Waste Management Units at Fort Stewart, Georgia, Volume 1* (Draft Report), U.S. Army Corps of Engineers, Savannah District, Contract No. DACA21-95-D-0022, Delivery Order 0009.

[d] Science Applications International Corporation (SAIC), March 1998. *Phase II RCRA Facility Investigation Report for the Burn Pits (SWMUs 4A – 4F) at Fort Stewart, Georgia* (Final Report), U.S. Army Corps of Engineers, Savannah District, Contract No. DACA21-95-D-0022, Delivery Order 0008.

[e] Radian International, LLC, January 1997. *Site Characterization Report, Open Burn/Open Detonation Units, Fort Stewart, Georgia* (Draft Report), U.S. Army Corps of Engineers, Mobile District.

[f] Metcalf & Eddy, Inc., December 1996. *Final Phase I RFI Report for Bulk Fuel Storage System at Wright Army Airfield, Fort Stewart, Georgia*, U.S. Army Corps of Engineers, Contract No. DACA21-93-D-0049, Delivery Order 0018.

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soil samples were used in the development of the surface soil background data set (Table 5-1). The reference background concentration for metals in surface soils was calculated as 2 times the average concentration of these 13 locations. Phase I data from SWMU 12A and SWMU 35 were determined to be of sufficient quality to include in the background data set. If a chemical was not detected at a site, then one-half the detection limit was used as the concentration in calculating the mean background concentration. The sample results included in the data set are presented in Table E-2, Appendix E. Metals are considered SRCs if their concentrations exceed the calculated reference background concentration. Organics were not screened against background; all organic compounds are considered SRCs if they were detected.

5.1.2 Subsurface Soil

Subsurface soil samples were taken from the interval between a depth of 2 feet bgs and the water table. Eighteen subsurface soil samples were used in the development of the subsurface soil background data set (Table 5-1). Phase I data from SWMUs 4A, 4B, 4D, 4E, 4F, 12A, and 35 were determined to be of sufficient quality to include in the subsurface soil background set. The reference background concentration for metals in subsurface soil was calculated as 2 times the mean of the chemical detected at the 19 locations. If a chemical was not detected in a sample, then one-half the detection limit was used in calculating the mean background concentration. The sample results included in the background data set are presented in Table E-3, Appendix E. Metals are considered SRCs if their concentrations exceed the calculated reference background concentration. Organics were not screened against background; all organic compounds are considered SRCs if they were detected.

5.1.3 Groundwater

Only groundwater samples collected using low-flow techniques (Phase II RFI) were used in the development of the groundwater background data set. Groundwater samples from 19 SWMUs were used (Table 5-1). The reference background concentration groundwater was calculated as two times the average of these 19 samples. If a chemical was not detected at a site, then one-half the detection limit was used in calculating the mean background concentration. The sample results included in the background data set are presented in Table E-4, Appendix E. Metals in groundwater are considered SRCs if their concentrations exceed the calculated reference background concentration. Organics were not screened against background; all organic compounds are considered SRCs if they were detected.

5.2 SURFACE SOIL CONTAMINATION

The nature and extent of surface soil contamination (0 to 1 foot bgs) was evaluated using the results from surface soil samples taken from three soil borings at each of the six Burn Pit sites and a total of eight monitoring well boreholes drilled during the Phase II investigation. This assessment presents Phase II contaminant data only, because no surface soil samples were collected during Phase I. The surface soil samples were analyzed for SVOCs and RCRA metals. Table 5-2 summarizes the analytical results for surface soil samples. Detailed discussions of the contaminants and their distribution in surface soils at each Burn Pit site are presented in Sections 9.0 through 14.0.

Table 5-2. Summary of Analytical Results for Surface Soil Samples
Burn Pits, Fort Stewart

Parameter	Reference Background	Maximum Detected Concentrations in Surface Soils					
		Burn Pit A	Burn Pit B	Burn Pit C	Burn Pit D	Burn Pit E	Burn Pit F
Semivolatile Organic Compounds (µg/kg)							
Benzo(a) pyrene	0.0					**21**	
Benzo(b)fluoranthene	0.0					**54.8**	
Fluoranthene	0.0					**63**	
RCRA Metals (mg/kg)							
Arsenic	2.10	**2.5**			0.34	0.17	**2.7**
Barium	14.7	**18.8**	14.4	**20.2**	12.6	**18.3**	13.6
Cadmium	0.18	**0.36**		**0.35**			
Chromium	6.21	3.7	1.5	3.7	2.1	2.3	**13.5**
Lead	8.81	**10.4**	**10.5**	**33.2**	7.7	8.5	7.3
Mercury	0.03	**0.04**	**0.04**	**0.06**	0.03	**0.04**	**0.04**
Selenium	0.41					0.39	
Silver	0.15						

Note: A blank indicates analyte not detected at that Burn Pit site.
Note: **BOLD** font indicates value exceeds reference background criteria for Resource Conservation and Recovery Act (RCRA) metals.

SVOCs. SVOCs were detected in surface soils at Burn Pit E, but not at any of the other five Burn Pit sites. Benzo(a)pyrene (21 µg/kg), benzo(b)flouranthene (54.8 µg/kg), and flouranthene (63 µg/kg), were detected at Burn Pit E in a single surface soil sample from MW-6 at the southeastern edge of the former burn area. SVOCs were not detected in any of the other surface soil samples at Burn Pit E.

RCRA metals. Arsenic, barium, cadmium, chromium, lead, and mercury were reported at concentrations above their reference background concentrations in surface soils at one or more Burn Pit sites. Selenium and silver were not detected above background at any of the six Burn Pit sites and are, therefore, not COPCs in surface soils.

It should be pointed out that the metal detections in surface soils are not overly high for natural soil conditions. With the exception of lead in surface soils at Burn Pit C, most detections are within reasonable ranges for inorganics in soils in the eastern United States. Published reference values (USGS 1984), as listed in Appendix E, are average concentrations of metals in regional soils. Lead (33.2 mg/kg) at Burn Pit C exceeds the USGS reference value (17 mg/kg) for lead in soils in the eastern United States.

- At Burn Pit A, arsenic (2.5 mg/kg), barium (18.8 mg/kg), cadmium (0.36 mg/kg), lead (10.4 mg/kg), and mercury (0.04 mg/kg) were detected above background in surface soils in the northern and eastern portions of the site.

- At Burn Pit B, lead (maximum 10.5 mg/kg) and mercury (0.04 mg/kg) were detected in one of the three surface soil samples taken from the site (SB3). Both lead and mercury were detected at concentrations only slightly greater than their respective reference background value.

- At Burn Pit C, four metals were reported above reference background, predominantly at two boring locations in the middle of the source area. These metals include barium (20.2 mg/kg), cadmium (0.35 mg/kg), lead (33.2 mg/kg), and mercury (0.06 mg/kg). Only mercury was found above background in two other borings at the site.

- At Burn Pit D, no constituent was detected above background. Therefore, no site-related constituents above the referenced background were located at Burn Pit D.

- At Burn Pit E, barium was detected in four of the five surface soil samples at a maximum of 18.3 mg/kg. Mercury was detected in a single sample at a concentration (0.04 mg/kg) that is only slightly greater than background and is not likely to be site related.

- At Burn Pit F, maximum concentrations of arsenic (2.7 mg/kg) and chromium (13.5 mg/kg) were reported above background at boring SB-1 in the northeastern portion of the source area. Chromium also exceeded reference background concentrations at the other two boring locations (SB-2 and SB-3). Mercury was detected in a single sample at a concentration (0.04 mg/kg) that is only slightly greater than background and is not likely to be site related.

5.3 SUBSURFACE SOIL CONTAMINATION

The nature and extent of subsurface soil contamination was evaluated using the results of VOC and RCRA metals analyses on soil samples taken from both soil borings and monitoring well boreholes. Subsurface soil samples were taken during both Phase I and Phase II investigations, including 4 samples at each of the 6 sites from the Phase I well boreholes, 3 samples at each of the 6 sites from the Phase II soil borings, and 8 samples from the Phase II well boreholes, for a total of 50 subsurface soil samples. Table 5-3 summarizes the analytical results for subsurface soil samples. Detailed discussions of the contaminants and their distribution in subsurface soils at each Burn Pit site are presented in Sections 9.0 through 14.0.

VOCs. BTEX compounds are target analytes because gasoline may have been used to ignite the debris at the Burn Pits. BTEX compounds were detected in both Phase I and Phase II subsurface soil samples from all six of the Burn Pit sites, but at relatively low concentrations. Maximum values were reported for benzene (30 µg/kg at Burn Pit B), toluene (69.6 µg/kg at Burn Pit C), and total xylenes (22 µg/kg at Burn Pit D). Ethylbenzene was not detected at any of the six sites. BTEX contamination in subsurface soils shows a consistent pattern of distribution only at Burn Pits B and C, although at relatively low concentrations.

- At Burn Pit A, BTEX compounds were identified in 4 of the 8 subsurface soil samples and from both Phase I and Phase II borings, but at low concentrations (28 µg/kg benzene, 12 µg/kg toluene, and 8.5 µg/kg total xylenes) that showed no consistent pattern of distribution.

- At Burn Pit B, BTEX compounds were detected in 5 of the 7 samples. The BTEX contamination, although present at relatively low concentrations (30 µg/kg benzene, 60.8 µg/kg toluene, and 9.9 µg/kg total xylenes), extends over most of the 1-acre Burn Pit B site.

- At Burn Pit C, BTEX compounds were found in 3 of the 10 samples (69.9 µg/kg toluene and 14 µg/kg total xylenes) at locations in the northern to northwestern portion of the Burn Pit C site.

Table 5-3. Summary of Analytical Results for Subsurface Soil Samples
Burn Pits, Fort Stewart

Parameter	Reference Background	Maximum Detected Concentration in Subsurface Soils					
		Burn Pit A	Burn Pit B	Burn Pit C	Burn Pit D	Burn Pit E	Burn Pit F
Volatile Organic Compounds (µg/kg)							
Acetone	0.0	**63**	**110**	**39.4**	**110**		
Benzene	0.0	**28**	**30**		**12**	**7.9**	
2-Butanone	0.0	**2.4**	**33.1**	**17.1**			
2-Hexanone	0.0				**1.4**		
Methylene Chloride	0.0		**5**	**4.3**			**7.4**
Tetrachloroethene	0.0	**8.8**	**8.9**	**48**	**9.7**		
Toluene	0.0	**12**	**60.8**	**69.9**	**21**	**8.8**	**5.5**
1,1,1 Trichloroethane	0.0			**10**			
Xylenes, Total	0.0	**8.5**	**9.9**	**14**	**22**		
RCRA Metals (mg/kg)							
Arsenic	8.04	0.5	1.4	0.39	3.1	0.2	3.3
Barium	17.0	6.5	11.6	13.9	15.6	**27**	**125**
Cadmium	0.24			0.12	**0.54**		
Chromium	11.6	9	**13**	9.6	11.1	**12**	**65.8**
Lead	11.1	**12**	8.5	**21.9**	11	5.9	**26.9**
Mercury	0.05	0.04	**0.06**	**0.07**	**0.063**	**0.08**	**0.051**
Selenium	1.12						
Silver	0.46					0.19	**2.6**
Total Organic Carbon	2200	**3210**	546	**9770**	**2400**	824	279

NOTE: A blank indicates analyte not detected at that Burn Pit site.
NOTE: **BOLD** font indicates value exceeds reference background criteria for Resource Conservation and Recovery Act (RCRA) metals.

- At Burn Pit D, BTEX compounds were reported in 3 of the 4 Phase I boreholes around the perimeter of the site, but were not detected in any of the 5 Phase II samples, including the 3 soil borings in the middle of the source area. Therefore, BTEX contamination is not considered to be present at Burn Pit D.

- At Burn Pit E, toluene was detected in 4 of the 5 Phase II samples, but at concentrations lower than the average detection limit for toluene and may, therefore, not be indicative of site-related contamination. Benzene, the only BTEX compound found in any of the Phase I subsurface soil samples at Burn Pit E, was not found in any Phase II sample. Therefore, BTEX contamination is not considered to be present at Burn Pit E.

- At Burn Pit F, toluene was detected in 2 of the 7 subsurface soil samples, but at concentrations lower than the average detection limit for toluene. As discussed in Section 5.4, BTEX contamination was found in groundwater at Burn Pit F, even though it was not found at significant concentrations in subsurface soils.

Two chlorinated organic compounds (PCE and 1,1,1-trichloroethane) were reported in subsurface soil at four of the Burn Pit sites. PCE was detected at Burn Pits A, B, and D at concentrations less than 10 µg/kg in Phase I samples only. At Burn Pit C, both PCE (maximum 48 µg/kg) and 1,1,1-trichloroethane (maximum 10 µg/kg) were detected in Phase I subsurface soil samples. However, neither compound was detected in any Phase II sample at any of the Burn Pit sites, including any sample taken from borings in the middle of the burn areas. In addition, as discussed below, neither compound was detected above levels of concern in groundwater at any of the six sites. Therefore, PCE and 1,1,1-trichloroethane are not considered related to releases which may have occurred from activities conducted at the Burn Pit sites.

Acetone, 2-butanone, 2-hexanone, and methylene chloride were detected in subsurface soil samples from most of the six Burn Pit sites. However, these constituents were found sporadically and at concentrations near those found in reference background samples and are not considered related to contaminant releases at the Burn Pit sites. These constituents are common laboratory contaminants.

RCRA metals. Metals are present in subsurface soils at each of the Burn Pit sites at concentrations exceeding their respective reference background concentrations. However, at most of the Burn Pit sites, the metal contamination does not appear to be site related. The maximum concentrations at most sites are generally less than twice background, and the metal contamination is not present in a consistent distribution in subsurface soils across the various sites. The most significant metal contamination was found at Burn Pits C and F, predominantly barium, lead, and chromium.

It should be pointed out that barium detections in subsurface soils are not overly high for natural soil conditions. Barium (maximum 125 mg/kg) in subsurface soils is within the reasonable range for barium (420 mg/kg) in soils in the eastern United States (USGS 1984), as listed in Appendix E. Lead in subsurface soils at Burn Pit C (maximum 21.9 mg/kg) and at Burn Pit F (maximum 26.9 mg/kg) exceeds the U.S. Geological Service (USGS) reference value (17 mg/kg) for lead in soils in the eastern United States. Similarly, chromium (65.8 mg/kg) in subsurface soils at Burn Pit F exceeds the USGS reference value (52 mg/kg).

- At Burn Pit A, lead (12 mg/kg) was reported in a single sample at a concentration only slightly above background. Lead is not present in a consistent pattern and is not considered site related.

- At Burn Pit B, chromium (13 mg/kg) was reported in one sample and mercury (0.06 mg/kg) in another sample at concentrations only slightly above background. These metals are not present in a consistent pattern and are not considered site related.

- At Burn Pit C, lead and mercury were found at concentrations above background in the soil borings made in the middle of the site and extend to the northeast. Maximum values of lead (21.9 mg/kg) and mercury (0.07 mg/kg) were found at Burn Pit C. Lead and mercury were also found at concentrations above background in surface soils at Burn Pit C.

- At Burn Pit D, although two metals were reported at concentrations above their reference background value, their distribution is not present in a consistent pattern. Maximum values of cadmium (0.54 mg/kg) and mercury (0.063) were reported at three different sample locations around the perimeter of the site only and, therefore, are not considered site related.

- At Burn Pit E, barium was detected at concentrations above background in one of the 9 subsurface soil samples; the maximum value of barium (27 mg/kg) was reported at MW-1, which is located more than 300 feet downgradient from the source area. Chromium and mercury, which were detected at concentrations only slightly above background, do not show a consistent pattern of distribution and are not considered site related.

- At Burn Pit F, five metals were reported in subsurface soils at concentrations above their reference background value. Barium was detected at concentrations above background in 3 of the 7 subsurface soil samples, with a maximum value (125 mg/kg) at SB-3 in the western portion of the source area. Chromium was also found in 3 of the 7 samples, with a maximum concentration of 65.8 mg/kg, at SB-3. Chromium was also found at concentrations above background in surface soils at Burn Pit F. Other metals detected above background in subsurface soils at Burn Pit F, but with less consistency, include lead, mercury, and silver.

5.4 GROUNDWATER CONTAMINATION

A total of 26 groundwater samples were collected from both existing Phase I and new Phase II monitoring wells. The samples were analyzed for VOCs and RCRA metals. Both filtered and unfiltered water samples were collected; only the total metal analysis on unfiltered water samples is presented in this section. Table 5-4 summarizes the analytical results for groundwater samples. This assessment presents Phase II contaminant data only, because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 5-4. Summary of Analytical Results for Groundwater Samples
Burn Pits, Fort Stewart

		Maximum Detected Concentrations in Groundwater						
Parameter	**Reference Background**	**Federal MCL**	**Burn Pit A**	**Burn Pit B**	**Burn Pit C**	**Burn Pit D**	**Burn Pit E**	**Burn Pit F**
Volatile Organic Compounds (µg/L)								
Acetone	0.0	--					**53.4**	
Ethylbenzene	0.0	700					**1.1**	**637**
Styrene	0.0	100						**33.5**
Tetrachloroethene	0.0	5					**1.0**	
Xylenes, Total	0.0	10000					**6.3**	**3170**
RCRA Metals (µg/L)								
Arsenic	3.02	50	1.5		2.5	4.2		
Barium	71.72	2000	**97.5**	**73.4**	**134**	**99.6**	17.7	49.1
Cadmium	0.43	5	0.36	**1.2**	**3**	0.43	**4.3**	**1.1**
Chromium	3.56	100	2.4	**5.9**		2.9	1.7	2.8
Lead	4.69	15	3.3	2.2	1.1	1.2		0.08
Mercury	0.14	2	**0.22**		**0.28**			
Selenium	1.90	50	0.7	**3.5**	1.6	1.6	0.43	
Silver	1.12	--	**1.6**	**4.9**	0.77	**3.6**	0.16	0.1

NOTE: A blank indicates analyte not detected in that medium.
NOTE: **BOLD** font indicates value exceeds reference background criteria for Resource Conservation and Recovery Act (RCRA) metals.
MCL = Maximum Contaminant Level.

VOCs. No VOC contamination was found in groundwater at Burn Pits A, B, C, or D. BTEX compounds were detected at both Burn Pits E and F, PCE and acetone were detected at Burn Pit E, and styrene was detected at Burn Pit F.

- At Burn Pit E, low concentrations of BTEX compounds were found in a single well (MW-4). Ethylbenzene (1.1 µg/L) and xylenes (6.3 µg/L) were reported at concentrations only slightly above their detection limits. PCE was detected at 1.0 µg/L, which is less than its average detection limit in background samples. Acetone was detected in 2 wells at a maximum of 53.4 µg/L. No VOCs were reported in Phase I groundwater.

- At Burn Pit F, two BTEX compounds (ethylbenzene at 637 µg/L and xylenes at 3170 µg/L) were found in groundwater at MW-4. These concentrations are less than the respective MCLs for ethylbenzene (700 µg/L) and xylenes (10,000 µg/L). In the Phase I sample

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results, both ethylbenzene (2,800 µg/L) and xylenes (15,800 µg/L) were reported at much higher concentrations, and both benzene (22,700 µg/L) and toluene (41,100 µg/L) were reported above their MCLs. These results suggest that the high concentrations of BTEX present in groundwater at the site may be attenuating naturally, either through dispersion, volatilization, or biodegradation. Styrene was also observed in MW-4 at 33.5 µg/L, and is considered a secondary contaminant in the primary BTEX plume.

The source and extent of the BTEX contamination is unknown. MW-4 is located hydraulically higher than other wells at the Burn Pit F site and is considered side-gradient to groundwater flow at the site. BTEX compounds were not detected at significant concentrations in the soil borings within the probable source area and were not detected in the remaining (downgradient) wells.

RCRA metals. Metals are present in groundwater at each of the Burn Pit sites at concentrations exceeding their respective reference background concentrations. However, none of the metal concentrations exceed their respective MCLs at any of the Burn Pit sites. In addition, metals in groundwater were found at significantly lower concentrations than reported in the Phase I RFI Report, suggesting that redevelopment of the wells and use of low-flow sampling equipment to reduce turbidity were successful.

Barium and cadmium are notable in that they exceeded background at more than half the sites. The broad presence of barium and cadmium may indicate that they are of natural origin, rather than site-related contamination. Given the limited background data, the reference background concentrations of these metals may not be representative of the range of naturally occurring background conditions.

- At Burn Pit A, barium was reported in a single downgradient well at a maximum concentration of 97.5 µg/L. Mercury (0.22 µg/L) and silver (1.6 µg/L) were detected in separate wells at concentrations only slightly above background and, therefore, do not indicate a pattern of distribution indicating a potential release of these metals from the former burn pit.

- At Burn Pit B, five metals were reported at concentrations above background in groundwater. Barium (73.4 µg/L), cadmium (1.2 µg/L), chromium (5.9 µg/L), selenium (3.5 µg/L), and silver (4.9 µg/L) were detected at concentrations only slightly exceeding background and in separate wells. These metals do not indicate a pattern of distribution indicating a potential release from the former burn pit.

- At Burn Pit C, three metals were reported at concentrations above background in groundwater. Barium (134 µg/L) and cadmium (3 µg/L) were detected in one well. Mercury was detected in a second, MW-7, but at a concentration (0.28 µg/L), that is only slightly above background. Well MW-7 is considered upgradient of the site; however, as discussed in Section 11.0, water table contours suggest that the water table may potentially be mounded beneath the Burn Pit C site.

- At Burn Pit D, three metals were reported at concentrations above background in different wells. Arsenic (4.2 µg/L) was reported in one well, and barium (99.6 µg/L) and silver (3.6 µg/L) were reported in another well. Because these metals were detected in separate wells at concentrations only slightly above background and do not indicate a pattern of distribution indicating a potential release of these metals from the former burn pit, they are not considered site related.

- At Burn Pit E, cadmium was the only RCRA metal detected above background in groundwater. Cadmium was found in two of the three downgradient wells at a maximum of 4.3 µg/L.

- At Burn Pit F, cadmium was again the only RCRA metal detected above its reference background concentration in groundwater. Cadmium was detected at a maximum of 1.1 µg/L at well MW-1. Well MW-1 is considered upgradient of the site; however, as discussed in Section 11.0, water table contours suggest that the water table may potentially be mounded beneath the Burn Pit F site.

5.5 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

The following summarizes the major findings of the Phase II sampling and analysis:

- SVOCs were found only in a single surface soil sample at low concentrations at Burn Pit E.

- Metals found above background in surface soils include arsenic, barium, cadmium, lead, and mercury in the northern and eastern portions of Burn Pit A; lead and mercury at Burn Pit B; barium, cadmium, lead, and mercury in the center of Burn Pit C; barium and mercury at Burn Pit E; and arsenic, chromium, and mercury in the northern and northeastern portion of Burn Pit F. With the exception of lead at Burn Pit C, these metals are well within the regional background range for metals in soils and may be indicative of natural soil conditions.

- BTEX compounds were found in subsurface soils at low concentrations at all six Burn Pit sites. A consistent pattern of distribution is evident only at Burn Pit B (whole site) and Burn Pit C (northern and northwestern portion of the site), although at low concentrations.

- Metals in subsurface soils were generally found at concentrations less than twice background and in no consistent pattern of distribution. Notable presence of metals in subsurface soils is characterized by lead and mercury in the central and northeastern portion of Burn Pit C and five metals (predominantly barium, lead, and chromium) throughout the Burn Pit F site.

- In groundwater, the highest levels of BTEX contamination were found in a single well located west (side-gradient) of the Burn Pit F site. Concentrations of BTEX were less than their respective MCLs and less than reported Phase I concentrations, suggesting that natural attenuation may be occurring. The source of the BTEX contamination is unknown; BTEX was not found at high concentrations in soils at Burn Pit F.

- Metals in groundwater were found at all six sites at concentrations less than their respective MCLs and much less than reported Phase I concentrations, suggesting that redevelopment of the wells and use of low-flow sampling equipment to reduce turbidity were successful.

- Metals found in groundwater are characterized by barium, mercury, and silver at Burn Pit A; barium, cadmium, chromium, selenium, and silver at Burn Pit B; barium, cadmium, and mercury at Burn Pit C; arsenic, barium, and silver at Burn Pit D; and cadmium at Burn Pits E and F.

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A summary of the SRCs by medium is presented in Table 5-5. SRCs include all organics that are detected and inorganics detected above reference background criteria. These SRCs are carried through for evaluation under fate and transport, human health preliminary risk evaluation (PRE), and ecological PRE.

Table 5-5. Summary of Site-Related Constituents, Burn Pits, Fort Stewart

	Burn Pit A			Burn Pit B			Burn Pit C			Burn Pit D			Burn Pit E			Burn Pit F		
	SS	SB	GW	SS	SB	GW	SS	SB	GW	SS	SB	GW	SS	SB	GW	SS	SB	GW
Acetone		X			X			X			X				X			
Benzene		X			X						X			X				
2-Bunatone		X			X			X										
Ethylbenzene															X			X
2-Hexanone											X							
Methylene chloride					X			X									X	
Styrene																		X
Tetrachloroethene		X			X			X			X				X			
Toluene		X			X			X			X			X			X	
1,1,1-Trichloroethane								X										
Xylenes, total		X			X			X			X				X			X
Benzo(a)pyrene													X					
Benzo(a) flouranthene													X					
Flouranthene													X					
Arsenic	X											X				X		
Barium	X		X			X	X		X			X	X	X			X	
Cadmium	X					X	X		X		X				X			X
Chromium					X	X								X		X	X	
Lead	X	X		X			X	X									X	
Mercury	X		X	X	X		X	X	X		X		X	X		X	X	
Selenium						X												
Silver			X			X						X					X	

X = Site-related constituent (SRC)
SS = Surface soil
SB = Subsurface soil
GW = Groundwater

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6.0 CONTAMINANT FATE AND TRANSPORT

6.1 INTRODUCTION

This section describes the potential migration pathways and mechanisms for transport of chemical substances found in surface and subsurface soils and groundwater at the Burn Pits (SWMUs 4A-4F). Based on the information presented in previous sections, the refined site conceptual model is developed in this section. Simple analytical methods were used to define contaminant movement from source areas to receptor locations. The overall objectives of these analyses are to evaluate potential future impact to human health and the environment.

Section 6.2 discusses the persistence, mobility, and other physical and chemical properties of the organics and metals found at the Burn Pits. Section 6.3 presents a conceptual model for potential contaminant migration pathways and describes contaminant release mechanisms through primary transport media (groundwater). Section 6.4 discusses the fate and transport of the contaminants at the Burn Pits with respect to their leachability and natural attenuation in the groundwater. Section 6.5 summarizes the conclusions drawn from the results of the analyses and discusses the uncertainties associated with the analyses.

6.2 PHYSICAL AND CHEMICAL PROPERTIES

The fate and transport of organic compounds and metals are functions of both site characteristics and the physical/chemical properties of the contaminants. Such properties include solubility in water, tendency to transform or degrade (usually described by a half-life or an environmental half-life in a given media), and chemical affinity for solids or organic matter (usually described by a partitioning coefficient K_d, K_{oc}, or K_{ow}). These properties and how they affect inorganic and organic contaminant behavior are described below.

6.2.1 Metals

Inorganic SRCs for soils at the Burn Pits site include arsenic, barium, cadmium, chromium, lead, mercury, and silver. These metals are subject to movement with soil moisture, and may be transported through the vadose zone to groundwater. Metals do not degrade, although some metals can transform to other oxidation states in soil, reducing their mobility and toxicity. Metals also react with soils or other solid surfaces by ion exchange, adsorption, precipitation, or complexation. Such reactions are affected by pH, oxidation-reduction conditions, and the type and amount of organic matter, clay, and hydrous oxides present. In general, these reactions are reversible and cause an element's mobility to be retarded. The retardation factor (R_d) describes, numerically, the extent to which the velocity of the contaminant, relative to water, is slowed. The R_d is largely derived from the partitioning coefficient (K_d), expressed by the following relation:

$$R_d = 1 + K_d . \rho_b / \theta \ ,$$

where: ρ_b = the soil bulk density (g/cm^3),
θ = soil moisture content.

K_d for the metals at the Burn Pits may vary by large ranges. It has been found that K_d can even vary by orders of magnitude between samples from the same site. The range of measured K_d

values [obtained from EPA (1996)] and the corresponding range of calculated R_d for the SRCs are presented in Table 6-1.

Table 6-1. Distribution Coefficients (K_d) and Retardation Factors (R_d)
Burn Pits, Fort Stewart

Site-related Analytes	K_d Range[a] (mL/kg)	R_d Range[b]
Arsenic	25 to 31	60 to 75
Barium	11 to 52	27 to 126
Cadmium	15 to 4300	37 to 10,320
Chromium	14 to 31	35 to 75
Lead	19 to 1405	25 to 3370
Mercury	0.04 to 200	1.1 to 480
Selenium	2.2 to 18	6.3 to 44
Silver	0.1 to 110	1.2 to 265

[a] The K_d-ranges represent the pH-dependent values for metals developed for soil screening level application (EPA 1996).
[b] The R_d-ranges represent calculated values using the K_d-range and site-specific parameters.

6.2.2 Organic Compounds

The organic compounds detected in soils at the Burn Pits are primarily VOCs, with the exception in Burn Pit E, where three SVOCs were detected in a single Phase II surface soil sample. These compounds may be degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, or biodegradation. Half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and environmental conditions. Degradation may either enhance or reduce the toxicity of contaminants if daughter products have different toxicological effects than the parents of a chemical. The biodegradation rates for relevant organic compounds are presented in Table 6-2. These values are based on the biodegradation half-lives taken from the *Handbook of Environmental Degradation Rates* (Howard et al. 1991). Although a range of values is presented in this book, only the lowest biodegradation rates corresponding to the highest half-lives are presented here to ensure conservatism in discussing contaminant loss through degradation/decay.

The mobility of an organic compound is affected by its volatility and its partitioning behavior between solids and water, water solubility, and concentration. The Henry's Law constant value (K_H) for a compound is a measure of the ratio of the compound's vapor pressure to its aqueous solubility. The K_H value can be used to make general predictions about the compound's tendency to volatilize from water. Substances with K_H values less than 10^{-7} atm/m^3/mol will generally volatilize slowly, while compounds with K_H greater than 10^{-3} atm/m^3/mol will volatilize rapidly. Vapor pressure is a measure of the pressure at which a compound and its vapor are in equilibrium. The value can be used to determine the extent to which a compound would travel in air, as well as the rate of volatilization from soils and solution. In general, compounds with vapor pressures lower than 10^{-7} mm Hg will not be present in the atmosphere or soil air in significant amounts, while compounds with vapor pressures higher than 10^{-2} mm Hg will exist primarily in the air. Unless the soil is saturated, VOCs will exist primarily in the atmosphere and soil air. Polyaromatic hydrocarbons (PAHs) and other SVOCs will exist in both the air and the soil. The air diffusion coefficient is a measure of the rate of spontaneous mixing, presented in units of cm^2/second, of one substance with another when in contact or separated by a permeable

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Table 6-2. Physical and Chemical Properties of Organic Site-Related Chemicals at Burn Pits, Fort Stewart

Constituents	Mol. Wt	Solubility S_w (mg/L)	S_w @ Temp. °C	K_{OW} (mL/mL)	Vapor Pressure (torr @ °C)	Henry's Constant (K_h) (atm•m^3/mol)	K_h @Temp. (°C)	Air Diff. Coeff. (cm/s)	K_{OC} ('mL/g)	Calculated K_d (mL/g)	Biodegradation Rate Constant λ (1/day)	Log (K_{OW})
					Volatile Organic Compounds							
Acetone	58.1	1.00E+06		5.75E-01	270 @ 30	5.14E-07	25[a]	0.11[b]	0.575	1.61E-03	2.48E-02	-0.24
Benzene	78.1	1.78E+03	20	1.35E+02	95 @ 25	5.55E-03	25	0.0932[b]	62[c]	1.74E-01	9.63E-04	2.13
2-Butanone	72.1	2.75E+05		1.82E+00	100 @ 25	6.61E-07	25[a]	0.092[b]	1.15	3.21E-03	2.48E-02	0.26
Ethylbenzene	106.2	1.52E+02	20	1.41E+03	10 @ 25.9	6.44E-03	25	0.075[e]	204[c]	5.71E-01	3.04E-03	3.15
2-Hexanone	100.2	3.50E+04	20	2.40E+01	2 @ 20	7.53E-06	20	0.078	15.1	4.23E-02		1.38
Methylene chloride	84.9	1.67E+04	25	1.78E+01	429 @ 25	3.19E-03	25	0.1037[b]	10[c]	2.80E-02	6.19E-03	1.25
Styrene	104.1	3.00E+02	20	1.45E+03	5 @ 20	2.28E-03		0.0071[b]	912[c]	2.55E+00	3.30E-03	3.16
Tetrachloroethene	165.8	1.50E+02	25	3.39E+02	19 @ 25	2.87E-02	25	0.077[b]	265[c]	7.42E-01	4.19E-04	2.53
Toluene	92.1	5.15E+02	20	4.90E+02	28 @ 25	5.92E-03	25	0.087[b]	140[c]	3.92E-01	3.30E-03	2.69
1,1,1-Trichloroethane	133.4	4.40E+03	20	2.95E+02	100 @ 25	4.08E-03	25	0.019	135[c]	3.78E-01	6.35E-04	2.47
Xylene	106.2	2.00E+02		5.89E+02	5 @ 20	5.25E-03	25	0.073[b]	196[c]	5.49E-01	1.93E-03	2.77
					Semivolatile Organic Compounds							
Benzo(a)pyrene	252.3	3.80E-03	25	9.55E+05	5E-9 @ 21	4.90E-07	25	0.043	968,774[c]	2.71E+03	3.27E-04	5.98
Benzo(b)fluoranthene	252.3	1.00E-03	[a]	3.72E+06	5E-7[d]@ 1	2.94E-07	25[a]	0.044[a]	2,340,000	6.55E+03	2.84E-04	6.57
Fluoranthene	202.3	2.65E-01	25	2.14E+05	5E-6[d]@ 1	6.50E-06	25	0.069	49,100[c]	1.37E+02	3.94E-04	5.33

Solubilities, Henry's Constant, and Log (K_{ow}) have been taken from RREL Treatability Data Base (EPA 1994) except as otherwise indicated.
Biodegrdation half-lives are based on biodegradation half-lives taken from Hand Book of Environmental Degradation Rates (Howard et. al. 1991) except as otherwise indicated.
Air diffusion coefficients are obtained from EPA 1987, except as otherwise indicated.
[a]STF Data Base (EPA 1991). [b]Indicates Shen et. al 1993 as the source.
[c]Measured K_{oc} values (EPA 1996). [d]Source from EPA 1995. [e]EPA (1996).
$K_d = K_{oc} * f_{oc}$, where f_{oc} is fraction of organic carbon content with a site average value of 0.028 obtained based on measurements from the six Burn pits.

membrane. The rate of diffusion is proportional to the concentration gradient of a substance, increases with temperature, and is inversely related to density and pressure. In soil systems, the principal type of diffusion is from a region of high concentration to a region of low concentration. Diffusion occurs most readily in gases, to a lesser extent in liquids, and least in solids.

Water solubility and the tendency to adsorb to particles or organic matter can correlate with retardation in groundwater transport. The adsorption coefficient/partition coefficient (K_d) of an organic compound is related to the organic carbon/water partition coefficient (K_{oc}) by

$$K_d = f_{oc} \times K_{oc}$$

where:

f_{oc} = fraction of soil organic carbon content.

Chemical-specific K_{oc} values may be obtained from literature or may be calculated using empirical formulas relating the octanol-water partitioning coefficient (K_{ow}) to the K_{oc}. The K_{ow} (mL/mL) is the ratio of a contaminant's concentrations in a system containing water and octanol. The most commonly used formula to relate K_{ow} to K_{oc} is given by (Mills et al. 1985):

$$K_{oc} = 0.63 \times K_{ow}$$

Chemicals with relatively high water solubilities and low adsorption coefficients (e.g., acetone, methylene chloride, etc.) are expected to remain primarily as dissolved phases and be transported at the same rate as the groundwater flow. Chemicals with lower water solubilities and higher adsorption coefficients (e.g., PAHs) are expected to remain primarily adsorbed to the surface of the soils; their transportation with the groundwater would be very limited and at a much slower rate. Table 6-2 presents the solubility, Henry's Law constant (K_H), vapor pressure, air diffusion coefficients, and biodegradation rate constants for the organic compounds detected in soils and groundwater at the Burn Pits. Log K_{ow}, K_{ow}, K_{oc}, and K_d for these compounds are also presented in this table.

6.3 CONCEPTUAL SITE MODEL

The CSM is a statement of expected site conditions that serves as a paradigm against which observations can be compared and within which predictions can be made. The predictive function of the CSM, of primary importance to contaminant fate and transport analysis, relies on known information and informed assumptions about the site. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the site.

The CSM presented in this section summarizes the hydrogeologic components (presented in Section 4.0) and the distribution of contaminants in the subsurface soils and groundwater (presented in Section 5.0). Contaminant migration pathways and release mechanisms are also based on the information presented in Section 5.0. The CSM for contaminant fate and transport at the Burn Pits is diagrammatically illustrated in Figure 6-1. The summary of the model elements follows.

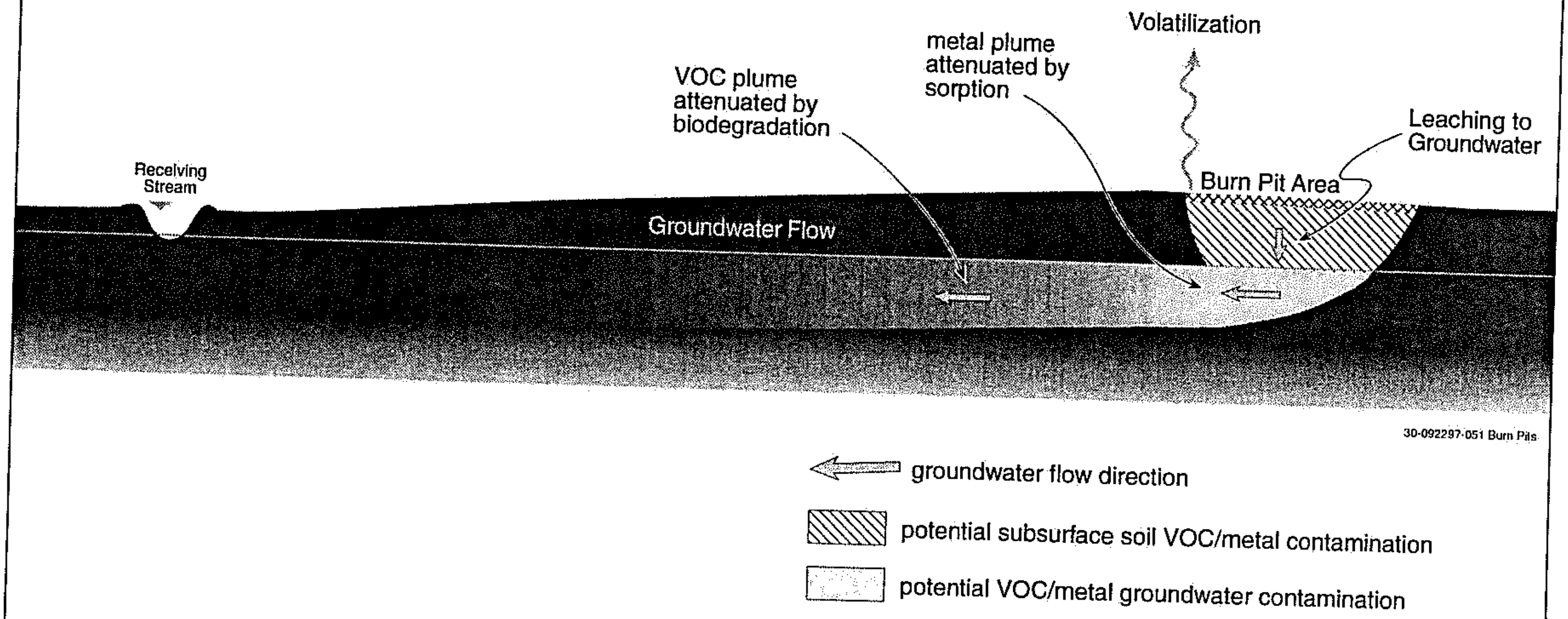

Figure 6-1. Generalized Conceptual Site Model for Contaminant Fate and Transport at Burn Pits A through F, Fort Stewart

6.3.1 Water Balance Components

The potential for contaminant transport begins with precipitation. The actual amount of rainwater available for flow is highly variable and dependent upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all the components of the hydrologic cycle at the Burn Pits. The components of a simple steady-state water balance model include: precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or percolation (Gr), and is defined as follows:

$$P = ET + Sr + Gr$$

or

$$\text{Rain water available for flow} \quad = \quad Sr + Gr = P - ET$$

The annual average water balance estimates for the Fort Stewart area indicate an evapotranspiration of 65.5 percent (31.4 inches) of total precipitation (48 inches) as compared to 34.5 percent (16.4 inches) for rain water available for flow. Of this 34.5 percent (14.7 inches), groundwater recharge (percolation) accounts for 30.7 percent (14.7 inches) and surface runoff accounts for the remaining 3.8 percent (1.8 inches). The water balance estimations were based on Hydrologic Evaluation of Landfill Performance model (EPA 1994) calculations using precipitation and temperature data for the years 1974 through 1978 at Savannah, Georgia.

6.3.2 Contaminant Release Mechanisms and Migration Pathways

Past pathways were:

- The burn pits were not actually "pits," but surface piles of clearing and grubbing debris that could have been doused with gasoline and burned. Some of these liquids might have infiltrated the soil and contaminated soil and groundwater below the individual Burn Pits.
- Organic contamination in groundwater has spread and/or been degraded to reach its current extent.
- Residues from burning have left some metals at concentrations higher than reference background criteria in surface and subsurface soils.
- If past operations at Burn Pit F have contaminated soils with BTEX compounds, then those contaminants have degraded to negligible concentrations in the mean time.

Current pathways are:

- Percolating rainwater through contaminated soil below the Burn Pits leaches contaminants and transports contaminants to the water table.
- Contaminants migrate in groundwater along the flow path by advection toward the downgradient receiving streams.
- Organic compounds in groundwater and probably in soil are being biologically degraded.
- Organic compounds in soil and probably in groundwater are being volatilized.

Release Mechanisms. The potential release mechanism at the Burn Pit sites is infiltration of rain water with leaching to groundwater. Precipitation that does not leave the site as surface runoff infiltrates into the subsurface. The rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions. As discussed previously, the rate of percolation at these sites is quite high (14.7 inches/year).

Factors that affect the leaching rate include a contaminant's solubility and partitioning coefficient (K_d) and the amount of percolation. Insoluble compounds will precipitate out of solution in the subsurface or remain in their insoluble form with little leaching. Those contaminants with a small K_d (lower sorption) will be leached more effectively than those with a larger K_d (higher sorption).

A factor that affects the persistence of a contaminant is the contaminant's rate of decay. Most of the organic compounds decay or break down at characteristic rates that are described by the substance's half-life. For a given percolation rate, those contaminants with long half-lives have a greater potential for contaminating groundwater than do those contaminants with shorter half-lives. Organic contaminants with shorter half-lives and higher K_{oc} values will be completely degraded before reaching the water table.

Release by gaseous emission and airborne particulates is not significant at the Burn Pits. Concentrations of organic contaminants in the surface soil are relatively insignificant so gaseous emissions to the atmosphere would be minor. Wind erosion is not likely to be significant at the Burn Pits because of the vegetative cover.

Migration Pathways. The most likely pathway of contaminant migration from the Burn Pits is via groundwater discharge to downgradient streams. Groundwater from Burn Pits A through D flows toward Mill Creek and Horse Creek tributaries that, in turn, discharge into Taylors Creek. Groundwater from Burn Pit E discharges to a small unnamed stream or swampy area that discharges directly to the Canoochee River. Groundwater from Burn Pit F discharges into Goshen Swamp, which in turn discharges southward into Peacock Creek.

In the saturated zone, the contaminants are carried either in solution or adsorbed to fine particulates (colloids) laterally to the hypothetical receptor locations. The horizontal hydraulic conductivity, which controls the flow rate, is a function of soil grain size and the pressure gradient. Saturated hydraulic conductivities for the Burn Pit sites range from 3.1×10^{-4} to 1.7×10^{-3} cm/second with an overall average of 9.2×10^{-4} cm/second (Section 4.0). The horizontal hydraulic gradient varies from 0.0006 foot/foot across the Burn Pit B site to 0.009 foot/foot across the Burn Pit E with groundwater flow occurring in different directions from the individual sites. The calculated groundwater seepage velocity with these gradients and hydraulic conductivities range from 1.2 feet/year (Burn Pit B) to 35 feet/year (Burn Pit A) using the effective porosity measurements in Table 4-1. Therefore, the arrival time for the site groundwater to reach the nearest receptor location is expected to range from 43 years (for Burn Pit A) to 3750 years (for Burn Pit B). These ranges are summarized in Table 6-3.

6.4 FATE AND TRANSPORT ANALYSIS

6.4.1 Soil Leachability Analysis

Contaminant fate and transport analysis at this site involves a series of screening steps to define the contaminant migration constituents of potential concern (CMCOPCs). The CMCOPCs are defined as the constituents that may pose potential problems in groundwater if they were to migrate from the site source. The CMCOPCs were identified through a screening process, using a simple analytical approach for vertical migration from source soils to groundwater and lateral migration in groundwater from the source site to the nearest receptor stream. The screening steps are discussed in the following sections.

Table 6-3. Arrival Time Estimates for Contaminant Migration in Groundwater
Burn Pits, Fort Stewart

Site	Hydraulic Conductivity, k (cm/second)	Horizontal Hydraulic Gradient, i (feet/feet)	Effective Porosity, n	Groundwater Flow Velocity, v (feet/year)	Distance to Receptor Stream (feet)	Receptor Stream	Arrival Time (years)
Burn Pit A	1.73E-03	0.0083	0.42	35	1500	Mill Creek	43
Burn Pit B	7.07E-04	0.0006	0.365	1.2	4500	Horse Creek	3750
Burn Pit C	1.24E-03	0.0043	0.396	14.1	4000	Mill Creek	284
Burn Pit D	9.45E-04	0.0015	0.368	4.0	2500	Mill Creek	625
Burn Pit E	3.11E-04	0.009	0.464	6.2	1000	Canoochee R	161
Burn Pit F	5.81E-04	0.0023	0.408	3.4	1000	Goshen Swamp	294

The first step of the screening process represents the development of the SRCs. The SRCs were selected by comparing the maximum detected concentrations of all the analytes measured in surface and subsurface soils with their respective reference background concentration. The reference background concentrations represent the average site background concentration multiplied by a factor of two. If the maximum concentration of an analyte in the soil exceeds its reference background concentration, then that analyte is selected as an SRC.

The second step of the screening process involves comparing the maximum concentrations of all the SRCs, developed in the previous step, with EPA generic soil screening levels (GSSLs). The GSSLs are set for Superfund Sites for the migration to the groundwater pathway (EPA 1996). For conservatism, a default dilution attenuation factor (DAF) of 1, as applicable based on source area and depth to water table, was used to select the GSSLs for the organic chemicals. A DAF of 1 is appropriate for organic chemicals because organic constituents are not easily adsorbed to the sandy inorganic soils present at the Burn Pits and because the depth to the water table is less than 13 feet. However, for the metals, because of their higher retardation factor, a DAF of 20 was used to select GSSLs. The GSSL is defined as the concentration of a contaminant in soil that represents a level of contamination below which there is no concern under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), provided conditions associated with soil screening levels (SSLs) are met. Generally, if contaminant concentrations in soil fall below the GSSL, and there are no significant receptors of concern, then no further study or action is warranted for that area. However, it should be noted here that the purpose of this screen is not to identify the contaminants that may pose risk at a downgradient location, but to target those contaminants that may pose a potential problem if they were to migrate from the site. The results of this screening for individual Burn Pits are presented in Sections 9.0 through 14.0. The resulting CMCOPCs are summarized in Table 6-4. The predicted maximum concentration of a contaminant in groundwater is calculated as follows (EPA 1996):

$$C_{GW(P)} = \frac{C_s}{GSSL} \times MCL$$

where:

$C_{GW(P)}$ = predicted maximum concentration in groundwater,
C_s = observed maximum concentration in soil,
GSSL = generic soil screening level,
MCL = maximum contaminant level.

Table 6-4. CMCOPCs in Soil and Predicted Maximum Concentrations in Groundwater Burn Pits, Fort Stewart

Site	Parameter	Maximum Observed Concentration in Soil[a]	GSSL[a]	MCL (µg/L)	Predicted Maximum Concentration in Groundwater (µg/L)
Burn Pit A	Benzene	28	2	5	70
	Tetrachloroethene	8.8	3	5	15
Burn Pit B	Benzene	30	2	5	75
	Tetrachloroethene	8.9	3	5	15
	Methylene Chloride	5	1	5	25
Burn Pit C	Tetrachloroethene	48	3	5	80
	Methylene Chloride	4.3	1	5	22
Burn Pit D	Benzene	12	2	5	30
	Tetrachloroethene	9.7	3	5	16
Burn Pit E	Benzene	7.9	2	5	20
Burn Pit F	Chromium	65.8	38	100	173
	Methylene Chloride	7.4	1	5	37

[a] Concentrations for metals in mg/kg, for organics in µg/kg.
CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
MCL = Maximum Contaminant Level.

6.4.2 Natural Attenuation of the CMCOPCs

The organic CMCOPCs in soils at the Burn Pits include benzene, methylene chloride, and PCE. These contaminants may be degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, or biodegradation. As already discussed in Section 6.2, environmental half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and environmental conditions. Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical, while complete biodegradation is the biologically mediated degradation of an organic compound into carbon dioxide, water, oxygen, and other metabolic inorganic products. The biodegradation rate of an organic compound is proportional to the concentration:

$$-dC/dt = kC^n$$

where:

C = concentration,
k = biodegradation rate constant = 1/t Ln (a/[a-x]),
t = time,

a = initial concentration,
x = change in concentration with time,
n = reaction order , n=1 for first order kinetics.

The half-life ($t_{1/2}$ = Ln2/k) is the time necessary for half of the chemical concentration to react. The biodegradation rate of an organic chemical is generally dependent on the presence and population size of soil micro-organisms, capable of degrading the chemical.

Based on the above equation and the predicted maximum concentrations of these constituents if they were to migrate to groundwater, a simple first-order correlation can be obtained between the constituents' half-lives and the time required to degrade the contaminant to the concentration equal to its MCL. These correlations indicate that benzene, with its predicted maximum concentration of 75 µg/L (using linear equilibrium relationship) in groundwater, will degrade to its MCL value in less than 4 times its half-life. Using the most conservative half-life reported in the literature, it appears that the maximum expected concentration of benzene will degrade to its MCL value in less than 10 years. This time frame is much less than the 43 years that is the shortest time expected for the site groundwater to reach the receptor location among all of the individual Burn Pit sites. Similarly, PCE with its predicted maximum concentration of 42 parts per billion (ppb) will degrade to its MCL in less than 14 years, and methylene chloride with its predicted maximum concentration of 18 ppb will degrade to its MCL in less than 0.6 years. It should be further noted here that this analysis does not account for attenuation due to adsorption and dispersion, making the analysis highly conservative.

6.5 SUMMARY AND CONCLUSIONS

Based on site characterization and monitoring data, some metals and VOCs were detected in soils at the Burn Pit sites. Among the metals, only chromium from Burn Pit F is considered a CMCOPC based on the contaminant transport analysis. At Burn Pit F, chromium could reach the water table at a predicted concentration exceeding its MCL. However, off-site migration of chromium would be very limited due to its high K_d (i.e., high retardation factor) as well as the slow movement of groundwater flow to the receptor location (unnamed tributary of Goshen Swamp located approximately 1000 feet west of the site).

None of the organic compounds currently observed in the site groundwater exceeds its respective MCL in groundwater. Based on contaminant transport analysis, benzene, methylene chloride, and PCE could migrate from soils to the water table at concentrations exceeding their respective MCLs; however, off-site migration of these contaminants will be very limited due to retardation and biodegradation as well as the slow movement of groundwater flow. Predicted maximum concentration of these constituents at a distance 500 feet from the source is not expected to exceed 1 ppb (i.e., less than the MCL of 5 ppb) even with the most conservative assumption for their biodegradation half-lives.

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7.0 HUMAN HEALTH RISK ASSESSMENT

This HHRA uses a Step 1 risk evaluation approach that is based on guidance from the GEDP. This is done to determine if there are potential risks to human health associated with contamination detected at the Burn Pits (SWMUs 4A through 4F). This process involves the following steps:

- for inorganics, compare detected concentrations to naturally occurring background levels to determine if detected inorganics are naturally occurring or are associated with past activities at the site;
- identify potential migration and exposure pathways associated with the site, and identify potential exposure scenarios in order to identify appropriate action levels;
- identify available risk-based action levels for each contaminant detected above background levels or develop levels if they do not exist; and
- compare sample concentrations to action levels to determine if site conditions warrant further evaluation.

Chemicals that exceed action levels will be identified as COPCs and will be evaluated in a baseline risk assessment (BRA).

7.1 DATA EVALUATION

The objective of this evaluation is to develop a set of chemical data which is suitable for use in the HHRA. The data for the Burn Pits were evaluated to establish (1) which data are of sufficient quality for use in the quantitative risk assessment and (2) which detected chemicals are believed to be site related. This is discussed in site-specific chapters.

7.1.1 Data Quality Evaluation

The data used in the risk assessment were verified and validated using the methodology described in the QAPP. Data qualified during the validation as rejected data ("R") were not used in the risk assessment.

Detection limits achieved during sample analysis were reviewed to ensure that the required detection limits were met. Typically, detection limit requirements are established to ensure that characterization has occurred to levels that are low enough to determine if chemicals are present at hazardous levels. These levels are chemical specific and related to each chemical's toxicity. Required detection limits are presented in the QAPP. In some cases recommended detection limits cannot be achieved by a laboratory, e.g., if matrix or chemical interference requires that a sample be diluted. Samples with elevated detection limits that exceed 10 times the required detection limit were excluded from the risk assessment data set.

An organic chemical was removed from further consideration if it was a common laboratory contaminant and the reported sample concentration was less than 10 times the concentration in an associated quality control sample (i.e., trip blank, field blank, equipment rinsate, or laboratory blank). Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene, or phthalate esters. Other organic chemicals were not included if results were less than five times the highest concentration detected in an associated quality control sample. Where this has occurred, it is discussed in the site-specific chapter.

7.1.2 Background Screening

EPA Region 4 methods for comparison to background (EPA 1995) were used to screen metals data. If enough samples (e.g., >20) are collected across the entire site to develop a more robust background level, background upper tolerance level (UTL) can be calculated and compared to site data. In cases where there are a low number of samples to define background, as is the case for FSMR, a second method can be used to define background: 2 times the mean background concentration (EPA 1995). Given that less than 20 background samples were collected for the site, the latter method was used for estimating background concentrations in this study.

Metal concentrations in surface soils, subsurface soils, and groundwater were compared with respective background concentrations to determine what chemicals are site related. Appendix E presents the summary of background data and presents the 2 times mean background concentrations. The mean concentrations for soils in the eastern United States are also presented for comparative purposes (USGS 1981). Given the limited number of background samples at the FSMR, the screening value for background may not be representative of the true upper range of background levels. The mean concentrations for soils in the eastern United States provide some perspective on how representative the background screening values are relative to regional background concentration. The results of the site-specific background screening for various environmental media are discussed in the respective chapters for each SWMU.

Organic chemicals are generally not ubiquitous in the environment. Therefore, it is assumed that any organic chemicals detected are the result of site-specific activities. No background screening was performed for organic chemicals, and all detected organics are considered SRCs.

7.2 EXPOSURE EVALUATION

The objective of this exposure evaluation is to identify potential human populations that may be exposed to site-related chemicals under current and future land-use conditions. A complete exposure pathway consists of five elements: (1) a potential receptor population, (2) a source of contamination, (3) a transport or retention medium, (4) a point of contact for a receptor, and (5) a route of exposure (ingestion dermal absorption or inhalation) at the point of contact through which the chemical may be taken into the body. When all of these elements of an exposure pathway are present, an exposure of a receptor population can take place. The assessment considers both on-site and off-site receptors and their relationship to the potential migration pathways, and exposure pathways and points of exposure for site-related chemicals.

7.2.1 Receptor Assessment

This section identifies those populations that may be exposed to site-related chemicals. Although a receptor population may be identified under current conditions, potential changes in land use may result in the presence of more sensitive receptor populations in the future.

Generally, receptor populations are divided into two groups: on-site and off-site receptors. On-site receptors are those individuals who may be present within the site boundaries and come into direct contact with contaminants present. The exposure to an off-site receptor requires that the contaminant be transported to an off-site exposure point.

The on-site receptors will vary from site to site depending on the current land use. The on-site receptors for those sites which are currently in active use would include occupational receptors. On-site receptors for inactive sites would include juvenile trespassers and hunters. None of the sites are secured; therefore, a juvenile trespasser may come onto the site to explore or play. In addition, hunting takes place near many of the Burn Pits. Hunters may come in contact with site-related contaminants while hunting in the area.

Land use may change in the future. The burn pits are all located in areas that have been designated for use as maneuver areas or similar purposes. Military operations may increase in the areas of sites which are not currently used. This would result in the presence of military personnel on site. Heavy industrial development of these areas is highly unlikely.

The future on-site receptor populations identified will be representative of those populations that are likely to be present given the potential changes in current land use. The current land use at a site may remain unchanged. Given this scenario, the future receptor populations would remain the same as those identified as current receptor populations. However, to be sure that the first step of the risk assessment process does not exclude any potential receptors, this assessment assumes that residential use of the site could occur in the future. Residential use of the site is highly unlikely, but is presented as a scenario in accordance with Risk-Based Corrective Action (RBCA) guidance.

The current off-site receptor populations are individuals working or hunting in the area. The off-site receptor populations would remain unchanged for those sites where the land use at the site and in the surrounding area remain unchanged. The off-site receptor population would change from occupational receptors to residential receptors if the area surrounding the site were to be developed into base housing or a residential area, which is highly unlikely.

7.2.2 Migration Pathway Analysis

This section describes the potential pathways related to chemical transport that may result in potential exposure points for humans. In general, the major routes of migration from these sites are volatilization into air, wind erosion resulting in fugitive dust, and leaching of contaminants into groundwater. All of the sites are relatively flat, and most are completely vegetated; therefore, migration via surface water runoff is not a viable migration pathway.

Air Pathway. Site-related compounds in soils may be released via volatilization. This could result in potential exposures to human receptors via inhalation. This migration pathway is generally limited to VOCs found in the surface soils.

Particulate-bound chemicals may also be transported through soil erosion or generation of fugitive dust. This pathway is limited to compounds that have a high affinity for soils and a low vapor pressure, thus reducing the possibility of volatilization. This migration pathway is limited to chemicals found in surface soils at sites that lack complete vegetative cover (i.e., Burn Pit A).

Groundwater. Migration of soil contaminants to groundwater could occur from infiltration and percolation of rainwater through the soil. The extent of contaminant migration depends primarily on the amount of rainfall, evaporation, solubility of the chemical in water, the absorption coefficient, and distance to the groundwater. In general, VOCs (such as BTEX) travel more easily through soils than SVOCs. Solubility of metals is dependent on the metal species and is difficult to generalize. Groundwater occurs approximately 2 to 13 feet bgs at the Burn Pit sites. Calculation of the likelihood for contaminants to migrate to groundwater at the Burn Pits is discussed in Section 6.0.

There are no surface water bodies in the vicinity of any of the Burn Pits. The sites are relatively flat and most are completely vegetated. Therefore, migration of contaminants to surface waters via the discharge of groundwater is not a viable migration pathway.

7.2.3 Identification of Exposure Pathways

Potential human exposure may occur by primary pathways (e.g., dermal contact, inhalation, or direct consumption of soil or water) or through secondary pathways involving the transfer of site-related chemicals into food sources (i.e., crops, livestock, and game).

Primary Pathways. Potential primary pathways for exposure of receptor populations include ingestion of soils, inhalation of volatile organics and air-borne particulates, and dermal contact with soils.

Current on-site receptor populations may be exposed to contaminants in surface soil via inadvertent ingestion of soils, inhalation of volatile organics from soils, inhalation of fugitive dust and dermal contact with soils. Military personnel are at greatest potential risk for exposure because training may require the soilders to lie on the ground, resulting in dermal contact of soils, inadvertant ingestion of soils adhering to the hands, and inhalation of volatiles and fugitive dust.

The hunter is not expected to come in direct contact with the soils. The hunter's activities include primarily walking and standing, with minimal kneeling or sitting. The hunter is expected to wear long pants and boots; therefore, dermal contact with soils is expected to be minimal. The hunter's activities are expected to be in areas that are well vegetated, providing habitat for game animals. Therefore, exposure via inhalation of fugitive dust is expected to minimal because the vegetation would prevent generation of fugitive dust.

Off-site occupational receptors and hunters may be exposed via inhalation of fugitive dust. It is unlikely the volatile compounds will migrate off site in any significant concentrations, therefore, off-site receptor populations would not be exposed to volatilized compounds.

The surficial groundwater aquifer underlying Fort Stewart is 2 to 13 feet bgs. Below this aquifer is the Principal Artesian aquifer, which is hydrogeologically isolated from the surficial aquifer. The surficial groundwater aquifer is too shallow to be used as a drinking water source. If groundwater were to be used as a source of drinking water, the Principal Artesian aquifer would be used. The shallow aquifer is currently used in some areas of Fort Stewart for irrigation or watering lawns. However, the groundwater underlying the Burn Pits is not currently in use; therefore, there are no current exposure pathways for contaminants in groundwater.

Potential future on-site and off-site occupational receptor populations would have the same exposure pathways as current occupational receptors. The on-site resident may be exposed to contaminants in soils via inadvertent ingestion, inhalation of volatile organics and fugitive dust, and dermal contact. The construction worker may be exposed to contaminants in surface and subsurface soils via inadvertent ingestion, inhalation of volatiles, and dermal exposure. Surficial groundwater may be used for watering lawns and grounds. Potential exposure to contaminants in groundwater includes inhalation of volatile organics and dermal exposure.

Indirect pathways. Hunting is allowed on the FSMR. Game species may bioaccumulate contaminants as a result of ingesting soils and contaminated vegetation. Current off-site receptors may be exposed as a result of consuming contaminated game. Fort Stewart does not currently lease agricultural lands and is unlikely to allow agricultural practices within the base in the future. Therefore, exposure via uptake into food crops is not a viable exposure pathway.

The risk-based screening values are based on a residential receptor population. The potential exposure pathways addressed in deriving the screening values for soils include soil ingestion, inhalation of fugitive dust and volatiles, and ingestion of contaminants leaching into groundwater from soils. Exposure pathways for groundwater include ingestion and inhalation of volatiles during showering. The residential exposure scenario does address all of the potential exposure pathways, although none of the potential receptor populations would be exposed via all of the pathways addressed under a residential exposure scenario. The derivation of the risk-based screening values is discussed further in the following section.

7.3 SELECTION OF SCREENING VALUES

Screening values represent risk-based concentrations that are publicly available. Due to their conservative nature, screening values can be used with a high degree of confidence to indicate sites for which no further action is required. Screening values inherently incorporate assumptions about land use. In identifying COPCs, it is generally accepted that screening levels will reflect any potential future land uses and, thus, usually reflect a conservative residential use scenario (EPA 1991, 1996b; ASTM 1995).

If risk-based screening values are not available, it generally reflects (1) that the chemical is not considered to be toxic except perhaps at extremely high concentrations (e.g., aluminum, sodium, etc.); (2) no dose-response data indicate a toxic effect; or (3) EPA is currently reviewing toxicity information, and no reference dose or cancer slope factor currently is available.

7.3.1 Screening Values for Soils

The EPA Region III risk-based screening values for ingestion of soils were taken from EPA (1996c). The risk-based values were adjusted to reflect a potential incremental lifetime cancer risk of 1×10^{-6} or a hazard index of 0.1. The risk-based values are given for residential and industrial land use. Residential land use is unlikely to occur at this site. However, as a conservative measure, residential land use values were used to screen surface soil samples. Exposure of subsurface soils would be limited to a person working with an excavation, i.e., an industrial exposure scenario. Therefore, the industrial land use values were used to screen the subsurface soil samples.

Step 1 screening levels generally reflect residential land uses; use of these levels in the first step of the risk process ensures that no chemical will be screened from consideration prematurely. The EPA does provide guidance and default parameter values for developing screening levels that reflect industrial land-use assumptions. These levels are developed using equations and default values from EPA (1991). Residential land use is unlikely at any of the Burn Pits.

The default residential exposure assumptions for soil are as follows:

- Soil ingestion—For noncarcinogens, the receptor is a child (age 1 to 6) who ingests 200 mg of soil/day for 6 years; for carcinogens, the soil ingestion rate is age-adjusted over a time period of birth until age 30, assuming an adult ingests 114 mg/day (EPA 1996a, 1996c).

- Inhalation of volatiles or fugitive dust, where a resident is exposed to airborne contaminants for 30 years (EPA 1996a).

- Leaching of contaminants to groundwater, with subsequent ingestion of groundwater (EPA 1996a).

The potential exposure pathways for soils present at the Burn Pits include ingestion of surface soils, ingestion of subsurface soils (construction worker), inhalation of volatiles, and inhalation of fugitive dust for future land-use scenarios. For those chemicals detected, the screening values for soil ingestion are lower (i.e., more conservative) than the risk-based inhalation values; therefore, the soil ingestion values were selected.

The EPA Region III risk-based screening values give two values for arsenic. One value is based on the carcinogenic risks for arsenic, and the other value is based on systemic toxicity or noncarcinogenic risk. As a conservative measure, the lower value (carcinogenic value) will be used for the screening value.

Chromium may exist in two valence states, trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium. The hexavalent chromium is significantly more toxic than $Cr^{+3,}$ and Cr^{+6} is more mobile in the environment. However, Cr^{+6} is not naturally occurring and is unstable in the environment, oxidizing to the trivalent state. The risk-based screening values for residential soils include both trivalent and hexavalent chromium. It is unlikely that the chromium present is hexavalent chromium, given there is no likely source for Cr^{+6}. In addition, the value given represents the total chromium present, which includes the naturally occurring trivalent chromium. As a conservative assumption, the hexavalent chromium value will be used for the screening value.

7.3.2 Screening Values for Groundwater

The groundwater screening values reflect the use of groundwater as a source of drinking water (EPA, 1996b, 1996d). These values include the Region III screening values for tap water based on a cancer risk of 10^{-6} and a hazard index (HI) of 0.1. As previously discussed, groundwater at this site is unlikely to be used as a drinking water source, but may be used as a source of water for irrigation or watering in the future. The drinking water screening values are considered to be health protective values given the conservative assumptions used.

The default residential exposure assumptions for groundwater are as follows:

- Groundwater ingestion—For noncarcinogens, the receptor is an adult who ingests 2 L of groundwater/day; for carcinogens, the water ingestion rate is age-adjusted over a time period of birth until age 30, assuming a child age 1-6 ingests 1 L/day (EPA 1996a, 1996c).

- Inhalation of volatiles during showering.

There is no reference dose for lead; however, the EPA has derived an Action Level for acceptable lead levels at the tap (EPA 1991). The 15 µg/L action level will be used for the lead screening value.

Region III risk-based screening values for arsenic include values for carcinogenic and noncarcinogenic effects. As a conservative measure, the carcinogenic value for arsenic will be used for exposure via drinking water. However, it should be noted that the drinking water scenario is not applicable at this site, and is being used in the absence of a more appropriate screening value.

As previously discussed, chromium may exist in two valence states, trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium. Hexavalent chromium is more toxic but is also unlikely to be present at this site because of the absence of a potential source and the instability of the chemical, which oxidizes readily into Cr^{+3}. As a conservative assumption the hexavalent chromium value will be used for the screening value.

7.4 RISK EVALUATION

The risk evaluation compares the maximum value detected in each medium with its respective screening value. If chemicals exceed a screening value, then a risk may exist and those chemicals should be evaluated more carefully. Contaminants identified as COPCs will be evaluated further in a BRA.

The selection of COPCs for each environmental media (surface soil, subsurface soil, groundwater, sediment and surface water) at each of the Burn Pits is addressed in the respective chapters (Sections 9.0 through 14.0). The selection process involves two steps. The initial step is the comparison of the maximum concentrations to the appropriate screening values. Given the conservative nature of the screening values, a weight-of-evidence analysis of those chemicals passing the screen is done to determine if those chemicals selected should be analyzed further in a BRA.

The potential risks associated with exposure to chemicals are not quantified. However, toxicity values and associated data (reference doses, target organs, cancer slope factors, etc.) are presented in Appendix G for informational purposes.

7.5 CONCLUSIONS OF THE HUMAN HEALTH RISK EVALUATION

In surface soil, arsenic is a potential COPC at Burn Pits A and F. At these two sites, arsenic exceeds its risk-based screening value for exposure of a residential receptor. Maximum concentrations of arsenic of 2.5 mg/kg and 2.7 mg/kg were found at Burn Pits A and F, respectively, which exceed the risk-based screening value of 0.43 mg/kg. It should be noted that these maximum concentrations of arsenic are below the average concentration of arsenic for soils regionally, which is 7.4 mg/kg. In addition, a residential screening value was used, although residential land use at this site is unlikely. No other constituent in surface soil exceeded its risk-based screening value at any of the Burn Pits.

In subsurface soil, no constituent exceeded its respective risk-based screening value for exposure to a residential receptor. As discussed in Section 6.0, benzene, PCE, methylene chloride, and chromium are potential COPCs in subsurface soils due to potential for leaching to groundwater resulting in groundwater concentrations exceeding their respective MCLs. However, off-site migration of these contaminants would be very limited due to retardation and biodegradation as well as the slow movement of groundwater. In addition, none of these four constituents has been detected in groundwater at levels exceeding its risk-based screening value or its MCL.

In groundwater, arsenic is a potential COPC at Burn Pit D, where the maximum concentration of arsenic in groundwater (4.2 μg/L) exceeded its risk-based screening value of 0.045 μg/L for residential use of groundwater as drinking water. However, the maximum concentration of arsenic was well below its MCL of 50 μg/L. Arsenic was detected at a concentration only slightly above its reference background concentration of 3.4 μg/L, and in only a single well at Burn Pit D (MW-6). In addition, use of the surficial groundwater at this site for drinking water is unlikely. Therefore, arsenic is not considered a potential threat to human health at the Burn Pits.

Similarly, cadmium is a potential COPC in groundwater at Burn Pits C and E, where the maximum concentrations of cadmium in groundwater (3 µg/L and 4.3 µg/L, respectively) exceed their risk-based screening value of 1.8 µg/L for residential use of groundwater as drinking water. The maximum concentration of cadmium was less that its MCL of 5 µg/L at each site. In addition, use of the surficial groundwater at these sites for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health at the Burn Pits.

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at the Burn Pits. A human health BRA is not warranted. No further action is required for protection of human health.

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8.0 ECOLOGICAL RISK ASSESSMENT

The State of Georgia requires that all RCRA facilities choosing to set remediation levels based on an assessment of risk to human health and the environment prepare risk assessment documentation and propose remediation levels according to the *Guidance for Selecting Media Remediation Levels at RCRA Solid Waste Management Units* (GEPD 1996). GEPD (1996) guidance is based on the guidance contained in EPA Region 4 Bulletins, *Supplemental Guidance to RAGS, Ecological Risk Assessment* (EPA 1996a) and a 1994 draft of *Ecological Risk Assessment for Superfund, Process for Designing and Conducting Ecological Risk Assessments* (EPA 1997). The EPA has also proposed guidelines for conducting ecological risk assessments (EPA 1996b). Where there are differences with EPA guidance (EPA 1996a, 1997), the GEPD 1996 guidance document takes precedence.

Risk is the likelihood of experiencing adverse effects. ERAs identify and evaluate the risk to biota exposed to chemical contaminants and physical and biological hazards. The ERA for the Burn Pits A through F focuses on evaluating the potential for harmful effects on ecological receptors as a result of exposure to chemicals.

The assessment of risk for ecological receptors at the Burn Pits A through F is being conducted in a phased approach according to GEPD guidance (GEPD 1996). As shown in the flowchart of the GEPD ecological risk assessment process, the two phases are:

- PRE and
- ERA.

The PRE compares measured concentrations of SRCs to conservative ecological screening values (ESVs) for one or more ecological receptors. Only those facility-related contaminants that are indicated to be potential hazards in the PRE are evaluated as ecological COPCs in an ERA. The basic approach to ERAs is similar to that of the PRE, but site-specific data are used to quantify exposure and evaluate effects in the ERA (GEPD 1996). Appropriate site-specific data include concentrations of contaminants in animals and plants (tissue residues) and toxicity tests (EPA 1996a). Remediation levels for protection of ecological resources are developed and proposed only for those COPCs identified as ecological COCs in the ERA, if one is required.

The medium of primary concern to ecological receptors at the Burn Pits A through F is surface soil. Chemicals in surface soil can be contacted directly by ecological receptors, or their presence in soil can result in the accumulation of contaminants in plants and animals, which can cause ecological receptors to be exposed by ingesting those biota. Groundwater at the Burn Pits A through F is also evaluated because EPA Region 4 guidance (EPA 1996a) directs that, in the PRE, groundwater be screened as surface water. However, there are no surface water bodies in the vicinity of any of the Burn Pits. Therefore, migration of contaminants to surface waters via the discharge of groundwater is not a complete exposure pathway at the Burn Pits.

8.1 PRELIMINARY RISK EVALUATION

The purpose of the PRE is to identify substances detected at the Burn Pits that pose a potential hazard to ecological receptors. Ecological COPCs are those substances that are detected at the Burn Pits A through F at concentrations exceeding ESVs.

According to GEPD (1996), the PRE consists of five steps:

i. ESV comparison,
ii. Preliminary problem formulation,
iii. Preliminary ecological effects evaluation,
iv. Preliminary exposure estimate, and
v. Preliminary risk calculation.

As shown in the flowchart of the GEPD ERA process (Figure 8-1), all substances detected are screened as ecological COPCs by comparing the maximum detected concentration to the ESVs. This approach assumes that the most sensitive receptors are those that live in direct contact with the medium and are exposed by multiple pathways to contaminants. If no ecological COPCs are identified based on the screening (Step i), then no further evaluation is required. If ecological COPCs are identified based on the screening, then ecological COPCs are evaluated further (Steps ii through v). Because there are no ESVs for soil, all analytes detected in surface soil at the Burn Pits A through F are evaluated further in PRE Steps ii through v.

8.1.1 Ecological Screening Value Comparison (Step i)

The ESVs used to identify ecological COPCs at the Burn Pits A through F are EPA Region 4 screening values for hazardous waste sites. For analytes without Region IV ESVs, screening values are proposed based on other methods and data obtained from published sources (e.g., Clayton and Clayton 1981) and toxicological data bases, e.g., Hazardous Substances Data Bank, Integrated Risk Information System. Screening values are conservative to prevent elimination of any contaminant that may pose ecological risk (EPA 1997). If no data are available to support the development of an ESV for an analyte, the analyte is an ecological COPC by default (GEPD 1997a).

For groundwater, EPA Region 4 ESVs are chronic ambient water quality criteria (AWQC) for the protection of aquatic life, such as aquatic plants, invertebrates, and fish, or similarly derived values (EPA 1996a). There are no EPA Region 4 ESVs for barium, acetone, and xylenes, so proposed ESVs for these analytes are identified from published data sources (Suter and Tsao 1996, Clayton and Clayton 1981).

The results of the screening value comparisons for groundwater are presented in the individual sections for each burn pit. The maximum detected concentration in groundwater sampled from the monitoring well locations at each of the former burn pits (Burn Pits A through F) is used to screen for ecological COPCs.

A preliminary problem formulation (Step ii), preliminary ecological effects evaluation (Step iii), preliminary exposure estimate (Step iv), and preliminary risk calculation (Step v) are conducted for SRCs in surface soil because there are no ESVs for soil. These four steps evaluate the potential for risk from COPCs to categories of receptors potentially occurring at the Burn Pits.

8.1.2 Preliminary Problem Formulation (Step ii)

The preliminary problem formulation (Step ii) qualitatively identifies categories of potential ecological receptors that occur at the Burn Pits A through F and contaminants that may pose a risk to those receptors in the environmental setting of the Burn Pits A through F. Ecological

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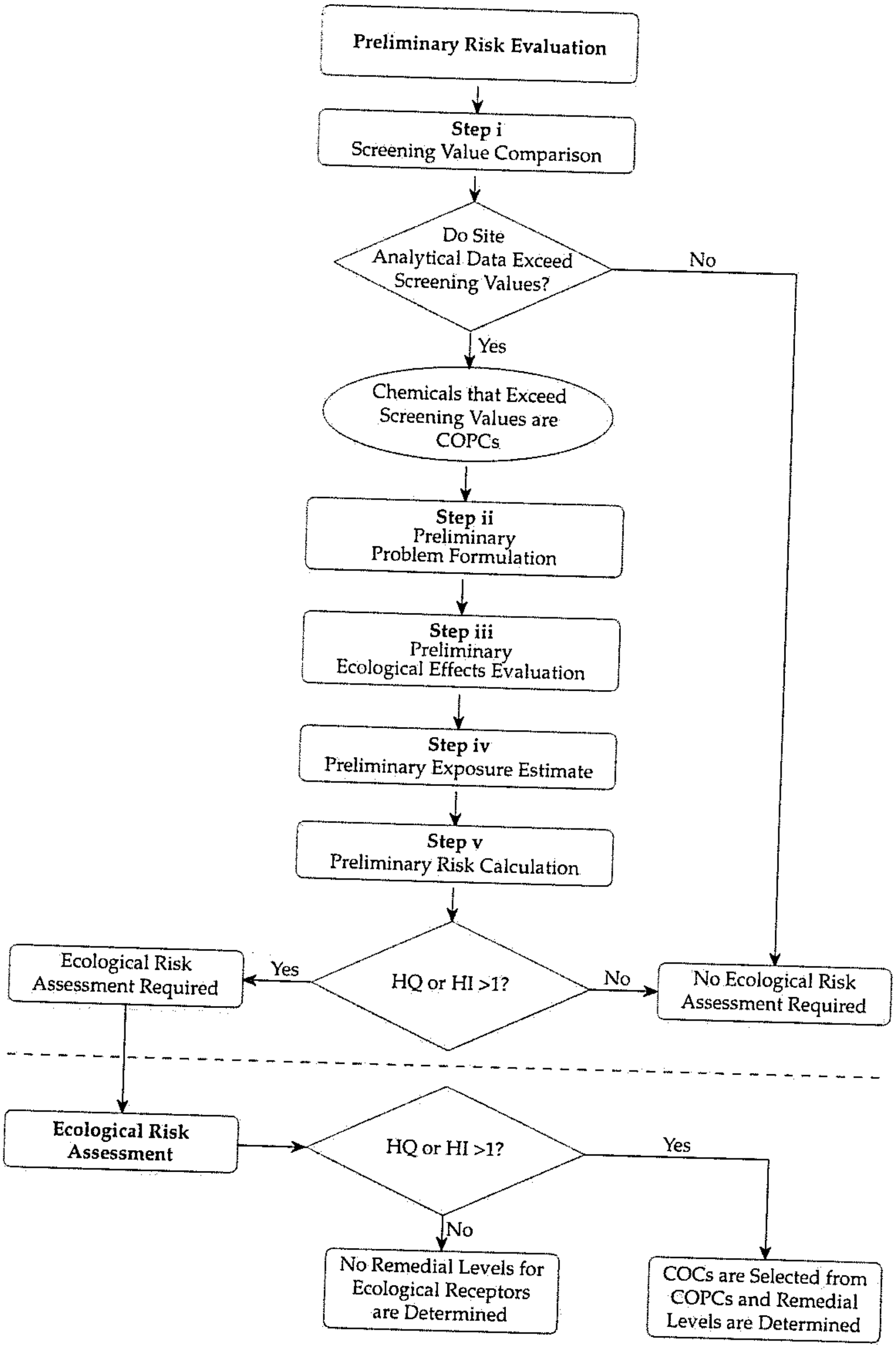

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Figure 8-1. General Process for Assessing Risk and Selecting Remedial Levels for Ecological Receptors (adapted from GEPD 1996)

COPCs identified in the PRE screen for groundwater are considered, as well as all analytes detected in soil. Preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors are selected for evaluation in the preliminary risk calculation.

GEPD (1996) specifies that the PRE develop "risk characterization for a model ecological receptor." Developing risk characterization for multiple ecological receptors, e.g., mammals and birds, is allowable for sites where more than one type of potentially hazardous chemical is detected (GEPD 1997b). Characterizing the risk to multiple receptors, where each may be more sensitive to one or more chemical contaminant, can make the PRE more protective of ecological resources. At the Burn Pits A through F, the risk characterization for surface soil considers both mammals and birds as ecological receptors.

Environmental Setting

The Burn Pits A through F are located in the area surrounding the cantonment, or garrison, area of the FSMR (Figure 2-3). This area of the FSMR is used for ranges and training areas or held as non-use areas. The open range and training areas comprise 11 percent of the base and consist of grasses, shrubs, and scrub oak.

Sixty-six percent of the approximately 367.2 square miles of forest in the FSMR is pine, with the major species being slash pine, loblolly pine *(Pinus taeda)*, and longleaf pine *(P. palustris)*. The remainder of FSMR forests is composed of river bottomlands and swamps, whose major species include tupelo, other gum trees, water oak, and bald cypress trees. The understory of the pine forest is saw-palmetto *(Serenoa repens)* and is managed by controlled burning, as evidenced by the presence of burn marks on the mature trees.

The terrestrial habitat in the vicinity of the Burn Pits A through F consists primarily of palmetto-pine forest. The individual burn pits are in various phases of succession from deforested open grassy areas, through shrub and scrub oak to the surrounding pine forest community.

The principal surface water body receiving drainage from the FSMR is the Canoochee River, which joins the Ogeechee River (part of the northwestern boundary of the reservation). The individual Burn Pit sites are located within different subwatersheds (Figure 2-3). Burn Pits A through D are located west of the garrison area within the Taylors Creek watershed; drainage from these sites is collected by Mill Creek and Horse Creek tributaries that discharge into Taylors Creek, which in turn discharges into Canoochee Creek. Canoochee Creek is a tributary of the Canoochee River that drains much of the western portion of the FSMR. Burn Pit E is located near the Canoochee River; drainage from the site is collected in small unnamed streams that discharge directly to the Canoochee River. Burn Pit F is located south of Savannah Road in the Peacock Creek watershed. Drainage from the Burn Pit F site flows into Goshen Swamp, which discharges southward into Peacock Creek and, ultimately, into the Jerico River.

Numerous mammals and birds were noted by SAIC field personnel while conducting the field investigations at the former burn pits. The red-headed woodpecker *(Melanerpes eryhrocephalus)* and the turkey vulture *(Cathartes aura)* were observed by SAIC personnel on numerous occasions. Scat or tracks of white-tailed deer *(Odocoileus virginianus)*, coyote *(Canis latrans)*, armadillo *(Dasypus novemcinctus)*, and raccoon *(Procyon lotor)* were noted by SAIC field personnel.

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Surface Soil at Burn Pits A through F

The PRE for surface soil (0 to 1 foot) at the Burn Pits A through F evaluates the potential for risk to ecological receptors from ecological COPCs detected at surface soil sampling locations at each of the Burn Pits. All analytes detected in surface soil are ecological COPCs because there are no EPA Region 4 ESVs for soil.

The categories of ecological receptors that are potentially directly exposed to substances in surface soil at the Burn Pits A through F are soil bacteria and fungi, vegetation, and animals that come in direct contact with or ingest soil, e.g., soil-dwelling invertebrates. Other categories of receptors are potentially exposed indirectly to soil contaminants that are taken up and stored in the cells or tissues of those organisms that are directly exposed. Herbivorous invertebrates (e.g., insects) and vertebrates (e.g., birds and mammals) are potentially indirectly exposed when they ingest vegetation growing in contaminated soil. Carnivorous animals are potentially exposed when they ingest animals exposed directly or indirectly to contaminated soil.

Nine substances from two broad categories of chemicals were detected above background criteria in surface soil samples from one or more of the Burn Pits A through F: 15 RCRA metals and 3 SVOCs. Based on the greater amount of published data on the effects of these nine substances on vertebrate wildlife, mammals and birds in particular, and the potential for three of the metals to biomagnify in soil-dwelling invertebrates (cadmium, lead and mercury), the proposed ecological receptors for soil at the Burn Pits A through F are carnivorous small mammals and birds that prey upon soil-dwelling invertebrates.

The preliminary assessment endpoint for soil at the Burn Pits A through F is protection of small mammals and bird populations from adverse effects. The surrogate species to represent the generic small mammal and bird receptors are the short-tailed shrew (*Blarina brevicauda*) and the American robin (*Turdus migratorius*). The home range of the shrew is small, and robins are territorial during the spring mating season. Earthworms and other soil-dwelling invertebrates represent a large percentage of both species' diets. The life history and behavior of these two surrogate species ensure a conservative estimate of risk.

Groundwater at Burn Pits A through F

The PRE for the Burn Pits A through F screens groundwater for exposure to ecological COPCs per GEPD (1996) and EPA Region 4 (1995) guidance. However, groundwater is not evaluated further in the PRE for the Burn Pits because ecological receptors are not likely to be exposed to groundwater at these sites. There are no surface water bodies in the vicinity of any of the Burn Pits. Also, groundwater contaminants are not expected to migrate from the Burn Pits because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit soils. Therefore, migration of contaminants to surface waters via groundwater discharge is not a complete exposure pathway, and PRE steps ii through v are not conducted for groundwater.

8.1.3 Preliminary Effects Evaluation (Step iii)

The preliminary ecological effects evaluation (Step iii) identifies toxicity reference values (TRVs) for use in the preliminary risk calculation. TRVs are derived from no observed adverse effect levels (NOAELs) from laboratory toxicity studies on test species from groups closely related to the surrogate species (EPA 1996a).

In the PRE for the Burn Pits A through F, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the Burn Pits. For these receptors, TRVs are expressed as threshold concentrations of the contaminant in the soil. The TRVs for ecological receptors exposed by ingestion of ecological COPCs in soil are calculated from dietary limit concentrations corresponding to the NOAEL doses. Dietary limit concentrations (mg/kg) are calculated from the NOAEL (mg/kg/d) by multiplying by the body weight (kg) and dividing by the ingestion rate (kg/d). That is,

$$\text{dietary limit concentration} = \text{NOAEL} \times \text{body weight/ingestion rate.}$$

NOAELs and dietary limits for surrogate species are reported in Sample et al. (1996).

For shrews and robins, which are exposed indirectly by ingestion of biota, the maximum detected soil concentration is compared to the threshold soil concentration (i.e., the TRV), which is calculated as the dietary limit concentration associated with the NOAEL dose divided by the unitless bioaccumulation factor (BAF) for the contaminant in the tissue of the ingested soil-dwelling biota. That is,

$$\text{HQ} = \text{maximum soil concentration (mg/kg)} \times \text{BAF/dietary limit concentration (mg/kg).}$$
$$\text{HQ} = \text{maximum soil concentration (mg/kg)/dietary limit concentration (mg/kg)/BAF.}$$

This approach to calculating and presenting TRVs allows direct comparison of measured concentrations of COPCs in the abiotic media against the abiotic media concentration assumed to be protective of the ecological receptor by virtue of its equivalence to the NOAEL.

If toxicity data are not available for the surrogate species, data for a test species of the same taxonomic class may be used and adjusted for the body weight of the surrogate species; i.e., mammal test species data are used for mammal surrogate species, bird test species data are used for bird surrogate species. NOAELs for test species based on daily dose (mg/kg body weight/day) are adjusted to surrogate species based on body weight, according to the following equation:

$$\text{surrogate species NOAEL} = \text{test species NOAEL x } (bw_{ts}/bw_{ss})^z,$$

where bw_{ts} and bw_{ss} are the body weights (kg) of the test species (ts) and surrogate species (ss), respectively, and $z = 0.25$ for mammals (EPA 1997) and $z = 0$ for birds (Sample et al. 1996). For example, the published NOAEL for a chemical might be based on data for a 0.35-kg rat. The NOAEL for a 0.022-kg field mouse would be nearly 2 times larger than the rat NOAEL. If a NOAEL is not available for a contaminant, a concentration associated with the lowest observed adverse effect level (LOAEL) divided by a conservative uncertainty factor of 10 (LOAEL/10) will be used as the screening value (EPA 1996a). If neither a NOAEL nor LOAEL is available for a contaminant, a TRV for a similar contaminant divided by an uncertainty or 'safety' factor of 10 may be used as a surrogate TRV (GEPD 19976a).

The TRVs derived for shrews and robins for ecological COPCs detected in soil at Burn Pits A through F are presented in Table 8-1. There are mammal and bird TRVs for seven of eight RCRA metals, silver being the exception. For organic ecological COPCs, there is only one TRV, and that is for shrews for benzo(a)pyrene. Surrogate TRVs are derived for benzo(b)fluoranthene and fluoranthene by dividing the benzo(a)pyrene TRV by an uncertainty factor of 10. There are no TRVs for birds exposed to organic contaminants.

Table 8-1. Derivation of Toxicity Reference Values for Ecological COPCs in Soil, Burn Pits A through F, Fort Stewart

Analyte	NOAEL[a] (mg/kg BW/d)		Dietary Limit[b] (mg/kg)		Earthworm BAF[c]	TRV (mg/kg)	
	Shrew	Robin	Shrew	Robin		Shrew	Robin
Inorganics							
Arsenic	0.15	5.1	0.25	4.3	0.0066	37.9	651.5
Barium	11.8	20.8	19.7	17.2	0.0075	2627	2293
Cadmium	2.12	1.45	3.5	1.2	11	0.321	0.109
Chromium	6015	1.0	10026	0.83	0.16	62663	5.2
Lead	17.6	1.13	29.3	0.94	0.4	73.3	2.35
Mercury[d]	2.9	0.45	4.8	0.37	0.34	14.1	1.1
Semivolatile Organic Compounds							
Benzo(a)pyrene	1.19	-	1.98	-	0.05	39.6	-
Benzo(b)fluoranthene	-	-	-	-	0.05	3.96[e]	-
Fluoranthene	-	-	-	-	0.05	3.96[e]	-

[a] Sample et al. (1996).

[b] Dietary Limit = NOAEL x BW (kg)/Food Ingestion Rate (kg/d); see Table 8-2 for BW and Food Ingestion Rate.

[c] Earthworm BAFs from HAZWRAP (1994); lead BAF assumes calcium concentration >500 mg/kg and lead concentration >1 mkg/kg.

[d] Assumed to be mercuric chloride.

[e] Surrogate value = benzo(a)pyrene TRV × 0.1.

COPCs = Chemicals/Contaminants of Potential Concern.

NOAEL = No Observed Adverse Effect Level.

TRV = Toxicity Reference Value = Dietary Limit/$\text{BAF}_{\text{earthworm}}$.

- = No data to derive TRV.

8.1.4 Preliminary Exposure Estimate (Step iv)

The preliminary exposure estimate (Step iv) evaluates the potential pathways of exposure appropriate to the preliminary assessment endpoints and ecological receptors at Fort Stewart SWMUs. Exposure factors are selected for receptors likely to be exposed to ecological COPCs in groundwater or surface water by ingestion of contaminated groundwater or soil and biota exposed to contaminated soil.

The exposures of the surrogate species for the Burn Pits A through F are estimated using conservative assumptions. It is assumed that the surrogate species at each Burn Pit spend their entire lives and obtain 100 percent of their diet or drinking water from that area, i.e., the area use factor (AUF) equals 1. Shrews and robins are assumed to eat only soil-dwelling invertebrates, such as worms, that bioaccumulate contaminants from soil, in accordance with guidance that the screen be based on exposure through two trophic transfers (EPA 1997, GEPD 1997b). Contaminants are assumed to bioaccumulate in the soil-dwelling invertebrate prey of ecological receptors at levels equal to published BAFs for earthworms and other invertebrates (e.g., HAZWRAP 1994). The exposure parameters for shrews and robins exposed to COPCs in soil are presented in Table 8-2.

The concentration of ecological COPCs to which endpoint receptors at the Burn Pits are directly or indirectly exposed is estimated by the maximum detected concentration at each former Burn Pit.

Table 8-2. Exposure Parameters for Surrogate Species Exposed to COPCs in Soil or Groundwater, Burn Pits A through F, Fort Stewart

Parameter	Surrogate Species	
	Shrew	**Robin**
Body Weight (kg)	0.015*	0.077*
Food Ingestion Rate (kg/d)	0.009*	0.093*
AUF	1	1
Relative Bioavailability	1	1
Diet	100 percent earthworm	100 percent earthworm
Source Medium	Surface soil	Surface soil

*Sample et al. (1996); Table B-1.
AUF = Area Use Factor.
COPCs = Chemicals/Contaminants of Potential Concern.

8.1.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses hazard quotients (HQs), the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to produce an HI. An HI greater than 1 for a category of COPCs is a useful indicator of potential risk when no individual COPC in that category has an HQ greater than 1. An HI assumes that the effects of the individual COPCs in the category are additive. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1 and when HQs are calculated for more than one chemical.

Because of uncertainties in quantifying exposure and effects, the exposure and effects assessments for the Burn Pits A through F are designed to produce HQs that minimize the probability of falsely concluding that there is no risk when, in fact, there is. Therefore, ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. To minimize the probability of falsely concluding there is risk when there is none, an ERA for those ecological COPCs with calculated HQs or HIs exceeding 1 is performed using site-specific data (GEPD 1996).

8.1.6 Uncertainties

To evaluate the uncertainty associated with preliminary HQs that exceed 1, supplemental risk calculations are presented for selected ecological COPCs identified in the PRE. Supplemental risk calculations are made using published dietary fractions of plant tissue, animal tissue, and incidental soil for shrews and robins (EPA 1993b), instead of 100 percent earthworms, and an estimated fractional absorption from ingested soil of 10 percent, instead of 100 percent absorption. Evaluating the exposure from ingested plant tissues requires uptake factors, which are similar to BAFs for animal tissue, for both vegetative parts and reproductive parts of plants. Plant uptake factors are those reported in Baes et al. (1986). These adjustments to the exposure estimates are used to derive TRVs based on both published NOAELs and LOAELs. The LOAELs used to derive TRVs for the supplemental evaluation are those reported in Sample et al. (1996).

Supplemental risk calculations are presented for shrews and robins exposed to cadmium, chromium, or lead in surface soil at one or more of the six Burn Pits. The shrew dietary fractions used in the supplemental risk calculations are 13.8 percent plant vegetative parts, 86.2 percent earthworms, and an incidental soil ingestion of 13 percent of total food ingestion. The robin dietary fractions are 62.5 percent plant reproductive parts, 37.5 percent earthworms, and an incidental soil ingestion of 3.9 percent of total food ingestion. The NOAELs used to derive TRVs are those used and reported in the PRE. The LOAEL used to derive the cadmium TRV for the shrew (1.74 mg/kg) is the 10 mg/kg/d chronic cadmium chloride dose causing a 50 percent reduction in fetal rat survival. This level of reproductive effect may not be ecologically significant for small mammals with high fecundity, such as shrews and mice. The LOAEL used to derive the cadmium TRV for the robin (3.9 mg/kg) is the 20 mg/kg/d chronic cadmium chloride dose causing a significant reduction in egg production in ducks. The LOAEL used to derive the chromium TRV for the robin (62.1 mg/kg) is the 5 mg/kg/d chronic dose causing a reduction in duckling survival. The LOAEL used to derive the lead TRV for the shrew (366.3 mg/kg) is the 80 mg/kg/d chronic lead acetate dose causing reduced offspring weight and kidney damage in young rats. The LOAEL used to derive the lead TRV for the robin (48.1 mg/kg) is the 11.3 mg/kg/d chronic lead acetate dose causing a reduction in successful quail egg hatching. These diets and LOAELs provide a lower bound on the preliminary risk estimate to compliment the conservative risk estimate reported in the PRE.

8.2 CONCLUSIONS AND RECOMMENDATIONS

A PRE is conducted for surface soil and groundwater at each individual Burn Pit site, according to GEPD (1996) and EPA (1996a) guidance, and is presented in Sections 9 through 14.

Barium, cadmium, lead, mercury, silver, and ethylbenzene are present in groundwater at one or more of the former Burn Pits at concentrations that exceed EPA Region 4 ESVs for surface water (Table 8-3). However, treating groundwater as surface water is unrealistic because there are no surface water bodies in the vicinity of any of the Burn Pits. As indicated in Section 6.0, off-site migration of these contaminants would be limited due to retardation as well as the slow movement of groundwater. Therefore, migration of contaminants to surface waters via groundwater discharge is not a complete exposure pathway for ecological receptors.

Cadmium, lead, and chromium are present in surface soil at one or more of the former Burn Pits at concentrations that exceed the TRVs for the robin and, in some cases, the shrew (Table 8-4).

Table 8-3. Summary of the Ecological COPCs Identified in EPA Region 4 Ecological Screening Value Comparison for Groundwater at Burn Pits A through F, Fort Stewart

	Burn Pits					
	A	B	C	D	E	F
Concentration Exceeds ESV	Barium Mercury Silver	Barium Cadmium Silver	Barium Cadmium Mercury	Barium Silver	Cadmium	Ethylbenzene

COPCs = Chemicals/Contaminants of Potential Concern.
EPA = U.S. Environmental Protection Agency.
ESV = Ecological Screening Value.

Table 8-4. Summary of the Preliminary Risk Evaluation for Ecological COPCs in Surface Soil at Burn Pits A through F, Fort Stewart

	Burn Pits					
	A	B	C	D	E	F
HQ > 1	Cadmium (shrew, robin) Lead (robin)	Lead (robin)	Cadmium (shrew, robin) Lead (robin)	(none)	(none)	Chromium (robin)

COPCs = Chemicals/Contaminants of Potential Concern.
HQ = Hazard Quotient.
TRV = Toxicity Reference Value.

Supplemental site-specific ecological risk evaluations are presented for Burn Pits A, B, C, and F in their individual sections. For these sites, the PRE conducted according to GEPD and EPA Region 4 guidance (GEPD 1996, EPA 1996a) identified site-related ecological COPCs in surface soil, indicating that there is a possibility of adverse effects to ecological receptors from exposure to contaminated media. Further evaluation in the uncertainty sections considers the potential for soil concentrations to exceed TRVs associated with more realistic exposure estimates and effects levels for cadmium, chromium, and lead that are associated with low-level effects. There are no ecological COPCs for Burn Pits D and E, and no further action is recommended for those sites. Based on the results of the supplemental evaluation, it is concluded that the ecological COPCs identified in the PRE do not pose a risk to ecological receptors, and no further action is recommended for Burn Pits A, B, and F. These recommendations are made in the individual sections for each Burn Pit and are summarized in Section 15.0.

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9.0 CHARACTERIZATION OF BURN PIT A (SWMU 4A)

9.1 HISTORY AND DESCRIPTION OF BURN PIT A

Burn Pit A (SWMU 4A) comprises approximately 2.3 acres and is located on Fort Stewart Route 38, approximately 1200 feet southwest from its junction with Fort Stewart Route 40. The site is essentially flat and surrounded by woods. Sparse grass currently covers the area. Burn Pit A is currently being used as a staging area for (1) the Rail Marshaling Area and (2) the Tank Commander's Course.

The elevation of the site varies between approximately 69 and 73 feet above mean seal level (amsl) (Figure 9-1). Surface (overland) drainage occurs through overland flow radially to the west, north, and east. A roadside ditch south of the site captures runoff from the road, but does not receive runoff from the site. An unnamed tributary of Taylors Creek lies approximately 500 feet west of the site, and Mill Creek, also a tributary of Taylors Creek, lies approximately 1500 feet east of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 9-1). VOCs, including acetone and PCE, and RCRA metals, including barium and lead, were detected above site-specific background levels in soils. VOCs, including carbon disulfide, benzene, and acetone, and RCRA metals, including arsenic, selenium, chromium, lead, and mercury, were detected above site-specific background levels in groundwater.

During the Phase II RFI activities, one additional downgradient monitoring well (MW-5) was nstalled, and three soil borings (SB-1 through SB-3) were drilled at the site (Figure 9-1). These wells and borings were used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of slightly silty sands. Geologic cross-sections of the Burn Pit A site are presented in Figures 9.2 and 9.3. Geotechnical parameters were measured in a bulk soil sample taken from MW-5 at a depth of 4.5 to 6.5 feet and in a Shelby tube sample taken from boring SB-2 at a depth of 9.5 to 11.5 feet. The results of the geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic sands with less than 6 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from SB-2, is 1.73×10^{-3} cm/second, typical for a fine sand.

Water levels in the monitoring wells were measured during well development between July 16 and 30, 1997, and again during well sampling between August 6 and 13, 1997. The water table is present at a depth between 5 and 12 feet bgs. A water table contour map is provided as Figure 9-4. Groundwater contours measured during the Phase I RFI activities in August 1993 indicate similar groundwater elevations and flow directions. The shallow groundwater flow across the site is to the east, discharging ultimately to Mill Creek, which is located approximately 1500 feet east of the Burn Pit A site. The calculated horizontal hydraulic gradient across the site was 0.0083 foot/foot. Based on a hydraulic conductivity of 1.73×10^{-3} cm/second and a porosity of 0.42, the groundwater flow rate is approximately 35 feet/year towards Mill Creek.

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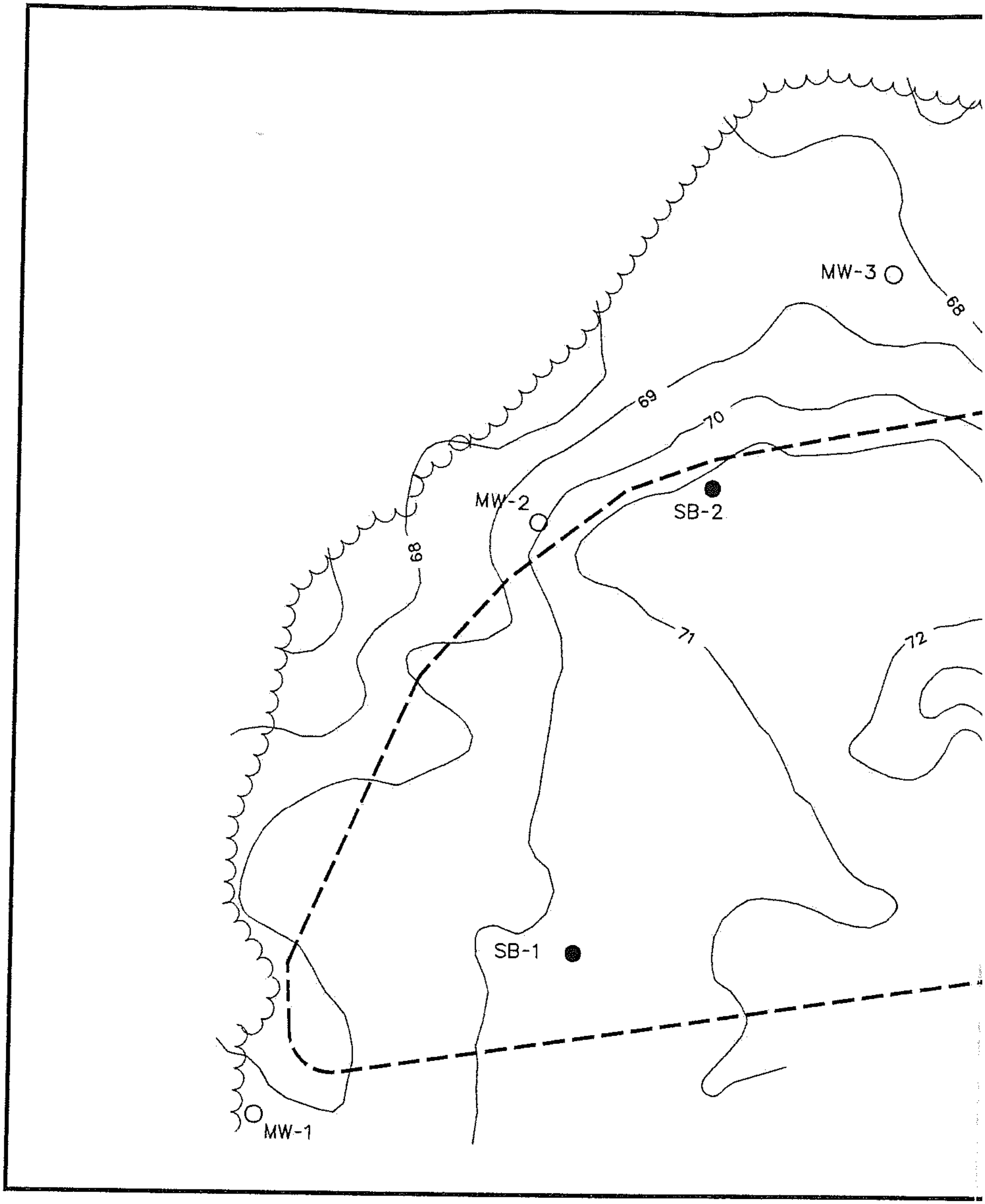

Figure 9-1. Locations of Sampling

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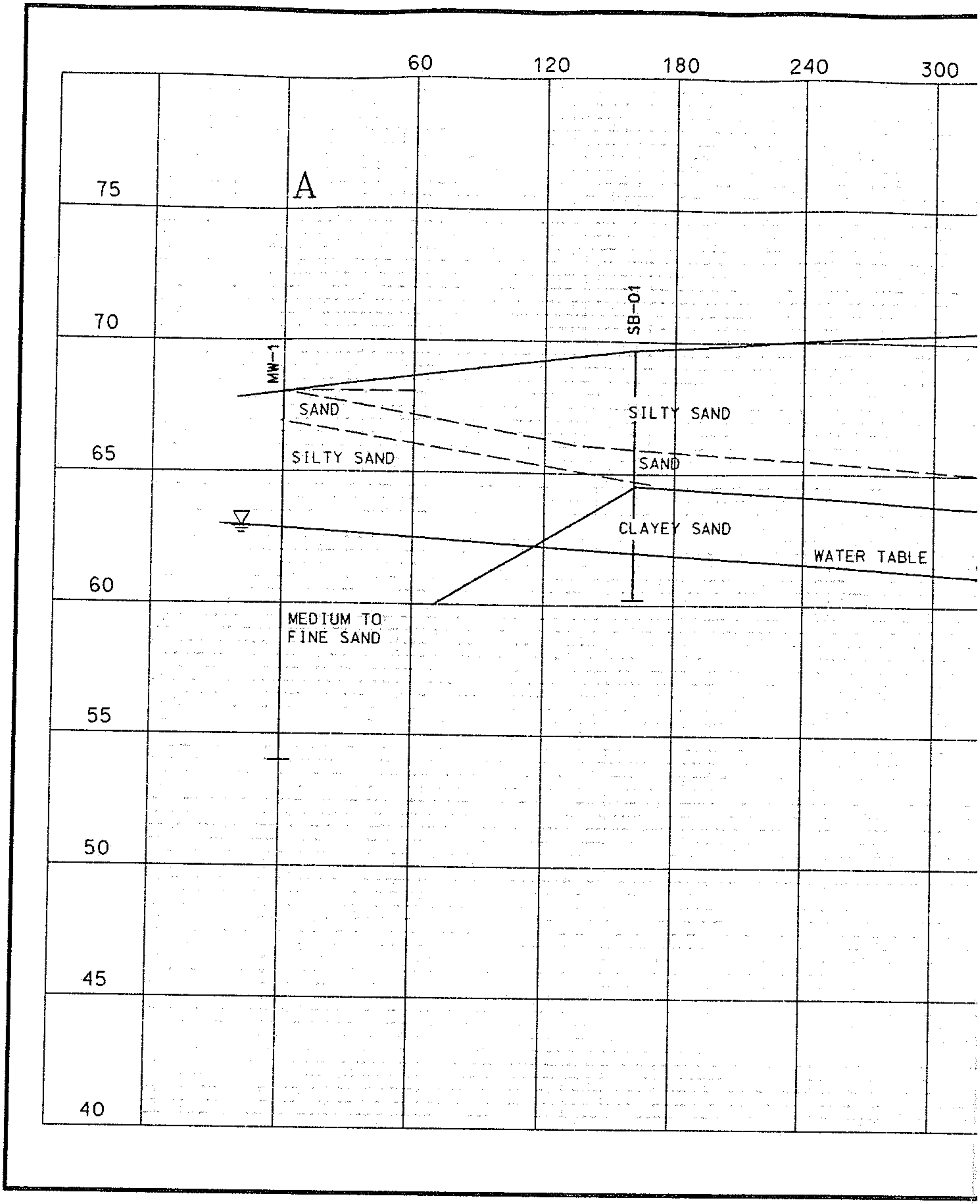

Figure 9-2. Geologic Cross-

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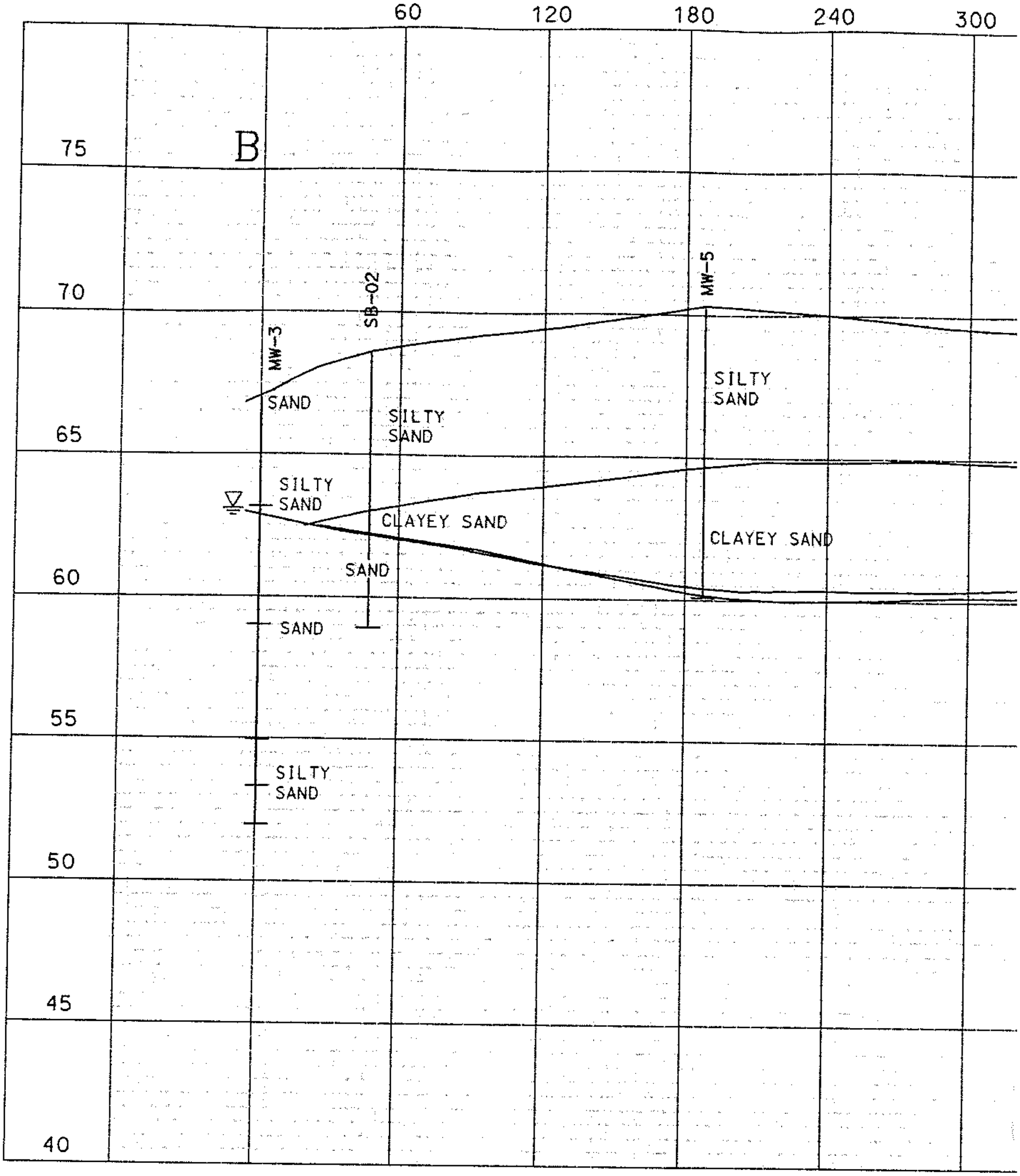

Figure 9-3. Geologic Cross-Se

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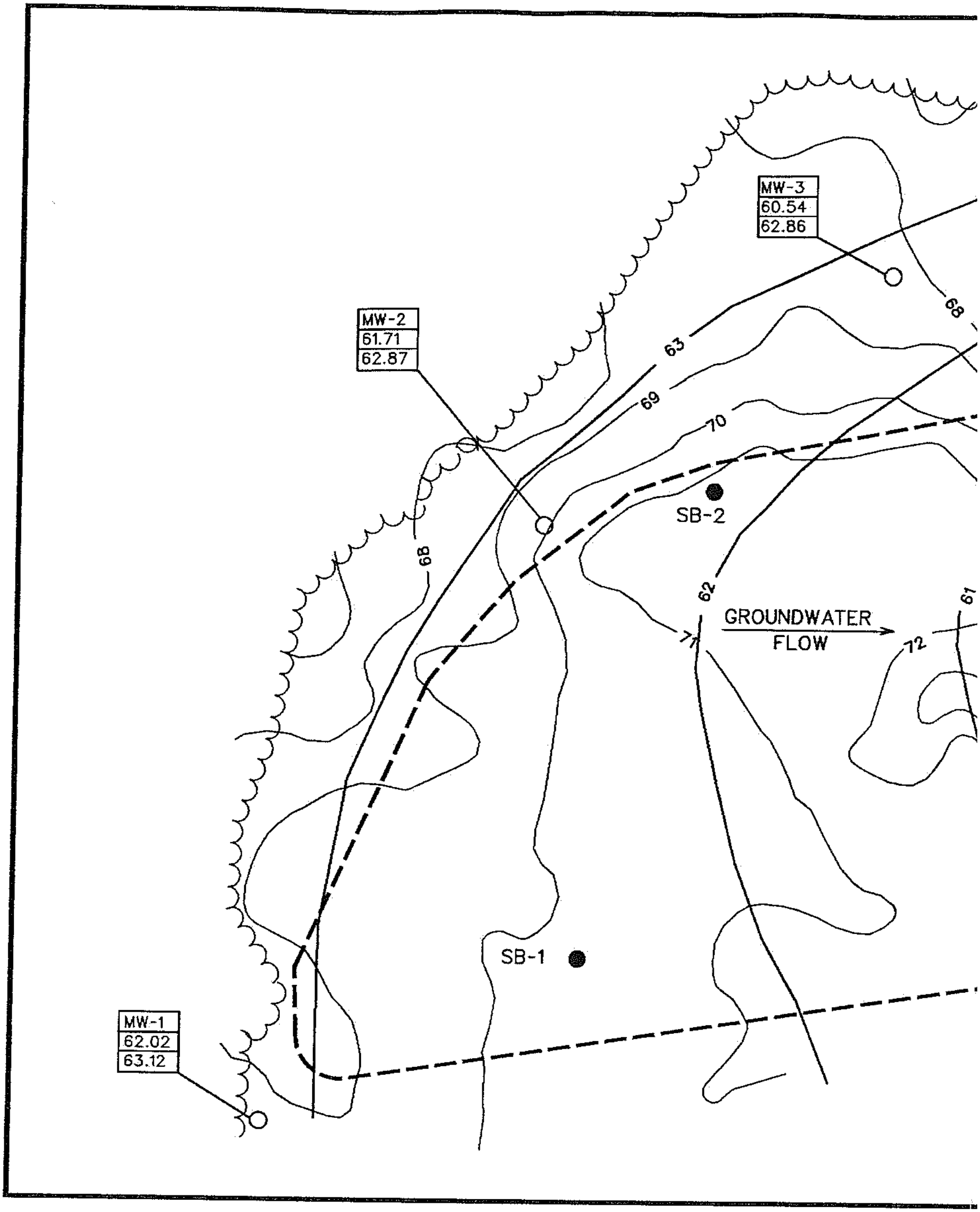

Figure 9-4. Water Table Contour Map (

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9.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT A

9.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results from four surface soil samples taken from the monitoring well MW-5 borehole and the three soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 9-1 summarizes the analytical results for surface soil samples, and Figure 9-5 shows their distribution. This assessment presents Phase II contaminant data only, because no surface soil samples were collected during Phase I.

Table 9-1. Summary of Analytical Results for Surface Soils, Burn Pit A, Fort Stewart

Parameter	Reference Background	Phase II Samples SB-1 4A1111 07/11/97 (0-1 foot)	SB-2 4A1211 07/12/97 (0-1 foot)	SB-3 4A1311 07/11/97 (0-1 foot)	MW-5 4A1511 07/11/97 (0-1 foot)
RCRA Metals (mg/kg)					
Arsenic	2.1		0.99		**2.5**
Barium	14.7	4.5	**18.8**	8	8.6
Cadmium	0.18		**0.36**		0.15
Chromium	6.21	2	3.5	2.5	3.7
Lead	8.81	2.6	**10.4**	5.3	8.8
Mercury	0.03	0.02	**0.04**	**0.04**	**0.04**

Note: A blank indicates analyte not detected.
Note: **BOLD** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

SVOCs. No SVOCs were reported above the detection limit in surface soil samples.

RCRA metals. Analytical results were compared to the soil reference background concentrations presented in Section 5.0. Only those metals that exceeded their respective background concentrations are considered SRCs. Three metals have been identified as SRCs in surface soils, and they include arsenic (maximum 2.5 mg/kg at MW-5), barium (maximum 18.8 mg/kg at SB-2), cadmium (maximum 0.36 mg/kg at SB-2), lead (maximum 10.4 mg/kg at SB-2), and mercury (maximum 0.04 mg/kg at SB-2, SB-3, and MW-5).

9.2.2 Subsurface Soil Contamination

Subsurface soil samples were collected from all five monitoring well boreholes and the three soil borings. The samples were analyzed for VOCs and RCRA metals. Table 9-2 summarizes analytical results for the subsurface soil samples, and Figure 9-6 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. BTEX compounds were identified in both Phase I and Phase II subsurface soil samples. Maximum concentrations of benzene (28 µg/kg), toluene (12 µg/kg), and xylenes (8.5 µg/kg) were reported at MW-4 during Phase I. Lower concentrations of BTEX were reported at MW-1, MW-2, and SB-2.

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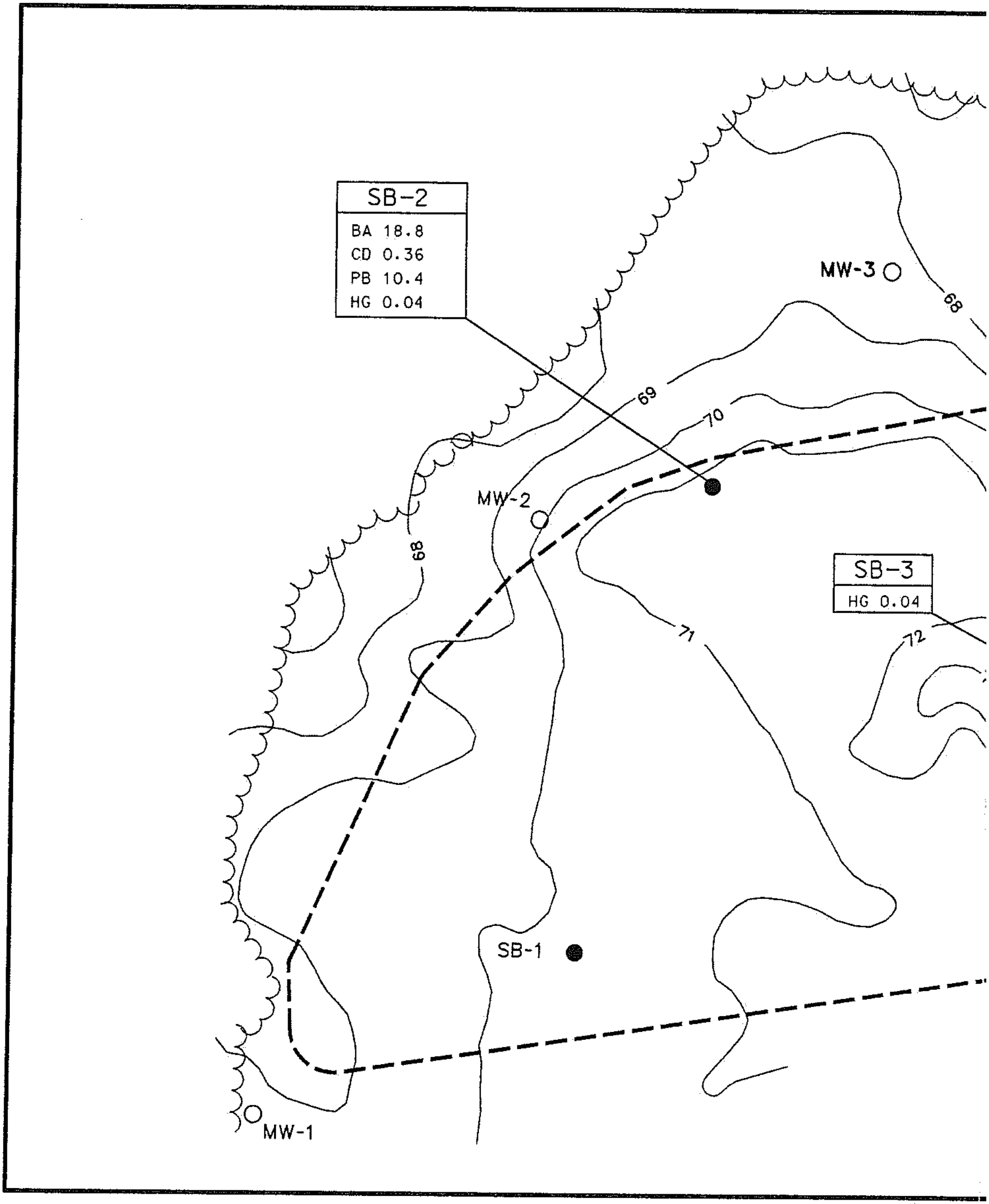

Figure 9-5. Results of Analyses in Sur

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Table 9-2. Summary of Analytical Results for Subsurface Soils
Burn Pit A, Fort Stewart

Parameter	Reference Background	Phase I Samples				Phase II Samples			
		MW1 SL1-6 06/25/93 (4-6 feet)	MW2 SL2-4 06/25/93 (2-4 feet)	MW3 SL3-4 06/25/93 (2-4 feet)	MW4 SL4-8 06/25/93 (6-8 feet)	MW5 4A1512 07/11/97 (7-9.5 feet)	SB-1 4A1112 07/11/97 (2.5-4.5 feet)	SB-2 4A1212 07/12/97 (4.5-7 feet)	SB-3 4A1312 07/11/97 (5-7.5 feet)
Volatile Organic Compounds (ug/kg)									
2-Butanone	0.0							**2.4**	
Acetone	0.0		**63**					**4.5**	
Benzene	0.0				**28**				
Tetrachloroethene	0.0	**6.1**	**8.8**						
Toluene	0.0	**8.1**			**12**			**4**	
Xylenes, Total	0.0	**6.1**	**8.2**		**8.5**				
RCRA Metals (mg/kg)									
Arsenic	8.04							0.5	
Barium	17.00	5.7	6.5	1.4	6.4	2.4	4.9	5.8	3.9
Chromium	11.60	9	2.5	0	6.4	0.6	1.3	2.2	1.5
Lead	11.10	9.4	4	1.5	**12**	1.3	2.4	1.9	3
Mercury	0.05		0.018	0.017	0.016		0.04	0.01	0.04
Other Inorganics (mg/kg)									
Total Organic Carbon	2,200.00							**3210**	

Note: A blank indicates analyte not detected.
Note: BOLD font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

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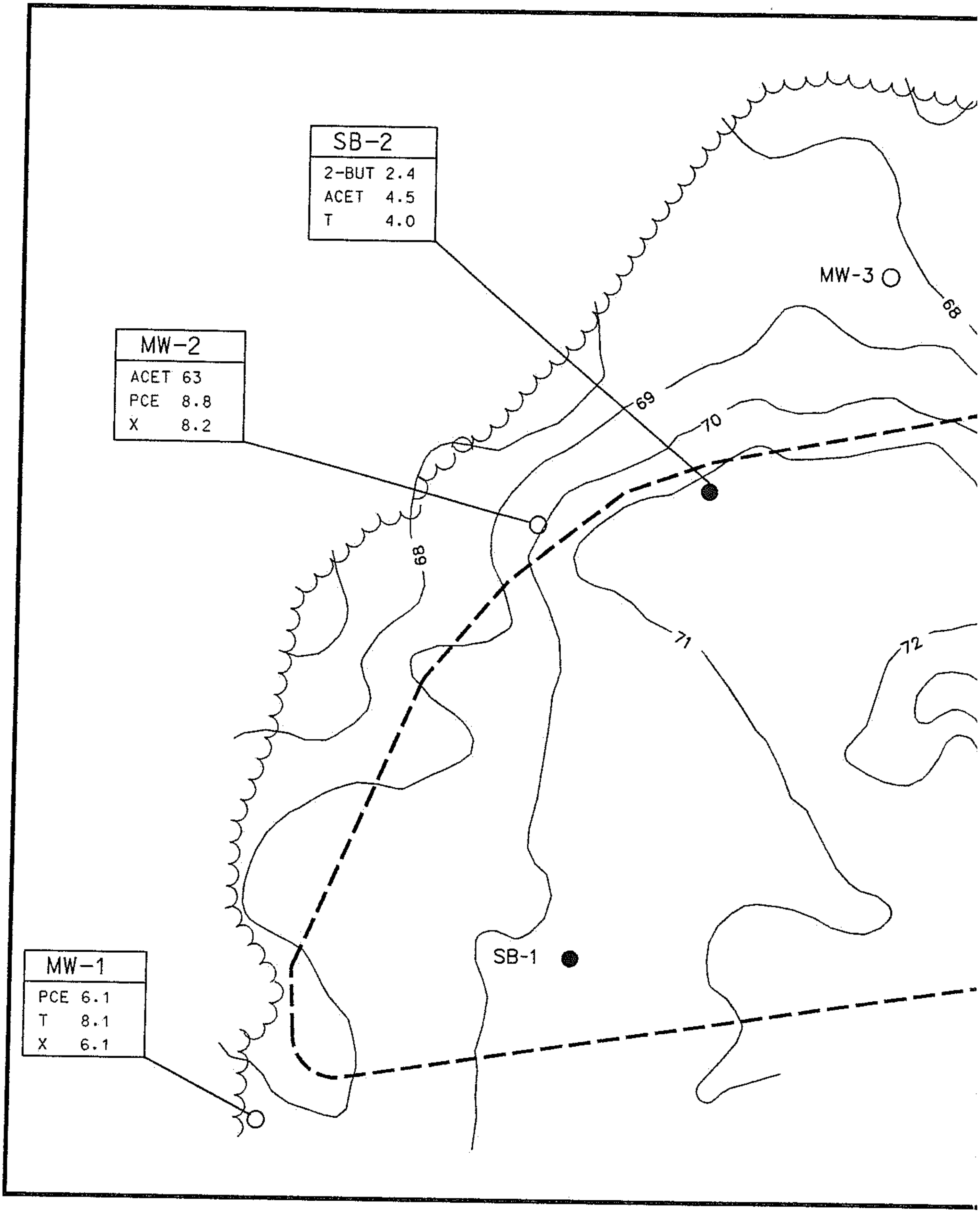

Figure 9-6. Results of Analyses

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PCE was reported in two Phase I samples at a concentration of 8.8 µg/kg at MW-2 and 6.1 µg/kg at MW-1. PCE was not detected in the Phase II soil samples. Acetone and 2-butanone were detected at MW-2 and SB-2 at concentrations at or below their average concentration in background samples and are, therefore, not considered site related.

RCRA metals. Only one metal was reported at a concentration above its reference background value. The maximum value of lead (12 mg/kg at MW-4) was reported at a concentration above background in only a single Phase I soil sample. Therefore, lead does not appear to be due to releases that may have occurred from site-related activities.

9.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples taken from the four monitoring wells installed during Phase I (MW-1 through MW-4) and one well (MW-5) installed during the Phase II field work at the site. These samples were analyzed for VOCs and RCRA metals. Both filtered and unfiltered water samples were collected; only the total metal analysis on unfiltered water samples is presented in this section. Table 9-3 summarizes the analytical results for groundwater samples, and Figure 9-7 shows their distribution. This assessment focuses on the Phase II contaminant data, because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 9-3. Summary of Analytical Results for Groundwater, Burn Pit A, Fort Stewart

Parameter	Reference Background	MCL	Phase II Groundwater Samples				
			MW-1 4A4111 08/08/97	MW-2 4A4211 08/07/97	MW-3 4A4311 08/07/97	MW-4 4A4411 08/08/97	MW-5 54A4511 08/13/97
RCRA Metals (µg/L)							
Arsenic	3.02	50				1.5	
Barium	71.72	2000	18.5	63.5	26.2	**97.5**	66.7
Cadmium	0.43	5	0.34		0.36		
Chromium	3.56	100	2.4			1.5	
Lead	4.69	15	1.1	3.3	1.8		0.82
Mercury	0.14	2		**0.2**	**0.22**		
Selenium	1.9	50					0.7
Silver	1.12	--	0.14	0.44	0.28	**1.6**	

Note: A blank indicates analyte not detected.
Note: **BOLD** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.
-- = No MCL available.

VOCs. No VOCs were reported above the detection limit in Phase II groundwater samples. During Phase I, benzene was reported in MW-4 at a concentration of 51.8 µg/L; this benzene contamination was not confirmed by the Phase II data. Although carbon disulfide and acetone were also detected in Phase I, these analytes are common laboratory artifacts and were not found in Phase II samples.

RCRA metals. Analytical results were compared to the reference groundwater background concentrations presented in Section 5.0. Only those metals that exceed their respective background concentrations are considered SRCs. Barium was reported at a maximum

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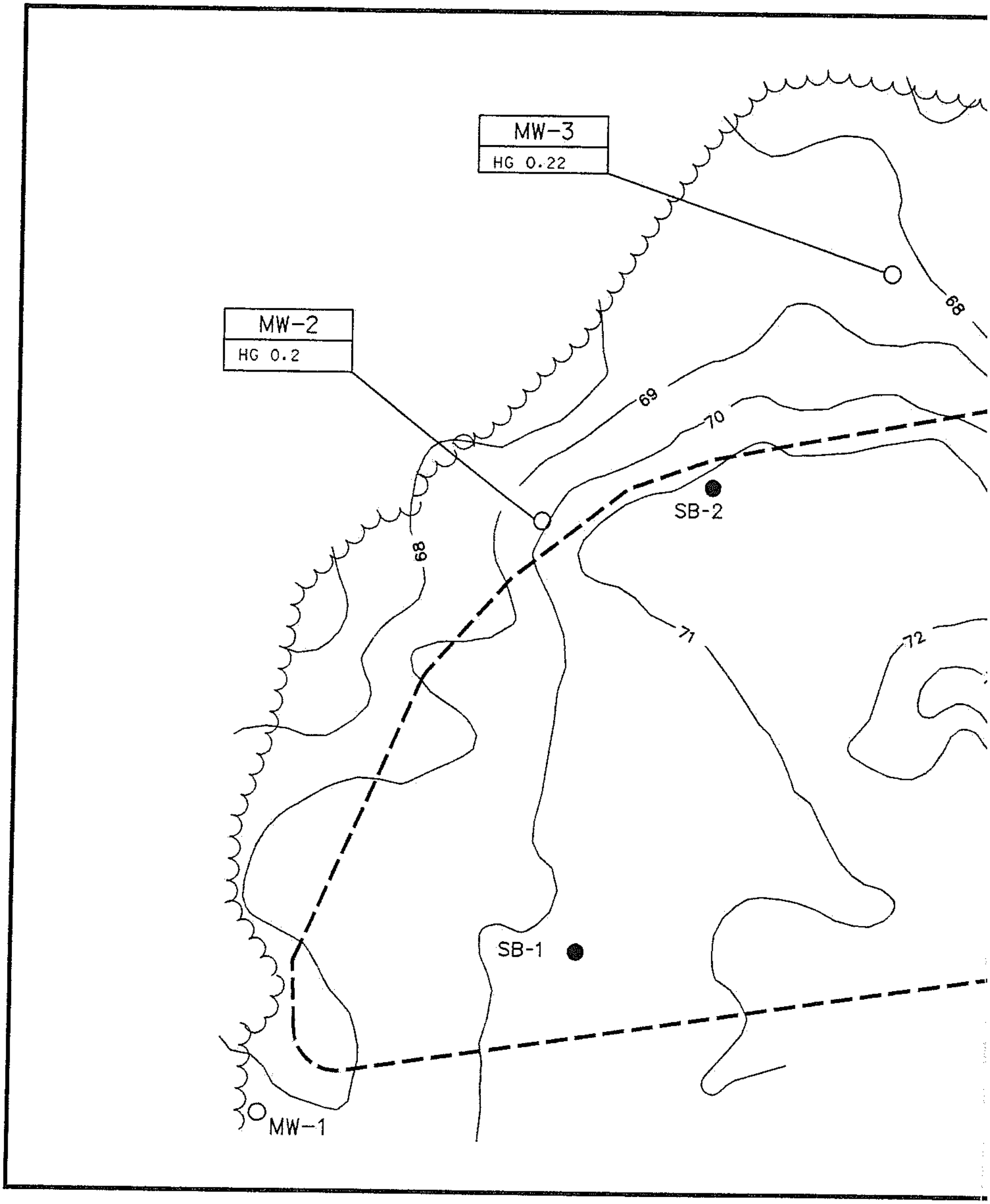

Figure 9-7. Results of Analyse

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concentration in a single groundwater sample from MW-4 (97.5 µg/L), which is downgradient from the site. Barium was not present at concentrations above background in any other wells.

Mercury was reported in two wells (MW-2 and MW-3) at concentrations of 0.2 and 0.22 µg/L, respectively. Silver exceeds its reference background concentration in a single well (MW-4 at 1.6 µg/L).

9.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 9-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

Table 9-4. Summary of Site-Related Constituents
Burn Pit A, Fort Stewart

Analyte	Surface Soil	Subsurface Soil	Groundwater
	(µg/kg)	(µg/kg)	(µg/L)
Acetone	na	**63**	nd
Benzene	na	**28**	nd
2-Butanone	na	**2.4**	nd
Tetrachloroethene	na	**8.8**	nd
Toluene	na	**12**	nd
Xylenes, total	na	**8.5**	nd
	(mg/kg)	(mg/kg)	(µg/l)
Arsenic	**2.5**	brc	brc
Barium	**18.8**	brc	**97.5**
Cadmium	**0.36**	nd	brc
Chromium	brc	brc	brc
Lead	**10.4**	**12**	brc
Mercury	**0.04**	brc	**0.22**
Selenium	nd	nd	brc
Silver	nd	nd	**1.6**

brc = Below background reference criteria.
na = Not analyzed in any sample in that medium.
nd = Not detected in any sample in that medium.
BOLD font indicates the analyte is an SRC in that medium.

9.3 FATE AND TRANSPORT CONSIDERATIONS AT BURN PIT A

The results of contaminant migration soil screening (discussed in Section 6.0) for Burn Pit A are presented in Table 9-5. Only benzene and PCE are identified as CMCOPCs based on leaching to groundwater. However, these constituents were not currently observed in groundwater indicating that they may be degraded before reaching the water table.

Table 9-5. CMCOPCs Based on Soil Screening for Burn Pit A

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration > GSSL?
RCRA Metals (mg/kg)			
Arsenic	2.5	29	No
Barium	18.8	1600	No
Cadmium	0.36	8	No
Lead	12.0	400	No
Mercury	0.04	0.40	No
Volatile Organic Compounds (µg/kg)			
2-Butanone	2.4	38.4	No
Acetone	63.0	800	No
Benzene	28.0	2	Yes
Tetrachloroethene	8.8	3	Yes
Toluene	12.0	600	No
Xylenes	8.5	10000	No

CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
RCRA = Resource Conservation and Recovery Act.

The predicted maximum concentration of benzene in groundwater, based on a maximum of 28 µg/kg in soil and a DAF of 1, is 70 µg/L. Through biodegradation, even if the benzene were to reach groundwater at such a concentration, it would degrade to its MCL value (5 µg/L) in less than 3.8 times its half-life. Assuming a conservative half-life of 2.0 years, the benzene would degrade to its MCL value in 7.6 years. Similarly, PCE with its predicted maximum concentration of 15 µg/L in groundwater, would degrade to its MCL in less than 1.6 times its half-life, or 7.2 years.

The maximum concentrations of benzene and PCE were reported in Phase I soil samples only and were not detected in Phase II samples. The most likely pathway of contaminant migration from Burn Pit A is via groundwater discharge to Mill Creek, located approximately 1500 feet east of the site. Based on the calculated groundwater flow velocity of 35 feet/year, the estimated arrival time for the site groundwater to reach Mill Creek is expected to be 43 years. Therefore, both benzene and PCE would degrade to below their MCLs within 300 feet of the Burn Pit A site, well before reaching Mill Creek.

Metals detected in the groundwater at this site include barium, lead, mercury, and selenium. However, the maximum concentrations of these metals do not exceed their respective MCLs and, based on fate and transport analysis, they are not expected to increase in the future. Therefore, none of the constituents is expected to be of concern for contaminant migration from Burn Pit A.

9.4 HUMAN HEALTH RISK CHARACTERIZATION OF BURN PIT A

SRCs were identified in Section 9.2 for surface soil, subsurface soil, and groundwater. The identification of risk-based screening values for all of the Burn Pits has been previously discussed in Section 7.3 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit A is given below.

9.4.1 Exposure Evaluation

This site is partially covered by vegetation. In areas where active maneuvers are taking place, the grass and other vegetation have been killed as a result of physical stress (i.e., repeated wear from tanks, vehicles, etc.). Current potential receptors would include soldiers involved in training operations at the site. Hunting is not allowed in this area; however, hunting occurs in nearby areas. Therefore, a hunter is considered to be an off-site receptor. A child may visit the site, but given the types of activity occurring in this area, frequent visits are unlikely.

Future land use at this site is unlikely to change from its current use as a training area; however, the type of training taking place may change. The current receptor populations are likely to be present in the future. Construction activities may take place at the site in the future. A construction worker would be an additional potential receptor population in the future.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current and future juvenile trespasser. The juvenile trespasser may be exposed to contaminants in surface soil. Inhalation of fugitive dust, incidental ingestion, and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Off-site hunter. The hunter may be exposed to fugitive dust and contaminants that have bioaccumulated in game.

On-site military personnel. The on-site worker may be exposed to surface soil. Inhalation of fugitive dust, incidental ingestion, and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Construction Worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

9.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals, identified as possible COPCs, are evaluated further below.

Arsenic in surface soil is the only contaminant that exceeds its risk-based screening concentration for direct exposure of a receptor population (Table 9-6). Arsenic in surface soil is a potential COPC at Burn Pit A, because it exceeds the risk-based screening value for exposure of a residential receptor. It should be noted that the maximum concentration of arsenic (2.5 mg/kg) is below the average concentration for soils in the eastern United States and only slightly exceeds reference background criteria (2.1 mg/kg) at one location, MW-5. Arsenic was not found above background in either subsurface soil or groundwater. In addition, a residential screening value was used although residential land use at this site is unlikely. Therefore, arsenic is not considered a potential threat to human health at Burn Pit A.

Table 9-6. Comparison to Action Levels–Burn Pit A, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit A Surface Soil								
Arsenic	mg/kg	2/4	0.99	2.5	2.10	0.43	Yes	Max Detect > Screening Criteria
Barium	mg/kg	4/4	4.5	18.8	14.70	550	No	Max Detect < Screening Criteria
Cadmium	mg/kg	2/4	0.15	0.36	0.18	3.9	No	Max Detect < Screening Criteria
Lead	mg/kg	4/4	2.60	10.40	8.81	400	No	Max Detect < Screening Criteria
Mercury	mg/kg	4/4	0.02	0.04	0.03	2.30	No	Max Detect < Screening Criteria
Burn Pit A Subsurface Soil								
Lead	mg/kg	7/7	1.3	12	11.1	400	No	Max Detect < Screening Criteria
2-Butanone	mg/kg	1/4	0.0024	0.0024		100,000	No	Max Detect < Screening Criteria
Acetone	mg/kg	2/7	0.0045	0.063		20,000	No	Max Detect < Screening Criteria
Benzene	mg/kg	1/7	0.028	0.028		200	No	Max Detect < Screening Criteria
Tetrachloroethene	mg/kg	1/6	0.0088	0.0088		110	No	Max Detect < Screening Criteria
Toluene	mg/kg	2/6	0.004	0.012		41,000	No	Max Detect < Screening Criteria
Xylenes, Total	mg/kg	2/6	0.0082	0.0085		100,000	No	Max Detect < Screening Criteria
Burn Pit A Groundwater								
Barium	µg/L	4/4	26.2	97.5	71.72	260	No	Max Detect < Screening Criteria
Mercury	µg/L	2/4	0.2	0.22	0.14	1.1	No	Max Detect < Screening Criteria
Silver	µg/L	3/4	0.28	1.6	1.12	18	No	Max Detect < All Screening Criteria

COPC = Chemical/Contaminant of Potential Concern.
EPA = U.S. Environmental Protection Agency.

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None of the other contaminants in surface soils, subsurface soils, or groundwater exceeded its respective risk-based screening value for direct exposure of a potential receptor population (Table 9-6).

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit A. A human health BRA is not warranted. No further action is required for protection of human health at Burn Pit A.

9.5 ECOLOGICAL RISK EVALUATION OF BURN PIT A

The ecological risk evaluation of Burn Pit A is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are considered further (PRE Steps ii through v). The results of the five steps of the PRE are reported in the following sections.

9.5.1 Ecological Screening Value Comparison (Step i)

Three RCRA metals were detected in groundwater at Burn Pit A at concentrations above reference background criteria. The results of the ecological screening value comparison for groundwater at Burn Pit A are presented in Table 9-7. Where detected in the four downgradient monitoring wells (MW-2 through MW-5), barium, mercury, and silver exceed the ESVs for those analytes. The ecological COPCs identified by the ESV comparison for groundwater at Burn Pit A are barium, mercury, and silver.

Table 9-7. EPA Region 4 Ecological Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit A, Fort Stewart

Analyte	ESV	MW-1*	MW-2	MW-3	MW-4	MW-5	Maximum
			RCRA Metals (μg/L)				
Barium	3.9[a]	**18.5 J**	**63.5 J**	**26.2 J**	**97.5 J**	**66.7 J**	**97.5 J**
Mercury	0.0123		**0.2**	**0.22**			**0.22 J**
Silver	0.012	**0.14 J**	**0.44**	**0.28**	**1.6 J**		**1.6 J**

*Upgradient monitoring well.
J = Estimated concentration.
ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1996) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
[a]Office of Solid Waste and Emergency Response Ambient Water Quality Criteria or Tier-II value (Suter and Tsao 1996).
Bold font indicates detected concentration exceeds ESV.

Although ecological COPCs are identified in groundwater at Burn Pit A when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit A. There are no surface water bodies in the vicinity of Burn Pit A. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit A soils.

Because there are no ESVs for soil, all analytes detected in soil at the Burn Pit A are evaluated further in PRE Steps ii through v.

9.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit A comprises approximately 2.3 acres (Figure 9-1). The site is essentially flat, sparsely covered with grass, and surrounded by woods. An unnamed tributary of Taylors Creek lies approximately 500 feet west of Burn Pit A, and Mill Creek, also a tributary of Taylors Creek, lies approximately 1500 feet east of the site, which is the flow direction of the surficial groundwater.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit A are described in Section 8.1.2.

9.5.3 Preliminary Effects Evaluation (Step iii)

In the PRE for Burn Pit A, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the facility. The derivations of TRVs are discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8.1.

9.5.4 Preliminary Exposure Estimate (Step iv)

Ecological receptors at Burn Pit A are likely exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews, and robins exposed to COPCs in soil are presented in Table 8-2.

9.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate an HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0 and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. The preliminary risk calculation for shrews and robins exposed to ecological COPCs detected in soil at the Burn Pit A is presented in Table 9-8. This table shows the maximum detected concentrations and the TRVs for shrews and robins. Concentrations resulting in HQs exceeding 1.0 are shown in boldface font. The ecological COPCs present in Burn Pit A surface soil at concentrations exceeding the TRVs for the surrogate species are cadmium and

lead. Both the shrew and robin are potentially at risk from cadmium in surface soil. However, cadmium was detected in a single soil sample at a concentration (0.36 mg/kg) above background (0.18 mg/kg). Therefore, cadmium may not be site related. Lead was detected in all four surface soil samples at concentrations exceeding the TRV for robins (2.35 mg/kg). However, lead was detected in a single soil sample at a concentration (10.4 mg/kg) above background (8.81 mg/kg). Therefore, lead may not be site related. An HI is not calculated for the surrogate species exposed to RCRA metals detected in surface soil, because they are assumed to have dissimilar mechanisms of toxicity.

Table 9-8. Preliminary Risk Evaluation of Ecological COPCs in Surface Soil (0 to 1 foot) at Burn Pit A, Fort Stewart

Analyte	TRV		MW-5	SB-1	SB-2	SB-3	Maximum
	Shrew	Robin					
			RCRA Metals (mg/kg)				
Arsenic	37.8	651	2.5 J		0.99 J		2.5 J
Barium	2627	2293	8.6 J	4.5 J	18.8 J	8 J	18.8 J
Cadmium	0.32	0.11	**0.15 J**		**0.36**		**0.36**
Lead	73.3	2.35	**8.8 J**	**2.6 J**	**10.4**	**5.3 J**	**10.4**
Mercury	14.1	1.1	0.04	0.02 J	0.04	0.04	0.04

COPCs = Chemicals/Contaminants of Potential Concern.
J = estimated concentration.
RCRA = Resource Conservation and Recovery Act.
TRV = Toxicity Reference Value = (NOAEL x BW/Food Ingestion)/BAF$_{earthworm}$ (see Table 8-1).
Blank cells indicate analyte not detected at location.
Bold font indicates detected concentration exceeds TRV (HQ > 1).

9.5.6 Uncertainties

The risk to ecological receptors from cadmium and lead in surface soil at Burn Pit A is overestimated by the preliminary risk calculations. The single cadmium detect in surface soil (0.36 mg/kg in SB-2) does not exceed the NOAEL-based TRV for shrews (0.365 mg/kg) calculated using published dietary fractions, and only barely exceeds that for the robin (0.284 mg/kg). Cadmium in surface soil at Burn Pit A is many times less than the LOAEL-based TRVs for shrews and robins calculated using published dietary fractions, 1.74 and 3.92 mg/kg, respectively. Likewise, lead was detected in two surface soil samples at Burn Pit A at concentrations exceeding the NOAEL-based TRV for the robin (5.89 mg/kg), but lead in Burn Pit A surface soil does not exceed the LOAEL-based TRV for the robin calculated using published dietary fractions (48 mg/kg). Therefore, cadmium and lead in surface soil at Burn Pit A are unlikely to pose a risk to ecological receptors.

9.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT A

The following are the conclusions of the Phase II RFI for Burn Pit A:

- In surface soils, arsenic, barium, cadmium, lead, and mercury were detected above background in the northern and eastern portions of the site.
- Arsenic is a potential human health COPC in surface soil at Burn Pit A because it exceeds the risk-based screening value for exposure of a residential receptor. However, the maximum concentration of arsenic is below the average concentration for regional soils, and residential land use is unlikely. Therefore, arsenic is not considered a potential threat to human health, and there are no human health COPCs in surface soil.
- Cadmium and lead are potential ecological COPCs in surface soils because they exceed the TRVs for the surrogate species (shrew and robin). However, both cadmium and lead were detected in only a single sample at a concentration above background and may, therefore, not be site related. The maximum concentration for both cadmium and lead is well within the USGS range of background concentrations for soils in the Eastern United States (2 mg/kg for

cadmium and up to 300 mg/kg for lead). The risk to ecological receptors from cadmium and lead in surface soil at Burn Pit A is overestimated by the preliminary risk calculations. As discussed in the uncertainties section (9.5.6), the maximum detected concentrations of cadmium and lead in surface soil are expected to result in exposures to the surrogate ecological receptors (shrews or robins) that are less than the lowest exposures associated with adverse effects on them (LOAEL-based TRV). Therefore, neither cadmium nor lead is considered to be an ecological COPC for Burn Pit A, and further investigation and/or evaluation of these constituents is not required.

- In subsurface soil, lead was reported in a single sample at a concentration only slightly above background. Lead is not present in a consistent pattern and is not considered site related. Similarly, BTEX compounds, PCE, 2-butanone, and acetone were identified in four of the eight subsurface soil samples, but at low concentrations that showed no consistent pattern of distribution.

- There are no human health COPCs in subsurface soil because no constituent exceeded its risk-based screening value.

- PCE and benzene are potential contaminant migration COPCs in subsurface soil because these chemicals may leach to groundwater, resulting in groundwater concentrations exceeding their respective MCLs. However, they were not detected in groundwater and were detected in only one soil sample of the seven collected. Off-site migration of these contaminants would be very limited due to retardation and biodegradation and the slow movement of groundwater. Even if these constituents were to reach groundwater at their predicted maximum concentrations, they would degrade to concentrations less than their MCLs in less than 7.6 years, and would have traveled less than 300 feet from the Burn Pit A site. Therefore, migration of these constituents is considered unlikely, and there are no contaminant migration COPCs in subsurface soil.

- In groundwater, barium, mercury, and silver were detected in separate wells at concentrations only slightly above background and, therefore, do not indicate a pattern of distribution indicating a potential release from the former Burn Pit.

- There are no human health COPCs in groundwater because no constituent exceeded its risk-based screening value or its MCL in groundwater.

- Barium, mercury, and silver are potential ecological COPCs in groundwater because they exceed the ESVs for surface water and may present a potential risk to amphibians. However, there are no surface water bodies in the vicinity of Burn Pit A, and off-site migration would be limited due to retardation and the slow movement of groundwater. Therefore, exposure of ecological receptors to these metals in surface water bodies downgradient from Burn Pit A is not a complete pathway. Thus, no constituent in groundwater is considered a threat to ecological receptors and there are no ecological COPCs in groundwater.

The following are the recommendations for Burn Pit A:

1. No further action is recommended for Burn Pit A.
2. All potential human health COPCs were eliminated for Burn Pit A (Section 9.4), and a BRA is not recommended for the site.
3. All potential ecological COPCs were eliminated for Burn Pit A (Section 9.5), and an ERA is not recommended for the site.

10.0 CHARACTERIZATION OF BURN PIT B (SWMU 4B)

10.1 HISTORY AND DESCRIPTION OF BURN PIT B

Burn Pit B (SWMU 4B) comprises approximately 1 acre and is located on Fort Stewart Route 90, approximately 200 feet northeast from its junction with the cut-off to State Route 196. The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees.

The site is generally flat, with elevations varying between approximately 75 and 78 feet amsl (Figure 10-1). A large pile of wood stumps and logs about 4 feet high is present in the southern portion of the site, which prevented drilling of borings beneath the pile. Drainage occurs through overland flow radically in all directions. The closest surface stream to the site is Horse Creek, a tributary of Taylors Creek, which lies approximately 4500 feet east of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 10-1). VOCs, including acetone and PCE, and RCRA metals, including arsenic, barium, chromium, lead, and mercury were detected above site-specific background levels in soils. VOCs were not detected in groundwater samples above detection limits. RCRA metals detected above site-specific background levels in groundwater included chromium and lead.

During the Phase II RFI activities, three soil borings (SB-1 through SB-3) were drilled at the site (Figure 10-1). These borings, together with the Phase I wells, were used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of slightly silty sands. Geologic cross-sections of the Burn Pit B site are presented in Figures 10-2 and 10-3. Geotechnical parameters were measured in a Shelby tube sample taken from boring SB-3 at a depth of 13 to 15 feet. The results of the Geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic sands with less than 4 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from SB-3, is 7.07×10^{-4} cm/second, typical for a fine sand.

Water levels in the monitoring wells were measured during well development on July 23, 1997, and again during well sampling between August 8 and 10, 1997. The water table is present at a depth between 3 and 6 feet bgs. A water table contour map is provided as Figure 10-4. Groundwater contours measured during the Phase I RFI activities in August 1993 indicate similar groundwater flow directions and gradients, although water levels were generally 5 feet lower in August 1993 than measured in August 1997. The shallow groundwater flow across the site is to the east, discharging ultimately to Horse Creek, which is located approximately 4500 feet east of the Burn Pit B site. The water table is very flat, with a calculated horizontal hydraulic gradient across the site of 0.0006 foot/foot. Based on a hydraulic conductivity of 7.07×10^{-4} cm/second and a porosity of 0.365, the groundwater flow rate is approximately 1.2 feet/year toward Horse Creek.

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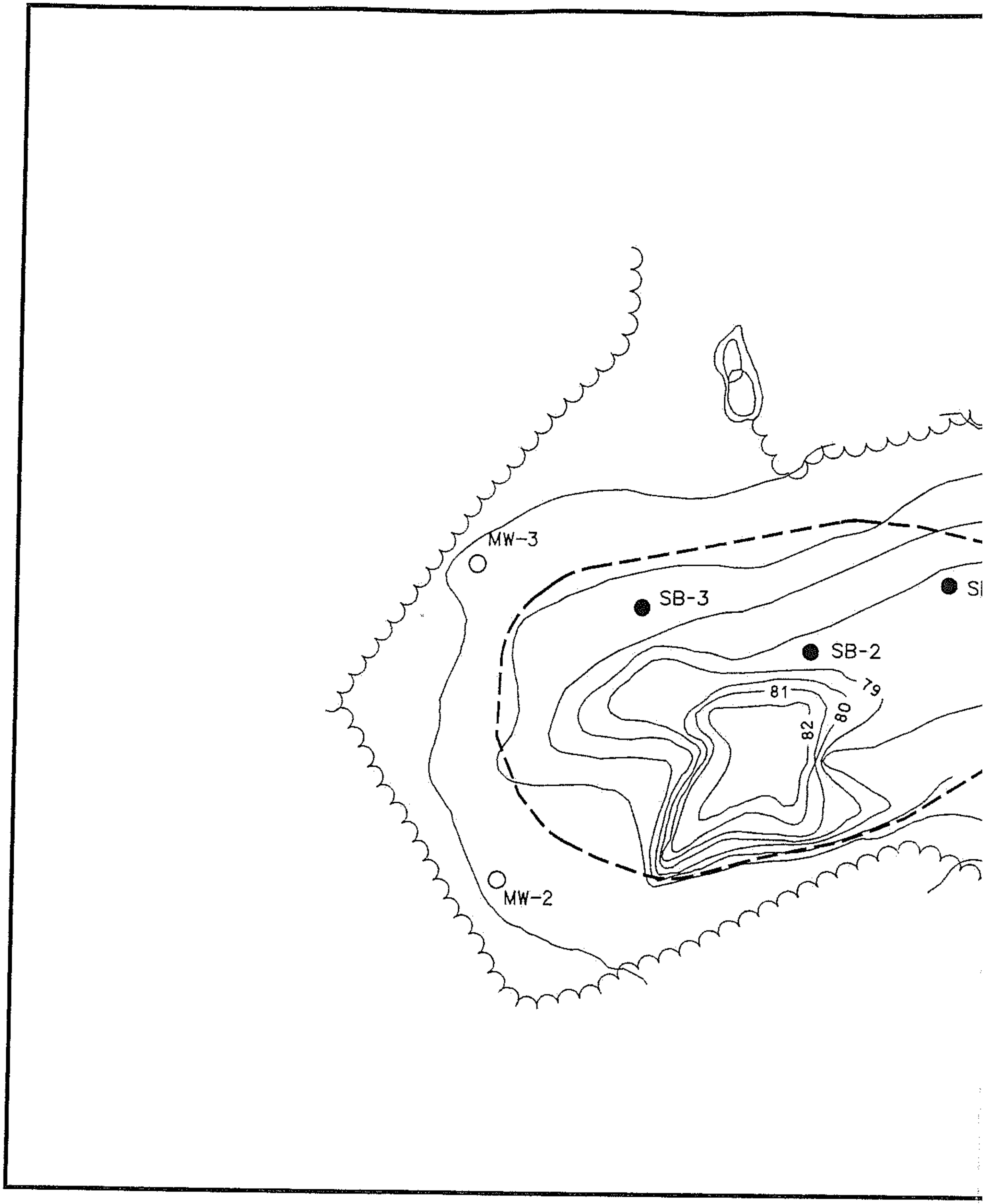

Figure 10-1. Locations of Sa

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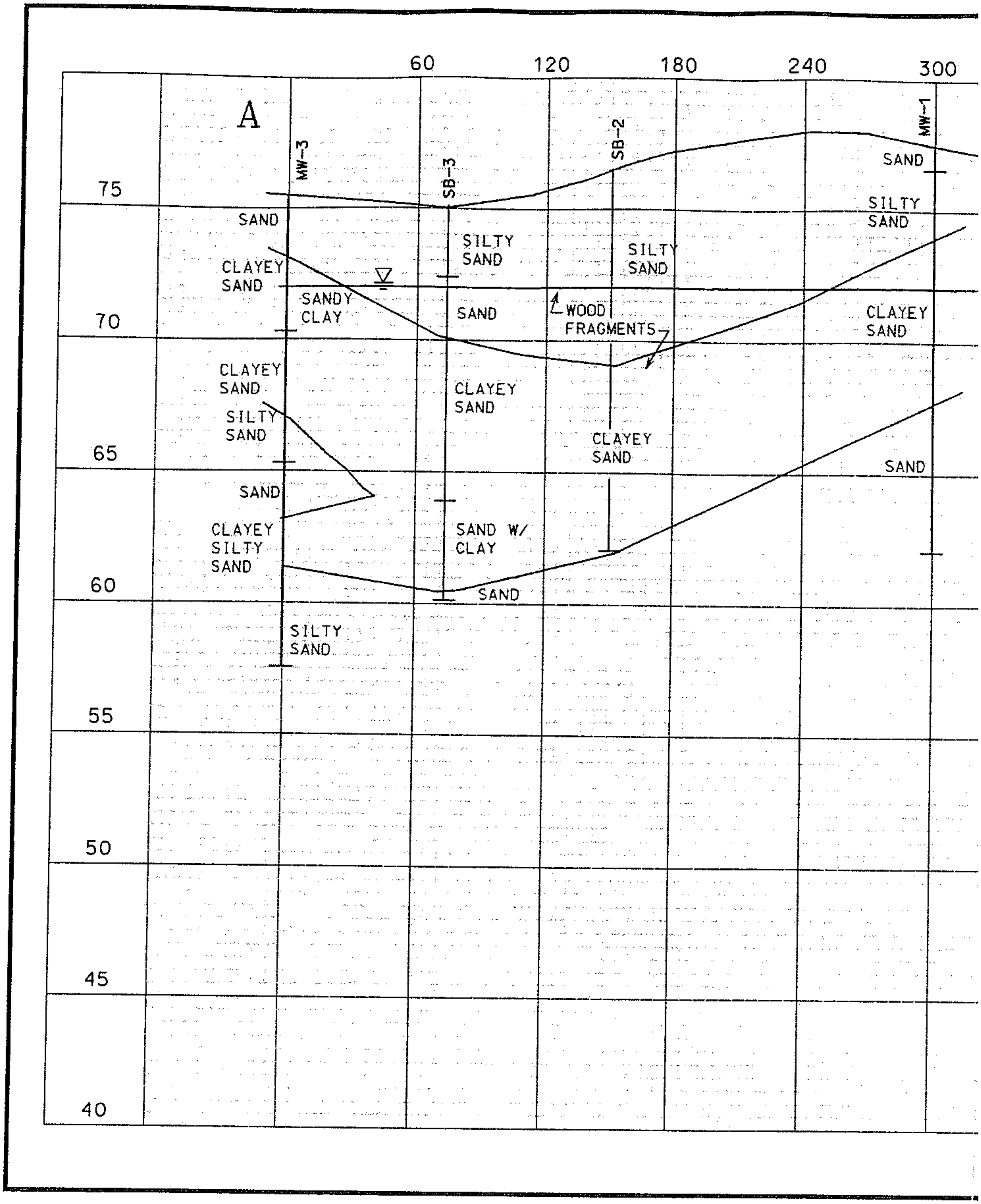

Figure 10-2. Geologic Cross

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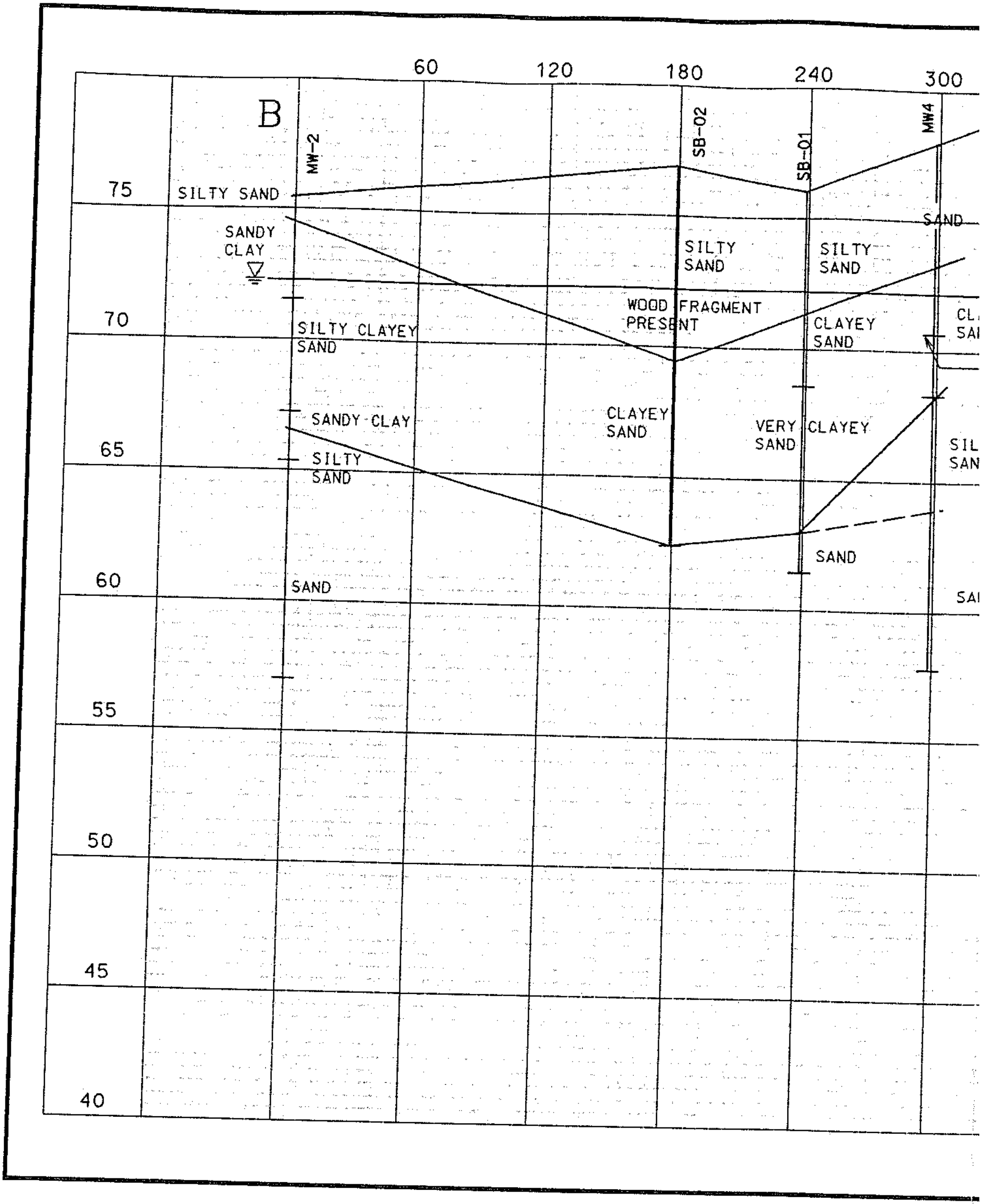

Figure 10-3. Geologic Cross-

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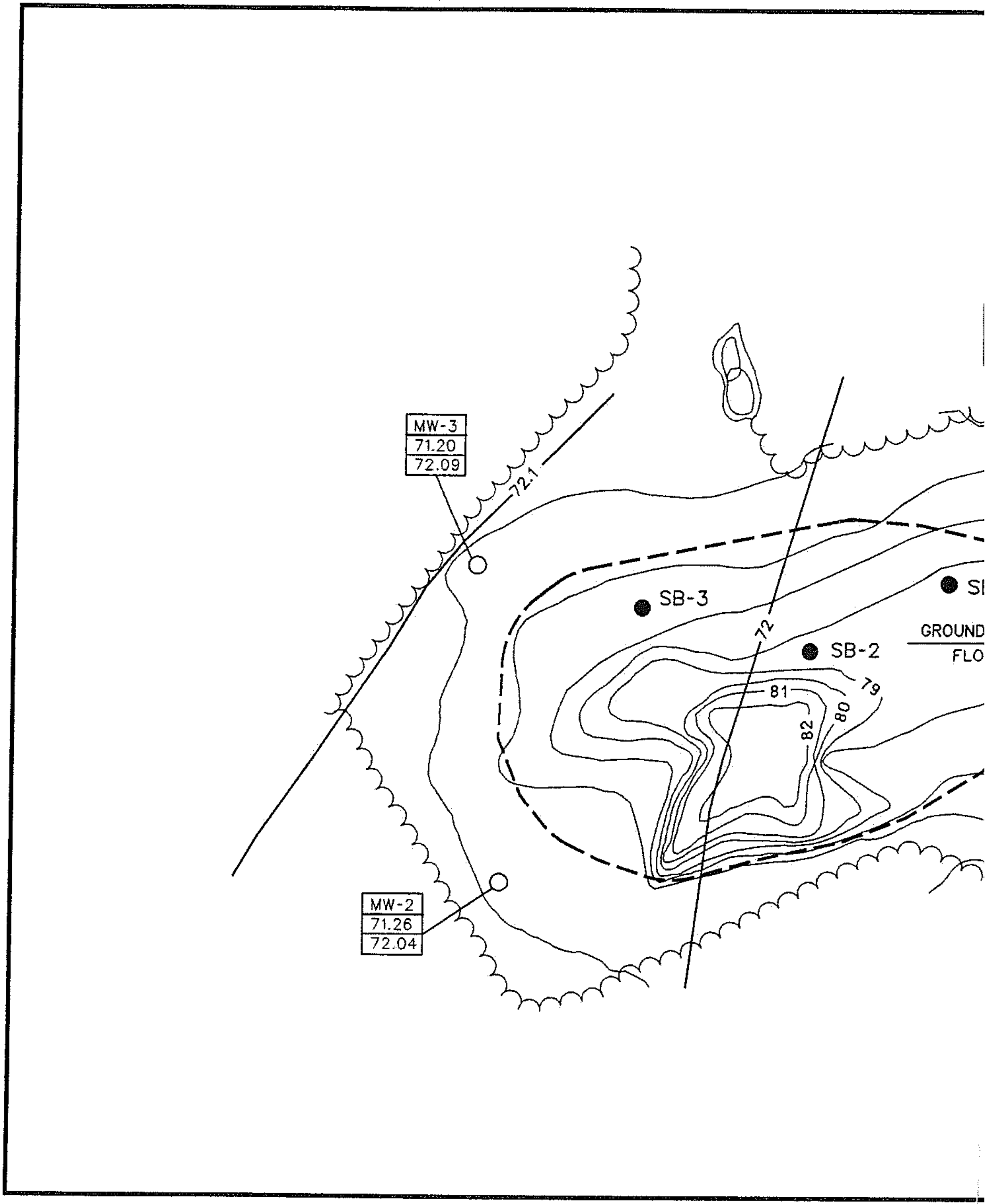

Figure 10-4. Water Table Conto

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10.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT B

10.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results of analyses on surface soil samples taken from the three soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 10-1 summarizes the analytical results for surface soil samples, and Figure 10-5 shows their distribution. This assessment presents Phase II contaminant data only because no surface soil samples were collected during Phase I.

Table 10-1. Summary of Analytical Results for Surface Soils
Burn Pit B, Fort Stewart

		Phase II Samples		
Parameter	**Reference Background**	**SB-1 4B1111 07/12/97 (0-1 foot)**	**SB-2 4B1211 07/17/97 (0-1 foot)**	**SB-3 4B1311 07/12/97 (0-1 foot)**
RCRA Metals (mg/kg)				
Barium	14.7	11.5	14.4	10.9
Chromium	6.21	1.4	1.4	1.5
Lead	8.81	7.8	5.4	**10.5**
Mercury	0.03	0.03	0.03	**0.04**

Note: **BOLD** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

SVOCs. No SVOCs were reported above the detection limit in surface soil samples.

RCRA metals. Lead (maximum 10.5 mg/kg at SB-3) and mercury (0.04 mg/kg at SB-3) were reported above reference in a single boring (SB-3). No other metals were detected above background.

10.2.2 Subsurface Soil Contamination

The subsurface soil samples were collected from the four Phase I monitoring well boreholes and the three Phase II soil borings. The samples were analyzed for VOCs and RCRA metals. Table 10-2 summarizes analytical results for the subsurface soil samples, and Figure 10-6 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. BTEX compounds were identified in both Phase I and Phase II subsurface soil samples. Maximum concentrations of benzene (30 µg/kg at MW-4), toluene (60.8 µg/kg at SB-2), and xylenes (9.9 µg/kg at MW-4) were reported. Lower concentrations of BTEX, notably toluene, were reported also at MW-1, SB-1, SB-2, and SB-3. The extent of BTEX contamination, although present at relatively low concentrations, extends over most of the 1-acre site.

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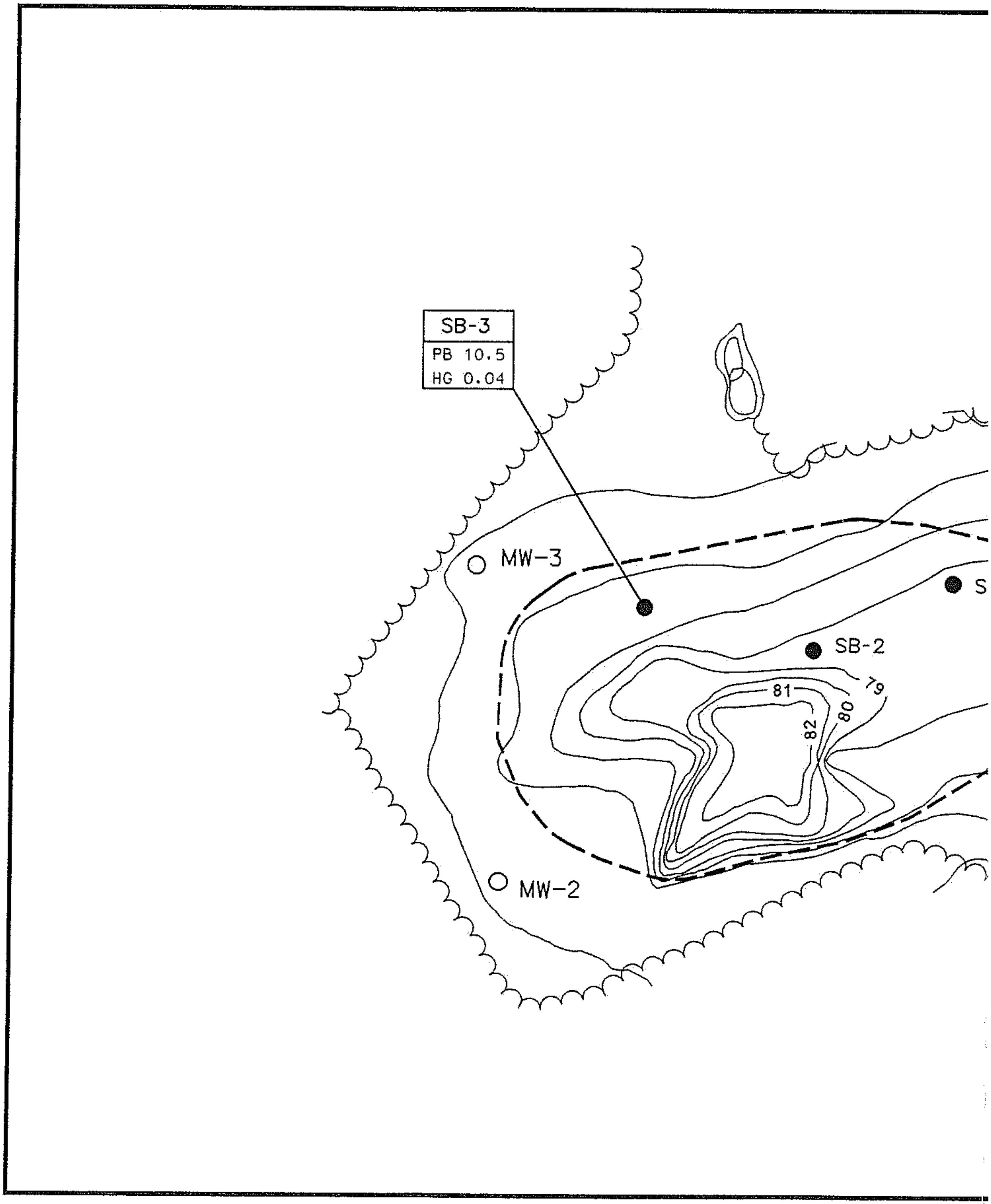

Figure 10-5. Results of Analyse

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Table 10-2. Summary of Analytical Results for Subsurface Soils
Burn Pit B, Fort Stewart

Parameter	Reference Background	Phase I Samples MW1 SL1-8 06/25/93 (4-6 feet)	MW2 SL2-8 06/25/93 (2-4 feet)	MW3 SL3-8 06/25/93 (2-4 feet)	MW4 SL4-4 06/25/93 (6-8 feet)	Phase II Samples SB-1 4B1112 07/11/97 (2.5-4.5 feet)	SB-2 4B1212 07/12/97 (4.5-7 feet)	SB-3 4B1312 07/11/97 (5-7.5 feet)
Volatile Organic Compounds (μg/kg)								
2-Butanone	0.0							
Acetone	0.0						**33.1**	
Benzene	0.0				**110**	**7.6**	**42.8**	
Methylene Chloride	0.0				**30**			
Tetrachloroethene	0.0	**8.9**					**5**	
Toluene	0.0	**8.3**						
Xylenes, Total	0.0				**9.9**	**5.2**	**60.8**	**6.8**
RCRA Metals (mg/kg)								
Arsenic	8.04	1.4				0.31	0.5	0.76
Barium	17.00	9	8	3.7	9.8	6.7	11.6	5.7
Chromium	11.60	**13**	2.7	4.5	7.1	1.7	1.5	5
Lead	11.10	7.3	2.2	2.7	4.2	1.9	8.5	3.6
Mercury	0.05	0.013			0.021	**0.06**	0.04	
Other Inorganics (mg/kg)								
Total Organic Carbon	2,200							546

Note: A blank indicates analyte not detected.

Note: BOLD font indicates value exceeds reference background criterion.

RCRA = Resource Conservation and Recovery Act.

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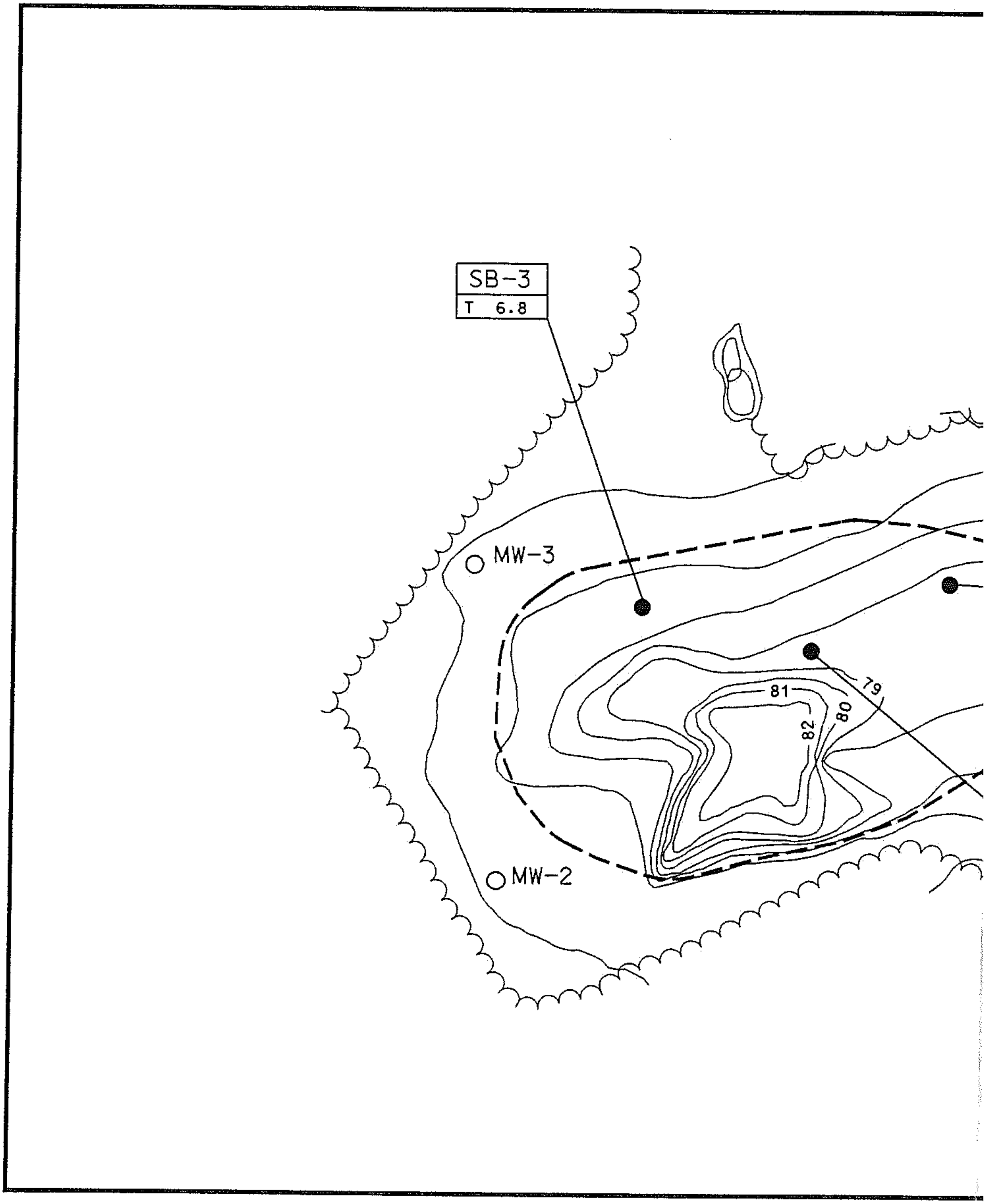

Figure 10-6. Results of Analyse

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PCE was reported in a single Phase I sample at a concentration of 8.9 µg/kg at MW-1. PCE was not detected in the Phase II soil samples. Acetone (110 µg/kg), 2-butanone (33.1 µg/kg), and methylene chloride (5 µg/kg) were detected at SB-1, SB-2, and MW-4.

RCRA metals. Two metals were reported at concentrations above their reference background value. Maximum values of chromium (13 mg/kg at MW-1) and mercury (0.06 mg/kg at SB-1) were reported at concentrations only slightly above background.

10.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples obtained during the resampling of the four monitoring wells installed during Phase I (MW-1 through MW-4). These samples were analyzed for VOCs and RCRA metals. Both filtered and unfiltered water samples were collected; only the total metal analysis on unfiltered water samples is presented in this section. Table 10-3 summarizes the analytical results for groundwater samples, and Figure 10-7 shows their distribution. This assessment focuses on the Phase II contaminant data, because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 10-3. Summary of Analytical Results for Groundwater
Burn Pit B, Fort Stewart

Parameter	Reference Background	MCL	Phase II Samples			
			MW-1 4B111 08/10/97	**MW-2 4B4311 08/09/97**	**MW-3 4B4411 08/09/97**	**MW-4 4B4411 08/09/97**
RCRA Metals (ug/L)						
Barium	71.72	2000	21	23.9		**73.4**
Cadmium	0.43	5		**1.2**		
Chromium	3.56	100	2.4	**5.9**	**3.7**	0.61
Lead	4.69	15	2		2.2	
Selenium	1.90	50		**3.2**		**3.5**
Silver	1.12		0.39	0.53	0.14	**4.9**

Note: A blank indicates analyte not detected.
Note: **BOLD** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.

VOCs. No VOCs were reported above the detection limit in either Phase I or Phase II groundwater samples. These results suggest that, although low concentrations of BTEX are present in subsurface soils at the site, the soil contamination has not impacted groundwater.

RCRA metals. Five metals were reported at concentrations above background in groundwater. Barium was reported at a maximum concentration in MW-4 (73.4 µg/L); cadmium in MW-2 (1.2 µg/L); chromium in MW-2 and MW-3 (5.9 and 3.7 µg/L, respectively); selenium in both MW-2 and MW-4 (3.2 and 3.5 µg/L, respectively); and silver in MW-4 (4.9 µg/L). These metals are present at concentrations only slightly exceeding background.

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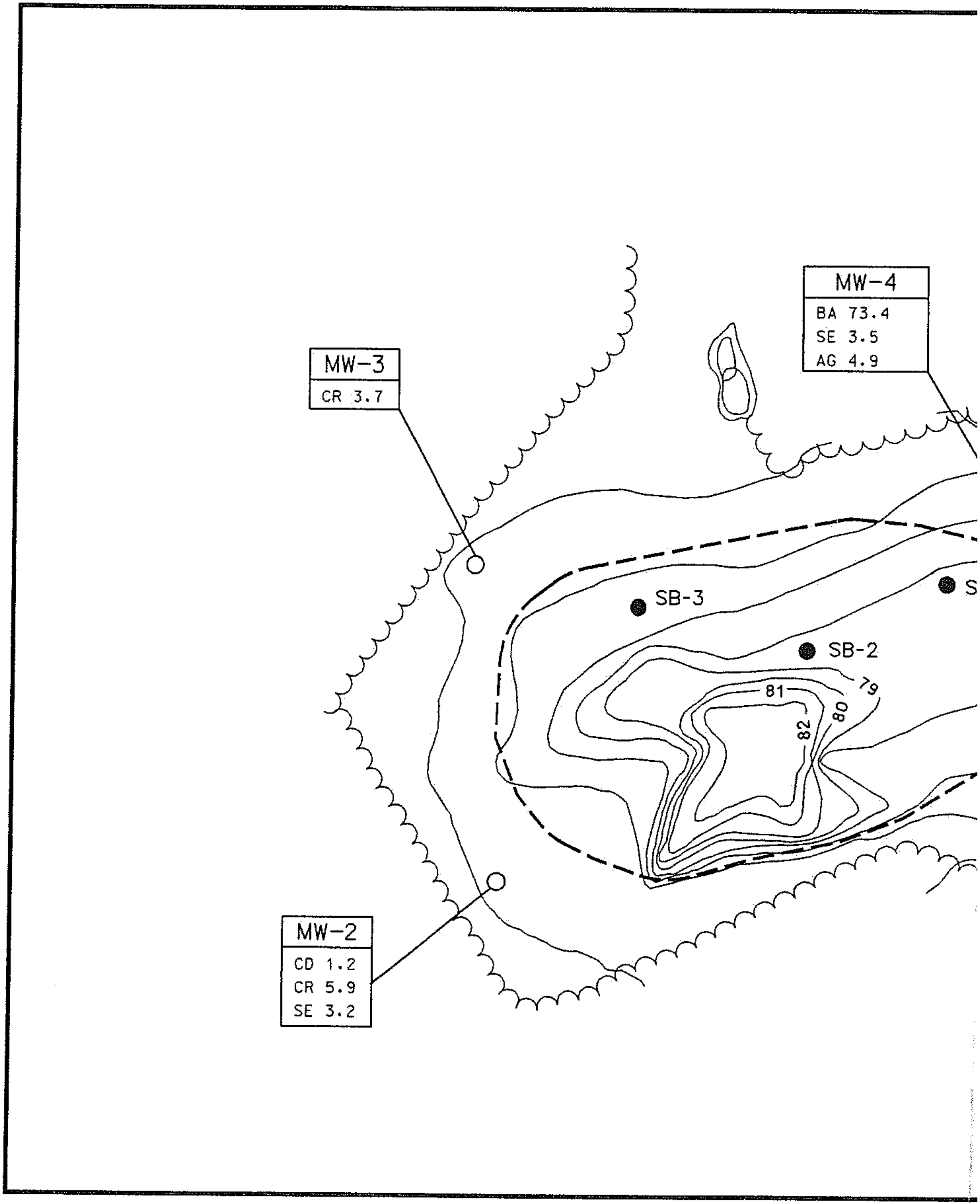

Figure 10-7. Results of Anal

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10.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 10-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

Table 10-4. Summary of Site-Related Constituents
Burn Pit B, Fort Stewart

Analyte	Surface Soil	Subsurface Soil	Groundwater
	(µg/kg)	**(µg/kg)**	**(µg/L)**
Acetone	na	**110**	nd
Benzene	na	**30**	nd
2-Butanone	na	**33.1**	nd
Methylene Chloride	na	**5**	nd
Tetrachloroethene	na	**8.9**	nd
Toluene	na	**60.8**	nd
Xylenes, total	na	**9.9**	nd
	(mg/kg)	**(mg/kg)**	**(µg/L)**
Arsenic	nd	brc	nd
Barium	brc	brc	**73.4**
Cadmium	nd	nd	**1.2**
Chromium	brc	**13**	**5.9**
Lead	**10.5**	brc	brc
Mercury	**0.04**	**0.06**	nd
Selenium	nd	nd	**3.5**
Silver	nd	nd	**4.9**

brc = Below background reference criteria
na = Not analyzed in any sample in that medium
nd = Not detected in any sample in that medium
BOLD font indicates the analyte is an SRC in that medium

10.3 FATE AND TRANSPORT CONSIDERATIONS AT BURN PIT B

The results of contaminant migration soil screening (discussed in Section 6.0) for Burn Pit B are presented in Table 10-5. Only benzene and PCE are identified as CMCOPCs based on leaching to groundwater. However, these constituents were not currently observed in groundwater, indicating that they may be degraded before reaching the water table. The predicted maximum concentration of benzene in groundwater, based on a maximum of 30 µg/kg in soil and a DAF of 1, is 75 µg/L. Through biodegradation, even if the benzene were to reach groundwater at such a concentration, it would degrade to its MCL value (5 µg/L) in less than 3.9 times its half-life. Assuming a conservative half-life of 2.0 years, the benzene would degrade to its MCL value in 7.8 years. Similarly, PCE with its predicted maximum concentration of 15 µg/L in groundwater would degrade to its MCL in less than 1.6 times its half-life, or 7.2 years, and methylene chloride with its predicted maximum concentration of 25 µg/L in groundwater would degrade to its MCL in less than 2.3 times its half-life, or 0.7 years.

The maximum concentrations of benzene and PCE were reported in Phase I soil samples only and were not detected in Phase II samples. The most likely pathway of contaminant migration from Burn Pit B is via groundwater discharge to Horse Creek, located approximately 4500 feet east of the site. Based on the calculated groundwater flow velocity of 1.2 feet/year, the estimated arrival time for the site groundwater to reach Horse Creek is expected to be more than 3750 years. Therefore, benzene, PCE, and methylene chloride would degrade to less than their MCLs within 10 feet of the Burn Pit B site, well before reaching Horse Creek.

Table 10-5. CMCOPCs Based on Soil Screening for Burn Pit B

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration > GSSL?
	RCRA Metal (mg/kg)		
Chromium	13.00	38	No
Lead	10.5	400	No
Mercury	0.06	0.4	No
	Volatile Organic Compounds (µg/kg)		
2-Butanone	33.10	38.4	No
Acetone	110.00	800	No
Methylene Chloride	5	1	Yes
Benzene	30.00	2	Yes
Tetrachloroethene	8.90	3	Yes
Toluene	60.80	600	No
Xylenes	9.90	10000	No

CMCOPs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
RCRA = Resource Conservation and Recovery Act.

Metals detected in the groundwater at this site include barium, cadmium, chromium, selenium, and silver. However, the maximum concentrations of these metals do not exceed their respective MCLs and, based on fate and transport analysis, they are not expected to increase in the future. Therefore, none of the constituents are expected to be of concern for contaminant migration from Burn Pit B.

10.4 HUMAN HEALTH RISK EVALUATION OF BURN PIT B

SRCs were identified in Section 10.2 for surface soil, subsurface soil, and groundwater. The identification of risk-based action levels for all of the Burn Pits has been previously discussed in Section 4.7 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit B is given below.

10.4.1 Exposure Evaluation

This site is completely covered by vegetation, and no VOCs were detected in surface soils. Therefore, exposure via inhalation based on current land use is not a viable exposure pathway. The site is not currently used by the U.S. Army. Therefore, current on-site receptors include a juvenile trespasser and a hunter. Current off-site receptors would be represented by an off-site hunter.

Land use at this site is unlikely to change in the future. However, the U.S. Army may use the site as a training area in the future. Construction may occur on the site or the vegetative cover may be gone as a result of on-site activities. Future on-site receptors include military personnel and a construction worker. Future off-site receptors include hunters in the area.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current juvenile trespasser. The juvenile trespasser may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Hunter. The hunter is representative of a current on-site receptor and a current and future off-site receptor. The current on-site receptor is not likely to be exposed to chemicals given the absence of an air migration pathway, and clothing the hunter would be wearing would eliminate potential dermal exposure. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

The current off-site hunter may be exposed via ingestion of contaminants bioaccumulated in game animals. The future off-site hunter may be exposed via ingestion of game and inhalation of fugitive dust if the vegetative cover was removed.

Future on-site military personnel. The on-site military personnel may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Future construction worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

10.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals will be evaluated further in a BRA.

None of the contaminants in surface soils or subsurface soils exceeded its respective risk-based screening value for direct exposure of a potential receptor population (Table 10-6).

None of the contaminants in groundwater exceeded its screening value (Table 10-6).

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit B. A human health BRA is not warranted. No further action is required for protection of human health.

Table 10-6. Comparison to Action Levels–Burn Pit B, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit B Surface Soil								
Lead	mg/kg	3/3	5.4	10.5	8.81	400	No	Max Detect < Screening Criteria
Mercury	mg/kg	3/3	0.03	0.04	0.03	2.30	No	Max Detect < Screening Criteria
Burn Pit B Subsurface Soil								
Chromium	mg/kg	6/6	1.5	13	11.6	1,000	No	Max Detect < Screening Criteria
Mercury	mg/kg	4/6	0.013	0.06	0.05	61.0	No	Max Detect < Screening Criteria
2-Butanone	mg/kg	1/3	0.0331	0.0331		100,000	No	Max Detect < Screening Criteria
Acetone	mg/kg	3/6	0.0076	0.11		20,000	No	Max Detect < Screening Criteria
Benzene	mg/kg	1/5	0.03	0.03		200	No	Max Detect < Screening Criteria
Tetrachloroethene	mg/kg	1/5	0.0089	0.0089		110	No	Max Detect < Screening Criteria
Toluene	mg/kg	4/6	0.0052	0.0608		41,000	No	Max Detect < Screening Criteria
Xylenes, Total	mg/kg	1/5	0.0099	0.0099		100,000	No	Max Detect < Screening Criteria
Burn Pit B Groundwater								
Barium	µg/L	3/3	21	73.4	71.72	260	No	Max Detect < Screening Criteria
Cadmium	µg/L	1/3	1.2	1.2	0.43	1.8	No	Max Detect < Screening Criteria
Chromium	µg/L	3/3	0.61	5.9	3.56	18	No	Max Detect < All Screening Criteria
Selenium	µg/L	2/3	3.2	3.5	1.90	18	No	Max Detect < Screening Criteria
Silver	µg/L	3/3	0.39	4.9	1.12	18	No	Max Detect < Screening Criteria

COPC = Chemical/Contaminant of Potential Concern.
EPA = U.S. Environmental Protection Agency.

10.5 ECOLOGICAL RISK EVALUATION OF BURN PIT B

The ecological risk evaluation of Burn Pit A is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are evaluated further (Steps ii through v). The results of the five steps of the PRE are reported below.

10.5.1 Ecological Screening Value Comparison (Step i)

Five RCRA metals were detected in groundwater at Burn Pit B at concentrations exceeding reference background criteria. The results of the ecological screening value comparison for groundwater at Burn Pit B are presented in Table 10-7. Where detected in the three downgradient monitoring wells (MW-1, MW-2, and MW-4), barium and silver exceed the ESVs for those analytes. Cadmium was only detected in MW-2, and it exceeds the ESV. The ecological COPCs identified by the ESV comparison for groundwater at Burn Pit B are barium, cadmium, and silver.

Table 10-7. EPA Region 4 Ecological Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit B, Fort Stewart

Analyte	ESV	MW-3*	MW-1	MW-2	MW-4	Maximum
			RCRA Metals (μg/L)			
Barium	3.9[a]		**21 J**	**23.9 J**	**73.4 J**	**73.4 J**
Cadmium	0.66[b]			**1.2**		**1.2**
Chromium	117[b,c]	3.7 J	2.4 J	5.9 J	0.61 J	5.9 J
Selenium	5			3.2 J	3.5 J	3.5 J
Silver	0.012[b]	**0.14 J**	**0.39 J**	**0.53**	**4.9**	**4.9**

*Upgradient monitoring well.
J = Estimated concentration.
ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1996) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
[a] Office of Solid Waste and Emergency Response Ambient Water Quality Criteria or Tier-II value (Suter and Tsao 1996).
[b] Hardness dependent, assumes 50 mg/L $CaCO_3$.
[c] Chromium (III); hardness dependent, assumes 50 mg/L $CaCO_3$; ESV for Chromium (VI) = 11.
Bold font indicates detected concentration exceeds ESV.

Although ecological COPCs are identified in groundwater at Burn Pit B when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit B. There are no surface water bodies in the vicinity of Burn Pit B. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit B soils.

Because there are no ESVs for soil, all analytes detected in soil at the Burn Pit B are evaluated further in PRE Steps ii through v.

10.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit B comprises approximately 1 acre (Figure 10-1). The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees. A large pile of wood stumps and logs about 4 feet high is present in the southern portion of the site. The closest surface stream is Horse Creek, a tributary of Taylors Creek, which lies approximately 4500 feet east of the site.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit B are described in Section 8.1.2.

10.5.3 Preliminary Effects Evaluation (Step iii)

In the PRE for Burn Pit B, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the site. The derivation of TRVs is discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8-1.

10.5.4 Preliminary Exposure Estimate (Step iv)

Ecological receptors at the Burn Pit B are likely to be exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews, and robins exposed to COPCs in soil are presented in Table 8-2.

10.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate a HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0, and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. The preliminary risk calculation for shrews and robins exposed to ecological COPCs detected in soil at Burn Pit B is presented in Table 10-8. This table shows the maximum detected concentrations and the TRVs for shrews and robins. Concentrations resulting in HQs exceeding 1.0 are shown in boldface font. The ecological COPC present in Burn Pit B surface soil at concentrations exceeding the TRV for the surrogate species is lead. Lead was detected in all three samples at concentrations exceeding the TRV for the robin. However, lead was detected in a single soil sample at a concentration (10.5 mg/kg) above background criteria (8.81 mg/kg). Therefore, lead may not be site related. An HI is not calculated for the surrogate species exposed to RCRA metals detected in surface soil because they are assumed to have dissimilar mechanisms of toxicity.

Table 10-8. Preliminary Risk Evaluation of Ecological COPCs in Surface Soil (0 to 1 foot) at Burn Pit B, Fort Stewart

Analyte	TRV (mg/kg)		SB-1	SB-2	SB-3	Maximum
	Shrew	Robin				
RCRA Metals (mg/kg)						
Lead	73.3	2.35	**7.8**	**5.4**	**10.5**	**10.5**
Mercury	14.1	1.1	0.03 J	0.03	0.04	0.04

COPCs = Chemicals/Contaminants of Potential Concern.
J = Estimated concentration.
RCRA = Resource Conservation and Recovery Act.
TRV = Toxicity Reference Value = NOAEL × BW/Food Ingestion)/BAF$_{earthworm}$ (see Table 8-1).
Blank cells indicate analyte not detected at site
Bold font indicates detected concentration exceeds TRV (HQ > 1).

10.5.6 Uncertainties

The risk to ecological receptors from lead in surface soil at Burn Pit B is overestimated by the preliminary risk calculations. Lead was detected in the three surface soil samples at concentrations ranging from 5.4 to 10.5 mg/kg. Lead was detected in two surface soil samples at Burn Pit B at concentrations exceeding the NOAEL-based TRV for the robin with a realistic diet (5.89 mg/kg). However, lead concentrations in Burn Pit A surface soil are many times less than the LOAEL-based TRV for the robin calculated using published dietary fractions (48 mg/kg). Therefore, lead in surface soil at Burn Pit A is unlikely to pose a risk to ecological receptors.

10.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT B

The following are the conclusions of the Phase II RFI for Burn Pit B:

- In surface soils, lead and mercury were detected in one of the three surface soil samples taken from the site. Neither lead nor mercury poses a human health risk.
- Lead is a potential ecological COPC in surface soil because it exceeds the TRV for the surrogate species (robin). However, lead was detected in only a single sample at a concentration above background and may not be site related. The maximum concentration of lead was well within the USGS range of background concentrations for soils in the Eastern United States (up to 300 mg/kg) and many times less than the LOAEL-based TRV. Therefore, lead is estimated as an ecological COPC in surface soil at Burn Pit B, and further investigation and/or evaluation of this constituent is not required.
- In subsurface soils, PCE and BTEX compounds were detected in five of the seven samples, extending over most of the site. 2-Butanone, acetone, and methylene chloride were also detected. Chromium and mercury were reported in one sample at concentrations only slightly above background. These metals are not present in a consistent pattern and are not considered site related.
- There are no human health COPCs in surface soil or subsurface soil because no constituent exceeded its risk-based screening value.

- PCE, benzene, and methylene chloride are potential contaminant migration COPCs in subsurface soil because these chemicals may leach to groundwater, resulting in groundwater concentrations exceeding their respective MCLs. However, they were not detected in groundwater and were detected in only one soil sample of the nine collected. Off-site migration of these contaminants would be very limited due to retardation and biodegradation and the slow movement of groundwater. Even if these constituents were to reach groundwater at their predicted maximum concentrations, they would degrade to concentrations less than their MCLs in less than 7.8 years, and would have traveled less than 10 feet from the Burn Pit B site. Therefore, migration of these constituents is considered unlikely, and there are no contaminant migration COPCs in subsurface soils.

- In groundwater, five metals were detected at concentrations only slightly exceeding background and in separate wells. These metals (barium, cadmium, chromium, selenium, and silver) do not indicate a pattern of distribution indicating a potential release from the former Burn Pit.

- There are no human health COPCs in groundwater because no constituent exceeded its risk-based screening value.

- Barium, cadmium, and silver are ecological COPCs in groundwater because they exceed the ESVs for surface water. However, there are no surface water bodies in the vicinity of Burn Pit B, and off-site migration would be limited due to retardation and the slow movement of groundwater. Therefore, exposure of ecological receptors to these metals in surface water bodies downgradient from Burn Pit B is not a complete pathway. Thus, no constituent in groundwater is considered a threat to ecological receptors, and there are no ecological COPCs in groundwater.

The following are the recommendations for Burn Pit B:

1. No further action is recommended for Burn Pit B.
2. Because there are no human health COPCs, a BRA is not recommended for Burn Pit B.
3. All potential ecological COPCs were eliminated for Burn Pit B (Section 10.5), and an ERA is not recommended for the site.

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11.0 CHARACTERIZATION OF BURN PIT C (SWMU 4C)

11.1 HISTORY AND DESCRIPTION OF BURN PIT C

Burn Pit C (SWMU 4C) comprises approximately 2 acres and is located on Fort Stewart Route 90, approximately 300 feet west from its junction with 15th Street. The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees.

The site is slightly mounded, with elevations varying between approximately 71 feet amsl around the perimeter of the site and 76 feet amsl in the center of the site (Figure 11-1). Drainage occurs through overland flow radically in all directions and is collected in a series of man-made ditches that convey runoff to Mill Creek. The closest surface stream to the site is Mill Creek, a tributary of Taylors Creek, which lies approximately 4000 feet northeast of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 11-1). RCRA metals, including barium, chromium, and lead were detected above site-specific background levels in soils. RCRA metals were also detected above site-specific background levels in groundwater and included arsenic, chromium, lead, and silver. No VOCs were detected in either soil or groundwater samples in Phase I.

During the Phase II RFI activities, three new monitoring wells (MW-5 through MW-7) were installed, and three soil borings (SB-1 through SB-3) were drilled at the site (Figure 11-1). Redevelopment of the existing Phase I wells was attempted, but the wells remained very turbid even after several hours of purging. The four Phase I wells were, therefore, abandoned by filling the well casing with grout. The Phase II wells and borings were therefore used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of silty to clayey sands. Geologic cross-sections of the Burn Pit C site are presented in Figures 11-2 and 11-3. Geotechnical parameters were measured in bulk soil samples taken from MW-5 at a depth of 7.5 to 10 feet and MW-7 at a depth of 10 to 12.5 feet, and in a Shelby tube sample taken from MW-6 at a depth of 12 to 14 feet. The results of the Geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic or low-plasticity silty to clayey sands with less than 12 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from MW-6, is 1.24×10^{-3} cm/second, typical for a fine sand.

Water levels in the monitoring wells were measured during well development between July 11 and 15, 1997, and again during well sampling on August 6 and 7, 1997. The water table is present at a depth between 2 and 3 feet bgs around the perimeter of the site, and is likely mounded beneath the center of the site. A water table contour map is provided as Figure 11-4, showing an interpreted water table mound beneath the site with radial flow in all directions. Groundwater contours measured during the Phase I RFI activities in August 1993 indicate similar water levels, although the groundwater flow direction was interpreted to be planar flow to the east. The current interpretation is that groundwater may be slightly perched within the clayey soils beneath the site, forming a mound beneath the site; groundwater flow is likely radial, flowing in all directions before joining the regional shallow groundwater flow. Regional groundwater flow is expected to be to the northeast, discharging ultimately to Mill Creek, which is located approximately 4000 feet northeast of the Burn Pit C site.

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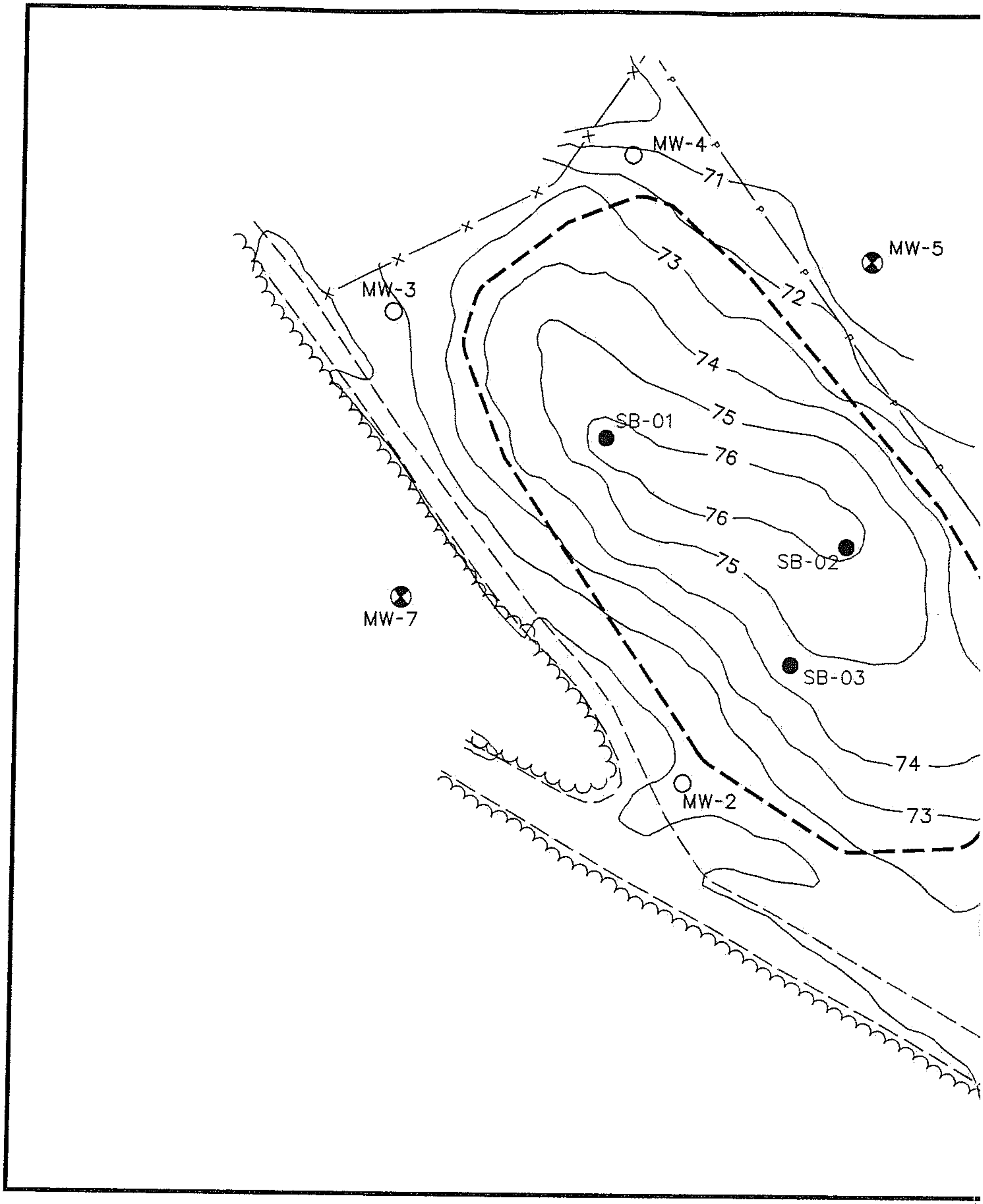

Figure 11-1. Locations of S

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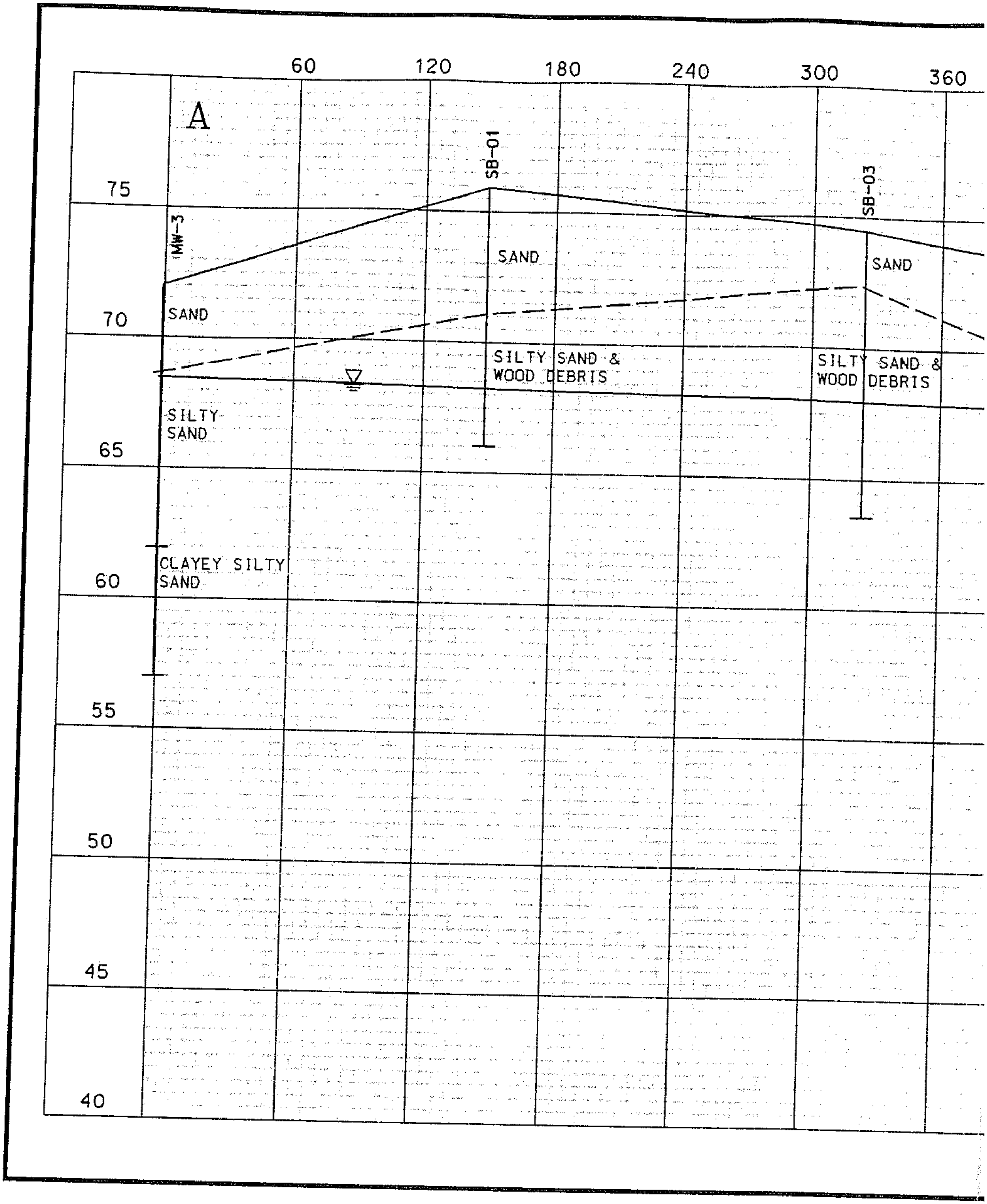

Figure 11-2. Geologic Cros

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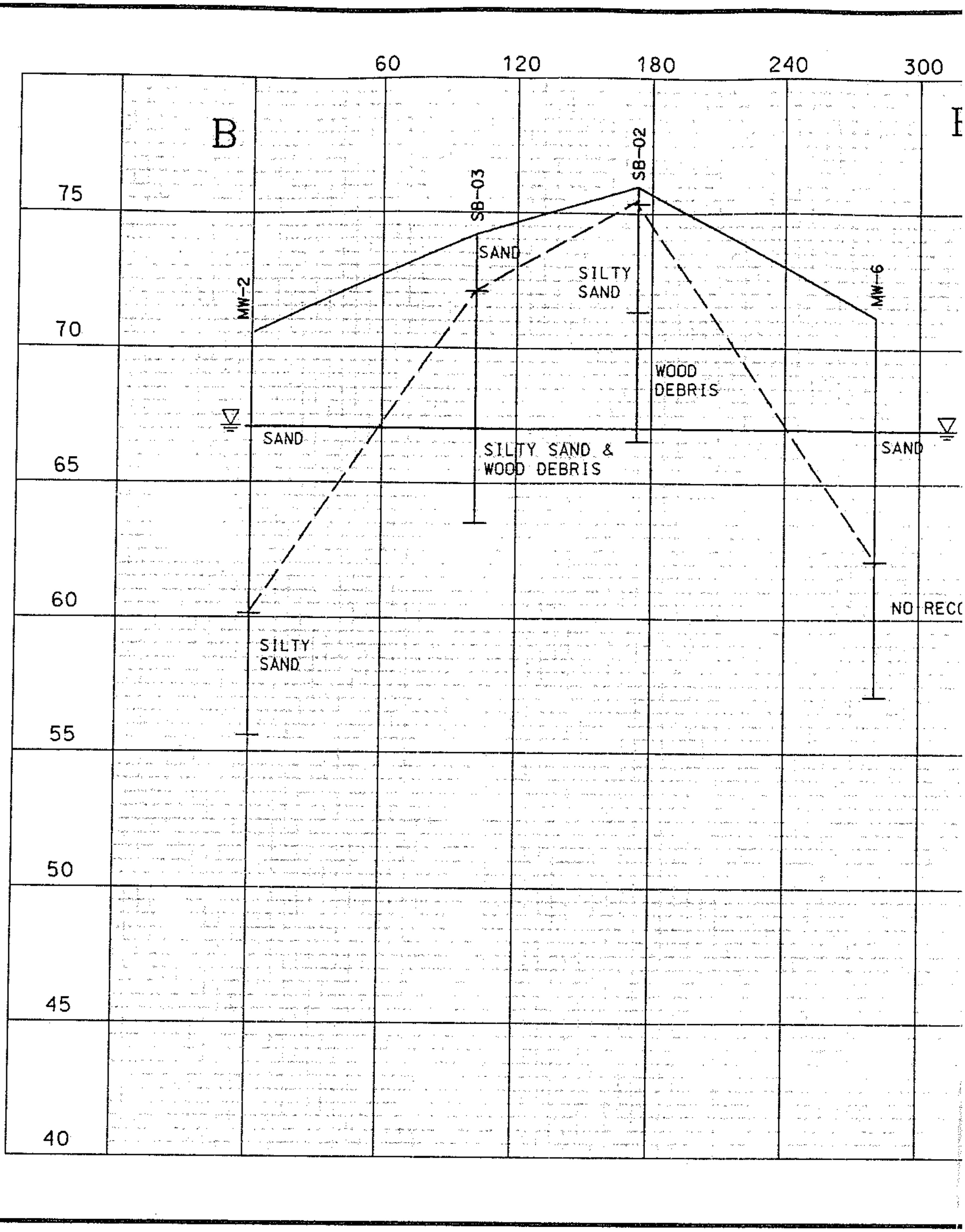

Figure 11-3. Geologic Cr

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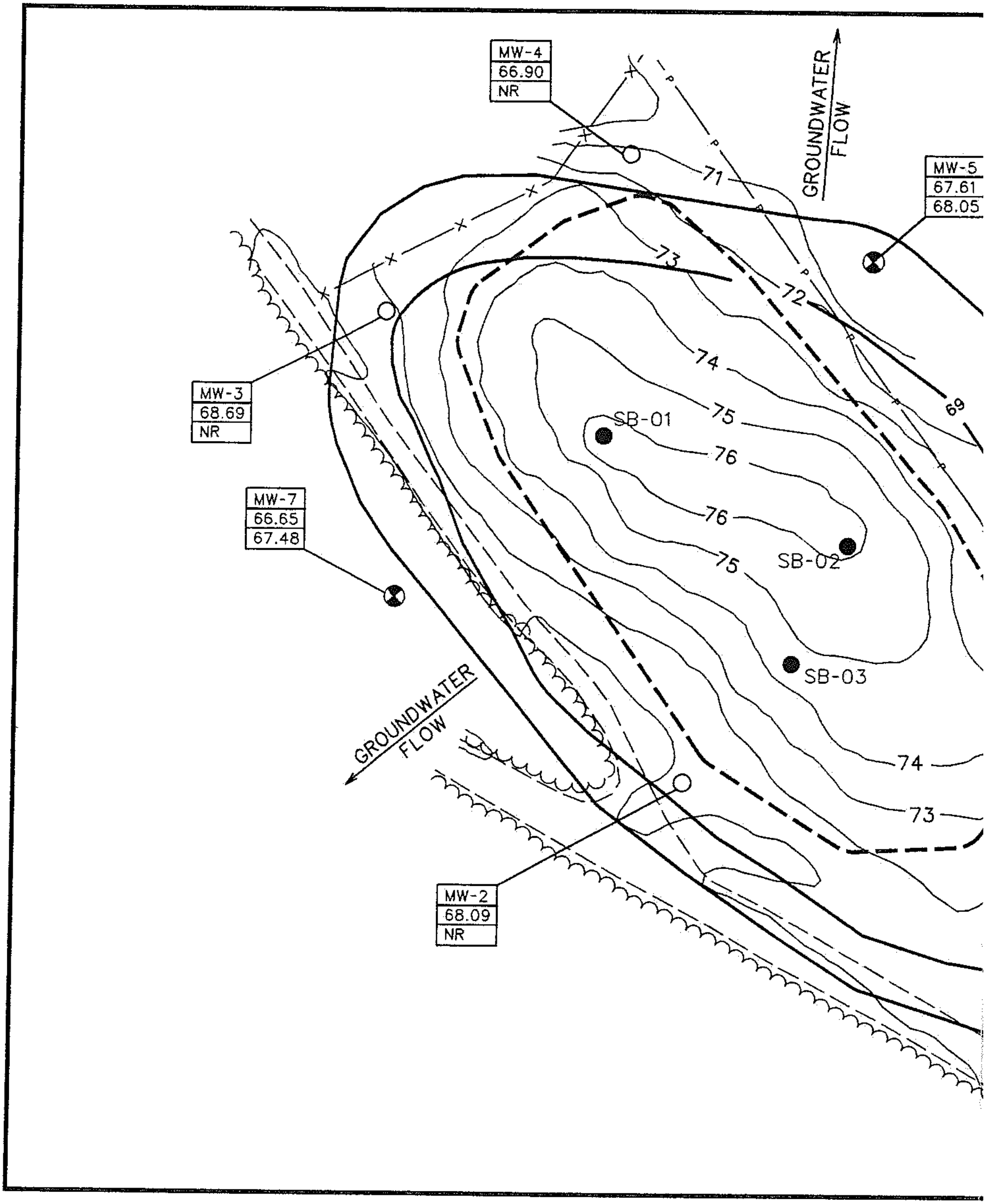

Figure 11-4. Water Table Contour

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11.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT C

11.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results of analyses on surface soil samples taken from the three new monitoring wells (MW-5 through MW-7) and the three soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 11-1 summarizes the analytical results for surface soil samples, and Figure 11-5 shows their distribution. This assessment presents Phase II contaminant data only, because no surface soil samples were collected during Phase I.

Table 11-1. Summary of Analytical Results for Surface Soils
Burn Pit C, Fort Stewart

		Phase II Samples					
Parameter	**Reference Background**	**SB-1 4C1111 07/10/97 (0-1 foot)**	**SB-2 4C1211 07/13/97 (0-1 foot)**	**SB-3 4C1311 07/10/97 (0-1 foot)**	**MW-5 4C1511 07/10/97 (0-1 foot)**	**MW-6 4C1611 07/10/97 (0-1 foot)**	**MW-7 4C1711 07/11/97 (0-1 foot)**
RCRA Metals (mg/kg)							
Barium	14.7	7	**20.2**	13.3	6.2	6.9	5.2
Cadmium	0.18		**0.35**				
Chromium	6.21	3.7	3.5	2.8	0.78	2	0.67
Lead	8.81	6.5	**33.2**	**29.9**	3.5	5.3	3.1
Mercury	0.03	**0.05**	**0.06**	**0.06**	0.03	**0.06**	

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

SVOCs. No SVOCs were reported above the detection limit in surface soil samples.

RCRA metals. Four RCRA metals were reported above reference background values. Maximum concentrations were reported at SB-2 for all four metals, including barium (20.2 mg/kg), cadmium (0.35 mg/kg), lead (33.2 mg/kg), and mercury (0.06 mg/kg). Lead and mercury were also above background at SB-3, and mercury was above background at SB-1 and MW-6. The extent of these metals in surface soil is limited to the area surrounding these borings in the center of the Burn Pit C site, approximately one acre in extent.

11.2.2 Subsurface Soil Contamination

The subsurface soil samples were collected from the four Phase I monitoring well boreholes, the three Phase II well boreholes, and the three Phase II soil borings. The samples were analyzed for VOCs and RCRA metals. Table 11-2 summarizes analytical results for the subsurface soil samples, and Figure 11-6 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. BTEX compounds were identified in both Phase I and Phase II subsurface soil samples. Maximum concentrations of toluene (69.9 μg/kg at SB-2) and xylenes (14 μg/kg at MW-3) were reported. Lower concentrations of BTEX, notably toluene at 5 μg/kg, were reported also at SB-1. The extent of BTEX contamination, although present at relatively low concentrations, extends from the area of SB-2 to the northwest at MW-3.

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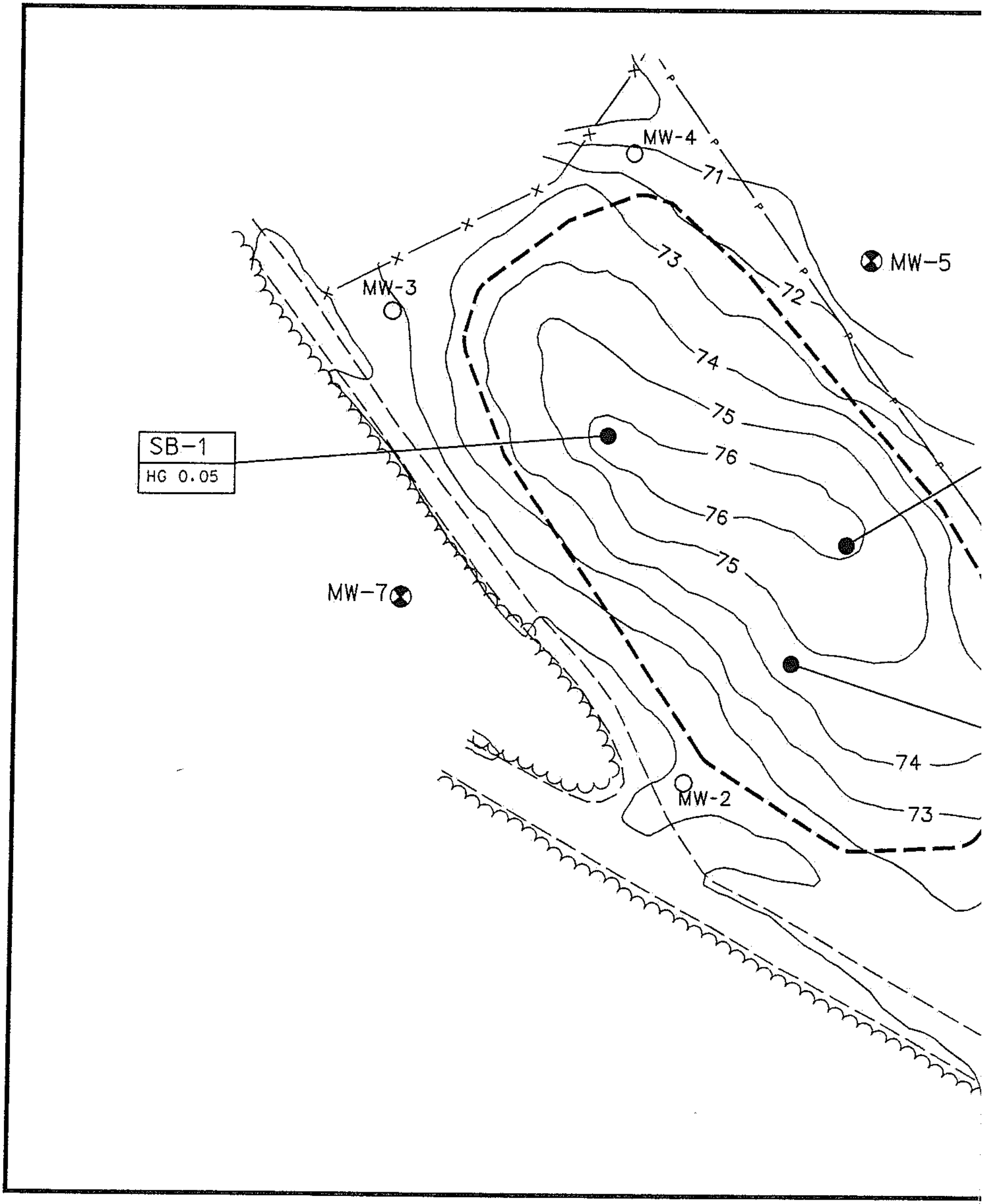

Figure 11-5. Results of Analy

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Table 11-2. Summary of Analytical Results for Subsurface Soils
Burn Pit C, Fort Stewart

Parameter	Reference Background	Phase I Samples				Phase II Samples					
		MW1 SL1-4 06/23/93 (2-4 feet) 0002.0 0004.0	MW2 SL2-4 06/23/93 (2-4 feet) 0002.0 0004.0	MW3 SL3-4 06/23/93 (2-4 feet) 0002.0 0004.0	MW4 SL4-4 06/23/93 (2-4 feet) 0002.0 0004.0	MW-5 4C1512 07/10/97 (2.5-5 feet) 0002.5 0005.0	MW-6 4C1612 07/10/97 (2.5-5 feet) 0002.5 0005.0	MW-7 4C1712 07/11/97 (2.5-5 feet) 0002.5 0005.0	SB-1 4C1112 07/10/97 (2.5-5 feet) 0002.5 0005.0	SB-2 4C1212 07/13/97 (2.5-4.5 feet) 0002.5 0004.5	SB-3 4C1312 07/10/97 (10-10.5 feet) 0010.0 0010.5
Volatile Organic Compounds (mg/kg)											
1,1,1 Trichloroethane	0.0			10							
2-Butanone	0.0										
Acetone	0.0									17.1	
Methylene Chloride	0.0									39.4	
Tetrachloroethene	0.0			48	15					4.3	
Toluene	0.0			14							
Xylene	0.0			14					5	69.9	
RCRA Metals (mg/kg)											
Arsenic	8.04								0.37	0.39	
Barium	17.0	1.3	1.5	2.5	3.2	13.9	4.9	1.1	10.2	13.4	5.4
Cadmium	0.24								0.12		
Chromium	11.6	1.5	1.5	4	4.8	9.6	2.7	1.2	2.9	1.2	4.6
Lead	11.1	0.67	0.73	2	2.7	9.1	3	1.6	**21.9**	14	3.2
Mercury	0.05					**0.06**	0.02	0.03	**0.07**	0.03	0.03
Other Inorganics (mg/kg)											
Total Organic Carbon	2,200						9770				

Note: A blank indicates analyte not detected.

Note: **Bold** font indicates value exceeds reference background criterion.

RCRA = Resource Conservation and Recovery Act

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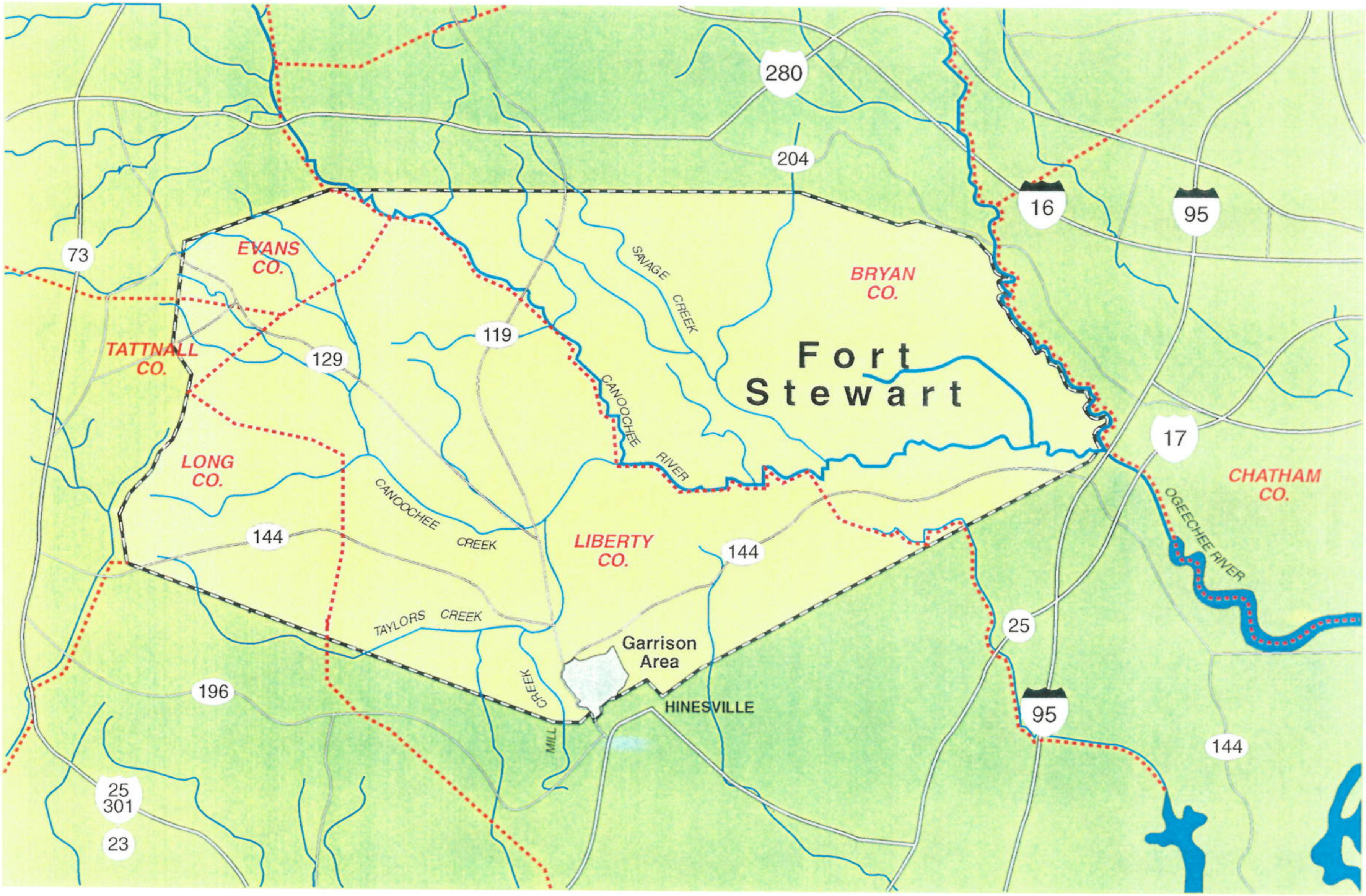

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Figure 2-2. Location Map for Fort Stewart Military Reservation, Georgia

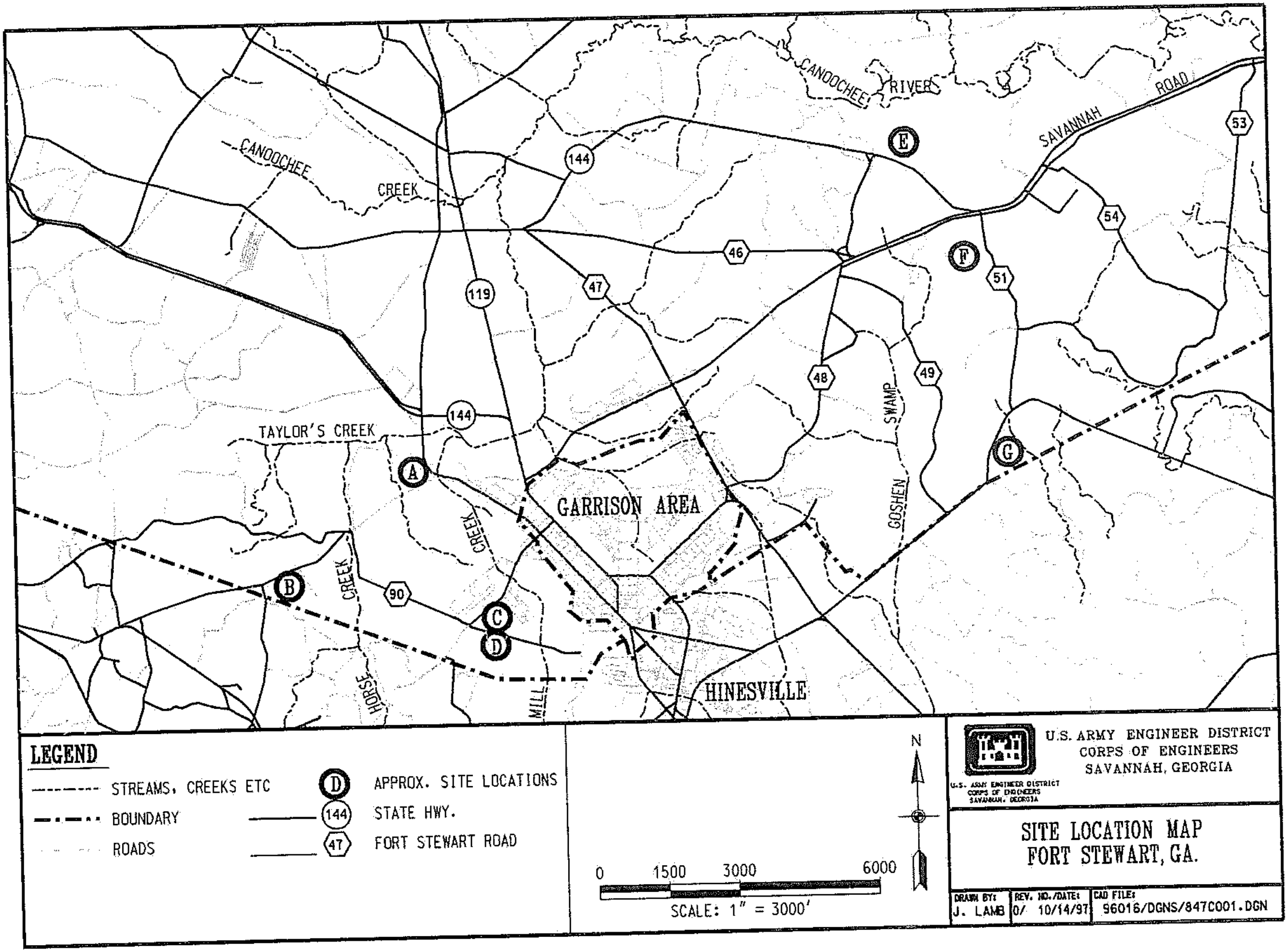

Figure 2-3. Location of the Burn Pits (SWMUs 4A through 4F)

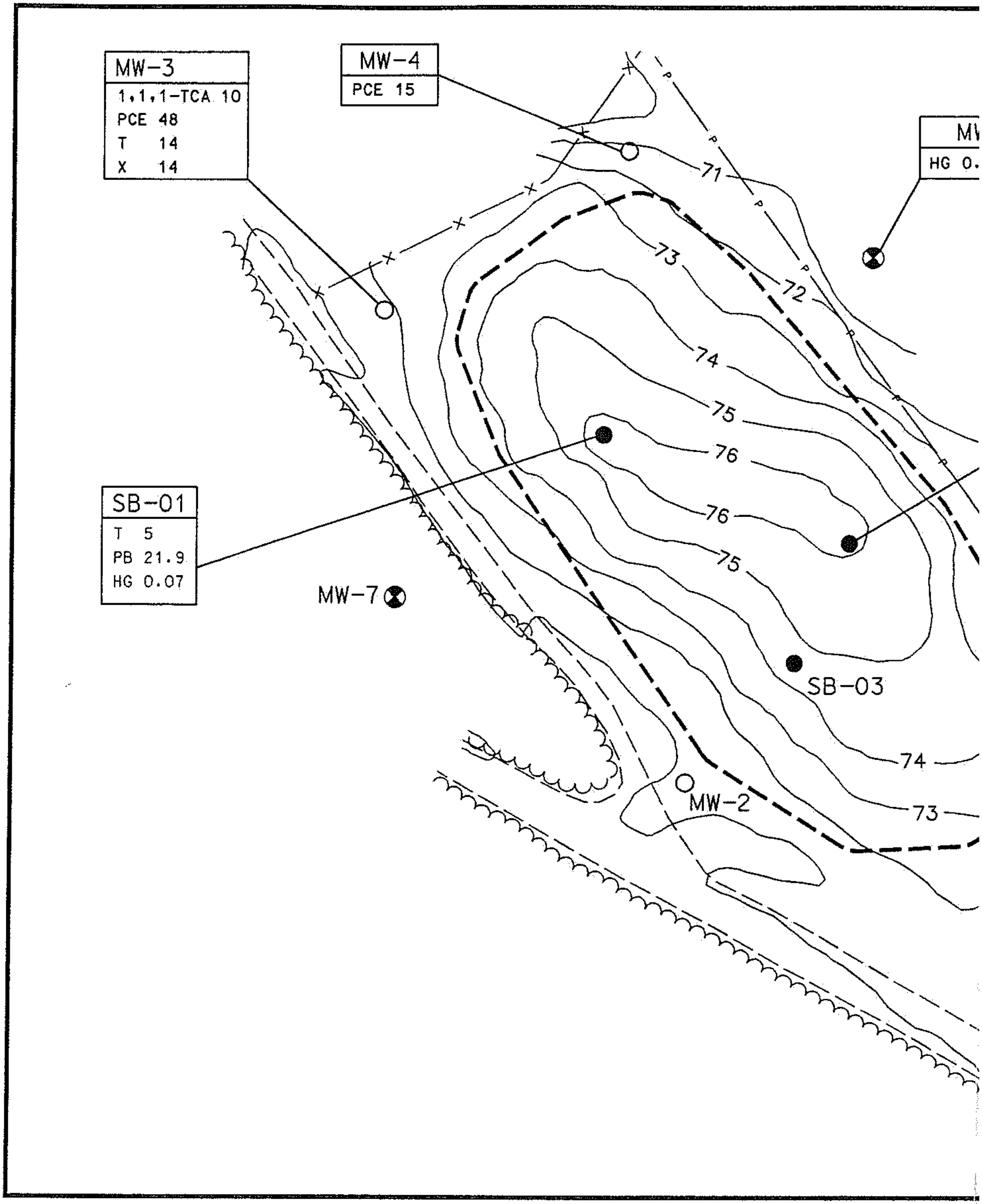

Figure 11-6. Results of Analys

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PCE was reported in two Phase I samples at a concentration of 48 µg/kg at MW-3 and 15 µg/kg at MW-4. 1,1,1-Trichloroethane was also reported in a Phase I sample (MW-3 at 10 µg/kg). Neither PCE nor 1,1,1-trichloroethane was detected in the Phase II soil samples. Acetone, 2-butanone, and methylene chloride were detected only at SB-2 at concentrations near their average concentration in background samples and are, therefore, not considered site related.

RCRA metals. Two metals were reported at concentrations above their reference background value. Maximum values of lead (21.9 mg/kg at SB-1) and mercury (0.07 mg/kg at MW-1) were reported. The extent of these metals above background is characterized by borings SB-1, SB-2, and MW-5, extending from the center of the site to the northeast, approximately 1.5 acres in size.

11.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples taken from the three monitoring wells installed during Phase II (MW-5 through MW-7). Waters removed from the Phase I monitoring wells were very turbid, and the wells could not be adequately redeveloped; after consultation with GEPD, the wells were abandoned. The groundwater samples from MW-5 through MW-7 were analyzed for VOCs and RCRA metals. Both filtered and unfiltered water samples were collected; only the total metal analysis on unfiltered water samples is presented in this section. Table 11-3 summarizes the analytical results for groundwater samples, and Figure 11-7 shows their distribution. This assessment focuses on the Phase II contaminant data because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 11-3. Summary of Analytical Results for Groundwater, Burn Pit C, Fort Stewart

		Phase II Samples			
Parameter	**Reference Background**	**MCL**	**MW-5 8/07/97 4C4511**	**MW-6 08/06/97 4C4611**	**MW-7 08/07/97 4C4711**
		RCRA Metals (ug/L)			
Arsenic	3.02	50		2.5	
Barium	71.72	2000	70.6	**134**	26.6
Cadmium	0.43	5		**3**	
Lead	4.69	15	0.3	1.1	
Mercury	0.14	2		0.14	**0.28**
Selenium	1.90	50	0.88	1.6	
Silver	1.12		0.24	0.77	0.08

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.

VOCs. No VOCs were reported above the detection limit in either Phase I or Phase II groundwater samples. These results suggest that although low concentrations of BTEX are present in subsurface soils at the site, the soil contamination has not impacted groundwater.

RCRA metals. Three metals were reported at concentrations above background in groundwater. Barium was reported at a maximum concentration in MW-6 (134 µg/L), cadmium in MW-6 (3 µg/L), and mercury in MW-7 (0.28 µg/L). Because MW-6 is downgradient on the site, barium

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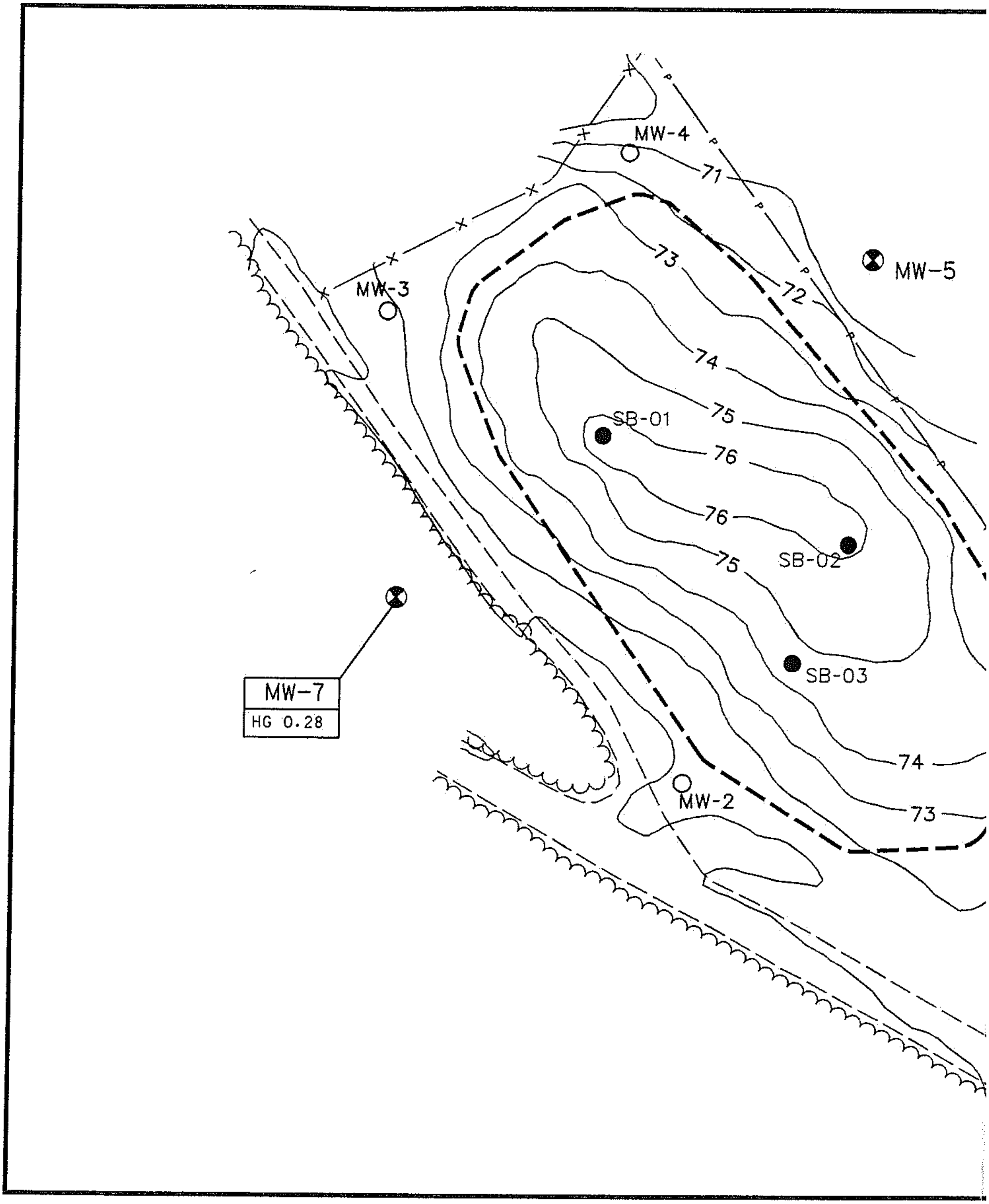

Figure 11-7. Results of Analys

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and cadmium are considered potentially site related. MW-7 is considered upgradient of the site; however, as discussed in Section 11.1, the water table may be mounded beneath the Burn Pit C site.

11.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 11-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

Table 11-4. Summary of Site-Related Constituents
Burn Pit C, Fort Stewart

Analyte	Surface Soil	Subsurface Soil	Groundwater
	(µg/kg)	**(µg/kg)**	**(µg/L)**
Acetone	na	**39.4**	nd
2-Butanone	na	**17.1**	nd
Methylene Chloride	na	**4.3**	nd
Tetrachloroethene	na	**48**	nd
Toluene	na	**69.9**	nd
1,1,1-Trichloroethane	na	**10**	nd
Xylenes, total	na	**14**	nd
	(mg/kg)	**(mg/kg)**	**(µg/L)**
Arsenic	nd	brc	brc
Barium	**20.2**	brc	**134**
Cadmium	**0.35**	brc	**3**
Chromium	brc	brc	nd
Lead	**33.2**	**21.9**	brc
Mercury	**0.06**	**0.07**	**0.28**
Selenium	nd	nd	brc
Silver	nd	nd	brc

brc = Below background reference criteria
na = Not analyzed in any sample in that medium
nd = Not detected in any sample in that medium
BOLD font indicates the analyte is an SRC in that medium

11.3 FATE AND TRANSPORT CONSIDERATIONS AT BURN PIT C

The results of contaminant migration soil screening (discussed in Section 6) for Burn Pit C are presented in Table 11-5. Only PCE is identified as a CMCOPC based on leaching to groundwater. However, PCE is not currently observed in groundwater, indicating that it may be degraded before reaching the water table. The predicted maximum concentration of PCE in groundwater, based on a maximum of 48 µg/kg in soil and a DAF of 1, is 80 µg/L. Through biodegradation, even if the PCE were to reach groundwater at such a concentration, it would degrade to its MCL value (5 µg/L) in less than 4.0 times its half-life. Assuming a conservative half-life of 4.5 years, the PCE would degrade to its MCL value in 18 years. Similarly, methylene chloride with its predicted maximum concentration of 22 µg/L in groundwater would degrade to its MCL in less than 2.1 times its half-life, or 0.6 years.

The maximum concentrations of PCE were reported in Phase I samples only and were not detected in Phase II samples.

Table 11-5. CMCOPCs Based on Soil Screening for Burn Pit C

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration > GSSL?
RCRA Metals (mg/kg)			
Barium	20.20	1600	No
Cadmium	0.35	8	No
Lead	33.20	400	No
Mercury	0.07	0.4	No
Volatile Organic Compounds (µg/kg)			
1,1,1-Trichloroethane	10.00	100.0	No
2-Butanone	17.10	38.4	No
Acetone	39.40	800	No
Methylene Chloride	4.3	1	Yes
Tetrachloroethene	48.00	3	Yes
Toluene	69.90	600	No
Xylenes	14.00	10000	No

CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
RCRA = Resource Conservation and Recovery Act.
SRCs = Site-related Contaminants.

The most likely pathway of contaminant migration from Burn Pit C is via groundwater discharge to Mill Creek, located approximately 4000 feet northeast of the site. Based on an average groundwater flow velocity of 14.1 feet/year, the estimated arrival time for the site groundwater to reach Mill Creek is expected to be more than 284 years. Therefore, PCE and methylene chloride would degrade to less than their MCLs within 300 feet of the Burn Pit C site, well before reaching Mill Creek.

Metals detected in the groundwater at this site include barium, cadmium, and mercury. However, the maximum concentrations of these metals do not exceed their respective MCLs and, based on fate and transport analysis, they are not expected to increase in the future. Therefore, none of the constituents are expected to be of concern for contaminant migration from Burn Pit C.

11.4 HUMAN HEALTH RISK EVALUATION OF BURN PIT C

SRCs were identified in Section 11.2 for surface soil, subsurface soil, and groundwater. The identification of risk-based action levels for all of the Burn Pits has been previously discussed in Section 4.7 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit C is given below.

11.4.1 Exposure Evaluation

This site is completely covered by vegetation, and no VOCs were detected in surface soils. Therefore, exposure via inhalation based on current land use is not a viable exposure pathway. The site is currently used by the Army to conduct outdoor classroom type training. Therefore, current on-site receptors include a juvenile trespasser and a hunter. Current off-site receptors would be represented by an off-site hunter.

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Land use at this site is unlikely to change in the future. However, the Army may use the site as a training area in the future. Construction may occur on the site or the vegetative cover may be gone as a result of on-site activities. Future on-site receptors include military personnel and a construction worker. Future off-site receptors include hunters in the area.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current juvenile trespasser. The juvenile trespasser may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Hunter. The hunter is representative of a current on-site and a current and future off-site receptor. The current on-site receptor is not likely to be exposed to chemicals given the absence of an air migration pathway, and clothing the hunter would be wearing would eliminate potential dermal exposure. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

The current off-site hunter may be exposed via ingestion of contaminants bioaccumulated in game animals. The future off-site hunter may be exposed via ingestion of game and inhalation of fugitive dust if the vegetative cover were to be removed.

Future on-site military personnel. The on-site military personnel may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Future construction worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

11.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals will be evaluated further in a BRA.

None of the contaminants in surface soils or subsurface soils exceeded its respective risk-based screening value for direct exposure of a potential receptor population (Table 11-6).

The maximum concentration of cadmium in groundwater (3 µg/L) only slightly exceeded the screening value of 1.8 µg/L (Table 11-6). However, the maximum concentration of cadmium was below its MCL of 5 µg/L. The remaining chemicals were below their respective screening values. In addition, the use of surface ground water at the sites for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health.

Table 11-6. Comparison to Action Levels–Burn Pit C, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit C Surface Soil								
Barium	mg/kg	6/6	6.2	20.2	14.70	550	No	Max Detect < Screening Criteria
Cadmium	mg/kg	1/6	0.35	0.35	0.18	3.90	No	Max Detect < Screening Criteria
Lead	mg/kg	6/6	3.5	33.2	8.81	400	No	Max Detect < Screening Criteria
Mercury	mg/kg	6/6	0.03	0.06	0.03	2.3	No	Max Detect < Screening Criteria
Burn Pit C Subsurface Soil								
Lead	mg/kg	10/10	0.67	21.9	11.1	400	No	Max Detect < Screening Criteria
Mercury	mg/kg	6/10	0.02	0.07	0.05	61.0	No	Max Detect < Screening Criteria
1,1,1-Trichloroethane	mg/kg	1/9	0.01	0.01		4,100	No	Max Detect < Screening Criteria
2-Butanone	mg/kg	1/6	0.0171	0.0171		100,000	No	Max Detect < Screening Criteria
Acetone	mg/kg	1/10	0.0394	0.0394		20,000	No	Max Detect < Screening Criteria
Tetrachloroethene	mg/kg	2/8	0.015	0.048		110	No	Max Detect < Screening Criteria
Toluene	mg/kg	4/10	0.005	0.0699		41,000	No	Max Detect < Screening Criteria
Xylenes, Total	mg/kg	1/8	0.014	0.014		100,000	No	Max Detect < Screening Criteria
Burn Pit C Groundwater								
Barium	µg/L	2/2	70.6	134	71.72	260	No	Max Detect < Screening Criteria
Cadmium	µg/L	1/2	3	3	0.43	1.8	Yes	Max Detect > Screening Criteria
Mercury	µg/L	2/2	0.14	0.14[a]	0.14	1.1	No	Max Detect < Screening Criteria

[a] Maximum detected value of mercury in MW-7 (upgradient well) was 0.28 µg/L.

COPC = Chemical/Contaminant of Potential Concern.

EPA = U.S. Environmental Protection Agency.

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit C. A human health BRA is not warranted. No further action is required for protection of human health.

11.5 ECOLOGICAL RISK EVALUATION OF BURN PIT C

The ecological risk evaluation of Burn Pit C is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are considered further in PRE Steps ii through v. The results of the five steps of the PRE are reported below.

11.5.1 Ecological Screening Value Comparison (Step i)

Three RCRA metals were detected in groundwater at Burn Pit C at concentrations exceeding reference background criteria. The results of the ecological screening value comparison for groundwater at Burn Pit C are presented in Table 11-7. At MW-7, barium and mercury concentrations exceed the surface water ESVs. Where detected in the remaining two monitoring wells (MW-5 and MW-6), barium, cadmium, and mercury exceed the ESVs for those analytes. The ecological COPCs identified by the ESV comparison for groundwater at Burn Pit C are barium, cadmium, and mercury.

Table 11-7. EPA Region 4 Ecological Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit C, Fort Stewart

Analyte	ESV	MW-7	MW-5	MW-6	Maximum
RCRA Metals (μg/L)					
Barium	3.9[a]	**26.6 J**	**70.6 J**	**134 J**	**134 J**
Cadmium	0.66[b]			**3**	**3**
Mercury	0.0123	**0.28**		**0.14**	**0.28**

ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1995) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
[a]Office of Solid Waste and Emergency Response Ambient Water Quality Criteria or Tier-II value (Suter and Tsao 1996).
[b]Hardness dependent, assumes 50 mg/L $CaCO_3$.
Bold font indicates detected concentration exceeds ESV.

Although ecological COPCs are identified in groundwater at Burn Pit C when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit C. There are no surface water bodies in the vicinity of Burn Pit C. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit C soils.

Because there are no ESVs for soil, all analytes detected in soil at Burn Pit C are evaluated further in PRE Steps ii through v.

11.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit C comprises approximately 2 acres (Figure 11-1). The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees. Drainage occurs through overland flow radically in all directions and is collected in a series of man-made ditches that convey runoff to Mill Creek. The closest surface stream to the site is Mill Creek, a tributary of Taylors Creek, which lies approximately 4000 feet northeast of the site.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit C are described in Section 8.1.2.

11.5.3 Preliminary Effects (Step iii)

In the PRE for Burn Pit C, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the site. The derivation of TRVs is discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8-1.

11.5.4 Preliminary Exposure (Step iv)

Ecological receptors at the Burn Pit C are likely exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews and robins exposed to COPCs in soil are presented in Table 8-2.

11.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate a HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0 and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. The preliminary risk calculation for shrews and robins exposed to ecological COPCs detected in soil at Burn Pit C is presented in Table 11-8. This table shows the maximum detected concentrations and the TRVs for shrews and robins. Concentrations resulting in HQs exceeding 1.0 are shown in boldface.

The ecological COPCs present in Burn Pit C surface soil at concentrations exceeding the TRVs for the surrogate species are cadmium and lead. Both the shrew and robin are potentially at risk from cadmium in surface soil. However, cadmium was detected in only a single sample at a concentration above background criteria and may not be site related. The robin is potentially at risk from lead in surface soil. The concentrations of lead in all six surface soil samples exceed the robin TRV. An HI is not calculated for the surrogate species exposed to RCRA metals in surface soil because they are assumed to have dissimilar mechanisms of toxicity.

Table 11-8. Preliminary Risk Evaluation of Ecological COPCs in Surface Soil (0 to 1 foot) at Burn Pit C, Fort Stewart

Analyte	TRV		MW-5	MW-6	MW-7	SB-1	SB-2	SB-3	Maximum
	Shrew	Robin							
RCRA Metals (mg/kg)									
Barium	2627	2293	6.2 J	6.9 J	5.2 J	7 J	20.2 J	13.3 J	20.2 J
Cadmium	0.321	0.109					**0.35**		**0.35**
Lead	73.3	2.35	**3.5 J**	**5.3 J**	**3.1 J**	**6.5 J**	**33.2**	**29.9 J**	**33.2**
Mercury	14.1	1.09	0.03	0.06		0.05	0.06	0.06	0.06

COPCs = Chemicals/Contaminants of Potential Concern.

J = Estimated concentration.

\- = No data to derive TRV.

RCRA = Resource Conservation and Recovery Act.

TRV = Toxicity Reference Value = (NOAEL x BW/Food Ingestion)/$BAF_{earthworm}$ (see Table 8-1).

Blank cells indicate analyte not detected at site.

Bold font indicates detected concentration exceeds TRV (HQ > 1).

11.5.6 Uncertainties

The risk to ecological receptors from cadmium and lead in surface soil at Burn Pit C is overestimated by the preliminary risk calculations. The single cadmium detect in surface soil (0.35 mg/kg in SB-2) does not exceed the NOAEL-based TRV for shrews (0.365 mg/kg) calculated using published dietary fractions, and only barely exceeds that for the robin (0.284 mg/kg). Cadmium in surface soil at Burn Pit C is many times less than the LOAEL-based TRVs for shrews and robins calculated using published dietary fractions, 1.74 and 3.92 mg/kg, respectively. Likewise, lead was detected in three of six surface soil samples at Burn Pit C at concentrations exceeding the NOAEL-based TRV for the robin (5.89 mg/kg), but in no sample did lead exceed the LOAEL-based TRV for the robin calculated using published dietary fractions (48 mg/kg). Therefore, cadmium and lead in surface soil at Burn Pit C are unlikely to pose a risk to ecological receptors.

11.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT C

The following are the conclusions of the Phase II RFI for Burn Pit C:

- In surface soils, four metals (barium, cadmium, lead, and mercury) were reported above reference background at boring locations in the middle of the source area. The extent of these metals in surface soil is, therefore, limited to the area surrounding these borings (SB-1, SB-2, SB-3, and MW-6) in the center of the Burn Pit C site, approximately one acre in size.

- There are no human health COPCs in surface soil or subsurface soil because no constituent exceeded its risk-based screening value.

- Cadmium and lead are ecological COPCs in surface soils because they exceed the TRVs for the surrogate species (shrew and robin). The maximum concentration of cadmium (0.35 mg/kg) is much less than the average USGS background concentration for soils in the Eastern United States (2 mg/kg). Cadmium was detected above background in only one sample and may not be site related. Lead is possibly site related and may pose a risk to ecological receptors (mammals and birds ingesting earthworms and other soil-dwelling invertebrates). However, the maximum concentration of lead (33.2 mg/kg) is well within the USGS range of background concentration for soils in the Eastern United States (up to 300 mg/kg). In addition, lead concentrations in surface soil are many times less than the LOAEL-based TRV and are unlikely to pose a risk to ecological receptors. The risk to ecological receptors from cadmium and lead in surface soil at Burn Pit C is overestimated by the preliminary risk calculations. As discussed in the uncertainties section (11.5.6), the maximum detected concentrations of cadmium and lead in surface soil are expected to result in exposures to the surrogate ecological receptors (shrews or robins) that are less than the lowest exposures associated with adverse effects on them (LOAEL-based TRV). Therefore, cadmium and lead are eliminated as ecological COPCs for Burn Pit C, and further investigation and/or evaluation of these constituents is not required.

- In subsurface soil, two metals (lead and mercury) occur in the middle of the site and extend to the northeast, defining the extent of potential metal contamination. Similarly, BTEX compounds and PCE were identified in four of the eight subsurface soil samples, extending from the center of the site to the northwest.

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- There are no human health COPCs in subsurface soil because no constituent exceeded its risk-based screening value.

- PCE is a potential contaminant migration COPC in subsurface soil because it may leach to groundwater, resulting in groundwater concentrations exceeding its respective MCL. Off-site migration of PCE would be very limited due to retardation and biodegradation and the slow movement of groundwater. Even if it were to reach groundwater at its predicted maximum concentration, it would degrade to concentrations less than its MCL in less than 18 years, and having traveled less than 300 feet from the Burn Pit C site. Therefore, migration of PCE is considered unlikely, and there are no contaminant migration COPCs in subsurface soil.

- In groundwater, three metals (barium, cadmium, and mercury) were reported above background and are considered SRCs. Mercury was detected in well MW-7 at concentrations only slightly above background. Well MW-7 is considered upgradient of the site; however, water table contours suggest that the water table may potentially be mounded beneath the Burn Pit C site.

- Cadmium is a potential human health COPC at Burn Pit C where the maximum concentration of cadmium in groundwater exceeded its risk-based screening value for residential use of groundwater. The maximum concentration of cadmium was less than its MCL of 5 μg/L at the site. In addition, use of the surficial groundwater at the site for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health at Burn Pit C and does not require further investigation and/or evaluation.

- Barium, cadmium, and mercury, are ecological COPCs in groundwater because they exceed the ESVs for surface water. However, there are no surface water bodies in the vicinity of Burn Pit C, and off-site migration would be limited due to retardation and the slow movement of groundwater. Therefore, exposure of ecological receptors to these metals in surface water bodies downgradient from Burn Pit C is not a complete exposure pathway. Therefore, barium, cadmium, and mercury are eliminated as ecological COPCs for Burn Pit C, and further investigation and/or evaluation of these constituents is not required.

The following are recommendations for Burn Pit C:

1. No further action is recommended for Burn Pit C.
2. All potential human health COPCs were eliminated for Burn Pit C, and a BRA is not recommended for the site.
3. All potential ecological COPCs were eliminated for Burn Pit C, and an ERA is not recommended for the site.

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12.0 CHARACTERIZATION OF BURN PIT D (SWMU 4D)

12.1 HISTORY AND DESCRIPTION OF BURN PIT D

Burn Pit D (SWMU 4D) comprises approximately 4 acres and is located on Fort Stewart Route 90, approximately 500 feet west from its junction with 6th Street. The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees. Trees in the center of the site have become large enough that access to truck-mounted drilling equipment was restricted.

The site is slightly mounded, with elevations varying between approximately 71 to 72 feet amsl around the perimeter of the site and 77 feet amsl in the center of the site (Figure 12-1). Drainage occurs through overland flow radially in all directions and is collected in a series of man-made ditches that convey runoff to Mill Creek. The closest surface stream to the site is Mill Creek, a tributary of Taylors Creek, which lies approximately 2500 feet east-northeast of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 12-1). PCE and four RCRA metals, including arsenic, chromium, lead, and mercury were detected above site-specific background levels in soils. RCRA metals were also detected above site-specific background levels in groundwater and included chromium, lead, mercury, and selenium. No VOCs were detected in groundwater samples in Phase I.

During the Phase II RFI activities, two new monitoring wells (MW-5 and MW-6) were installed, and three soil borings (SB-1 through SB-3) were drilled at the site (Figure 12-1). These wells and borings, together with the existing Phase I wells, were used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of slightly silty sands. Geologic cross-sections of the Burn Pit D site are presented in Figures 12-2 and 12-3. Geotechnical parameters were measured in a bulk soil sample taken from MW-6 at a depth of 12.8 to 13.8 feet and in a Shelby tube sample taken from MW-5 at a depth of 10.7 to 12.5 feet. The results of the geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic sands with less than 8 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from MW-5, is 9.45×10^{-4} cm/second, typical for a fine sand.

Water levels in the monitoring wells were measured during well development between July 9 and 13, 1997, and again during well sampling between July 28 and August 10, 1997. The water table is present at a depth between 7 and 8 feet bgs around the perimeter of the site and up to 13 feet bgs beneath the center of the site. A water table contour map is provided as Figure 12-4. Groundwater contours measured during the Phase I RFI activities in August 1993 indicate similar water levels and groundwater flow direction. Groundwater flow is generally to the east-northeast, discharging ultimately to Mill Creek, which is located approximately 2500 feet east-northeast of the Burn Pit D site. The water table is relatively flat, with a calculated horizontal hydraulic gradient across the site of 0.0015 foot/foot. Based on a hydraulic conductivity of 9.45×10^{-4} cm/second and a porosity of 0.368, the groundwater flow rate is approximately 4.0 feet/year toward Mill Creek.

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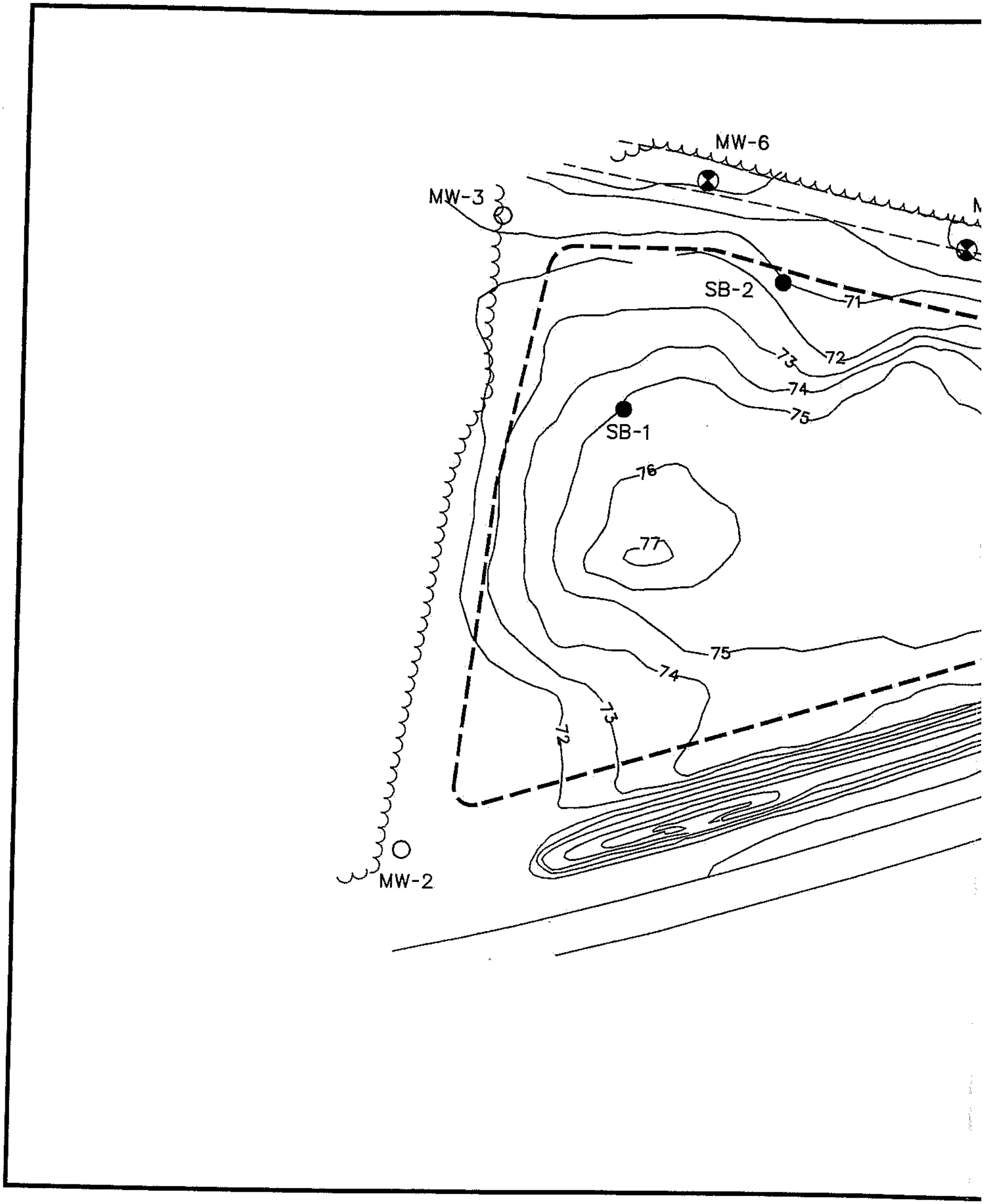

Figure 12-1. Locations of Sa

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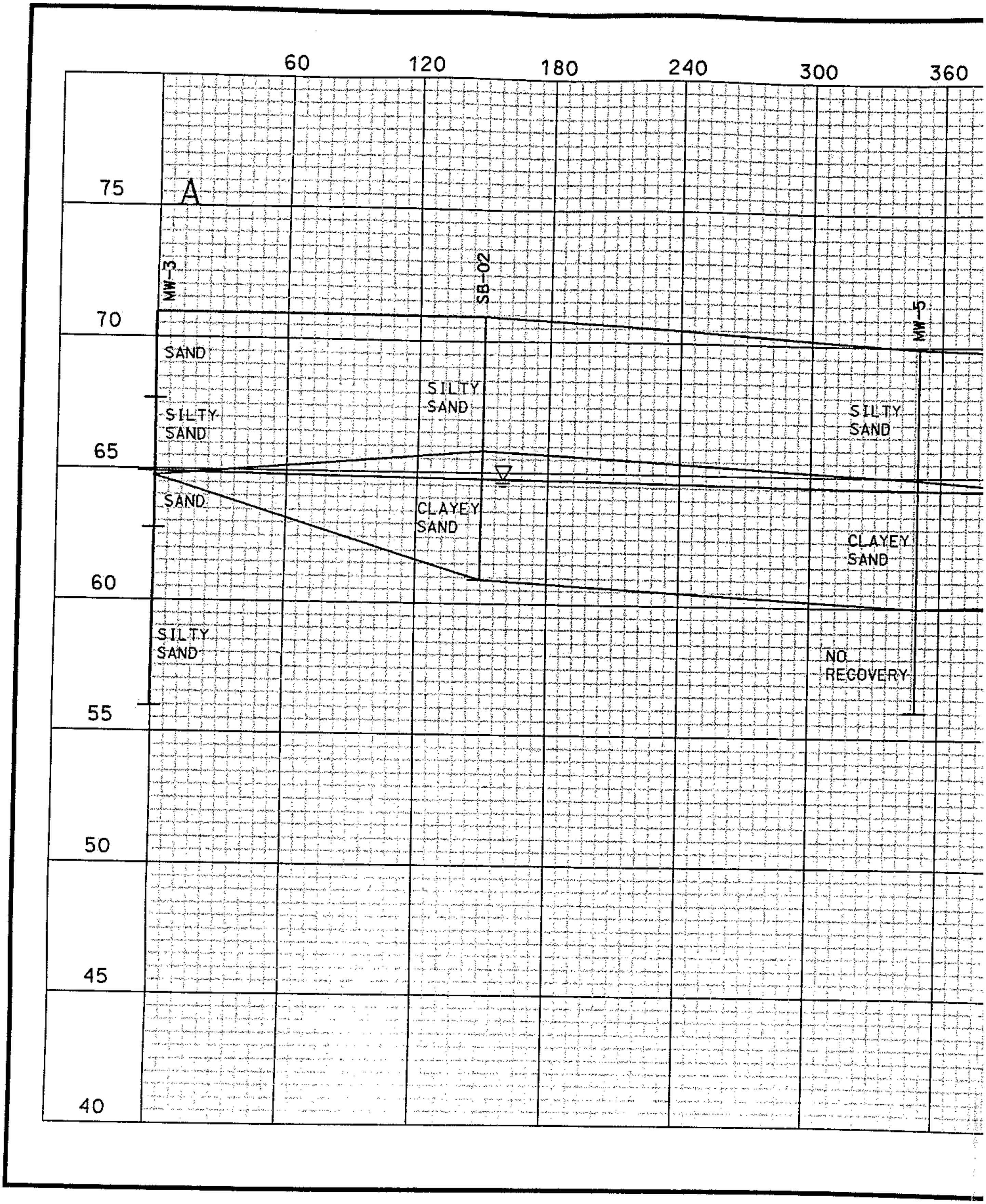

Figure 12-2. Geologic Cros

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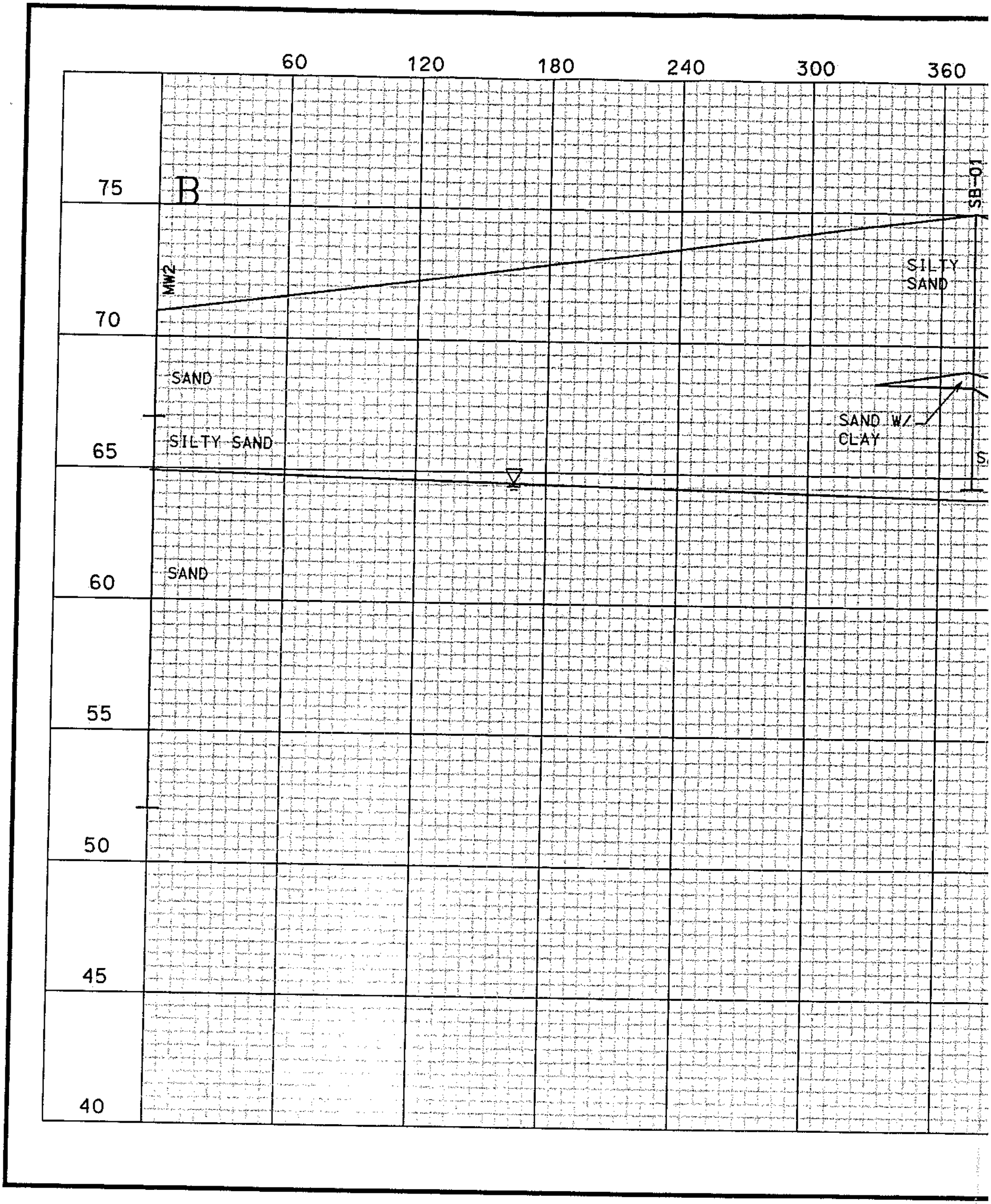

Figure 12-3. Geologic Cros

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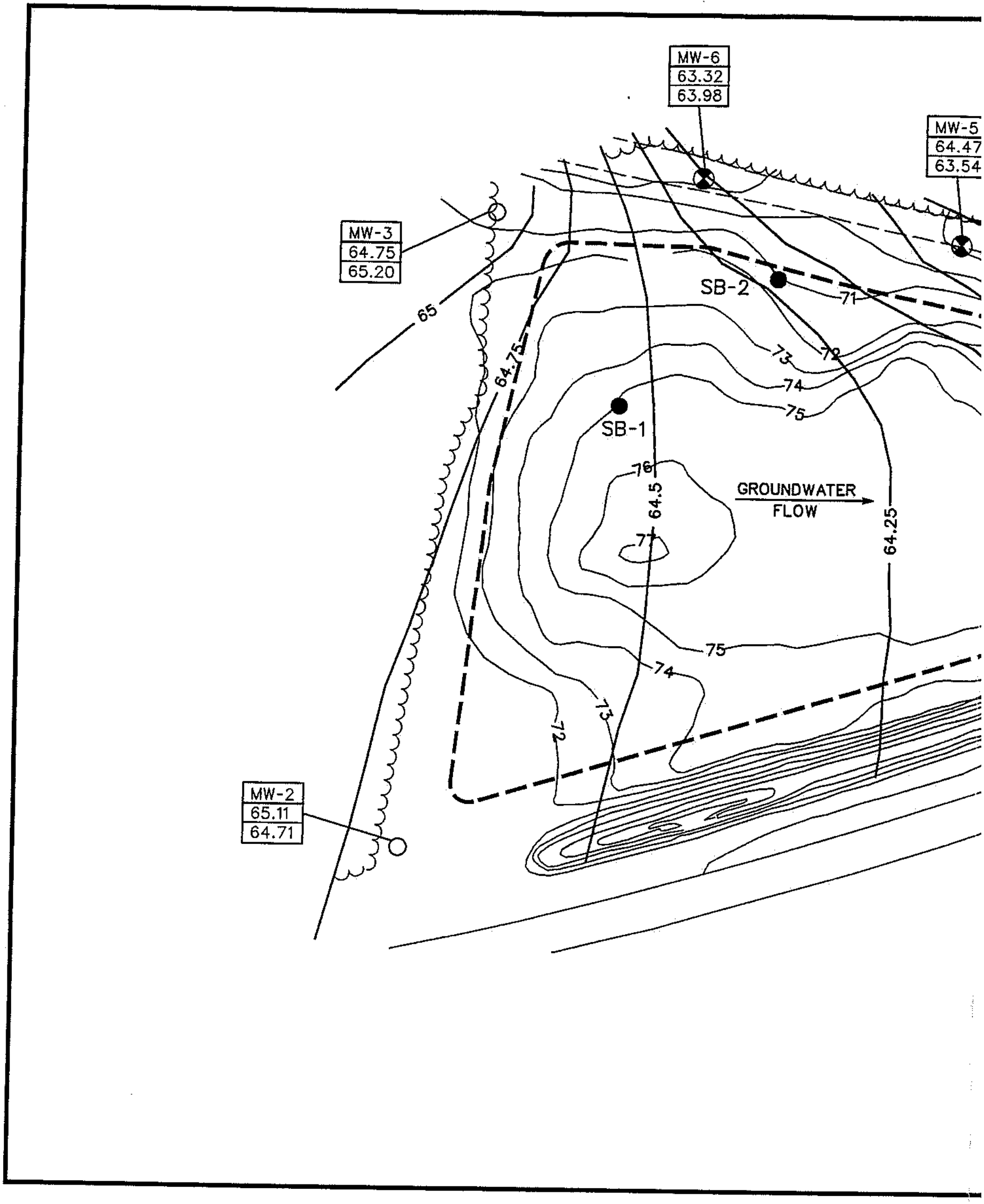

Figure 12-4. Water Table Contou

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12.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT D

12.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results of analyses on surface soil samples taken from the two new monitoring wells (MW-5 and MW-6) and the three soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 12-1 summarizes the analytical results for surface soil samples and Figure 12-5 shows their distribution. This assessment presents Phase II contaminant data only, because no surface soil samples were collected during Phase I.

Table 12-1. Summary of Analytical Results for Surface Soils
Burn Pit D, Fort Stewart

		Phase II Samples				
Parameter	**Reference Background**	**SB-1 4D1111 07/08/97 (0-1 foot)**	**SB-2 4D1211 07/08/97 (0-1 foot)**	**SB-3 4D1311 07/08/97 (0-1 foot)**	**MW-5 4D1511 07/09/97 (0-1 foot)**	**MW-6 4D1611 07/09/97 (0-1 foot)**
RCRA Metals (mg/kg)						
Arsenic	2.10	0.34		0.27		
Barium	14.7	8.6	0.71	12.6	2.8	2
Chromium	6.21	1.1		2	2.1	0.74
Lead	8.81	6.4		7.7	2.6	1.2
Mercury	0.03	0.02		0.02	0.03	

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

SVOCs. No SVOCs were reported above the detection limit in surface soil samples.

RCRA metals. None of the RCRA metals was reported above reference background values; therefore, metals in surface soil are not considered site related.

12.2.2 Subsurface Soil Contamination

The subsurface soil samples were collected from the four Phase I monitoring well boreholes, the two Phase II well boreholes, and the three Phase II soil borings. The samples were analyzed for VOCs and RCRA metals. Table 12-2 summarizes analytical results for the subsurface soil samples, and Figure 12-6 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. BTEX compounds were identified only in the Phase I subsurface soil samples at MW-1, MW-2, and MW-3. Maximum concentrations of benzene (12 µg/kg at MW-1), toluene (21 µg/kg at MW-2), and xylenes (22 µg/kg at MW-2) were reported. No BTEX compounds were found in any of the Phase II subsurface soil samples.

PCE was reported in a single Phase I sample at a concentration of 9.7 µg/kg at MW-4. PCE was not detected in the Phase II soil samples. Acetone was detected at SB-1, SB-3, and MW-2 at a maximum concentration of 110 µg/kg, and 2-hexanone was detected in SB-1 at a concentration less than its average detection limit in background samples and is, therefore, not considered site related.

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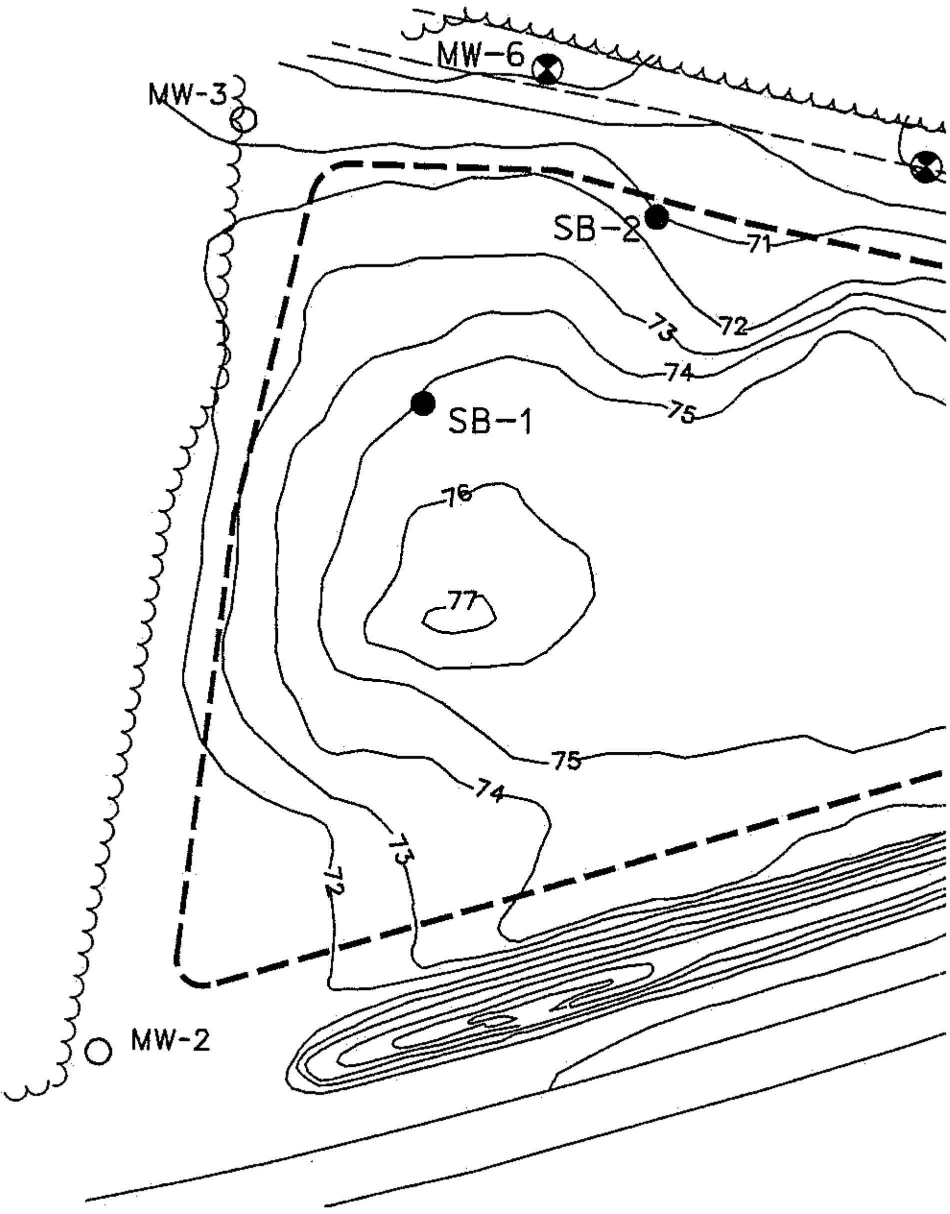

Figure 12-5. Results of Analy

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Table 12-2. Summary of Analytical Results for Subsurface Soils
Burn Pit D, Fort Stewart

Parameter	Reference Background	Phase I Samples MW1 SL1-4 06/24/93 (2-4 feet)	MW2 SL2-6 06/24/93 (4-6 feet)	MW3 SL3-6 06/24/93 (4-6 feet)	MW4 SL4-4 06/24/93 (2-4 feet)	Phase II Samples MW-5 4D1512 07/09/97 (2.5-5 feet)	MW-6 4D1612 07/09/97 (5-7.5 feet)	SB-1 4D1112 07/08/97 (10-12.1 feet)	SB-2 4D1212 07/08/97 (5-7.5 feet)	SB-3 4D1312 07/08/97 (10-12.5 feet)
Volatile Organic Compounds (ug/kg)										
2-Hexanone	0.0							**1.4**		
Acetone	0.0		**110**					**76.2**		**32.8**
Benzene	0.0	**12**								
Tetrachloroethene	0.0				**9.7**					
Toluene	0.0	**5.8**	**21**	**5.8**						
Xylene	0.0	**5.5**	**22**							
RCRA Metals (mg/kg)										
Arsenic	8.04			1.2		1.4		0.29	0.47	3.1
Barium	17.0	2.9	5.9	4.8	4.2	9.3	15.6	5.3	10.4	11.8
Cadmium	0.24	**0.54**								
Chromium	11.6	3.4	3.3	6.4	3.7	9.2	7.7	5.9	11.1	5.3
Lead	11.1	2.7	3.7	11	2.5	6.4	8.3	5.5	7.5	3.3
Mercury	0.05	0.016	0.016	**0.063**	0.017	**0.06**	0.05	0.02	0.03	0.03
Other Inorganics (mg/kg)										
Total Organic Carbon	2,200					**2400**				

Note: A blank indicates analyte not detected.

Note: **Bold** font indicates value exceeds reference background criterion.

RCRA = Resource Conservation and Recovery Act.

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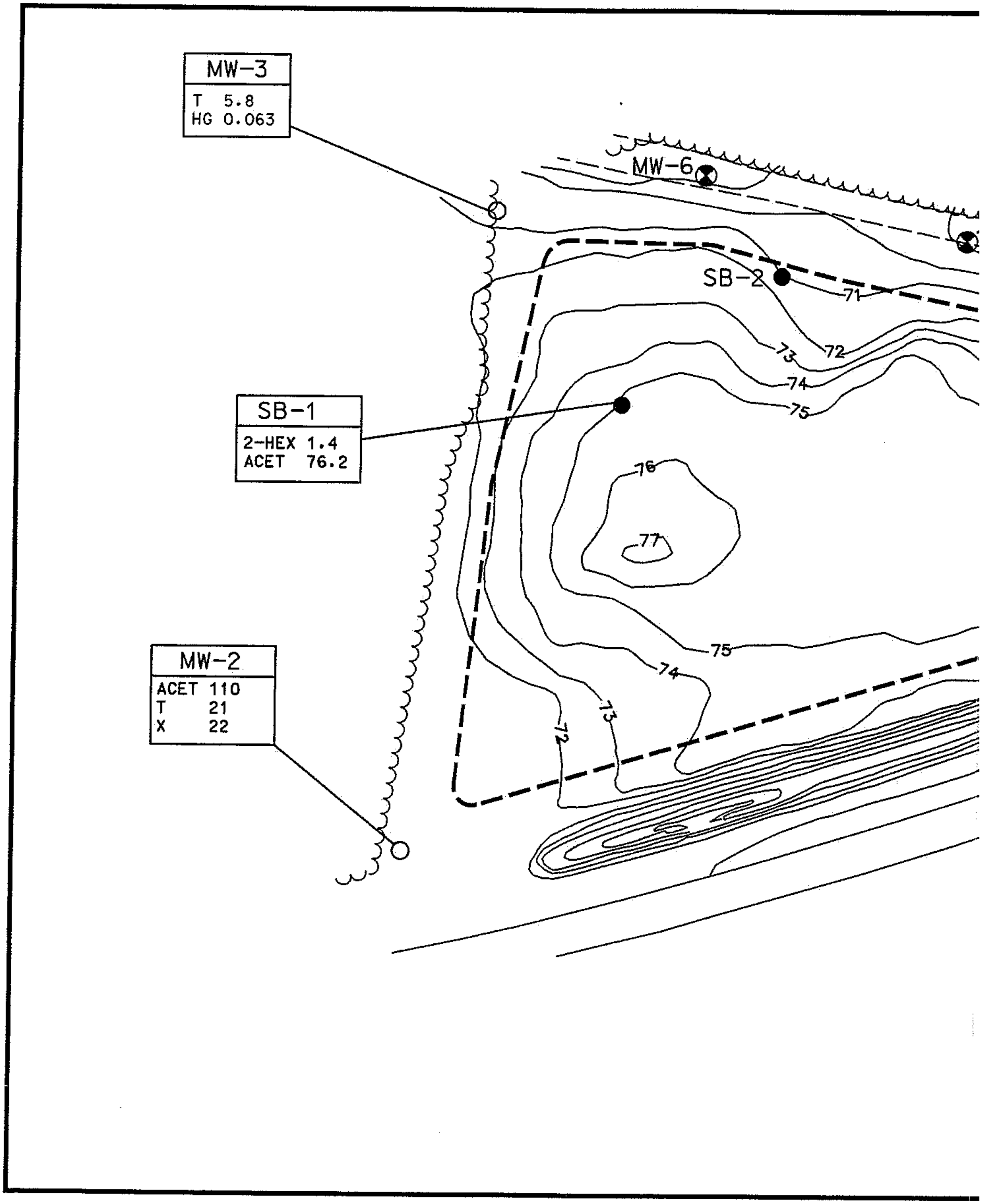

Figure 12-6. Results of Analys

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RCRA metals. Two metals were reported at concentrations above their reference background value. Maximum values of cadmium (0.54 mg/kg at MW-1) and mercury (0.063 mg/kg at MW-3) were reported. The distribution of these metals at concentrations above background does not indicate a distinctive pattern; the metals are sporadically within the area defined by borings MW-1, MW-3, and MW-5.

12.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples taken from the four monitoring wells installed during Phase I (MW-1 through MW-4) and two monitoring wells installed during Phase II (MW-5 and MW-6). The groundwater samples were analyzed for VOCs and RCRA metals (total metal analysis on unfiltered water samples). Table 12-3 summarizes the analytical results for groundwater samples, and Figure 12-7 shows their distribution. This assessment focuses on the Phase II contaminant data because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 12-3. Summary of Analytical Results for Groundwater, Burn Pit D, Fort Stewart

			Phase II Samples					
Parameter	Reference Background	MCL	MW-1 07/27/97 4D4111	MW-2 07/29/97 4D4211	MW-3 07/28/97 4D4311	MW-4 07/28/97 4D4411	MW-5 08/10/97 4D4511	MW-6 08/10/97 4D4611
RCRA Metals (µg/L)								
Arsenic	3.02	50						**4.2**
Barium	71.72	2000	**99.6**	58	12	63.5	51.7	50.1
Cadmium	0.43	5		0.43			0.22	
Chromium	3.56	100	1.8		0.67	2.9	2.7	2.5
Lead	4.69	15		0.2				1.2
Selenium	1.90	50					1.1	1.6
Silver	1.12		**3.6**	0.37	0.09	0.53	0.23	0.85

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.

VOCs. No VOCs were reported above the detection limit in either Phase I or Phase II groundwater samples. These results suggest that although low concentrations of BTEX are present in subsurface soils at the site, the soil contamination has not impacted groundwater.

RCRA metals. Three metals were reported at concentrations above background in groundwater. Arsenic was reported at a maximum concentration in MW-6 (4.2 µg/L), barium in MW-1 (99.6 µg/L), and silver in MW-1 (3.6 µg/L).

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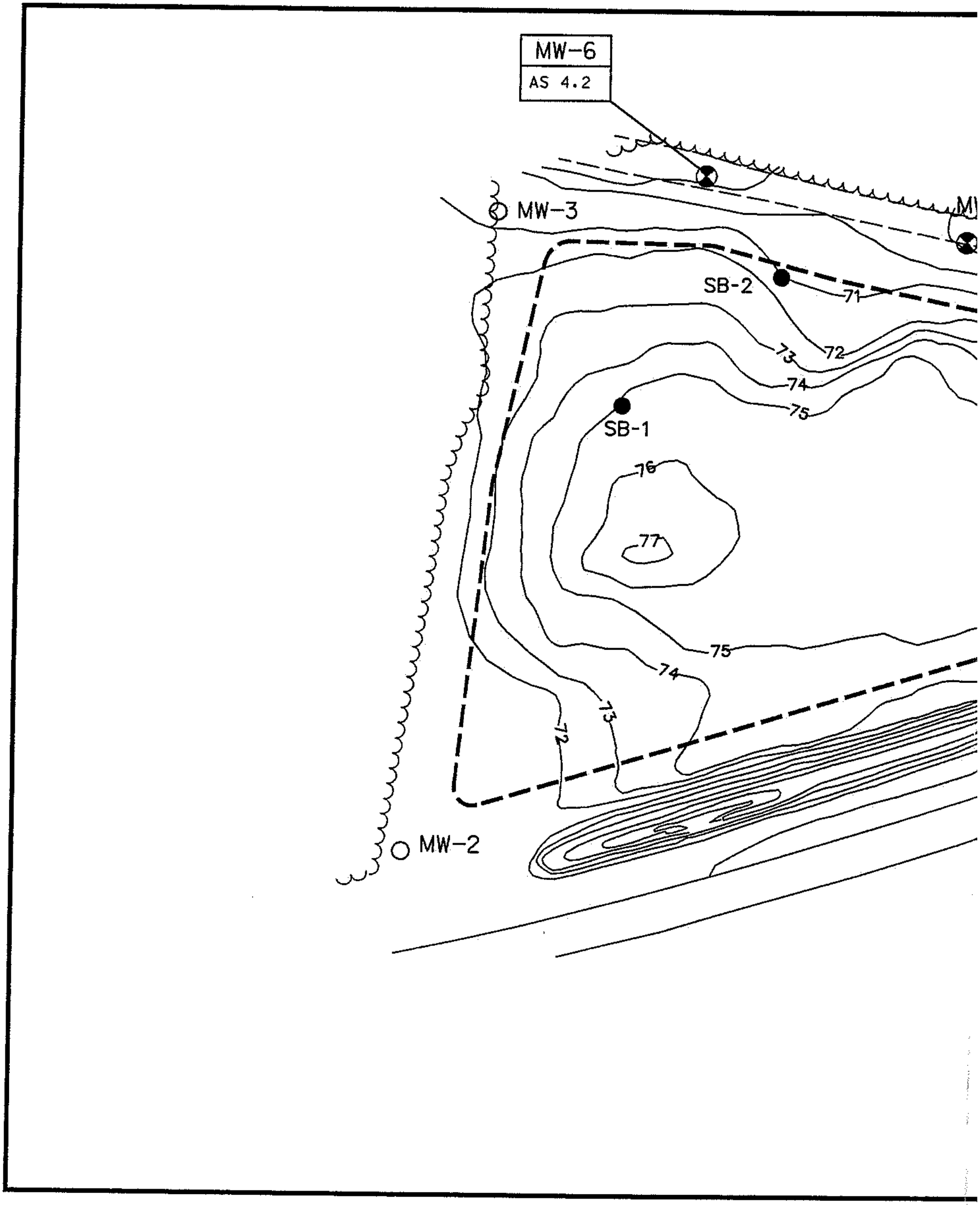

Figure 12-7. Results of Analy

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12.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 12-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

Table 12-4. Summary of Site-Related Constituents
Burn Pit D, Fort Stewart

Analyte	**Surface Soil**	**Subsurface Soil**	**Groundwater**
	(µg/kg)	**(µg/kg)**	**(µg/L)**
Acetone	na	**110**	nd
Benzene	na	**12**	nd
2-Hexanone	na	**1.4**	nd
Tetrachloroethene	na	**9.7**	nd
Toluene	na	**21**	nd
Xylenes, total	na	**22**	nd
	(mg/kg)	**(mg/kg)**	**(µg/L)**
Arsenic	brc	brc	**4.2**
Barium	brc	brc	**99.6**
Cadmium	nd	**0.54**	brc
Chromium	brc	brc	brc
Lead	brc	brc	brc
Mercury	brc	**0.063**	nd
Selenium	nd	nd	brc
Silver	nd	nd	**3.6**

brc = Below background reference criteria.
na = Not analyzed in any sample in that medium.
nd = Not detected in any sample in that medium.
BOLD font indicates the analyte is an SRC in that medium.

12.3 FATE AND TRANSPORT CONSIDERATIONS AT BURN PIT D

The results of contaminant migration soil screening (discussed in Section 6) for Burn Pit D are presented in Table 12-5. Benzene and PCE are identified as CMCOPCs based on leaching to groundwater. However, these constituents were not currently observed in groundwater, indicating that they may be degraded before reaching the water table. The predicted maximum concentration of benzene in groundwater, based on a maximum of 12 µg/kg in soil and a DAF of 1, is 30 µg/L. Through biodegradation, even if the benzene were to reach groundwater at such a concentration, it would degrade to its MCL value (5 µg/L) in less than 2.6 times its half-life. Assuming a conservative half-life of 2.0 years, the benzene would degrade to its MCL value in 5.2 years. Similarly, PCE with its predicted maximum concentration of 16 µg/L in groundwater would degrade to its MCL in less than 1.7 times its half-life, or 7.7 years.

The maximum concentrations of benzene and PCE were reported in Phase I samples only and were not detected in Phase II samples.

Table 12-5. CMCOPCs Based on Soil Screening for Burn Pit D

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration > GSSL?
RCRA Metal (mg/kg)			
Cadmium	0.54	8	No
Mercury	0.063	0.4	No
Volatile Organic Compounds (µg/kg)			
2-Hexanone	1.40		No
Acetone	76.20	800	No
Benzene	12.00	2	Yes
Tetrachloroethene	9.70	3	Yes
Toluene	5.80	600	No
Xylenes	5.50	1000	No

CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
RCRA = Resource Conservation and Recovery Act.

The most likely pathway of contaminant migration from Burn Pit D is via groundwater discharge to Mill Creek, located approximately 2500 feet east-northwest of the site. Based on the calculated groundwater flow velocity of 4.0 feet/year, the estimated arrival time for the site groundwater to reach Mill Creek is expected to be over 625 years. Therefore, benzene and PCE would degrade to less than their MCLs within 40 feet of the Burn Pit D site, well before reaching Mill Creek.

Metals detected in the groundwater at this site include arsenic, barium, and silver. However, the maximum concentrations of these metals do not exceed their respective MCLs and, based on fate and transport analysis, they are not expected to increase in the future. Therefore, none of the constituents is expected to be of concern for contaminant migration from Burn Pit D.

12.4 HUMAN HEALTH RISK EVALUATION OF BURN PIT D

SRCs were identified in Section 12.2 for subsurface soil and groundwater; there were no SRCs identified for surface soil. The identification of risk-based action levels for all of the Burn Pits has been previously discussed in Section 4.7 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit D is given below.

12.4.1 Exposure Evaluation

This site is completely covered by vegetation, including thick stands of pine trees and other trees, and no VOCs were detected in surface soils. Therefore, exposure via inhalation based on current land use is not a viable exposure pathway. The site is not currently used by the Army. Therefore, current on-site receptors include a juvenile trespasser and a hunter. Current off-site receptors would be represented by an off-site hunter.

Land use at this site is unlikely to change in the future. However, the Army may use the site as a training area in the future. Construction may occur on the site or the vegetative cover may be gone as a result of on-site activities. Future on-site receptors include military personnel and a construction worker. Future off-site receptors include hunters in the area.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current juvenile trespasser. The juvenile trespasser may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Hunter. The hunter is representative of a current on-site and a current and future off-site receptor. The current on-site receptor is not likely to be exposed to chemicals given the absence of a air migration pathway, and clothing the hunter would be wearing would eliminate potential dermal exposure. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

The current off-site hunter may be exposed via ingestion of contaminants bioaccumulated in game animals. The future off-site hunter may be exposed via ingestion of game and inhalation of fugitive dust if the vegetative cover were to be removed.

Future on-site military personnel. The on-site military personnel may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Future construction worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

12.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals will be evaluated further in a BRA.

None of the contaminants in surface soils or subsurface soils exceeded its respective risk-based screening value for direct exposure of a potential receptor population (Table 12-6).

In groundwater, arsenic is a potential COPC because the maximum concentration of arsenic (4.2 μg/L) exceeds its risk-based screening value of 0.045 μg/L for residential use of groundwater as drinking water. However, the maximum concentration of arsenic is well below its MCL of 50 μg/L. Arsenic was detected at a concentration only slightly above its reference background concentration of 3.02 μg/L, and in only a single well at Burn Pit D (MW-6). Arsenic was not found above reference background criteria in either surface or subsurface soil of Burn Pit D. In addition, use of the surficial groundwater at this site for drinking water is unlikely. Therefore, arsenic is not considered a potential threat to human health at Burn Pit D. No other constituent exceeded its risk-based screening value or its MCL in groundwater at Burn Pit D.

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit D. A human health BRA is not warranted. No further action is required for protection of human health.

Table 12-6. Comparison to Action Levels–Burn Pit D, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit D Subsurface Soil								
Cadmium	mg/kg	1/8	0.54	0.54	0.24	1,000	No	Max Detect < Screening Criteria
Mercury	mg/kg	8/8	0.016	0.063	0.05	61.0	No	Max Detect < Screening Criteria
2-Hexanone	mg/kg	1/6	0.0014	0.0014			No	Max Detect < Screening Criteria
Acetone	mg/kg	2/9	0.0328	0.0762		20,000	No	Max Detect < Screening Criteria
Benzene	mg/kg	1/9	0.012	0.012		200	No	Max Detect < Screening Criteria
Tetrachloroethene	mg/kg	1/9	0.0097	0.0097		110	No	Max Detect < Screening Criteria
Toluene	mg/kg	2/9	0.0058	0.0058		41,000	No	Max Detect < Screening Criteria
Xylenes, Total	mg/kg	1/9	0.0055	0.0055		100,000	No	Max Detect < Screening Criteria
Burn Pit D Groundwater								
Arsenic	µg/L	1/5	4.2	4.2	3.02	0.045	Yes	Max Detect > Screening Criteria
Barium	µg/L	5/5	12	99.6	71.72	260	No	Max Detect < Screening Criteria
Silver	µg/L	5/5	0.09	3.6	1.12	18	No	Max Detect < Screening Criteria

COPC = Chemical/Contaminant of Potential Concern.
EPA = U.S. Environmental Protection Agency.

12.5 ECOLOGICAL RISK EVALUATION OF BURN PIT D

The ecological risk evaluation of Burn Pit A is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are considered further in PRE Steps ii through v. The results of the five steps of the PRE are reported below.

12.5.1 Ecological Screening Value Comparison (Step i)

Three RCRA metals were detected in groundwater at Burn Pit D at concentrations exceeding reference background criteria. The results of the ESV comparison for groundwater at Burn Pit D are presented in Table 12-7. At the upgradient monitoring well (MW-2), barium and silver concentrations exceed the surface water ESVs. Where detected in the remaining five monitoring wells (MW-1, and MW-3 through MW-6), barium and silver again exceed the ESVs for those analytes. The ecological COPCs identified by the ESV comparison for groundwater at Burn Pit D are barium and silver.

Although ecological COPCs are identified in groundwater at Burn Pit D when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit D. There are no surface water bodies in the vicinity of Burn Pit D. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit D soils.

Because there are no ESVs for soil, all analytes detected in soil at the Burn Pit D are evaluated further in PRE Steps ii through v.

Table 12-7. EPA Region 4 Ecological Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit D, Fort Stewart

Analyte	ESV	MW-2*	MW-1	MW-3	MW-4	MW-5	MW-6	Maximum
				RCRA Metals (μg/L)				
Arsenic	190[a]						4.2 J	4.2 J
Barium	3.9[b]	**58 J**	**99.6 J**	**12 J**	**63.5 J**	**51.7 J**	**50.1 J**	**99.6 J**
Silver	0.012[c]	**0.37 J**	**3.6 J**	**0.09 J**	**0.53 J**	**0.23 J**	**0.85 J**	**3.6 J**

*Upgradient monitoring well.
J = Estimated concentration.
ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1996) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
[a]Arsenic III.
[b]Office of Solid Waste and Emergency Response Ambient Water Quality Criteria or Tier-II value (Suter and Tsao 1996).
[c]Hardness dependent, assumes 50 mg/L CaCo$_3$.
Bold font indicates detected concentration exceeds ESV.

12.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit D comprises approximately 4 acres (Figure 12-1). The site is surrounded by woods and has become overgrown with grass, shrubs, and small pine trees. There are a few large trees in the center of the site. Drainage occurs through overland flow radially in all directions and is collected in a series of man-made ditches that convey runoff to Mill Creek. The closest surface stream to the site is Mill Creek, a tributary of Taylors Creek, which lies approximately 2500 feet east-northeast of the site.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit D are described in Section 8.1.2.

12.5.3 Preliminary Effects (Step iii)

In the PRE for Burn Pit D, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the site. The derivation of TRVs is discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8-1.

12.5.4 Preliminary Exposure (Step iv)

Ecological receptors at Burn Pit D are likely exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews and robins exposed to COPCs in soil are presented in Table 8-2.

12.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate a HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0, and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. There are no constituents detected above background criteria in surface soil at Burn Pit D. Therefore, no preliminary risk calculation was performed.

12.5.6 Uncertainties

There are no ecological COPCs identified in the PRE for Burn Pit D, so no supplemental evaluation of risk using published dietary fractions and LOAELs is necessary.

12.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT D

The following are the conclusions of the Phase II RFI for Burn Pit D:

- In surface soils, no constituent was found above background. There are, therefore, no human health or ecological COPCs in surface soil.

- In subsurface soil, two metals (cadmium and mercury) were reported at concentrations above their reference background value. The metals are not present in a consistent pattern and are not considered to be due to releases that may have occurred from site-related activities. BTEX compounds were detected in three of the four Phase I boreholes around the perimeter of the site, but were not detected in any of the four Phase II samples, including the three soil borings in the middle of the source area. Therefore, BTEX contamination is not considered to be present at Burn Pit D. PCE was identified in only one of the nine subsurface soil samples collected.

- PCE and benzene are potential contaminant migration COPCs in subsurface soil because these chemicals may leach to groundwater, resulting in groundwater concentrations exceeding their respective MCLs. However, they were not detected in groundwater and were detected in only one soil sample of the nine collected. Off-site migration of these contaminants would be very limited due to retardation and biodegradation and the slow movement of groundwater. Even if these constituents were to reach groundwater at their predicted maximum concentrations, they would degrade to concentrations less than their MCLs in less than 7.7 years, and would have traveled less than 40 feet from the Burn Pit D site. Therefore, migration of these constituents is considered unlikely, and there are no contaminant migration COPCs.

- In groundwater, three metals (arsenic, barium, and silver) were reported at concentrations above background in different wells and at concentrations only slightly above background. The metals do not indicate a pattern of distribution indicating a potential release from the former Burn Pit.

- In groundwater, arsenic is a potential COPC because it exceeded its risk-based screening value for residential use of groundwater as drinking water. However, arsenic did not exceed its MCL and was detected only slightly above its reference background concentration in a single well. In addition, use of the surficial groundwater at this site for drinking water is unlikely. Therefore, arsenic is not considered a potential threat to human health at Burn Pit D. No other constituent exceeded its risk-based screening value or its MCL in groundwater at Burn Pit D.

- Barium and silver are ecological COPCs in groundwater because they exceed the ESVs for surface water. However, there are no surface water bodies in the vicinity of Burn Pit D, and off-site migration would be limited due to retardation and the slow movement of groundwater. Therefore, exposure of ecological receptors to these metals in surface water bodies downgradient from Burn Pit D is not a complete pathway. Therefore, barium and silver are eliminated as ecological COPCs for Burn Pit D, and further investigation and/or evaluation of these constituents is not required.

The following are the recommendations for Burn Pit D:

1. No further action is recommended for Burn Pit D.
2. All potential human health COPCs were eliminated for Burn Pit D (Section 12.4), and a BRA is not recommended for the site.
3. Because there are no ecological COPCs identified in the PRE for Burn Pit D (Section 12.5), an ERA is not recommended for the site.

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13.0 CHARACTERIZATION OF BURN PIT E (SWMU 4E)

13.1 HISTORY AND DESCRIPTION OF BURN PIT E

Burn Pit E (SWMU 4E) comprises approximately 0.8 acres and is located on the north side of Fort Stewart Route 144, approximately 800 feet east from its junction with Fort Stewart Route 50 and approximately 1.1 miles north-northwest of State Highway 144 (Savannah Highway). Most of the site is grass covered. Isolated pine and hardwood trees are present, and the site is surrounded by woods to the north, east, and west. Some debris (e.g., a few pieces of plastic, such as a plastic knife) were observed during a Phase I site reconnaissance on November 29, 1993. A low, bermed and railroad cross-tie barricaded square excavation with a sign labeled "Misfire Pit 5" is located among trees in the eastern area of the site.

Surface elevations vary from approximately 74 to 75 feet amsl. The site slopes gently eastward with about 4 feet of relief from the western site boundary to MW-1, located about 300 feet east of the site (Figure 13-1). Drainage occurs through overland flow to the east, collecting in small unnamed streams and swampy areas that discharge directly to the Canoochee River. The closest surface stream to the site is the Canoochee River, which lies approximately 2500 feet north of the site. Swampy areas within the Canoochee River floodplain lie approximately 1000 feet east of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 13-1). Three RCRA metals, including barium, chromium, and lead, were detected above site-specific background levels in soils. RCRA metals were also detected above site-specific background levels in groundwater and included arsenic, cadmium, chromium, and lead. No VOCs were detected in either soil or groundwater samples in Phase I.

During the Phase II RFI activities, two new monitoring wells (MW-5 and MW-6) were installed and three soil borings (SB-1 through SB-3) were drilled at the site (Figure 13-1). During redevelopment of the Phase I wells, MW-2 was discovered to have a bent or separated pipe casing, which prevented the surge block from being inserted into the well. MW-2 was, therefore, abandoned by filling the well with grout, and well MW-6 was constructed to replace it. MW-1 could not be developed or sampled due to a depth of water in the well of less than 1 foot and an extremely slow recharge rate, which resulted in the well being purged dry. Therefore, Phase I wells MW-3 and MW-4, together with the Phase II wells and borings, were used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of slightly silty sands. Geologic cross-sections of the Burn Pit E site are presented in Figure 13-2. Geotechnical parameters were measured in a bulk soil sample taken from MW-6 at a depth of 15 to 17.5 feet and in a Shelby tube sample taken from MW-5 at a depth of 15 to 17 feet. The results of the geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic sands with less than 4 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from MW-5, is 3.11×10^{-4} cm/second, typical for a fine sand.

Water levels in the monitoring wells were measured during well development between July 13 and 27, 1997, and again during well sampling between July 29 and August 11, 1997. The water table is present at a depth 13 feet bgs. A water table contour map is provided as Figure 13-3.

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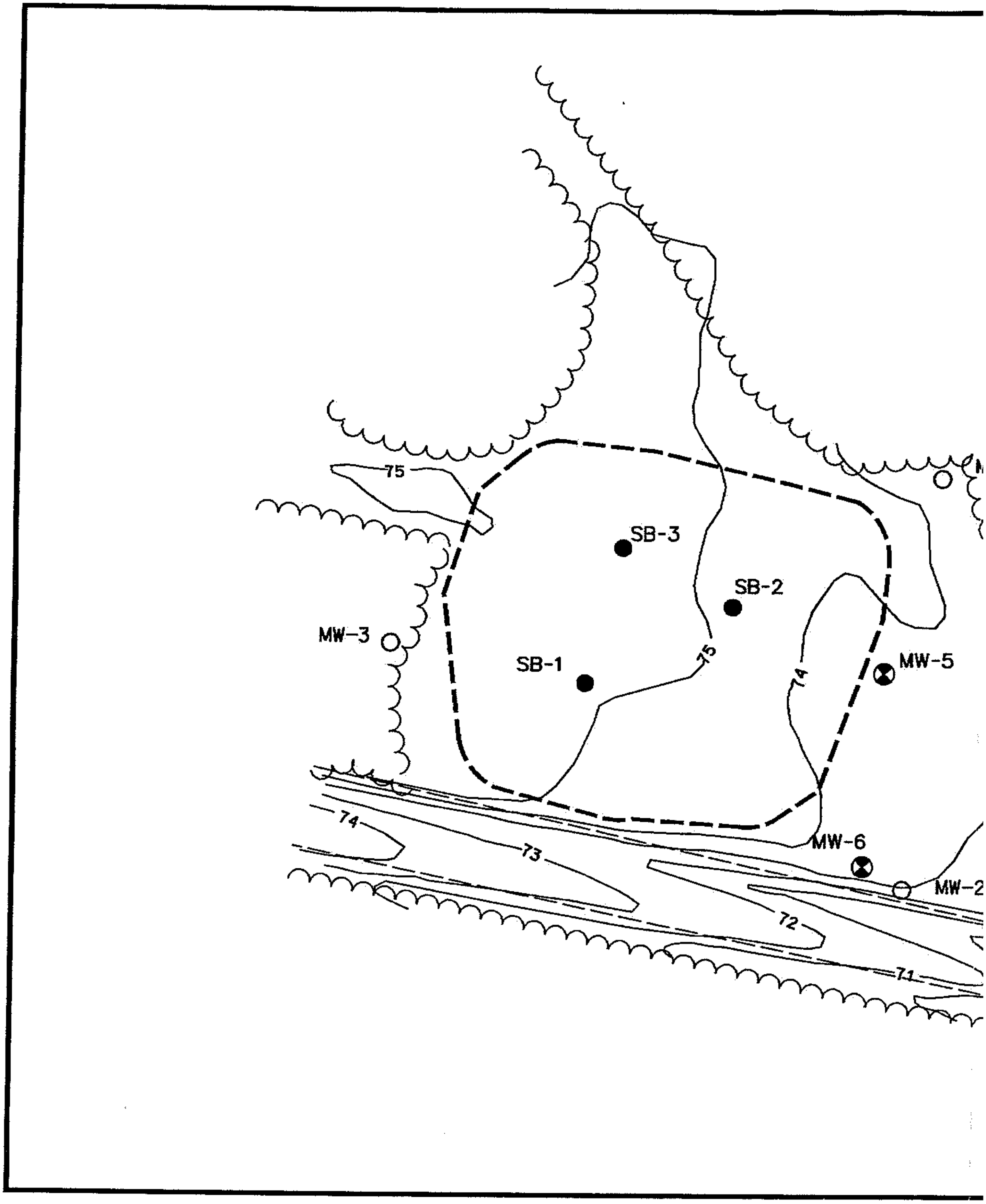

Figure 13-1. Locations of

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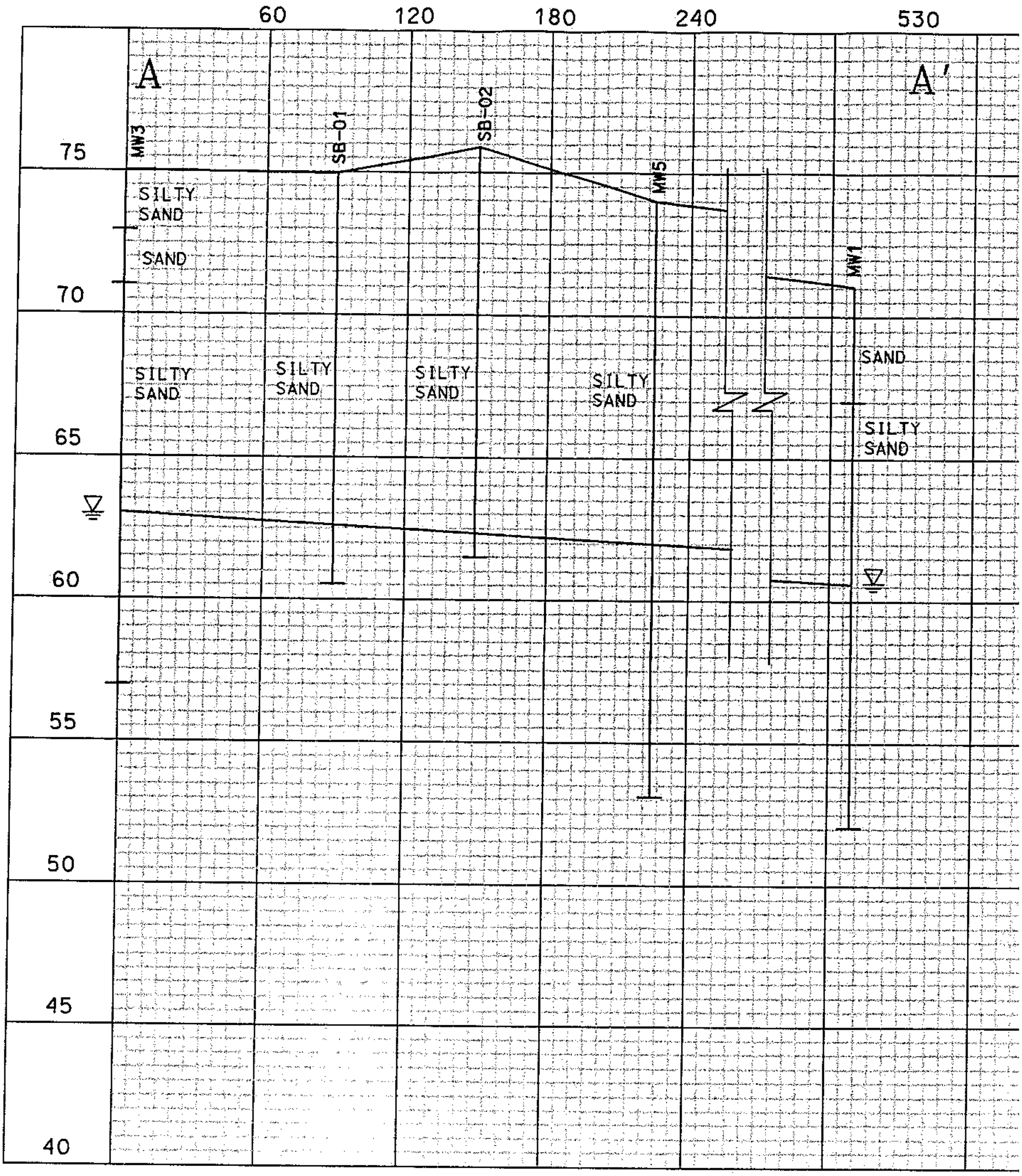

Figure 13-2. Geologic Cross-Sec

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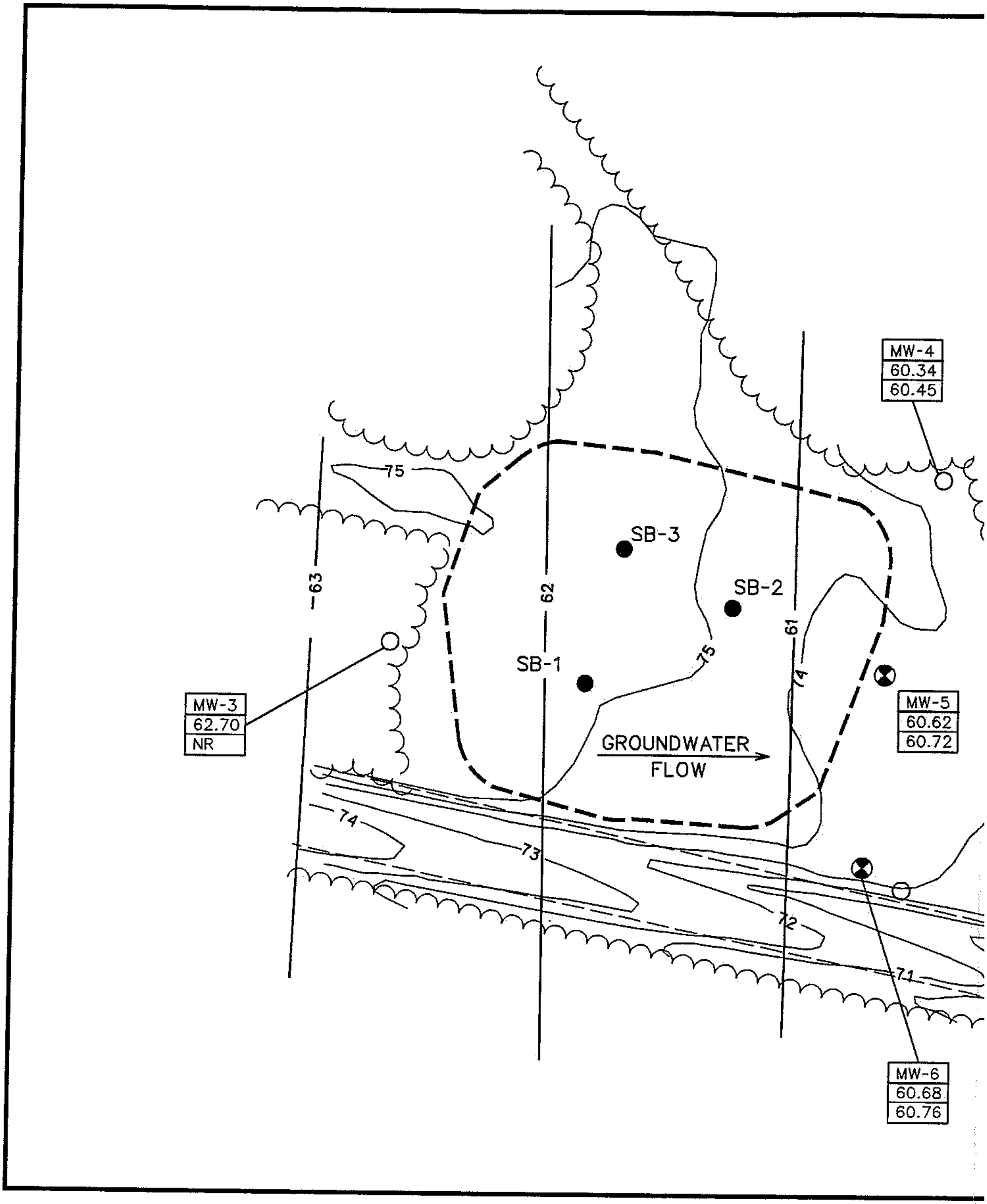

Figure 13-3. Water Table Contou

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Groundwater contours measured during the Phase I RFI activities in August 1993 indicate similar groundwater flow direction, although water levels were about 2 feet higher in the August 1993 data. Groundwater flow is generally to the east, discharging ultimately to low-lying swampy areas within the Canoochee River floodplain, approximately 1000 feet east of the Burn Pit E site. The calculated horizontal hydraulic gradient in the water table across the site is 0.009 foot/foot. Based on a hydraulic conductivity of 3.11×10^{-4} cm/second and a porosity of 0.464, the groundwater flow rate is approximately 6.2 feet/year toward the east.

13.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT E

13.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results of analyses on surface soil samples taken from the two new monitoring wells (MW-5 and MW-6) and the three soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 13-1 summarizes the analytical results for surface soil samples, and Figure 13-5 shows their distribution. This assessment presents Phase II contaminant data only because no surface soil samples were collected during Phase I.

Table 13-1. Summary of Analytical Results for Surface Soils
Burn Pit E, Fort Stewart

		Phase II Samples				
Parameter	**Reference Background**	**SB-1 4E1111 07/13/97 (0-1 foot)**	**SB-2 4E1211 07/13/97 (0-1 foot)**	**SB-3 4E1311 07/13/97 (0-1 foot)**	**MW-5 4E1511 07/23/97 (0-1 foot)**	**MW-6 4E1611 07/24/97 (0-1 foot)**
Semivolatile Organic Compounds (µg/kg)						
Benzo(a)pyrene	0.0					**21**
Benzo(b)fluoranthene	0.0					**54.8**
Fluoranthene	0.0					**63**
RCRA Metals (mg/kg)						
Arsenic	2.10				0.17	
Barium	14.7	**15.4**	11.4	**15**	**18.3**	**17.2**
Chromium	6.21	1.8	1.3	1.6	1.2	2.3
Lead	8.81	3	4.4	6.4	8.5	5.4
Mercury	0.03	0.03		**0.04**		0.03
Selenium	0.41				0.39	

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

SVOCs. Benzo(a)pyrene (21 µg/kg), benzo(b)flouranthene (54.8 µg/kg), and flouranthene (63 µg/kg) were detected in the surface soil sample at MW-6 at the southeastern edge of the former burn area. SVOCs were not detected in other surface soil samples at the site.

RCRA metals. Barium and mercury were the only RCRA metals reported above reference background values. Barium was found at four of the five surface soil sampling locations with a

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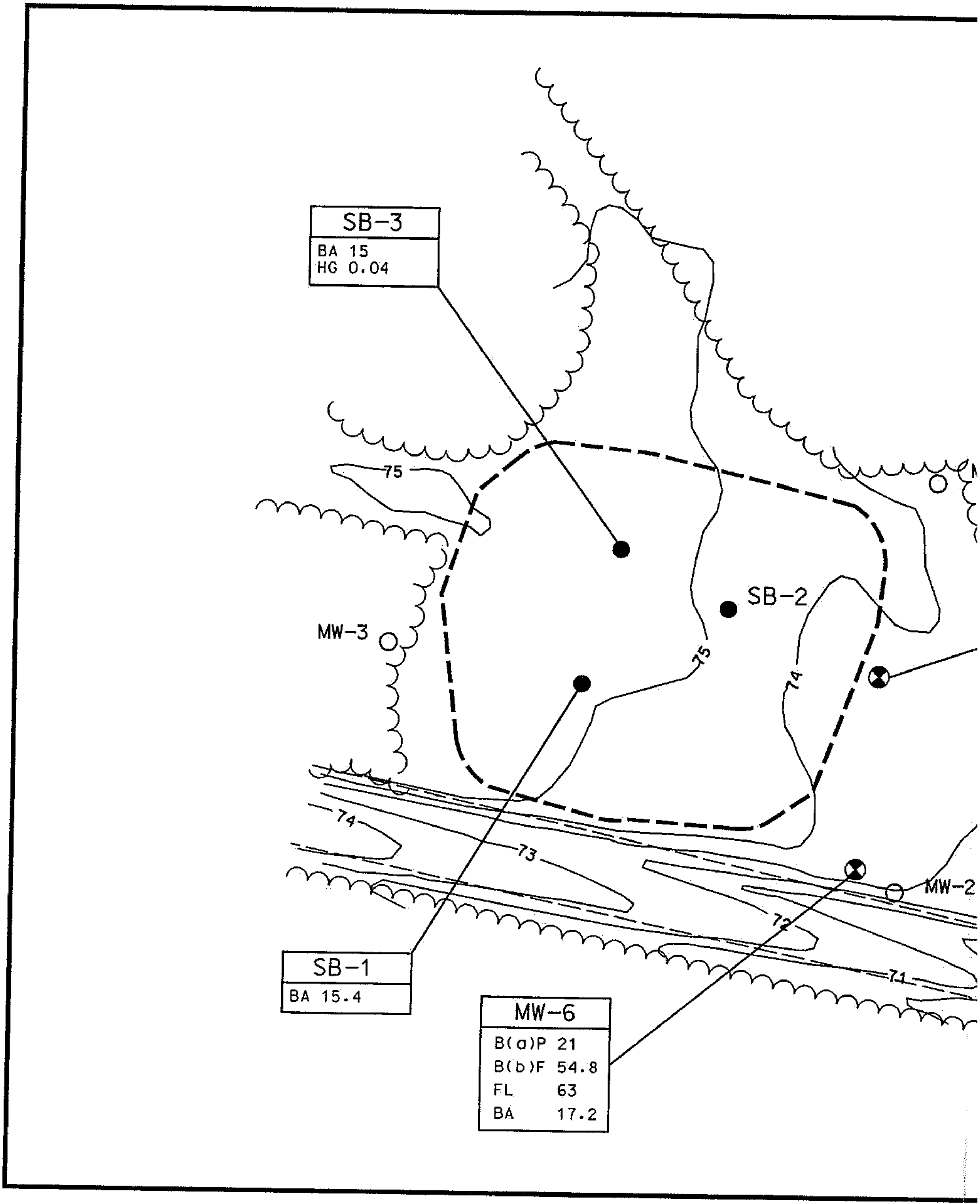

Figure 13-4. Results of Analys

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maximum concentration reported at MW-6 (18.3 mg/kg). Mercury was reported only at SB-3 at a concentration (0.04 mg/kg) that is only slightly greater than background and is, therefore, not likely to be site related.

13.2.2 Subsurface Soil Contamination

The subsurface soil samples were collected from the four Phase I monitoring well boreholes, the two Phase II well boreholes, and the three Phase II soil borings. The samples were analyzed for VOCs and RCRA metals. Table 13-2 summarizes analytical results for the subsurface soil samples, and Figure 13-5 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. Toluene was identified in four of the Phase II subsurface soil samples, at SB-1, SB-3, MW-5, and MW-6. Maximum concentration of toluene (8.8 µg/kg) was reported at MW-2. These concentrations are lower than the average detection limit for toluene and may, therefore, not be indicative of site-related contamination. Benzene (7.9 µg/kg at MW-4) was the only BTEX compound found in any of the Phase I subsurface soil samples.

RCRA metals. Three metals were reported in subsurface soils at concentrations above their reference background value. Barium was detected at concentrations above background in one of the nine subsurface soil samples, with a maximum value (27 mg/kg) at MW-1, which is located approximately 300 feet from the burn area. Maximum concentrations of chromium (9.5 mg/kg at SB-2) and mercury (0.063 mg/kg at MW-3) were also reported. These metals were detected at concentrations only slightly above background and do not show a consistent pattern of distribution.

13.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples taken from two monitoring wells installed during Phase I (MW-3 and MW-4) and two monitoring wells installed during Phase II (MW-5 and MW-6). The groundwater samples were analyzed for VOCs and RCRA metals (total metal analysis on unfiltered water samples). Table 13-3 summarizes the analytical results for groundwater samples, and Figure 13-6 shows their distribution. This assessment focuses on the Phase II contaminant data because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

VOCs. Low concentrations of BTEX compounds were found in groundwater at MW-4. Ethylbenzene (1.1 µg/L) and xylenes (6.3 µg/L) were reported at concentrations only slightly above their detection limits. No VOCs were reported above the detection limit in Phase I groundwater samples. These results suggest that the low concentrations of BTEX present in subsurface soils at the site may have also impacted groundwater, but not at significant concentrations.

PCE was detected in MW-4 at 1.1 µg/L, but was not detected in other wells during Phase II. No PCE was reported in Phase I groundwater samples. Acetone was reported in MW-4 and MW-6 at a maximum concentration (53.4 µg/L).

RCRA metals. Cadmium was the only RCRA metal detected above background in groundwater. Cadmium was found at a maximum concentration in MW-4 (4.3 µg/L) and was also detected above background in MW-6 (1.2 µg/L). Because both of these wells are downgradient of the site, cadmium is considered a potential SRC.

Table 13-2. Summary of Analytical Results for Subsurface Soils
Burn Pit E, Fort Stewart

Parameter	Reference Background	Phase I Samples				Phase II Samples				
		MW1 SL1-6 06/26/93 (4-6 feet) 0004.0 0006.0	MW2 SL2-8 06/29/93 (6-8 feet) 0006.0 0008.0	MW3 SL3-8 06/30/93 (6-8 feet) 0006.0 0008.0	MW4 SL4-6 06/29/93 (4-6 feet) 0004.0 0006.0	MW-5 4E1512 07/23/97 (2.5-5 feet) 0002.5 0005.0	MW-6 4E1612 07/24/97 (10-12.5 feet) 0010.0 0012.5	SB-1 4E1112 07/13/97 (2.5-4.5 feet) 0002.5 0004.5	SB-2 4E1212 07/13/97 (4.5-7 feet) 0004.5 0007.0	SB-3 4E1312 07/13/97 9.5-12 feet) 0009.5 0012.0
Volatile Organic Compounds (μg/kg)										
Benzene	0.0				**7.9**					
Toluene	0.0					**2.7**	**8.8**	**7.4**		**5.5**
RCRA Metals (mg/kg)										
Arsenic	8.04								0.2	
Barium	17.0	**27**	14	8.5	11	14.5	4.8	11	14.6	11.3
Chromium	11.6	**12**	6.5	9.5	6.9	1.8	5.7	2.5	8	7.9
Lead	11.1	5.9	2.6	5.2	4.8	2.9	2.2	2.5	4.7	5.2
Mercury	0.05	0.026	0.039	**0.062**	0.043		0.03	0.03	**0.08**	0.04
Silver	0.46					0.19				
Other Inorganics (mg/kg)										
Total Organic Carbon	2,200					824				

Note: A blank indicates analyte not detected.

Note: **Bold** font indicates value exceeds reference background criterion.

RCRA = Resource Conservation and Recovery Act.

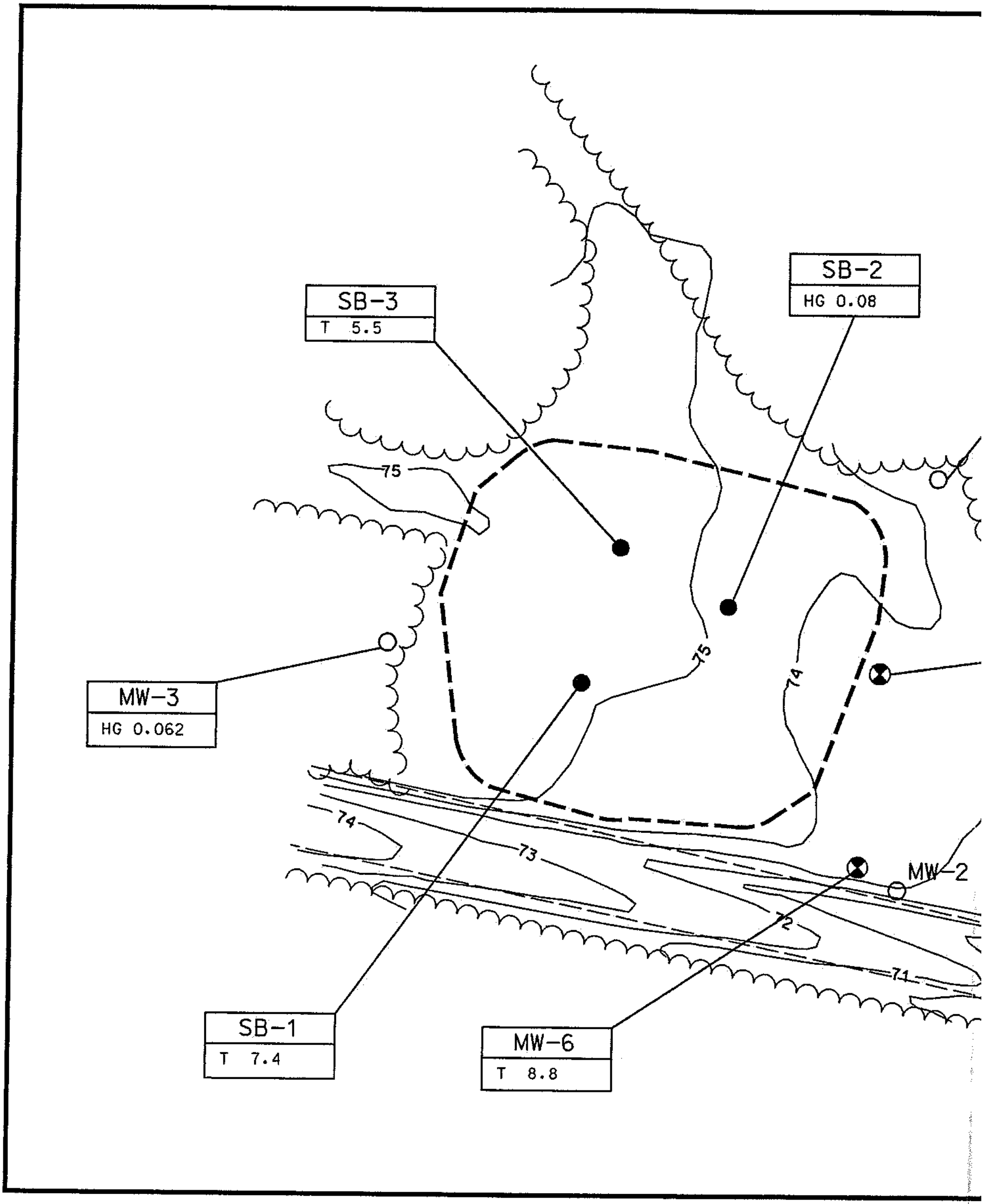

Figure 13-5. Results of Analyse

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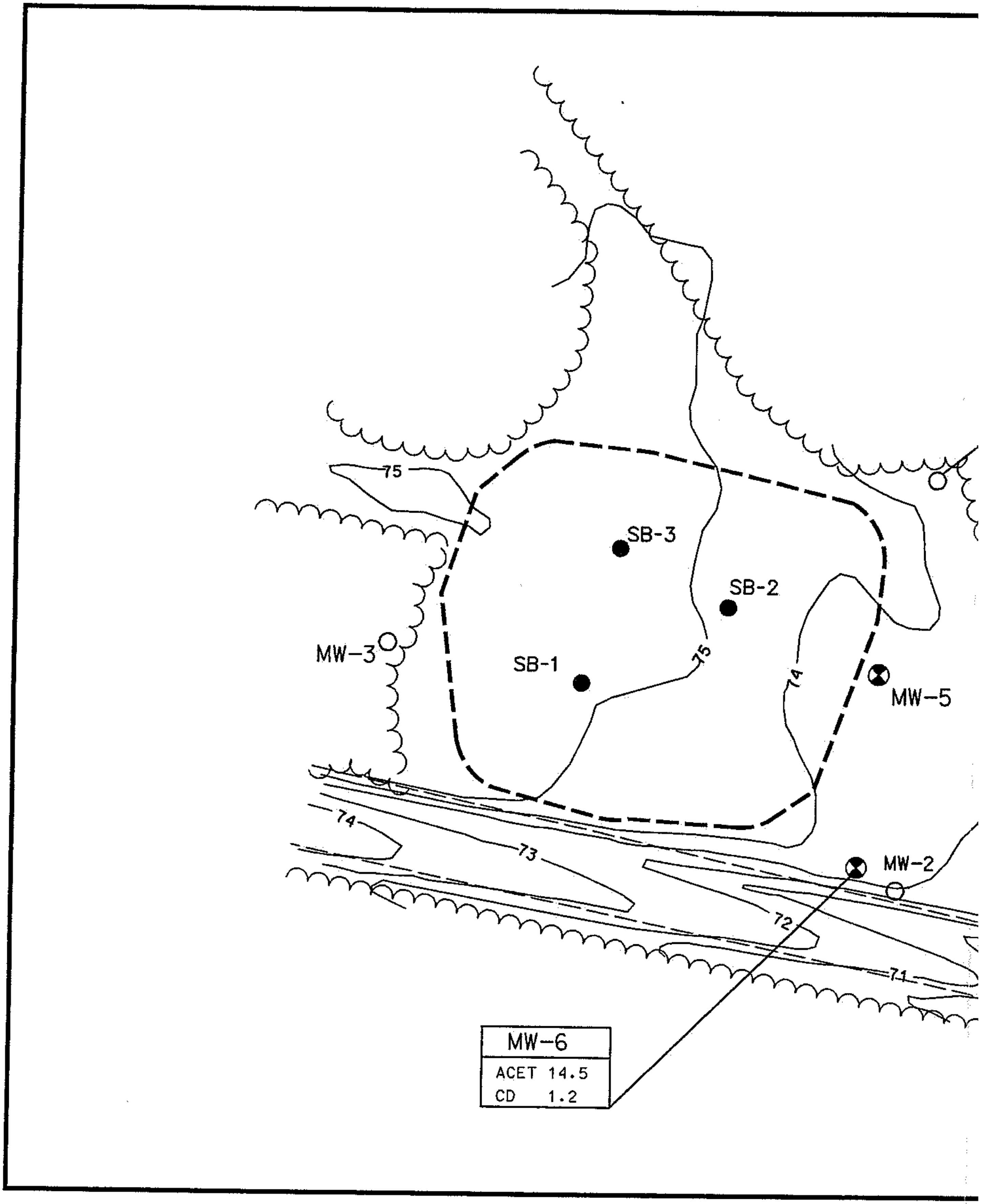

Figure 13-6. Results of Analy

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Table 13-3. Summary of Analytical Results for Groundwater
Burn Pit E, Fort Stewart

			Phase II Samples			
Parameter	**Reference Background**	**MCL**	**MW-3 07/29/97 4E4311**	**MW-4 07/30/97 4E4411**	**MW-5 08/11/97 4E4511**	**MW-6 08/11/97 4E4611**
Volatile Organic Compounds (μg/L)						
Acetone	0.0			**53.4**		**14.5**
Ethylbenzene	0.0	700		**1.1**		
Tetrachloroethene	0.0	5		**1**		
Xylenes, Total	0.0	10,000		**6.3**		
RCRA Metals (μg/L)						
Barium	71.72	2000	6.9	10.2	17.7	
Cadmium	0.43	5		**4.3**	0.23	1.2
Chromium	3.56	100	1.5	1.3	1.7	1.7
Selenium	1.90	50			0.43	
Silver	1.12			0.1	0.16	

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.

13.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 13-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

13.3 FATE AND TRANSPORT CONSIDERATIONS OF BURN PIT E

The results of contaminant migration soil screening (discussed in Section 6.0) for Burn Pit E are presented in Table 13-5. Only benzene is identified as a CMCOPC based on leaching to groundwater. However, benzene is not currently observed in groundwater, indicating that it may be degraded before reaching the water table. The predicted maximum concentration of benzene in groundwater, based on a maximum of 7.9 μg/kg in soil and a DAF of 1, is 20 μg/L. Through biodegradation, even if the benzene were to reach groundwater at such a concentration, it would degrade to its MCL value (5 μg/L) in less than 2.0 times its half-life. Assuming a conservative half-life of 2.0 years, the benzene would degrade to its MCL value in 4.0 years.

The maximum concentrations of benzene were reported in Phase I soil samples only and were not detected in Phase I samples.

Table 13-4. Summary of Site-Related Constituents
Burn Pit E, Fort Stewart

Analyte	Surface Soil	Subsurface Soil	Groundwater
	(µg/kg)	**(µg/kg)**	**(µg/L)**
Acetone	na	nd	**53.4**
Benzene	na	**7.9**	nd
Ethylbenzene	na	nd	**1.1**
Tetrachloroethene	na	nd	**1**
Toluene	na	**8.8**	nd
Xylenes, total	na	nd	**6.3**
	(µg/kg)	**(µg/kg)**	**(µg/L)**
Benzo(a)pyrene	**21**	na	na
Benzo(b)flouranthene	**54.8**	na	na
Flouranthene	**63**	na	na
	(mg/kg)	**(mg/kg)**	**(µg/L)**
Arsenic	brc	brc	nd
Barium	**18.3**	**27**	brc
Cadmium	nd	nd	**4.3**
Chromium	brc	**12**	brc
Lead	brc	brc	nd
Mercury	**0.04**	**0.08**	nd
Selenium	brc	nd	brc
Silver	Nd	brc	brc

brc = Below background reference criteria
na = Not analyzed in any sample in that medium
nd = Not detected in any sample in that medium
BOLD font indicates the analyte is an SRC in that medium

Table 13-5. CMCOPCs Based on Soil Screening for Burn Pit E, Fort Stewart, Georgia

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration >GSSL?
RCRA Metals (µg/kg)			
Barium	27.00	1600	No
Chromium	12.00	38	No
Mercury	0.08	0.4	No
Volatile Organic Compounds (µg/kg)			
Benzene	7.90	2	Yes
Toluene	7.00	600	No
Semivolatile Organic Compounds (µg/kg)			
Benzo(a)pyrene	21.00	400	No
Benzo(b)fluoranthene	54.80	200	No
Fluoranthene	63.00	210000	No

CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
SRCs = Site-related Contaminants.

The most likely pathway of contaminant migration from Burn Pit E is via groundwater discharge to swampy areas along the Canoochee River, located approximately 1000 feet east of the site. Based on the calculated groundwater flow velocity of 6.2 feet/year, the estimated arrival time for the site groundwater to reach the Canoochee River is expected to be more than 161 years. Therefore, benzene would degrade to less than its MCL within 30 feet of the Burn Bit E Site, well before reaching the Canoochee River.

Although acetone, ethylbenzene, PCE, and xylene are not identified as CMCOPCs based on leaching to groundwater from Burn Pit E, these constituents are currently observed in the site groundwater. However, the maximum observed concentrations for these constituents are below their respective MCLs. Metals detected in the groundwater at concentrations above background include cadmium only. However, the maximum concentration of cadmium does not exceed its MCL and, based on fate and transport analysis, cadmium is not expected to increase in the future. Therefore, none of the constituents is expected to be of concern for contaminant migration from Burn Pit E.

13.4 HUMAN HEALTH RISK CHARACTERIZATION OF BURN PIT E

SRCs were identified in Section 13.3 for surface soil, subsurface soil, and groundwater. The identification of risk-based action levels for all of the Burn Pits has been previously discussed in Section 4.7 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit E is given below.

13.4.1 Exposure Evaluation

This site is completely covered by vegetation, and no VOCs were detected in surface soils. Therefore, exposure via inhalation based on current land use is not a viable exposure pathway. The site is infrequently used by the Army as a training area. Therefore, current on-site receptors include a juvenile trespasser and a hunter. Current off-site receptors would be represented by an off-site hunter.

Land use at this site is unlikely to change in the future. However, the Army may use the site as a training area in the future. Construction may occur on the site or the vegetative cover may be gone as a result of on-site activities. Future on-site receptors include military personnel and a construction worker. Future off-site receptors include hunters in the area.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current juvenile trespasser. The juvenile trespasser may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Hunter. The hunter is representative of a current on-site receptor and a current and future off-site receptor. The current on-site receptor is not likely to be exposed to chemicals given the absence of an air migration pathway, and clothing the hunter would be wearing would eliminate potential dermal exposure. VOCs were only detected in subsurface soils. Significant exposure via volatilization is not likely.

The current off-site hunter may be exposed via ingestion of contaminants bioaccumulated in game animals. The future off-site hunter may be exposed via ingestion of game and inhalation of fugitive dust if the vegetative cover were to be removed.

Future on-site military personnel. The on-site military personnel may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Future construction worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

13.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals will be evaluated further in a BRA.

None of the contaminants in surface soils or subsurface soils exceeded its respective risk-based screening value for direct exposure of a potential receptor population (Table 13-6).

The maximum concentration of cadmium in groundwater (4.3 μg/L) exceeds the screening value of 1.8 μg/L (Table 13-6). However, the maximum concentration of cadmium was below its MCL of 5 μg/L. The remaining chemicals were below their respective screening values. In addition, the use of surficial groundwater at the sites for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health.

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit E. A human health BRA is not warranted. No further action is required for protection of human health.

13.5 ECOLOGICAL RISK EVALUATION AT BURN PIT E

The ecological risk evaluation of Burn Pit A is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are considered further in PRE Steps ii through v. The results of the five steps of the PRE are reported below.

13.5.1 Ecological Screening Value Comparison (Step i)

One RCRA metal and four VOCs were detected in groundwater at the Burn Pit E at concentrations exceeding reference background criteria. The results of the ESV comparison for groundwater at the Burn Pit E are presented in Table 13-7. At the upgradient monitoring well

Table 13-6. Comparison to Action Levels–Burn Pit E, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit E Surface Soil								
Barium	mg/kg	5/5	11.4	18.3	14.7	550	No	Max Detect < Screening Criteria
Benzo(a)pyrene	mg/kg	1/5	0.02	0.02		0.08	No	Max Detect < Screening Criteria
Benzo(b)fluoranthene	mg/kg	1/5	0.054	0.054		0.8	No	Max Detect < Screening Criteria
Fluoranthene	mg/kg	1/5	0.06	0.06		310	No	Max Detect < Screening Criteria
Mercury	mg/kg	3/5	0.03	0.04	0.03	2.3	No	Max Detect < Screening Criteria
Burn Pit E Subsurface Soil								
Barium	mg/kg	7/7	11	27	17.0	14,000	No	Max Detect < Screening Criteria
Chromium	mg/kg	7/7	1.8	12	11.6	1,000	No	Max Detect < Screening Criteria
Mercury	mg/kg	6/7	0.026	0.08	0.05	61.0	No	Max Detect < Screening Criteria
Benzene	mg/kg	1/6	0.0079	0.0079		200	No	Max Detect < Screening Criteria
Toluene	mg/kg	3/6	0.0027	0.0074		41,000	No	Max Detect < Screening Criteria
Burn Pit E Groundwater								
Cadmium	µg/L	3/3	0.23	4.3	0.43	1.8	Yes	Max Detect > Screening Criteria
Acetone	µg/L	2/3	14.5	53.4		3700	No	Max Detect < Screening Criteria
Ethylbenzene	µg/L	1/3	1.1	1.1		1300	No	Max Detect < Screening Criteria
Tetrachloroethene	µg/L	1/3	1	1		1.1	No	Max Detect < Screening Criteria
Xylenes, Total	µg/L	1/3	6.3	6.3		12000	No	Max Detect < Screening Criteria

COPC = Chemical/Contaminant of Potential Concern.
EPA = U.S. Environmental Protection Agency.

Table 13-7. EPA Region 4 Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit E, Fort Stewart

Analyte	ESV	MW-3*	MW-4	MW-5	MW-6	Maximum
RCRA Metals (μg/L)						
Cadmium	0.66[a]		**4.3 J**	0.23 J	**1.2**	**4.3 J**
Volatile Organic Compounds (μg/L)						
Acetone	10000[b]		53.4		14.5 J	53.4
Ethylbenzene	453		1.1 J			1.1 J
Tetrachloroethene	84		1 J			1 J
Xylenes, Total	7100[c]		6.3			6.3

*Upgradient monitoring well.
J = Estimated concentration.
ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1996) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
[a] Hardness dependent, assumes 50 mg/L $CaCO_3$.
[b] LC_{50} daphnid (Verchueren 1977).
[c] LC_0 salmonid (Clayton and Clayton 1981).
Bold font indicates detected concentrations exceeds ESV.

(MW-3), no constituent concentration exceeds the surface water ESVs. Where detected in the remaining three monitoring wells (MW-4 through MW-6), the maximum detected concentration of cadmium exceeds the ESV. The only ecological COPC identified by the ESV comparison for groundwater at Burn Pit E is cadmium.

Although ecological COPCs are identified in groundwater at Burn Pit E when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit E. There are no surface water bodies in the vicinity of Burn Pit E. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of the contaminants in Burn Pit E soils.

Because there are no ESVs for soil, all analytes detected in soil at the Burn Pit E are evaluated further in PRE Steps ii through v.

13.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit E (SWMU E) comprises approximately 0.8 acres (Figure 13-1). Most of the site is grass covered. Isolated pine and hardwood trees are present, and the site is surrounded by woods to the north, east, and west. The site slopes gently eastward. Drainage occurs through overland flow to the east, collecting in small unnamed streams and swampy areas that discharge directly to the Canoochee River. The closest surface stream to the site is the Canoochee River, which lies approximately 2500 feet north of the site.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit E are described in Section 8.1.2.

13.5.3 Preliminary Effects (Step iii)

In the PRE for the Burn Pit E, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the site. The derivation of TRVs is discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8-1.

13.5.4 Preliminary Exposure (Step iv)

Ecological receptors at Burn Pit E are likely exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews, and robins exposed to COPCs in soil are presented in Table 8-2.

13.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate a HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0, and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. The preliminary risk calculation for shrews and robins exposed to ecological COPCs detected in soil at Burn Pit E is presented in Table 13-8. This table shows the maximum detected concentrations and the TRVs for shrews and robins. Concentrations resulting in HQs exceeding 1.0 are shown in boldface font.

There is no RCRA metal present in Burn Pit E surface soil at concentrations exceeding the TRV for the surrogate species. An HI is not calculated for the surrogate species exposed to RCRA metals detected in surface soil because they are assumed to have dissimilar mechanisms of toxicity.

The three organic ecological COPCs are not likely to pose a risk to ecological receptors. The maximum detected concentrations are several hundred times smaller than the conservative TRVs for small mammals. An HI can be calculated for the surrogate species exposed to SVOCs detected in surface soil, assuming that they have similar mechanisms of toxicity on small mammals. The HI for the shrew exposed to the three SVOCs in surface soil is 0.03, using the surrogate TRVs for benzo(b)fluoranthene and fluoranthene. Because the HI is less than 1.0, these three SVOCs in soil at Burn Pit E are not ecological COPCs for populations of small mammals ingesting earthworms and other soil-dwelling invertebrates. There are, therefore, no ecological COPCs in Burn Pit E surface soil.

Table 13-8. Preliminary Risk Evaluation of Ecological COPCs in Surface Soil (0 to 1 ft) at Burn Pit E, Fort Stewart

Analyte	TRV		MW-5	MW-6	SB-1	SB-2	SB-3	Maximum
	Shrew	Robin						
RCRA Metals (mg/kg)								
Barium	2627	2293	18.3	17.2	15.4 J	11.4 J	15 J	18.3
Mercury	14.1	1.1		0.03	0.03		0.04	0.04
Semivolatile Organic Compounds (mg/kg)								
Benzo(a)pyrene	39.6	-		0.021				0.021
Benzo(b)fluoranthene	3.96	-		0.055				0.055
Fluoranthene	3.96	-		0.063				0.063

J = Estimated concentration.
- = No data to derive TRV.
RCRA = Resource Conservation and Recovery Act.
TRV = Toxicity Reference Value = (NAOEL × BW/Food Ingestion)/$BAF_{earthworm}$ (see Table 8-1).
Blank cells indicate analyte not detected at site.
Boldface indicates detected concentration exceeds TRB (HQ>1).

13.5.6 Uncertainties

There are no ecological COPCs identified in the PRE for Burn Pit E, so no supplemental evaluation of risk using published dietary fractions and LOAELs is necessary.

13.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT E

The following are the conclusions of the Phase II RFI for Burn Pit E:

- In surface soils, barium and mercury were detected in four of the five samples. Barium contamination extends throughout the Burn Pit E site and is an SRC. Mercury was found at a concentration only slightly above background in a single sample and is not likely site related.
- SVOCs were detected in a single surface soil sample at Burn Pit E at the southeastern edge of the former burn area. The SVOCs were detected at concentrations only slightly above their detection limit and do not pose a human health or ecological risk.
- There are no human health COPCs in surface or subsurface soil because no constituent exceeded its risk-based screening value.
- There are no ecological COPCs in surface soils because no constituent was detected above background that also exceeded its TRVs for ecological receptors.
- In subsurface soil, three metals (barium, chromium, and mercury) were reported at concentrations above their reference background value. Barium was detected in one of the nine subsurface soil samples. Chromium and mercury were detected at concentrations only slightly above background, are not present in a consistent pattern, and are, therefore, not considered to be due to releases that may have occurred from site-related activities. BTEX compounds were detected in five of the nine subsurface soil samples, although at concentrations near their detection limits.

- Benzene is a potential contaminant migration COPC in subsurface soil because it may leach to groundwater, resulting in groundwater concentrations exceeding its MCL. However, benzene was not detected in groundwater and was detected in only one soil sample of the nine collected. Off-site migration of benzene would be very limited due to retardation and biodegradation and the slow movement of groundwater. Even if it were to reach groundwater at its predicted maximum concentration, it would degrade to a concentration less than MCL in less than 4.0 years, and would have traveled less than 30 feet from the Burn Pit E site. Therefore, migration of benzene is considered unlikely, and there are no contaminant migration COPCs.

- In groundwater, cadmium was the only RCRA metal detected above background. Cadmium was found in two of the three downgradient wells and is considered a potential SRC. BTEX compounds (ethylbenzene and xylenes) and PCE were also reported, although at concentrations only slightly above their detection limits. No VOCs were reported in Phase I groundwater sampling.

- Cadmium is a potential human health COPC at Burn Pit E, where the maximum concentration of cadmium in groundwater exceeded its risk-based screening value for residential use of groundwater. The maximum concentration of cadmium was less than its MCL of 5 µg/L at each site. In addition, use of the surficial groundwater at the sites for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health at Burn Pit E.

- Cadmium is an ecological COPC in groundwater because it exceeds its ESV for surface water. However, there are no surface water bodies in the vicinity of Burn Pit E, and off-site migration would be limited due to retardation and the slow movement of groundwater. Therefore, exposure of ecological receptors to cadmium in surface water bodies downgradient from Burn Pit E is not a complete pathway. Therefore, cadmium is eliminated as an ecological COPC for Burn Pit E, and further investigation and/or evaluation of this constituent is not required.

The following are the recommendations for Burn Pit E:

1. No further action is recommended for Burn Pit E.
2. All potential human health COPCs were eliminated for Burn Pit E (Section 13.4), and a BRA is not recommended for the site.
3. Because there are no ecological COPCs identified in the PRE for Burn Pit E (Section 13.5), an ERA is not recommended for the site.

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14.0 CHARACTERIZATION OF BURN PIT F (SWMU 4F)

14.1 HISTORY AND DESCRIPTION OF BURN PIT F

Burn Pit F (SWMU 4F) comprises approximately 3 acres and is located on the western side of Fort Stewart Route 51, approximately 3400 feet south from its junction with State Highway 144 (Savannah Highway). Clearing and grubbing debris are present in small mounded areas within the site. The debris consist of stumps, branches, and similar vegetative material. Two dump trucks were observed off-loading branches at the site during a November 16, 1993, reconnaissance of the site. Occasional stands of pine or small individual trees are present. Grass covers some of the debris piles and open areas. The site is surrounded by woods.

Surface elevations vary from approximately 33 to 39 feet amsl, sloping gently southeastward (Figure 14-1). Drainage occurs through overland flow to the southeast, collecting in swampy areas that comprise Big Swamp and Goshen Swamp. The closest surface stream to the site is an unnamed tributary of Goshen Swamp, which lies approximately 2000 feet west of the site. Swampy areas located within the floodplain of Goshen Swamp lie approximately 1000 feet south and west of the site.

During the Phase I RFI activities, four monitoring wells were installed at the site (Figure 14-1). Methylene chloride was detected in soil samples, and three RCRA metals, including barium, chromium, and mercury, were detected above site-specific background concentrations in soils. In groundwater, carbon disulfide and methylene chloride were detected, and BTEX compounds were present at levels exceeding MCLs. RCRA metals were also detected above site-specific background levels in groundwater and included chromium and lead.

During the Phase II RFI activities, three soil borings (SB-1 through SB-3) were drilled at the site (Figure 14-1). These borings, together with the four Phase I wells, were used to determine physical and chemical characteristics of the site.

Soils encountered in the soil borings and well boreholes consisted predominantly of slightly silty sands. Geologic cross-sections of the Burn Pit F site are presented in Figures 14-2 and 14-3. Geotechnical parameters were measured in a Shelby tube sample taken from SB-2 at a depth of 19.5 to 21.5 feet. The results of the Geotechnical testing, listed in Table 4-1, indicate that the soils are non-plastic sands with less than 9 percent by weight of fine-grained material. Permeability, as measured in the Shelby tube sample from SB-2, is 5.81×10^{-4} cm/second, typical of a fine sand.

Water levels in the monitoring wells were measured during well development on July 14, 1997, and again during well sampling between July 30 and August 11, 1997. The water table is present at a depth 7 to 13 feet bgs. A water table contour map is provided as Figure 14-4. Groundwater contours measured during the Phase I RFI activities in August 1993 indicate water levels were about 4 feet lower in the August 1993 data. The groundwater flow direction was interpreted in the Phase I RFI to be strongly influenced by a potentiometric trough oriented toward the southeast. The current interpretation is based on water levels measured at the time of well development (instead of at the time of sampling) because the wells were not all sampled at the same time. The current interpretation suggests that groundwater may be slightly mounded beneath the site, highest at MW-4 and lowest at MW-1 and MW-3. This interpretation assumes that the water table is a subdued reflection of the overlying topography. Groundwater

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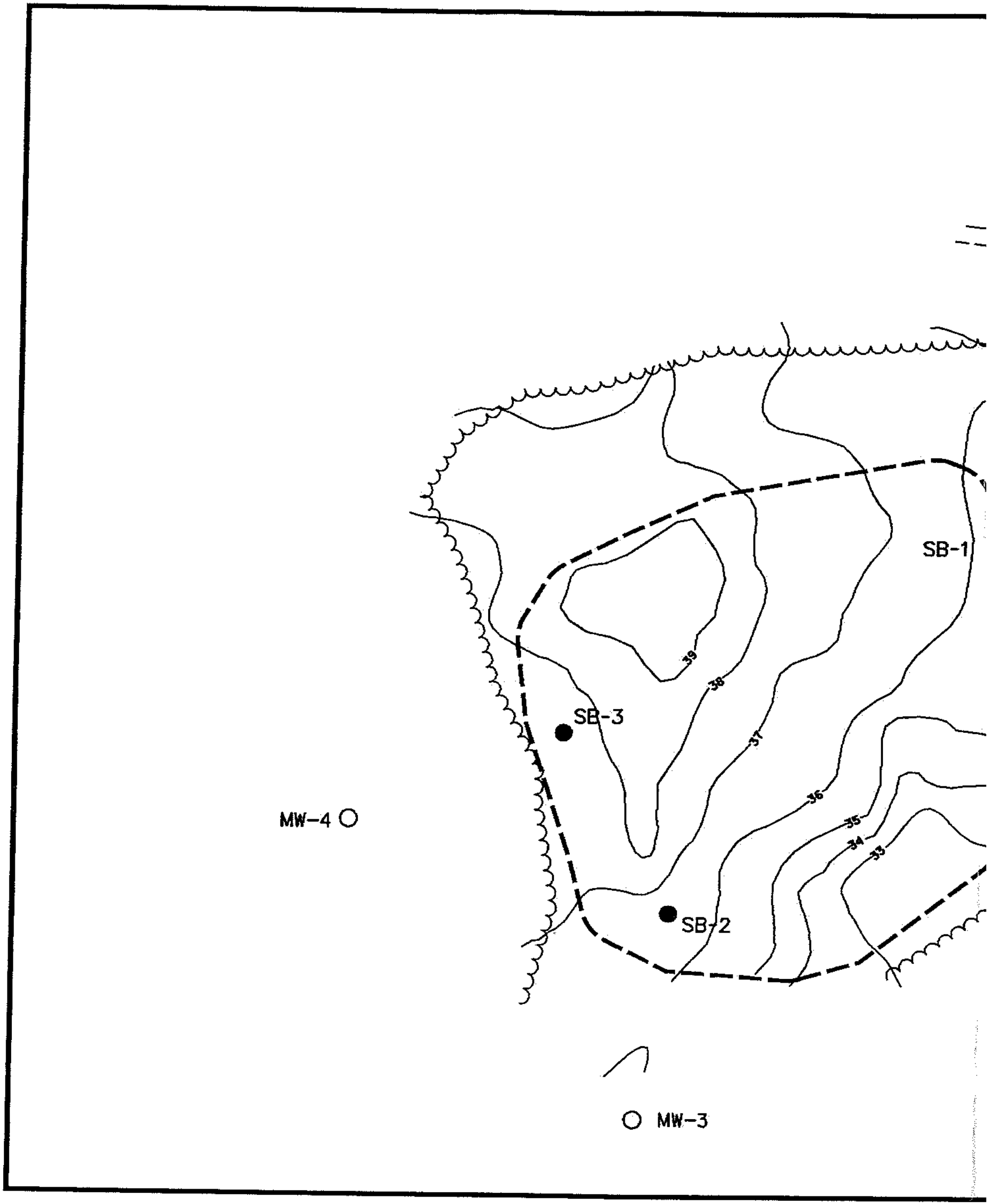

Figure 14-1. Locations of S

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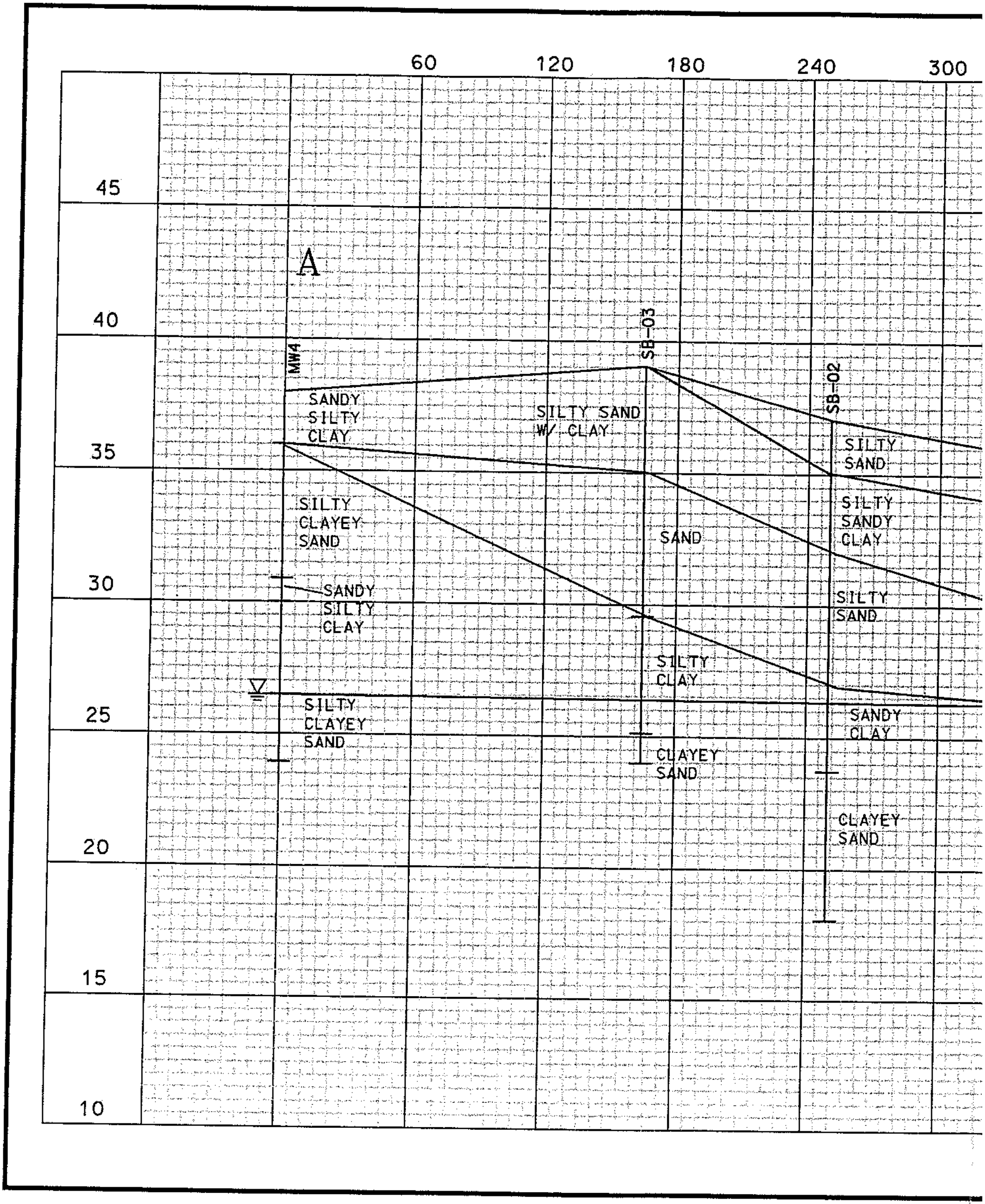

Figure 14-2. Geologic Cro

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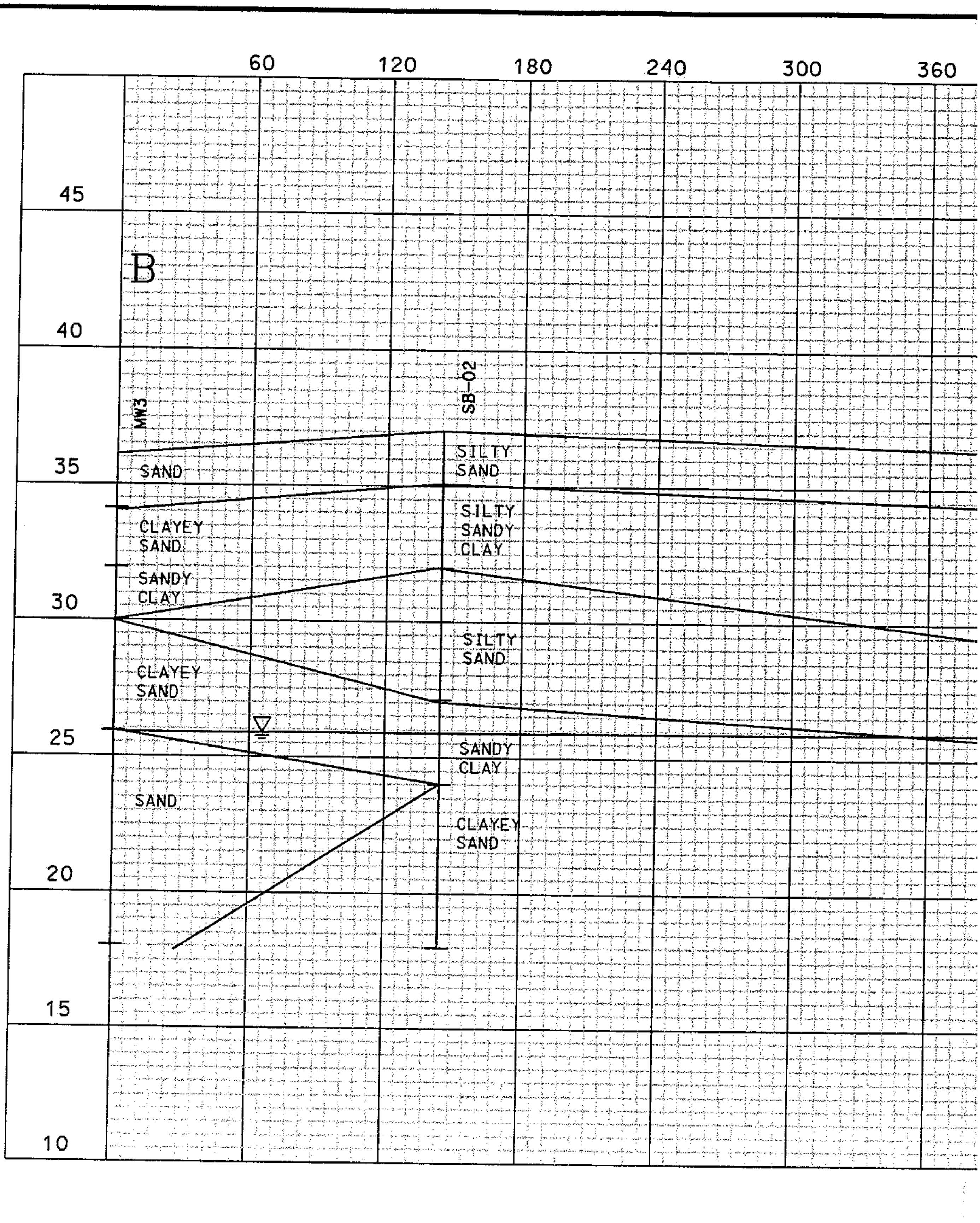

Figure 14-3. Geologic Cro

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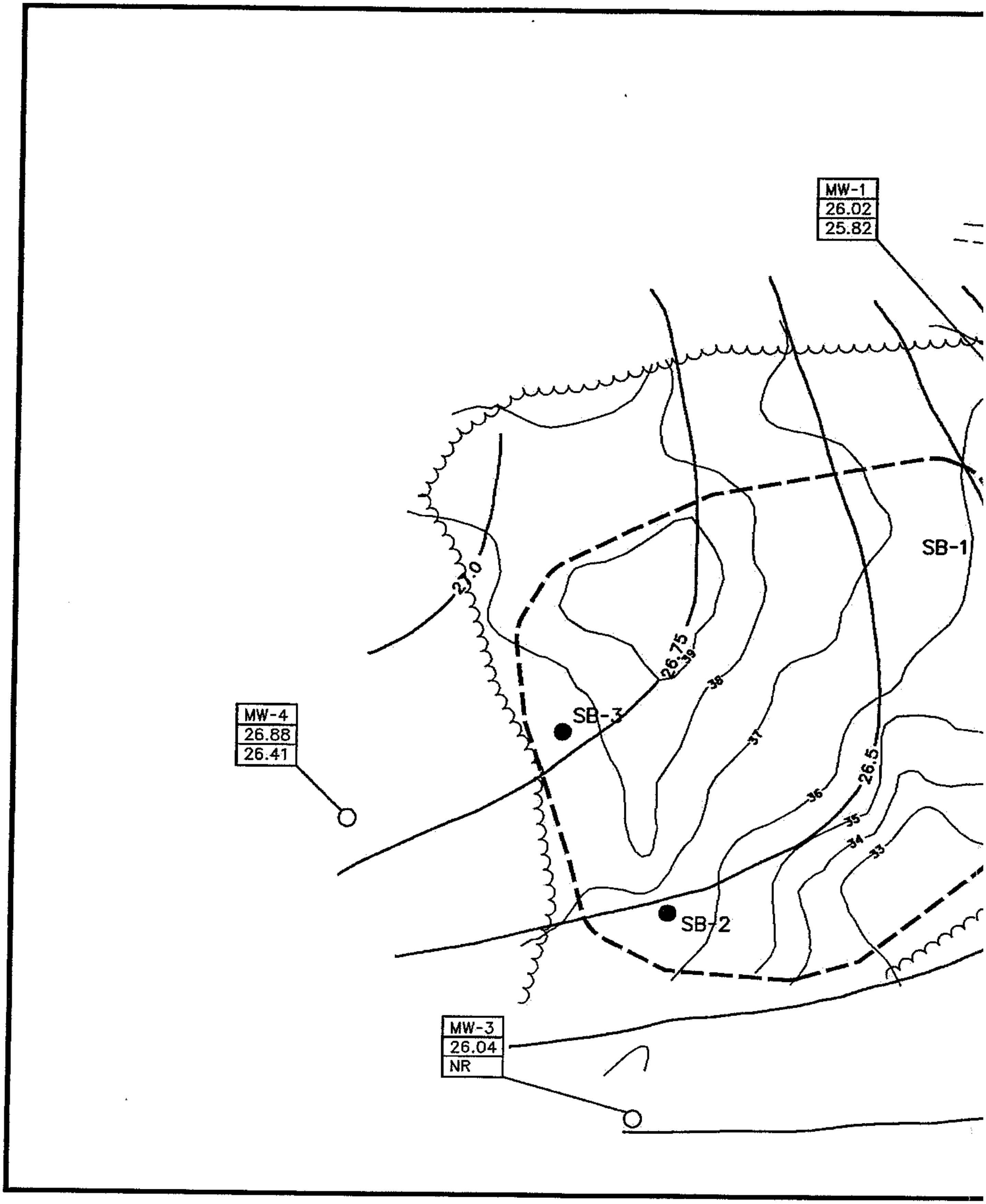

Figure 14-4. Water Tabl

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flows from a high in the north and west portion of the site to the south, southeast, and east before joining the regional shallow groundwater flow. Regional groundwater flow is expected to be to the south or southwest, discharging ultimately to low-lying swampy areas within the Big Swamp and Goshen Swamp, approximately 1000 feet south and west of the Burn Pit F site. The calculated horizontal hydraulic gradient in the water table across the site is 0.0023 foot/foot. Based on a hydraulic conductivity of 5.81×10^{-4} cm/second and a porosity of 0.408, the groundwater flow rate is approximately 3.4 feet/year toward the south, southeast, and east.

Following receipt of GEPD comments dated October 28, 1999, on the Phase II RFI for Burn Pit F, Fort Stewart conducted a supplemental investigation of groundwater. The scope of that supplemental investigation included the installation of temporary piezometers to verify groundwater flow directions, sampling of water from piezometers to verify whether a source of BTEX contamination is present, and sampling and analysis of the four existing wells to verify that natural attenuation of BTEX is occurring. Results of the supplemental investigation are given in Appendix H.

14.2 NATURE AND EXTENT OF CONTAMINATION AT BURN PIT F

14.2.1 Surface Soil Contamination

The nature and extent of surface soil contamination was evaluated using the results of analyses on surface soil samples taken from the three Phase II soil borings (SB-1 through SB-3) at the site. These samples were analyzed for SVOCs and RCRA metals. Table 14-1 summarizes the analytical results for surface soil samples, and Figure 14-5 shows their distribution. This assessment presents Phase II contaminant data only because no surface soil samples were collected during Phase I.

Table 14-1. Summary of Analytical Results for Surface Soils
Burn Pit F, Fort Stewart, Georgia

		Phase II Samples		
	Reference	SB-1 4F1111 07/13/97	SB-2 4F1211 07/14/97	SB-3 4F1311 07/14/97
RCRA Metals (mg/kg)				
Arsenic	2.10	**2.7**	0.88	0.91
Barium	14.7	13.6	10.7	11.1
Chromium	6.21	**13.5**	**8.1**	**6.3**
Lead	8.81	6.9	7.3	5.7
Mercury	0.03	0.03	0.03	**0.04**

Note: **Bold** font indicates value exceeds reference background criterion.
RCRA = Resource Conservation and Recovery Act.

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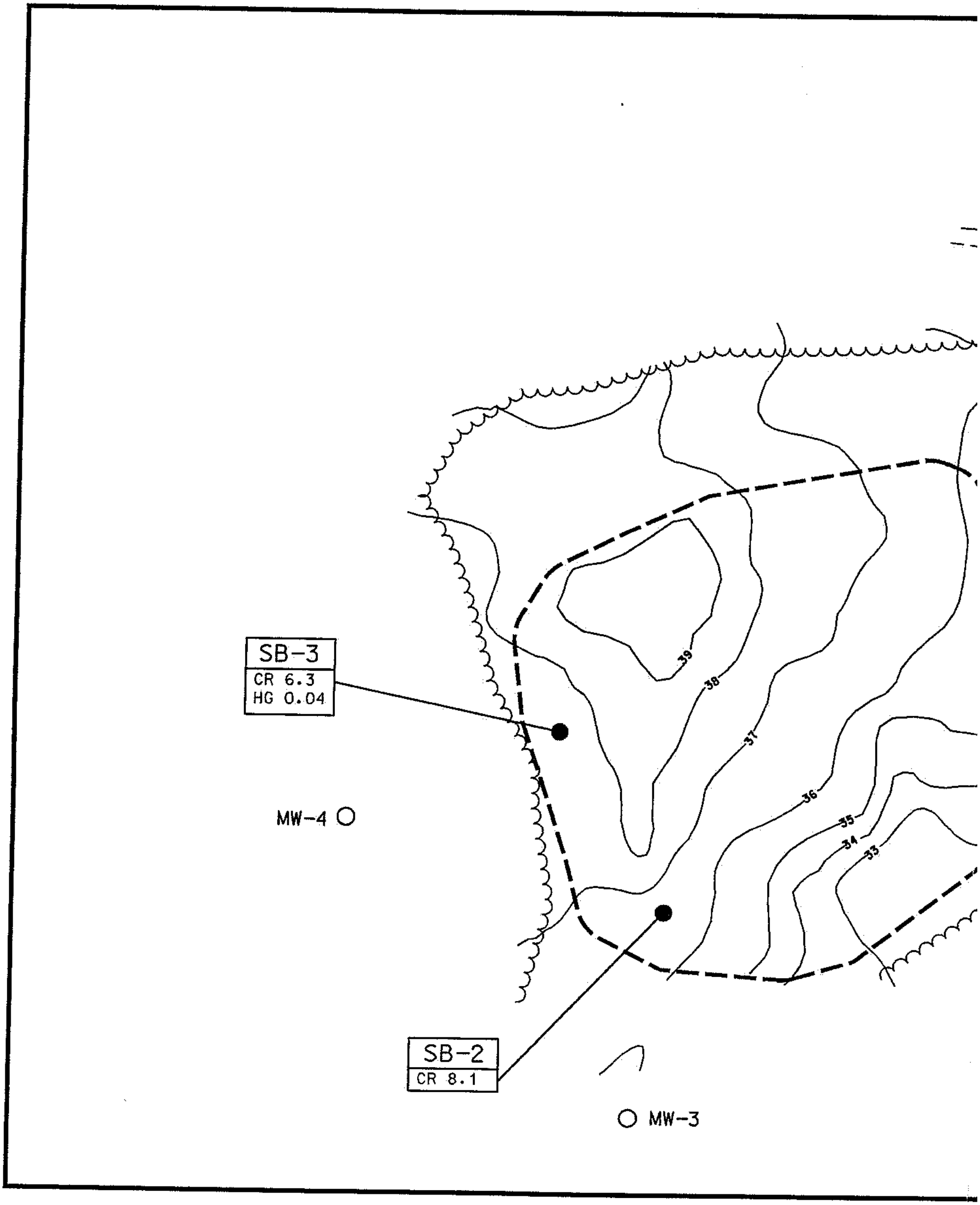

Figure 14-5. Results of Analy

SVOCs. No SVOCs were detected in surface soil samples at the site.

RCRA metals. Maximum concentrations of arsenic (2.7 mg/kg) and chromium (13.5 mg/kg) were reported at SB-1 at concentrations exceeding background. Chromium also exceeded reference background concentrations at the other two boring locations (SB-2 and SB-3). Mercury was reported only at SB-3 at a concentration (0.04 mg/kg), which is only slightly greater than background, and is, therefore, not likely to be site related.

14.2.2 Subsurface Soil Contamination

The subsurface soil samples were collected from the four Phase I monitoring well boreholes and the three Phase II soil borings. The samples were analyzed for VOCs and RCRA metals. Table 14-2 summarizes analytical results for the subsurface soil samples, and Figure 14-6 shows their distribution. Both Phase I and Phase II data are shown.

VOCs. Toluene was detected in two subsurface soil samples at SB-1 and MW-4, with the maximum concentration (5.5 µg/kg) reported at MW-4. These concentrations are lower than the average detection limit for toluene and may, therefore, not be indicative of site-related contamination. Methylene chloride was detected in MW-1 and MW-3 at concentrations up to 7.4 µg/kg.

RCRA metals. Five metals were reported in subsurface soils at concentrations above their reference background value. Barium was detected at concentrations above background in three of the seven subsurface soil samples, with a maximum value (125 mg/kg) at SB-3. Chromium was also found in three of the seven samples, with a maximum concentration of (65.8 mg/kg) also at SB-3. Other metals detected above background include lead (26.9 mg/kg at SB-3), mercury (0.051 mg/kg at MW-4), and silver (2.6 mg/kg at SB-1).

Table 14-2. Summary of Analytical Results for Subsurface Soils
Burn Pit F, Fort Stewart

Parameter	Reference Background	Phase I Samples				Phase II Samples		
		MW1 SL1-8 06/29/93 (6-8 feet)	MW2 SL2-8 06/29/93 (6-8 feet)	MW3 SL3-8 06/30/93 (6-8 feet)	MW4 SL4-4 06/30/93 (2-4 feet)	SB-1 4F1112 07/13/97 (10-12.5 feet)	SB-2 4F1212 07/14/97 (12-14.5 feet)	SB-3 4F1312 07/14/97 (9.5-12 feet)
Volatile Organic Compounds (ug/kg)								
Methylene Chloride	0.0	**6**		**7.4**				
Toluene	0.0				**5.5**	**2.9**		
RCRA Metals (mg/kg)								
Arsenic	8.04					0.9		3.3
Barium	17.0	6.2	17	17	**18**	16	**110**	**125**
Chromium	11.6	5.1	4.6	**15**	8.8	4.3	**13**	**65.8**
Lead	11.1	**16**	8.3	7.7	4.8	3	6.4	**26.9**
Mercury	0.05		0.023		**0.051**	0.02		0.04
Silver	0.46					**2.6**		
Other Inorganics (mg/kg)								
Total Organic Carbon	2,200						279	

Note: A blank indicates analyte not detected.

Note: **Bold** font indicates value exceeds reference background criterion.

RCRA = Resource Conservation and Recovery Act.

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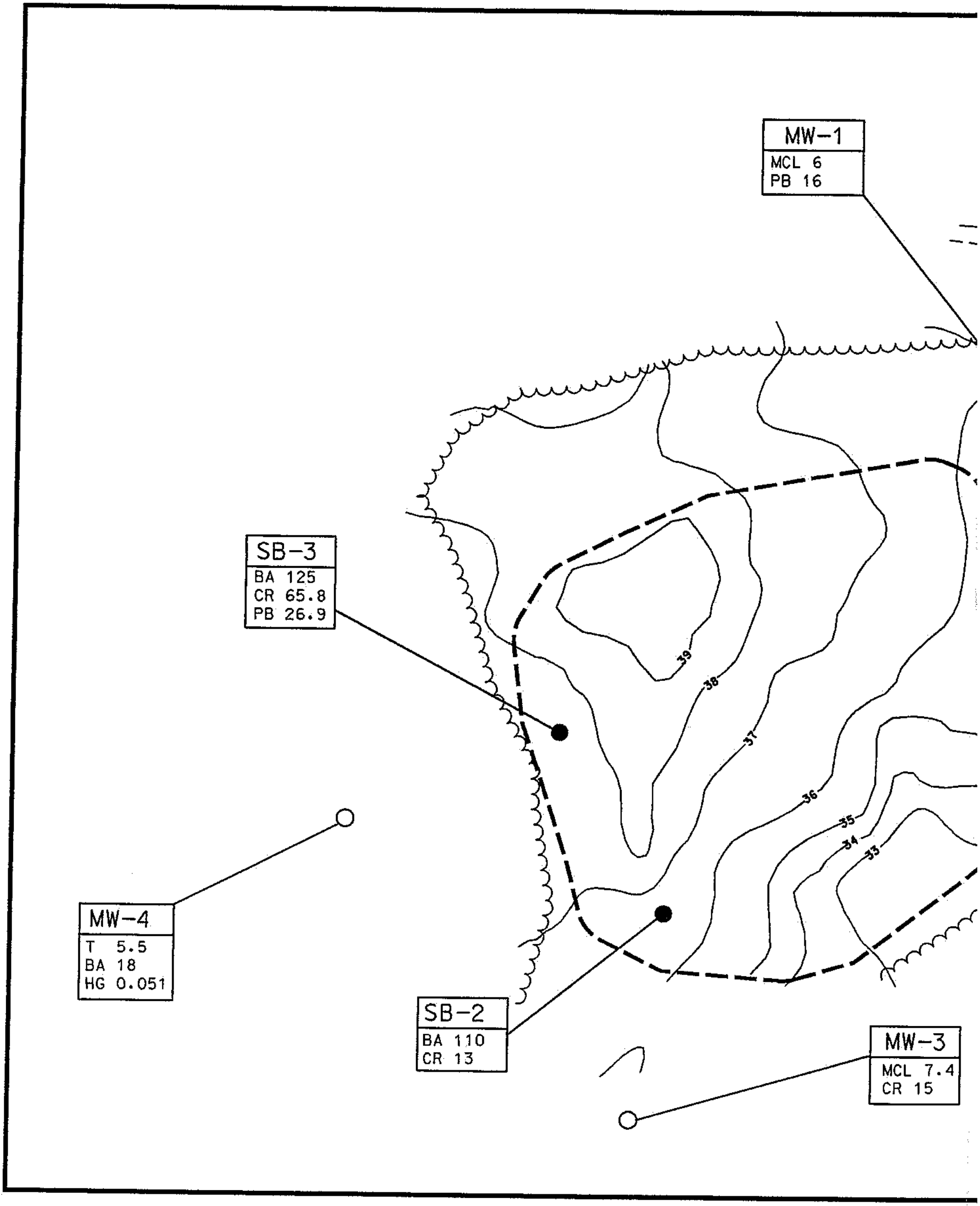

Figure 14-6. Results of Analy

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14.2.3 Groundwater Contamination

Groundwater contamination was evaluated using the results from water samples taken from the four monitoring wells installed during Phase I (MW-1 through MW-4). The groundwater amples were analyzed for VOCs and RCRA metals (total metal analysis on unfiltered water samples). Table 14-3 summarizes the analytical results for groundwater samples and Figure 14-7 shows their distribution. This assessment focuses on the Phase II contaminant data because the Phase I data are considered suspect due to high metals content as a result of turbidity. Phase I VOCs data are discussed qualitatively with respect to trends observed.

Table 14-3. Summary of Analytical Results for Groundwater
Burn Pit F, Fort Stewart

		Phase II Samples				
Parameter	**Reference Background**	**MCL**	**MW-1 07/30/97 4F4111**	**MW-2 07/30/97 4F4211**	**MW-3 08/11/97 4F4311**	**MW-4 07/30/97 4F4411**
Volatile Organic Compounds (µg/L)						
Ethylbenzene	0.0	700				**637**
Styrene	0.0	100				**33.5**
Xylenes, Total	0.0	10,000				**3170**
RCRA Metals (µg/L)						
Barium	71.72	2,000	22.8	49.1	26.3	24.6
Cadmium	0.43	5	**1.1**		**0.65**	
Chromium	3.56	100		0.7	2.8	1.6
Lead	4.69	15	0.08			
Silver	1.12					0.1

Note: A blank indicates analyte not detected.
Note: **Bold** font indicates value exceeds reference background criterion.
MCL = Maximum Contaminant Level.
RCRA = Resource Conservation and Recovery Act.

VOCs. Two BTEX compounds (ethylbenzene at 637 µg/L and total xylenes at 3170 µg/L) were found in groundwater at MW-4. These concentrations are less than the respective MCLs for ethylbenzene (700 µg/L) and total xylenes (10,000 µg/L). In the Phase I sample results, both ethylbenzene and total xylenes were reported at much higher concentrations (2,800 and 15,800 µg/L, respectively), and benzene (22,700 µg/L) and toluene (41,100 µg/L) were also reported above their MCLs. These results suggest that the high concentrations of BTEX present in groundwater at the site may be attenuating naturally, either through dispersion, volatilization, or biodegradation.

Styrene was also observed in MW-4 at 33.5 µg/L and is considered a secondary contaminant in the primary BTEX plume. The source and extent of the BTEX contamination is unknown. MW-4 is located hydraulically higher than other wells at the Burn Pit F site and is considered side-gradient to flow from the site. BTEX compounds were not detected at significant concentrations in the soil borings within the probable source area and were not detected in the remaining (downgradient) monitoring wells.

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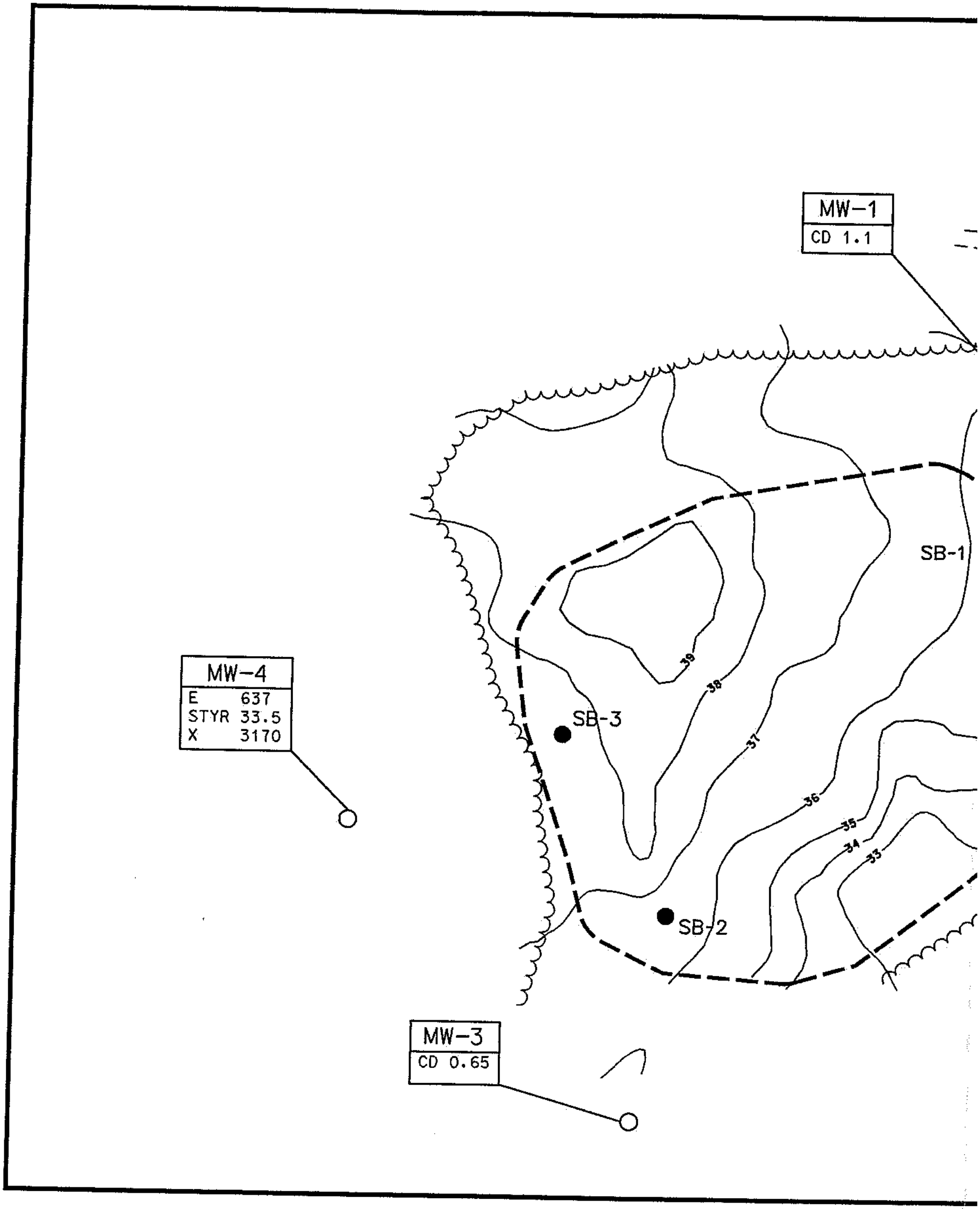

Figure 14-7. Results of Analys

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RCRA metals. Cadmium was the only RCRA metal detected above its background concentration in groundwater and was detected at such concentrations in MW-1 (1.1 µg/L) and MW-3 (0.65 µg/L). MW-1 is considered upgradient of the site.

14.2.4 Summary of Site-related Contaminants

A summary of the SRCs by medium and their maximum concentrations is presented in Table 14-4. SRCs include all organics that are detected, and inorganics detected above reference background criteria. These SRCs are carried forward for evaluation under fate and transport, human health PRE, and ecological PRE.

Table 14-4. Summary of Site-Related Constituents
Burn Pit F, Fort Stewart

Analyte	Surface Soil	Subsurface Soil	Groundwater
	(µg/kg)	(µg/kg)	(µg/L)
Ethylbenzene	na	nd	**637**
Methylene Chloride	na	**7.4**	nd
Styrene	na	nd	**33.5**
Toluene	na	**5.5**	nd
Xylenes, total	na	nd	**3170**
	(mg/kg)	(mg/kg)	(µg/L)
Arsenic	**2.7**	brc	nd
Barium	brc	**125**	brc
Cadmium	nd	nd	**1.1**
Chromium	**13.5**	**65.8**	brc
Lead	brc	**26.9**	brc
Mercury	**0.04**	**0.051**	nd
Selenium	nd	nd	nd
Silver	nd	**2.6**	brc

brc = Below background reference criteria.
na = Not analyzed in any sample in that medium.
nd = Not detected in any sample in that medium.
BOLD font indicates the analyte is an SRC in that medium.

14.3 FATE AND TRANSPORT CONSIDERATIONS AT BURN PIT F

The results of contaminant migration soil screening (discussed in Section 6.0) for Burn Pit F are presented in Table 14-5. Chromium and methylene chloride are identified as CMCOPCs based on leaching to groundwater from this site. Neither of these two constituents are currently observed in groundwater. However, there is a potential for chromium to be leaching from the soil and migrate to the water table at concentration exceeding its MCL. Methylene chloride, on the other hand, may be degraded before reaching the water table, or it may be a laboratory artifact.

The predicted maximum concentration of methylene chloride in groundwater, based on a maximum of 7.4 µg/kg in soil and a DAF of 1, is 37 µg/L. Through biodegradation, even if the methylene chloride were to reach groundwater at such a concentration, it would degrade to its

MCL value (5 μg/L) in less than 2.9 times its half-life. Assuming a conservative half-life of 0.3 years, the methylene chloride would degrade to its MCL value in 0.9 years. The methylene chloride was reported in Phase I soil samples only and was not detected in Phase II samples.

Table 14-5. CMCOPCs Based on Soil Screening for Burn Pit F

SRCs	Maximum Concentration	GSSL	Is Maximum Concentration > GSSL?
RCRA Metal (mg/kg)			
Arsenic	3.30	29	No
Barium	125.00	1600	No
Chromium	65.80	38	Yes
Lead	26.90	400	No
Mercury	0.05	0.4	No
Sliver	2.6	34	No
Volatile Organic Compound (μg/kg)			
Methylene Chloride	7.40	1	Yes
Toluene	5.50	600	No

CMCOPCs = Contaminant Migration Constituents of Potential Concern.
GSSL = Generic Soil Screening Level.
RCRA = Resource Conservation and Recovery Act.

The most likely pathway of contaminant migration from Burn Pit A is via groundwater flow toward Goshen Swamp, located approximately 1000 feet south and west of the site. Based on the calculated groundwater flow velocity of 3.4 feet/year, the estimated arrival time for the site groundwater to reach Goshen Swamp is expected to be more than 294 years. Methylene chloride would degrade to less than its MCL within a few feet of the Burn Pit F site, well before reaching Goshen Swamp.

Although cadmium, ethylbenzene, styrene, and total xylenes are not identified as CMCOPCs based on leaching to groundwater from Burn Pit F, they are currently observed in the site groundwater. However, the maximum observed concentrations for these constituents are below their respective MCLs and, based on fate and transport analysis, they are not expected to increase in the future. Therefore, it can be concluded that chromium is the only constituent that is expected to be of potential concern for contaminant migration from Burn Pit F.

14.4 HUMAN HEALTH RISK EVALUATION OF BURN PIT F

SRCs were identified in Section 14.2 for surface soil, subsurface soil, and groundwater. The identification of risk-based action levels for all of the Burn Pits has been previously discussed in

Section 7.3 and will not be discussed in detail here. The site-specific risk evaluation for Burn Pit F is given below.

14.4.1 Exposure Evaluation

This site is completely covered by vegetation, and no VOCs were detected in surface soils. Therefore, exposure via inhalation based on current land use is not a viable exposure pathway.

The site is not currently used by the Army. Therefore, current on-site receptors include a juvenile trespasser and a hunter. Current off-site receptors would be represented by an off-site hunter.

Land use at this site is unlikely to change in the future. However, the Army may use the site as a training area in the future. Construction may occur on the site or the vegetative cover may be gone as a result of on-site activities. Future on-site receptors include military personnel and a construction worker. Future off-site receptors include hunters in the area.

A summary of the potential exposure pathways for each of the receptor populations is given below.

Current juvenile trespasser. The juvenile trespasser may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for the juvenile trespasser. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Hunter. The hunter is representative of a current on-site receptor and a current and future off-site receptor. The current on-site receptor is not likely to be exposed to chemicals given the absence of an air migration pathway, and clothing the hunter would be wearing would eliminate potential dermal exposure. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

The current off-site hunter may be exposed via ingestion of contaminants bioaccumulated in game animals. The future off-site hunter may be exposed via ingestion of game and inhalation of fugitive dust if the vegetative cover were to be removed.

Future on-site military personnel. The on-site military personnel may be exposed to surface soil. Incidental ingestion and dermal absorption are complete exposure pathways for this receptor. Volatile organics were only detected in subsurface soils. Significant exposure via volatilization is not likely.

Future construction worker. The construction worker may be exposed to surface and subsurface soils. Complete exposure pathways include incidental ingestion, inhalation of volatiles and fugitive dust, and dermal absorption.

14.4.2 Risk Evaluation

The purpose of the risk evaluation is to determine what contaminants present a potential threat to human health. These chemicals will be evaluated further in a BRA.

Arsenic in surface soil is the only contaminant that exceeds its risk-based screening concentration for direct exposure of a receptor population (Table 14-6). Arsenic in surface soil is a potential COPC at this site because it exceeds the risk-based screening value for exposure of a residential receptor. It should be noted that the maximum concentration of arsenic (2.7 mg/kg) is below the average concentration for soils in the eastern United States and only slightly exceeds reference background criteria (2.1 mg/kg) at one location, SB-1. Arsenic was not found above background in either subsurface soil or groundwater. In addition, a residential screening value was used although residential land use at this site is unlikely. Therefore, arsenic is not considered a potential threat to human health at Burn Pit F.

Table 14-6. Comparison to Action Levels–Burn Pit F, Fort Stewart

Analyte	Units	Frequency of Detects	Minimum Detect	Maximum Detect	Background Criteria	EPA III Screening Criteria	COPC?	Justification
Burn Pit F Surface Soil								
Arsenic	mg/kg	3/3	0.88	2.7	2.1	0.43	Yes	Max Detect > Screening Criteria
Chromium	mg/kg	3/3	6.3	13.5	6.21	39	No	Max Detect < Screening Criteria
Mercury	mg/kg	3/3	0.03	0.04	0.03	2.3	No	Max Detect < Screening Criteria
Burn Pit F Subsurface Soil								
Barium	mg/kg	6/6	16	125	17.0	14,000	No	Max Detect < Screening Criteria
Chromium	mg/kg	6/6	4.3	65.8	11.6	1,000	No	Max Detect < Screening Criteria
Lead	mg/kg	6/6	3	26.9	11.1	400	No	Max Detect < Screening Criteria
Mercury	mg/kg	4/6	0.02	0.051	0.05	61.0	No	Max Detect < Screening Criteria
Silver	mg/kg	1/6	2.6	2.6	0.46	1,000	No	Max Detect < Screening Criteria
Methylene chloride	mg/kg	1/6	0.0074	0.0074		76	No	Max Detect < Screening Criteria
Toluene	mg/kg	2/6	0.0029	0.0055		41,000	No	Max Detect < Screening Criteria
Burn Pit F Groundwater								
Cadmium	µg/L	1/3	0.65	0.65	0.43	1.8	No	Max Detect < Screening Criteria
Ethylbenzene	µg/L	1/3	637	637		1300	No	Max Detect < Screening Criteria
Styrene	µg/L	1/3	33.5	33.5		1600	No	Max Detect < Screening Criteria
Xylenes, Total	µg/L	1/3	3170	3170		12000	No	Max Detect < Screening Criteria

COPC = Chemical/Contaminant of Potential Concern.
EPA = U.S. Environmental Protection Agency.

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All of the contaminants in subsurface soils and groundwater were below their respective risk-based screening concentration for direct exposure of a receptor population (Table 14-6).

In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at Burn Pit F. A human health BRA is not warranted. No further action is required for protection of human health.

14.5 ECOLOGICAL RISK EVALUATION OF BURN PIT F

The ecological risk evaluation of Burn Pit A is a PRE conducted according to GEPD (1996) guidance (see Section 8.0). The PRE compares the maximum detected concentrations of analytes directly to conservative screening values for those substances. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the Step i screening, then those ecological COPCs are considered further in PRE Steps ii through v. The results of the five steps of the PRE are reported below.

14.5.1 Ecological Screening Value Comparison (Step i)

One RCRA metal and three VOCs were detected in groundwater at Burn Pit F at concentrations exceeding background criteria. The results of the ESV comparison for groundwater at Burn Pit F are presented in Table 14-7. Because the detected concentrations of cadmium in the downgradient wells MW-2 through MW-4 did not exceed the ESV, cadmium is not considered an ecological COPC. The maximum detected concentration of ethylbenzene exceeded its surface water ESV; therefore, the ecological COPC identified by the ESV comparison for groundwater at Burn Pit F is ethylbenzene.

Although ecological COPCs are identified in groundwater at Burn Pit F when it is screened according to GEPD (1996) and EPA Region 4 (1995) guidance, groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at Burn Pit F. There are no surface water bodies in the vicinity of Burn Pit F. Also, groundwater contaminants are not expected to migrate from the site because the movement of groundwater is slow relative to the high adsorption and biodegradation of contaminants in Burn Pit F soils.

Because there are no ESVs for soil, all analytes detected in soil at Burn Pit F are evaluated further in PRE Steps ii through v.

14.5.2 Preliminary Problem Formulation (Step ii)

Burn Pit F comprises approximately 3 acres (Figure 14-1). Clearing and grubbing debris are present in small mounded areas within the site. The debris consist of stumps, branches, and similar vegetative material. Occasional stands of pine or small individual trees are present. Grass covers some of the debris piles and open areas. The site is surrounded by woods. Drainage occurs through overland flow to the southeast, collecting in swampy areas that comprise Big Swamp and Goshen Swamp. The closest surface stream to the site is an unnamed tributary of Goshen Swamp, which lies approximately 1000 feet west of the site.

Table 14-7. EPA Region 4 Ecological Screening Value Comparison for Analytes Detected in Groundwater at Burn Pit F, Fort Stewart

Analyte	ESV	MW-1*	MW-2	MW-3	MW-4	Maximum
RCRA Metals (µg/L)						
Cadmium	0.66^a	**1.1 J**		0.65 J		0.65
Volatile Organic Compound (µg/L)						
Ethylbenzene	453				**637**	**637**
Styrene	10,000^b				33.5 J	33.5 J
Xylenes, Total	7,100^c				3170	3170

*Upgradient monitoring well.
J = Estimated concentration.
ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values (EPA 1996) and, where indicated, alternative values for analytes without Region 4 ESVs.
RCRA = Resource Conservation and Recovery Act.
^{a}Hardness dependent; assumes 50 mg/L $CaCO_3$.
$^b LC_{50}$ fish (Clayton and Clayton 1981).
$^c LC_0$ salmonid (Clayton and Clayton 1981).
Bold font indicates detected concentration exceeds ESV.

The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation for Burn Pit F are described in Section 8.1.2.

14.5.3 Preliminary Effects (Step iii)

In the PRE for Burn Pit F, TRVs are required for shrews and robins ingesting contaminated biota exposed to soils near the site. The derivation of TRVs is discussed in Section 8.1.3. The TRVs derived for shrews and robins for ecological COPCs in soil are presented in Table 8-1.

14.5.4 Preliminary Exposure (Step iv)

Ecological receptors at Burn Pit F are likely exposed by ingestion of contaminated soil or biota exposed to contaminated soil. The exposure parameters for the surrogate species, shrews and robins exposed to COPCs in soil are presented in Table 8-2.

14.5.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the measured maximum concentration and the TRV, to evaluate the potential for risk. The HQs of ecological COPCs with consistent modes of toxicity and effects endpoints are added to calculate an HI. Metals are assumed to have distinct modes of toxicity and effects endpoints. Therefore, HIs are only calculated for VOCs and SVOCs when no individual ecological COPC has an HQ greater than 1.0, and HQs are calculated for more than one chemical. Ecological COPCs with HQs and HIs less than 1.0 indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ecological COPCs with calculated HQs or HIs exceeding 1.0 (GEPD 1996).

Surface Soil. The preliminary risk calculation for shrews and robins exposed to ecological COPCs detected in soil at Burn Pit F is presented in Table 14-8. This table shows the maximum detected concentrations and the TRVs for shrews and robins. Concentrations resulting in HQs exceeding 1.0 are shown in boldface font.

The only ecological COPC present in Burn Pits F surface soil at concentrations exceeding the TRV for the surrogate species is chromium. Only the robin is potentially at risk from chromium in surface soil. An HI is not calculated for the surrogate species exposed to RCRA metals detected in surface soil because they are assumed to have dissimilar mechanisms of toxicity.

Table 14-8. Preliminary Risk Evaluation of Ecological COPCs in Surface Soil (0 to 1 foot) at Burn Pit F, Fort Stewart

Analyte	TRV		SB-1	SB-2	SB-3	Maximum
	Shrew	Robin				
RCRA Metals (mg/kg)						
Arsenic	37.8	651	2.7 J	0.88 J	0.91 J	2.7 J
Chromium	62662	5.18	**13.5**	**8.1**	**6.3**	**13.5**
Mercury	14.1	1.1	0.03	0.03	0.04	0.04

J = Estimated concentration.
- = No data to derive TRV.
RCRA = Resource Conservation and Recovery Act.
TRV = Toxicity Reference Value = (NOAEL × BW/Food ingestion)/$BAF_{earthworm}$ (see Table 8-1).
Boldface indicates detected concentration exceeds TRV (HQ>1).

14.5.6 Uncertainties

The risk to ecological receptors from chromium in surface soil at Burn Pit F is overestimated by the preliminary risk calculations. Chromium was detected in the three surface soil samples at concentrations ranging from 6.3 to 13.5 mg/kg. Chromium was detected in only one surface soil sample at a concentration barely exceeding the NOAEL-based TRV for the robin with a realistic diet (12.44 mg/kg). However, chromium concentrations in surface soil at Burn Pit F are many times less than the LOAEL-based TRV for the robin calculated using published dietary fractions (62.1 mg/kg). Therefore, chromium in surface soil at Burn Pit F is unlikely to pose a risk to ecological receptors.

14.6 CONCLUSIONS AND RECOMMENDATIONS FOR BURN PIT F

The following are the conclusions of the Phase II RFI for Burn Pit F:

- In surface soils, arsenic, chromium, and mercury were reported above background concentrations and are considered possible SRCs. Chromium was found in all three surface soil samples and, therefore, extends throughout the Burn Pit F site.

- Arsenic is a potential human health COPC in surface soil at Burn Pit F because it exceeds the risk-based screening value for exposure of a residential receptor. However, the maximum concentration of arsenic is below the average concentration for regional soils, and residential land use is unlikely. Therefore, arsenic is eliminated as a human health COPC.

- Chromium and mercury are not human health COPCs in surface soil because the maximum concentration of each constituent did not exceed its respective screening criteria.

- Chromium is a potential ecological COPC in surface soils because it exceeds the TRV for one of the surrogate species (robin only). Chromium is considered to be site related and was found in all three of the surface soil samples within the source area at concentrations exceeding its TRV. However, the maximum concentration of chromium (13.5 mg/kg) is within the USGS range of background concentrations for soils in the Eastern United States (up to 1000 mg/kg). In addition, chromium concentrations in surface soil are many times less than the LOAEL-based TRV for the robin and are unlikely to pose a risk to ecological receptors. The risk to ecological receptors from chromium in surface soil at Burn Pit F is overestimated by the preliminary risk calculations. As discussed in the uncertainties section (14.5.6), the maximum detected concentration of chromium in surface soil is expected to result in exposures to the surrogate ecological receptors (shrews or robins) that are less than the lowest exposures associated with adverse effects on them (LOAEL-based TRV). Therefore, chromium is eliminated as an ecological COPC for Burn Pit F, and further investigation and/or evaluation is not required.

- In subsurface soil, five metals (barium, chromium, lead, mercury, and silver) were reported at concentrations above their reference background value. Barium and chromium were detected in three of the seven samples. Toluene and methylene chloride were each detected in two subsurface soil samples.

- There are no human health COPCs in subsurface soil because no constituent exceeded its risk-based screening value.

- Chromium and methylene chloride are potential contaminant migration COPCs in subsurface soil because they may leach to groundwater, resulting in groundwater concentrations exceeding their respective MCLs. However, chromium was not detected in groundwater at concentrations above its reference background value. Off-site migration of chromium would be limited due to retardation and the slow movement of groundwater. Similarly, methylene chloride was not detected in groundwater, and its migration would be limited due to retardation and biodegradation as well as the slow movement of groundwater. Therefore, migration of either chromium or methylene chloride is considered unlikely, and there are no contaminant migration COPCs.

- In groundwater, cadmium was the only RCRA metal detected above its reference background value. Cadmium was detected at its highest concentration in well MW-1, which is considered upgradient of the site.

- BTEX compounds (ethylbenzene and total xylenes) were reported in groundwater at MW-4, although they were present at concentrations less than their respective MCLs and less than the concentrations reported during the Phase I RFI, suggesting that they may be attenuating naturally, either through dispersion, volatilization, or biodegradation.

- There are no human health COPCs in groundwater because no constituent exceeded its risk-based screening value or its MCL in groundwater.

- Ethylbenzene is an ecological COPC in groundwater because it exceeds the ESV for surface water and may present a potential risk to amphibians. However, there are no surface water bodies in the vicinity of Burn Pit F, and off-site migration would be limited due to retardation and/or biodegradation and the slow movement of groundwater. Therefore, exposure of ecological receptors to constituents in surface water bodies downgradient from Burn Pit F is not a complete pathway. Therefore, ethylbenzene is eliminated as an ecological COPC for Burn Pit F, and further investigation and/or evaluation of this constituent is not required.

The following are recommendations for Burn Pit F:

1. No further action is recommended for Burn Pit F.

2. All potential human health COPCs were eliminated for Burn Pit F (Section 14.4), and a BRA is not recommended for the site.

3. All potential ecological COPCs were eliminated for Burn Pit F (Section 14.5), and an ERA is not recommended for the site.

4. As discussed in Section 14.1, a supplemental groundwater characterization was performed in November 1998 at Burn Pit F (Appendix H). Based upon the results of that supplemental characterization, BTEX contamination is restricted to the immediate area around well MW-4. Concentrations of ethylbenzene and total xylenes are less than their respective MCLs and continue to decline, indicating that they are attenuating naturally. The groundwater flow direction at the Burn Pit F site has been better defined (as indicated on Figure H-2). These results fully support Fort Stewart's request for "No Further Action" for this site.

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15.0 CONCLUSIONS AND RECOMMENDATIONS

15.1 SUMMARY OF FINDINGS

The Phase II RFI presented in this report was conducted to collect additional analytical data for determining the nature and extent of contamination in environmental media in the vicinity of the former Burn Pits (SWMUs 4A through 4F). The data were derived from analyzing samples of surface soils, subsurface soils, and groundwater at each of the six Burn Pit sites. Surface soil samples were analyzed for SVOCs and RCRA metals; subsurface soil and groundwater samples were analyzed for VOCs and RCRA metals.

Results of these analyses indicated that soils and groundwater at the various sites contain both organic and metal contaminants at concentrations greater than their reference background concentrations. The following summarizes the significant findings of the Phase II RFI sampling and analysis:

- SVOCs were found only in a single surface soil sample at low concentrations at Burn Pit E.
- Metals found above background in surface soils include arsenic, barium, cadmium, lead, and mercury in the northern and eastern portions of Burn Pit A; lead and mercury at Burn Pit B; barium, cadmium, lead, and mercury in the center of Burn Pit C; barium and mercury at Burn Pit E; and arsenic, chromium, and mercury in the northern and northeastern portion of Burn Pit F.
- BTEX compounds were found sporadically in subsurface soil at low concentrations at all six Burn Pit sites. A consistent pattern of distribution is evident only at Burn Pit B and Burn Pit C.
- Metals in subsurface soils were generally found sporadically at all six Burn Pit sites at concentrations less than twice background and in no consistent pattern of distribution. Notable presence of metals found in subsurface soils includes lead and mercury in the central and northeastern portion of Burn Pit C, and five metals (predominantly barium, lead, and chromium) throughout the Burn Pit F site.
- In groundwater, the highest levels of BTEX contamination were found in a single well located west (side-gradient) of the Burn Pit F site. Concentrations of BTEX were less than their respective MCLs and less than reported Phase I concentrations, suggesting that natural attenuation may be occurring. The source of the BTEX contamination is unknown; BTEX compounds were not found at high concentrations in soils at Burn Pit F.
- Metals in groundwater were found at all six sites at concentrations less than their respective MCLs and much less than reported Phase I concentrations, suggesting that redevelopment of the wells and use of low-flow sampling equipment to reduce turbidity in the samples were successful.
- Metals found in groundwater include barium, mercury, and silver at Burn Pit A; barium, cadmium, chromium, selenium, and silver at Burn Pit B; barium, cadmium, and mercury at Burn Pit C; arsenic, barium, and silver at Burn Pit D; and cadmium at Burn Pits E and F.

15.2 CONCLUSIONS

Several assessments were conducted to determine the significance of the contaminant concentrations found at the six Burn Pit sites with respect to their impact on human health and the environment. The assessments included the following:

- A contaminant fate and transport analysis (Section 6.0), which provided an assessment of the potential migration pathways and transport mechanisms affecting the chemicals at the sites.
- An HHRA (Section 7.0), which conducted a Step 1 risk evaluation to determine potential human health risks associated with the contaminants.
- An ERA (Section 8.0), which provided a Phase 1 PRE for potential terrestrial and aquatic receptors at the sites.

The following summarizes the conclusions regarding contaminant fate and transport:

- Among the metal constituents, only chromium from Burn Pit F is considered a contaminant migration COPC based on contaminant transport analysis for leaching from soil to groundwater. At Burn Pit F, chromium could reach the water table at a predicted concentration exceeding its MCL. However, off-site migration of chromium would be very limited due to its high K_d (i.e., high retardation factor) as well as the slow movement of groundwater toward Goshen Swamp, located approximately 1000 feet west of the site.
- Benzene, methylene chloride, and PCE could migrate from soils to the water table at concentrations exceeding their respective MCLs. However, off-site migration of these constituents would be very limited due to retardation and biodegradation as well as the slow movement of groundwater. Predicted maximum concentrations of these constituents at a distance of 300 feet from the source are not expected to exceed their MCLs even with the most conservative assumption for their biodegradation half-lives. None of the organic compounds that is currently observed in groundwater exceeds its respective MCL in groundwater.

The following summarizes the conclusions of the HHRA:

- In surface soil, arsenic is a potential COPC at Burn Pits A and F, where arsenic exceeds its risk-based screening value for exposure of a residential receptor. It should be noted that the maximum concentration of arsenic at these sites (2.7 µg/kg) is below the average concentration of arsenic for soils regionally (7.4 µg/kg). In addition, a residential screening value was used, even though residential land use at these sites is unlikely. Therefore, arsenic in surface soil is not considered a potential threat to human health at the Burn Pits.
- In subsurface soil, no constituent exceeded its respective risk-based screening value for exposure to an industrial receptor.
- In groundwater, arsenic is a potential COPC only at Burn Pit D, where the maximum concentration of arsenic in groundwater exceeded its risk-based screening value for residential use of groundwater as drinking water. However, the maximum concentration of arsenic (4.2 µg/L) was well below its MCL of 50 µg/L, and was only slightly above its reference background concentration of 3.4 µg/L. Arsenic exceeded background in only a single well at Burn Pit D (MW-6). In addition, use of the surficial groundwater at this site for

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drinking water is unlikely. Therefore, arsenic in groundwater is not considered a potential threat to human health at the Burn Pits.

- Similarly, cadmium is a potential COPC at Burn Pits C and E, where the maximum concentrations of cadmium in groundwater exceeded its risk-based screening value for residential use of groundwater. The maximum concentrations of cadmium were less than its MCL of 5 µg/L at each site. In addition, use of the surficial groundwater at the sites for drinking water is unlikely. Therefore, cadmium is not considered a potential threat to human health at the Burn Pits.

- In conclusion, there are no constituents in either surface soil, subsurface soil, or groundwater that are considered a potential threat to human health at the Burn Pits. A human health BRA is not warranted. No further action is required for protection of human health.

The following summarizes the conclusions of the ERA:

- According to GEPD and EPA Region 4 guidance, groundwater was screened as surface water in the ecological PRE. Barium, cadmium, lead, mercury, silver, and ethylbenzene are present in groundwater at one or more of the former Burn Pits at concentrations that exceed EPA Region 4 ESVs for surface water.

- Groundwater is not evaluated further in the PRE because ecological receptors are not likely to be exposed to groundwater at the Burn Pits. Treating groundwater as surface water is unrealistic because there are no surface water bodies in the vicinity of the Burn Pit sites. As concluded in the fate and transport evaluation (Section 6.0), off-site migration of these contaminants would be limited due to retardation or biodegradation as well as the slow movement of groundwater. Therefore, migration of contaminants to surface waters via groundwater discharge is not a complete exposure pathway for ecological receptors.

- Cadmium, chromium, and lead are present in surface soil at one or more of the former Burn Pits at concentrations that exceed the TRVs for the robin and, in some cases, the shrew. Cadmium, chromium, and lead in surface soil at these two sites are, therefore, identified as potential ecological COPCs in the PRE. Based on the results of additional evaluations using published dietary fractions and LOAEL-based TRVs and the uncertainties in the preliminary risk calculations, cadmium, chromium, and lead in surface soil at the Burn Pits are unlikely to pose a risk to ecological receptors.

15.3 SUPPLEMENTAL PHASE II GROUNDWATER CHARACTERIZATION

VOCs. Two BTEX compounds (ethylbenzene at 289 µg/L and total xylenes at 1420 µg/L) were detected in groundwater at MW-4 during the supplemental groundwater sampling at Burn Pit F conducted in November 1998 (Appendix H). The concentrations are less than the respective MCLs for ethylbenzene (700 µg/L) and total xylenes (10,000 µg/L). In Phase I sample results, both ethylbenzene and total xylenes were reported at much higher concentrations (2,800 and 15,800 µg/L, respectively). In the Phase II RFI, both ethylbenzene and total xylenes were also reported at higher concentrations of 637 and 3170 µg/L, respectively. These results indicate that the concentrations of BTEX present in groundwater at the site are attenuating naturally, either through dispersion, volatilization, or biodegradation.

Low concentrations of total xylenes (3.8 µg/L) were also found in MW-1. Total xylenes were found at a concentration only slightly above their detection limit and significantly less than their MCL of 10,000 µg/L. No VOCs were reported above the detection limit in MW-1 during the Phase II RFI groundwater sampling.

Chloroform and styrene (2.8 µg/L and 12.2 µg/L, respectively) were observed in MW-4. Styrene is considered a secondary contaminate in the primary BTEX plume. Chloroform is a common laboratory contaminant, was not detected in the Phase II RFI sampling event, and is substantially less than its MCL of 100 µg/L.

The following conclusions and recommendations have been made based on the results of the Phase II RFI and the supplemental groundwater investigation (Appendix H):

1. The exact source of the BTEX contamination at Burn Pit F is unknown. MW-4 is located hydraulically higher than the other wells at the Burn Pit F site and is considered side-gradient to the existing groundwater flow. BTEX compounds were not detected at significant concentrations in the soil borings within the potable source area, were not detected in the remaining downgradient wells, and were not detected in the eight additional piezometers installed around the perimeter of MW-4. Therefore, the source and extent of contamination is expected to be localized and confined to the immediate vicinity of MW-4.

2. BTEX compounds (ethylbenzene and total xylenes) continue to be present in groundwater at MW-4. However, their concentrations are less than their respective MCLs and less than the concentrations reported during the Phase I and II RFIs, indicating they are attenuating naturally, either through dispersion, volatilization, or biodegradation.

3. No further investigation or action is recommended for Burn Pit F. The existing wells should be retained in the event that future site monitoring is required to confirm that concentrations of ethylbenzene and total xylenes continue to decrease.

15.4 RECOMMENDATIONS

The results of the RFI and supplemental groundwater sampling, conclusions regarding nature and extent of contamination, fate and transport, human health risk, and ecological risk, result in the following recommendations:

1. No further action is recommended for all six Burn Pits (i.e., SWMUs 4A, 4B, 4C, 4D, 4E, and 4F). If approved by GEPD, Fort Stewart respectfully requests that the Installation's Subpart B permit be amended to reflect this change in investigative status.

2. Due to the fact that all human health COPCs have been eliminated in site-specific evaluations, none of the Burn Pits will require a BRA.

3. Due to the fact that all ecological COPCs have been eliminated in site-specific evaluations, none of the Burn Pits will require an ERA.

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4. If GEPD approves Fort Stewart's recommendation for "No Further Action" at SWMUs 4A, 4B, 4C, 4D, 4E, and 4F, the existing site monitoring wells will be properly abandoned, with the exception of the wells located at SWMU 4F. Fort Stewart proposes to retain the wells at SWMU 4F in the event that future site monitoring is required to confirm that concentrations of ethylbenzene and total xylenes continue to decrease.

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