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ENSAFE INC

VOLUME 91

RCRA FACILITY INVESTIGATION REPORT
ASSEMBLY E
SWMUs 2, 9, 14, 38, 59, and 65
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

REVISION 1

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Department of the Navy
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Naval Facilities Engineering Command
North Charleston, South Carolina

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

February 2, 1998

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The Contractor, EnSafe Inc. hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0318 is complete, accurate, and complies with all requirements of the contract.

Date: February 2, 1998
Signature:
Name: Robert Smith
Title: Task Order Manager

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Acronyms List

μg/kg	micrograms per kilogram
ASTM	American Society for Testing and Materials
atm-m^3/mole	atmospheric-cubic meter per mole
BCT	BRAC Cleanup Team
bls	below land surface
BRAC	Base Closure and Realignment Act
BTX	benzene, toluene, and xylene
BUPERS	Bureau of Personnel
CAP	Corrective Action Plan
CEC	cation exchange capacity
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/sec	centimeter per second
COCs	contaminants of concern
CSI	Confirmatory Sampling Investigation
CS/VP	Confirmatory Sampling/Verification Phase
DERA	Defense Environmental Restoration Account
DPT	direct push technology
DRO	diesel range organics
E/A&H	EnSafe/Allen & Hoshall
EDGe	Engineering Design and Geosciences Group Inc.
f_{oc}	fraction of organic carbon
ft/bls	feet below land surface
ft/msl	feet mean sea level
FWQC	Fresh Water Quality Criteria
g/cm^3	grams per cubic centimeter
G/M	Geraghty and Miller
gpm/ft	gallons per minute/feet
GRO	gasoline range organic
Hg	mercury
HHRA	human health risk assessment
HSWA	Hazardous and Solid Waste Amendments of 1984
ILCR	incremental lifetime excess cancer risk
K	hydraulic conductivity
K_d	distribution coefficient
kg/m^3	kilograms per cubic meter
K_{oc}	organic carbon partition coefficient
MCLs	maximum contaminant levels
mg/L	milligrams per liter
mL/g	milliliters per gram
mm Hg	millimeters of mercury
NA	not applicable

NAS	Naval Air Station
NSA	Naval Support Activity
og	organic compound
OSWER	Office os Solid Waste and Emergency Response
PCBs	polychlorinated biphenyls
RBCs	risk-based concentrations
RCRA	Resource Conservation and Recovery Act
RCs	risk concentrations
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SG	specific gravity
SSL	soil screening level
SSVs	sediment screening values
SVOCs	semivolatile organic compounds
SWMU	solid waste management unit
TDEC	Tennessee Department of Environment and Conservation
TOC	total organic compounds
TPH	total petroleum hydrocarbons
TTAL	treatment technique action level
USDA	United States Department Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VSI	Visual Site Inspection
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

As part of the U.S. Navy Installation Restoration Program, the following Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report has been prepared for the six Assembly E solid waste management units (SWMUs) on the Southside of Naval Support Activity (NSA) Memphis in Millington, Tennessee. The SWMUs required an RFI to identify and characterize known or suspected releases of hazardous constituents. The Southside of NSA Memphis has been "realigned" as a result of the Base Closure and Realignment Act of 1990 (BRAC). The Assembly E RFI, undertaken by EnSafe/Allen & Hoshall (E/A&H) and the U.S. Geological Survey (USGS), was conducted in accordance with the Hazardous and Solid Waste Amendments (HSWA) portion (HSWA-TN002) of RCRA Permit No. TN2-170-022-600 (issued in September 1986), the HSWA portion of permit modification No. TNHW-094 (issued in September 1996), and the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

SWMU	Name
• 2	Southside Landfill
• 9	Sewage Lagoons
• 14	Building S-140 and Seventh Avenue Ditch
• 38	Miscellaneous Drainage Ditches (Southside Only)
• 59	Pesticide Storage Facility (Old Pesticide Shop)
• 65	Building S-362 Training Mock-up Site

SWMU 2 SUMMARY

Site Description and History

SWMU 2, the Southside Landfill, covers 42 acres of the southeast quadrant of NSA Memphis. The landfill is covered with mature trees and dense undergrowth. SWMU 2 is relatively flat, subtly sloping downward to the south and rising near Big Creek Drainage Canal south of the landfill, which flows from east to west. The southern boundary of NSA Memphis and undeveloped land are south of Big Creek Drainage Canal. West of the landfill, Seventh Avenue and the NSA Memphis South Gate open onto civilian-controlled Singleton Parkway. The NSA Memphis shooting range is near the landfill's northwest corner. A wooded lot and a residential neighborhood are approximately 1,000 feet north of the landfill. SWMU 2 is bounded on the east by Perimeter Road, woods, and residential areas.

The Southside Landfill reportedly received solid waste generated from both the Southside and Northside of NSA Memphis from 1942 until 1970. Waste disposed of included residential waste generated by onsite housing, office solid waste, aircraft parts, wastewater-treatment plant sludge, incinerator ash, waste oil, oily sludge, and solvents generated from industrial operations. An estimated one ton per year of oily waste and sludge (possibly containing polychlorinated biphenyls [PCBs]) and approximately two tons per year of wastewater-treatment plant sludge were disposed of by trench-and-cover in the landfill. Combustible materials disposed of were reportedly burned with waste oil to aid in the burning process and reduce waste volume in the landfill.

The Southside Landfill has been the subject of two previous investigations in which limited groundwater and soil-gas samples were collected and analyzed. During the 1984 Confirmation Study/Verification Phase (CS/VP), five monitoring wells were installed around the landfill and sampled for volatile organic compounds (VOCs) and select inorganics. In 1991, the USGS conducted a limited soil-gas survey and electromagnetic (EM) survey of the landfill.

Additional Sampling Required for SWMU 2 RFI Completion

The Assembly E RFI at SWMU 2 began with a direct push technology (DPT) soil and groundwater screening investigation. The DPT results were used to determine the optimum location and depth of soil borings and monitoring wells. Soil, groundwater, sediment, and surface water samples were collected during the RFI. A preliminary evaluation of the SWMU 2 RFI data indicates that VOCs and metals, especially chromium, are present in SWMU 2 groundwater at concentrations exceeding their U.S. Environmental Protection Agency (USEPA) risk-based concentrations (RBCs) for tap water or maximum contaminant levels (MCLs) for drinking water. Additional investigation, including installing and sampling additional monitoring wells, is scheduled to complete the SWMU 2 RFI. Therefore, the nature and extent of contamination at SWMU 2, and the resulting risk and fate and transport evaluations are not presented in this report. When SWMU 2 has been adequately characterized and evaluated with respect to risk and fate and transport, the RFI results will be incorporated in a subsequent revision of this report.

SWMU 9 SUMMARY

Site Description and History

SWMU 9 consists of two inactive sewage lagoons on the NSA Memphis Southside southern boundary, approximately 175 feet south of Big Creek Drainage Canal and 450 feet southwest of the South Gate. The approximately 400,000-square-foot western lagoon is separated from the approximately 141,000-square-foot eastern lagoon by a 25-foot wide dike. The lagoons are bordered by woods and Big Creek Drainage Canal to the north, woods to the south and west, and Singleton Parkway to the east.

The lagoons, which support a variety of wildlife, are constructed of clay. NSA Memphis personnel have reported that the water level in the lagoons does not noticeably change from season to season and are influenced by rainfall. The land surrounding the lagoons slopes away on all sides for a few feet, with surface water draining generally west before it enters Big Creek Drainage Canal, which flows to the west. The lagoon bottom sediments are clay and wastewater sludge, underlain by clayey silt.

The two lagoons were used as part of the wastewater treatment system from 1969 to 1978. Although primarily domestic wastewater was treated, limited amounts of industrial wastewater from aircraft maintenance were also treated. This industrial wastewater may have contained a wide variety of contaminants, including VOCs, semivolatile organic compounds (SVOCs), and metals. The lagoons received approximately 35% of the wastewater produced at NSA Memphis, with the other 65% going to SWMU 28, the former Southside wastewater treatment plant.

An influent line from the former wastewater treatment plant crossed Big Creek Drainage Canal and entered the lagoon area at the northwest corner of the larger western lagoon. The wastewater was chlorinated prior to discharge into Big Creek Drainage Canal through the effluent line at the northeast corner of the lagoons. According to NSA Memphis personnel, all influent and effluent control valves were closed and concrete-sealed in 1978, when the sewer system was connected to the City of Millington sewage treatment system.

The sewage lagoons have been the subject of one previous investigation during which limited sediment sampling was conducted. In 1984, Geraghty and Miller (G&M) collected five sediment samples from the bottom material in the two lagoons. The samples were analyzed for total cadmium, chromium, copper, nickel, and lead by Solid Waste (SW)-846 Method 1310, and the results were compiled in the *NACIP Confirmation Study, Verification Phase* report (G&M, 1985). No metal was detected above its method detection limit (0.01 milligrams per kilogram [mg/kg] for cadmium and nickel and 0.1 mg/kg for chromium, copper, and lead); therefore, the 1985 G&M report recommended no further investigation for SWMU 9. However, the subsequent *RCRA Facility Assessment* (ERC/EDGe, 1990b) recommended an RFI at SWMU 9 due to the lack of analytical data for the SWMU.

SWMU 9 RFI Sampling Rationale

The SWMU 9 RFI consisted of collecting and analyzing soil, groundwater, sediment, surface water, and fish tissue samples. The sampling methods, intervals, analyses, and rationale are listed in the following table.

SWMU 9
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Soil	DPT	15	8 to 10 feet	VOCs	Screening investigation to determine optimum soil boring and monitoring well placement and depth. DPT soil borings surrounded the perimeter of the lagoons, with the depth of soil sample collection corresponding to the interval just below the base of the lagoons.
Soil	Soil Boring	4	0 - 2 feet	FSA[a]	To determine surface and subsurface soil quality in the upper alluvium at each corner of the lagoons; human health risk to potential residents, site workers, maintenance workers, and trespassers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
		4	8 - 10 feet		
		4	14 - 16 feet		
Soil	Hand Auger	8	0 - 6 inches	FSA	To determine what constituents were present in surface soil on the lagoon banks; the human health risk from soil contaminant exposure to potential residents, site workers, maintenance workers, and trespassers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
Groundwater	DPT	15	Deep Alluvium	VOCs	Screening investigation to determine optimum soil boring and monitoring well placement and depth. DPT groundwater samples surrounded the perimeter of the lagoons.

SWMU 9
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Groundwater	Monitoring Well	4	Deep Alluvium	FSA, less TPH-GRO	To determine groundwater quality in the deep alluvium at each corner of the lagoons; the human health risk from consumption (assuming alluvial groundwater is a drinking water source) to potential residents and site workers.
Sediment	Hand Auger	8	0 - 6 inches	FSA	To determine potential contaminants in lagoon bottom sediments and the risk to aquatic species.
		8	18 - 24 inches		
Sediment	Hand Auger	4	0 - 6 inches	FSA	To determine if contaminants potentially associated with SWMU 9 had affected the sediment in Big Creek Drainage Canal; the risk of exposure to ecological receptors.
		4	18 - 24 inches		
Surface Water	Grab	2	Surface water	FSA, less TPH-GRO	To determine if contaminants potentially associated with SWMU 9 had affected the surface water quality in Big Creek Drainage Canal downstream from the SWMU; the surface water quality upstream of the SWMU; the risk to ecological receptors.
Fish Tissue	Trotline	3	Not applicable	SVOCs, Pesticides/PCBs, Appendix IX Metals, Cyanide	To determine the potential risk to humans and ecological receptors that might consume the fish.

Note:
a — FSA = Full-Scan Analysis. FSA consists of the following Target Compound List parameters: VOCs by SW-846 Method 8240; SVOCs by SW-846 Method 8270; chlorinated pesticides/PCBs by SW-846 Method 8080; organophosphorus pesticides by SW-846 Method 8140; chlorinated herbicides by SW-846 Method 8150; Appendix IX Metals and cyanide by SW-846 Methods 6010, 7060, 7241, 7841, and 9012; and total petroleum hydrocarbons - gasoline- and diesel-range organics (TPH-GRO and TPH-DRO) by the Modified Tennessee SW-846 Method 8015.

SWMU 9 Analytical Results

This discussion presents only those contaminants that exceeded USEPA screening values for soil, groundwater, sediment, and fish tissue; contaminants that were pertinent to the human health risk assessment (HHRA), ecological risk assessment (ERA), and/or fate and transport evaluations; or contaminants attributed to former SWMU 9 operations.

Soil Contaminants: VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides and PCBs, herbicides, and Appendix IX metals were detected in SWMU 9 soil samples. Although the VOC acetone, the SVOC benzo(a)pyrene, the chlorinated pesticide dieldrin, and the inorganics barium and nickel exceeded one or more screening values in a limited number of soil samples, these exceedances did not significantly affect the HHRA, ERA, or fate and transport evaluations.

Groundwater Contaminants: VOCs, SVOCs, TPH-DRO, and Appendix IX metals were detected in RFI groundwater samples. No SVOCs exceeded a screening value. VOCs, TPH-DRO, and Appendix IX metals of interest are summarized below.

VOCs: The chlorinated solvent trichloroethene (TCE) was identified in one deep alluvium DPT groundwater sample (11 μg/L) exceeding its tap water RBC (1.6 μg/L) and MCL (5 μg/L). A second deep alluvium DPT groundwater sample indicated TCE (1.68 μg/L) exceeding only the tap water RBC. TCE was detected in one of four alluvium groundwater monitoring wells, but its concentration did not exceed the tap water RBC or MCL.

TPH-DRO: One of four deep alluvium groundwater wells indicated TPH-DRO (230 μg/L) exceeding the Tennessee Department of Environment and Conservation (TDEC) cleanup standard of 100 μg/L for drinking water.

Inorganics: Arsenic was identified in one deep alluvium groundwater sample (12.2 μg/L) exceeding both its reference concentration (RC, or two times the mean background concentration) (4.2 μg/L) and tap water RBC (0.045 μg/L); however, the detected concentration did not exceed its MCL (50 μg/L).

April/May Groundwater Sampling Event: During the April/May 1997 groundwater sampling event, a duplicate sample from one deep alluvium groundwater sample indicated TCE below its tap water RBC and MCL, and tetrachloroethene (PCE) above its tap water RBC but below its MCL.

Sediment Contaminants: VOCs, SVOCs, TPH, chlorinated pesticides, PCBs, herbicides, and Appendix IX metals were detected in sediment samples from the sewage lagoon and Big Creek Drainage Canal. Sediment contaminants of interest are summarized as follows.

Big Creek Drainage Canal Sediment Contaminants:

Pesticides: USEPA Sediment Screening Values (SSVs) were exceeded for the pesticides 4,4'-DDD, 4,4'-DDT, and dieldrin in Big Creek Drainage Canal surface sediment samples. At one sample location north of SWMU 9, the 4,4'-DDD (140 μg/kg) and 4,4'-DDT (150 μg/kg) concentrations exceeded their SSVs (3.3 μg/kg for both compounds). At a location upstream (northeast) of SWMU 9, dieldrin (3.5 μg/kg) was identified exceeding its SSV (3.3 μg/kg); however, the dieldrin concentration did not exceed the RC for dieldrin in soil at NSA Memphis (262 μg/kg).

Inorganics: Arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, and/or selenium were detected in numerous Big Creek Drainage Canal surface sediment samples. The SSVs exceeded most often are shown below.

Inorganic	Range (mg/kg)	No. Exceedances	SSV (mg/kg)
Arsenic	6.1 - 32	3/4	7.24
Cadmium	1 - 4	3/4	1
Nickel	5.3 - 22.2	2/4	15.9

Sewage Lagoon Sediment Contaminants:

PCBs: The PCB Aroclor-1254 was identified in three surface sediment samples from the sewage lagoons at concentrations ranging from 320 to 950 μg/kg which exceeded the PCB SSV (33 μg/kg).

Inorganics: Arsenic, chromium, copper, lead, mercury, silver, and/or zinc were detected in numerous sewage lagoon sediment samples. The SSVs exceeded most often are shown below.

Inorganic	Range (mg/kg)	No. Exceedances	SSV (mg/kg)
Copper	33.8 - 162	8/8	18.7
Mercury	0.31 - 2.1	6/6	0.13
Silver	1.7 - 21	5/6	2

Surface Water Contaminants: Barium and silver were the only detected analytes in the two surface water samples from Big Creek Drainage Canal. Neither inorganic exceeded its Fresh Water Quality Standard (FWQS), tap water RBC, or MCL.

Fish Tissue Contaminants: One SVOC, two pesticides, two PCBs, and eighteen inorganics were detected in the three composite fish tissue samples collected from the sewage lagoons. 4,4'-DDE, Aroclor-1254, Aroclor-1260, and arsenic concentrations in fish tissue samples exceeded their respective RBCs for fish tissue consumption. The RBC exceedances are summarized as follows:

Analyte	Range	No. Exceedances	RBC (μg/kg)
4,4'-DDE	27 - 88 μg/kg	3/3	9.3 μg/kg
Aroclor-1254	100 - 280 μg/kg	3/3	27 μg/kg
Aroclor-1260	38 - 100 μg/kg	3/3	0.41 μg/kg
Arsenic	0.12 μg/kg	1/3	0.0021 mg/kg

SWMU 9 HHRA

The HHRA estimated the risk and hazard for three land use scenarios: future site residents, future site workers, and current and future site trespassers. The media and exposure pathways included in each scenario are:

Land Use	Media and Exposure Pathway
Future Site Residents	Alluvial Groundwater - Ingestion, Inhalation Fish Ingestion
Future Site Workers	Alluvial Groundwater - Ingestion, Inhalation
Current and future trespassers	Fish Ingestion

The HHRA also evaluated exposure pathways for the hypothetical future construction worker. Although risk was not formally estimated for this scenario, subsurface soil data were screened by comparing detected concentrations to RBCs. No chemicals of potential concern (COPCs) were identified for this scenario, so no risk calculations were performed.

HHRA risk estimates in the following table include media-specific as well as multi-pathway risk estimates. Numbers in **bold** indicate risk or hazard has exceeded USEPA's acceptable risk range or hazard index point of departure.

Summation of Exposure Pathways for SWMU 9

	Future Site Residents			Future Site Workers		Current and Future Site Trespassers		
Medium and Exposure Pathway	Adult HI	Child HI	LWA ILCR	Worker HI	Worker ILCR	Adolescent HI	Child HI	LWA ILCR
Alluvial Groundwater — Ingestion	**1**	**3**	**3e-04**	0.4	6e-05	NA	NA	NA
Alluvial Groundwater — Inhalation	0.05	0.1	2e-06	0.02	5e-07	NA	NA	NA
Sum of Groundwater	***1***	***3***	***3e-04***	***0.4***	***6e-05***	***NA***	***NA***	***3e-08***
Fish Tissue: East Lagoon — Ingestion	**3.7**	**17.3**	**2e-04**	NA	NA	**2.3**	**6.9**	6e-05
Fish Tissue: West Lagoon — Ingestion	**3**	**14**	**4e-04**	NA	NA	**1.8**	**5.6**	**1.1e-04**

Notes:
HI — Hazard Index
ILCR — Incremental Lifetime Cancer Risk
NA — Not Applicable
LWA — Lifetime Weighted Average

Identification of COCs was based on the multi-pathway risk and hazard exceedances provided in the table above. COCs are listed in the following box for each land use scenario, separated on a medium-specific basis.

Land Use	Medium Exposure Pathway	COC
Future Site Residents	Alluvial groundwater ingestion	Arsenic, Chloroform, TCE
	Fish ingestion - East Lagoon	4,4'-DDE, Aroclor-1254, Aroclor-1260
	Fish ingestion - West Lagoon	4,4'-DDE, Aroclor-1254, Aroclor-1260, Arsenic
Future Site Trespassers	Fish ingestion - East Lagoon	4,4'-DDE, Aroclor-1254, Aroclor-1260
	Fish ingestion - West Lagoon	4,4'-DDE, Aroclor-1254, Aroclor-1260, Arsenic

SWMU 9 ERA

According to the conclusions in the ERA, no lethal or sublethal effects were predicted for terrestrial wildlife species at SWMU 9, except for the short-tailed shrew. Aroclor-1260 produced a sublethal Hazard Quotient (HQ) of 1.35, which contributed to the cumulative Hazard Index (HI) of 1.62 for this species (the risk threshold for lethal effects is 10). The dietary exposure model for fish tissue consumption by the belted kingfisher predicted a limited risk from pesticide contamination. The sublethal HI was 4.5, indicating some risk to piscivorus birds. In addition, no impacts to aquatic species from contamination present in lagoon sediment or Big Creek Drainage Canal are predicted.

SWMU 9 Fate and Transport Assessment

In the fate and transport discussion, the soil-to-groundwater and soil-to-sediment cross-media transport mechanisms were evaluated. SWMU 9 contaminants that exceeded their soil-to-groundwater SSLs or contaminants identified as COCs in the HHRA were assessed to determine their transport potential. The assessment identified acetone, dieldrin, barium, and nickel as the SWMU 9 contaminants exhibiting the potential for soil-to-groundwater transport, and identified acetone and dieldrin as exhibiting the potential for soil-to-sediment transport.

The fate and transport assessment concluded that widespread impact to the alluvial aquifer by acetone is not expected, because this compound was detected only in soil samples. Furthermore,

acetone was not detected in SWMU 9 groundwater during the April 1996 sampling event. Dieldrin, also detected only in soil, is expected to be immobile and persistent in the environment, not readily diffusing to groundwater. Dieldrin was absent in SWMU 9 groundwater samples collected during the April 1996 sampling event. Widespread impact to alluvial groundwater by barium and nickel are not expected, based on the relative immobility of these constituents.

SWMU 9 Recommendations

- Based on previous detections in DPT and monitoring well samples, conduct annual sampling and analysis of all SWMU 9 monitoring wells for VOCs, TPH-GRO, and TPH-DRO to verify the presence of these contaminants and determine whether their concentrations are increasing.

- Continue the ban on fishing at the lagoons.

- Assess the TCE in SWMU 9 groundwater during the SWMU 2 investigation.

SWMU 14 Summary

Site Description and History

SWMU 14, a flat, grass-covered area on the NSA Memphis Southside, is the former site of Building S-140, several related former buildings and structures, and the Seventh Avenue and Polaris Drive drainage ditches west and south of the site, respectively. The grass covering SWMU 14 is regularly mowed to maintain lawn-like conditions. According to engineering plans of the building obtained from Public Works, four smaller structures were associated with Building S-140: a gear locker (Building S-275), a mobile building along the eastern edge of the site (Building S-1602), a prefabricated metal storage building southeast of Building S-140 used as a paint locker (Building S-351), and SWMU 46, a hazardous waste accumulation point northeast of the building. Building S-140 was demolished along with all associated structures in 1985.

Building S-140 housed a paint spray booth, paint removing area, and paint wash down area, associated with training Navy personnel in various painting-related processes from 1943

until 1985. According to building diagrams, two drainage systems were associated with painting activities at Building S-140. One was in the central portion of the building near the paint spray booths and water wash pits; the other was in the northern portion near the interior wash down area and work table. Navy records indicate paint-related wastes generated by the paint spray booth and water wash pits collected in two floor drains which emptied into two 1,885-gallon sump pits. Paint waste and sludge from these sumps were most likely removed as-needed, and any overflow was discharged directly to the Seventh Avenue ditch until 1980. After 1980, the flow from the paint booth and wash down area was redirected to a paint separator/sump in the building's mechanical room, while overflow was discharged to the sanitary sewer.

The paint waste and sludge likely contained chromium, lead, and various hydrocarbons and paint solvents including mineral spirits, toluene, and phenols. Wastes generated by the paint wash down area and work tables were discharged to an unidentified drain line exiting the building's east side. In 1968, these wastes were diverted to an interceptor/separator installed beneath the north end of a sidewalk immediately east of the building. According to construction diagrams, this interceptor was 3.5 x 5 feet across with the deepest portion of the bottom 4.5 feet below land surface (bls). Discharge from the interceptor was directed to the sanitary sewer line to the north.

A former outdoor wash basin adjacent to Building S-140's south side consisted of a 36 x 40-foot concrete slab surrounded by a 6-inch berm. According to sewer modification diagrams, the drain in this basin discharged to the Polaris Drive drainage ditch south of SWMU 14 until it was diverted to the sanitary sewer in 1980. A small discharge pipe still visible in the Polaris Drive ditch has been included in the SWMU 14 RFI.

In July 1995, E/A&H geophysically surveyed SWMU 14 in an attempt to verify the approximate location of the former building and subsurface structures. Geophysical anomalies due to disturbed soil or metal objects were plotted on a map, and proposed sample locations were chosen after results were reviewed. The geophysical survey showed one moderate anomaly at SWMU 14 near the former location of the outdoor wash basin. The remainder of the surveyed area was anomaly-free, indicating the sumps and separators may have been removed during building

demolition. A linear feature along the site's eastern survey boundary may be an abandoned potable water line that supplied water to the adjacent property when it was a trailer park.

SWMU 14 Sampling Rationale

The SWMU 14 RFI consisted of collecting and analyzing soil, groundwater, and ditch sediment samples. The sampling methods, intervals, analyses, and rationale are provided in the following table.

SWMU 14
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Soil	DPT	11	5 - 7 feet	VOCs	Screening investigation to determine optimum soil boring and monitoring well placement and depth. VOCs chosen as the indicator parameter because of the known usage of solvents. The screening investigation focused on the location of the former waste-receiving interceptor/ separator and its associated piping on Building S-140's northeast corner.
		3	11 - 13 feet		
Soil	Soil Borings	8	0.5 - 2 feet	FSA	To determine surface and subsurface soil quality in the loess in the SWMU 14 vicinity; to provide a geologic cross section of loess and fluvial deposits; to determine human health risk to potential site residents and site workers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
		8	4 - 6 feet		
		8	8 - 10 feet		
Soil	Hand auger	2	0 - 6 inches	FSA	To determine the surface and subsurface soil quality near the outfall in the Polaris Drive ditch; human health risk to potential site residents and site workers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
		2	18 - 24 inches		
Groundwater	DPT	9	Loess	VOCs	Screening investigation to determine optimum soil boring and well placement. VOCs chosen as the indicator parameter because of the known usage of solvents at SWMU 14.
		9	Upper Fluvial Deposits		
Groundwater	Monitoring Wells	5	Loess	FSA, less TPH-GRO	To determine the nature and extent of chlorinated solvents identified in groundwater during the DPT investigation; to determine the human health risk to potential site residents and workers due to inhalation or ingestion of groundwater, assuming loess and fluvial deposits groundwater is used as a drinking water source; to determine the risk to ecological receptors.
		4	Lower Fluvial Deposits		
Sediment	Hand Auger	2	0 - 6 inches	FSA	To determine the presence of any residual contaminants in Seventh Avenue drainage ditch sediment associated with past operations; the human health risk to potential site residents and workers and adolescent trespassers; the ecological risk to terrestrial species.
		2	18 - 24 inches		

SWMU 14 Analytical Results

This discussion presents only those contaminants that exceeded USEPA screening values for soil, groundwater, and sediment; contaminants that were pertinent to the HHRA, ERA, and/or fate and transport evaluations; or contaminants attributed to former SWMU 14 operations.

Soil Contaminants: The VOC acetone, the SVOCs benzo(a)pyrene and dibenz(a,h)anthracene, the pesticides aldrin and dieldrin, and the inorganics barium and nickel exceeded one or more screening values in a limited number of soil samples. However, these exceedances did not significantly affect the HHRA, ERA, or fate and transport evaluations; nor were they definitively attributed to former operations at SWMU 9. The VOCs TCE and PCE were detected in surface and subsurface soil samples at one location near the former interceptor/separator at concentrations below their residential soil RBCs; however, these contaminants were also detected in loess groundwater samples from the same locations at concentrations that exceeded both the tap-water RBC and MCL. The fate and transport evaluation concluded these VOCs are relatively mobile and likely to be transported from soil to groundwater; however, once in groundwater, they are expected to attenuate rather quickly. Detected concentrations of TCE and PCE in soil were:

VOC	Concentration (μg/kg)	Interval (feet bls)
TCE	3	4 - 6
	19	8 - 10
PCE	2	0 - 2
	8	4 - 6
	23	8 - 10

Groundwater Contaminants: VOCs, SVOCs, TPH, and Appendix IX metals were detected in groundwater samples collected during the RFI. No SVOC concentration exceeded a screening value. Exceedances of concern for VOCs, TPH, and Appendix IX metals were:

VOCs: The highest TCE and PCE concentrations were detected near the former interceptor/separator on the northeast corner of former building S-140. TCE

concentrations exceeded its tap water RBC (1.6 μg/L) and/or MCL (5 μg/L) in six loess DPT groundwater samples, two upper fluvial deposits DPT groundwater samples, and in one loess monitoring well. Detected concentrations ranged from 3.09 to 285 μg/L. PCE concentrations exceeded its tap water RBC (1.1 μg/L) and MCL (5 μg/L) in one loess DPT groundwater sample (230 μg/L) and in one loess monitoring well (150 μg/L). Benzene was identified in one fluvial deposits groundwater sample submitted for confirmation analysis above its tap water RBC (0.36 μg/L).

Inorganics: Arsenic was identified above its RC (3.5 μg/L) and tap-water RBC (0.045 μg/L), but not above its MCL (50 μg/L), in groundwater samples from two lower fluvial deposits monitoring wells (3.6 and 3.9 μg/L). Barium was identified above its RC (232 μg/L), but not its tap-water RBC (2,600 μg/L) or MCL (2,000 μg/L), in groundwater samples from all four lower fluvial deposits monitoring wells (concentration range 422 to 638 μg/L). Vanadium was identified above its RC (17.4 μg/L), but not its tap-water RBC (260 μg/L), in one lower fluvial deposits groundwater sample (54 μg/L).

April/May 1997 Groundwater Sampling Event: Groundwater samples were collected from five loess and four lower fluvial deposits groundwater monitoring wells at SWMU 14 and analyzed for VOCs, TPH, TPH-DRO, and TPH-GRO. Exceedances of applicable standards were as follows: TCE's tap water RBC and MCL were exceeded by one loess groundwater sample; PCE's tap water RBC and MCL were exceeded by one loess groundwater sample; and TPH, TPH-GRO, and/or TPH-DRO concentrations in three loess groundwater samples and two lower fluvial deposits samples exceeded the TDEC groundwater cleanup level for total TPH in drinking water aquifers.

Sediment Contaminants: SVOCs, TPH, chlorinated pesticides, herbicides, and Appendix IX metals were detected in one or more Seventh Avenue drainage ditch sediment samples. The detected concentrations were compared to both sediment and soil screening values, because the sediment sample locations are only intermittently submerged. No TPH or herbicide concentrations

exceeded a screening value. SVOC, pesticide, and Appendix IX metals exceedances of concern are briefly discussed below.

SVOCs: Five SVOCs in surface sediment — benzo(a)pyrene, BEHP, chrysene, fluoranthene, and pyrene — exceeded residential soil RBCs or soil-to-groundwater SSLs. With the exception of BEHP, these SVOCs are typical constituents of vehicle emissions and asphalt road materials; therefore, their presence in the Seventh Avenue ditch may be a result of runoff from Seventh Avenue during rain events. The detected SVOC concentrations are similar to those found in SWMU 38 Southside drainage ditch sediment samples along Seventh Avenue.

Pesticides: Four pesticides — 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin — exceeded their SSVs and/or soil-to-groundwater SSLs. These pesticides were routinely applied for pest control throughout NSA Memphis; therefore, they cannot definitively be attributed to former SWMU 14 operations. Concentrations were similar to those detected in SWMU 38 drainage ditch sediment samples throughout the Southside, with the exception of 4,4'-DDT (1,900 μg/kg) in one surface sediment sample, which exceeded both its SSV (3.3 μg/kg) and soil-to-groundwater SSL (1,000 μg/kg).

Inorganics: Arsenic, copper, lead, and nickel exceeded their SSVs in one or both sediment intervals. The detected concentrations were similar to those identified in SWMU 38 drainage ditch sediment samples throughout the Southside.

SWMU 14 HHRA

The HHRA evaluated exposure for four land use scenarios: future site residents, current and future site workers, current and future maintenance workers, and current and future site trespassers. The media and exposure pathways included in each scenario are:

Land Use	Media and Exposure Pathway
Future Site Residents	Soil - Incidental Ingestion, Dermal Contact Loess Groundwater - Ingestion, Inhalation of VOCs Fluvial Deposits Groundwater - Ingestion, Inhalation
Current and Future Site Workers	Soil - Incidental Ingestion, Dermal Contact Sediment - Incidental Ingestion, Dermal Contact Loess Groundwater - Ingestion, Inhalation of VOCs Fluvial Deposits Groundwater - Ingestion, Inhalation
Current and Future Maintenance Workers	Sediment - Incidental Ingestion, Dermal Contact
Current and Future Trespassers	Sediment - Incidental Ingestion, Dermal Contact

The HHRA also evaluated exposure pathways for the hypothetical future construction worker. Although risk was not formally estimated for this scenario, subsurface soil data were screened by comparing detected concentrations to RBCs. No COPCs were identified for this scenario, so no risk calculations were performed. HHRA risk estimates in the following table include media-specific as well as multi-pathway risk estimates. Numbers in **bold** indicate risk or hazard has exceeded USEPA's acceptable risk range or hazard index point of departure.

Summation of Exposure Pathways for SWMU 14

	Future Site Residents			Current and Future Site Workers		Current and Future Maintenance Workers		Current and Future Site Trespassers	
Medium and Exposure Pathway	Adult HI	Child HI	LWA ILCR	Worker HI	Worker ILCR	Worker HI	Worker ILCR	Adult HI	Adult ILCR
Soil — Incidental Ingestion	NA	NA	5e-06	NA	5e-07	NA	NA	NA	NA
Soil — Dermal Contact	NA	NA	2e-06	NA	8e-07	NA	NA	NA	NA
Sum of Soil	*NA*	*NA*	*7e-06*	*NA*	*1e-06*	*NA*	*NA*	*NA*	*NA*
Sediment — Incidental Ingestion	NA	NA	NA	0.01	2e-06	0.002	5e-07	0.007	6e-07
Sediment — Dermal Contact	NA	NA	NA	0.004	1e-06	0.0009	3e-07	0.001	2e-07
Sum of Sediment	*NA*	*NA*	*NA*	*0.01*	*3e-06*	*0.003*	*8e-07*	*0.008*	*8e-07*
Loess Groundwater — Ingestion	2	5	**2e-04**	0.7	5e-05	NA	NA	NA	NA
Loess Groundwater — Inhalation of	2	5	3e-05	0.7	8e-06	NA	NA	NA	NA

Summation of Exposure Pathways for SWMU 14

Medium and Exposure Pathway	Future Site Residents			Current and Future Site Workers		Current and Future Maintenance Workers		Current and Future Site Trespassers	
	Adult HI	Child HI	LWA ILCR	Worker HI	Worker ILCR	Worker HI	Worker ILCR	Adult HI	Adult ILCR
Sum of Loess Groundwater	*4*	*10*	*2e-04*	*1.4*	*6e-05*	*NA*	*NA*	*NA*	*NA*
Sum of Soil, Sediment, and Loess	*4*	*10*	*2e-04*	*1.4*	*6e-05*	*0.003*	*8e-07*	*0.008*	*8e-07*
Fluvial Deposits Groundwater - Ingestion	0.9	2	9e-05	0.3	2e-05	NA	NA	NA	NA
Fluvial Deposits Groundwater - Inh.	0.1	0.2	3e-06	0.04	6e-07	NA	NA	NA	NA
Sum Of Fluvial Deposits Groundwater	*1.0*	*2*	*9e-05*	*.0.3*	*2e-05*	*NA*	*NA*	*NA*	*NA*
Sum of Soil, Sediment, and Fluvial	*1.0*	*2*	*9.7e-05*	*0.3*	*2e-05*	*0.003*	*8e-07*	*0.008*	*8e-07*

Notes:
ILCR — Incremental lifetime excess cancer risk
HI — Hazard Index
NA — Not applicable
LWA — Lifetime weighted average

Identification of COCs was based on the multi-pathway risk and hazard estimate exceedances provided on the table above. COCs were identified only for the future site resident scenario, as shown in the following box.

Land Use	Exposure Pathway	COC
Future Site Residents	Loess groundwater ingestion and inhalation Fluvial deposits groundwater ingestion	1,2-DCE,TCE, PCE Arsenic, Barium, Benzene, Vanadium

SWMU 14 ERA

The ERA determined that no quality habitat is available at SWMU 14, which has no viable terrestrial community. According to the ERA conclusions, exposure risk to terrestrial species near SWMU 14 is low compared to the potential for effects to lower-level infaunal species. However, biotransfer of contaminants up the food chain should not be a concern because contaminant concentrations are not at levels indicative of accumulation. In addition, the low soil concentrations

and limited contaminant distribution limits the incidental ingestion risk to acceptable concentrations for bird species that might forage in the area.

SWMU 14 Fate and Transport Evaluation

In the fate and transport discussion, the soil-to-groundwater and soil-to sediment cross-media transport mechanisms were evaluated. TCE and PCE, detected in both soil and groundwater samples, are relatively mobile due to their high solubility and vapor pressure; however, they are expected to attenuate rather quickly. Aldrin and dieldrin, detected in soil only, are expected to be immobile and not likely to diffuse to groundwater due to their physical and chemical properties. The portion of the Seventh Avenue drainage ditch west of SWMU 14 is part of a larger system — the SWMU 38 Southside drainage ditches. Therefore, the SVOCs, pesticides, and inorganics detected in both soil and sediment samples cannot be attributed solely to SWMU 14 activities. Most of the SVOCs in Seventh Avenue drainage ditch sediment are typical constituents of vehicle emissions and asphalt road materials, both of which may emanate from Seventh Avenue, the main street of the NSA Memphis Southside.

SWMU 14 Recommendations

- Remediation of PCE and TCE in loess groundwater should be evaluated in a Corrective Measures Study. At a minimum, all site monitoring wells should be analyzed for VOCs on an annual basis and for remedial design parameters, including those needed to evaluate natural attenuation.

SWMU 38 Summary

SWMU 38 is the Miscellaneous Ditches in Industrial Areas at NSA Memphis. Only the ditches on the Southside of NSA Memphis were studied during the Assembly E RFI; the Northside ditches were investigated in 1995 during the Assembly B RFI. In general, the Southside drainage ditches slope downward 1% to 3% to the west, eventually draining into Big Creek Drainage Canal in the southwest corner of NSA Memphis. Water levels in the ditches may vary as much as several feet during storms. Southside drainage ditches receive influent from surface runoff and storm sewers, and formerly received wastewater discharges from floor drains in industrial buildings on the

NSA Memphis Southside. The original design of many buildings at NSA Memphis (circa 1943) included floor drains which discharged to storm sewers, storm sewer drains, and drainage ditches. As buildings were remodeled and replaced, these drains were eliminated or re-routed to the sanitary sewer. Until 1980, when most of these drains were replaced, it is reported that various substances, including solvents, degreasers, oils, and paints, may have been discharged to the drainage ditches. Most wastes entering the drainage ditches would have been transported downstream with flow; however, due to their relative immobility, contaminants such as metals can potentially accumulate in soil and sediments near outfalls and in areas of low flow.

SWMU 38 Sampling Rationale

The SWMU 38 RFI consisted of collecting sediment samples as summarized in the following table.

SWMU 38
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Sediment	Hand auger	16	0 - 6 inches	FSA	Results were used to determine the following: the nature and extent of contamination in the drainage ditch sediments; human health risk to potential maintenance workers, site workers, and adolescent trespassers; ecological risk to aquatic and terrestrial species; and the migration potential for soil constituents to sediment or groundwater.
		2	0 - 6 inches	PCBs only	
		16	18 - 24 inches	FSA	
Sediment	Hand auger/ grab samples	9	0 - 6 inches	PCBs (EnSys Ris^{g} Screening System)	To characterize the nature and extent of PCBs in the western perimeter ditch area.

SWMU 38 Analytical Results

SWMU 38 sediment samples contained VOCs, SVOCs, TPH, pesticides, PCBs, herbicides, and inorganics; however, no VOCs, TPH, or herbicides were at concentrations exceeding screening values. Seven SVOCs, six pesticides, one PCB, and six inorganics exceeded screening values. Most exceedances did not affect the outcome of the HHRA, ERA, or fate and transport evaluation; however, several specific areas of the drainage ditches had multiple exceedances. Exceedances of concern are summarized below.

SVOCs: Benzo(a)anthracene, benzo(a)pyrene, BEHP, chrysene, fluoranthene, phenanthrene, and pyrene exceeded one or more screening values in a limited number of samples. Except for BEHP, these SVOCs are common constituents of vehicle emissions and asphalt road materials. Nearly all of the SVOC exceedances were in the portions of the drainage ditches along main roads on the Southside (Seventh Avenue, First Avenue, B Street). Therefore, their presence may be the result of runoff from these adjacent roadways during rain events rather than former industrial wastewater discharge.

Pesticides: Aldrin, DDT and its degradation products DDE and DDD, dieldrin, and endrin exceeded one or more screening values. Exceedances were most frequent for dieldrin, DDT, DDD, and DDE. Dieldrin and DDT were routinely applied throughout NSA Memphis for pest control, and were likely transported to the drainage system in site runoff during precipitation events. These pesticides were detected more frequently and at higher concentrations in the upstream portion of the west leg of the drainage ditches (i.e., the northwest side of the Southside). The degradation products of DDT were more common, but detected in lower concentrations, in downstream portions of the drainage ditches (i.e., toward the southwest portion of the Southside where SWMU 38 discharges to Big Creek Drainage Canal). The portion of the drainage ditches near Building S-335 (SWMU 59, Old Pesticide Shop) did not exhibit higher concentration of pesticides than other areas of the drainage ditches.

PCBs: Aroclor-1260 exceeded its SSV (33 μg/kg) in five surface sediment samples; one of these samples also exceeded the residential soil RBC (320 μg/kg). Detected concentrations, ranging from 34 to 1,900 μg/kg, were confined to the western portion of the SWMU 38 drainage ditch, between Navy Road and the Seabee compound on the southwest corner of NSA Memphis. Aroclor-1260 was not present in the most downgradient sediment sample (between the Seabee compound and the outfall to Big Creek Drainage Canal).

Inorganics: Several inorganics exceeding screening values were detected throughout the SWMU 38 drainage ditches. Arsenic, cadmium, and nickel were the inorganics detected most frequently at concentrations exceeding screening values. Most inorganic concentrations were similar to their background RC. However, the inorganics copper and nickel were detected in the south-central portion of the ditches at concentrations much higher than detected elsewhere. At one location, the surface sediment copper and nickel concentrations were 2,250 mg/kg and 2,240 mg/kg, which exceeded their SSVs (18.7 mg/kg and 15.9 mg/kg, respectively). The nickel concentration at this location also exceeded its RC (20.62 mg/kg), residential RBC (1,600 mg/kg), and SSL (21 mg/kg). At a nearby location, a subsurface sediment sample contained 2,160 mg/kg copper and 2,110 mg/kg nickel; both analytes exceeded their respective SSVs, and nickel exceeded its SSL. These two locations are near Buildings S-394 and S-197, a mechanical maintenance shop and battery storage shed. Additional sediment samples were collected from these two same areas and upstream and downstream of the areas. The re-sampling of these areas could not duplicate the elevated copper and/or nickel concentrations, so the original values were considered inaccurate and were not used during the assessment of SWMU 38.

SWMU 38 HHRA

The HHRA evaluated exposure for two land use scenarios: current and future maintenance workers and future adolescent trespassers. The media and exposure pathways included in each scenario are:

Land Use	Media and Exposure Pathway
Current and Future Maintenance Workers	Sediment - Incidental Ingestion, Dermal Contact
Current and Future Adolescent Trespassers	Sediment - Incidental Ingestion, Dermal Contact

Sediment samples were collected throughout the NSA Memphis Southside. For the purposes of the RFI, each sediment sample represented a specific area of the drainage ditch system; therefore, each was assessed independently in the HHRA. Estimated risk and hazard for each land use scenario for each sediment sample did not exceed USEPA's acceptable risk range or hazard index point of departure; consequently, no COCs were identified. Based on the HHRA, the property consisting of the Southside Industrial Drainage Ditches is considered suitable for use, assuming exposure to sediment would be limited to the land use scenarios evaluated in the HHRA.

SWMU 38 ERA

The ERA concluded that although some contaminant concentrations in the ditches exceeded SSV values, the lack of suitable habitat for sediment- or surface-water-dwelling organisms limits the exposure potential. The habitat and biota survey indicated the ditches do not have sufficient annual water flow to support year-round aquatic life; water in the ditches appears to flow only in immediate response to precipitation. Most of the ditches have a cement or hard clay-sediment bottom; these substrates do not provide the cover and/or food requirements for aquatic organisms. NSA Memphis groundskeeping personnel regularly conduct devegetation and flow maintenance in the ditches, which further limits their ability to support wildlife. The ERA recommended no further ecological study be conducted at SWMU 38.

SWMU 38 Fate and Transport Evaluation

Contaminant fate and transport was evaluated to assess the potential for contaminant migration in sediment. The migration pathway for constituents detected at SWMU 38 is predominantly soil to sediment by transport within drainage ditches during rainfall which results in high water levels. The soil-to-groundwater migration pathway is mitigated by the fact that contaminants in surface sediment are migrating with the flow of water during drainage, limiting the potential for leaching through the soil column to groundwater. Due to the relative immobility of the contaminants, most residual contamination is likely concentrated nearest the outfalls.

SWMU 38 Recommendations

- No further action is recommended for SWMU 38.

SWMU 59 Summary

Site Description and History

SWMU 59 consists of Building S-335, the Pesticide Storage Facility (commonly referred to as the Old Pesticide Shop). Building S-335, a wood-framed, sheet-metal exterior structure, stored pesticides and fertilizers used throughout NSA Memphis. A small grassy area adjacent to the north, east, and south sides of the building separates it from First Avenue on the east, while an asphalt parking lot is north, west, and south of Building S-335. The SWMU 59 area slopes gently to the east, with runoff flowing toward a storm drain northeast of the building in the grassy area. This storm drain conveys the water southeast under First Street to an outfall in the SWMU 38 secondary drainage ditch along the east side of First Street. SWMU 38 then conveys runoff approximately 1,800 feet south to Big Creek Drainage Canal. Any storm water runoff which does not enter the storm drain northeast of the building would move across the parking lot as sheet flow to First Street, where it would travel south to Big Creek Drainage Canal. The exact age of Building S-335 is unknown, although it is estimated to be approximately 40 years old. Pesticides reportedly stored at the building included chlordane, dieldrin, and DDT, and arsenic, a common component of early pesticide formulations. SWMU 59 was flooded in 1974 and 1987. Water marks from flooding are present on the walls inside the building approximately 2.5 feet above the floor.

In 1990, an investigation was conducted at SWMU 59 because the Navy planned to demolish Building S-335 and needed to generate data for project planning issues, including worker health and safety and demolition waste disposal. The investigation consisted of collecting 16 shallow soil samples from eight boring locations (SS1 to SS8) surrounding Building S-335 and 30 wipe samples from the building's interior surfaces. Hand auger soil samples were collected from 0 to 1 foot bls (upper interval) and 1 to 2 feet bls (lower interval) at all eight boring locations. The soil samples and wipe samples were specifically analyzed for chlordane, DDT and related isomers, dieldrin, and arsenic.

Chlorinated pesticides and arsenic were identified in shallow (0 to 2 feet bls) soil surrounding the building and on surfaces inside the building. The primary contaminant identified during the 1990

investigation was chlordane, identified in all eight upper interval soil samples at concentrations ranging from 801 to 279,719 μg/kg. The chlordane concentration in six samples exceeded the residential soil RBC (1,825 μg/kg), and the concentration in two of the samples exceeded the industrial soil RBC (16,352 μg/kg). Additionally, the soil-to-groundwater SSL for chlordane (2,000 μg/kg) was exceeded in six of the upper interval samples and two lower interval samples.

SWMU 59 RFI Sampling Rationale

During the SWMU 59 RFI, soil and groundwater samples were collected throughout SWMU 59 as outlined in the following table:

SWMU 59
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Soil	DPT	10 10 10	0 - 2 feet 3 - 5 feet 9 - 11 feet	VOCs, Pesticides/PCBs	Screening investigation which focused on the area surrounding Building S-335 and analyzed for chlorinated pesticides/PCBs and VOCs. Results were used to determine the following: the optimum soil boring and monitoring well placement and depth; the human health risk to potential residents and site workers; the ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
Soil	Soil Boring	3 3 3	0 - 2 feet * 4 - 8 feet * 10 - 12 feet	FSA	Results were used to determine the following: surface and subsurface soil quality in the loess upgradient, downgradient, and near Building S-335; human health risk to potential residents and site workers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
Soil	Hand Auger	2	0 - 6 inches	FSA	Results were used to determine the following: constituents in surface soil in the grassy area next to Building S-335, where the highest pesticide concentrations were detected during the 1990 RFI; the human health risk to potential residents and site workers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
Groundwater	DPT	1	Upper Fluvial Deposits	VOCs	Screening investigation to determine if VOCs from pesticide carriers (such as xylene) were present in the area of highest pesticide contamination in soil. Due to the limited sample volume collected with the DPT sampler, the sample was not analyzed for pesticides.

SWMU 59
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Groundwater	Monitoring Wells	3	Loess	FSA, less TPH-GRO	Loess monitoring well results were used to determine groundwater quality upgradient, downgradient, and in the area of highest pesticide contamination detected during the DPT screening investigation. Upper fluvial deposits monitoring well results were used to determine groundwater quality in this aquifer downgradient of Building S-335. The groundwater results were also used to determine the human health risk to potential residents and site workers from ingestion, assuming the loess or fluvial deposits groundwater is used as a drinking water source.
		1	Upper Fluvial Deposits		
Sediment	Hand Auger	1	0 - 6 inches	Full-Scan Analysis	This sample was collected during the SWMU 38 investigation; due to its proximity to SWMU 59, its results were incorporated in the SWMU 59 RFI. The sample was collected from an outfall in the SWMU 38 drainage ditch which leads from a storm drain in the grassy area adjacent to Building S-335.
		1	18 - 24 inches		

Note:
* — These are general sampling intervals; surface soil samples from two of the soil borings were exclusive of asphalt; yielding a surface soil interval of 1 to 2 feet bls. The intermediate soil interval was 4 to 6 feet bls in two of three loess soil borings; in the third, it was 6 to 8 feet bls due to poor sample recovery in the 4- to 6-foot interval.

SWMU 59 RFI Analytical Results

This discussion presents only those contaminants that exceeded screening values; significantly affected the results of the HHRA, ERA, and fate and transport assessments; or contaminants that were obviously the result of SWMU 59 operations.

Soil Contaminants: VOCs, SVOCs, TPH, chlorinated pesticides, PCBs, herbicides, and Appendix IX metals were detected in RFI soil samples. Soil samples from under the asphalt-paved areas did not indicate significant screening value exceedances, while soil samples from the grassy area indicated numerous significant exceedances, as described below.

SVOCs: Surface soil samples from the grassy area indicated several SVOCs above their screening values. The SVOCs identified in the grassy area, their maximum concentration detected, and the applicable screening value exceeded are as follows: benzo(a)anthracene (760 μg/kg) above its SSL (700 μg/kg); benzo(a)pyrene (950 μg/kg) above its residential RBC (88 μg/kg); benzo(b)fluoranthene (1,200 μg/kg) above its residential RBC (880 μg/kg); chrysene (1,200 μg/kg)

above its SSL (1,000 μg/kg); and pentachlorophenol (2,600 μg/kg) above its SSL (200 μg/kg).

Pesticides: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, alpha-chlordane, gamma-chlordane, technical chlordane, dieldrin, heptachlor, and heptachlor epoxide, were indicated in surface and/or subsurface soil samples exceeding screening values. Several pesticides were at concentrations significantly exceeding their screening values, including surface soil samples from the grassy area which indicated maximum concentrations of technical chlordane (52,000 μg/kg), alpha-chlordane (6,500 μg/kg), and gamma-chlordane (8,800 μg/kg), which were above chlordane's residential RBC (1,825 μg/kg), industrial RBC (16,352 μg/kg), and/or SSL (2,000 μg/kg).

PCBs: Aroclor-1260 was the only PCB detected in surface soil. Its detected concentration (5,400 μg/kg) in a sample from the grassy area exceeded both the residential and industrial RBCs (320 μg/kg and 2,850 μg/kg, respectively).

Inorganics: The only inorganics in SWMU 59 soil samples that exceeded both their RCs and RBCs or SSLs were arsenic, lead, and nickel. Arsenic's surface soil RC (14.58 mg/kg), residential RBC (0.43 mg/kg), industrial RBC (3.8 mg/kg), and SSL (15 mg/kg) all were exceeded in two surface soil samples from the grassy area (15.3 mg/kg and 27 mg/kg). Lead, which has no RBC or SSL, was compared to its surface soil RC (26.03 mg/kg) and the USEPA residential and industrial soil cleanup goals of 400 mg/kg and 1,300 mg/kg. Concentrations of lead in two surface soil samples from the grassy area (625 mg/kg and 521 mg/kg) exceeded both the surface soil RC and the USEPA residential soil cleanup goal. Nickel's subsurface RC (non-detect) and SSL (21 mg/kg) were both exceeded in a 10- to 12-foot bls soil sample from the grassy area (27.8 mg/kg).

Groundwater Contaminants: VOCs, SVOCs, TPH-DRO, pesticides, and Appendix IX metals were detected in SWMU 59 groundwater samples. No VOCs, SVOCs, or total TPH concentration in groundwater exceeded a screening value. Significant exceedances of screening values are described below.

Pesticides: The loess monitoring well in the grassy area indicated the presence of the following pesticides at concentrations which exceeded their respective tap-water RBCs, but not their MCLs: technical chlordane (1.1 μg/L), dieldrin (0.052 μg/L), heptachlor (0.069 μg/L), and heptachlor epoxide (0.19 μg/L). The corresponding tap-water RBCs are as follows: chlordane (0.192 μg/L), dieldrin (0.0042 μg/L), heptachlor (0.0023 μg/L), and heptachlor epoxide (0.0012 μg/L).

Inorganics: Two loess monitoring well samples indicated lead concentrations (18 and 30.6 μg/L) exceeding its loess groundwater RC (17.5 μg/L) and the USEPA treatment technique action level for lead (15 μg/L). Although barium and vanadium did not exceed their tap-water RBCs (2,600 μg/L and 260 μg/L) or MCLs (2,000 μg/L for barium; no MCL is available for vanadium), detected concentrations in loess groundwater exceeded loess background RCs. The loess groundwater RC for barium (442 μg/L) was exceeded in two loess groundwater samples (445 and 463 μg/L) and the loess groundwater RC for vanadium (40.3 μg/L) was exceeded in one loess groundwater sample (46.8 μg/L).

April/May 1997 Groundwater Sampling Event: The three loess and one upper fluvial deposits groundwater monitoring wells installed at SWMU 59 were sampled and analyzed for chlorinated pesticides/PCBs and VOCs. The only VOC identified was methylene chloride in one loess well and the concentration was below both its tap water RBC and MCL. Dieldrin was identified in one loess well above its tap water RBC. Heptachlor epoxide was identified in the same loess well as the dieldrin detection and it was above its tap water RBC, but below its MCL. No MCL is available for dieldrin.

Sediment Contaminants: As part of the SWMU 38 (Southside Drainage Ditches) RFI, surface and subsurface sediment samples were collected from a location southeast of SWMU 59 near the outfall of the underground storm sewer line leading from the grassy area adjacent to Building S-335 to the SWMU 38 secondary drainage ditch. The surface sediment sample indicated concentrations of the pesticides 4,4'-DDD (56 μg/kg) and 4,4'-DDE (23 μg/kg) exceeding their SSV (3.3 μg/kg for both compounds), the PCB Aroclor-1260 (290 μg/kg) exceeding its SSV (33 μg/kg), and the inorganics cadmium (5.3 mg/kg), copper (27.1 mg/kg), lead (39.4 mg/kg), and nickel (17.5 mg/kg) exceeding their SSVs (1 mg/kg, 18.7 mg/kg, 30.2 mg/kg, and 15.7 mg/kg, respectively). No organic or inorganic contaminant in the surface sediment sample exceeded both its residential RBC or SSL and its RC for surface soil, where applicable. No organic or inorganic contaminant in the subsurface sediment sample exceeded both its SSL and RC for subsurface soil. Note that other sediment samples from the SWMU 38 drainage ditches upgradient (north) of SWMU 59 exhibited higher concentrations of contaminants than were detected in the sample collected near SWMU 59.

SWMU 59 HHRA

The HHRA evaluated exposure for two land use scenarios: future site residents, and current and future site workers. The media and exposure pathways included in each scenario are:

Land Use	Media and Exposure Pathway
Future Site Residents	Soil - Incidental Ingestion, Dermal Contact Loess Groundwater - Ingestion
Current and Future Site Workers	Soil - Incidental Ingestion, Dermal Contact Loess Groundwater - Ingestion

The HHRA also evaluated exposure pathways for the hypothetical future construction worker. Although risk was not formally estimated for this scenario, subsurface soil data were screened by comparing detected concentrations to RBCs. No COPCs were identified for this scenario, so no risk calculations were performed.

HHRA risk estimates in the following table include media-specific as well as multi-pathway risk estimates. Numbers in **bold** indicate risk or hazard has exceeded USEPA's acceptable risk range or hazard index point of departure.

Summation of Exposure Pathways for SWMU 59

	Future Site Residents			Current and Future Site Workers	
Medium and Exposure Pathway	**Adult HI**	**Child HI**	**LWA ILCR**	**Worker HI**	**Worker ILCR**
Soil - Incidental Ingestion	0.3	**3**	**1e-04**	0.1	1e-05
Soil - Dermal Exposure	0.2	0.5	2e-05	0.1	9e-06
Sum of Soil	***0.5***	***3.5***	***1.2e-4***	***0.2***	***1.9e-05***
Loess Groundwater - Ingestion	0.8	**2**	7e-05	0.2	2e-05
Sum of Soil and Loess Groundwater	***1.3***	***5***	***1.9.e-04***	***0.4***	***3.9e-05***

Notes:
HI — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average

Identification of COCs was based on the multi-pathway risk and hazard estimate exceedances provided on the table above. COCs, identified only for the future site resident scenario, are shown in the following box.

Land Use	**Exposure Pathway**	**COC**
Future Site Residents	Surface soil - Ingestion	Aldrin, alpha-Chlordane, Arsenic, Aroclor-1260, BEQ, Dieldrin, gamma-Chlordane, Heptachlor, Heptachlor epoxide
	Loess groundwater ingestion	Barium, Vanadium, Heptachlor epoxide, Lead

SWMU 59 ERA

The SWMU 59 Ecological Risk Assessment concluded there is no quality habitat available and no viable terrestrial community exists. The site is surrounded by asphalt and the grassy area covers only an estimated 1,600 square feet.

SWMU 59 Fate and Transport Assessment

The fate and transport assessment concluded the migration pathways of surface soil erosion, leaching from soil-to-groundwater, soil-to-sediment transfer, and soil-to-air transfer should not be significant at SWMU 59 due to the predominance of asphalt cover and the grass that covers the small, unpaved area.

SWMU 59 Recommendations

- Pesticide contamination on the interior surface of Building S-335 and in the grass covered area surrounding the building should be addressed through the demolition of the building and a limited soil excavation. Proper removal and disposal of the building debris and shallow soil would limit future risk to human health or the environment. Also, since loess monitoring well 059G02LS is in the grass area surrounding Building S-335, it will need to be abandoned prior to any soil removal in accordance with Memphis and Shelby County well abandonment regulations. A Voluntary Corrective Action Work Plan for the demolition of Building S-335 and the removal of contaminated soil under the building and in the grass covered area adjacent to the building has been prepared and is being reviewed by the Navy. The work plan will be submitted to the BRAC Cleanup Team (BCT) after Navy comments have been reviewed and addressed.

- Reassess the human health risk associated with SWMU 59 following the building demolition and soil excavation, in order to decide future actions concerning the SWMU.

- Conduct annual sampling and analysis of down gradient monitoring well pair 059G03LS and 059G03UF, and upgradient monitoring well 059G01LS for pesticides.

SWMU 65 Summary

Site Description and History

SWMU 65 includes Building S-362, a concrete pad mock-up area with spaces for approximately 15 planes; Building S-1503, a wood storage shelter; Building S-346, the former engine test cell building; and the surrounding grass-covered area. SWMU 65 has been used since the early 1950s

to train personnel in aircraft startup and has been used to park various aircraft on the concrete pads west of Building S-362. SWMU 65 is bound to the south by Big Creek Drainage Canal and to the east by Seventh Avenue. A broad grassy area and levee separate the concrete pad area from Big Creek Drainage Canal. The topography slopes gently south, with storm water runoff from the concrete pads flowing across the grassy area into a linear drainage depression along the south side of the site. An additional drainage depression bisects the site, conveying water from its west and east sides to the southern drainage depression. Drainage from both linear depressions enters a north-south drainage depression at the site's southeast corner, where it exits the SWMU and eventually enters Big Creek Drainage Canal at an outlet near Seventh Avenue.

Two 30,000-gallon underground storage tanks (USTs), formerly used to fuel the test cell, were present north of Building S-346. The USTs were removed in 1984, and no free product was observed in the excavated area; however, a hydrocarbon odor and discolored soil were noted in the excavation. Underground piping likely transported the jet fuel to the test cell; however, this piping has not been located.

Prior investigations at SWMU 65 were in response to a 25-gallon jet propulsion fuel #5 (JP-5) release on April 28, 1992. On May 4, 1992, Navy personnel excavated the impacted soil in the JP-5 spill area near the easternmost concrete pad, collected four surface and subsurface soil samples, then backfilled with the excavated material. The soil samples were submitted to a laboratory for total TPH analysis. Analytical results indicated TPH concentrations ranged from 38,900 mg/kg at the surface to 5,090 mg/kg at a depth of approximately 6 feet bls near the spill area. In October and November 1992, a limited site investigation was performed at SWMU 65 in response to the JP-5 spill. The investigation consisted of advancing and sampling four soil borings and installing an upper alluvium groundwater monitoring well within each open borehole. Five additional soil borings were completed in the upper alluvium. Soil and groundwater samples were analyzed for TPH-GRO, TPH-DRO, and benzene, toluene, and xylene (BTX). Total TPH in soil, obtained by adding the GRO and DRO fractions, ranged from non-detect to 7,930 mg/kg. The majority of total TPH in the soil samples consisted of the TPH-DRO fraction, with concentrations increasing with depth in seven of the nine soil borings. The sum of BTX

constituents in soil samples ranged from non-detect to 28.0 mg/kg with the majority consisting of xylene. Total TPH in upper alluvium groundwater ranged from 295 to 3,156 μg/L and consisted primarily of TPH-DRO. No BTX was detected in the groundwater samples.

SWMU 65 RFI Sampling Rationale

The SWMU 65 RFI consisted of collecting and analyzing soil, groundwater, and sediment samples, as summarized below.

SWMU 65
Sample Summary

Media	Type	Number of Samples	Interval Sampled	Analysis	Purpose
Soil	DPT	30 30	0 - 2 feet 5 - 7 feet*	TPH-GRO, TPH-DRO	Screening investigation to determine the optimum soil boring and monitoring well placement and depth. DPT soil borings surrounded the perimeter of the lagoons, with the depth of soil sample collection corresponding to the interval just below the base of the lagoons.
Soil	Soil Boring	3 3 3	0.5 - 2 feet 6 - 8 feet 12 - 14 feet	FSA	To determine surface and subsurface soil quality in the upper alluvium at each corner of the lagoons; the human health risk to potential residents, site workers, maintenance workers, and trespassers; ecological risk to terrestrial species; and the migration potential for soil constituents to groundwater and sediment.
Groundwater	DPT	17	Upper and Deep alluvium	VOCs	Screening investigation to determine the optimum soil boring and monitoring well placement and depth.
Groundwater	Monitoring Well	4	Upper and Deep alluvium	FSA, less TPH-GRO	To determine groundwater quality in the deep alluvium at each corner of the lagoons; the human health risk from consumption (assuming alluvial groundwater is a drinking water source) to potential residents and site workers.
Sediment	Hand Auger	10 10	0 - 6 inches 18 - 24 inches	FSA	To determine potential contaminants in SWMU 65 drainage ditch sediments and the risk of exposure to ecological receptors.

SWMU 65 Analytical Results

This discussion presents only those contaminants that exceeded screening values; significantly affected the results of the HHRA, ERA, and fate and transport assessments; or contaminants that were obviously the result of SWMU 65 operations.

Soil Contaminants: Soil samples collected during the SWMU 65 RFI indicated the presence of one SVOC, TPH, one chlorinated pesticide, and two inorganics exceeding screening values. The

significant exceedances of screening values were as follows: total TPH (910,000 μg/kg) in one DPT soil sample from the 5- to 7-foot bls interval exceeded the TDEC cleanup level for total TPH (500,000 μg/kg); and dieldrin (340 μg/kg) in one surface soil sample exceeded its residential RBC (40 μg/kg), SSL (1 μg/kg), and the RC (262 μg/kg) established for dieldrin at NSA Memphis.

Groundwater Contaminants: No SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, or herbicides were detected in groundwater samples from monitoring wells. Chloromethane was identified in one upper alluvium DPT sample (15 μg/L) exceeding its tap water RBC (1.4 μg/L). Arsenic was identified in one upper alluvium groundwater monitoring well (4.5 μg/L) and the deep alluvium well (5.6 μg/L) exceeding both its tap water RBC (0.045 μg/L) and RC (4.2 μg/L).

April/May 1997 Groundwater Sampling Event: The four upper alluvium groundwater wells installed in 1992 and the three upper alluvium and one deep alluvium groundwater wells installed in 1996 were sampled and analyzed for VOCs, TPH, TPH-GRO, and TPH-DRO. The TPH, TPH-GRO, or TPH-DRO concentrations identified in five of the seven upper alluvium monitoring wells exceeded the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers.

Sediment Contaminants: The only constituents detected in SWMU 65 sediment were TPH-GRO and toluene. No concentration of either constituent exceeded a soil or sediment screening value.

SWMU 65 HHRA

The HHRA evaluated exposure for two land use scenarios: future site residents, and current and future site workers. The media and exposure pathways included in each scenario are:

Land Use	Media and Exposure Pathway
Future Site Residents	Soil - Incidental Ingestion, Dermal Contact Alluvial Groundwater - Ingestion
Current and Future Site Workers	Soil - Incidental Ingestion, Dermal Contact Alluvial Groundwater - Ingestion

The HHRA also evaluated exposure pathways for the hypothetical future construction worker. Although risk was not formally estimated for this scenario, subsurface soil data were screened by comparing detected concentrations to RBCs. No COPCs were identified for this scenario, so no risk calculations were performed.

HHRA risk estimates in the following table include media-specific as well as multi-pathway risk estimates. Numbers in **bold** indicate risk or hazard has exceeded USEPA's acceptable risk range or hazard index point of departure.

Summation of Exposure Pathways for SWMU 65

	Future Site Residents			Current and Future Site Workers	
Media and Exposure Pathway	**Adult HQ**	**Child HQ**	**LWA ILCR**	**Worker HQ**	**Worker ILCR**
Soil - Incidental Ingestion	0.005	0.04	4.3e-06	0.002	4.8e-07
Soil - Dermal Exposure	0.008	0.03	3.8e-06	0.005	2e-06
Sum of Soil	0.013	0.07	8.1e-06	0.007	2.5e-06
Alluvial Groundwater - Ingestion	0.5	**1.2**	**1.2e-04**	0.5	3e-05
Sum of Soil and Alluvial Groundwater	0.5	**1.3**	**1.2e-04**	0.5	3e-05

Notes:
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average

Identification of COCs was based on the multi-pathway risk and hazard estimate exceedances shown on the table above. No COCs were identified for the current and future site worker scenario. The only COC identified for the future site resident scenario was arsenic, based on the risk and hazard estimates for ingestion of alluvial groundwater as a drinking water source. The maximum concentration reported for arsenic in alluvial groundwater (5.6 μg/L) is approximately one order of magnitude less than the corresponding MCL (50 μg/L), and only slightly exceeds the alluvial groundwater background RC (4.2 μg/L). It should be noted that the upper alluvium and the loess are lithologically and hydrogeologically similar, and the maximum detected concentration does not exceed the loess groundwater RC (7.32 μg/L). In addition, arsenic was not an anticipated site constituent, and no records are available that indicate its use at SWMU 65. Therefore, arsenic in SWMU 65 alluvial groundwater may be naturally occurring or residual background concentrations from past agricultural practices.

SWMU 65 ERA

The Ecological Risk Assessment determined no quality habitat is available at SWMU 65, which has no viable terrestrial community. Surface soil contaminant concentrations at SWMU 65 do not indicate a risk to lower-level terrestrial receptors and the biotransfer of contaminants up the food chain would not be a concern because concentrations are not at levels indicative of accumulation.

SWMU 65 Fate and Transport Assessment

The fate and transport evaluation concluded soil contaminants identified at SWMU 65 are not expected to adversely impact the alluvial aquifer, based on their limited impact to alluvial groundwater during the April 1996 groundwater sampling event, and the tendency for inorganics and pesticides to sorb to the soil matrix.

SWMU 65 Recommendations

- Assess the need for a Voluntary Corrective Action to remove soil around the JP-5 spill area after the BCT evaluates the data from the soil sample collected to characterize the former JP-5 fuel spill area.

- Final determination on SWMU 65 groundwater should be deferred until the analytical results from the most recent groundwater sampling event have been evaluated by the BCT.

1.0 INTRODUCTION

As part of the U.S. Navy Installation Restoration Program, the following Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report has been prepared for six Solid Waste Management Units (SWMUs) on the Southside of Naval Support Activity (NSA) Memphis (formerly Naval Air Station [NAS] Memphis), Millington, Tennessee.

The Southside of NSA Memphis, on which these SWMUs are located, is being "realigned" for other uses as a result of the Base Closure and Realignment Act of 1990 (BRAC). Additionally, one portion of the Northside (primarily the airfield and associated buildings) has been closed and prepared for property disposal; the remainder is being realigned along with the Southside. Under the closure and realignment, Navy airfield operations ceased in October 1995. Training operations moved to NAS Pensacola in 1996, and Navy Bureau of Personnel (BUPERS) operations are scheduled to move from the Washington, D.C. area to NSA Memphis in 1998.

NSA Memphis received RCRA Permit No. TN2-170-022-600 from the U.S. Environmental Protection Agency (USEPA) Region IV in September 1986. The Hazardous and Solid Waste Amendments (HSWA) portion of the permit (HSWA-TN002) required a RCRA Facility Assessment (RFA) to identify and characterize all active and inactive SWMUs at which there were known or suspected releases of hazardous constituents. To comply with this requirement, the Navy retained Engineering Design and Geosciences Group Inc. (EDGe) in December 1986 to conduct the RFA and followup RFI to evaluate these SWMUs. EDGe completed the RFA and RFI concurrently and submitted the draft reports in April 1987. The reports identified 58 potential SWMUs and recommended 34 for additional study. Since 1987, eight more sites have been added and a formerly identified site has been divided into two sites, bringing the total number of SWMUs to 67. On September 24, 1996, the Tennessee Department of Environment and Conservation (TDEC) issued a permit modification (Installation Identification Number TN2-170-022-600; Permit Number TNHW-094) to add the new SWMUs and Area of Concern (AOC) A, the

Northside Fluvial Deposits Groundwater. Thus, there are currently 68 sites needing investigation which are listed in the modified permit.

At the present time, 27 of the 68 sites require full RFI characterization, 25 require a confirmatory sampling investigation (CSI), and the remaining 15 require no further action. The RFI and CSI SWMUs (including the one AOC) were grouped as eight *Assemblies* (A, B, C, D, E, F, G, and H) under the RCRA Corrective Action Program (CAP) at NSA Memphis. Grouping was based on:

- the BRAC status of the SWMU and the type of funds used to investigate them. Assemblies A, B, C, and D, on the closing portions of NSA Memphis, are being investigated using BRAC funds. Assemblies E, F, G, and H, on portions of NSA Memphis that will remain open, are being investigated using funds provided by the Defense Environmental Restoration Account [DERA];

- whether the SWMU requires an RFI or CSI. SWMUs in Assemblies A, B, and E required initial full RFI investigations; the remaining SWMUs required CSIs; and

- the SWMUs associated waste sources (surface or subsurface) and the type of field sampling methods involved (drilling, direct push technology [DPT], hand-auger, etc.)

The six Assembly E SWMUs that are the subject of this RFI require full characterization. These SWMUs are on the portion of NSA Memphis that will remain open. Therefore, their investigations are funded by DERA. The Assembly E SWMUs are:

- SWMU 2, the Southside Landfill;
- SWMU 9, the Sewage Lagoons;
- SWMU 14, Building S-140 Site and Seventh Avenue Ditch;

- SWMU 38, Miscellaneous Drainage Ditches (Southside only);
- SWMU 59, Pesticide Storage Facility (Old Pesticide Shop); and
- SWMU 65, Building S-362 Training Mock-up Site.

Figure 1.1 provides a vicinity map of the NSA Memphis Southside showing the SWMU locations.

The Assembly E RFI, undertaken by EnSafe/Allen & Hoshall (E/A&H) and the U.S. Geological Survey (USGS), was conducted in accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a). The RFI adhered to the requirements of the HSWA portion (HSWA-TN002) of RCRA Permit No. TN2-170-022-600, the HSWA portion of permit modification No. TNHW-094, and applicable regulations.

1.1 Assembly E SWMU Descriptions and Site Histories

This section provides a description and site history of each Assembly E SWMU.

1.1.1 SWMU 2 — Southside Landfill

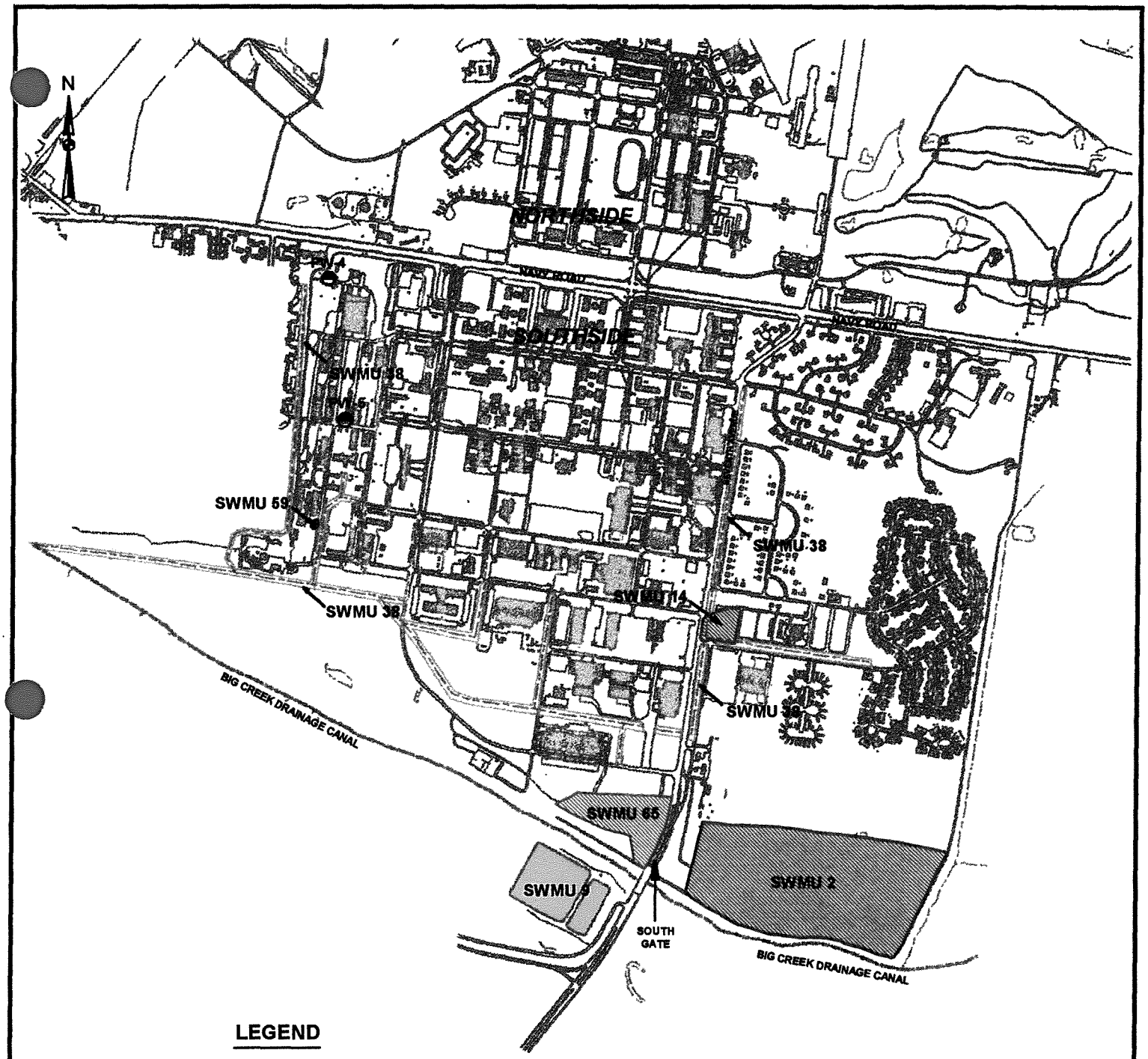
SWMU 2, the Southside Landfill, covers 42 acres of the southeast quadrant of NSA Memphis. It is bounded on the east by Perimeter Road, wooded areas, and residential areas. South of the landfill lies Big Creek Drainage Canal, which flows to the west. South of Big Creek Drainage Canal lies the southern boundary of NSA Memphis and undeveloped land. West of the landfill lies Seventh Avenue and the NSA Memphis South Gate. The NSA Memphis shooting range is near the landfill's northwest corner. A wooded lot and a residential neighborhood are approximately 1,000 feet north of the landfill. Figure 1.2 provides a site map of SWMU 2.

The landfill is covered with mature hardwood trees and dense undergrowth, as documented in the *Visual Site Inspection (VSI) Report* (ERC/EDGe, 1990a). It is relatively flat, subtly sloping

downward to the south approximately 0.5% and rising 1% near Big Creek Drainage Canal (refer to the topographic map in Appendix A).

The landfill receives surface drainage from the north, which apparently discharges generally to the south and west into Big Creek Drainage Canal. During the Assembly E investigation, no visual evidence of surface-water discharge into Big Creek Drainage Canal was identified, although topographic features were noted where runoff from the landfill may be concentrated. During current and previous site investigations, several areas of standing water, up to several inches deep, have been noted at various landfill locations. These areas are believed to have resulted from a combination of precipitation and blocked surface drainage pathways, and not from upward groundwater movement. The drainage pathways have not been maintained since the landfill closed in 1970, and dense undergrowth and plant debris may have filled areas which once drained low-lying areas of the landfill.

According to the *RCRA Facility Assessment (RFA)* (ERC/EDGe, 1990b), the Southside Landfill reportedly received solid waste generated from both the Northside and Southside from 1942 until 1970. Disposed waste included residential waste generated by onsite housing, office solid waste, aircraft parts, wastewater-treatment plant sludge generated by the trickling filter plant, incinerator ash, waste oil, oily sludge, and solvents generated from industrial operations. An estimated one ton per year of oily waste and sludge (possibly containing polychlorinated biphenyls [PCBs]) and approximately two tons per year of wastewater-treatment plant sludge were disposed of by trench-and-cover in the landfill. Combustible materials were reportedly burned with waste oil to aid in the burning process and to reduce the waste volume in the landfill.



LEGEND

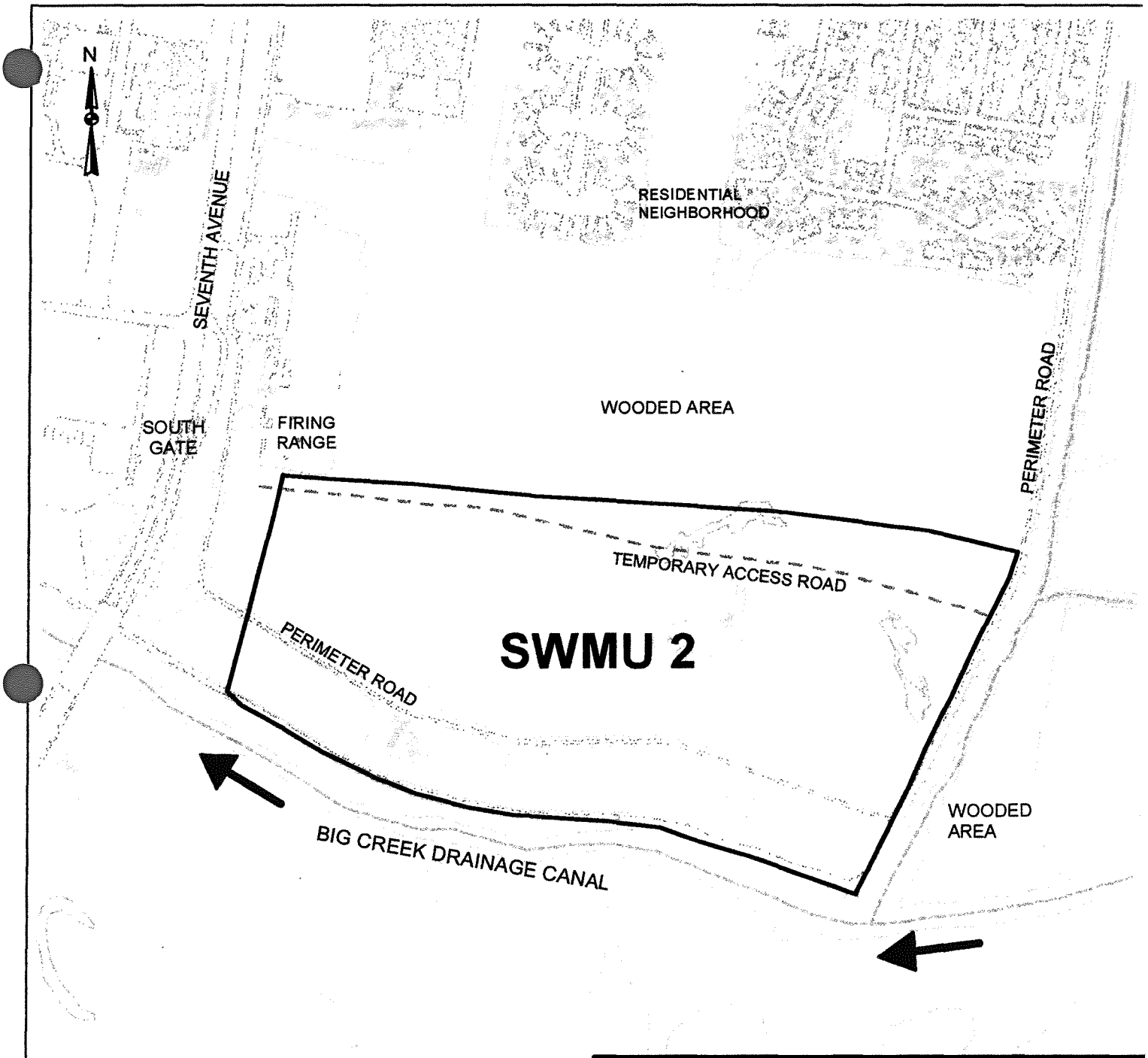
SWMU 9 — SOLID WASTE MANAGEMENT UNIT DESIGNATION AND LOCATION

PW-5 — PUBLIC SUPPLY DRINKING WATER WELL DESIGNATION AND LOCATION

1000 0 1000 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.1
VICINITY MAP
ASSEMBLY E SWMUs



LEGEND

FLOW DIRECTION OF BIG CREEK DRAINAGE CANAL

FENCE

500 0 500 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.2
SITE MAP
SWMU 2 - SOUTHSIDE LANDFILL

The Southside Landfill has been the subject of two previous investigations in which limited groundwater and soil-gas samples were collected and analyzed. During the 1984 Confirmation Study/Verification Phase (CS/VP), five monitoring wells were installed around the landfill and sampled for volatile organic compounds (VOCs) and select inorganics. The analytical results were compiled in the *NACIP Confirmation Study, Verification Phase* report (Geraghty and Miller [G&M], 1985). In 1991, the USGS conducted a limited soil-gas survey and electromagnetic (EM) survey of the landfill.

A preliminary evaluation of the SWMU 2 RFI data indicates that additional sampling should be performed to complete the SWMU 2 RFI. Therefore, the nature and extent of contamination at SWMU 2, and the resulting risk and fate and transport evaluations are not presented in this report. However, lithologic and hydrogeologic information generated during RFI activities performed to date have been included in Sections 2 and 3 because they are relevant to understanding the geology and characteristics of groundwater transport on the Southside of NSA Memphis. Once SWMU 2 has been adequately characterized and evaluated with respect to risk and fate and transport, the RFI results will be incorporated in subsequent revisions to this report.

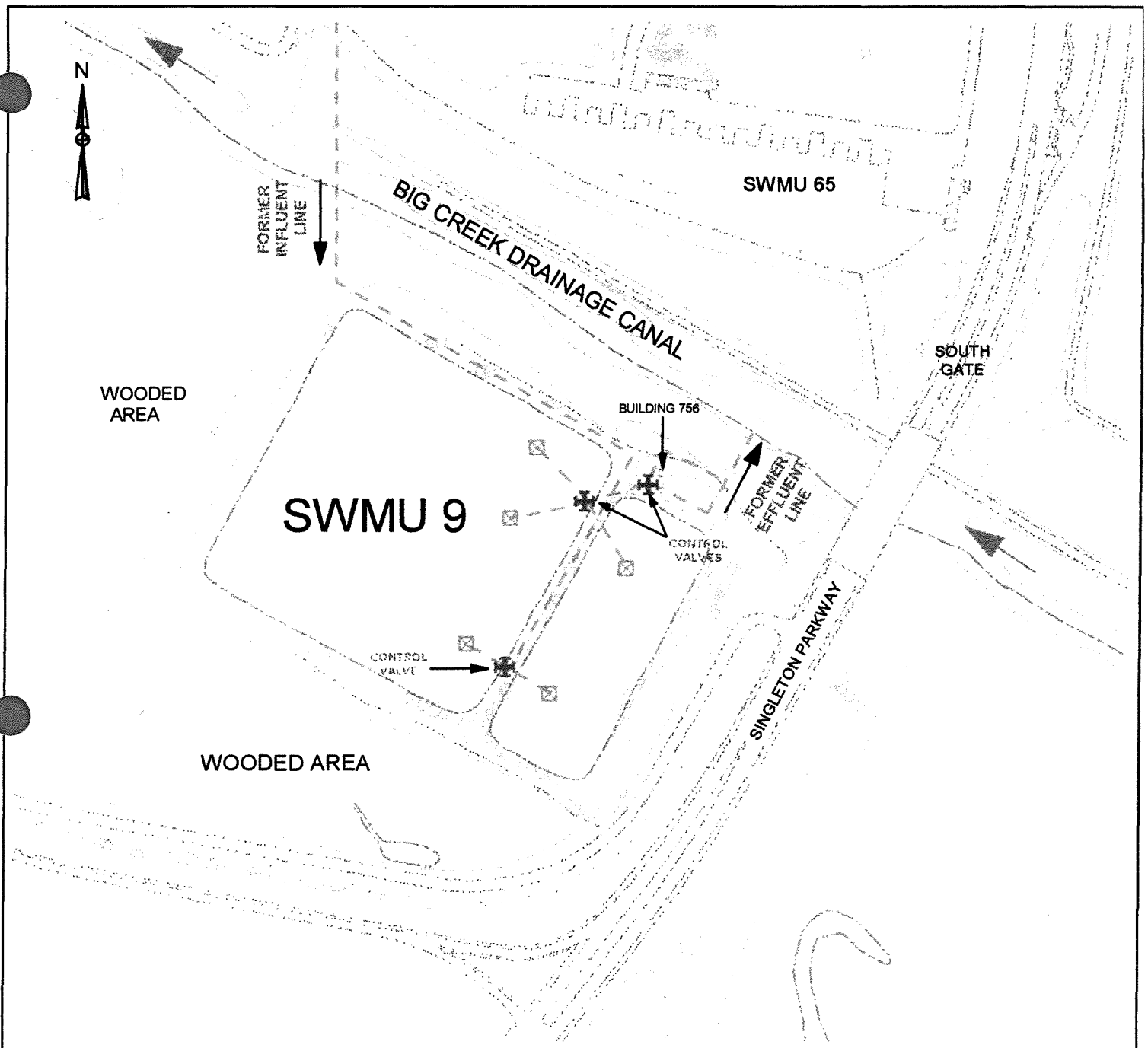
1.1.2 SWMU 9 — Sewage Lagoons

SWMU 9 consists of two sewage lagoons on the Southside's southern boundary, approximately 175 feet south of Big Creek Drainage Canal and 450 feet southwest of the South Gate. The approximately 400,000-square-foot western lagoon is separated from the approximately 141,000-square-foot eastern lagoon by a 25-foot wide dike. The lagoons are bordered by Big Creek Drainage Canal to the north, wooded areas to the south and west, and Singleton Parkway to the east. Big Creek Drainage Canal flows to the west. Figure 1.3 provides a site map of SWMU 9.

The lagoons, which support a wide variety of wildlife, are constructed of brown clay and are currently fed by rainfall. They are surrounded by 10-foot high dikes designed to retain approximately 3 feet of water. NSA Memphis personnel have reported that the water level in the lagoons does not noticeably change from season to season. The land surrounding the lagoons slopes away on all sides for a short distance, with surface water draining generally west before it enters Big Creek Drainage Canal (refer to the topographic map in Appendix A). The lagoon bottom sediments are clay and wastewater sludge, underlain by clayey silt. During the Assembly E investigation, a temporary road was constructed on top of the dikes by clearing the vegetation with a bulldozer. The levees appeared to be in good condition, except for a beaver tunnel connecting the south side of the larger western lagoon with, presumably, the surface, at an unknown point south of the temporary road.

The two lagoons were used as part of the NSA Memphis wastewater treatment system from 1969 to 1978. Although primarily domestic wastewater was treated, limited amounts of industrial wastewater from aircraft maintenance were also treated. This industrial wastewater may have contained a wide variety of contaminants, including VOCs, semivolatile organic compounds (SVOCs), and metals. The lagoons received approximately 35% of the wastewater produced at NSA Memphis, with the other 65% going to SWMU 28, the former Southside wastewater treatment plant. SWMU 28, which was classified as a no-further-action SWMU, was located at the current site of Building S-787.

An influent line from the former wastewater treatment plant crossed Big Creek Drainage Canal and entered the lagoon area at the northwest corner of the western lagoon (Figure 1.3). The wastewater was chlorinated prior to discharge into Big Creek Drainage Canal through an effluent line at the northeast corner of the lagoons. According to NSA Memphis personnel, all influent and effluent control valves were closed and concrete-sealed in 1978, when the sewer system was connected to the City of Millington sewage treatment system.



LEGEND

INFLUENT AND EFFLUENT LINES

INFLUENT/EFFLUENT CONTROL VALVES

FLOW DIRECTION OF BIG CREEK DRAINAGE CANAL

FENCE

300 0 300 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.3
SITE MAP
SWMU 9 - SEWAGE LAGOONS

Visual inspections by E/A&H personnel during the Assembly E RFI did not identify any evidence of discharge into Big Creek Drainage Canal.

The sewage lagoons have been the subject of one previous investigation during which limited sediment sampling was conducted. In 1984, Geraghty and Miller collected five sediment samples from the bottom material in the two lagoons during the CS/VP. Each sediment sample was analyzed for total cadmium, chromium, copper, nickel, and lead by SW-846 Method 1310 for Extraction Procedure (EP) Toxicity. No metal was detected above its method detection limit (0.01 milligrams per kilogram [mg/kg] for cadmium and nickel and 0.1 mg/kg for chromium, copper, and lead). According to the *NACIP Confirmation Study, Verification Phase* report (G&M, 1985), no further investigation was recommended for the SWMU. However, the subsequent *RCRA Facility Assessment* (ERC/EDGe, 1990b) recommended an RFI at SWMU 9 due to the lack of analytical data for the SWMU. Copies of the CS/VP and RFA reports were provided as attachments to the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

1.1.3 SWMU 14 — Building S-140 Site and Seventh Avenue Ditch

SWMU 14, the former site of Building S-140, is now a flat, grass-covered area on the Southside, east of Seventh Avenue and north of Polaris Drive. Drainage ditches are south and west of the site. The site's eastern portion has a small stand of pine trees, several sidewalks, and a large open field once used as a trailer park. Residential property is at the far east end of this open field. Figure 1.4 provides a site map of SWMU 14.

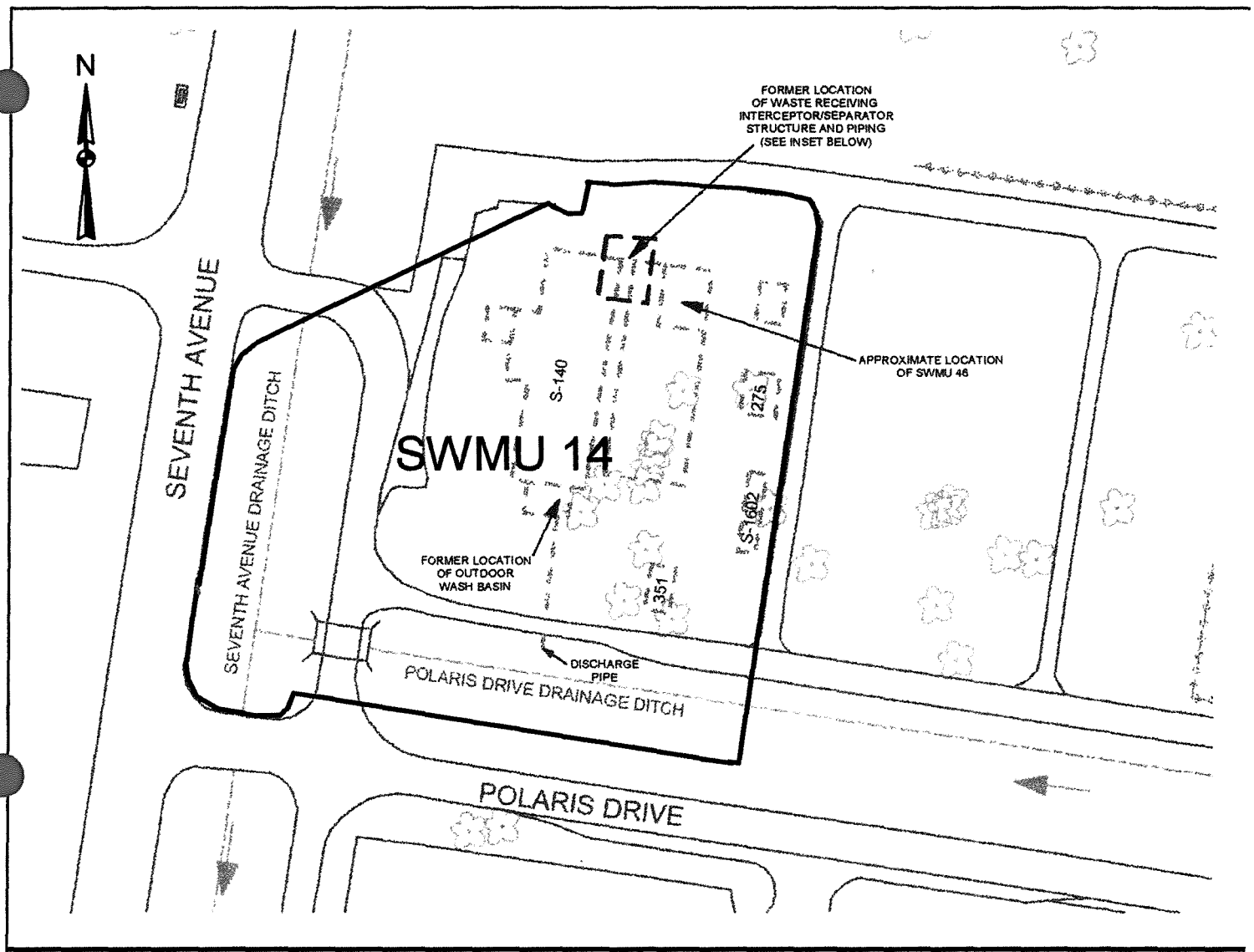
Building S-140, demolished in 1985, housed a paint spray booth, a paint removing area, and a paint wash-down area used to train Navy personnel in painting-related processes from 1943 to 1985. According to building diagrams, two drainage systems were associated with painting activities at S-140: one was in the central portion of the building which housed the paint spray

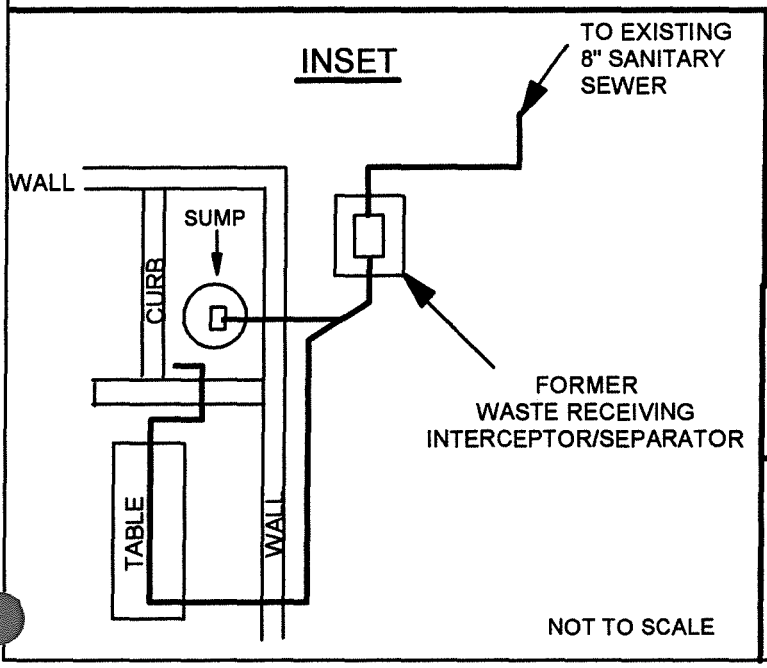
booths and water-wash pits, and the other was in the northern portion near the interior wash-down area and work table.

Paint-related wastes generated by the paint spray booth and water wash pits in the central portion of Building S-140 apparently collected in two floor drains which emptied into two 1,885-gallon sump pits. Paint waste and sludge from these sumps were most likely removed on an as-needed basis, with any overflow discharged directly to the Seventh Avenue ditch until 1980. After 1980, the flow from the paint booth and wash-down area was redirected to a paint separator/sump in the building's mechanical room with the overflow discharged to the sanitary sewer. The paint waste and sludge likely contained chromium, lead, and various hydrocarbons and paint solvents, including mineral spirits, toluene, and phenols.

Wastes generated by the paint wash-down area and work tables in the northern portion of the building were discharged to an unidentified drain line exiting the building's east side. In 1968, these wastes were diverted to an interceptor-separator beneath the north end of a sidewalk immediately east of the building. According to construction diagrams, this interceptor-separator was 3.5 x 5 feet wide and 4.5 feet deep. Interceptor discharge was directed to the sanitary sewer line to the north.

A former outdoor wash basin next to Building S-140's south side consisted of a 36- x 40-foot concrete slab surrounded by a 6-inch berm. According to sewer modification diagrams, the basin's drain connected to a 12-inch concrete line which discharged directly into the Polaris Drive drainage ditch (Figure 1.4). When the drain line was plugged in 1980, drainage was diverted to the sanitary sewer. Today, there is no evidence of the drain, but the associated outfall (a small discharge pipe) can be seen in the Polaris Drive ditch, which has been included in the SWMU 14 RFI.





LEGEND

FORMER BUILDING OR FEATURE

DRAINAGE DITCH SURFACE WATER FLOW DIRECTION

100 0 100 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.4
SITE MAP
SWMU 14 - BUILDING S-140 AND
SEVENTH AVENUE DRAINAGE DITCH

According to the building's engineering plans obtained from Public Works, four smaller structures were also associated with the building. Building 275, a gear locker approximately 50 feet east of S-140, was constructed in 1944 and demolished in 1985. Building S-1602, reportedly a temporary building along the eastern edge of the site, was removed in August 1989. Building 351, 50 feet southeast of S-140, reportedly was a 12-foot by 20-foot, pre-fabricated metal storage building used as a paint locker prior to its demolition in 1985. Also associated with Building S-140 is SWMU 46, a former hazardous waste accumulation point at the north end of a paved area east of the building. From 1980 until 1985, SWMU 46 was used for less-than-90-day storage of drummed hazardous waste, including waste paints and thinners. Although SWMU 46 is in Assembly G, it is included in the SWMU 14 study area and therefore, will not require a separate investigation.

The site is relatively flat with no obvious direction for surface-water runoff. It is likely, however, that all runoff currently discharges as sheet flow into the Seventh Avenue ditch to the west and the Polaris Drive drainage ditch to the south. These ditches, which ultimately discharge into Big Creek Drainage Canal, are partially concrete-lined.

1.1.4 SWMU 38 — Miscellaneous Drainage Ditches (Southside Only)

In its entirety, SWMU 38 covers most of the open ditches on NSA Memphis. These ditches drain the Northside and Southside of NSA Memphis; however, only the Southside ditches are included in the Assembly E RFI, while the Northside ditches were part of the Assembly B RFI. They receive influent from surface runoff, storm sewers, and formerly, wastewater discharges from various industrial buildings on the NSA Memphis Southside. The locations of the SWMU 38 primary and secondary drainage ditches were illustrated on Figure 1.1 (shown previously).

SWMU 38's general topography on the Southside of NSA Memphis subtly slopes downward 1% to 3% to the west. SWMU 38 ditches, which appear to have been eroded in several areas, drain

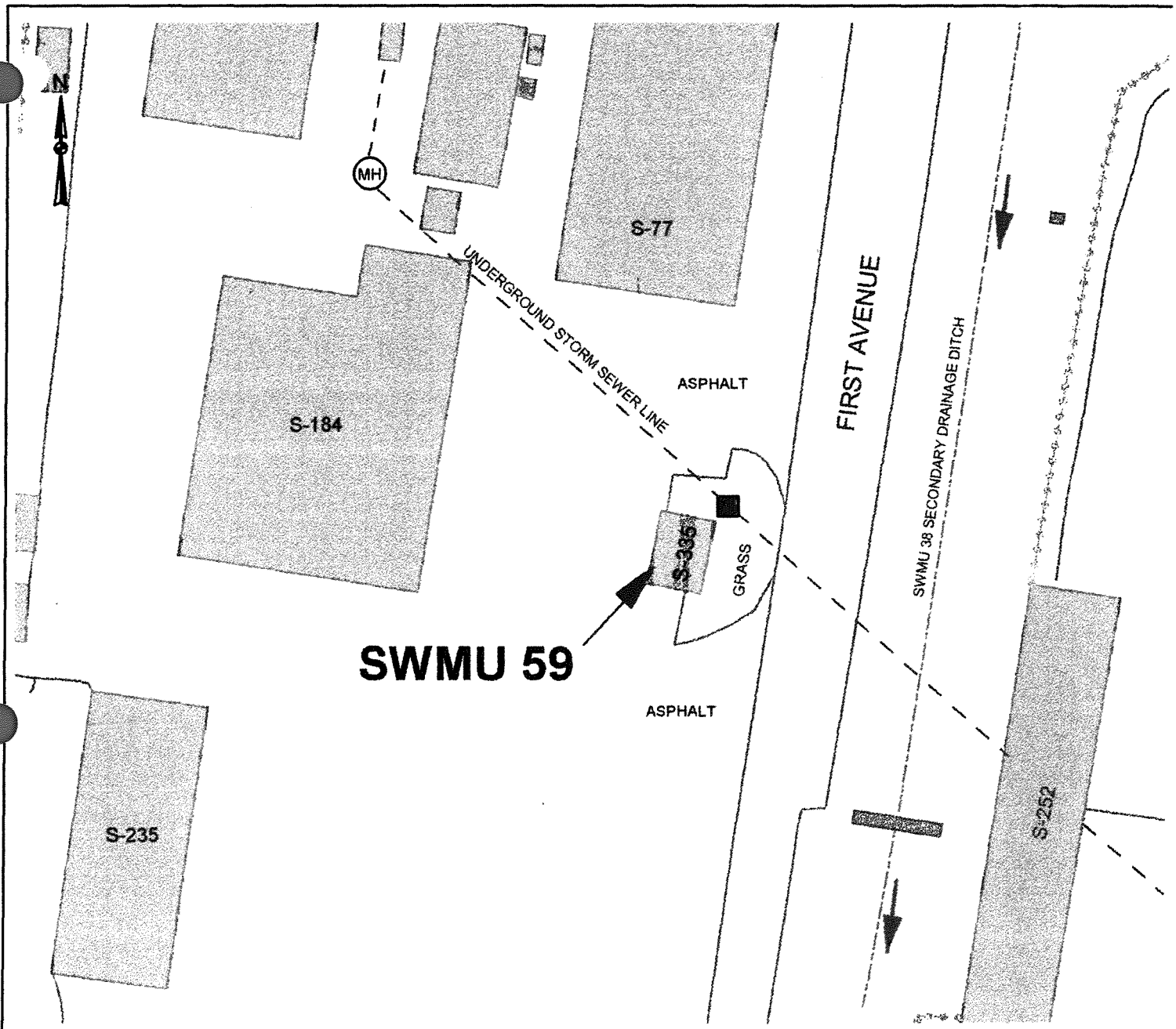
to Big Creek Drainage Canal in the southwest corner of NSA Memphis. Water levels in the ditches may vary as much as several feet during storms. A topographic map showing local surface elevations for SWMU 38 is provided as Appendix A.

The original design of many buildings at NSA Memphis (circa 1943) provided for floor drains to discharge to storm sewers, storm drains, and drainage ditches. As buildings were remodeled and replaced, however, these drains were eliminated or re-routed to the sanitary sewer. Until 1980, when most of these drains were replaced, it is reported that various substances, including solvents, degreasers, oils, and paints, may have been discharged into them. The 1990 RFA description for SWMU 38 (ERC/EDGe, 1990b) was provided in Attachment A of the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

1.1.5 SWMU 59 — Pesticide Storage Facility (Old Pesticide Shop)

The Pesticide Storage Facility (commonly referred to as the "Old Pesticide Shop") consists of Building S-335, a wood-framed, sheet-metal exterior structure. A small grassy area on the north, east, and southeast sides of the building separates the building from the adjacent asphalt lot, which surrounds the building on the north, south, and west sides. A grassy area on the building's east side separates it from First Avenue. Figure 1.5 provides a site map of SWMU 59.

The SWMU 59 area slopes gently to the east, with runoff flowing toward a storm drain in the grassy area east and northeast of Building S-355. This storm drain conveys the water southeast under First Street to an outfall in the SWMU 38 secondary drainage ditch along the east side of First Street. SWMU 38 then conveys runoff approximately 1,800 feet south to Big Creek Drainage Canal. Any storm runoff which does not enter the storm drain northeast of the building would move across the parking lot as sheet flow to First Street, where it would travel south to Big Creek Drainage Canal. A topographic map showing local land surface elevations for SWMU 59 is provided as Appendix A.



LEGEND

STORM DRAIN

MH MANHOLE

SURFACE WATER FLOW DIRECTION

50 0 50 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.5
SITE MAP
SWMU 59 - S-335 OLD PESTICIDE SHOP

According to the 1990 RFA, the building's exact age is unknown, but it is estimated to be at least 30 years old. It was used to store pesticides and fertilizers used at NSA Memphis. Pesticides reported to have been stored at the building included chlordane, dieldrin, and DDT, and arsenic, a common component of early pesticide formulations. According to NSA Memphis personnel, employees associated with the SWMU 59 pesticide operation are no longer at NSA Memphis, and current employees were not involved in the aforementioned activities. Therefore, no personnel were available for interviews regarding SWMU 59's operating procedures.

SWMU 59 was flooded in 1974 and 1987, as evidenced by the water mark on the wall inside the building approximately 2.5 feet above the floor. The 1990 VSI conducted by the Navy and the USGS indicated a pesticide odor emanating from the building's window. A water line leak was present at the time of this Navy/USGS visit, resulting in clear water trickling from beneath the building and saturating the ground on the building's east side. According to the *Draft Final RCRA Facility Investigation Work Plan for Naval Air Station — Memphis* (SOUTHDIV, 1990), the building was scheduled for demolition in 1990; however, at the present time it has not been demolished or cleaned. It is locked, and hazard signs are present on the building's exterior. At the request of the BRAC Cleanup Team (BCT), EnSafe is currently preparing a Voluntary Corrective Action (VCA) Work Plan for SWMU 59. The VCA Work Plan will outline the demolition of the building and its asphalt flooring, removal of soil beneath the building and its adjoining grassy area, and disposal of construction debris and excavated soil.

SWMU 59 has been the subject of one previous investigation — a 1990 RFI performed by EnSafe and ERC in anticipation of the planned building demolition. During the RFI, 16 shallow soil samples were collected from eight locations surrounding the shop, and 30 wipe samples were collected from the building's interior surfaces. The samples were analyzed for arsenic, DDT and related isomers, chlordane, and dieldrin. The *RCRA Facility Investigation Report , NAS Memphis Site No. 59 (Building No. S-335, Former Pesticide Storage Facility), NAS Memphis*

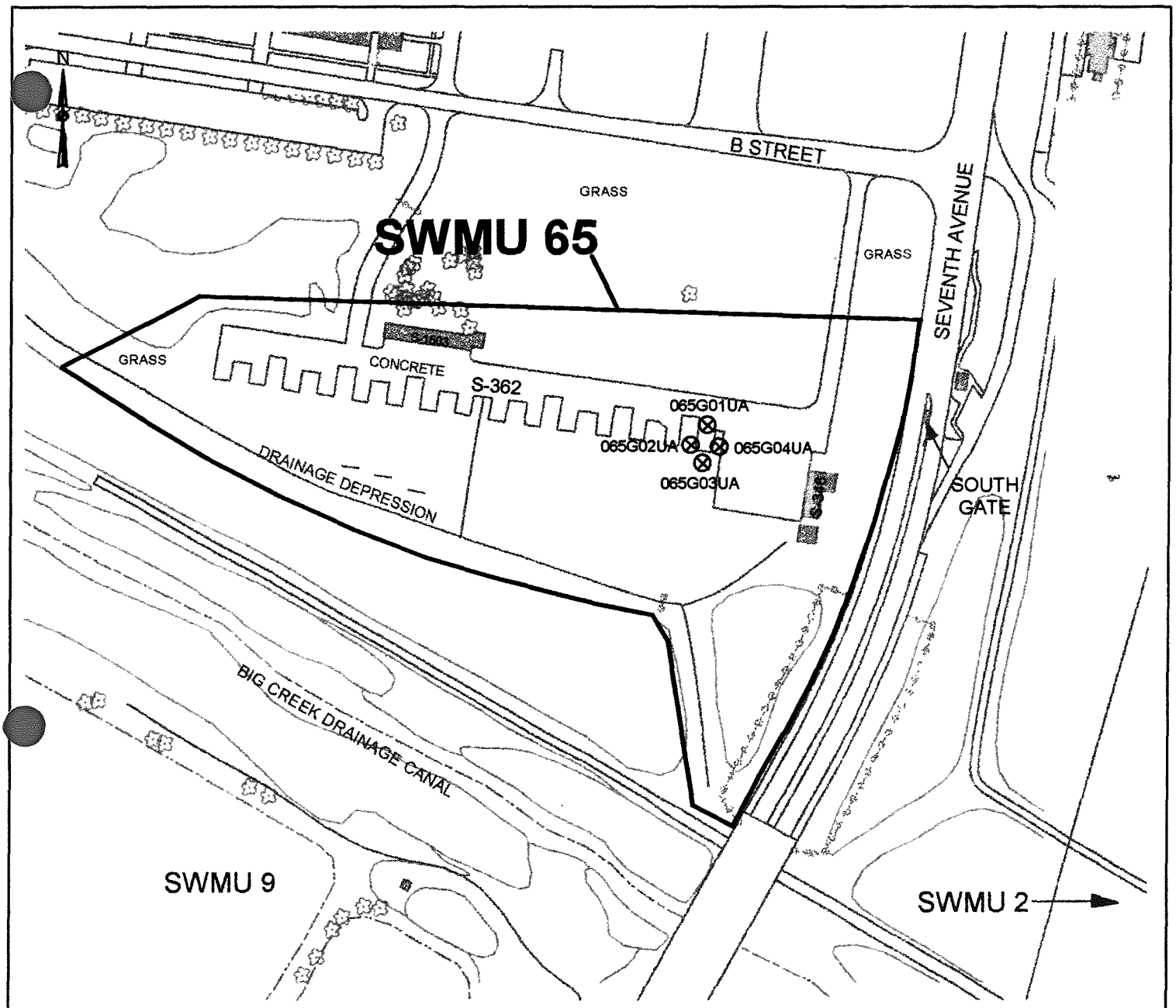
(ERC/EnSafe, 1990) confirmed the presence of chlorinated pesticides and arsenic in shallow (0 to 2 feet below land surface [bls]) soil surrounding the building and on surfaces inside the building. The body of the 1990 RFI report was provided in Attachment 1 of the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

1.1.6 SWMU 65 — Building S-362 Training Mockup Site

The Building S-362 Training Mock-Up Site (SWMU 65) has been used since the early 1950s to train personnel in aircraft startup. The SWMU 65 area includes: S-362, a concrete pad mock-up area with spaces for approximately 15 planes; Building S-1503, a 128-foot by 16-foot by 9-foot wood storage shelter; and Building S-346 (formerly the engine test cell building), presently used for classroom space, training, and a storm shelter. Presently, the U.S. Army Reserves are parking vehicles on the concrete pads west of Building S-362. SWMU 65 is bound by Big Creek Drainage Canal on the south and Seventh Avenue on the east. A broad grassy area and a levee separate the concrete pad area from Big Creek Drainage Canal. Figure 1.6 provides a site map of SWMU 65.

SWMU 65 topography slopes gently south. Storm water runoff from the concrete pads flows across the grassy area into a linear drainage depression along the south side of the site. An additional drainage depression bisects the site, conveying water from the west and east sides of the site to the southern drainage depression. Stormwater flows east along the southern drainage way and enters Big Creek Drainage Canal at an outlet near Seventh Avenue. A topographic map showing local land surface elevations is provided in Appendix A.

According to the *RCRA Facility Assessment* report (ERC/EDGe, 1990b), the jet aircraft at SWMU 65 were refueled by pumper truck, and no fuel lines or underground storage tanks (USTs) were present. However, NSA Memphis personnel stated that two 30,000-gallon USTs, formerly used to fuel the test cell, were present north of Building S-346. The USTs were removed in 1984, and no free product was observed in the excavated area; however, a fuel odor and discolored soil



LEGEND

065G01UA ⊗ EXISTING MONITORING WELL LOCATION/DESIGNATION (FROM 1992 SITE INVESTIGATION)

200 0 200 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 1.6
SITE MAP
SWMU 65 - BUILDING S-362
TRAINING MOCK-UP SITE

were noted in the excavation. Underground piping likely transported the jet fuel to the test cell, but this piping has not been located. The RFA listed the following potential contaminants at SWMU 65: jet fuel, hydraulic fluid, and lubricating oil.

Two previous studies have been conducted at SWMU 65 in response to a reported 25-gallon jet propulsion fuel (JP-5) release in April 1992. In May 1992, Navy personnel excavated the soil in the spill area (near the easternmost concrete airplane pad), collected four soil samples for total petroleum hydrocarbons (TPH) analyses, and filled the excavation with the excavated material. In response to the jet fuel spill, a limited site investigation was performed at SWMU 65 by Memphis Environmental Center Inc. The November 1992 investigation consisted of advancing and sampling four soil borings and five hand-auger soil borings. The four soil borings were converted to groundwater monitoring wells (Figure 1.6). Soil and groundwater samples collected during the investigation were analyzed for TPH and benzene, toluene, and xylenes (BTX). According to the *Site Investigation Report* (Memphis Environmental Center, 1992), "significant" hydrocarbon concentrations were present at this site, and the jet fuel spill was probably not the sole source of hydrocarbon contamination in soil and groundwater. Copies of the reports associated with these previous investigations were provided in Appendix A of the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

1.2 RFI Report Organization

To facilitate review of the RFI report, general information for Assembly E, the overall technical approach, and evaluation methodologies are presented first. These general sections are sequenced according to the natural progression of an RFI investigation. The general sections are as follows:

1.0 INTRODUCTION

2.0 PHYSICAL SETTING

3.0 ANALYTICAL AND FIELD INVESTIGATION METHODS

4.0 METHODS FOR DETERMINING THE NATURE AND EXTENT OF CONTAMINATION

5.0 HUMAN HEALTH RISK ASSESSMENT PROCEDURES

6.0 ECOLOGICAL RISK ASSESSMENT PROCEDURES

7.0 FATE AND TRANSPORT EVALUATION PROCEDURES

The site-specific sections are:

8.0 SITE-SPECIFIC EVALUATIONS

9.0 CONCLUSIONS

Followed by:

10.0 REFERENCES

Section 8 follows the same chronology as Sections 1 through 7, except site-specifically. The section is subdivided by specific SWMUs and includes the actual data summaries, human health and ecological risk evaluations, fate and transport evaluations, and conclusions. In this manner, the entire investigation sequence, including conclusions and recommendations, can be referenced within a specific tabbed section.

Section 9 summarizes the conclusions for each Section 8 site-specific summary. This organization makes it easy to determine which SWMUs have been recommended for further investigation, remediation, or no further action. Section 10 provides references for the entire report.

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2.0 PHYSICAL SETTING

2.1 Regional Geology and Hydrogeology

The general hydrogeology of the Memphis area and a conceptual model of NSA Memphis hydrogeology are presented in Sections 2.11 and Section 2.12 of the *Comprehensive RFI Work Plan* (E/A&H, 1994a). Updated information is available in the *Hydrogeology of Post-Wilcox Group Stratigraphic Units in the Area of the Naval Air Station Memphis, Near Millington, Tennessee* (Kingsbury and Carmichael, 1995). Additional information was provided by the USGS after its review of the data collected during the Assembly E RFI (personal communication with USGS, 1996 and 1997). On the basis of this updated information, the regional geology and hydrogeology of NSA Memphis are summarized in this section.

The stratigraphic units investigated during the RFIs at NSA Memphis are, in descending order: the alluvium of Holocene and Pleistocene age, the loess of Pleistocene age, the fluvial deposits of Pleistocene to Pliocene age, and the Cockfield and Cook Mountain Formations of Eocene age. The loess — eolian deposits consisting of silt, silty clay, clay, and minor amounts of sand — is the principal unit at land surface on most of the NSA Memphis Southside, except for the alluvial plains of streams, where alluvium is present. Water-bearing zones have been encountered in each of the stratigraphic units investigated during the NSA Memphis RFIs. The following sections discuss the geology and hydrogeology of each stratigraphic unit.

2.1.1 Alluvium

Alluvium, which underlies the alluvial plains of streams, includes alluviated or reworked loess in the upper part and locally the fluvial deposits in the lower part. The alluvium's lateral and vertical extent have not been mapped, because the alluvium is lithologically similar to the loess and fluvial deposits. For purposes of this RFI report, it is assumed that alluvium is present from land surface to the top of the Cockfield Formation. Therefore, the total thickness of the alluvium is assumed

to be between 42 and 72 feet at the Assembly E SWMUs near stream valleys (SWMUs 2, 9, and 65; refer to Figure 1.1 shown previously).

The lithology of the upper part of the alluvium (called the "upper alluvium") is similar to the loess. It is composed primarily of silt with varying clay content. At Assembly E SWMUs near Big Creek Drainage Canal, the upper alluvium is present from ground surface to depths between 22 and 41 feet bls. Fine-grained sand lenses, generally water-bearing and less than 6 inches thick, are common in the upper alluvium, but are encountered at greater depths than the first water-bearing zone in the loess.

The lithology of the lower part of the alluvium (called the "deep alluvium" and consisting of the middle and deep alluvium) is similar to the fluvial deposits. It is composed of fine to very coarse-grained sand and gravel with varying clay and silt content. The sand coarsens and the gravel content increases with depth. Generally, a coarse sand and gravel mixture is present at the base of the alluvium just above the Cockfield Formation. Locally, this sand and gravel may be equivalent to the fluvial deposits. At Assembly E SWMUs near Big Creek Drainage Canal, the thickness of the deep alluvium ranges between 6 and 34 feet.

As previously mentioned, the alluvium's lateral extent has not been determined. Due to the nature of alluvial deposition and the lithologic similarity of the lower part of the fluvial deposits and the deep alluvium, it is reasonable to assume that the lower part of the fluvial deposits and the deep alluvium are hydraulically connected. It has not been determined if the water-bearing zones of the loess and upper alluvium are hydraulically connected. The fluvial deposits and deep alluvium are the preferential zones of groundwater flow and the route for contaminant transport at NSA Memphis based on their higher permeability compared to the overlying loess/upper alluvium and underlying Cockfield Formation.

2.1.2 Loess

The loess is typically 0 to 65 feet thick in the Memphis area; on the Southside of NSA Memphis it ranges from 30 to 39 feet thick. Water-bearing zones in the loess (if present), are generally in the upper part of the unit. However, yields are low (less than 1 gallon per minute), and loess groundwater does not meet select primary and secondary drinking water standards (e.g., antimony, cadmium, chromium, iron, thallium, nickel, and turbidity), based on water quality analyses of loess groundwater samples from background monitoring wells throughout NSA Memphis and previous water use surveys performed during Northside UST investigations. Refer to the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for metals concentrations in loess background monitoring wells. Refer to the *Final Site Specific Standard Request — Building N-126* (E/A&H, 1994b) for metals concentrations and turbidity measurements for groundwater samples collected from the Building N-126 UST loess monitoring wells.

Previous investigations at NSA Memphis have identified depth-to-water in the loess varying between 5 and 15 feet bls and vertical hydraulic conductivities from 10^{-6} to 10^{-8} centimeters per second (cm/sec). Although the loess may be considered an aquitard on the basis of the relatively low hydraulic conductivities, the shallowest water-bearing zone may be present within this interval. In some areas of NSA Memphis, there is no water-bearing zone in the loess; therefore, the zone is not laterally continuous throughout NSA Memphis and may be considered a "perched zone" in some areas. Groundwater in the loess, where present, most likely moves primarily downward to recharge the deeper part of the fluvial deposits, although some groundwater in the loess may discharge to nearby streams, drainage ditches, and other surface-water bodies. Lateral groundwater movement in the loess is most likely controlled by topography.

2.1.3 Fluvial Deposits

The fluvial deposits underlie the loess in upland areas; they consist of sand, gravel, and some clay, with thin layers of ferruginous sandstone and conglomerate at the base. This unit ranges from 0 to

100 feet thick in the Memphis area. On the Southside of NSA Memphis, where it ranges from 12 to 59 feet thick, it represents the most significant component of the surficial aquifer. Groundwater wells screened in the upper or lower part of the fluvial deposits are respectively called upper fluvial deposits or lower fluvial deposits wells throughout this report. In the past, many shallow domestic wells in Memphis rural areas were completed in the fluvial deposits, but most have been abandoned or are not used as a source of drinking water since public water supplies have been extended into these areas.

Relative groundwater elevations between wells completed in the loess and fluvial deposits indicate semiconfined to confined conditions in the fluvial deposits. Typically a downward vertical gradient exists between water in the loess and the fluvial deposits. Sediments in the fluvial deposits generally coarsen with depth, and typically, the upper portion consists of a mixture of very fine sand with varying degrees of silt and clay that become increasingly less silty with depth, grading into a fine to medium sand near the middle of the unit. Grain sizes typically coarsen below this interval, grading into a gravelly sand near the basal section of the fluvial deposits.

2.1.4 Cockfield Formation

The Cockfield Formation, a part of the Jackson-upper Claiborne confining unit, is a heterogeneous formation of very fine silty sand interbedded with clay and silt lenses or clay with interbedded fine sand lenses. It underlies the fluvial deposits and deep alluvium, and locally serves as part of the lower confining unit for the alluvial-fluvial deposits aquifer.

2.1.5 Cook Mountain Formation

The Eocene-age Cook Mountain Formation, which underlies the Cockfield Formation, consists predominantly of clay and silt; however, minor lenses of silty fine sand may be present locally. The Cook Mountain Formation, which contains the most aerially extensive clay in the upper part of the Claiborne Group in Shelby County, locally serves as the lower confining unit for the alluvial-fluvial deposits and Cockfield aquifers and is the upper confining unit for the Memphis aquifer, which is the principal source of public drinking water in the Memphis area.

2.2 Site-Specific Geology and Hydrogeology

Of the stratigraphic formations described in Section 2.1, only the following were encountered during the Assembly E investigation: alluvium, loess, fluvial deposits, and the Cockfield Formation. For this RFI report, it is presumed that alluvium is present from ground surface to the top of the Cockfield Formation at SWMUs within approximately 1,000 feet of Big Creek Drainage Canal (SWMUs 2, 9, 65, and the southernmost portion of the SWMU 38 drainage ditches), and that loess and fluvial deposits are present from ground surface to the top of the Cockfield Formation elsewhere (SWMUs 14, 59, and the central and northern portions of the SWMU 38 drainage ditches).

2.2.1 Sources of Stratigraphic and Hydrogeologic Information

Several sources of information were used to evaluate the site-specific geology and hydrogeology of Assembly E SWMUs. The sources of information are listed below, followed by the data they generated. Based on these data, the site-specific geology and hydrogeology of the Assembly E SWMUs are discussed in detail in Section 2.2.2.

2.2.1.1 DPT Screening Investigation of Assembly E SWMUs

Stratigraphic and hydrogeologic information generated during DPT screening investigations of Assembly E SWMUs was used to guide the placement of Assembly E soil borings and monitoring wells. Twelve piezocone soundings performed at SWMUs 2, 9, 14, and 65 generated stratigraphic information. Data measured with a transducer attached to a hydrocone groundwater sampler were used in computer programs to produce horizontal permeability estimates and other hydrogeologic information and to generate 56 hydrocone plots during the DPT investigations of SWMUs 2, 9, and 14. *(Note: Horizontal permeability estimates are not available from the DPT investigations of SWMUs 59 and 65, where a GeoProbe sampling device was used to collect groundwater screening samples).* Figure 2.1 shows the DPT piezocone and sampling locations. Appendix B contains the piezocone soundings, lithologic descriptions, and hydrocone plots. Section 3.2.1 describes the procedures used to collect these measurements.

The information generated during the DPT investigations identified two discrete units at the Assembly E SWMUs. The upper unit (loess or upper alluvium, depending on the proximity to Big Creek Drainage Canal) consisted of less-permeable silty material. The lower unit (fluvial deposits or deep alluvium, depending on the proximity to Big Creek Drainage Canal) consisted of more-permeable sand. Table 2.1 summarizes the estimated contact between the silt and sand units at SWMUs 2, 9, 14, and 65, and lists horizontal permeability estimates for the loess and upper fluvial deposits at SWMU 14 and the upper and deep alluvium at SWMUs 2 and 9.

2.2.1.2 Stratigraphic Soil Borings

The following were used to evaluate Assembly E SWMU stratigraphy: stratigraphic soil boring logs from a Southside public water supply well, two USGS stratigraphic test holes, eight Southside background monitoring wells, two SWMU 2 soil borings, and 57 new and previously installed monitoring wells at Assembly E SWMUs. Figure 2.2 shows the locations of the Southside soil borings and monitoring wells used for the evaluation. Table 2.2 lists the depth of each soil boring along with the thickness of each stratigraphic unit encountered during drilling activities. Appendix C contains copies of the boring logs for the stratigraphic soil borings listed in Table 2.2, except for USGS test holes TH-7 and TH-8. Lithologic descriptions for TH-7 and TH-8 in this section were based on oral and written communication between E/A&H and USGS during 1996. The following paragraphs identify the soil borings used to evaluate the Assembly E stratigraphy.

Public Supply Well PW-5

A stratigraphic boring (Sh:U-59) was drilled and visually logged by Layne Western Company, Inc., in 1983 before the company installed Southside production well PW-5 in 1985. This soil boring was advanced from land surface through the loess, fluvial deposits, Cockfield Formation, Cook Mountain Formation, Memphis Sand, Flour Island Formation, and terminated in the Old Breastworks Formation just below the base of the Fort Pillow Sand at 1,496 feet bls.

Table 2.1
Assembly E DPT Screening Investigation — Piezocone and Hydrocone Results Summary

DPT Piezocone/Hydrocone Result	SWMU 2	SWMU 9	SWMU 14	SWMU 65
Estimated Contact Between Silt and Sand Units from Piezocone Soundings (feet bls)	34 - 35' (P-23; northwest corner) 32 - 33' (P-24, northeast corner) 24 - 25' (P-20; southwest corner) 29 - 30' (P-13; southeast corner)	40 - 41' (09-P14; northwest corner) 40 - 41' (09-P09; northeast corner) 34 - 35' (09-P17; southwest corner) 34 - 35' (09-P21; southeast corner)	37 - 38' (14-P05; north side of site) 29 - 30' (14-P06; south side of site)	23 - 24' (65-P06; west side of site) 28 - 29' (65-P01; east side of site)
Horizontal Permeability Range — Loess	NA[a]	NA	2.07×10^{-6} cm/sec[b] to 1.37×10^{-4} cm/sec	NA
Horizontal Permeability Range — Upper Fluvial Deposits	NA	NA	6.39×10^{-7} cm/sec to 1.81×10^{-4} cm/sec	NA
Horizontal Permeability Range — Upper Alluvium	1.10×10^{-7} cm/sec to 1.59×10^{-5} cm/sec	NA	NA	—[c]
Horizontal Permeability Range — Deep Alluvium	9.87×10^{-7} cm/sec to 1.18 to 10^{3} cm/sec	3.47×10^{-6} cm/sec to 1.0×10^{3} cm/sec	NA	—

Notes:
a — NA denotes not applicable; this unit is either not present at the SWMU or does not contain adequate water for sampling.
b — cm/sec denotes centimeters per second
c — denotes that horizontal permeability measurements are not available; groundwater samples were collected with a GeoProbe sampler (which is not equipped with a transducer) at SWMU 65.

Table 2.2
Summary of Assembly E and Other Southside Soil Borings/Monitoring Wells

Soil Boring/ Monitoring Well Designation	Date Completed or Installed	Lithologic Unit[a]	Borehole Depth[b] (ft bls)[c]	Screened Interval (ft bls)	Loess or Upper Alluvium Interval and Thickness (ft bls)	Fluvial Deposits or Deep Alluvium Interval and Thickness (ft bls)	Cockfield Formation Interval and Thickness (ft bls)	TOC[d]/Ground Surface Elevation (feet msl)[e]
Stratigraphic Test Boring for Production Well PW-5								
PW-5 (Sh:U-59)	1983	FPS	1,500	NA[f]	0 - 38 (38)	38 - 97 (59)	97 - 134 (37)	NA/265
USGS Stratigraphic Test Borings								
TH-7 (Sh:V-79)[g]	04/08/95	CM	202	NA	0 - 34 (34)	34 - 47 (13)	47 - 173 (126)	NA/266
TH-8 (Sh:V-80)[g]	04/12/95	CM	182	NA	0 - 35 (35)	35 - 45 (10)	45 - 153 (108)	NA/267
Southside Background Soil Borings/Monitoring Wells								
0BGS02LS/0BGG02LS	01/12/95	LS	20	9.5 - 19.5	0 - 30 (30)	30 - 77 (47)	77 - > 87 (> 10)	274.87/273.00
0BGS02UF/0BGG02UF	01/17/95	UF	46	35.5 - 45.5	0 - 30 (30)	30 - 77 (47)	77 - > 87 (> 5)	274.67/272.77
0BGS02LF/0BGG02LF	01/17/95	LF	87	53.8 - 63.8	0 - 30 (30)	30 - 77 (47)	77 - > 87 (> 10)	274.74/272.82
0BGS04LS/0BGG04LS	01/11/95	LS	20	9.5 - 19.5	0 - 38 (38)	38 - 71 (33)	71 - > 76 (> 5)	265.08/262.18
0BGS04UF/0BGG04UF	01/16/95	UF	50	39.5 - 49.5	0 - 38 (38)	38 - 71 (33)	71 - > 76 (> 5)	264.63/262.30
0BGS04LF/0BGG04LF	01/11/95	LF	76	59.5 - 69.5	0 - 38 (38)	38 - 71 (33)	71 - > 76 (> 5)	264.63/262.25
0BGS11MA/0BGG11MA	02/18/96	MA	76	38 - 48	0 - 36 (36)	36 - 69 (33)	69 - > 76 (> 7)	263.84/261.81
0BGS12UF/0BGG12UF	02/18/96	UF	66	36 - 46	0 - 30 (30)	30 - 47 (17)	47 - > 66 (> 19)	268.71/268.90
SWMU 2 — Existing Monitoring Wells								
0GMG01DA	12/07/84	DA	49	44 - 49	0 - 35 (35)	35 - > 50 (> 15)	NA	1.01064108809
0GMG02DA	06/17/85	DA	44	39 - 44	0 - 30 (30)	30 - 46 (16)	46 - > 48 (> 2)	269.45/266.71
0GMG03DA	12/14/84	DA	45	40 - 45	0 - 30 (30)	30 - > 47 (> 17)	NA	270.54/267.47
0GMG04UA	12/15/84	UA	22	17 - 22	0 - > 22.5 (> 22.5)	NA	NA	270.30/267.64
0GMG05DA	12/15/84	DA	57	52 - 57	0 - 40 (40)	40 - > 50 (> 10)	NA	268.29/265.58
SWMU 2 — Assembly E Soil Borings								
002S0029	02/06/96	CF	55	NA	0 - 35 (35)	35 - 50 (15)	50 - > 55 (> 5)	NA/266.60
002S0030	02/01/96	CF	50	NA	0 - 24 (24)	24 - 48 (24)	48 - > 50 (> 2)	NA/265.60

Table 2.2
Summary of Assembly E and Other Southside Soil Borings/Monitoring Wells

Soil Boring/ Monitoring Well Designation	Date Completed or Installed	Lithologic Unit[a]	Borehole Depth[b] (ft bls)[c]	Screened Interval (ft bls)	Loess or Upper Alluvium Interval and Thickness (ft bls)	Fluvial Deposits or Deep Alluvium Interval and Thickness (ft bls)	Cockfield Formation Interval and Thickness (ft bls)	TOC[d]/Ground Surface Elevation (feet msl)[e]
SWMU 2 — Assembly E Soil Borings/Monitoring Wells								
002S01UA/002G01UA	02/13/96	UA	27	17 - 27	0 - 39 (39)	39 - 59 (20)	59 - > 66 (> 7)	269.30/266.72
OO2S01DA/002G01DA	02/13/96	DA	66	48 - 58	0 - 39 (39)	39 - 59 (20)	59 - > 66 (> 7)	269.55/266.90
002S02UA/002G02UA	02/13/96	UA	27	17 - 27	0 - 38 (38)	38 - 53 (15)	53 - > 56 (> 3)	269.57/267.43
002S02DA/002G02DA	02/07/96	DA	56	41 - 51	0 - 38 (38)	38 - 53 (15)	53 - > 56 (> 3)	269.56/267.09
002S03UA/002G03UA	02/06/96	UA	27	17 - 27	0 - 29 (29)	29 - 48 (19)	48 - > 60 (> 12)	269.73/267.28
002S03DA/002G03DA	02/06/96	DA	60	38 - 48	0 - 29 (29)	29 - 48 (19)	48 - > 60 (> 12)	269.62/267.16
002S04UA/002G04UA	02/05/96	UA	27	17 - 27	0 - 35 (35)	35 - 50 (15)	50 - > 55 (> 5)	268.76/266.53
002S05UA/002G05UA	02/05/96	UA	27	17 - 27	0 - 34 (34)	34 - 50 (16)	50 - > 55 (> 5)	269.39/267.14
002S05DA/002G05DA	02/05/96	DA	55	40.5 - 50.5	0 - 34 (34)	34 - 50 (16)	50 - > 55 (> 5)	269.33/267.16
002S06UA/002G06UA	02/02/96	UA	27	17 - 27	0 - 32 (32)	32 - 54 (22)	54 - > 55 (> 1)	269.61/267.82
002S06DA/002G06DA	02/02/96	DA	55	44.5 - 54.5	0 - 32 (32)	32 - 54 (22)	54 - > 55 (> 1)	269.69/267.86
002S07UA/002G07UA	02/01/96	UA	27	17 - 27	0 - 24 (24)	24 - 48 (24)	48 - > 50 (> 2)	268.21/266.10
002S08UA/002G08UA	02/01/96	UA	27	17 - 27	0 - 22 (22)	22 - 45 (23)	45 - > 51.5 (> 6.5)	269.37/267.05
002S08DA/002G08DA	01/31/96	DA	51.5	35 - 45	0 - 22 (22)	22 - 45 (23)	45 - > 51.5 (> 6.5)	269.33/267.10
002S09UA/002G09UA	01/30/96	UA	27	17 - 27	0 - 26 (26)	26 - 46 (20)	46 - > 55 (> 9)	268.09/265.68
002S09DA/002G09DA	01/30/96	DA	55	36 - 46	0 - 26 (26)	26 - 46 (20)	46 - > 55 (> 9)	267.96/265.51
002S10UA/002G10UA	02/13/96	UA	32	22 - 32	0 - 36 (36)	36 - 50 (14)	50 - > 56 (> 6)	270.19/270.36
002S10DA/002G10DA	02/13/96	DA	56	40 - 50	0 - 36 (36)	36 - 50 (14)	50 - > 56 (> 6)	270.17/270.36
002S11UA/002G11UA	01/18/96	UA	26.75	16.75 - 26.75	0 - 33 (33)	33 - 43 (10)	43 - > 46 (> 3)	266.91/265.12
002S11DA/002G11DA	01/17/96	DA	46	32.2 - 42.2	0 - 33 (33)	33 - 43 (10)	43 - > 46 (> 3)	266.77/265.17
002S12UA/002G12UA	01/29/96	UA	27	17 - 27	0 - 35 (35)	35 - 51 (16)	51 - > 51.5 (> 1.5)	268.63/266.64
002S12DA/002G12DA	01/30/96	DA	50	38.5 - 48.5	0 - 35 (35)	35 - 51 (16)	51 - > 51.5 (> 1.5)	268.63/266.56
002S13UA/002G13UA	01/23/96	UA	27	17 - 27	0 - 34 (34)	34 - 66 (32)	66 - > 67 (> 1)	268.96/267.13

Table 2.2
Summary of Assembly E and Other Southside Soil Borings/Monitoring Wells

Soil Boring/ Monitoring Well Designation	Date Completed or Installed	Lithologic Unit[a]	Borehole Depth[b] (ft bls)[c]	Screened Interval (ft bls)	Loess or Upper Alluvium Interval and Thickness (ft bls)	Fluvial Deposits or Deep Alluvium Interval and Thickness (ft bls)	Cockfield Formation Interval and Thickness (ft bls)	TOC[d]/Ground Surface Elevation (feet msl)[e]
SWMU 2 — Assembly E Soil Borings/Monitoring Wells								
002S13MA/002G13MA	01/22/96	MA	46	36 - 46	0 - 34 (34)	34 - 66 (32)	66 - > 67 (> 1)	269.20/267.23
002S13DA/002G13DA	01/20/96	DA	67	55 - 65	0 - 34 (34)	34 - 66 (32)	66 - > 67 (> 1)	269.12/267.05
002S14UA/002G14UA	02/14/96	UA	27	17 - 27	0 - 32 (32)	32 - 66 (34)	66 - > 76 (> 10)	271.23/269.17
002S14DA/002G14DA	02/14/96	DA	76	40 - 50	0 - 32 (32)	32 - 66 (34)	66 - > 76 (> 10)	271.00/269.00
SWMU 9 — Assembly E Soil Borings/Monitoring Wells								
009S01DA/009G01DA	02/15/96	DA	66	46 - 56	0 - 39 (39)	39 - 56 (17)	56 - > 66 (> 10)	271.62/269.69
009S02DA/009G02DA	02/16/96	DA	56	36 - 46	0 - 40 (40)	40 - 46 (6)	46 - > 56 (> 10)	270.80/268.85
009S03DA/009G03DA	02/01/96	DA	62	45 - 55	0 - 34 (34)	34 - 56 (22)	56 - > 62 (> 6)	269.05/267.18
009S04DA/009G04DA	02/15/96	DA	76	62 - 72	0 - 41 (41)	41 - 72 (31)	72 - > 76 (> 4)	270.09/268.15
SWMU 14 — Assembly E Soil Borings/Monitoring Wells								
014S01LS/014G01LS	01/29/96	LS	20.6	10.3 - 20.3	0 - 35 (35)	35 - 47 (12)	47 - > 51 (> 4)	269.17/267.37
014S01LF/014G01LF	01/29/96	LF	51	37 - 47	0 - 35 (35)	35 - 47 (12)	47 - > 51 (> 4)	269.11/267.24
014S02LS/014G02LS	02/14/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	270.12/268.44
014S03LS/014G03LS	02/14/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	271.09/268.64
014S04LF/014G04LF	01/23/96	LF	55	39 - 49	0 - 30 (30)	30 - 50 (20)	50 - > 55 (> 5)	270.88/268.82
014S05LS/014G05LS	01/21/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	270.12/268.24
014S06LF/014G06LF	01/21/96	LF	56	39 - 49	0 - 37 (37)	37 - 49 (12)	49 - > 56 (> 5)	270.57/268.62
014S07LF/014G07LF	01/22/96	LF	50	38 - 48	0 - 36 (36)	36 - 48 (12)	48 - > 50 (> 2)	270.63/268.88
014S08LS/014G08LS	01/22/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	268.14/268.52

Table 2.2
Summary of Assembly E and Other Southside Soil Borings/Monitoring Wells

Soil Boring/ Monitoring Well Designation	Date Completed or Installed	Lithologic Unit[a]	Borehole Depth[b] (ft bls)[c]	Screened Interval (ft bls)	Loess or Upper Alluvium Interval and Thickness (ft bls)	Fluvial Deposits or Deep Alluvium Interval and Thickness (ft bls)	Cockfield Formation Interval and Thickness (ft bls)	TOC[d]/Ground Surface Elevation (feet msl)[e]
SWMU 59 — Assembly E Soil Borings/Monitoring Wells								
059S01LS/059G01LS	03/04/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	263.24/263.40
059S02LS/059G02LS	03/02/96	LS	20	10 - 20	0 - > 20 (> 20)	NA	NA	265.18/263.16
059S03LS/059G03LS	03/04/96	LS	20	10 - 20	0 - 39 (39)	39 - > 56 (> 17)	NA	263.35/263.54
059S03UF/059G03UF	03/04/96	UF	56	44 - 54	0 - 39 (39)	39 - > 56 (> 17)	NA	263.32/263.51
SWMU 65 — Existing Monitoring Wells								
065MW01UA	10/29/92	UA	15	5 - 15	0 - > 15 (> 15)	NA	NA	263.74/263.94
065MW02UA	11/02/92	UA	14	4 - 14	0 - > 14 (> 14)	NA	NA	263.27/263.50
065MW03UA	11/02/92	UA	14	4 - 14	0 - > 14 (> 14)	NA	NA	263.17/263.30
065MW04UA	11/02/92	UA	14	4 - 14	0 - > 14 (> 14)	NA	NA	263.59/263.74
SWMU 65 — Assembly E Soil Borings/Monitoring Wells								
065S05UA/065G05UA	02/17/96	UA	20	10 - 20	0 - > 20 (> 20)	NA	NA	266.04/264.10
065S06UA/065G06UA	02/17/96	UA	20	10 - 20	0 - 29 (29)	29 - 42 (13)	42 - > 46 (> 4)	266.28/264.25
065S06DA/065G06DA	02/17/96	DA	46	32 - 42	0 - 29 (29)	29 - 42 (13)	42 - > 46 (> 4)	266.12/264.18
065S07UA/065G07UA	02/17/96	UA	20	10 - 20	0 - > 20 (> 20)	NA	NA	264.86/262.85

Notes:

a — For soil borings, the indicated lithologic unit is the one present at the base of the soil boring. For monitoring wells, the lithologic unit at the base of each soil boring is indicated. For soil borings/monitoring wells, the indicated lithologic unit is the one present in the screened interval. Lithologic symbols are as follows: FPS = Fort Pillow Sand; MS = Memphis Sand; LS = loess; UF = upper fluvial deposits; LF = lower fluvial deposits; UA = upper alluvium; MA = middle alluvium; DA = deep alluvium; CF = Cockfield Formation

b — Borehole depth is the depth in feet below land surface of the soil boring.

c — ft bls = feet below land surface

d — TOC = top of casing elevation

e — ft msl = feet with respect to mean sea level

f — NA = not applicable

g — No boring logs are available for the USGS stratigraphic soil borings; USGS provided oral and written lithologic descriptions to E/A&H during 1996.

USGS Stratigraphic Test Holes

In 1995, the USGS completed two Southside stratigraphic test holes near Assembly E SWMUs. Test hole TH-7, approximately 75 feet north of SWMU 14, was advanced through the loess, fluvial deposits, and Cockfield Formation, and terminated in the Cook Mountain Formation at a depth of 202 feet bls. Test hole TH-8, near the southeast corner of the SWMU 9 sewage lagoons, was advanced through the alluvium and Cockfield Formation and terminated at a depth of 182 feet in the Cook Mountain Formation.

Background Monitoring Wells

During the Assembly A RFI, two background well clusters (0BGG02LS/0BGG02UF/0BGG02LF and 0BGG04LS/0BGG04UF/0BGG04LF) were installed on the Southside in January 1995. Wells in each of these clusters were screened in the loess, upper fluvial deposits, and lower fluvial deposits. Two additional background wells (0BGG11MA and 0BGG12UF) were installed on the Southside in February 1996. Well 0BGG11MA was screened in the middle alluvium, and well 0BGG12UF was screened in the upper fluvial deposits. A USGS geologist logged the stratigraphic soil borings associated with these monitoring wells.

New and Existing Soil Borings and Monitoring Wells at Assembly E SWMUs

During the Assembly E RFI, an E/A&H or USGS geologist continuously sampled, classified, and logged two deep alluvium soil borings at SWMU 2 near existing G&M monitoring wells, and 30 fluvial deposits or deep alluvium soil borings associated with the installation of 48 Assembly E monitoring wells. Of these monitoring wells, 24 were installed in the loess or upper alluvium, one was installed in the middle alluvium, and 23 were installed in the deep alluvium. Twenty-eight of the wells were installed in shallow-deep well pairs. Three were installed in a cluster. The 17 remaining wells were installed as single wells.

Prior to the Assembly E RFI, Geraghty and Miller (G&M) installed one upper alluvium monitoring well and four deep alluvium monitoring wells at SWMU 2 in 1984 and 1985 as part of the CS/VP. In 1992, Memphis Environmental Center installed four upper alluvium monitoring wells at SWMU 65 in response to a jet fuel spill. Appendix C contains the boring logs for the new and existing monitoring wells at the Assembly E SWMUs.

2.2.1.3 Geotechnical Analyses

Supplemental information was obtained through geotechnical laboratory analysis of two soil samples from the Southside USGS stratigraphic test holes and 11 soil samples from various Assembly E soil borings. USGS collected soil samples from select intervals at stratigraphic test holes TH-7 and TH-8 for geotechnical analyses of porosity and permeability. Table 2.3 lists the geotechnical laboratory results for the USGS test holes. E/A&H collected Shelby tube soil samples from at least one soil boring per Assembly E SWMU from the loess/upper alluvium and the fluvial deposits/deep alluvium, except for the deep alluvium at SWMU 9 due to poor sample recovery. The samples were analyzed for the following geotechnical parameters: bulk density, percent moisture, porosity, specific gravity, and vertical permeability. Table 2.3 summarizes the porosity and vertical permeability results. Appendix C to this report contains the geotechnical laboratory reports for the soil samples collected from Assembly E soil borings.

Table 2.3
Geotechnical Laboratory Test Results — Assembly E and USGS Soil Samples

SWMU	Soil Boring	Depth (ft bls)[a]	Lithologic Unit[b]	Porosity[c]	Coefficient of Permeability (cm/sec)[c][d]	Soil Description
2	002S0030	17 - 19	UA	0.42	2.3×10^{-6}	Clayey silt
2	002S0030	41 - 43	DA	0.33	3.4×10^{-4}	Coarse sand with gravel and some clay
2	002S03DA	41 - 43	DA	0.29	8.6×10^{-4}	Clean sand with some small gravel
2	002S0029	17 - 19	UA	0.41	6.8×10^{-7}	Clayey silt
9	009S01DA	16 - 18	UA	0.43	9.6×10^{-7}	Silty clay

Table 2.3
Geotechnical Laboratory Test Results — Assembly E and USGS Soil Samples

SWMU	Soil Boring	Depth (ft bls)[a]	Lithologic Unit[b]	Porosity[c]	Coefficient of Permeability (cm/sec)[c][d]	Soil Description
9	USGS TH-8	17 - 19.5	UA	0.48	2.41×10^{-6}	Lean silt
14	014S01LF	8 - 10	LS	0.44	4.2×10^{-7}	Clayey silt
14	014S01LF	41 - 43	LF	0.32	4.0×10^{-7}	Silty clay with sand and small gravel
14	USGS TH-7	10 - 12	LS	0.41	2.83×10^{-7}	Lean silt
59	059S03UF	13 - 15	LS	0.36	5.7×10^{-7}	Clayey silt
59	059S03UF	41 - 43	UF	0.3	2.6×10^{-4}	Sandy gravel
65	065S06DA	14 - 16	UA	0.43	4.8×10^{-6}	Clayey silt
65	065S06DA	38 - 40	DA	0.2	1.8×10^{-4}	Gravelly sand; trace of silt

Notes:
a — ft bls = feet below land surface
b — Lithologic unit refers to the sampled interval. LS = loess; UF = upper fluvial deposits; LF = lower fluvial deposits; UA = upper alluvium; DA = deep alluvium
c — Porosity and the coefficient of permeability were analyzed using American Society of Testing and Materials (ASTM) Method D-5084-90.
d — cm/sec = centimeters per second.

2.2.1.4 Geophysical Logging

At least one of the deepest monitoring wells at each of SWMUs 2, 9, 14, 59, and 65, and both of the Southside background wells installed in 1996 were geophysically logged to provide additional stratigraphic information. Geophysical logging was not performed at SWMU 38; only sediment samples were collected from this SWMU. Appendix C to this report contains the geophysical logs. The following wells were logged:

SWMU 2 002G03DA, 002G09DA, 002G11DA, 002G14DA

SWMU 9 009G04DA

SWMU 14 014G04LF

SWMU 59 059G03UF

SWMU 65 065G06DA

Background 0BGG11MA, 0BGG12UF

2.2.1.5 Stratigraphic Cross Sections

The boring logs, geotechnical laboratory results, and geophysical logs were used to generate geologic cross sections defining stratigraphic relationships at SWMU 2 (Figures 2.3 and 2.4), SWMU 9 (Figures 2.5 and 2.6), SWMU 14 (Figures 2.7 and 2.8), SWMU 59 (Figure 2.9), and SWMU 65 (Figure 2.10). Section 2.2.2 discusses the stratigraphy at each Assembly E SWMU.

2.2.1.6 Groundwater Elevation Measurements

In April 1996, E/A&H collected groundwater elevation data from new and existing monitoring wells at Assembly E SWMUs, background monitoring wells throughout NSA Memphis, and select Northside monitoring wells completed in the upper and lower fluvial deposits. Groundwater elevations have been measured twice since then: once in August 1996 for SWMU 2 and background monitoring wells, and again in September 1996 for SWMU 2 monitoring wells only. Table 2.4 lists measurement dates, depth-to-water measurements, and groundwater elevations for the Assembly E and Southside background monitoring wells. The April 1996 event was the most comprehensive sampling event, so measurements from this event were used for potentiometric map construction and display. Figures 2.11 and 2.12 show potentiometric maps of the upper fluvial deposits and upper alluvium, respectively. The groundwater elevation measurements from the lower fluvial deposits and deep alluvium were combined and used to prepare Figure 2.13, because of the lithologic similarity of these units on the Southside and the probability that they are hydraulically interconnected.

2.2.1.7 Specific Capacity Testing

Groundwater movement and possible contaminant migration rates in the upper alluvium, upper fluvial deposits, lower fluvial deposits, and deep alluvium were evaluated through limited aquifer characterization of nine select wells from SWMUs 2, 9, 14, 59, and 65. Limited aquifer characterization consisted of conducting specific capacity tests for two upper alluvium monitoring wells at SWMU 2, one upper fluvial deposits well at SWMU 59, one lower fluvial deposits well at SWMU 14, and five deep alluvium monitoring wells — two at SWMU 2, two at SWMU 9, and one at SWMU 65. Groundwater migration rates in the loess were not evaluated during the RFI due to the abundant historical information from previous investigations across NSA Memphis.

E/A&H input the data from specific capacity testing into a computer program developed by Bradbury and Rothschild (1985) to facilitate the process of estimating specific capacity, transmissivity, hydraulic conductivity, and potential well yield. The procedures used for specific capacity testing and data reduction are discussed in Section 3.12.1 of this report, which also presents a table of hydraulic conductivity estimates for each tested well. Refer to Appendix D for the data from the Bradbury and Rothschild program used to estimate hydraulic conductivity. The hydraulic conductivities calculated from the lower fluvial deposits and deep alluvium were averaged to determine the mean hydraulic conductivity, because of the lithologic similarity of these units and the probability that they are hydraulically interconnected. The mean hydraulic conductivity was used to calculate estimated horizontal groundwater velocities at each SWMU.

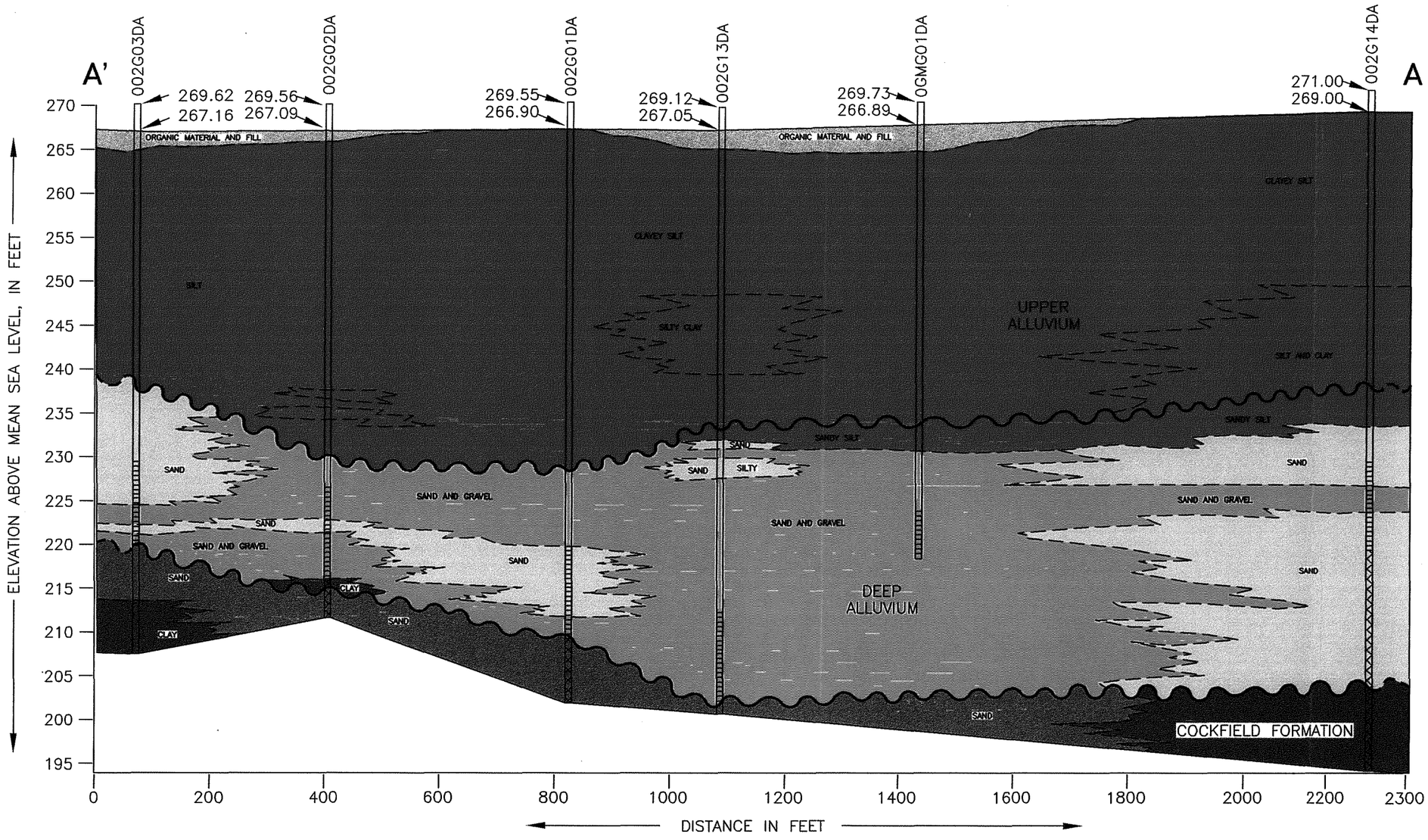
As previously outlined, Shelby tube soil samples collected from each aquifer were submitted for physical parameter analysis to obtain porosity estimates (refer to Table 2.3 and the laboratory reports in Appendix C). Based on these results, average effective porosities of 0.43 and 0.29 were calculated for the upper alluvium and fluvial deposits/deep alluvium, respectively. Horizontal hydraulic gradients for each SWMU's aquifers were obtained from the well measurements and piezometric map contours (Figures 2.11, 2.12, and 2.13).

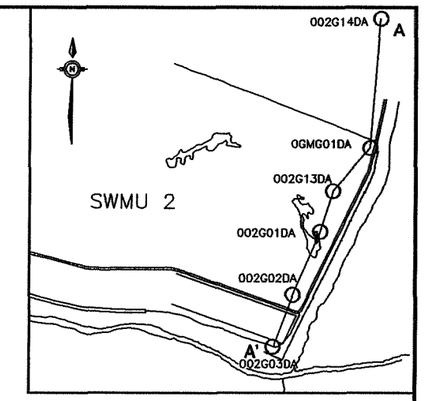
Horizontal groundwater velocities were calculated for the upper alluvium, upper fluvial deposits, and deep alluvium/lower fluvial deposits aquifers using the average hydraulic conductivities from Table 2.5 and the following derivation of Darcy's law:

$$V = Ki/n$$

where:

K = hydraulic conductivity from specific capacity tests
i = groundwater gradient
n = effective porosity of aquifer matrix





LEGEND

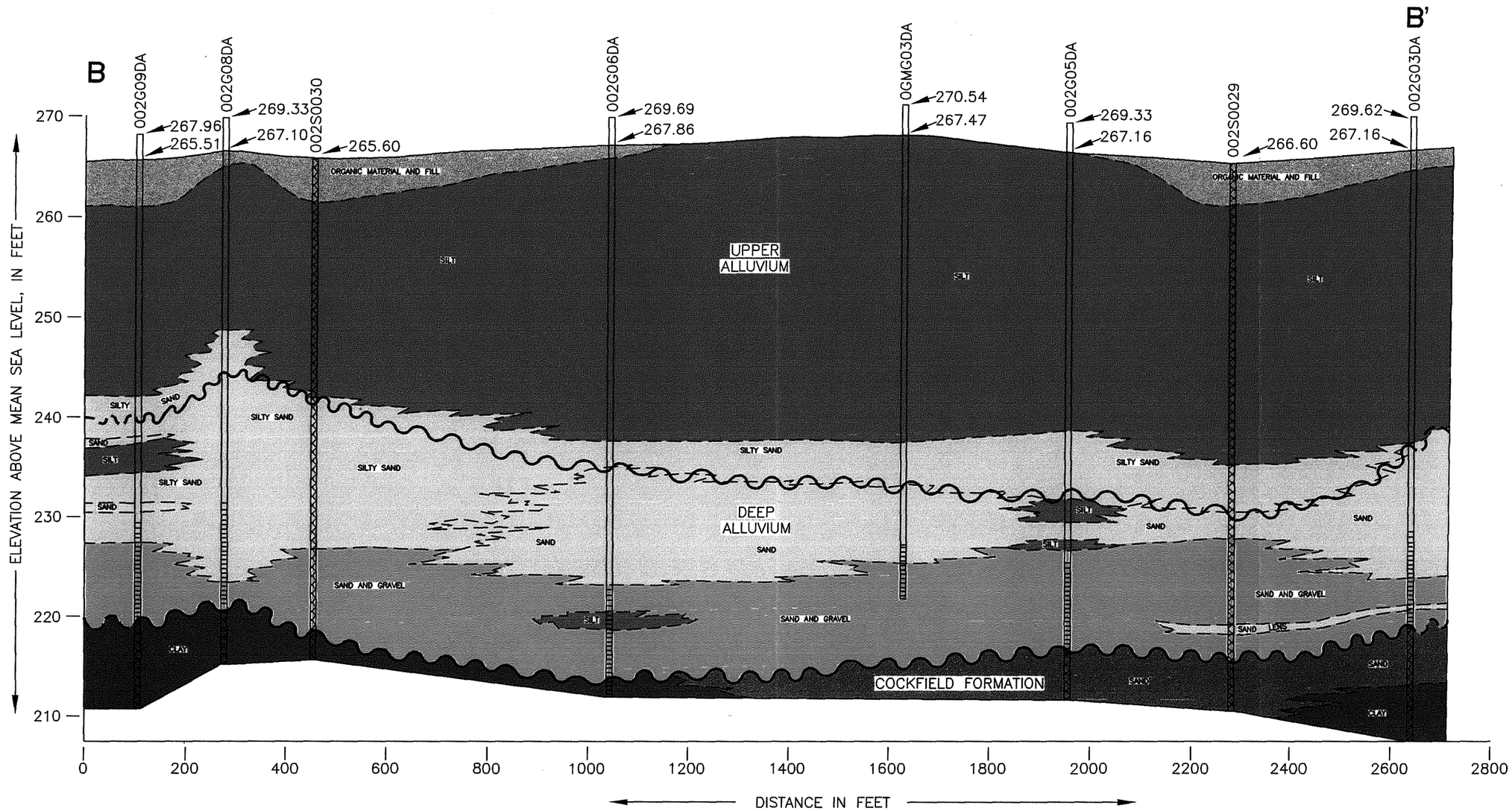
- ORGANIC MATERIAL AND FILL
- SILTY CLAY, CLAYEY SILT, SILT SANDY SILT
- SILTY SAND, SAND
- SAND AND GRAVEL
- SAND WITH CLAY, SAND
- CLAY, CLAY WITH SAND LAMINATIONS
- EROSIONAL CONTACT
- INFERRED CONTACT

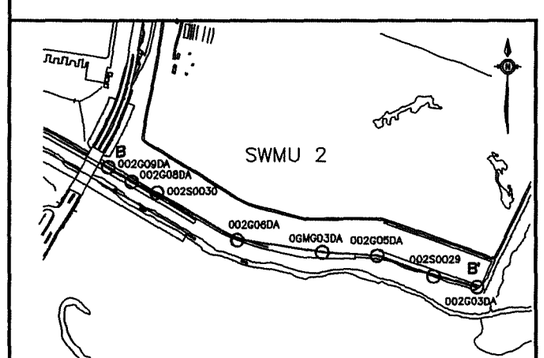
0 400
HORIZONTAL SCALE FEET
VERTICAL EXAGGERATION = 15X

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.3
GEOLOGIC CROSS SECTION (A'–A)
SWMU 2

DWG DATE:12/03/97 | DWG NAME:106S02AA





LEGEND

- ORGANIC MATERIAL AND FILL
- SILTY CLAY, CLAYEY SILT, SILT
- SILTY SAND, SAND
- SAND AND GRAVEL
- SAND WITH CLAY, SAND
- CLAY, CLAY WITH SAND LAMINATIONS
- EROSIONAL CONTACT
- INFERRED CONTACT

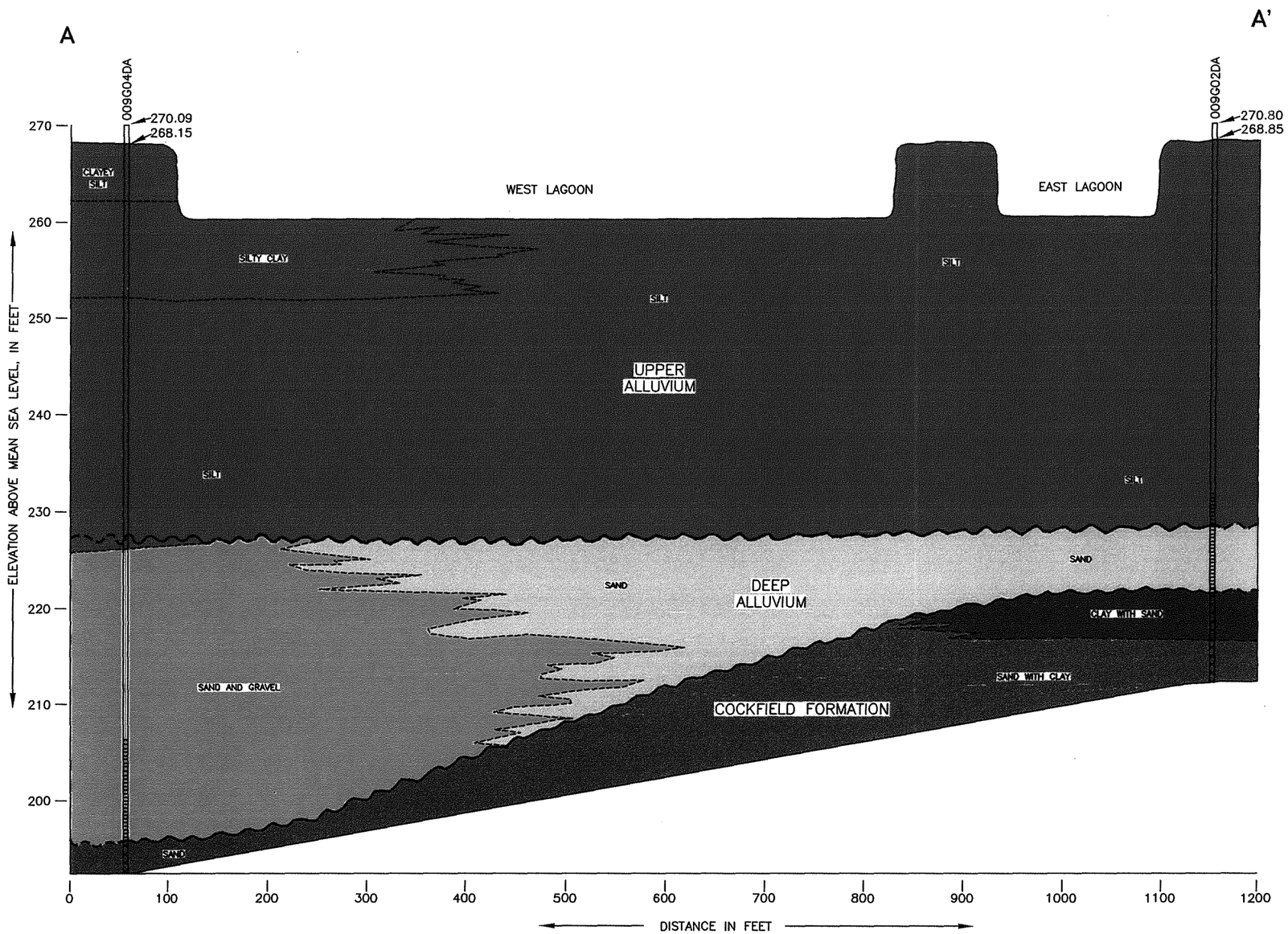
0 500
HORIZONTAL SCALE FEET

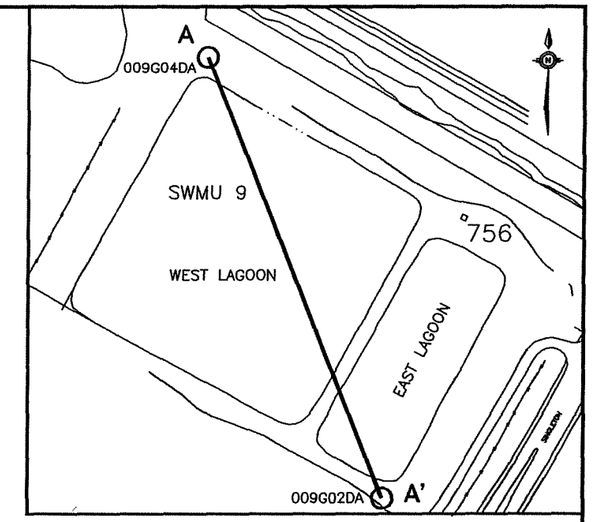
VERTICAL EXAGGERATION = 20X

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.4
GEOLOGIC CROSS SECTION (B–B')
SWMU 2

DWG DATE: 11/03/97 | DWG NAME: 106S02BB





LEGEND

- SILTY CLAY, CLAYEY SILT, SILT
- SAND
- SAND AND GRAVEL
- SAND WITH CLAY, SAND
- CLAY, CLAY WITH SAND LAMINATIONS
- EROSIONAL CONTACT
- INFERRED CONTACT

100 0 100

HORIZONTAL SCALE FEET

VERTICAL EXAGGERATION = 10X

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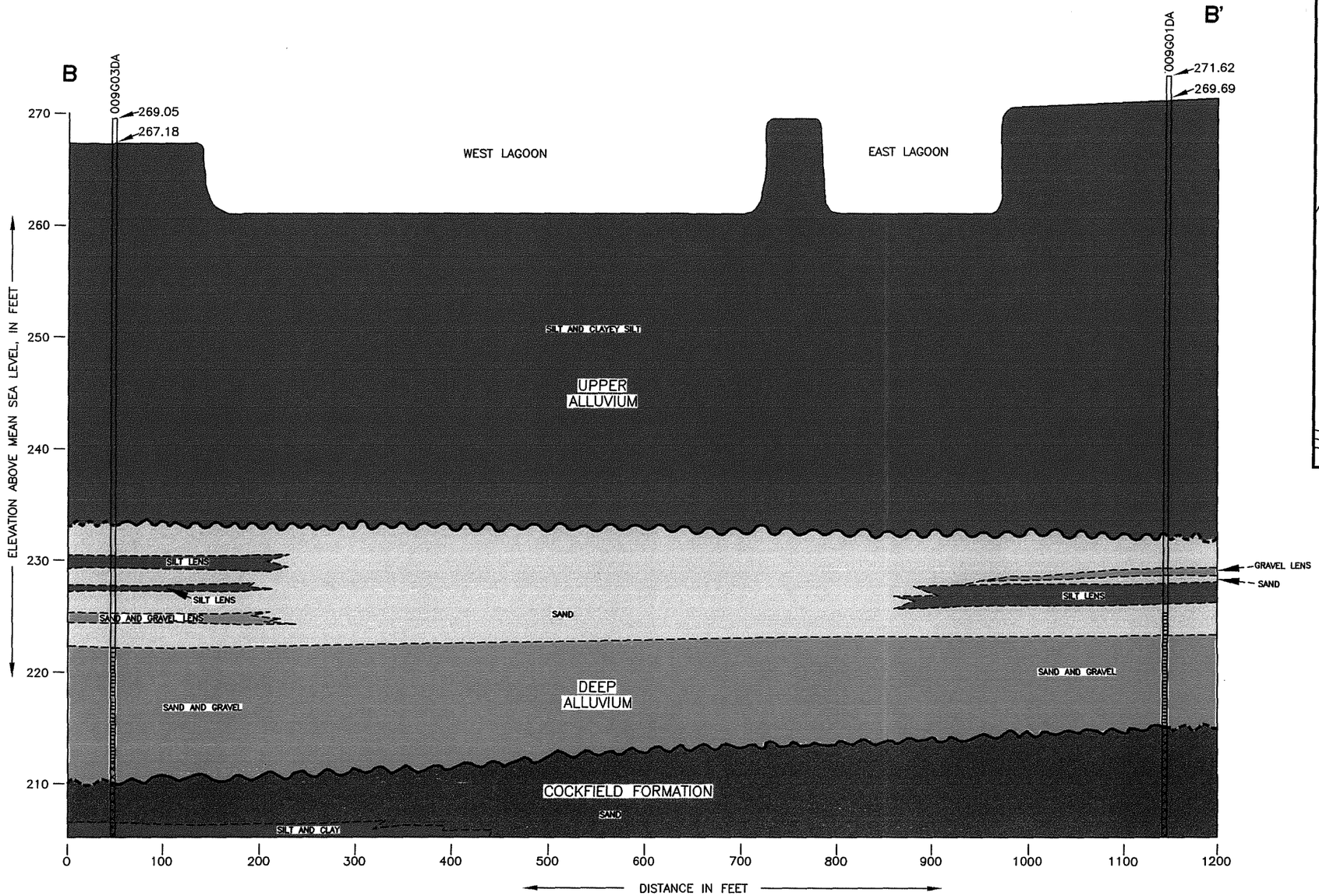
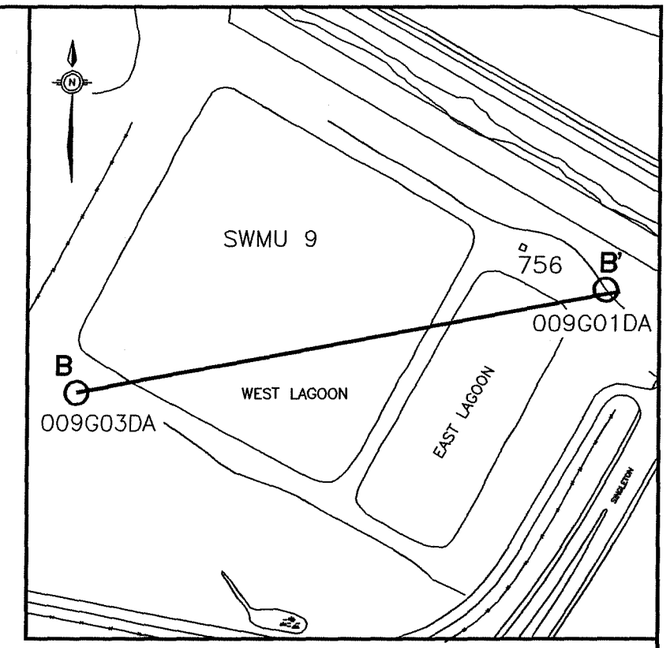
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.5
GEOLOGIC CROSS SECTION (A–A')
SWMU 9

DWG DATE: 11/03/97 | DWG NAME: 106S09AA





LEGEND

- SILTY CLAY, CLAYEY SILT, SILT
- SAND
- SAND AND GRAVEL
- SAND WITH CLAY, SAND
- EROSIONAL CONTACT
- INFERRED CONTACT

NOTE: NO SOIL SAMPLES WERE RECOVERED BETWEEN 53 AND 60 FEET BELOW LAND SURFACE AT MONITORING WELL LOCATION 009G03DA; THEREFORE, THE LITHOLOGIC CONTACT BETWEEN THE DEEP ALLUVIUM AND THE COCKFIELD FORMATION HAS BEEN ESTIMATED.

100 0 100

HORIZONTAL SCALE FEET

VERTICAL EXAGGERATION = 10X

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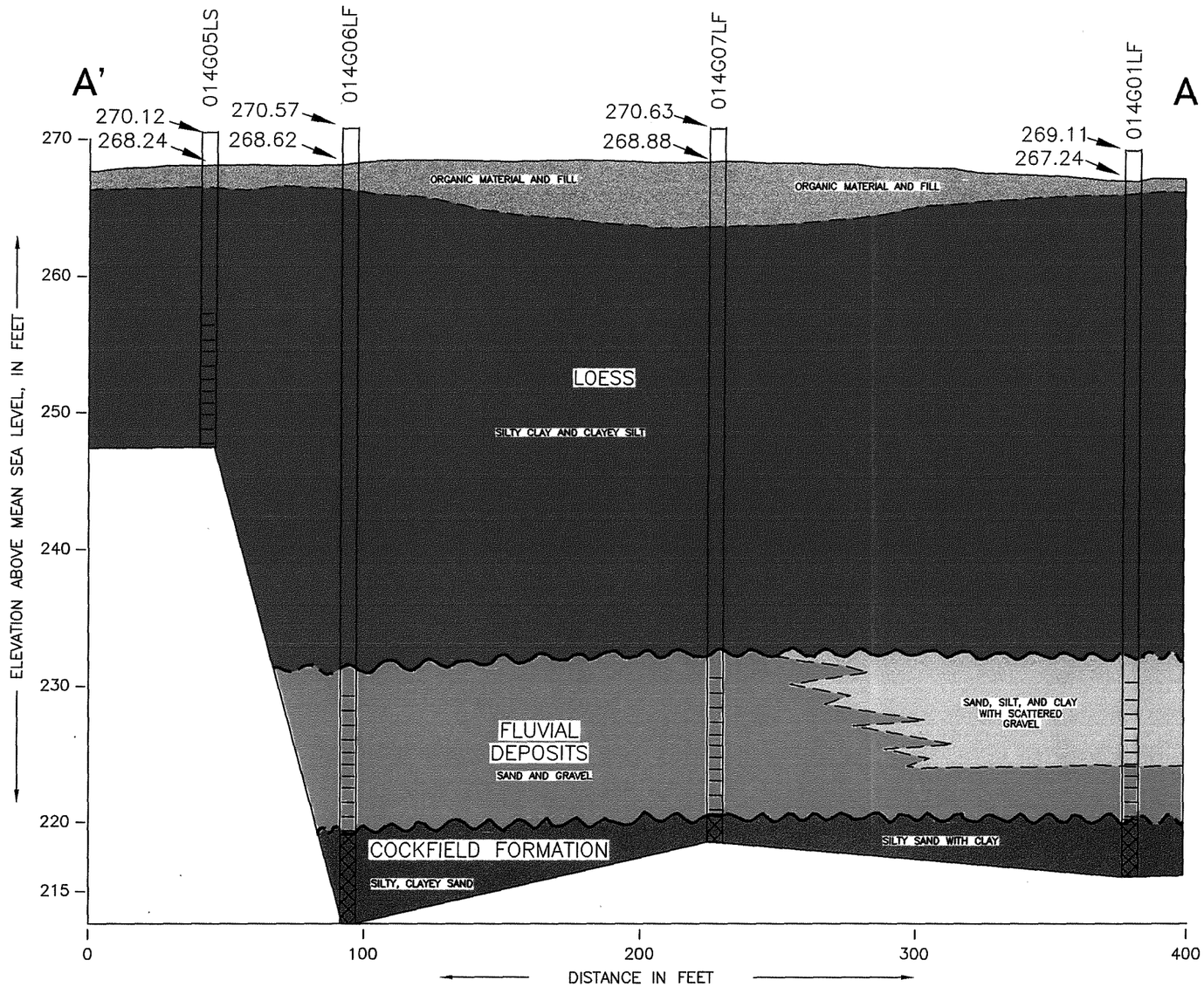
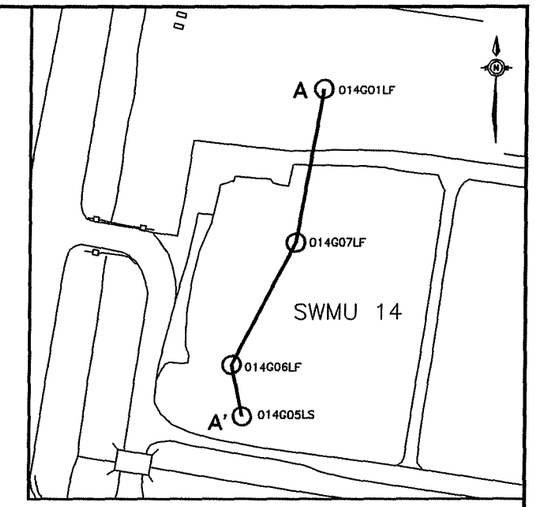
MILLINGTON, TENNESSEE

FIGURE 2.6
GEOLOGIC CROSS SECTION (B–B')
SWMU 9

DWG DATE: 11/04/97 | DWG NAME: 106S09BB





LEGEND

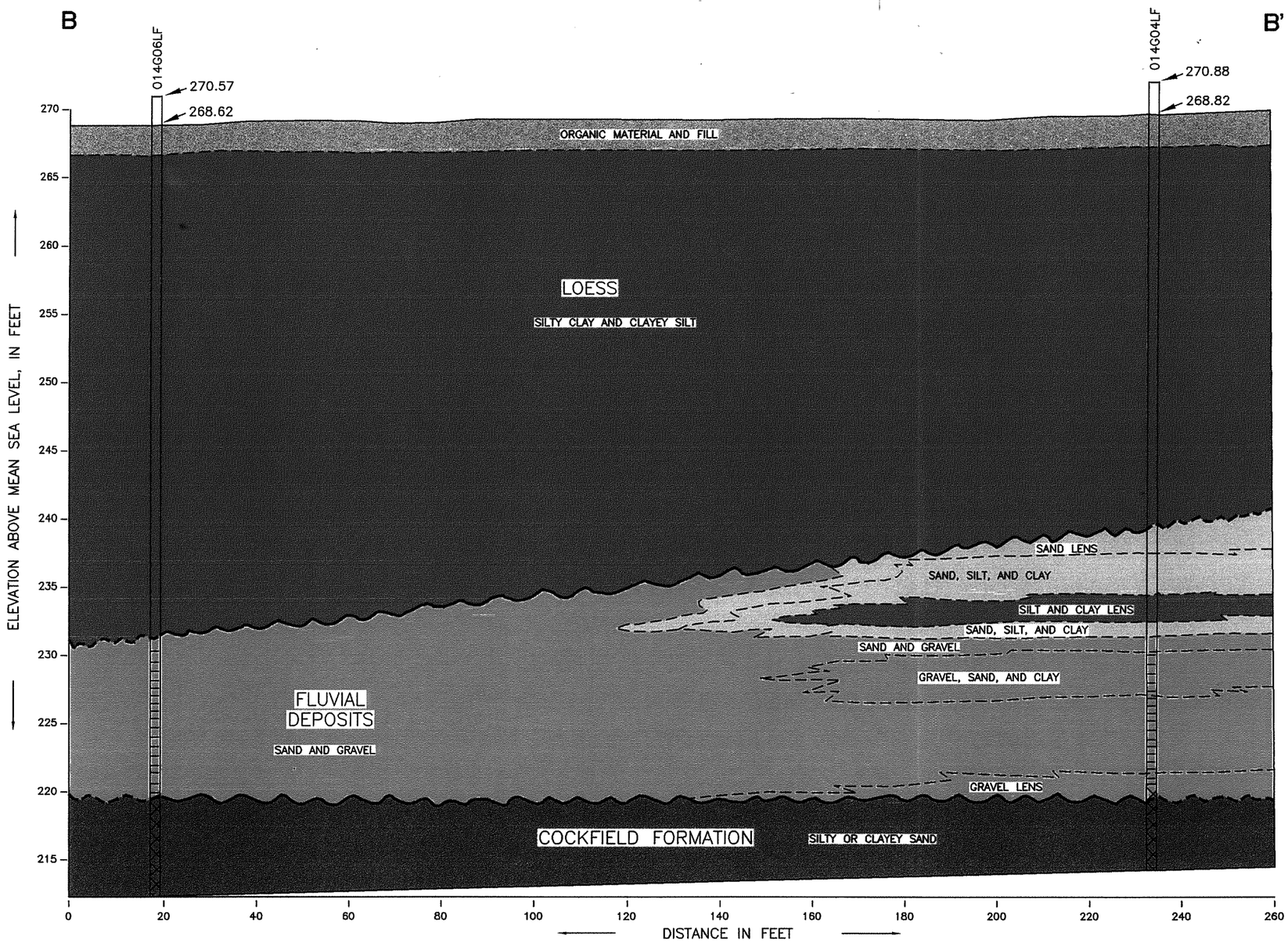
- ORGANIC MATERIAL AND FILL
- SILTY CLAY, CLAYEY SILT, SILT
- SAND; SAND, SILT, AND CLAY MIXTURES
- SAND AND GRAVEL
- SAND WITH CLAY, SAND
- EROSIONAL CONTACT
- INFERRED CONTACT

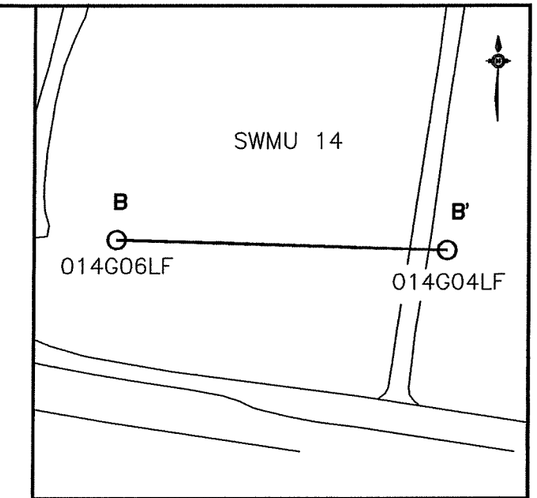
0 100
HORIZONTAL SCALE FEET
VERTICAL EXAGGERATION = 5X

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.7
GEOLOGIC CROSS SECTION (A'–A)
SWMU 14

DWG DATE: 11/04/97 | DWG NAME: 106S14AA





LEGEND

- ORGANIC MATERIAL AND FILL
- SILTY CLAY, CLAYEY SILT, SILT
- SAND; SAND, SILT, AND CLAY MIXTURES
- SAND AND GRAVEL
- SILTY OR CLAYEY SAND
- EROSIONAL CONTACT
- INFERRED CONTACT

0 — 100
HORIZONTAL SCALE — FEET

VERTICAL EXAGGERATION = 3X

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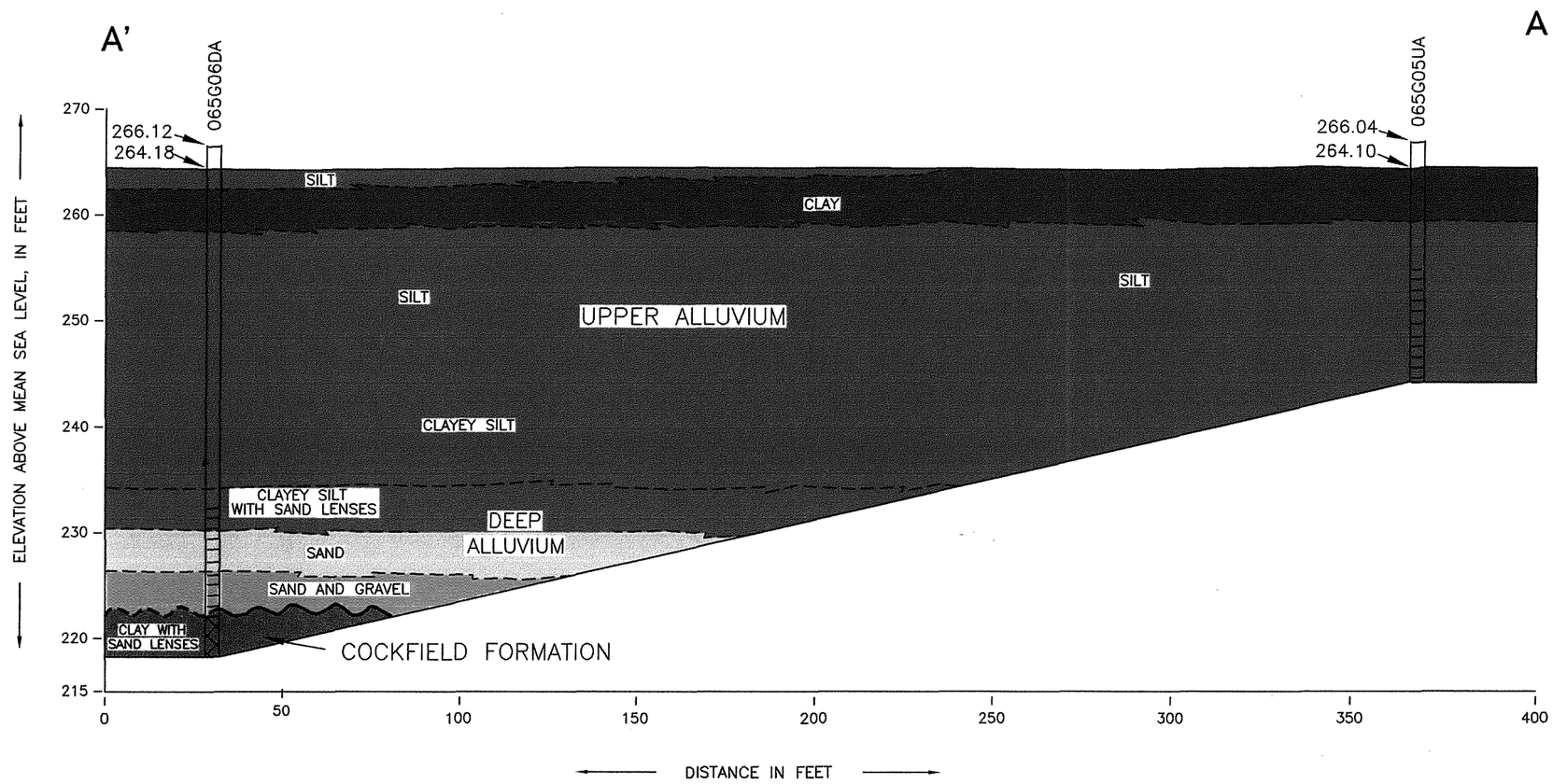
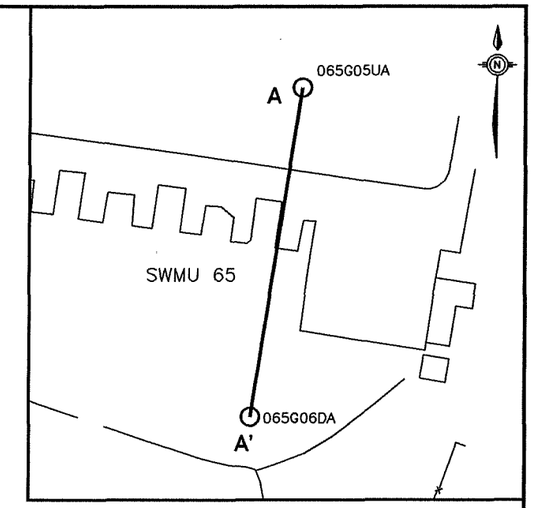
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.8
GEOLOGIC CROSS SECTION (B–B')
SWMU 14

DWG DATE: 11/04/97 | DWG NAME: 106S14BB





LEGEND

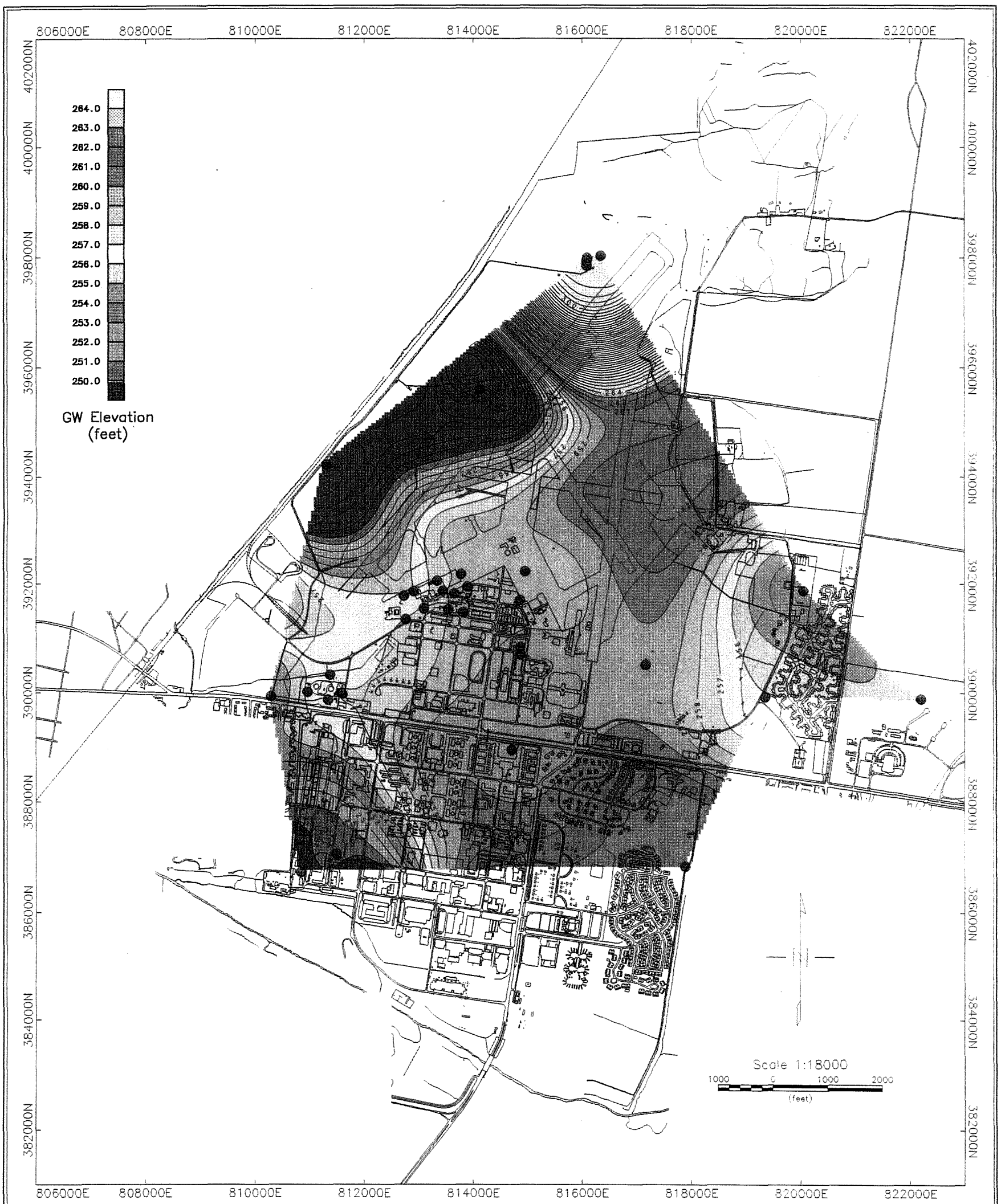
- CLAYEY SILT, SILT, SILT WITH SAND LENSES
- SAND
- SAND AND GRAVEL
- CLAY WITH SAND LENSES
- CLAY
- EROSIONAL CONTACT
- INFERRED CONTACT

0 100
HORIZONTAL SCALE FEET
VERTICAL EXAGGERATION = 3X

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.10
GEOLOGIC CROSS SECTION (A'–A)
SWMU 65

DWG DATE: 11/04/97 | DWG NAME: 106S65AA



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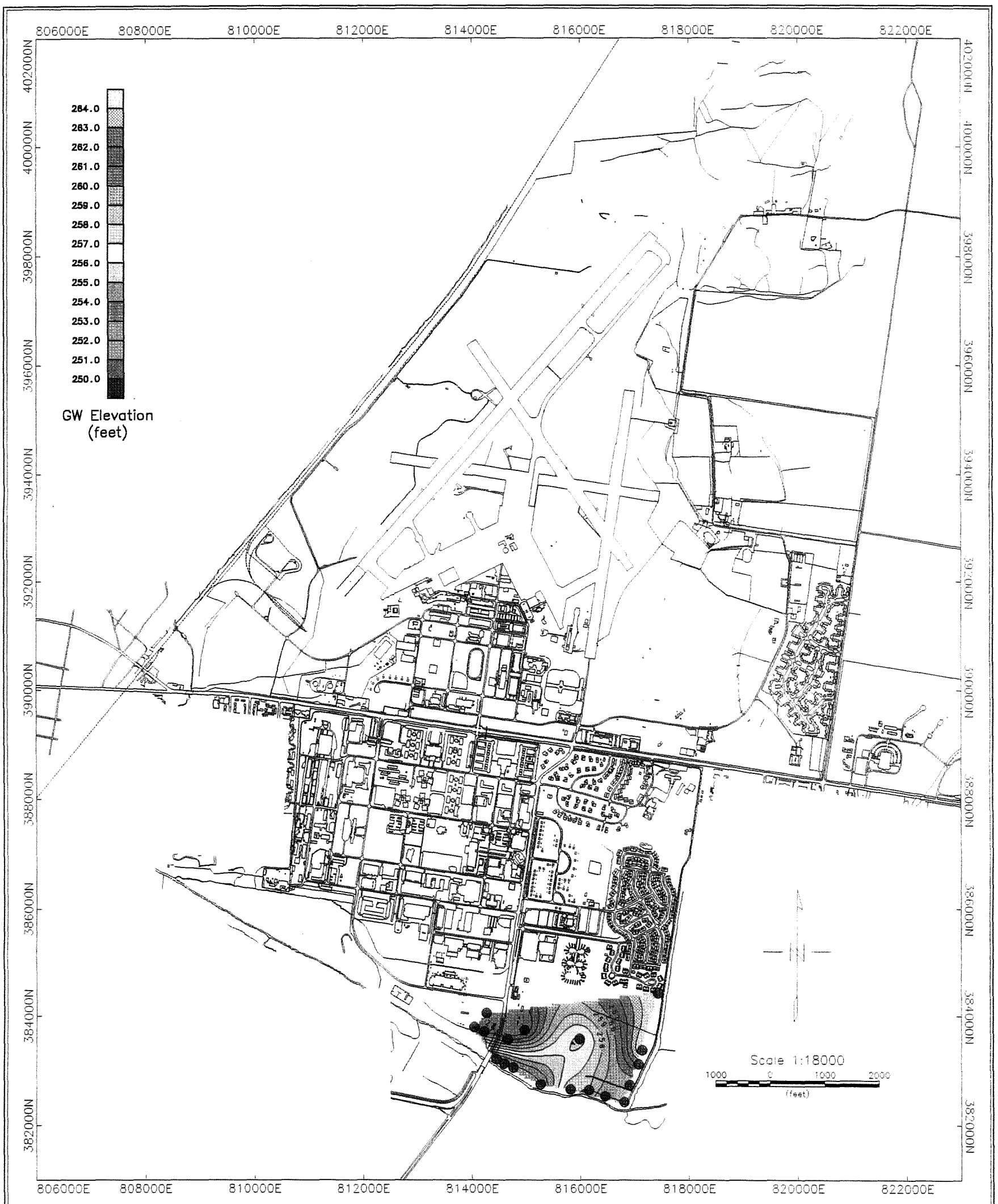
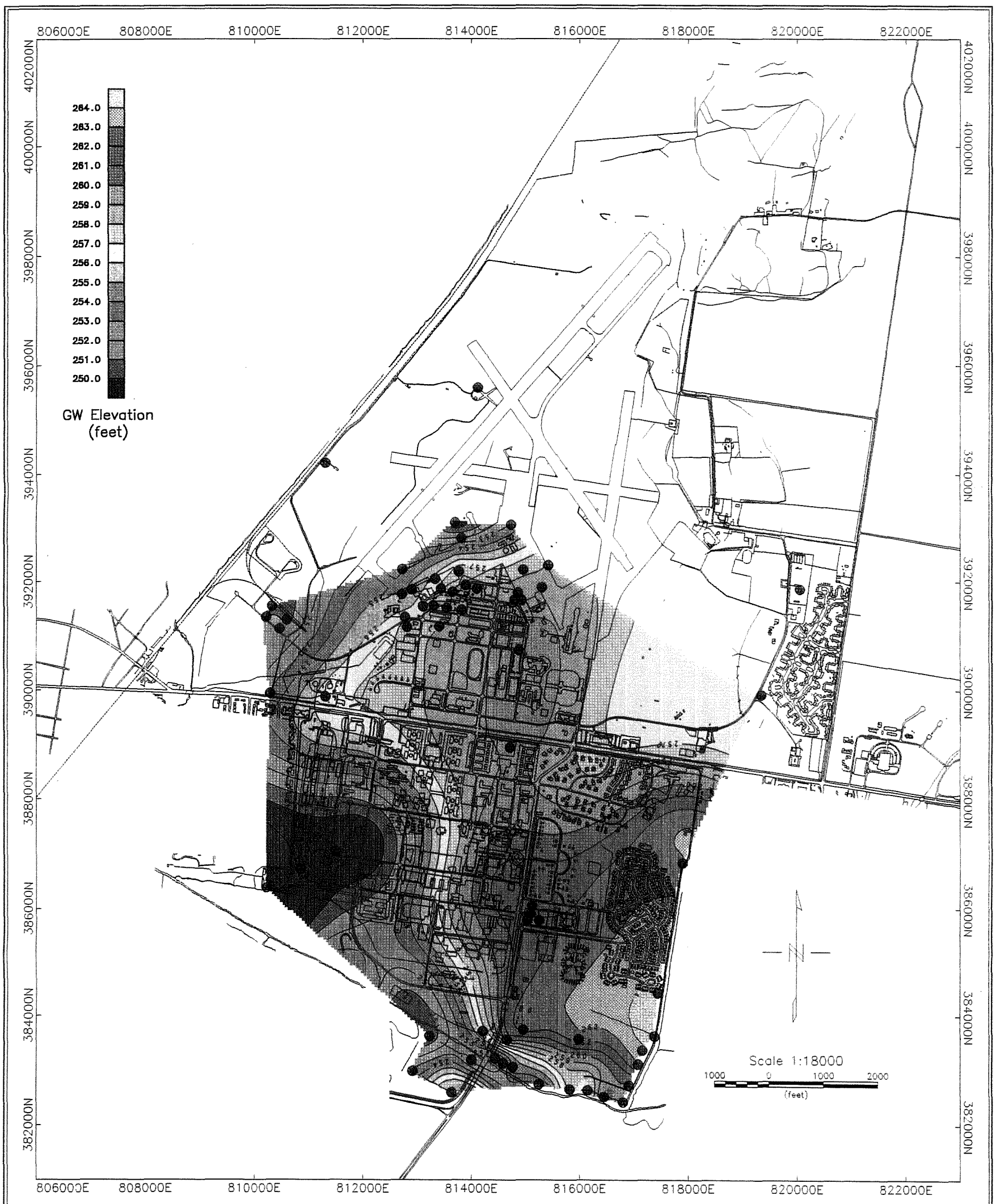
ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.11
POTENTIOMETRIC MAP OF THE
UPPER FLUVIAL DEPOSITS
GROUNDWATER ELEVATIONS
MEASURED APRIL, 1996



RCRA FACILITY
INVESTIGATION REPORT
NAVAL SUPPORT
ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.12
POTENTIOMETRIC MAP OF THE
UPPER ALLUVIUM
GROUNDWATER ELEVATIONS
MEASURED APRIL, 1996



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INVESTIGATION REPORT
NAVAL SUPPORT
ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.13
POTENTIOMETRIC MAP OF THE
LOWER FLUVIAL DEPOSITS/
DEEPER ALLUVIUM
GROUNDWATER ELEVATIONS
MEASURED APRIL, 1996

Table 2.4
Summary of Groundwater Elevations in Assembly E and Other Southside Monitoring Wells

Monitoring Well Designation	Lithologic Unit[a]	Well Depth[b] (feet bls)[c]	Screened Interval (feet bls)[c]	TOC[d]/Ground Surface Elevation (feet msl)[e]	Stickup[f] (feet)	Date Measured	Depth to Water (feet btoc[g])	Depth to Water (feet bls)[c]	Groundwater Elevation (feet msl)
Background Monitoring Wells									
0BGG02LS	LS	20.0	9.5 - 19.5	274.87/273.00	1.87	NM[h]	NM	NM	NM
0BGG02UF	UF	45.96	35.5 - 45.5	274.67/272.77	1.90	04/18/96 08/14/96	12.04 14.48	10.14 12.58	262.63 260.19
0BGG02LF	LF	64.25	53.8 - 63.8	274.74/272.82	1.92	04/18/96 08/14/96	12.09 14.61	10.17 12.69	262.65 260.13
0BGG04LS	LS	20.0	9.5 - 19.5	265.08/262.18	2.90	NM	NM	NM	NM
0BGG04UF	UF	50.0	39.5 - 49.5	264.63/262.30	2.33	04/18/96 08/14/96	14.01 16.27	11.68 13.94	250.62 248.36
0BGG04LF	LF	70.0	59.5 - 69.5	264.63/262.25	2.38	04/18/96 08/14/96	14.54 16.84	12.16 14.46	250.09 247.79
0BGG11MA	MA	48.0	38.0 - 48.0	263.84/261.81	2.03	04/08/96 08/14/96	16.42 19.02	14.39 16.99	247.42 244.82
0BGG12UF	UF	46.0	36.0 - 46.0	268.71/268.90	-0.19	04/08/96 08/14/96	9.09 10.66	9.28 10.85	259.62 258.05
SWMU 2 — Existing Monitoring Wells									
0GMG01DA	DA	49.0	44.0 - 49.0	269.73/266.89	2.84	04/23/96 08/14/96 09/11/96	5.23 10.24 12.36	2.39 7.40 9.52	264.50 259.49 257.37
0GMG02DA	DA	44.0	39.0 - 44.0	269.45/266.71	2.74	04/23/96 08/15/96 09/12/96	9.27 14.98 16.53	6.53 12.24 13.79	260.18 254.47 252.92
0GMG03DA	DA	45.0	40.0 - 45.0	270.54/267.47	3.07	04/23/96 08/15/96 09/12/96	13.28 17.94 19.36	10.21 14.87 16.29	257.26 252.60 251.18
0GMG04UA	UA	22.0	17.0 - 22.0	270.30/267.64	2.66	04/23/96 08/15/96 09/12/96	12.15 18.15 19.85	9.49 15.49 17.19	258.15 252.15 250.45
0GMG05DA	DA	57.0	52.0 - 57.0	268.29/265.58	2.71	04/23/96 08/15/96 09/11/96	13.31 18.50 19.86	10.60 15.79 17.15	254.98 249.79 248.43

Table 2.4
Summary of Groundwater Elevations in Assembly E and Other Southside Monitoring Wells

Monitoring Well Designation	Lithologic Unit[a]	Well Depth[b] (feet bls)[c]	Screened Interval (feet bls)[c]	TOC[d]/Ground Surface Elevation (feet msl)[e]	Stickup[f] (feet)	Date Measured	Depth to Water (feet btoc[g])	Depth to Water (feet bls)[c]	Groundwater Elevation (feet msl)
SWMU 2 — Assembly E Monitoring Wells									
002G01UA	UA	27.0	17.0 - 27.0	269.30/266.72	2.58	04/10/96	6.98	4.40	262.32
						08/14/96	12.38	9.80	256.92
						09/11/96	15.60	13.02	253.70
002G01DA	DA	58.0	48.0 - 58.0	269.55/266.90	2.65	04/10/96	6.49	3.84	263.06
						08/14/96	12.40	9.75	257.15
						09/03/96	14.20	11.55	255.35
002G02UA	UA	27.0	17.0 - 27.0	269.57/267.43	2.14	04/08/96	10.64	8.50	258.93
						08/14/96	14.37	12.23	255.20
						09/03/96	16.06	13.92	253.51
002G02DA	DA	51.0	41.0 - 51.0	269.56/267.09	2.47	04/08/96	9.74	7.27	259.82
						08/14/96	14.81	12.34	254.75
						09/03/96	16.19	13.72	253.37
002G03UA	UA	27.0	17.0 - 27.0	269.73/267.28	2.45	04/08/96	13.09	10.64	256.64
						08/15/96	16.28	13.83	253.45
						09/10/96	17.92	15.47	251.81
002G03DA	DA	48.0	38.0 - 48.0	269.62/267.16	2.46	04/10/96	10.91	8.45	258.71
						08/15/96	15.77	13.31	253.85
						09/10/96	17.36	14.90	252.26
002G04UA	UA	27.0	17.0 - 27.0	268.76/266.53	2.23	04/10/96	8.91	6.68	259.85
						08/15/96	14.70	12.47	254.06
						09/06/96	15.96	13.73	252.80
002G05UA	UA	27.0	17.0 - 27.0	269.39/267.14	2.25	04/10/96	11.45	9.20	257.94
						08/15/96	18.42	16.17	250.97
						09/11/96	18.67	16.42	250.72
002G05DA	DA	50.5	40.5 - 50.5	269.33/267.16	2.17	04/08/96	12.99	10.82	256.34
						08/15/96	16.33	14.16	253.00
						09/10/96	17.91	15.74	251.42
002G06UA	UA	27.0	17.0 - 27.0	269.61/267.82	1.79	04/08/96	16.74	14.95	252.87
						08/15/96	19.18	17.39	250.43
						09/06/96	19.74	17.95	249.87
002G06DA	DA	54.5	44.5 - 54.5	269.69/267.86	1.83	04/08/96	16.52	14.69	253.17
						08/15/96	19.76	17.93	249.93
						09/11/96	20.69	18.86	249.00
002G07UA	UA	27.0	17.0 - 27.0	268.21/266.10	2.11	04/08/96	15.56	13.45	252.65
						08/15/96	22.00	19.89	246.21
						09/05/96	23.18	21.07	245.03
002G08UA	UA	27.0	17.0 - 27.0	269.37/267.05	2.32	04/08/96	17.34	15.02	252.03
						08/15/96	23.13	20.81	246.24
						09/05/96	24.62	22.30	244.75
002G08DA	DA	45.0	35.0 - 45.0	269.33/267.10	2.23	04/08/96	17.54	15.31	251.79
						08/15/96	23.56	21.33	245.77
						09/05/96	24.25	22.02	245.08

Table 2.4
Summary of Groundwater Elevations in Assembly E and Other Southside Monitoring Wells

Monitoring Well Designation	Lithologic Unit[a]	Well Depth[b] (feet bls)[c]	Screened Interval (feet bls)[c]	TOC[d]/Ground Surface Elevation (feet msl)[e]	Stickup[f] (feet)	Date Measured	Depth to Water (feet btoc[g])	Depth to Water (feet bls)[c]	Groundwater Elevation (feet msl)
SWMU 2 —Assembly E Monitoring Wells									
002G09UA	UA	27.0	17.0 - 27.0	268.09/265.68	2.41	04/08/96	16.19	13.78	251.90
						08/15/96	21.91	19.50	246.18
						09/10/96	23.70	21.29	244.39
002G09DA	DA	46.0	36.0 - 46.0	267.96/265.51	2.45	04/08/96	17.15	14.70	250.81
						08/15/96	22.24	19.79	245.72
						09/10/96	23.03	20.58	244.93
002G10UA	UA	32.0	22.0 - 32.0	270.19/270.36	-0.17	04/08/96	8.79	8.96	261.40
						08/15/96	14.04	14.21	256.15
						09/11/96	18.89	19.06	251.30
002G10DA	DA	50.0	40.0 - 50.0	270.17/270.36	-0.19	04/08/96	9.36	9.55	260.81
						08/15/96	16.45	16.64	253.72
						09/11/96	19.48	19.67	250.69
002G11UA	UA	26.75	16.75-26.75	266.91/265.12	1.79	04/08/96	3.92	2.13	262.99
						08/15/96	11.48	9.69	255.43
						09/09/96	14.20	12.41	252.71
002G11DA	DA	42.2	32.2 - 42.2	266.77/265.17	1.60	04/08/96	4.17	2.57	262.60
						08/15/96	11.92	10.32	254.85
						09/09/96	14.54	12.94	252.23
002G12UA	UA	27.0	17.0 - 27.0	268.63/266.64	1.99	04/08/96	12.87	10.88	255.76
						08/15/96	17.01	15.02	251.62
						09/12/96	19.44	17.45	249.19
002G12DA	DA	48.5	38.5 - 48.5	268.63/266.56	2.07	04/08/96	6.02	3.95	262.61
						08/15/96	11.65	9.58	256.98
						09/12/96	14.04	11.97	254.59
002G13UA	UA	27.0	17.0 - 27.0	268.96/267.13	1.83	04/08/96	3.30	1.47	265.66
						08/15/96	12.20	10.37	256.76
						09/11/96	15.25	13.42	253.71
002G13MA	MA	46.0	36.0 - 46.0	269.20/267.23	1.97	04/08/96	5.38	3.41	263.82
						08/15/96	10.99	9.02	258.21
						09/10/96	13.22	11.25	255.98
002G13DA	DA	65.0	55.0 - 65.0	269.12/267.05	2.07	04/08/96	5.36	3.29	263.76
						08/15/96	10.76	8.69	258.36
						09/10/96	12.94	10.87	256.18
002G14UA	UA	27.0	17.0 - 27.0	271.23/269.17	2.06	04/08/96	5.50	3.44	265.73
						08/15/96	10.65	8.59	260.58
						09/06/96	11.98	9.92	259.25
002G14DA	DA	50.0	40.0 - 50.0	271.00/269.00	2.00	04/08/96	6.90	4.90	264.10
						08/15/96	10.84	8.84	260.16
						09/06/96	12.57	10.57	258.43

Table 2.4
Summary of Groundwater Elevations in Assembly E and Other Southside Monitoring Wells

Monitoring Well Designation	Lithologic Unit[a]	Well Depth[b] (feet bls)[c]	Screened Interval (feet bls)[c]	TOC[d]/Ground Surface Elevation (feet msl)[e]	Stickup[f] (feet)	Date Measured	Depth to Water (feet btoc[g])	Depth to Water (feet bls)[c]	Groundwater Elevation (feet msl)
SWMU 9 — Assembly E Monitoring Wells									
009G01DA	DA	56.0	46.0 - 56.0	271.62/269.69	1.93	04/08/96	19.87	17.94	251.75
009G02DA	DA	46.0	36.0 - 46.0	270.80/268.85	1.95	04/08/96	11.65	9.70	259.15
009G03DA	DA	55.0	45.0 - 55.0	269.05/267.18	1.87	04/08/96	15.79	13.92	253.26
009G04DA	DA	72.0	62.0 - 72.0	270.09/268.15	1.94	04/08/96	19.89	17.95	250.21
SWMU 14 — Assembly E Monitoring Wells									
014G01LS	LS	20.4	10.4 - 20.4	269.17/267.37	1.80	04/08/96	6.79	4.99	262.38
014G01LF	LF	47	37 - 47	269.11/267.24	1.87	04/08/96	7.46	5.59	261.65
014G02LS	LS	20	10 - 20	270.12/268.44	1.68	04/08/96	7.61	5.93	262.51
014G03LS	LS	20	10 - 20	271.09/268.64	2.45	04/08/96	8.39	5.94	262.70
014G04LF	LF	49	39 - 49	270.88/268.82	2.06	04/08/96	8.79	6.73	262.09
014G05LS	LS	20	10 - 20	270.12/268.24	1.88	04/08/96	9.84	7.96	260.28
014G06LF	LF	49	39 - 49	270.57/268.62	1.95	04/08/96	10.32	8.37	260.25
014G07LF	LF	48	38 - 48	270.63/268.88	1.75	04/08/96	9.30	7.55	261.33
014G08LS	LS	20	10 - 20	268.14/268.52	-0.38	04/16/96	6.48	6.86	261.66
SWMU 59 — Assembly E Monitoring Wells									
059G01LS	LS	20	10 - 20	263.24/263.40	-0.16	04/08/96	7.55	7.71	255.69
059G02LS	LS	20	10 - 20	265.18/263.16	2.02	04/08/96	10.14	8.12	255.04
059G03LS	LS	20	10 - 20	263.35/263.54	-0.19	04/08/96	9.50	9.69	253.85
059G03UF	UF	54	44 - 54	263.32/263.51	-0.19	04/08/96	14.63	14.82	248.69
SWMU 65 — Existing Monitoring Wells									
065MW01UA	UA	15	5 - 15	263.74/263.94	-0.20	NM	NM	NM	NM
065MW02UA	UA	14	4 - 14	263.27/263.50	-0.23	NA	NM	NM	NM
065MW03UA	UA	14	4 - 14	263.17/263.30	-0.13	NA	NM	NM	NM
065MW04UA	UA	14	4 - 14	263.59/263.74	-0.15	NA	NM	NM	NM

Table 2.4
Summary of Groundwater Elevations in Assembly E and Other Southside Monitoring Wells

Monitoring Well Designation	Lithologic Unit[a]	Well Depth[b] (feet bls)[c]	Screened Interval (feet bls)[c]	TOC[d]/Ground Surface Elevation (feet msl)[e]	Stickup[f] (feet)	Date Measured	Depth to Water (feet btoc[g])	Depth to Water (feet bls)[c]	Groundwater Elevation (feet msl)
SWMU 65 — Assembly E Monitoring Wells									
065G05UA	UA	20	10 - 20	266.04/264.10	1.94	04/08/96	3.99	2.05	262.05
065G06UA	UA	20	10 - 20	266.28/264.25	2.03	04/08/96	4.90	2.87	261.38
065G06DA	DA	42	32 - 42	266.12/264.18	1.94	04/08/96	9.62	7.68	256.50
065G07UA	UA	20	10 - 20	264.86/262.85	2.01	04/08/96	4.13	2.12	260.73

Notes:
a — The indicated lithologic unit is the one present in the screened interval of the monitoring well. LS = loess, UF = upper fluvial deposits, LF = lower fluvial deposits, UA = upper alluvium, MA = middle alluvium, DA = deep alluvium.
b — Total depth for monitoring wells is the base of the monitoring well.
c — feet bls = feet below land surface
d — TOC = top of casing elevation
e — feet msl = feet with respect to mean sea level
f — Stickup was calculated by subtracting the ground surface elevation from the top-of-casing elevation.
g — feet btoc = feet below top-of-casing
h — NM indicates groundwater levels were not measured in this well during 1996.

Table 2.5
Specific Capacity Test Hydraulic Conductivity Estimates — Assembly E Monitoring Wells

Aquifer	Monitoring Well	Hydraulic Conductivity (K) (feet/day)
Upper Alluvium	002G03UA	0.34
	002G09UA	0.92
	Geometric Mean	**0.63**
Upper Fluvial Deposits	059G03UF	**60.2**
Lower Fluvial Deposits/ Deep Alluvium	002G03DA	4
	002G09DA	6.5
	009G01DA	21.9
	009G03DA	9
	014G07LF	1
	065G06DA	6.3
	Geometric Mean	**8.1**

The estimated horizontal groundwater velocities for each SWMU's aquifers are:

SWMU 2 Upper Alluvium = 0.63 feet/day X 0.0085 feet/foot / 0.43 = 0.012 feet/day
Deep Alluvium = 8.1 feet/day X 0.0083 feet/foot / 0.29 = 0.23 feet/day

SWMU 9 Deep Alluvium = 8.1 feet/day X 0.0091 feet/foot / 0.29 = 0.25 feet/day

SWMU 14 Lower Fluvial Deposits = 8.1 feet/day X 0.005 feet/foot / 0.29 = 0.14 feet/day

SWMU 59 Upper Fluvial Deposits = 60.2 feet/day X 0.0029 feet/foot / 0.29 = 0.6 feet/day

SWMU 65 Deep Alluvium = 8.1 feet/day X 0.014 feet/foot / 0.29 = 0.39 feet/day

These data, along with historical data from other NSA Memphis monitoring wells, were used to evaluate the hydrogeology for Assembly E SWMUs, which is discussed in Section 2.2.2.

2.2.2 Geology and Hydrogeology of Assembly E SWMUs

The following sections describe the geology and hydrogeology of Assembly E SWMUs by stratigraphy. Section 2.2.2.1 summarizes the geology and hydrology for SWMUs 2, 9, and 65, where alluvium is present. Section 2.2.2.2 summarizes the geology and hydrogeology of SWMUs 14 and 59, where loess and fluvial deposits are present.

2.2.2.1 Alluvium

Alluvium is assumed to be present from land surface to the top of the Cockfield Formation near Big Creek Drainage Canal. Therefore, soil borings and monitoring wells at SWMUs 2, 9, and 65, and background well location 0BGG11MA are presumed to be completed in the alluvium. These borings and wells are within 100 to 1,000 feet of Big Creek Drainage Canal.

Two water-bearing zones are present in the alluvium. The first water-bearing zone, present in thin sand lenses near the middle and base of the upper alluvium, appears to be unconfined. The second water-bearing zone, in the sand and gravel of the deep alluvium, appears to be semi-confined in some locations and unconfined in others, based on water elevations measured in paired monitoring wells (refer to groundwater elevations on Table 2.4).

Upper Alluvium

The upper alluvium consists of clay, silty clay, clayey silt, and silt. In general, the clay content decreased while the sand content increased with depth. The basal portion of the upper alluvium in most soil boring locations consisted of a sandy silt and silty or clayey sand. Sand laminations or lenses in the middle to lower portions of the upper alluvium were generally water-bearing, and ranged from less than 0.01 inches to 6 inches thick. The water-bearing sand laminations were more common in soil borings at SWMUs 2 and 65 than at SWMU 9.

The color of the material in the uppermost portion of the upper alluvium varied from brown, yellowish-brown, olive gray, gray, brownish-gray, and yellowish-gray with sparse to common

iron staining. The lower portion of the upper alluvium was generally greenish-gray to olive gray, with infrequent dark yellowish-orange mottling. Iron or manganese nodules were present at various depths throughout the upper alluvium. At SWMUs 2 and 9, snail shells, which are characteristic constituents of alluvium, were sparse to common from 16 to 39 feet bls. Wood fragments were occasionally observed in SWMU 2 soil borings from 23 to 39 feet bls.

The thickness of the upper alluvium ranged from 22 feet in soil boring 002S08DA to 41 feet in soil boring 009S04DA. Soil boring 002S08DA is at the southwest corner of the SWMU 2 landfill, and soil boring 009S04DA is at the northwest corner of the SWMU 9 sewage lagoons. Table 2.2 lists the thickness of the upper alluvium for soil borings at SWMUs 2, 9, and 65, and background location 0BGG11MA, while the lithologic cross sections (Figures 2.3, 2.4, 2.5, 2.6, and 2.10) graphically depict the vertical thickness. As the cross sections demonstrate, the upper alluvium thickness is fairly consistent (averaging 35 feet) across the southern portion of the NSA Memphis Southside, except for the landfill's southwest corner, where it averages 25 feet in thickness.

Soil samples collected for geotechnical analysis from the upper alluvium consisted of two SWMU 2 samples (locations 002S0029 and 002S0030 from 17 to 19 feet bls), one SWMU 9 soil sample (location 009S01DA from 16 to 18 feet bls), the USGS test hole near SWMU 9 (location TH-8 from 17 to 19.5 feet bls), and SWMU 65 (location 065S06DA from 14 to 16 feet bls). The vertical permeability coefficient for these samples ranged from 4.8 x 10^{-6} cm/sec to 6.8 x 10-7 cm/sec, as previously shown on Table 2.3. The sieve analyses of the samples indicated a silty clay or clayey silt classification, with porosities ranging from 0.41 to 0.48. The geotechnical reports are provided in Appendix C of this report.

Depth-to-groundwater measurements were collected during April, August, and September 1996 for SWMU 2 monitoring wells, whereas wells at SWMU 65 were measured only in April 1996. Table 2.4 presents the depth-to-groundwater measurements for individual upper alluvium wells

and shows what appears to be a seasonal trend in groundwater elevations in the SWMU 2 upper alluvium monitoring wells; i.e., water is higher in the spring and lower in the fall.

Groundwater in the upper alluvium flows south, southwest, and southeast near SWMUs 2 and 65, with an average horizontal gradient of 0.0085 at SWMU 2 and 0.0065 at SWMU 65 (refer to Figure 2.12). Relative groundwater elevations between monitoring wells screened in the upper and deep alluvium indicate an upward gradient at some locations and a downward gradient at others. Therefore, no conclusion can be made regarding the recharge/discharge potential of the upper alluvium at SWMU 2.

Horizontal groundwater velocities in the upper alluvium were calculated from the SWMU 2 DPT investigation results, the upper alluvium potentiometric map, and specific capacity test results of upper alluvium wells at SWMUs 2 and 65. Table B-1 in Appendix B provides the DPT horizontal groundwater velocity calculations, Figure 2.12 presents the upper alluvium potentiometric map, and Section 2.2.1.7 summarizes the specific capacity test results. The horizontal groundwater velocity calculated during the SWMU 2 DPT investigation averaged 4.95×10^{-6} cm/sec, or 0.01 feet per day. Likewise, the calculated horizontal groundwater velocity from the specific capacity tests averaged 0.012 feet per day.

Deep Alluvium

The deep alluvium consists of sand and gravel. In general, its uppermost portion is a silty or clayey fine- to medium-grained sand with sparse to frequent gravel, which coarsens downward to a medium to very coarse-grained sand and gravel above the erosional contact above the Cockfield Formation. Most of the gravel is subangular to rounded gray quartz or chert, with the longest diameter generally ranging from 0.5 to 2 inches in the upper portion and from 0.75 to 4 inches in the lower portion. Some clay, silt, or sandy silt seams, along with occasional snail shells and wood fragments, is present in the upper portion of the deep alluvium. Sandy gravel

lenses are common throughout the deep alluvium, as shown on the Appendix C boring logs. In several borings, portions of the gravel were iron-cemented.

Material in the uppermost portion varied from light olive gray, olive gray, greenish-gray, light yellowish-brown, and dusky yellow, with common iron staining. In the lower portion, the sand ranged from very light to light gray, yellowish-brown, and yellowish-orange.

The thickness of the deep alluvium ranged from 6 feet in soil boring 009S03DA to 34 feet in soil boring 002S14DA. Soil boring 009S03DA is at the southwest corner of the SWMU 9 sewage lagoons. Soil boring 002S14DA is at the northeast corner of the SWMU 2 landfill. Table 2.2 lists the thickness of the deep alluvium for SWMU 2, 9, and 65 soil borings and background soil boring 0BGS11MA, while the lithologic cross sections (Figures 2.3, 2.4, 2.5, 2.6, and 2.10) graphically depict the vertical thickness of the deep alluvium. As the cross sections demonstrate, the thickness of the deep alluvium decreases from north to south along the east side of the landfill (Figure 2.3), but it is generally consistent from west to east (Figures 2.4 and 2.6). Based on its thickness, the portion of Big Creek on the southeast side of NSA Memphis may have once transected the northeast to southwest portion of the area beneath the SWMU 2 landfill. The SWMU 9 cross section (Figure 2.5) shows the deep alluvium thins dramatically from north (009G04DA, 31 feet thick) to south (009G02DA, 6 feet thick), showing the typical configuration of the center to the edge of a buried stream channel.

Soil samples collected for geotechnical analysis from the deep alluvium consisted of two SWMU 2 samples and one SWMU 65 sample. SWMU 2 samples were collected from 41 to 43 feet bls at boring locations 002S03DA and 002S0030 and the SWMU 65 sample was collected from 38 to 40 feet bls at boring location 065S06DA. The vertical permeability coefficients of the samples ranged from 1.8×10^{-4} cm/sec to 8.6×10^{-4} cm/sec, as shown on Table 2.3. Sieve analyses of these samples indicated a sand with gravel or gravelly sand classification, with porosities ranging from 20% to 33%. The geotechnical reports are provided in Appendix C of this report.

As previously discussed, depth-to-groundwater measurements for SWMU 2 monitoring wells were collected during April, August, and September 1996, while the same measurements were collected in April 1996 only for monitoring wells at SWMUs 9 and 65. Table 2.4 presents the depth-to-groundwater measurements for individual deep alluvium wells and shows what appears to be a seasonal trend in groundwater elevations in the SWMU 2 deep alluvium monitoring wells and middle alluvium monitoring well 0BGG11MA; i.e., water is higher in the spring and lower in the fall.

The deep alluvium groundwater flowed southwest on the north side of Big Creek Drainage Canal and northwest on the south side of the canal during April 1996, as shown on Figure 2.13. Based on the potentiometric contour lines shown on Figure 2.13, average groundwater gradients in the deep alluvium were as follows: at SWMU 2 it was 0.0083; at SWMU 9 it was 0.0091; and at SWMU 65 it was 0.014. Relative groundwater elevations between monitoring wells screened in the upper and deep alluvium indicate an upward gradient at some locations and a downward gradient at others. Therefore no conclusion can be made regarding the recharge/discharge potential of the deep alluvium at SWMUs 2 and 65.

Horizontal groundwater velocities in the deep alluvium were calculated from the DPT investigation results at SWMU 2 and 9, from the lower fluvial deposits/deep alluvium potentiometric map, and specific capacity test results from SWMUs 2, 9, and 65. Table B-1 in Appendix B shows the DPT horizontal groundwater velocity calculations, Figure 2.13 provides the lower fluvial deposits/deep alluvium potentiometric map, and Section 2.2.1.7 summarizes the specific capacity test results. At SWMU 2, the horizontal groundwater velocity calculated during the DPT investigation averaged 2.32×10^{-4} cm/sec, or 0.65 feet per day; the calculated horizontal groundwater velocity from the SWMU 2 specific capacity tests averaged 0.23 feet per day. At SWMU 9, the horizontal groundwater velocity calculated during the DPT investigation averaged 1.31×10^{-4} cm/sec, or 0.37 feet per day; the calculated horizontal groundwater velocity from the SWMU 9 specific

capacity test was approximately 0.25 feet per day. At SWMU 65, the horizontal groundwater velocity calculated from the specific capacity test was 0.39 feet per day.

2.2.2.2 Loess and Fluvial Deposits

As previously discussed, SWMU 14 and 59 monitoring wells and background monitoring wells 0BGG02LS, 0BGG02UF, 0BGG02LF, 0BGG04LS, 0BGG04UF, 0BGG04LF, and 0BGG12UF were completed in either the loess or fluvial deposits. These wells are between 1,300 and 5,000 feet north of Big Creek Drainage Canal, as shown on Figure 2.1.

Loess

The loess encountered in soil borings consists of clay, silty clay, clayey silt, and silt from land surface to depths ranging from 30 to 39 feet. In general, the clay fraction decreases and the silt fraction increases with depth. The upper 6 or 7 feet are typically dry. A moist to wet zone encountered between 10 and 16 feet in most SWMU 14 and 59 soil borings represents the uppermost water-bearing zone in the loess. The loess color ranged from moderate to dark yellowish-brown, brown, brownish-gray, greenish-gray, and light olive gray. Sparse to common dark orangish-yellow or light olive gray mottling was observed in some soil borings, as was iron staining, iron/manganese nodules, and organic material. Hard, siliceous clayey material or concretions were present near 27 feet bls in one SWMU 14 soil boring.

Table 2.2 lists the loess thickness at SWMU 14, SWMU 59, and background locations, while the geologic cross sections (Figures 2.7, 2.8, and 2.9) show the vertical thickness. As shown on the geologic sections, the loess thickness was fairly consistent at SWMUs 14 and 59, except for the west-east geologic section of SWMU 14 (Figure 2.8), where the loess slightly thinned from west to east.

Loess soil samples collected for geotechnical analysis consisted of one sample from SWMU 14 (location 014S01LF, 8 to 10 feet bls), one from SWMU 59 (location 059S03UF, 13 to 15 feet bls),

and one from the USGS test hole north of SWMU 14 (location TH-7, 10 to 12 feet bls). The vertical coefficient of permeability for these samples, which was calculated from falling head permeability testing, ranged from 2.83 x 10^{-7} cm/sec to 5.7 x 10^{-7} cm/sec, as previously shown on Table 2.3. Sieve analyses of these samples indicated a clayey silt or silt classification, with porosities ranging from 0.36 to 0.44 percent. The geotechnical reports are provided in Appendix C of this report.

Table 2.4 (shown previously) summarized the depth-to-groundwater and groundwater elevation measurements in the loess monitoring wells at SWMUs 14 and 59. As shown on the table, depth-to-groundwater measurements in SWMU 14 loess monitoring wells ranged from 4.99 feet bls to 7.96 feet bls (014G01LS and 014G05LS). At SWMU 59, the depth to loess groundwater ranged from 7.71 feet bls to 9.69 feet bls (059G01LS and 059G03LS). Depth-to-groundwater measurements were not collected from loess background wells during 1996. As outlined in Section 2.1, loess groundwater migrates primarily downward, although locally, some may discharge to nearby streams, drainage ditches, and other surface-water bodies. Potentiometric maps were not constructed for the Assembly E loess monitoring wells.

The average loess horizontal groundwater velocity calculated from the DPT investigation results at SWMU 14 was 3.44 x 10^{-5} cm/sec, or 0.09 feet per day. Refer to Table B-1 in Appendix B for calculations. Since the hydrogeology of the loess has been adequately characterized during previous NSA Memphis investigations, specific capacity tests were not performed for the Assembly E loess monitoring wells.

Fluvial Deposits

The upper portion of the fluvial deposits consisted of a silty, clayey, fine to medium-grained sand. At some locations, it also contained scattered quartz and chert gravel up to 0.75 inches in diameter. In general, the sand's grain size coarsened with depth. The percentage of gravel and its maximum diameter also generally increased with depth. In most soil borings, the fluvial

deposit's base consisted of a sand-and-gravel mixture, with gravel up to 4 inches in diameter. The percentage of gravel within the sand matrix varied from approximately 10% to 75%, depending on the boring location.

The thickness of the fluvial deposits varies across the Southside as shown on Table 2.2. The fluvial deposits range from 12 to 20 feet thick at SWMU 14 to between 33 and 47 feet thick at Southside background well locations. Refer to the cross sections on Figures 2.7 and 2.8 for details. At SWMU 59, the deepest soil boring (059S03UF, terminated at 56 feet bls) did not encounter the base of the fluvial deposits as shown on the cross section, Figure 2.9.

Two soil samples were collected from 41 to 43 feet bls in the fluvial deposits for geotechnical analyses: one from SWMU 14 soil boring 014S01LF and the second from SWMU 59 soil boring 059S03UF. The vertical permeability coefficients were 4.0×10^{-7} cm/sec (location 014S01LF) and 2.6×10^{-4} cm/sec (location 059S03UF). Sieve analyses and porosity testing classified the sample from location 014S01LF as a silty clay containing sand and small gravel with a porosity of 32%. The sample from soil boring 059S03UF was classified as a gravelly sand with a trace of silt and a porosity of 30%. Appendix C contains the geophysical laboratory reports.

As previously discussed, depth-to-groundwater measurements for SWMUs 14 and 59 were collected in April 1996 and from background wells in both April and August 1996. Table 2.4 presents the depth-to-groundwater and groundwater elevation measurements for individual fluvial deposits wells. The groundwater measurements from the fluvial deposits background monitoring wells indicate a seasonal trend. Water levels are higher during the spring and lower during the late summer, as shown in Table 2.4.

Potentiometric maps for the April 1996 monitoring event are provided as Figures 2.11 (upper fluvial deposits) and 2.12 (lower fluvial deposits). The April 1996 water-level measurements were collected from upper and lower fluvial deposits wells at select locations throughout

NSA Memphis; therefore, the potentiometric maps cover all of NSA Memphis rather than only Assembly E SWMUs. The groundwater elevations for these lower fluvial deposits and deep alluvium were combined to generate Figure 2.13, because of the lithologic similarity between these units and the probability that they are hydraulically connected. The horizontal gradient at each SWMU was calculated from the well measurements and contour lines on the potentiometric maps.

As shown on Figure 2.11, groundwater in the upper fluvial deposits flows southwest near SWMU 59 and background well 0BGG04UF and west near background well 0BGG12UF. The horizontal gradient in upper fluvial deposits groundwater at SWMU 59 was approximately 0.0029. As shown on Figure 2.13, lower fluvial deposits groundwater near SWMU 14 and background well 0BGG04LF flows west, and flows north near background well 0BGG02LF. The approximate horizontal gradient of groundwater in the lower fluvial deposits beneath SWMU 14 was 0.005.

As shown on Table 2.4, relative groundwater elevations between upper and lower fluvial deposits background well pairs 0BGG02UF/0BGG02LF and 0BGG04UF/0BGG04LF are nearly identical, indicating the upper and lower fluvial deposits may be hydraulically connected at these locations and elsewhere on the Southside.

At SWMU 14, the horizontal groundwater velocity calculated from DPT investigations in the upper fluvial deposits averaged 3.98×10^{-5} cm/sec, or 0.11 feet per day (refer to Table B-1 in Appendix B). The horizontal velocity for groundwater in the lower fluvial deposits at SWMU 14 as calculated from specific capacity testing of monitoring well 014G07LF was 0.14 feet per day (refer to Section 2.2.1.7). At SWMU 59, the calculated horizontal groundwater velocity in the upper fluvial deposits was 0.6 feet per day, based on specific-capacity test results from monitoring well 059G03UF.

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3.0 ANALYTICAL AND FIELD INVESTIGATIONS METHODS

The RFI sampling program was developed to define the nature and extent of contamination associated with past activities at Assembly E SWMUs. The RFI's specific objectives were to:

- Determine the nature and extent of potential contamination in soil, sediment, surface water, and biota.
- Characterize the Southside alluvial and fluvial aquifers and their preferred contaminant migration pathways.
- Identify potential groundwater contamination in the loess, fluvial deposits, and alluvial aquifers.
- Identify the human health and ecological risks associated with any identified contamination.

The RFI was conducted in two phases. The first phase consisted of a DPT subsurface soil and groundwater screening investigation at each of the Assembly E SWMUs (except for SWMU 38, where only sediment samples were collected). Lithologic and analytical data from the DPT soil and groundwater investigation were used to determine the optimum placement and depth of samples collected during second phase RFI characterization. The second phase included advancing and sampling soil borings and installing and sampling monitoring wells to determine the vertical and lateral extent of contaminants, including those detected during the investigation's screening phase. Surface soil, sediment, surface water, and biota samples were also collected from various SWMUs to identify human health or ecological risk posed by site contaminants. In addition, ancillary data were collected through aquifer characterization (specific capacity testing of select monitoring wells) and borehole geophysics.

This section summarizes the analytical, drilling, and field sampling protocols employed during the Assembly E RFI, which were based on the USEPA and the TDEC-approved *Comprehensive RFI Work Plan* (E/A&H, 1994a) and the *Assembly E Site Investigation Plans* (E/A&H, 1995a). Sampling locations were chosen to provide adequate coverage around each SWMU's suspected source areas and to supplement previous investigation results at SWMUs 2 and 65, as outlined in the SWMU-specific tabbed sections (Section 8).

Sections 3.1 and 3.2 present the analytical test methods used for each of the medias sampled and provide an overview of the equipment used to conduct the DPT investigation, advance and sample soil borings, and install groundwater monitoring wells. The next five sections organize and present general sampling protocols for soil, groundwater, sediment, surface water, and fish tissue sampling. Specific sampling protocols (sample handling, field Quality Assurance/Quality Control [QA/QC], and decontamination) are in Section 3.8, which is followed by a summary of the data validation process and a discussion of decontamination procedures and investigation-derived waste (IDW). The last two sections summarize ancillary data collected during the RFI and survey techniques.

3.1 Analytical Methods

The organic analyte list for *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846) Methods 8240 (VOCs), 8270 (SVOCs), and 8080 (pesticides/PCBs) was selectively obtained from the Contract Laboratory Program (CLP) Target Compound List (TCL) statement of work OLM03.1 The inorganic analyte list for metals for SW-846 Method 6010/7000 series was obtained from USEPA Title 40 Code of Federal Regulations (CFR) Part 264, Appendix IX. The analyte lists for SW-846 Methods 8021 (VOCs), 8140 (organophosphorus pesticides), 8150 (chlorinated herbicides), 9010 (cyanide), and 8015 Tennessee (TN) Modified (TPH Gasoline Range Organics [TPH-GRO] and Diesel Range Organics [TPH-DRO]) were obtained directly from the respective test methods. Table 3.1 summarizes the SW-846 reporting levels and analytical methods used during the Assembly E RFI.

Table 3.1
Analytical Parameters and Methods
RFI Soil, Groundwater, Sediment, Surface Water, and Biota Samples

Media	Location and Description	Collection Method	Interval Sampled[a]	No. of Samples (No. of Duplicates)	Parameter and SW-846 Method	Laboratory	DQO[b] Reporting Level
SWMU 2							
Surface Soil	Six locations within landfill boundaries	Hand Auger	0 to 6 inches	6 (1)	FSA[c] less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings along landfill perimeter	Rotasonic	0.5 to 2 feet	13 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Subsurface Soil	DPT locations along landfill perimeter	DPT	5 to 7 feet 9 to 11 feet 11 to 13 feet	13 (3) 1 (0) 1 (0)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
	RFI soil borings along landfill perimeter	Rotasonic	2 to 4 feet 8 to 10 feet 13 to 15 feet 14 to 16 feet 19 to 21 feet	1 (0) 13 (1) 1 (0) 13 (4) 1 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Sediment	Big Creek Drainage Canal	Hand Auger	0 to 6 inches 18 to 24 inches	6 (2) 6 (0)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent
Groundwater	DPT locations along landfill perimeter	DPT	UA DA	13 (3) 16 (5)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
Groundwater (Event 1)	5 existing G&M wells and 27 new RFI wells	Submersible Electric Pump[d]	UA MA DA	15 (1) 1 (0) 16 (3)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent
Groundwater (Event 2)	5 existing G&M wells and 27 new RFI wells	Submersible Electric Pump	UA MA DA	15 (0)[e] 1 (0) 16 (4)[e]	TCL VOCs (Method 8240) Appendix IX metals (6010/7000 series)	Offsite (NET)	Level III/Level IV-equivalent
Surface Water	Big Creek Drainage Canal	Grab	0 to 6 inches	2 (1)	FSA less TPH - GRO	Offsite (NET)	Level III/Level IV-equivalent

Table 3.1
Analytical Parameters and Methods
RFI Soil, Groundwater, Sediment, Surface Water, and Biota Samples

Media	Location and Description	Collection Method	Interval Sampled[a]	No. of Samples (No. of Duplicates)	Parameter and SW-846 Method	Laboratory	DQO[b] Reporting Level
SWMU 9							
Surface Soil	Banks of the lagoons, just above water line	Hand Auger	0 to 6 inches	8 (1)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings at lagoon area's four corners	Rotasonic	0.5 to 2 feet	4 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Subsurface Soil	DPT locations along the lagoons' perimeter	DPT	8 to 10 feet	15 (4)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
	RFI soil borings at the lagoon area's four corners	Rotasonic	8 to 10 feet 14 to 16 feet	4 (0) 4 (2)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Sediment	Big Creek Drainage Canal	Hand Auger	0 to 6 inches 18 to 14 inches	4 (1) 4 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	Sediment within the sewage lagoons	Hand Auger	0 to 6 inches 18 to 24 inches	8 (2) 8 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Groundwater	DPT locations along lagoons' perimeter	DPT	DA	15 (4)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
	RFI monitoring wells at the lagoon area's four corners	Submersible Electric Pump	DA	4 (0)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent
Fish tissue	One composite sample from the east lagoon, and two composite samples from the west lagoon	Trotline	N/A	3 (0)	TCL SVOCs (Method 8270) TCL Chlorinated Pesticides/PCBs (Method 8080) Appendix IX Metals, Cyanide (6010/7000 series)	Offsite (NET)	Level IV-equivalent
Surface Water	Big Creek Drainage Canal	Grab	Surface	2 (1)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent

Table 3.1
Analytical Parameters and Methods
RFI Soil, Groundwater, Sediment, Surface Water, and Biota Samples

Media	Location and Description	Collection Method	Interval Sampled[a]	No. of Samples (No. of Duplicates)	Parameter and SW-846 Method	Laboratory	DQO[b] Reporting Level
SWMU 14							
Surface Soil	From above the outfall and concrete lining in the drainage ditch south of SWMU 14	Hand auger	0 to 6 inches	2 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings throughout SWMU 14	Rotasonic	0.5 to 2 feet	8 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Subsurface Soil	DPT locations throughout SWMU 14	DPT	5 to 7 feet 11 to 13 feet	11 (4) 3 (1)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
	From above the outfall and concrete lining in the drainage ditch south of SWMU 14	Hand auger	18 to 24 inches	2 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings throughout SWMU 14	Rotasonic	4 to 6 feet 8 to 10 feet	8 (1) 8 (3)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Sediment	7th Avenue drainage ditch west of SWMU 14	Hand Auger	0 to 6 inches 18 to 24 inches	2 (1) 2 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Groundwater	DPT locations throughout SWMU 14	DPT	LS UF	9 (1) 9 (3)	VOCs (All samples - Method 8021) TCL VOCs (Duplicates - Method 8240)	Onsite (Hydrologic) Offsite (NET)	Level II-equivalent (Hydrologic) Level III/Level IV-equivalent (NET)
	RFI monitoring wells throughout SWMU 14	Submersible Electric Pump	LS LF	5 (0) 4 (1)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent
SWMU 38							
Sediment	Various locations throughout the primary and secondary Southside drainage ditches	Hand auger	0 to 6 inches 18 to 24 inches	16 (3) 16 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	Various locations near SWMU 57; generally above and below the outfalls to the SWMU 38 drainage ditch	Hand auger/ grab samples	0 to 6 inches	9 (2)	PCB Rys System (Primary samples - Onsite) Pesticides/PCBs (Duplicates - Method 8080)	Onsite (E/A&H) Offsite (NET)	Level I-equivalent Level III/Level IV-equivalent

Table 3.1
Analytical Parameters and Methods
RFI Soil, Groundwater, Sediment, Surface Water, and Biota Samples

Media	Location and Description	Collection Method	Interval Sampled[a]	No. of Samples (No. of Duplicates)	Parameter and SW-846 Method	Laboratory	DQO[b] Reporting Level
SWMU 59							
Surface Soil	DPT (Geoprobe) locations surrounding the Old Pesticide Shop building	DPT (Geoprobe)	0 to 2 feet	10 (3)	TCL VOCs (8240) TCL Chlorinated Pesticides/PCBs (Method 8080)	Offsite (NET)	Level III/Level IV-equivalent
	From two locations in the grass next to Old Pesticide Shop building	Hand auger	0 to 6 inches	2 (1)	FSA	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings	Hand auger or Rotasonic	0 to 2 feet or 1 to 2 feet	3 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Subsurface Soil	DPT (Geoprobe) locations surrounding the old Pesticide Shop building	DPT (Geoprobe)	3 to 5 feet 9 to 11 feet	10 (0) 10 (0)	TCL VOCs (Method 8240) TCL Chlorinated Pesticides/PCBs (Method 8080)	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings	Rotasonic	4 to 6 feet or 6 to 8 feet 10 to 12 feet	3 (0) 3 (1)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Groundwater	South of Old Pesticide Shop building	DPT (Geoprobe)	UF	1 (0)	TCL VOCs (Method 8240) TCL Chlorinated Pesticides/PCBs (Method 8080)	Offsite (NET)	Level III/Level IV-equivalent
	RFI monitoring wells	Submersible Electric Pump	LS UF	3 (1) 1 (0)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent

Table 3.1
Analytical Parameters and Methods
RFI Soil, Groundwater, Sediment, Surface Water, and Biota Samples

Media	Location and Description	Collection Method	Interval Sampled[a]	No. of Samples (No. of Duplicates)	Parameter and SW-846 Method	Laboratory	DQO[b] Reporting Level
SWMU 65							
Surface Soil	South of each concrete airplane pad, near existing monitoring wells and the former UST area	DPT (Geoprobe)	0 to 2 feet	30 (3)	TPH-GRO and DRO (TN Modified 8015)	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings	Rotasonic	0.5 to 2 feet	3 (0)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Subsurface soil	South of each concrete airplane pad, near existing monitoring wells and the former UST area	DPT (Geoprobe)	5 to 7 feet or 7 to 9 feet	30 (3)	TPH-GRO and DRO (TN Modified 8015)	Offsite (NET)	Level III/Level IV-equivalent
	RFI soil borings	Rotasonic	6 to 8 feet 12 to 14 feet	3 (0) 3 (1)	FSA	Offsite (NET)	Level III/Level IV-equivalent
Sediment	From drainage swale along southern boundary of SWMU 65	Hand auger	0 to 6 inches 18 to 24 inches	5 (1) 5 (0)	BTEX.TPH-GRO (TN Modified 8015)	Offsite (NET)	Level III/Level IV-equivalent
Groundwater	From various Geoprobe soil boring locations spaced throughout SWMU	Geoprobe	UA DA	11 (1) 6 (1)	TCL VOCs (Method 8240)	Offsite (NET)	Level III/Level IV-equivalent
	RFI monitoring wells	Submersible Electric Pump	UA DA	3 (0) 1 (0)	FSA less TPH-GRO	Offsite (NET)	Level III/Level IV-equivalent

Notes:

a — Interval for soil and sediment samples is provided in inches or feet below land surface as indicated. The interval for groundwater refers to the aquifer within the screened interval of the DPT sample or monitoring well — LS = loess; UF = upper fluvial deposits, LF = lower fluvial deposits, UA = upper alluvium, MA = middle alluvium, DA = deep alluvium.

b — DQO = Data Quality Objective

c — FSA = Full Scan Analysis. FSA for soil and sediment samples consisted of the following Target Compound List parameters: VOCs by SW-846 Method 8240; SVOCs by SW-846 Method 8270; chlorinated pesticides/PCBs by SW-846 Method 8080; organophosphorus pesticides by SW-846 Method 8140; chlorinated herbicides by SW-846 Method 8150; Appendix IX metals and cyanide by SW-846 Methods 6010, 7060, 7421, 7841, and 9012; and TPH-GRO and DRO by the Modified Tennessee SW-846 Method 8015. FSA for groundwater and surface water samples consisted of the above parameters, except for TPH-GRO, because these lighter fraction hydrocarbons could be identified by the tentatively identified compounds in VOC analysis.

d — Wells were sampled using the low-flow micropurging technique as long as the static water level did not vary more than 1.0 foot during purging. When the static water level varied more than 1.0 foot, at least three well volumes were removed, or the well was purged dry and allowed to recharge prior to sampling.

3.1.1 Analytical Methods for DPT Samples

Soil and groundwater samples were collected during the DPT screening investigation to approximate the extent of anticipated contaminants at each SWMU. Based on the anticipated site constituents, samples were submitted for select analyses as outlined below.

SWMUs 2, 9, and 14: Anticipated site constituents included solvents and petroleum-related compounds. Therefore, VOCs were used as an indicator parameter during the DPT screening phase at these SWMUs. The DPT subsurface soil and groundwater samples were transported directly to an onsite mobile laboratory provided by Hydrologic, Inc., of Frankfort, Kentucky, for the immediate analysis of VOCs by SW-846 Method 8021. The laboratory analyzed the DPT samples using Level II-equivalent Data Quality Objectives (DQOs). In accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a), approximately 25% of the primary samples submitted to the onsite laboratory for VOC analysis were split as confirmation samples for QA/QC purposes. The confirmation samples were shipped to National Environmental Testing, Inc. (NET) laboratory in Bedford, Massachusetts, for VOC analysis by SW-846 Method 8240. Ninety-five percent of the confirmation samples were reported at Level III DQO-equivalent, while 5% of the samples were reported at Level IV DQO-equivalent. The analytes in SW-846 Method 8021 and the VOC TCL differ due to the instrumentation used; refer to the analytical data in the *Data Validation Report — Assembly E* (E/A&H, 1997a) for the analyte list for each VOC test method.

SWMU 59: Pesticides and their carriers (solvents) were anticipated site constituents. Therefore, subsurface soil and groundwater samples collected during the DPT screening investigation were submitted to NET for VOC and pesticide/PCB analyses by SW-846 Methods 8240 and 8080, respectively. In accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a), approximately 10% of the DPT samples were split for duplicate analysis. NET analyzed primary and duplicate samples using a Level III DQO-equivalent for 95% of the samples and a Level IV DQO-equivalent for the remaining 5%.

SWMU 65: Anticipated site constituents were petroleum-related compounds. Surface and subsurface DPT soil samples were submitted to NET for TPH-GRO and TPH-DRO analyses by SW-846 Method 8015 TN Modified, while groundwater samples were submitted to NET for VOC analysis by SW-846 Method 8240. In accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a), approximately 10% of the DPT samples were split for duplicate analysis. NET analyzed primary and duplicate samples using a Level III DQO-equivalent for 95% of the samples and a Level IV DQO-equivalent for the remaining 5%.

3.1.2 Analytical Methods for RFI Samples

Based on DPT investigation results, RFI soil and groundwater were collected and analyzed to further assess the nature and extent of contamination at the Assembly E SWMUs. Where present, sediment and surface water samples were collected to assess the nature and extent of contamination in the drainage pathways near the SWMUs. The samples were submitted to NET and analyzed using a modified full scan analysis in accordance with SW-846 Methods and analyte lists based on the CLP TCL with the following exception: groundwater and surface water samples were not submitted for TPH-GRO analysis, because the tentatively identified compounds (TICs) in the VOC analysis would identify many of these lighter fraction hydrocarbons. NET analyzed the RFI samples using a Level III DQO-equivalent for 95% of the samples and a Level IV DQO-equivalent for the remaining 5%. Table 3.1 summarizes the methods and reporting levels.

Biota (fish tissue) samples were collected from the SWMU 9 sewage lagoons and submitted to Ceimic Corporation of Naragansett, Rhode Island, for the following analyses: TCL SVOCs and TCL pesticides/PCBs and TAL metals according to the CLP Statement of Work (SOW) OLMO3.1 and ILMO3.0 (USEPA 1994a, 1994b). Ceimic analyzed the samples using a Level IV DQO-equivalent.

In addition, select soil samples were analyzed for design parameters for later remedial design, modeling, and (or) migration studies, if needed. Soil samples collected for physical characterization were submitted to Tri-State Testing, Inc. in Memphis, Tennessee, while soil samples collected for chemical characterization were submitted to NET. Table 3.2 summarizes the physical and chemical design parameters used for the soil sample analyses.

Table 3.2
Design Parameters and Methods
RFI Soil Samples Collected for Physical and Chemical Characterization

Parameter	Method	Number of Samples per SWMU/Interval Sampled[a]
Physical:		
Permeability	ASTM[b] 5084	SWMU 2 - 2 UA, 2 DA
Porosity	ASTM 5084	SWMU 9 - 1 UA
Particle Size	ASTM D422	SWMU 14 - 1 LS, 1 LF
Bulk Density	ASTM 4253	SWMU 59 - 1 LS, 1 UF
Specific Gravity	ASTM D854	SWMU 65 - 1 UA, 1 DA
Moisture Content	ASTM 2216	
Chemical:		
Total Phosphorus	USEPA 365.4	SWMU 2 - 2 UA
Nitrate-N	USEPA 352.1	SWMU 9 - 1 UA
Total Kjeldahl Nitrogen	USEPA 351.2	SWMU 14 - 1 LS, 1 UF
Heterotrophic Plate Count	SM[c] 9215B	SWMU 59 - 1 LS, 1 UF
Total Organic Carbon	USEPA 415.1/9060	SWMU 65 - 1 UA
Cation Exchange Capacity	USEPA 9081	

Notes:
a — Interval sampled refers to the lithologic unit from which the soil sample was collected. UA, DA, LS, and UF refer to upper alluvium, deep alluvium, loess, and upper fluvial deposits, respectively.
b — ASTM = American Society for Testing and Materials
c — SM = Standard Method

3.2 Equipment Overview

The following sections describe the DPT equipment used to conduct the first-phase screening investigation and the drilling equipment used to advance and sample soil borings and install monitoring wells during the investigation's second phase.

3.2.1 DPT Equipment

Between October 26 and December 18, 1995, E/A&H conducted DPT investigations at SWMUs 2, 9, 14, 59, and 65 to obtain soil and groundwater samples from the locations proposed in the *Assembly E Site Investigation Plans*. InSitu, Inc., of Travelers Rest, South Carolina, provided and operated the DPT equipment at SWMUs 2, 9, and 14. ProTech, Inc., of Baton Rouge, Louisiana, provided and operated the DPT Geoprobe equipment at SWMUs 59 and 65.

SWMUs 2, 9, and 14: The DPT investigations were conducted with truck-mounted, hydraulically operated probes and samplers, including the piezocone system and geocone and hydrocone samplers. The piezocone system, consisting of an electronic cone penetrometer, measured and plotted point-stress, sleeve friction, and pore pressure as the cone penetrometer was advanced from ground surface, through the loess or upper alluvium, and into the upper fluvial deposits or deep alluvium. The geocone sampler, a split-spoon sampler with a push plug on the leading end, was advanced and retracted to retrieve relatively undisturbed subsurface soil samples from specific depths at various locations throughout the SWMUs. The hydrocone groundwater sampler obtained groundwater samples from specific depths in the loess or upper alluvium and upper fluvial deposits or deep alluvium, with and without an applied vacuum, and generated hydraulic conductivity information when no vacuum was applied. Hydraulic conductivity information was generated by a transducer within the hydrocone that recorded rate of fill over time. Details for the DPT sampling methods were provided in Section 4.4.4.3 of the *Comprehensive RFI Work Plan*.

SWMUs 59 and 65: The DPT investigations were conducted using both truck-mounted and all-terrain vehicle (ATV) mounted Geoprobe sampling rigs. The Geoprobe is a hydraulically-powered soil probing machine that uses static force and percussion to advance small diameter sampling tools into the subsurface to collect soil core and groundwater samples. A closed-piston sampling tool with plastic liner was used to collect soil samples. From the ground surface, the sampler was

advanced 24 inches (sampling tool length) and retrieved from the borehole with the first sample. The plastic liner and soil core were removed, a new liner was installed, and the sampler was inserted back down the same hole to collect the next sample. The groundwater sampling device is a screen-point sampler with a stainless-steel wire mesh screen insert and screen sleeve that is driven to depth in an alloy steel sampler sheath using standard Geoprobe rods. The screen is sealed inside the sheath with rubber o-rings which prevent the infiltration of formation fluids until the screen is deployed.

3.2.2 Drilling Equipment

Between January 15 and March 4, 1996, soil borings were advanced and sampled, and groundwater monitoring wells were installed and developed at SWMUs 2, 9, 14, 59, and 65. Alliance Environmental, Inc., of Marietta, Ohio, provided and operated the drilling equipment. Most soil borings and monitoring wells were completed using the rotasonic drill rig, which is preferred over conventional drilling techniques due to its speed, high quality of lithologic information and well construction, and the minimal amount of IDW generated.

Where the soil was not adequately compacted to support the weight of the rotasonic drilling equipment, that is, wooded areas with limited access and areas with uneven terrain, Alliance used an all-terrain Doodlebug carrier equipped with a CME-55 hollow-stem auger rig to reach the soil boring locations. The following sections describe each drilling method used during the Assembly E RFI.

3.2.2.1 Rotasonic Drilling Method

The rotasonic drill mechanically induces vibrations through a drill head housing in which two steel rollers rotate in eccentric orbits, creating equal centrifugal forces. The combined centrifugal forces create a vertical force that is transmitted into the steel drill pipe and effectively transferred through the pipe to its bottom cutting edge. A series of high-frequency, sinusoidal, wave

vibrations are induced in the steel drill pipe at its resonance frequency or at a rate proportional to its ability to accept and reflect each wave. With the pipe resonating, the energy stored in it greatly exceeds the energy being dissipated on the medium being drilled and the maximum strain is imparted to the steel pipe's end, and in turn, to the medium being drilled. With this pressure pushing down on it, the steel drill pipe behaves like a spring, expanding and contracting as the vibrations are imparted through the sonic head, creating a cutting action at the bit face that allows a continuous core of the formation to move into the core barrel. Refer to *The Resonant Sonic Drilling Method: An Innovative Technology for Environmental Restoration Programs* (Barrow, 1994) for details on this drilling method.

Rotasonic drilling consists of advancing two drill casings, generally an inner 4-inch diameter core (or sample) barrel and an outer 6-inch diameter casing. The inner core barrel, which has a studded bit attached to its base, is first vibrated to the desired sample depth, which results in sample material being captured in the barrel. The outer 6-inch casing is then vibrated around and to the inner barrel's sample depth, displacing the 1-inch soil annulus between the core barrel and casing into the formation. The outer casing serves two purposes — it ensures that the borehole remains open during sampling, eliminating borehole "slough," and it prevents potential communication between shallower and deeper zones by continuously casing the borehole as it is advanced. After the outer casing is advanced, the inner core barrel is retrieved to the surface, leaving the outer casing in place, and the sample is vibrated out of the core barrel into a plastic sleeve. A decontaminated core barrel replaces the previous one, and the process is repeated until the desired sample depth is reached. Typically, 10-foot sections of core are collected at a time and extruded in two 5-foot lengths.

Potable water is used to drill below the saturated zone. After the inner barrel is advanced to the desired sample depth, water is pumped between the inner barrel and outer casing while the outer casing is vibrated down to flush soil out of the annular space. Soil in the annular space is either

circulated to the surface with the water and emptied into a tub or displaced into the borehole wall. Once the soil boring is complete, a monitoring well may be installed through the outer casing as outlined in the *Comprehensive RFI Work Plan*.

3.2.2.2 Hollow-Stem Auger Drilling Method

The hollow-stem auger consists of a 6¼-inch outer diameter, open steel shaft with a continuous spiraled steel flight welded to the outside. Each auger flight is connected in 5-foot sections to the lead flight auger, which is connected to an auger bit which cuts. Soil cuttings are brought to the surface as the top-head drive unit rotates the flights. A plug inserted into the center of the augers attaches to the drive unit with smaller rods to prevent soil from rising inside the auger until the desired sampling depth is reached. A 3-inch diameter, 2-foot long, split-spoon sampler is then attached to the inner rods and inserted into the center of the augers. After a drop-hammer drives the inner rods and split-spoon sampler 2 feet, a relatively undisturbed soil core collects in the sampler. The inner rods are then removed, and the split-spoon sampler is detached. When the sampler is opened, material is collected from the soil core. Once the soil boring is complete, a monitoring well may be installed through the hollow-stem augers as outlined in the *Comprehensive RFI Work Plan*.

The soil borings advanced and sampled with the all-terrain rig were as follows:

SWMU 2: Soil borings 002S11UA, 002S11DA, 002S12UA, 002S12DA, 002S13UA, 002S13MA, and 002S13DA, and their associated monitoring wells. These soil borings were along the temporary road constructed along the landfill's north side, and on the east central side of the landfill where trees were cleared with a bulldozer to allow access for the buggy rig.

SWMU 9: Soil boring 009S03DA and its associated monitoring well. This soil boring is on the southwest corner of the sewage lagoons in a wooded, low-lying area that could not be accessed by the rotasonic rig.

3.3 Soil Investigation

E/A&H collected 250 soil samples (excluding duplicate samples and samples split for confirmation purposes) during both phases of the Assembly E RFI:

- 40 surface soil samples and 94 subsurface soil samples from DPT screening investigations of SWMUs 2, 9, 14, 59, and 65

- 31 surface soil samples and 65 subsurface soil samples from drill rig soil borings at SWMUs 2, 9, 14, 59, and 65

- 18 surface soil samples and 2 subsurface soil samples collected with a stainless-steel hand auger from various locations at SWMUs 2, 9, 14, and 59

Table 3.1, shown previously, summarizes the location, number, media, collection depth, collection method, and analyses for surface and subsurface soil samples collected during the Assembly E RFI, while the following sections describe the soil sampling procedures.

3.3.1 DPT Soil Samples

An E/A&H or USGS geologist logged and processed the soil samples for field screening and submittal to the analytical laboratory. Soil samples were collected with either the DPT equipment using a 2-foot long, 2-inch outside diameter (OD), split-spoon geocone sampler, or the 2-foot long, 1.5-inch OD Geoprobe closed-piston sampler. After it was retrieved, the DPT sampler was opened and the soil was immediately screened for VOCs using an HNu photoionization detector (PID). When using the Geoprobe soil sampler, the geologist removed the plastic liner containing the sample, sliced it open, and screened the exposed sample for VOCs with the PID.

The geologist collected representative soil samples from the site-specific intervals (outlined in Section 8 of this report), placed them in unpreserved sample containers provided by the testing laboratory, and placed the containers on ice in a cooler. Samples for VOC analyses were collected directly from the sampling device, immediately placed in sample containers (minimizing headspace), placed on ice in a cooler, and transported directly to the onsite laboratory for analysis (samples from SWMUs 2, 9, and 14) or to the field trailer to be prepared for shipment to NET (samples from SWMU 59). The DPT soil samples from SWMUs 59 and 65 for pesticide/PCB and TPH analyses were homogenized in a stainless-steel bowl in accordance with Section 4.4 of the *Comprehensive RFI Work Plan* prior to containerization. As outlined in Section 3.1.1, 25% of the samples to be submitted for onsite VOC analyses were split and containerized separately for subsequent offsite shipment to NET for confirmation analyses. Ten percent of the samples to be submitted for offsite analysis were split and submitted to NET as duplicates. Each soil sample, the field screening results, and sample location, designation, and time of collection were described in the site logbook.

Grouting Procedure for DPT Boreholes

Each DPT boring was filled with neat cement grout to land surface following soil and groundwater sample collection. Many of the DPT boreholes, which were less than 2 inches in diameter, collapsed when the soil or groundwater sampler was removed. The DPT equipment operator poured cement grout powder into each borehole that remained open and hydrated the grout by pouring potable water into the borehole. The grout was allowed to cure for at least 24 hours to allow for shrinkage. After the waiting period, additional grout was added as necessary to bring the grout to land surface.

3.3.2 Soil Samples from Borings Associated with Monitoring Well Installation

During the Assembly E RFI, an E/A&H or USGS geologist continuously sampled, classified, and logged two deep alluvium soil borings at SWMU 2 near existing G&M monitoring wells and

30 fluvial deposits or deep alluvium soil borings associated with the installation of 48 Assembly E monitoring wells.

A sample team — a USGS or E/A&H geologist and an environmental scientist or technician — logged and processed soil samples for field screening and submittal to the analytical laboratory. When using the rotasonic drilling method, Alliance collected continuous soil cores to the termination depth of the soil boring. When using the hollow-stem auger drilling method, 2-foot-long soil cores were collected continuously with a split-barrel sampler to approximately the top of the sand and gravel unit, then at 5-foot intervals to the boring's termination depth.

Lithologic descriptions and soil samples for analytical testing were obtained from the soil cores collected from the soil borings. The intervals sampled varied between SWMUs; refer to Section 8 of this report for the sampling rationale and intervals sampled. Where well pairs or clusters were installed, the deepest monitoring well's soil core was used to prepare lithologic descriptions and to provide soil for organic vapor field screening. Soil samples for analytical testing were generally obtained from the soil cores from the shallowest monitoring well.

Rotasonic soil cores were split into 2-foot-long sections (hollow-stem auger soil cores were approximately 2 feet long). A portion of each core section was composited in 1-gallon resealable plastic bags and allowed to equilibrate for at least 15 minutes prior to field screening for organic vapors. Field screening consisted of placing the probe of an HNu PID into the soil headspace, measuring any organic vapor concentrations in the bag, and recording the readings on the individual boring logs. The field screening readings were used by the onsite geologist to determine if additional soil samples would be collected. However, no elevated field screening readings were detected in the Assembly E soil borings that warranted additional sample collection. The remaining soil in each core section was classified in the field by an E/A&H or USGS geologist. Classifications were recorded on individual boring logs, along with data such as soil

types, depth interval of samples submitted for analytical purposes, and other relevant information. Boring logs are provided in Appendix C of this report.

A new pair of disposable nitrile gloves was donned prior to sample collection. Representative soil samples from the site-specific intervals (outlined in Section 8 of this report) were collected with a stainless-steel sampling implement, placed in unpreserved sample containers provided by the analytical laboratory, and labeled with the sample designation, date and time collected, and requested analyses. Samples for VOC analysis were collected first directly from the soil core, and packed tightly into the sample container to minimize headspace and the potential loss of volatiles. The remaining portion of the soil core was trimmed, placed in a stainless-steel bowl, and homogenized in accordance with Section 4.4 of the *Comprehensive RFI Work Plan* (E/A&H, 1994a). Samples for remaining analyses (including chemical design parameters) were placed in the appropriate sample containers, labeled, and placed on ice for transportation to the field trailer to be prepared for shipment. As outlined in Section 3.1.2, approximately 10% of the samples were split for duplicate analysis. Each soil sample, the field screening results, and sample location, designation, and time of collection were described in the SWMU logbook.

Design Parameters

As outlined in Section 3.1.2, additional samples were collected from the soil borings and analyzed for the design parameters listed on Table 3.2 for later remedial design, modeling, and (or) migration studies, if needed.

Physical Design Parameters: Soil samples submitted for physical design parameters analysis (i.e., geotechnical testing) were collected with the drilling rig using a 2-foot-long, stainless-steel, Shelby tube sampler. At least one Shelby tube soil sample was collected per SWMU from each water-bearing unit (i.e., loess, upper alluvium, fluvial deposits, or deep alluvium), except for SWMU 9, where the Shelby tube did not retain the sample from the deep alluvium. Table 2.3 (shown previously) lists the locations and depth intervals of the Assembly E Shelby tube samples.

Once the Shelby tube had been driven through the desired sampling interval, it was retrieved, capped, labeled, and submitted to Tri-State Testing Services for the following geotechnical analyses: permeability, porosity, particle size, bulk density, specific gravity, and moisture content. The sample interval was recorded on the field boring log.

Chemical Design Parameters: At least one soil sample per SWMU was collected for chemical design parameters analysis in accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a). As outlined in the work plans, the following samples were collected:

- From above the first zone of saturation in the upper alluvium at SWMUs 2, 9, and 65.
- From above the first zone of saturation in the loess at SWMU 14.
- From above the zones of saturation in the loess and fluvial deposits at SWMU 59.

An additional sample was collected from the upper fluvial deposits at SWMU 14, because trichloroethene had been detected in upper fluvial deposits groundwater during the DPT screening investigation. This deviation was recorded in the field logbook. The samples for chemical characterization were collected in the same manner as the primary soil boring samples described above, labeled, placed on ice in a cooler, and transported to the field trailer to be prepared for shipment to NET for the following analyses: total phosphorus, nitrate-N, total Kjeldahl nitrogen, heterotrophic plate count, total organic carbon, and cation-exchange capacity.

Grouting Procedures for Soil Borings

A groundwater monitoring well was installed in each of the Assembly E soil borings, except for SWMU 2 soil borings 002S0029 and 002S0030, which were advanced and continuously sampled next to existing G&M monitoring wells to provide soil data for these locations. After they were completed, these borings were pressure-grouted from the bottom of the borehole to land surface with a cement-bentonite slurry using a tremie pipe. The grout was allowed to cure at least

24 hours to allow for shrinkage. After the waiting period, additional grout was added as necessary to bring the grout to land surface.

3.3.3 Hand-Auger Soil Samples

Between October 12 and November 2, 1995, E/A&H used a stainless-steel hand auger to collect surface and subsurface soil samples from various locations throughout SWMUs 2, 9, 14, and 59. Eighteen surface soil samples (0 to 6-inch interval) and two subsurface soil samples (18- to 24-inch interval) were collected using the hand-auger sampling procedures outlined in Section 4.4.3 of the *Comprehensive RFI Work Plan* (E/A&H, 1994a). Table 3.1 (shown previously) summarizes the location, number, depth interval, and analytical test methods for each hand-auger soil sample. The SWMU-specific tabbed sections within Section 8 of this report provide the sampling rationale for the hand-auger soil samples. The sampling procedures are summarized below.

Vegetation and debris were cleared from the sample location prior to sampling. Sampling personnel donned clean gloves and began to auger, continuing until the top of the desired sampling interval was reached, then the auger was retrieved from the borehole. A decontaminated auger was then inserted in the borehole, and augering proceeded until the bottom of the desired sample interval was reached. The auger was retrieved from the borehole, and personnel donned a new pair of disposable nitrile gloves prior to sample collection. A portion of the soil was immediately removed from the auger bucket and placed in a VOC sample container, which was completely filled to eliminate any headspace where volatilization might occur. The remaining soil was removed from the auger bucket and placed in a stainless steel bowl, where it was thoroughly homogenized in accordance with Section 4.4 of the *Comprehensive RFI Work Plan* (E/A&H, 1994a). The soil was then transferred to the appropriate sample containers, labeled, and placed on ice in a cooler chilled to 4°C (±2°C). The samples remained in the ice chest until the sampling team returned to the field trailer where they were prepared for shipment to the laboratory.

3.4 Groundwater Investigation

The groundwater investigation focused on two water-bearing zones: the loess or upper alluvium, and the underlying fluvial deposits or deep alluvium. The loess or upper alluvium are considered the zones most likely to contain contaminants associated with the site based on shallow depth, while the fluvial deposits or deep alluvium are a preferential zone of groundwater flow and, thus, a potential route for contaminant transport. One hundred thirty-three groundwater samples (excluding duplicate samples and samples split for confirmation purposes) were collected during the Assembly E investigation as outlined below:

- 80 groundwater samples collected during the DPT investigations of SWMUs 2, 9, 14, 59, and 65.

- 53 groundwater samples were collected from new and existing Assembly E monitoring wells during the April 1996 sampling event.

The following sections describe the groundwater sampling procedures used to collect groundwater samples from the DPT locations and the procedures used to install, develop, and sample the new and existing Assembly E monitoring wells.

3.4.1 DPT Groundwater Investigation

Groundwater samples were collected during the screening investigation using either a hydrocone groundwater sampler with the DPT rig or with a Geoprobe screen-point sampler. The following describes both techniques.

3.4.1.1 DPT Hydrocone Samples

Groundwater samples were collected from SWMUs 2, 9, and 14 by advancing the hydrocone sampler to the targeted depth, and retracting it approximately 1 foot to expose the sampling screen.

A transducer in the hydrocone, which records the volume of groundwater and the fill rate, transmitted the data to an on-board computer where it could be monitored on a computer screen. When approximately 300 milliliters (ml) of groundwater had entered the sampler, the hydrocone was returned to the surface. Groundwater samples were then collected directly from the hydrocone by inserting a new piece of Teflon tubing into the bottom port of the sampler and decanting the groundwater directly into the sample vials to minimize the loss of VOCs. If no groundwater entered the hydrocone after 30 minutes, a vacuum was applied to the sampling device. If no water had entered the hydrocone after 20 or 30 minutes, it was raised approximately 1 foot in an attempt to find a water-bearing zone. If no water entered the sampler after an additional waiting period (typically 15 minutes), attempts to collect a DPT groundwater sample were abandoned at that sampling location (SWMUs 2 and 9), or a subsurface soil sample was collected instead of a groundwater sample (SWMU 14 loess groundwater sampling locations). When time permitted, the hydrocone was left in the ground overnight to collect a groundwater sample where recharge was slow.

Groundwater samples for onsite VOC analysis were decanted into unpreserved 40-ml glass sample vials provided by Hydrologic. The onsite laboratory did not require a preservative in the samples, because they were transported on ice directly to the laboratory for immediate analysis. Twenty-five percent of the groundwater samples split for offsite VOC confirmation analyses were decanted into laboratory-provided 40-ml glass vials pre-preserved with hydrochloric acid. The sample designation, date, and collection time were recorded in the field logbook.

3.4.1.2 Geoprobe Screen-Point Samples

Groundwater samples were collected at SWMUs 59 and 65 by advancing the Geoprobe screen-point sampler to the target depth and opening it to expose the screen, through which groundwater flows into the sampler. A threaded adaptor was fitted on the end of a new piece of clean Teflon tubing. The tubing was inserted into the rod string and lowered through the rods to the top of the

sampler, where the adapter was attached to a threaded nipple on the top of the screen point. A peristaltic pump was attached to the tubing and water was drawn up into the tubing. Once the tubing filled with water, the pump was deactivated and the tubing crimped to prevent backflow into the sampler. The tubing was pulled free from the nipple and retrieved from the rod string. Once removed from the rods, the tube's contents were gently drained into sample containers.

All Geoprobe screen-point groundwater samples were submitted to NET, which provided the sample containers. Samples submitted for VOC analyses were decanted into pre-preserved 40-ml glass vials. The single Geoprobe groundwater sample collected for pesticide/PCB analysis from SWMU 59 was decanted into an unpreserved 2-liter amber glass bottle. Each sample was placed on ice in a cooler immediately upon sample collection, and subsequently shipped to NET for analyses. The sample designation, date, and collection time were recorded in the field logbook.

3.4.2 Groundwater Samples from Monitoring Wells

Forty-eight new monitoring wells were installed and sampled during the Assembly E RFI, along with five existing SWMU 2 monitoring wells. Of these monitoring wells, eight are screened in the loess, one in the upper fluvial deposits, four in the lower fluvial deposits, 18 in the upper alluvium, one in the middle alluvium, and 21 in the deep alluvium. Thirty-four are installed in shallow-deep well pairs. Three are installed in a cluster. The 16 remaining wells are installed as single wells. Table 2.2 summarizes the location, depth, and screened interval for each Assembly E monitoring well. The following sections describe the procedures used to install, develop, and sample the Assembly E monitoring wells.

3.4.2.1 Monitoring Well Installation

All Assembly E RFI monitoring wells were installed using the previously described drilling methods and constructed using a 10-foot section of 0.010-slotted, 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) screen, attached to 5- and 10-foot sections of Schedule 40 PVC riser.

After the soil boring was completed, the appropriate screened interval and depth of the monitoring well were determined, based on the lithology encountered in the soil boring. The borehole was prepared for monitoring well placement by placing a cement-bentonite plug in the bottom of the soil boring to bring the bottom of the boring up to within 6 inches of where the base of the monitoring well would be installed, and placing a 6-inch thick layer of filter pack sand in the borehole. The casing string, consisting of a bottom plug, 10-foot screen, and a predetermined length of riser pipe, was then lowered into the borehole. A tremie pipe, inserted along the outside of the casing string, emplaced the filter pack sand to approximately 2 feet above the top of the screen. A bentonite seal, at least 2 feet thick, was emplaced above the sand pack through the tremie pipe. A cement-bentonite slurry was then tremied from the bentonite seal to between 2 and 4 feet of land surface. Locking expansion caps were installed in each monitoring well. The monitoring wells were completed with stickup outer protective casings and surrounded by four outer protective guard posts set in a 4' x 4' x 6" concrete pad, or with a steel, flush-mount protective cover. All monitoring wells were tagged with the designated well name, date of completion, and depth of screened interval. Monitoring well completion data are provided in Table 2.2 (shown previously). Well construction logs are provided in Appendix C of this report.

3.4.2.2 Monitoring Well Development

Monitoring wells were developed using electric submersible pumps to improve flow to the well by removing fine sediments that may have accumulated from the sand pack during the drilling process. Well development was considered complete after conductivity, turbidity, temperature, and pH stabilized, as described in the *Assembly E Site Investigation Plans* (E/A&H, 1995a). Shallow (loess) monitoring wells typically bailed dry several times during development. Development water was containerized in 55-gallon drums and handled with other IDW as described in Section 3.11 and the *Investigation-Derived Waste Management Plan* (E/A&H, 1995b).

3.4.2.3 Monitoring Well Sampling

The new and existing Assembly E monitoring wells were sampled between April 9 and May 16, 1997 (designated "initial sampling event," or Event 1). Groundwater samples collected during this initial sampling event were analyzed for FSA, with the following exceptions: No samples were analyzed for chemical design parameters or TPH-GRO, as shown on Table 3.1. Chemical design parameters were excluded so that E/A&H could thoroughly review the groundwater data to keep from collecting unnecessary groundwater samples. TPH-GRO was not requested in the initial sampling event analyses, since VOC analysis (and associated TICs) would identify important gasoline-range hydrocarbons. A supplementary sampling event (designated "Event 2") was conducted for SWMU 2 monitoring wells only between September 3 and 12, 1996. Groundwater samples were submitted for VOC and Appendix IX analyses only, as shown on Table 3.1.

After reviewing the analytical data from the initial sampling event and Event 2, two additional sampling events were scheduled for all Assembly E monitoring wells — Event 3 was completed in May 1997, and Event 4 will be conducted one year later. During Event 3, select Assembly E monitoring wells were sampled for various parameters, including TPH-GRO and chemical design parameters, as outlined on Table 3.3. Ten percent of the samples were split for duplicate analysis as outlined in the *Comprehensive RFI Work Plan* (E/A&H, 1994a). The primary and duplicate Event 3 groundwater samples were submitted to Savannah Laboratories in Savannah, Georgia. At the current time, the analytical results have not been received from the laboratory. Therefore, they are not discussed in the SWMU-specific tabbed sections (Section 8). Once the Event 3 analytical results are received and validated, they will be incorporated in subsequent revisions of this RFI report.

Table 3.3
Analyses of Assembly E Groundwater Samples — Event 3 (April and May 1997)

SWMU	Parameter	Monitoring Wells Sampled
2	FSA[a]	All monitoring wells
	Chemical design parameters[b]	Upper alluvium monitoring wells 002G02UA, 002G03UA, 002G04UA, 002G08UA, 002G10UA, 002G11UA, 002G12UA, 002G13UA, 002G14UA, and deep alluvium monitoring well 002G06DA
9	VOCs, TPH-GRO, TPH-DRO	All monitoring wells
	Chemical design parameters	Deep alluvium monitoring wells 009G01DA, 009G02DA, and 009G03DA
14	VOCs	All monitoring wells
	Chemical design parameters	Loess monitoring wells 014G02LS, 014G03LS, 014G08LS and lower fluvial deposits monitoring wells 014G01LF and 014G04LF
59	VOCs, pesticides/PCBs, and chemical design parameters	All monitoring wells
65	VOCs, TPH-GRO, TPH-DRO	All monitoring wells, including monitoring wells 065G01UA through 065G04UA, which were installed during a 1992 site investigation
	Chemical design parameters	Upper alluvium monitoring wells 065G01DA, 065G05UA, and 065G07UA and deep alluvium monitoring well 065G06DA

Notes:

a — FSA = Full scan analysis, consisting of the following SW-846 analyses: VOCs (Method 8240), SVOCs (Method 8270), chlorinated pesticides/PCBs (Method 8080), organophosphorus pesticides (Method 8140), herbicides (Method 8150), Appendix IX metals (Method 6010/7000 series), cyanide (Method 9010), TPH (Method 418.1), and TPH-GRO and DRO (TN Modified Method 8015).

b — Chemical design parameters analysis consists of the following USEPA Methods: 5-day biological oxygen demand (Method 405.1), chemical oxygen demand (Method 410.1), hardness (Method 130.1), total suspended solids (Method 160.2), total dissolved solids (Method 160.1), alkalinity (Method 310.2), total phosphorus (Method 365.4), total Kjeldahl nitrogen (Method 351.2), Nitrate-N (Methods 352.1/9056), chloride and sulfate (Methods 300/9056), heterotrophic plate count (Standard Method 9215B), turbidity (Method 180.1), total iron and manganese (Method 6010), total organic carbon (Method 9060), and methane (Method 8020).

Groundwater Purge Methods

Three methods of purging were used for Assembly E monitoring well sampling: low-flow micropurging, removing three well volumes, or purging the well dry and allowing recharge prior to sampling. All wells were purged and sampled using dedicated Teflon tubing and submersible electric pumps. Groundwater was considered stable and ready for sampling after three consecutive pH, specific conductance, and temperature readings within ± 0.5 units, ± 10%, and ± 1° C, respectively, as outlined in the *Comprehensive RFI Work Plan* and the *Assembly E Site Investigation Plans*. In certain instances, the well did not recharge at a rate equivalent to the lowest purge rate allowed by the submersible pump, and the well purged dry. When this occurred, the well was allowed to recharge prior to sampling.

The monitoring well designation, date, purging procedure and equipment used, gallons removed, water quality parameters, and time sampled were recorded on a groundwater sampling form. Purge water was containerized in 55-gallon drums and handled with other IDW as described in Section 3.11 and the *Investigation-Derived Waste Management Plan* (E/A&H, 1995b). Table 3.4 lists the purge method used for Events 1 and 2, and the final water-quality data measured before each well was sampled. The purge methods are described in the following paragraphs.

Low-Flow Micropurging

Where possible, Assembly E monitoring wells were purged and sampled using micropurging techniques. In general, only the fluvial deposits and deep alluvium wells could be sampled by this method. Micropurging is based on the premise that stagnant water in the well casing does not completely mix with groundwater flowing through the screen when pumping at relatively low flow rates. Studies have suggested that flow in the well screen is horizontal and laminar, and that groundwater moving through the screened portion of a well interacts minimally with stagnant water in the overlying well casing (Robin and Gillham, 1987). Purging several well volumes prior to sample collection has been shown to be unnecessary and recent studies have demonstrated that water-chemistry results from micropurging methods are comparable to traditional sampling methods (Kearl et al., 1994). Micropurging also reduces purge-water volume and takes less time than conventional sampling. Micropurging consisted of using an electric submersible pump to remove groundwater from the wells at a rate roughly equivalent to their recharge rate. Drawdown, monitored during purging to ensure that the pumping rate did not significantly exceed the well's recharge rate, ranged from 0.0 to 0.80 feet during Event 1 groundwater sampling. Adequate volume was removed from each well to ensure that at least two sampling tube volumes were removed before pH, temperature, specific conductance, and turbidity were measured. Purging was considered complete after three consecutive readings stabilized.

Table 3.4
Summary of Assembly E Monitoring Well Purging Data — Event 1 (April 1996)

Monitoring Well ID	Date	pH (SU[a])	Specific Conductance (mS/cm[b] @ 25°C[c])	Temperature (°C)	Turbidity (NTUs[d])	Gallons Purged	Purge Method
SWMU 2 Monitoring Wells							
0GMG01DA	4/23/96	6.49	0.57	16.30	NA	24	3 well volumes removed
	9/11/96	6.38	0.319	19.63	128.5	1	Low-flow micropurging
0GMG02DA	4/23/96	6.99	1.70	16.5	NA	26	3 well volumes removed
	9/12/96	6.84	0.944	19.52	1,560	2.5	Low-flow micropurging
0GMG03DA	4/23/96	6.57	1.73	15.9	NA	20	3 well volumes removed
	9/12/96	6.69	0.87	19.28	244.7	1	Low-flow micropurging
0GMG04UA	5/16/96	8.27	0.279	17.8	8	6	3 well volumes removed
	9/12/96	6.57	0.301	17.26	NA	0.9	Purged dry
0GMG05DA	4/23/96	6.53	0.53	17.4	NA	19	3 well volumes removed
	9/11/96	6.41	0.269	20.29	1109.6	NA	Low-flow micropurging
002G01UA	4/10/96	7.0	0.95	15.2	76.1	8	Purged dry
	9/11/96	6.82	0.956	19.59	350	6	Purged dry
002G01DA	4/11/96	6.79	0.75	16.1	> 200	3	Low-flow micropurging
	9/3/96	6.48	0.162	20.37	2167.4	NA	Low-flow micropurging
002G02UA	4/10/96	6.77	0.80	16.0	> 200	5	Purged dry
	9/3/96	6.41	0.747	18.83	318	5	Purged dry
002G02DA	4/11/96	6.62	4.03	16.5	160	11	Low-flow micropurging
	9/3/96	6.54	0.248	18.48	1551	3	Low-flow micropurging
002G03UA	4/10/96	7.06	0.61	14.9	> 200	4.5	Purged dry
	9/10/96	6.77	0.648	21.96	978.3	3	Purged dry
002G03DA	4/10/96	7.02	0.73	16.5	> 200	2	Low-flow micropurging
	9/9/96	7.29	0.943	18.17	515.9	16.3	3 well volumes removed
	9/10/96	6.74	0.748	19.81	2,060.2	3	Low-flow micropurging
002G04UA	4/10/96	6.78	0.79	15.0	52.4	8	3 well volumes removed
	9/6/96	6.68	1.850	17.71	327.1	7	Purged dry
002G05UA	4/10/96	7.54	1.30	19.4	512	NA	Purged dry
	9/11/96	6.80	1.203	18.65	596	2.3	Purged dry
002G05DA	4/10/96	6.94	0.75	16.5	96	5	Low-flow micropurging
	9/10/96	7.44	0.711	19.29	709.4	3	Low-flow micropurging
002G06UA	4/9/96	6.86	1.34	19.7	128	6	Purged dry
	9/6/96	6.51	1.419	21.55	385.6	4	Purged dry
002G06DA	4/9/96	4.28	1.28	18.9	124.6	4.5	Low-flow micropurging
	9/11/96	6.84	1.475	18.84	106.9	4	Low-flow micropurging
002G07UA	4/10/96	6.83	0.97	17.8	70	5	Purged dry
	9/5/96	6.77	0.856	22.88	48.2	2	Purged dry
002G08UA	4/9/96	6.97	14.91	18.9	50.8	6	Purged dry
	9/5/96	6.79	1.342	24.72	165.3	2	Purged dry

Table 3.4
Summary of Assembly E Monitoring Well Purging Data — Event 1 (April 1996)

Monitoring Well ID	Date	pH (SU[a])	Specific Conductance (mS/cm[b] @ 25°C[c])	Temperature (°C)	Turbidity (NTUs[d])	Gallons Purged	Purge Method
SWMU 2 Monitoring Wells							
002G08DA	4/9/96	6.98	6.86	17.3	174	NA	Low-flow micropurging
	9/5/96	6.86	0.774	20.67	1,002	2.5	Low-flow micropurging
002G09UA	4/9/96	6.74	10.96	19.3	38	2	Purged dry
	9/10/96	6.66	0.594	23.28	411.3	1	Low-flow micropurging
002G09DA	4/9/96	6.94	6.67	19.3	132.2	3.5	Low-flow micropurging
	9/10/96	7.45	0.505	22.97	1,282.7	2	Low-flow micropurging
	9/10/96	7.12	0.845	17.92	209.4	14	3 well volumes removed
002G10UA	4/11/96	6.87	1.93	17.6	> 200	NA	Purged dry
	9/11/96	6.74	1.022	18.28	44.8	6.5	Purged dry
002G10DA	4/11/96	6.99	0.82	18.8	> 200	2	Low-flow micropurging
	9/11/96	6.92	0.888	20.89	376.6	2	Low-flow micropurging
002G11UA	4/11/96	6.89	0.73	14.1	> 200	16	3 well volumes removed
	9/9/96	6.83	0.748	16.64	982	5.5	Purged dry
002G11DA	4/11/96	6.95	0.69	17.7	> 200	NA	Low-flow micropurging
	9/9/96	6.82	0.643	18.97	2,362	3	Low-flow micropurging
002G12UA	4/11/96	6.84	0.97	15.3	> 200	8	3 well volumes removed
	9/12/96	6.72	0.546	16.19	27	8	3 well volumes removed
002G12DA	4/11/96	6.88	0.60	16.7	> 200	3	Low-flow micropurging
	9/12/96	6.40	0.139	15.86	194	23	3 well volumes removed
002G13UA	4/12/96	6.77	8.31	15.9	11.0	12	Purged dry
	9/11/96	6.75	0.456	19.87	1,181	10	Purged dry
002G13MA	4/12/96	6.62	2.48	16.3	187	3	Low-flow micropurging
	9/10/96	6.39	0.307	18.43	584	2	Low-flow micropurging
002G13DA	4/12/96	6.71	3.02	16.3	520	3.5	Low-flow micropurging
	9/10/96	6.56	0.347	18.51	3,744	2.5	Low-flow micropurging
002G14UA	4/11/96	6.79	1.42	15.6	62.3	6.5	Purged dry
	9/6/96	6.68	1.475	19.4	152.5	6.5	Purged dry
002G14DA	4/11/96	6.72	0.56	15.6	NA	1.5	Low-flow micropurging
	9/6/96	6.25	0.524	18.14	696.9	4	Low-flow micropurging
	9/6/96	6.21	0.489	17.18	272	18	3 well volumes removed
SWMU 9 Monitoring Wells							
009G01DA	4/12/96	6.89	6.52	18.7	> 200	NA	Low-flow micropurging
009G02DA	4/12/96	7.06	1.03	18.5	194	3.5	Low-flow micropurging
009G03DA	4/12/96	6.41	7.39	18.0	> 200	5	Low-flow micropurging
009G04DA	4/12/96	6.90	6.10	18.7	> 200	NA	Low-flow micropurging

Table 3.4
Summary of Assembly E Monitoring Well Purging Data — Event 1 (April 1996)

Monitoring Well ID	Date	pH (SU[a])	Specific Conductance (mS/cm[b] @ 25°C[c])	Temperature (°C)	Turbidity (NTUs[d])	Gallons Purged	Purge Method
SWMU 14 Monitoring Wells							
014G01LS	4/16/96	6.99	0.86	16.9	> 200	7.5	Purged dry
014G01LF	4/16/96	6.91	0.55	18.1	> 200	4	Low-flow micropurging
014G02LS	4/16/96	7.12	0.78	15.3	> 200	2	Purged dry
014G03LS	4/16/96	7.06	0.70	15.6	> 200	5	Purged dry
014G04LF	4/16/96	6.91	0.56	18.3	> 200	5	Low-flow micropurging
014G05LS	4/16/96	6.96	0.82	15.9	48.6	6	Purged dry
014G06LF	4/17/96	6.94	2.46	19.1	> 200	NA	Low-flow micropurging
014G07LF	4/17/96	6.82	2.20	19.1	> 200	NA	Low-flow micropurging
014G08LS	4/16/96	6.79	3.50	17.6	110	8	Purged dry
SWMU 59 Monitoring Wells							
059G01LS	4/18/96	6.52	2.28	18.9	NA	5.5	Purged dry
059G02LS	4/18/96	6.39	1.96	19.3	NA	5	Purged dry
059G03LS	4/18/96	6.66	2.62	21.6	NA	5	Purged dry
059G03UF	4/18/96	6.21	1.60	21.3	NA	5	Low-flow micropurging
SWMU 65 Monitoring Wells							
065G05UA	4/17/96	7.25	0.64	17.7	196	NA	Purged dry
065G06UA	4/17/96	7.23	1.16	16.3	> 200	5	Purged dry
065G06DA	4/17/96	7.12	1.11	17.7	> 200	NA	Purged dry
065G07UA	4/18/96	6.86	1.75	18.1	> 200	3	Low-flow micropurging

Notes:
SU[a] — Standard Units
mS/cm[b] — milli-Siemens per centimeter
°C — Degrees Celsius
NTUs[d] — Nephelometric Turbidity Units
> 200[e] — Turbidity reading greater than maximum instrument detection of 200 NTUs.
NA[f] — Information not available due to instrument malfunction
NR — Not Recorded

Purge Three Well Volumes

In most cases, the loess and upper alluvium wells would not sustain a recharge rate equivalent to the pumping rate. If the well did not purge dry, three well volumes of groundwater were removed, as shown on Table 3.4. The well was allowed to recharge to near-static levels prior to

sampling. The length of required recharge time varied between a few minutes and a few hours. During Event 2, three deep alluvium monitoring wells (002G03DA, 002G09DA, and 002G14DA) were purged and sampled using both low-flow micropurging and three well volume removal techniques, so that the analytical results from both methods could be compared. The results of these samples will be presented in the SWMU 2 site-specific section (to be included in subsequent revisions of this RFI report).

Purge Well Dry and Allow Recharge

In all loess monitoring wells and many upper alluvium monitoring wells, the recharge rate was less than the lowest possible purge rate allowed by the submersible pump, resulting in the well purging dry. Wells were allowed to recharge to near static groundwater levels prior to sampling. The length of required recharge time ranged from a few hours to overnight.

Groundwater Sampling Methods

As previously outlined, groundwater samples were collected using submersible electric pumps and dedicated Teflon tubing. For wells requiring recharge after removing three well volumes or purging dry, the pump was gently lowered into the well to approximately the middle of the screened interval and turned on. For micropurged wells, the pump was already operating in the middle of the screened interval. Sampling was conducted over a 5-gallon bucket to collect excess water flowing from the tubing. The excess water was containerized along with purge water in 55-gallon drums and handled with other IDW as described in Section 3.11 and the *Investigation-Derived Waste Management Plan* (E/A&H, 1995b).

Prior to sampling, clean nitrile gloves were donned and the sample container cap was removed. Personnel filled VOC containers first, being careful to reduce water disturbance, then SVOC containers and the remaining sample containers. Samples requiring chemical preservation were either collected in pre-preserved sample containers provided by the analytical laboratory or

preserved in the field according to Section 4.12.2 of the *Comprehensive RFI Work Plan*. The sample designation, time collected, sample date and time, and requested analyses were recorded on a sample label and affixed to each sample container. The samples were then immediately placed on ice in a cooler chilled to 4°C (±2°C) and transported to the field trailer to be prepared for shipment to the analytical laboratory.

3.5 Sediment Sampling

For the purposes of this RFI report, the samples collected from drainage pathways or sewage lagoons are designated as "sediment samples". Those sediment samples collected from the 0- to 6-inch interval are termed "surface sediment", and those collected from the 18- to 24-inch interval are termed "subsurface sediment". As shown in Table 3.1, 50 surface sediment samples and 41 subsurface sediment samples from the same locations were collected during the Assembly E RFI. All Assembly E SWMU sediment sampling locations were in areas of very shallow water or in dry areas along the water's edge. Specifically, sediment samples were collected from Big Creek Drainage Canal near SWMUs 2 and 9, from the SWMU 9 sewage lagoons, from the 7th Avenue drainage ditch west of SWMU 14, from the SWMU 38 primary and secondary drainage ditches on the Southside, and from the drainage depressions at SWMU 65. The sediment samples were collected with a stainless steel hand auger using the procedures for hand-auger soil sampling described in Section 3.3.3.

3.6 Surface Water Sampling

Four surface water samples were collected from Big Creek Drainage Canal at locations upgradient and downgradient of SWMUs 2 and 9, as summarized in Table 3.1. Surface water samples were collected using the submerged laboratory bottle method. Prior to sample collection, personnel donned clean nitrile gloves and removed the sample container cap. The container was gently submerged with the container opening pointing upstream. VOC samples were collected in unpreserved vials completely submerged and recapped underwater to ensure there was no

headspace in the container. Remaining sample containers were uncapped and slowly submerged until sufficient volume had been obtained. The container was then removed and recapped, labeled, placed in an ice chest, and chilled to 4°C (±2°C). The samples remained in the ice chest until the sampling team returned to the field trailer. Samples requiring chemical preservation (VOCs, TPH, Appendix IX metals, and cyanide) were preserved prior to shipment to the laboratory.

3.7 Fish Tissue Samples

To determine the potential risk of bioaccumulation of sediment contaminants by demersal (bottom-dwelling) species in the sewage lagoons, E/A&H conducted a fish study at SWMU 9, which included the collection of three composite fish samples, two from the larger lagoon and one from the smaller lagoon. For cost-effectiveness, trotlines were the chosen sampling device. A trotline is a cord stretched horizontally across the surface of the lagoon, from which baited fishing hooks are suspended vertically from equally spaced fishing lines along the cord. One trotline with approximately 50 baited hooks was set in the smaller lagoon (designated "Pond 1" during the study), while two trotlines with approximately 100 baited hooks each were set in the larger lagoon (designated "Pond 2" during the study).

Only one species of potentially edible game fish, the black bullhead catfish *Ictalurus melas*, was caught during the study. Clean nitrile gloves were worn during sample collection and preparation for shipment. Seven small to medium (0.25 to 1.5 pound) catfish were collected from the smaller lagoon and submitted as a composite sample designated 009J010001. Four small to medium catfish were collected from the larger lagoon and submitted as two composite samples designated 009J020001 and 009J020002. The whole fish were wrapped in aluminum foil, frozen alive, and shipped to Ceimic Corporation for analysis.

3.8 Sampling Protocol

All sampling activities adhered to the approved *Comprehensive RFI Work Plan* and the *Assembly E Site Investigation Plans*. Where warranted by field conditions, personnel deviated from the approved procedures and appropriately documented these deviations in the site logbook. These deviations are discussed in Section 8's SWMU-specific sections.

Samples were transferred from the sampling device to containers expediently, in as clean an environment as possible. Plastic sheeting was placed over the sample area (around the well or sampling table), and personnel donned a new pair of disposable nitrile gloves before collecting each sample. Empty containers were kept packaged until used, at which time they were placed on ice and isolated in coolers. Soil samples for VOC analysis were containerized first from unhomogenized material to lessen the loss of volatile constituents. All other soil samples were homogenized in a stainless-steel mixing bowl in accordance with the *Comprehensive RFI Work Plan*, the *Assembly E Site Investigation Plans*, and the *USEPA Standard Operating Procedures Quality Assurance/Quality Control Manual* (USEPA, 1991a) and then placed in the appropriate containers.

QA/QC samples were collected during the RFI to test the level of reproducibility attainable in the sampling and analytical process, quality of equipment decontamination, quality of source waters and materials, sample exposure to ambient contamination during handling, and the level of laboratory precision and accuracy. QA/QC samples were analyzed for the same contaminant assessment constituent parameters as the associated environmental samples. All field QA/QC samples were collected in accordance with the work plans and consisted of the following:

QA/QC Sample Type and Frequency

- *Confirmation Samples:* 25% of DPT soil and groundwater samples to be analyzed by the onsite laboratory were split and submitted to the offsite laboratory for VOC confirmation analysis.

- *Duplicate Samples:* 10% of soil, groundwater, sediment, and surface water samples were split as duplicates and analyzed along with the primary samples by the offsite laboratory.

- *Equipment Rinsates:* One per week during sampling. During rotasonic drilling, rinsates were collected from both the inner core barrels and from the stainless-steel sampling implements used for sample collection and soil homogenization. During groundwater sampling, equipment rinsates were obtained from the submersible electric pump.

- *Field Blanks:* One per sampling event (week) per source of water.

- *Matrix Spikes/Matrix Spike Duplicates:* 5% of the samples collected.

- *Trip blanks:* One per cooler containing VOC samples.

During the DPT screening investigation, unpreserved sample containers were shipped to E/A&H in sealed packages for use in onsite laboratory analysis. Since the DPT samples submitted to the onsite laboratory would be analyzed within seven days, no chemical preservation was required according to the *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (USEPA, 1994a). Sample containers requiring chemical preservation during the DPT investigation (i.e., groundwater VOC confirmation samples submitted to the offsite laboratory) were pre-preserved with hydrochloric acid by the testing laboratory and shipped to E/A&H in sealed packages. During the RFI, samples were preserved in the field with preservatives provided

by the analytical laboratory in accordance with the USEPA Region IV *Standard Operating Procedures and Quality Assurance Manual* (USEPA, 1991a). As soon as samples were collected, the containers were labeled with the sample identification number, date, sampler's name, and requested analytical parameter. Samples were individually bubble-wrapped, bagged in resealable plastic bags, and packed on sealed ice inside sturdy coolers.

Samples for onsite laboratory analysis were transported by the USGS or E/A&H geologist directly to the laboratory. The Hydrologic chemist recorded each sample in a sample logbook immediately upon receipt. Samples for offsite laboratory analysis were transported to the field trailer where they were prepared for shipment on the day when they were collected. Preparation involved logging the sample information into the E/A&H analytical database and arranging the samples in iced coolers with sufficient volume to maintain uniform and appropriate preservation temperatures during shipment. Temperature blanks were placed in all coolers for laboratory verification of their temperature upon arrival. Trip blanks were placed in coolers containing samples for VOC analysis. Cooler lids were secured with packing tape and sealed with signed custody seals. Packaged samples were shipped overnight via FedEx priority service for next morning delivery. The laboratory was notified the day of shipment of the number of samples to be submitted, and E/A&H personnel were contacted by the laboratory the following day to acknowledge receipt of the samples and their condition. When samples were collected on Fridays, E/A&H arranged for the laboratory to receive the samples on Saturday. When samples were collected on Saturday or Sunday, they were shipped the following Monday. All sample shipments were reported to have arrived at the testing laboratories in good condition and at appropriate temperatures.

To ensure the integrity of the sample transfer process, a strict chain-of-custody procedure was implemented. This procedure was initiated in the field for each sampling event and conducted through custody transfer to the analytical laboratory. A chain-of-custody form was completed for each sample batch. The following were listed on each form: sample numbers, containerization,

preservatives, analysis requested, date and time of sampling, and FedEx air bill shipping number. Custody transfers were recorded by signature, date, and time of relinquishment, and receipt of custody. A copy of each chain of custody is provided in the *Data Validation Report — Assembly E* (E/A&H, 1997a).

Sample Labeling

All samples collected in the field were labeled with a 10-digit alphanumeric code that identified the site, sample type, sample location, sample depth, and QA sample type (as appropriate). The first three digits identify the site location (SWMU 9 = 009). The fourth digit identifies the sample type (for instance, soil = S, soil duplicate = C, groundwater = G, groundwater duplicate = H). The matrix codes are listed with the analytical data in the *Data Validation Report — Assembly E*. The fifth through eighth digits represent the station location (location 12 = 0012, upper fluvial well 3 = 03UF). The final two digits represent the deepest point of the sample interval for soil (15 to 17 feet = 17), screened interval for DPT groundwater samples (39 to 40 feet = 40), or the sampling event for groundwater monitoring wells (01 = first sampling event). Examples of sample labels are:

DPT Samples

014S000507 SWMU 14 soil sample from location 5, 5- to 7-foot interval

002G001327 SWMU 2 groundwater sample from location 13, 26 to 27-foot screened interval

All Other Samples

059S02LS02 SWMU 59 soil sample from loess soil boring location 2, 0 to 2-foot interval

065G06UA01 SWMU 65 groundwater sample from upper alluvium monitoring well 6, first sampling event

3.9 Data Validation

The NSA Memphis data were validated by either E/A&H or E/A&H's subcontractors, Heartland Environmental Services, Inc., of St. Charles, Missouri, or Validata Chemical Services of Norcross, Georgia. Ninety-five percent of the data were validated at DQO Level III-equivalent while 5% were validated at DQO Level IV-equivalent. Data validation was performed in accordance with the following documents (as appropriate):

- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (OLMO3.1)*, OSWER, February 1994 (EPA-540/R-94/012). (Organic Functional Guidelines).

- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (ILMO3.0)*, OSWER, February 1994 (EPA-540/R-94/013). (Inorganic Functional Guidelines).

The data validation findings for Assembly E SWMUs are presented under separate cover within *Data Validation Report — Assembly E* (E/A&H, 1997a).

3.10 Decontamination Procedures

Field equipment was decontaminated in accordance with guidelines set forth in the *Assembly E Site Investigation Plans* and the *Comprehensive RFI Work Plan*. All downhole and sampling equipment for the Assembly E investigations were decontaminated before and after each use at the Southside decontamination pad set up at Wash Rack 1638 on C Street. Rinse water generated during the Assembly E investigation was stored in a 2,000-gallon holding tank at the wash rack. Following a VOC scan and approval from the City of Millington's wastewater consultant,

Fisher and Arnold, Inc., the holding tank contents were discharged to an oil-water separator and then to the sanitary sewer.

Decontamination procedures for downhole equipment consisted of the following steps:

1. High-pressure wash with a hot mixture of soap and water.
2. Potable water rinse.
3. Deionized, organic-free water rinse.
4. Two pesticide-grade isopropyl alcohol rinses.
5. Deionized organic-free water rinse.
6. Air dry.
7. Aluminum foil or plastic wrap.
8. Donning of a new pair of disposable nitrile gloves before handling decontaminated sampling equipment.

3.11 Investigation-Derived Waste

During the DPT screening investigations, soil samples were collected directly from the split-spoon samplers and groundwater samples directly from the hydrocone or screened sample chamber; therefore, these sampling activities generated no IDW. During the soil boring advancement and monitoring well installation, soil cuttings, water generated during drilling, and well development/purge fluids were stored in labeled 55-gallon drums.

The following was recorded in the Assembly E IDW logbook: drum contents, date filled, boring/well identification, and a tracking code. Soil and water drums were loaded on pallets and staged in a fenced and paved area at the former Aircraft Intermediate Maintenance Department van storage area (Facility N-1665).

The soil data were reviewed to characterize the waste soil generated during the investigation. The IDW generated from the Assembly E RFI did not meet the criteria for a hazardous waste (*Technical Memorandum — Characterization of Investigation-Derived Waste from Assembly E SWMUs* (E/A&H, 1996b). However, TPH was considered a potential disposal problem. TDEC requested that E/A&H screen the drums with a PID. Detectable levels of organic vapors were detected in some drums (*Technical Memorandum — Assembly E IDW Drum Screening Results* (E/A&H, 1997b). The drums with detectable levels were sampled for TPH analysis. Results for these were presented to TDEC and USEPA in *Technical Memorandum — Assembly E IDW TPH Sampling Results* (E/A&H, 1997c). The memorandums referenced above are included in Appendix E of this document. As a result of the data review and supplemental sampling, E/A&H segregated six drums for disposal as a special waste (petroleum-contaminated soil). The remainder was spread near SWMU 41 (Salvage Yard #1) in accordance with the *Investigation-Derived Waste Management Plan* (E/A&H, 1995b).

3.12 Ancillary Data Collection

Supplemental information collected during the Assembly E RFI consisted of aquifer characterization, borehole geophysics, geophysical surveys, and global positioning system (GPS) surveys, as outlined in the following sections.

3.12.1 Aquifer Characterization

The rate of groundwater movement and possible contaminant migration was evaluated through a limited aquifer characterization at Assembly E. Characterization involved testing the specific capacity of the monitoring wells listed on Table 3.5 and constructing potentiometric maps for Assembly E wells screened in the upper alluvium, upper fluvial deposits, and lower fluvial deposits/deep alluvium (shown previously as Figures 2.11, 2.12, and 2.13). Groundwater migration rates in the loess were not evaluated during the RFI due to the abundant historical information from previous investigations across NSA Memphis.

Table 3.5
Specific Capacity Testing of Select Assembly E Monitoring Wells

Aquifer Tested	SWMU	Monitoring Well ID
Upper Alluvium	SWMU 2	002G03UA
		002G09UA
Upper Fluvial Deposits	SWMU 59	059G03UF
Lower Fluvial Deposits/Deep Alluvium	SWMU 2	002G03DA
	SWMU 2	002G09DA
	SWMU 9	009G01DA
	SWMU 9	009G03DA
	SWMU 14	014G07LF
	SWMU 65	065G06DA

A well's specific capacity is the ratio of the yield per foot of drawdown, usually expressed in terms of gallons per minute per foot of drawdown. During specific capacity testing, E/A&H used an electric submersible or peristaltic pump to withdraw water from the well at a known discharge rate for a designated time. Drawdowns were measured with an electronic water level indicator until relative stabilization occurred at that pumping rate. Specific capacity is a function of the following variables:

- Well efficiency.
- Transmissivity of the zone supplying water to the well, which may be less than the transmissivity of the aquifer, depending on the length of the screen.
- Storage coefficient of the aquifer.
- Length of the pumping period.
- Effective radius of the well.
- Pumping rate.

The relationship between specific capacity and transmissivity is based on the Theis equation:

$$T = \frac{W(u)}{4\pi} \frac{Q}{s}$$

where T is the transmissivity, Q/s is the specific capacity, Q is the pumping rate, s is the drawdown, and $W(u)$ is the well function of u. This equation requires use of consistent units. The $W(u)$ is defined as:

$$u = \frac{r^2 S}{4Tt}$$

where T is defined as above, r is the effective radius of the well, S is the storage coefficient, and t is the duration of pumping. Once again, this equation requires use of consistent units.

Bradbury and Rothschild (1985) have developed a computer program to facilitate the parameter estimation process using the Theis solution modified for partial penetration of a well using a method adopted from Brons and Marting, and the Csallany-Walton correction for well loss. The data from the Bradbury and Rothschild program is in Appendix D to this report. Two assumed variables entered into the specific capacity program were the storage coefficient and well loss coefficient. Storage coefficients were calculated by multiplying the aquifer's specific storage by the thickness of the aquifer at each tested well. A specific storage value for the fluvial aquifer of 1.2E-6 per foot was used to calculate the storage coefficient for all tested wells except 002G03UA. A specific storage for the loess of 58E-6 per foot was used for this well because it is screened entirely in silt. These specific storage values were obtained during aquifer characterization of the fluvial deposits at the USGS well WL-2F (USGS, 1996). Aquifer thickness was obtained from the individual Assembly E boring logs. A well loss coefficient of 0.1 was selected from Todd (1980) for well screens and sand packs that are properly designed and developed. The

specific capacity data were used to derive T and the hydraulic conductivity (K), which were presented in the discussion of site-specific geology in Section 2.

3.12.2 Borehole Geophysics

The stratigraphy at SWMUs 2, 9, 14, 59, and 65 was characterized through physical description of the soil cores recovered while the soil borings and monitoring wells were being completed. Supplemental lithologic information was gathered through geophysically logging at least one of each SWMU's deepest monitoring wells. A combination probe consisting of natural-gamma ray and electrical induction was used to measure the natural gamma-ray emission and electrical conductivity of the adjacent strata penetrated by the monitoring well. Table 3.6 lists the monitoring wells which were geophysically logged. Selection of these wells was based on their areal coverage on the Southside. Appendix C of this document contains a copy of each geophysical log.

Table 3.6
Geophysical Logging of Select Assembly E Monitoring Wells
NSA Memphis — Millington, Tennessee

SWMU	Monitoring Well ID	Depth of Well (feet bls)	Lithologic Unit
SWMU 2	002G03DA	48	Deep Alluvium
	002G09DA	46	Deep Alluvium
	002G11DA	42.2	Deep Alluvium
	002G13DA	65	Deep Alluvium
SWMU 9	009G04DA	72	Deep Alluvium
SWMU 14	014G04LF	49	Lower Fluvial Deposits
SWMU 59	059G03UF	54	Upper Fluvial Deposits
SWMU 65	065G06DA	42	Deep Alluvium

The logging probe was approximately 5.5 feet long and designed to run in 2-inch, PVC-cased holes in or out of the water column. The probe was lowered and raised at a set speed by a cable attached to a winch. The cable contained electronic wiring connecting the probe to a computer inside the logging truck. The operator positioned the logging truck close to the hole and began entering well information into the computer, while the second operator attached the decontaminated probe to the cable and positioned the probe in the monitoring well for temperature equilibration. The probe was zeroed to ground surface before being lowered to the bottom of the well. At the bottom, the probe's temperature was allowed to equilibrate. Data were recorded at 0.1-foot intervals by digital computer as the probe ascended. When the probe reached the surface, it was detached from the cable and stored for transport to the decontamination pad. Before the logging unit left the monitoring well, a paper copy of the data was generated to check instrument function. QC was obtained daily by repeating 20-foot sections of various monitoring wells.

3.12.3 Geophysical Surveying

Prior to the DPT screening investigations, geophysical surveys were performed at SWMUs 2, 14, and 65 to identify former site features and structures, and to clear zones for subsequent soil and groundwater sampling. E/A&H conducted the geophysical surveys using frequency-domain electromagnetic instrumentation (EM-31). Each EM-31 survey included a conductivity survey and an in-phase (metal detection) survey. Geophysical anomalies due to disturbed soil or metal objects were plotted on a map and compared with the as-built engineering drawings (where available). Proposed sample locations were chosen after results were reviewed. The following sections summarize the geophysical surveys conducted at SWMUs 2, 14, and 65.

SWMU 2

The SWMU 2 geophysical survey was intended to identify landfill boundaries and clear zones for landfill soil sampling. Data were collected on four traverses; two across the northern section of the SWMU, and two along the southern boundary following the perimeter road. The traverses

were approximately 1,970 feet long with station readings every 10 feet. Survey results identified the landfill boundaries and several anomaly-free zones for subsequent drilling and sampling.

SWMU 14

On July 19, 1995, E/A&H performed a geophysical survey at SWMU 14 in an attempt to verify the approximate location of the former building and subsurface structures. The geophysical survey identified one moderate anomaly at SWMU 14 near the former location of an outdoor washbasin. The rest of the surveyed area was anomaly-free, indicating the sumps and separators may have been removed during building demolition. A linear feature along the site's eastern survey boundary may be an abandoned potable water line that supplied water to the adjacent property when it was a trailer park. The geophysical survey results for SWMU 14 were presented in *Geophysical Survey Report — SWMUs 14, 36, and 65* (E/A&H, 1995c).

SWMU 65

On July 18, 1995, E/A&H performed a geophysical survey at SWMU 65 in an attempt to verify the former location of the two USTs used to fuel the test cell in Building S-346. The geophysical survey identified a significant anomaly corresponding to the former location of the USTs. A strong, localized anomaly was identified along the southeastern boundary of the surveyed area, but its source is undetermined. Two additional linear anomalies may represent buried utility lines bisecting the survey area and along the eastern side of the site. The geophysical survey results for SWMU 65 were presented in *Geophysical Survey Report — SWMUs 14, 36, and 65* (E/A&H, 1995c).

3.12.4 GPS Surveying

E/A&H performed a GPS survey of the Assembly E sampling locations. The GPS survey established the horizontal position (latitude and longitude) of each DPT, soil boring, monitoring well, sediment, and surface water sample location. The survey also established the vertical position in feet above mean sea level to the nearest 0.01 foot of the ground surface and top of casing elevation for each Assembly E monitoring well. The GPS data were input into the Geographical Information System (GIS) database for display on maps shown in this report.

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4.0 NATURE AND EXTENT OF CONTAMINATION

This section outlines the methods used to organize and evaluate the analytical data for each Assembly E RFI sample. The nature and extent of contamination evaluations for individual Assembly E SWMUs are provided as tabbed sections in Section 8 of this report.

Detected concentrations of organic compounds and inorganics in each Assembly E sample were compared to published USEPA risk-based screening values and other criteria to determine if additional evaluation might be warranted. The screening values for each media are discussed in Sections 4.1 through 4.5. In addition, detected concentrations of inorganics in soil and groundwater were compared to their established NSA Memphis background reference concentrations (RCs, or two times the mean background concentration) to provide an indication whether the detected inorganic is naturally occurring or might be related to SWMU operations. RCs for soil and groundwater are summarized in Section 4.2. The calculations for the background RCs were provided in the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a). No background RCs have been established for sediment or surface water for NSA Memphis Southside.

4.1 General Procedures for Constituent Evaluation

4.1.1 Soil Samples

USEPA risk-based concentrations (RBCs) for residential and industrial soil, along with USEPA soil screening levels (SSLs) for evaluating the potential transfer from soil to groundwater, were used to assess individual concentrations of organic compounds and inorganics detected in surface soil samples collected from SWMUs 9, 14, 59, and 65. RBC and SSL criteria are outlined in the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). Since soil RBCs apply only to surface soil samples, SSLs were used to assess contaminants in subsurface soil samples. SSLs, as outlined in the USEPA *Soil Screening Guidance: Users Guide* (USEPA, 1996b), should be compared to the contaminant average in each borehole, beginning at 6 inches bls and ending

at the borehole's termination. The maximum concentration of each constituent was compared to the SSL value, rather than the borehole average, to simplify the comparison of SSLs to contaminants and because not all soil data collected during the RFI began at 6 inches bls. Using the maximum concentration provided a more conservative comparison. Individual contaminants exceeding SSL values are evaluated in the Section 8 SWMU-specific fate and transport evaluations.

In certain instances, RBCs or SSLs are not available. Therefore, values for similar compounds or other published risk values were substituted for residential and industrial soil RBCs to evaluate detected constituents in Assembly E surface soil samples. Benzo(g,h,i)perylene and phenanthrene do not have published RBCs. Therefore, the RBCs for a chemically similar compound, fluoranthene, were substituted for these analytes. No RBC is available for lead. Therefore, guidance concentrations of 400 and 1,300 mg/kg for lead in residential and industrial soil were substituted for the RBCs. These concentrations are from the *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (USEPA, 1994c). TPH-GRO and TPH-DRO have no published RBC or SSL. Therefore, the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{4} to 10^{-6} centimeters per second (cm/sec) was substituted for the SSL and compared to the sum of detected TPH-GRO and TPH-DRO concentrations in each soil sample. The TDEC soil cleanup standards are from the memorandum *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

Inorganics in surface and subsurface soil were compared to their RCs to determine if they may be naturally occurring or a result of SWMU operations. Section 4.2 discusses this issue.

4.1.2 Groundwater Samples

RBCs for tap water and maximum contaminant levels (MCLs) for drinking water were used to evaluate concentrations of organic compounds and inorganics in groundwater samples. Tap water

RBCs are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a), and MCLs are from *Drinking Water Regulations and Health Advisories* (USEPA, 1996c). Because lead does not have an MCL, its Treatment Technique Action Level (TTAL) from *Drinking Water Regulations and Health Advisories* (USEPA, 1996c) was used for comparison.

TPH, TPH-GRO, and TPH-DRO have no published RBC or MCL. Therefore, the TDEC cleanup standard of 100 μg/L for drinking water aquifers for petroleum-contaminated sites was substituted for the tap water RBC and compared with the TPH concentration or the sum of detected TPH-GRO and TPH-DRO concentrations in each groundwater sample. The TDEC groundwater cleanup standard is from the memorandum *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997). The water quality classification of the alluvial aquifer has not yet been established at NSA Memphis. Although groundwater wells completed in the fluvial deposits are present off of NSA Memphis property, USGS representatives have stated that they are not aware of any drinking water wells completed in the alluvial aquifer in the vicinity of NSA Memphis. EnSafe is currently conducting a water use survey to establish the absence or presence of alluvial water wells in the vicinity of NSA Memphis. The results of this survey will be included in subsequent revisions to this RFI report.

Detected inorganics in groundwater samples are also compared to their established RCs to determine if they may be naturally occurring or a result of SWMU operations. Section 4.2 discusses this issue.

4.1.3 Sediment Samples

For the purposes of this RFI report, the samples collected from drainage pathways or lagoons are defined as sediment samples. Samples collected from the 0- to 6-inch interval are termed *surface sediment*, and samples collected from the 18- to 24-inch interval are termed *subsurface sediment*.

Some sampling locations are submerged throughout the year and others are intermittently submerged. Sediment samples collected from locations that are submerged are those from Big Creek Drainage Canal (SWMUs 2 and 9) and the SWMU 9 sewage lagoons. Sediment samples collected from locations that are intermittently submerged are those from the SWMU 38 Southside drainage ditches (including the Seventh Avenue drainage ditch) and the drainage depressions at SWMU 65. Ecological risk was evaluated by comparing USEPA Sediment Screening Values (SSVs) to detected concentrations of organic and inorganic constituents in Assembly E surface sediment samples. SSVs were obtained from *Supplemental Guidance to RAGS: Region IV, Bulletin 2, Ecological Risk Assessment* (USEPA, 1995a).

At locations that are intermittently submerged, sediments have many of the exposure characteristics of soil. Human health risk was evaluated by comparing USEPA residential and industrial soil RBCs to contaminant concentrations in surface sediment from intermittently submerged locations. The potential for contaminants to leach from intermittently submerged sediment to underlying groundwater was evaluated by comparing contaminant concentrations in surface and subsurface sediment to USEPA SSLs for soil-to-groundwater transfer. No inorganic sediment RCs have been established for the NSA Memphis Southside. However, sediment samples from locations that are intermittently submerged are compared to soil RCs.

4.1.4 Surface Water Samples

Freshwater Quality Standards (FWQS) were used to evaluate detected concentrations of organic compounds and inorganics in surface water samples collected from Big Creek Drainage Canal. FWQSs were obtained from the water quality criteria specified in *40 CFR Part 131.36*. No inorganic surface water background RCs have been established for the NSA Memphis Southside.

4.1.5 Fish Tissue Samples

USEPA RBCs for fish tissue consumption, based on adult exposure, were used to evaluate the detected concentrations of organic compounds and inorganics in fish tissue samples from the SWMU 9 sewage lagoons. Fish tissue RBCs were obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

4.2 Background Reference Concentrations for Soil and Groundwater Samples

Background sample stations (shown on Figure 4.1) were established at 13 NSA Memphis locations to determine ambient soil and groundwater quality conditions. Table 4.1 summarizes the RCs used to compare inorganics detected in Assembly E samples. The RCs, and the methodologies used to calculate them, are further described in *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a).

If a detected soil or groundwater analyte did not exceed its established RC, the analyte was not evaluated as a contaminant of concern in the human health and ecological risk assessment, even if the analyte exceeded its residential RBC or SSL. However, if an analyte's chemical characteristics and the physical characteristics of the SWMU affected the analyte's migration potential, it was discussed in the fate and transport evaluation, even if the RC was not exceeded. The following sections describe the background samples used for each media.

4.2.1 Background RCs for Inorganics in Surface and Subsurface Soil

Background data for surface soil (0 to 1 foot bls) were collected from 13 soil boring locations (0BGS0001 through 0BGS1301), shown on Figure 4.1. Surface soil RCs were used for later health risk evaluation. Background data for subsurface soil (9 to 10 feet or 10 to 11 feet bls) were collected from five soil boring locations (0BGS0001 through 0BGS0005). As discussed in the *Comprehensive RFI Work Plan* (E/A&H, 1994a), NSA Memphis has 13 soil types. Eleven are silty loams, and two are fill containing silt. NSA Memphis soil was assumed to be homogeneous, and the RCs were assumed to represent conditions throughout NSA Memphis. RCs do not account for different soil types.

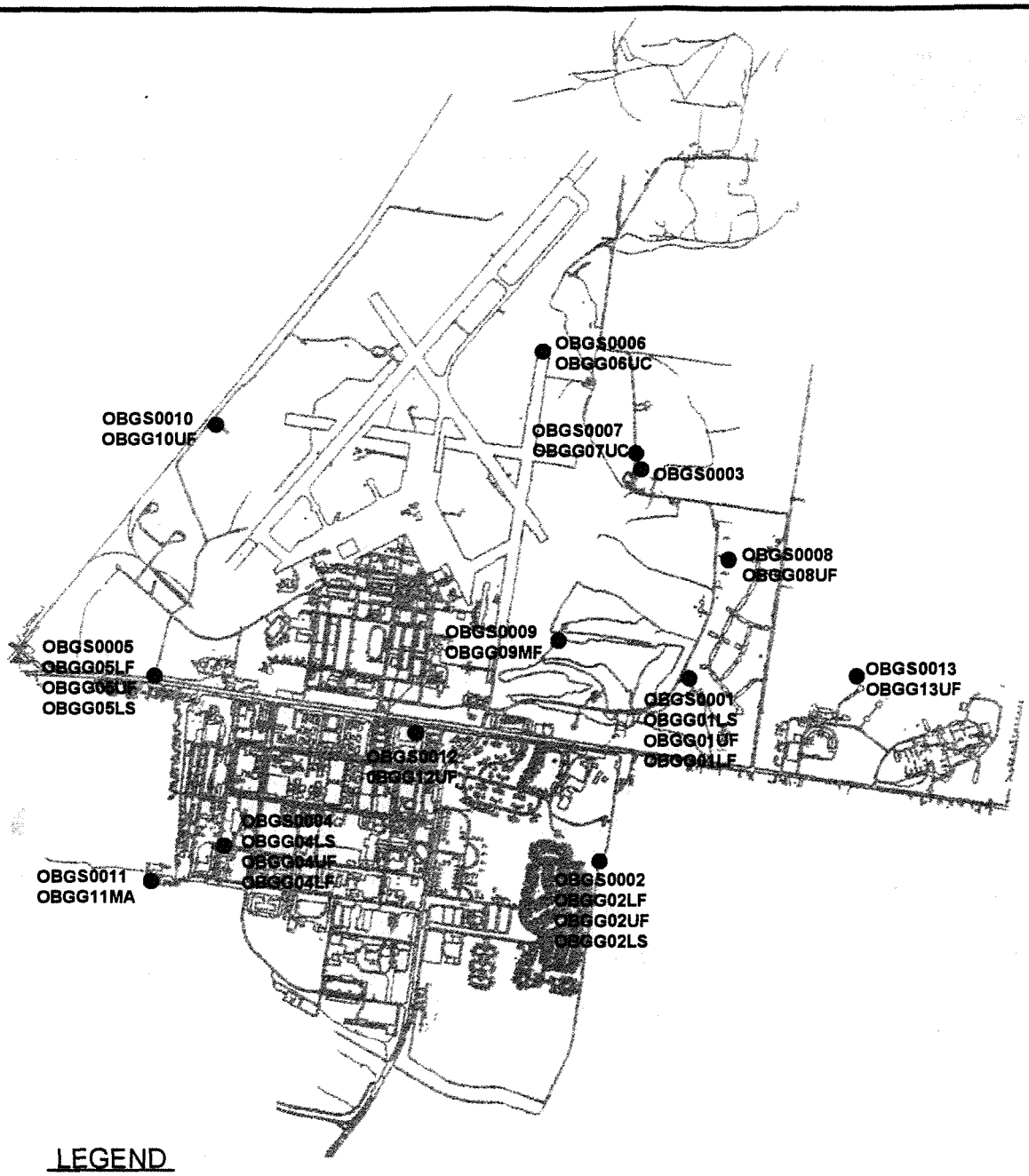
Table 4.1
Background Reference Concentrations

Analyte	Loess Groundwater (μg/L)[a]	Fluvial Deposits Groundwater (μg/L)	Alluvial Groundwater (μg/L)	Surface Soil (mg/kg)[b]	Subsurface Soil (mg/kg)
Antimony	50.1	ND[c]	ND	ND	ND
Arsenic	7.32	3.5	4.2	14.58	20.32
Barium	442	232	844	223.46	265.12
Beryllium	1.3	ND	ND	1	1.004
Cadmium	5.88	3.9	ND	1.54	3.24
Chromium	239	39.8	69.2	23.89	28.28
Cobalt	17.8	16.2	27	15.98	14.36
Copper	38.8	5.6	ND	24.19	32.52
Cyanide	ND	ND	ND	ND	ND
Lead	17.5	6.6	ND	26.03	19.8
Mercury	0.24	0.25	ND	0.46	0.176
Nickel	173.5	33.4	57.6	20.62	ND
Selenium	3.45	ND	ND	ND	ND
Silver	4.5	ND	ND	2.05	ND
Thallium	ND	ND	ND	ND	ND
Tin	ND	ND	ND	33.56	ND
Vanadium	40.9	17.4	11	45.11	43.68
Zinc	154.6	39.8	ND	98	109

Notes:
a — μg/L denotes background concentration is reported in micrograms per liter, or parts per billion.
b — mg/kg denotes background concentration is reported in milligrams per kilogram, or parts per million.
c — ND denotes this analyte was not detected in any background sample collected from the indicated interval.

4.2.2 Background RC for Dieldrin in Surface Soil

A RC for dieldrin in surface soil at NSA Memphis has been established as outlined in the *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d). As outlined in the technical memorandum, dieldrin is ubiquitous at NSA Memphis as a result of aerial applications during the 1950s and 1960s during a U.S. Department of Agriculture white-fringed beetle quarantine. Dieldrin was also used in the pest-control trade along with chlordane for general subterranean termite control. Samples



LEGEND

OBGS0013
OBGG13UF ● BACKGROUND SAMPLE LOCATION AND SOIL BORING/ MONITORING WELL DESIGNATION

3000 0 3000 Feet

NOTES:

1. *SURFACE SOIL SAMPLES COLLECTED FROM BACKGROUND SOIL BORINGS 0BGS0001 THROUGH 0BGS0013.*
2. *SUBSURFACE SOIL SAMPLES COLLECTED FROM BACKGROUND SOIL BORINGS 0BGS0001 THROUGH 0BGS0005.*
3. *LOESS GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELLS 0BGG01LS, 0BGG02LS, 0BGG04LS, AND 0BGG05LS.*
4. *FLUVIAL DEPOSITS GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELLS 0BGG01UF, 0BGG01LF, 0BGG02UF, 0BGG02LF, 0BGG04UF, 0BGG04LF, 0BGG05UF, 0BGG05LF, 0BGG08UF, 0BGG09MF, 0BGG10UF, 0BGG12UF, AND 0BGG13UF.*

IVIUM GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL 0BGG11MA.

UPPER COCKFIELD GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELLS 0BGG06UC AND 0BGG07UC.

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NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 4.1
SOIL AND GROUNDWATER BACKGROUND SAMPLE LOCATIONS

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collected from the 0- to 1-foot interval from five NSA Memphis background locations (0BGS0001, 0BGS0002, 0BGS0003, 0BGS0004, and 0BGS0005) were analyzed for dieldrin, resulting in an RC of 262 μg/kg. Figure 4.1 shows the background soil sample locations. The maximum dieldrin concentration reported in surface soil at each SWMU is compared to the RC and exceedances are discussed in the nature and extent of contamination summaries within the SWMU-specific portions of Section 8.

4.2.3 Background RCs for Inorganics in Groundwater

Background data for groundwater consist of samples collected from 12 of the 13 NSA Memphis background locations. Background monitoring wells were not installed at soil boring location 0BGS0003, near the horse stables on the NSA Northside, because the loess did not provide sufficient groundwater and the fluvial deposits are thin (less than 5 feet thick) in this area. The background samples for each groundwater interval evaluated during the Assembly E investigation are summarized in the following paragraphs.

Loess Groundwater

Background data for loess groundwater are from two sampling events of four loess background monitoring wells: two on the Northside and two on the Southside (0BGG01LS, 0BGG02LS, 0BGG04LS, and 0BGG05LS).

Fluvial Deposits Groundwater

Background data for fluvial deposits groundwater are from two sampling events of four upper fluvial deposits wells (0BGG01UF, 0BGG02UF, 0BGG04UF, and 0BGG05UF), two sampling events of four lower fluvial deposits monitoring wells (0BGG01LF, 0BGG02LF, 0BGG04LF, and 0BGG05LF), and one sampling event of five upper fluvial deposits monitoring wells (0BGG08UF, 0BGG09MF, 0BGG10UF, 0BGG12UF, and 0BGG13UF).

Alluvial Groundwater

Background data for alluvial groundwater are from one sampling event of middle alluvium monitoring well 0BGG11MA, on the southwest corner of the NSA Memphis Southside near Big Creek Drainage Canal.

5.0 HUMAN HEALTH RISK ASSESSMENTS

A baseline risk assessment (BRA) establishes a baseline of risk to facilitate risk management decisions. Risk is the estimated potential for toxic effects on actual or hypothetical human or ecological receptors, while baseline risk refers to risk arising from exposures to chemicals assuming site conditions remain unchanged. BRAs are used by risk managers to decide if remedial actions are necessary and to determine the extent of remediation necessary to reduce the risk to acceptable levels. Generally, a BRA is divided into two sections, one assessing human health risk, and a second addressing ecological risk.

The *Technical Memorandum — General Human Health Risk Assessment (HHRA) Approach for NSA Memphis* (E/A&H, 1997e), which is provided as Appendix F of this report, details the HHRA methodology applied to this RFI. Individual HHRAs for Assembly E SWMUs are in the Section 8 site-specific tabbed sections.

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6.0 ECOLOGICAL RISK ASSESSMENTS

An ecological risk assessment (ERA) has been prepared for each Assembly E SWMU. Individual ERAs for Assembly E SWMUs are in the Section 8 site-specific tabbed sections.

Each ERA focuses on the terrestrial ecosystem of each SWMU, and assesses the actual or potential risk to ecological receptors due to SWMU contamination. Each assessment evaluates the surface soil contaminant concentrations and distributions, media-specific physicochemical conditions, and exposure pathways which could result in unacceptable levels of exposure to ecological receptors now or in the future. The approach to this assessment is based on USEPA's *Risk Assessment Guidance for Superfund Vol. II — Environmental Evaluation Manual* (USEPA, 1989a), *Framework for Ecological Risk Assessment* (USEPA, 1992a), and *Ecological Risk Guidance for Superfund: Process for Designing and Conducting Ecological Risk* (USEPA, 1994d).

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7.0 FATE AND TRANSPORT

This section provides guidance for evaluating contaminants' environmental transport, transformation, and fate. Specifically, fate and transport assessment seeks to evaluate a constituent's ability to become mobile or change in the environment. To accomplish this, the assessor must understand the chemical and physical properties that govern the constituent's interaction with environmental media. Site characteristics, e.g., topography, geology, and hydrogeology, and characteristics of site soil, sediment, and water, as well as the contaminant's chemical and physical properties, play roles in evaluating the processes of fate and transport. To streamline the fate and transport discussion, this section focuses on providing an understanding of the properties which affect fate and transport. The SWMU-specific tabbed sections (Section 8) focus only on the primary contaminants detected in the various media at each SWMU.

The primary contaminants are defined as:

- Contaminants of concern (COCs) per the human health risk assessment (HHRA).
- Any organic contaminant which exceeds its soil to groundwater SSL.
- Any inorganic contaminant which exceeds both its soil to groundwater SSL and RC.

Also, all contaminants will be evaluated if they exceed the SSL for soil-to-air transport.

Based on the characteristics above, an evaluation of Assembly E SWMUs identified four potential routes of constituent migration:

- Air emissions from VOCs released from surface soil;
- Constituents leaching from soil to groundwater;
- Surface soil eroding and contaminating runoff; and
- Constituents migrating from shallow groundwater into surface water bodies.

7.1 Properties Which Affect Fate and Transport

The persistence, transport, and fate of chemicals in the environment depend on individual chemical and physical properties as well as properties of the media in which the chemicals reside. The following paragraphs briefly describe these properties, along with their significance to volatilization, sorption, diffusion, dispersion, biodegradation, and other attenuation processes.

7.1.1 Chemical and Physical Properties

The following chemical and physical properties are relevant to the evaluation of transport and fate of organic contaminants: water solubility, vapor pressure, Henry's law constant, specific gravity, organic carbon partition coefficient, distribution coefficient, and half life. For inorganic contaminants, water solubility and adsorption coefficients are the properties of interest. This subsection introduces the properties, then discusses their impact on each of the relevant compound classes. Table 7.1 provides an overview of chemical property behavior based on these properties.

Table 7.1
Chemical and Physical Properties

Chemical Property	Critical Value[a]	A chemical with a higher value may...	A chemical with a lower value may...
Vapor Pressure	10^{-3} mm Hg[b]	be more volatile.	be less volatile.
Density[c]	water: 1.0 g/cm^3[d] air: 1.20 kg/m^3[e]	sink in water or fall in the atmosphere.	float on water or rise in the atmosphere.
Solubility	0 to 100 mg/L[f]	leach from soil, is more mobile in water, and does not readily volatilize from water.	adsorb to soil, be immobile in water, and volatilizes from water.
Henry's Law Constant	10^{-3} to 10^{-5} atm-m^3/mole[g]	volatilize easily from water.	not volatilize easily from water.
Half-Life	biologically dependent	not degrade readily.	degrade readily.
Organic Carbon Partition Coefficient	10 to 10,000 L_{water}/kg_{oc}[h]	be more apt to remain in soil.	be more mobile and diffuse easily in water

Notes:
a — Critical values are based on literature review and professional judgement.
b — Hg = mercury
c — g/cm^3 = grams per cubic centimeter
d — Approximate density of air at standard temperature and pressure.
e — kg/m^3 = kilograms per cubic meter
f — mg/L = milligrams per liter
g — atm-m^3/mole = atmospheres-cubic meter per mole
h — L_{water}/kg_{oc} = kilograms of organic carbon per liter of water

Water Solubility

A chemical's solubility in water is the maximum amount of the chemical that will dissolve in pure water at a specified temperature. Chemicals with high solubility are relatively mobile in water and are likely to leach from wastes and soils. These chemicals tend to have low volatilization potential, but do tend to be biodegradable. Conversely, chemicals with low solubility tend to sorb on soils and sediments and are not readily biodegraded. They also have a greater tendency to volatilize.

Vapor Pressure

Vapor pressure is a measure of the tendency of a substance to pass from a solid or a liquid to a vapor state. It is measured as the pressure of the gas in equilibrium with the liquid or solid at a given temperature. From dry soils, vapor pressure determines a given chemical's volatilization to the atmosphere. From surface waters and moist soils, volatilization depends on vapor pressure and the Henry's law constant (discussed below). A chemical with a vapor pressure less than 10^{-6} millimeters of mercury (mm Hg) tends to associate with particulate matter; a chemical with a higher vapor pressure tends to associate with the vapor phase. Highly water-soluble compounds generally show little volatilization from water or moist soils, unless they also have a high vapor pressure.

Henry's Law Constant

The Henry's law constant describes a linear relation between vapor pressure and water solubility, providing a measure of a chemical's ability to move from water or moist soils to air. Compounds with Henry's law constants greater than 10^{-3} atmospheres-cubic meter per mole (atm-m^3/mole) can be expected to readily volatilize from water. Compounds with values ranging from 10^{-3} to 10^{-5} atm-m^3/mole exhibit moderate volatilization. Compounds with values less than 10^{-5} atm-m^3/mole show limited ability to volatilize from water or moist soils.

Specific Gravity

A substance's specific gravity (SG) is the ratio of its given volume weight to the same volume of water's weight. The water weight is usually measured at 4°C; the other substance is often measured at some other temperature, typically 20°C. If the SG of a substance is less than 1.0, that substance will float on water; if the SG is greater than 1.0, the substance will sink in water. The SG can sometimes be used to predict the vertical distribution of a chemical's immiscible or insoluble portion within an aquifer or other water body.

Organic Carbon Partition Coefficient

The organic carbon partition coefficient (K_{oc}) is a measure of an organic substance's tendency to sorb to organic carbon. Chemicals moving through the subsurface will alternately adsorb or desorb from available organic matter in the soil matrix. The higher the K_{oc} values, the more a chemical tends to be attracted to soil's organic fraction and lower its mobility in the subsurface.

Half-Life

A half-life is the time required for a substance's concentration to decrease from its initial level to one-half its initial level. The apparent decrease may be caused by various processes, including biodegradation, reactions with other substances, or mass removal from the media in question.

VOCs can be expected to be mobile in the environment based on their physical and chemical properties. They have the potential to volatilize to the atmosphere, leach to groundwater or erode to surface water, and to move with groundwater flow. Relative to other compound categories, VOCs have low molecular weight and high water solubility, vapor pressure, and Henry's law constant, along with a corresponding low K_{oc}. These properties all enhance the potential for degradability of VOCs. Relative to chemicals in other categories, many VOCs tend to have relatively short half-lives in groundwater and surface water. VOCs have a limited tendency to sorb to solids and can be expected to be moderately to highly mobile in the environment.

Especially in near-surface soils, VOCs can migrate via diffusion through soil-air pore spaces to the ground surface, where they can be transported by wind.

SVOCs generally have higher molecular weights, and lower solubilities, vapor pressures, and Henry's law constants than VOCs. Because of higher K_{oc}, SVOCs tend to sorb to solids and are relatively immobile in the environment. They are more likely to be transported as solids than in their dissolved phase. Because of these characteristics, SVOCs are likely to persist in the environment longer than VOCs, but be less mobile.

Pesticides/PCBs have moderate molecular weights; generally high densities, high K_{oc} values, and generally low solubilities, vapor pressures, and Henry's law constants. They tend to sorb to soil particles, are hydrophobic (avoid water), are immobile in the environment, and tend to degrade relatively slowly. Overall, pesticides/PCBs are anticipated to be immobile and persistent in the environment, not readily diffusing into groundwater.

Herbicides, which can leach from soil particles to groundwater, tend to be mobile in both soil and groundwater and to degrade relatively slowly. The chemical property most greatly influencing herbicide fate and transport is solubility. Herbicides have low Henry's law constants and vapor pressures, and moderate molecular weights, organic carbon/water partitioning coefficients, and solubilities. Overall, herbicides are expected to be moderately mobile in groundwater, with some retention in soil.

Inorganic chemicals do not degrade in the environment, but they may change chemical form or speciation. They are generally considered to be indefinitely persistent. Inorganics may interact with soil or other solids by ion exchange, adsorption, precipitation, or complexation, and they can act as catalysts in biodegradation processes. These processes are affected by pH, composition of leachate or groundwater oxidation-reduction condition, and the type and amount of organic matter,

minerals, clay, and hydrous oxides present. Groundwater containing elevated levels of chloride, bicarbonate, sulfate, or phosphate can enhance the solubility and mobility of metal compounds by forming aqueous complexes. Complexation is the process in which a cation (positively charge ion) combines with molecules containing free pairs of electrons (negatively charged ions). An aqueous complex forms when an inorganic in a cationic state is subjected to chloride, sulfate, or other compounds containing free pairs of electrons. Inorganics which have undergone aqueous complex formation become more aqueous and mobile in groundwater, and less able to sorb to soil particles.

7.1.2 Media Properties

The environmental media properties used to evaluate fate and transport are total organic carbon, soil sorptive capacity, cation exchange capacity, redox conditions, pH, and hydrogeology. The following briefly discusses them.

Total Organic Carbon

Sorption's abiotic process (contaminant accumulation at a solid surface) slows down a contaminant's movement as it accumulates on the subsurface medium. In organic contaminants and subsurface soil in which organic carbon is present, hydrophobic chemicals commonly sorb to the soil's organic carbon. As the subsurface soil's organic content increases, its total capacity to sorb the chemicals increases. Fate and transport calculations typically express the organic carbon as a fraction of organic carbon (f_{oc}).

Distribution Coefficient

The distribution coefficient (K_d) represents the partitioning between liquid and solids, or the ratio of the soil's contaminant mass to the contaminant mass dissolved in the groundwater. The K_d is used to model subsurface contaminant movement. The larger the K_d value, the greater the sorption to the solid phase. The simplest way to acquire a K_d value for a specific contaminant is to obtain it from a K_{oc} value listed in literature sources. K_{oc} is analogous to K_d, except that the sorbing

material is considered to be the organic carbon (oc) in the soil as opposed to the entire soil matrix. Normalizing K_d based on the soil's organic carbon content can eliminate much of the variation observed among K_d values in different soils; thus, K_d can be estimated from the chemical's K_{oc} and f_{oc} in the soil, e.g., $K_d = K_{oc} \, x \, f_{oc}$.

Cation Exchange Capacity

Cation exchange capacity (CEC) reflects the soil's capacity to adsorb ions by neutralizing an ionic deficiency on its surface. Certain compounds can either gain or lose a proton as a function of pH and thus go from a neutral to an ionic form. For organic compounds, this ionization greatly increases the chemical's groundwater solubility. Gaining a proton forms a positive ion. In this case, the ionic compound may associate to a greater degree with the clay minerals' CEC. The overall impact on sorption (mobility) depends on the relative sorption of the compound's neutral and ionic forms.

Redox Conditions

Oxidation and reduction (redox) refer to the ions or compounds transferring electrons or changing species. Redox includes oxidation (the loss of electrons) and reduction (the gain of electrons). As an example, consider iron in groundwater. When the groundwater reaches the surface in a highly reduced state, it is exposed to the atmosphere (oxygen), resulting in the iron's oxidation. This reverse process causes the iron to go from its soluble form to its insoluble complex.

pH

pH, a logarithmic measure of hydrogen ions in the soil and groundwater, indicates the medium's acidity or basicity. Chemicals react significantly different under changing pHs. Low pH conditions tend to mobilize chemicals, especially inorganics, while high pH conditions may lead to the formation of immobile metal hydroxides.

Hydrogeology

The physical properties of soil (mineralogical composition, particle size distribution, etc.) dictate how a contaminant is transported in the subsurface. Some of these properties are porosity, hydraulic gradient, hydraulic conductivity, unsaturated flow, and saturated flow.

Porosity: This property is defined as the ratio of openings (voids) to a soil or rock's total volume. Typically, fine-grained materials tend to be better sorted and, thus, tend to have the largest porosities. Porosity indicates the maximum amount of water that a rock or soil can contain when it is saturated. Total porosity represents all voids in soil or rock, whereas, effective porosity represents only those voids which are interconnected and may contribute to movement of fluids.

Hydraulic Gradient: The groundwater table's slope direction indicates groundwater movement direction. All other factors being constant, the groundwater movement rate depends on the hydraulic gradient, the change in head-per-unit distance in a given direction. The hydraulic gradient is important in contaminant transport because it may indicate the velocity and direction of contaminant migration in groundwater.

Hydraulic Conductivity: This property largely dictates the factors controlling groundwater movement. It depends on the pores' size and arrangement and groundwater's dynamic characteristics such as viscosity and density. Hydraulic conductivity refers to the water-transmitting characteristics of soil; it varies in different soil types. If the hydraulic conductivity is essentially the same in any area of soil, it is said to be homogeneous; otherwise, it is heterogeneous. Hydraulic conductivity tends to be greater in sand and less in material containing clay.

Unsaturated Flow: Most aquifer recharge occurs when water percolates across the unsaturated zone. Water movement in this unsaturated zone is controlled by both gravitational and capillary

forces. Capillarity results from two forces: the mutual attraction (cohesion) between water molecules and the molecular attraction (adhesion) between water and different solid materials. These two forces pull water upward into a capillary fringe above the water table. Flow in the unsaturated zone is important because contaminants released at the surface which percolate through the unsaturated zone may remain in the unsaturated zone due to capillarity, or may arrive in the unsaturated zone due to a fluctuating water table.

Saturated Flow: In the saturated zone, all interconnected openings are full of water, and groundwater moves through these openings in the direction controlled by the hydraulic gradient. Movement in this zone may be either laminar or turbulent. In laminar flow, water particles move in an orderly manner along streamlines. In turbulent flow, water particles move in a disordered, highly irregular manner, which results in a complex mixing of the particles. Dispersion is an important contaminant transport process in the saturated zone. This is the process by which solutes are mixed with uncontaminated water, diluted, and transported due to the aquifer's heterogeneity. Also, diffusion is the process by which solutes are transported from a region of high concentration to a region of low concentration. In very fine sediments, diffusive transport may be the dominant process. Typically, flow is advective, that is, dissolved substances migrate with flowing groundwater. Advective flow is the dominant transport process for contaminant movement in groundwater.

7.2 Fate and Transport Approach for Assembly E

Fate and transport discussion for each SWMU begins by describing site characteristics that have the potential to promote or inhibit migration of contaminants. As presented in 7.0, four potential contaminant migration routes may exist. Each SWMU was evaluated relative to site conditions that affect these migration pathways.

Evaluation of an individual contaminant's ability to migrate is based on four cross-media transfer mechanisms: soil to groundwater, groundwater to surface water, surface soil to sediment (erosion of sorbed contaminants), and surface soil to air. The contaminant's chemical and physical properties will be evaluated, where necessary, in support of each transfer mechanism. Table 7.2 presents the chemical and physical properties used to evaluate fate and transport for all contaminants detected at Assembly E. Table 7.3 presents the primary Assembly E contaminants and summarizes why they are considered primary contaminants for fate-and-transport discussion. The following describes the methods used to evaluate the potential migration of contaminants identified at each SWMU. In some cases, specific migration pathways do not exist for a SWMU. When this occurred, that pathway was not discussed in the site-specific fate and transport evaluations in Section 8.

7.2.1 Soil-to-Groundwater Cross-Media Transport

To evaluate the potential for soil-to-groundwater migration of constituents, a phased screening approach focused on chemicals with the greatest potential for impacting the water-bearing zones.

Qualitative: Analytical data for soil and groundwater were compared to determine which chemicals were present in both media. Due to the nature and age of most SWMU operations, it was assumed that any impacts associated with compounds with the potential to migrate from soil would be currently manifested in the shallow aquifer. The number and placement of monitoring wells or DPT groundwater samples were considered adequate to detect the presence of groundwater contamination. As a result, the qualitative comparison was used to identify those chemicals with reported concentrations in both media.

Quantitative: Soil results were compared to the leachability-based soil-to-groundwater screening levels as presented in the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). An organic contaminant is considered a threat for impacting a water-bearing zone if

Table 7.2
Fate and Transport Properties for
Contaminants Detected in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	Parameter	Molecular Weight[a] (g/mole)	Density[a] (g/cm^3)	Vapor Pressure[a,b] (mm Hg)	Solubility[a,b] (mg/L)	Henry's Law Constant[b,c] ($atm\text{-}m^3/mole$)	K_{oc}[b,c] (L/kg)	Soil-to-Groundwater SSL[d] (mg/kg)	Soil-to-Air SSL[d] (mg/kg)
Organic Compounds									
Carbon disulfide	VOC	76.13	1.30e+00	3.00e+02	2.10e+03	1.33e-02	2.95e+02	14	11
alpha-Chlordane	Pesticide	409.78	1.60e+00	1.00e-05	5.60e-02	4.80e-05	4.95e+04	NDA	NDA
gamma-Chlordane	Pesticide	409.80	1.60e+00	1.00e-05	5.60e-02	4.80e-05	4.95e+04	NDA	NDA
Chlorobenzene	VOC	112.56	1.10e+00	1.00e+01	4.90e+02	3.93e-03	1.73e+02	0.6	94
Chloroform	VOC	119.38	1.50e+00	1.60e+02	8.00e+03	3.23e-03	4.60e+01	0.3	0.2
Chloromethane	VOC	50.49	9.20e-01	3.80e+03	7.30e+03	8.82e-03	2.51e+01	0.0066	0.063
Chrysene	SVOC	228.30	1.27e+00	6.30e-09	1.80e-03	7.26e-20	2.45e+05	1	3.6
2,4-D	Herbicide	221.04	1.40e+00	1.10e-02	6.80e+02	1.37e-10	1.58e+00	1.7	7,000
2,4-DB	Herbicide	NDA	NDA	NDA	NDA	NDA	NDA	1	NDA
4,4'-DDD	Pesticide	320.05	1.50e+00	1.00e-06	2.00e-02	2.16e-05	4.37e+04	0.7	37
4,4'-DDE	Pesticide	319.03	6.49e-06	6.50e-06	4.00e-02	2.34e-05	2.45e+05	0.5	10
4,4'-DDT	Pesticide	354.49	1.60e+00	1.90e-07	5.00e-03	4.89e-05	3.87e+05	1	80
2,4,5-T	Herbicide	255.48	1.40e+00	7.50e-07	2.80e+02	8.68e-08	2.04e+02	NDA	NDA
2,4,5-TP (Silvex)	Herbicide	269.51	NDA	5.20e-06	1.40e+02	1.31e-07	2.57e+03	NDA	NDA
Dibenz(a,h)anthracene	SVOC	278.36	1.28e+00	1.00e-10	5.00e-03	7.33e-09	1.66e+06	11	7.2
Dibenzofuran	SVOC	168.20	1.10e+00	NDA	1.00e+01	NDA	1.00e+04	120	120
Dicamba	Herbicide	221.04	NDA	3.40e-05	6.50e+03	1.30e-09	NDA	NDA	NDA
1,2-Dichloroethene	VOC	98.96	NDA	3.00e+02	3.50e+03	5.00e-03	2.30e-02	NDA	NDA

Table 7.2
Fate and Transport Properties for
Contaminants Detected in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	Parameter	Molecular Weight[a] (g/mole)	Density[a] (g/cm^3)	Vapor Pressure[a,b] (mm Hg)	Solubility[a,b] (mg/L)	Henry's Law Constant[b,c] ($atm\text{-}m^3/mole$)	K_{oc}[b,c] (L/kg)	Soil-to-Groundwater SSL[d] (mg/kg)	Soil-to-Air SSL[d] (mg/kg)
Organic Compounds									
1,2-Dichloroethene	VOC	96.94	NDA	2.08e+02	3.50e+03	7.58e-03	4.90e-01	0.2	1,500
Dichlorprop	Herbicide	235.07	NDA	1.00e-06	3.50e+02	NDA	NDA	NDA	NDA
Dichlorodifluoromethane	VOC	120.91	1.35e+00	4.25e+03	2.80e+02	2.97e+00	5.80e+01	7.5	37
trans-1,2-Dichloroethene	VOC	96.94	1.25e+00	3.24e+02	6.30e+03	6.56e-03	5.90e+01	0.3	3,600
Dieldrin	Pesticide	380.93	1.80e+00	1.80e-07	2.00e-01	2.00e-05	1.34e+04	0.001	2
Diethylphthalate	SVOC	222.24	1.10e+00	2.00e-03	9.00e+02	8.46e-07	6.92e+01	110	520
Di-n-butylphthalate	SVOC	278.35	1.00e+00	1.00e-05	1.30e+01	6.30e-05	1.38e+03	120	100
Di-n-octylphthalate	SVOC	390.57	9.78e-01	1.40e-04	3.00e+00	1.41e-12	9.77e+08	1,000,000	NDA
Dinoseb	Herbicide	240.20	1.26e+00	1.00e+00	5.00e+01	NDA	NDA	NDA	NDA
Endrin aldehyde	Pesticide	380.92	NDA	2.00e-07	2.60e-01	3.86e-07	4.27e+05	0.4	16
Endrin ketone	Pesticide	380.93	NDA	2.00e-07	2.60e-01	4.00e-07	NDA	0.4	16
Ethylbenzene	VOC	106.16	8.70e-01	7.10e+00	1.50e+02	6.60e-03	1.87e+02	5	260
bis(2-Ethylhexyl)phthalate (BEHP)	SVOC	340.57	9.90e-01	2.00e-07	3.00e-01	1.10e-05	1.00e+05	11	210
Fluoranthene	SVOC	202.26	1.30e+00	5.00e-06	2.40e-01	1.69e-02	4.17e+04	980	68
Fluorene	SVOC	166.22	1.20e+00	7.00e-03	1.70e+00	2.10e-04	5.01e+03	160	89
Guthion	Pesticide	317.34	1.44e+00	8.00e-09	3.30e+01	NDA	NDA	NDA	NDA
Heptachlor	Pesticide	373.32	1.70e+00	3.00e-04	1.80e-01	2.30e-03	2.69e+04	0.06	0.3

Table 7.2
Fate and Transport Properties for
Contaminants Detected in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	Parameter	Molecular Weight[a] (g/mole)	Density[a] (g/cm^3)	Vapor Pressure[a,b] (mm Hg)	Solubility[a,b] (mg/L)	Henry's Law Constant[b,c] ($atm\text{-}m^3/mole$)	K_{oc}[b,c] (L/kg)	Soil-to-Groundwater SSL[d] (mg/kg)	Soil-to-Air SSL[d] (mg/kg)
Organic Compounds									
Heptachlor epoxide	Pesticide	389.32	NDA	2.60e-06	3.50e-01	3.20e-05	2.09e+04	0.03	1
Indeno(1,2,3-cd)pyrene	SVOC	276.34	6.20e-02	1.00e-10	6.20e-02	2.96e-20	3.09e+07	35	280
MCPA[f]	Herbicide	200.63	1.21e+00	1.50e-06	8.25e+02	NDA	NDA	NDA	NDA
MCPP[g]	Herbicide	214.60	1.21e+00	NDA	6.20e+02	NDA	NDA	NDA	NDA
2-Methylnaphthalene	SVOC	142.21	1.00e+00	NDA	2.50e+01	NDA	8.51e+03	NDA	NDA
4-Methyl-2-Pentanone (MIBK)	VOC	100.18	8.00e-01	1.50e+01	1.70e+04	1.49e-05	6.17e+00	NDA	NDA
2-Methylphenol (o-Cresol)	SVOC	108.14	1.00e+00	2.40e-01	2.50e+04	1.23e-06	2.19e+01	6	12,000
Methylene chloride	VOC	84.93	1.30e+00	3.50e+02	2.00e+04	2.00e-03	2.30e+01	0.01	7
Naled	Pesticide	380.80	1.96e+00	2.00e-03	Insoluble[h]	NDA	NDA	NDA	NDA
Naphthalene	SVOC	128.18	1.10e+00	5.40e-02	3.00e+01	4.60e-04	7.92e+02	30	180
Pentachlorophenol	SVOC	266.34	2.00e+00	1.10e-04	2.00e+01	2.10e-06	4.09e+02	0.2	7.9
Phenanthrene	SVOC	178.24	1.20e+00	6.80e-04	1.00e+00	3.90e-05	2.29e+04	NDA	NDA
Pyrene	SVOC	202.26	1.30e+00	2.50e-06	1.40e-01	1.09e-05	6.46e+04	1,400	56
Styrene	VOC	104.15	9.06e-01	5.00e+00	3.00e+02	2.61e-03	7.41e+02	2	1,400
TPH-DRO	TPH	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA
TPH-GRO	TPH	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA

Table 7.2
Fate and Transport Properties for
Contaminants Detected in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	Parameter	Molecular Weight[a] (g/mole)	Density[a] (g/cm^3)	Vapor Pressure[a,b] (mm Hg)	Solubility[a,b] (mg/L)	Henry's Law Constant[b,c] ($atm\text{-}m^3/mole$)	K_{oc}[b,c] (L/kg)	Soil-to-Groundwater SSL[d] (mg/kg)	Soil-to-Air SSL[d] (mg/kg)
Organic Compounds									
Toluene	VOC	92.13	8.70e-01	2.20e+01	5.20e+02	6.70e-03	1.29e+02	5	520
Technical Chlordane	Pesticide	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Tetrachloroethene (PCE)	VOC	165.85	1.60e+00	1.40e+01	1.50e+02	1.53e-02	2.64e+02	0.04	11
1,1,1,2-Trichloroethane	VOC	133.40	1.44e+00	1.90e+01	4.50e+03	7.40e-04	5.60e+01	0.01	0.8
Trichloroethene	VOC	131.40	1.50e+00	5.80e+01	1.10e+03	9.10e-03	8.70e+01	0.02	3
Vinyl Chloride	VOC	62.50	9.10e-01	2.60e+03	1.10e+03	1.22e+00	1.10e+01	0.01	0.002
Xylene	VOC	106.17	8.80e-01	8.70e+00	2.00e+02	7.10e-03	2.34e+02	74	320
Inorganics									
Antimony	Inorganic	121.80	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Arsenic	Inorganic	74.90	NDA	NDA	NDA	NDA	NDA	15	380
Barium	Inorganic	137.33	NDA	NDA	NDA	NDA	NDA	32	350,000
Beryllium	Inorganic	9.01	NDA	NDA	NDA	NDA	NDA	180	690
Cadmium	Inorganic	112.40	NDA	NDA	NDA	NDA	NDA	6	920
Chromium	Inorganic	52.00	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Cobalt	Inorganic	58.93	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Copper	Inorganic	63.55	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Cyanide	Inorganic	27.03	NDA	NDA	NDA	NDA	NDA	NDA	NDA

Table 7.2
Fate and Transport Properties for
Contaminants Detected in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	Parameter	Molecular Weight[a] (g/mole)	Density[a] (g/cm^3)	Vapor Pressure[a,b] (mm Hg)	Solubility[a,b] (mg/L)	Henry's Law Constant[b,c] ($atm\text{-}m^3/mole$)	K_{oc}[b,c] (L/kg)	Soil-to-Groundwater SSL[d] (mg/kg)	Soil-to-Air SSL[d] (mg/kg)
Inorganics									
Lead	Inorganic	207.20	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Mercury	Inorganic	200.60	NDA	NDA	NDA	NDA	NDA	3	7
Nickel	Inorganic	58.71	NDA	NDA	NDA	NDA	NDA	21	6,900
Selenium	Inorganic	78.96	NDA	NDA	NDA	NDA	NDA	3	NDA
Silver	Inorganic	107.90	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Tin	Inorganic	118.69	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Vanadium	Inorganic	50.94	NDA	NDA	NDA	NDA	NDA	NDA	NDA
Zinc	Inorganic	65.38	NDA	NDA	NDA	NDA	NDA	4,200	NDA

Notes:

a — Merck & Co., *The Merck Index*, Merck & Co., Rahway NJ. (1983).
Lide, *CRC Handbook of Chemistry and Physics*, CRC Press, Boca Raton. (1994).
USEPA, *Treatability Database*, USEPA Risk Reduction Engineering Laboratory, Cincinnati OH. (1992).
Resource Consultants, *Chemtox Release K*, 1985-1995.

b — Howard, *Fate and Exposure Data*, Lewis Publishers, Chelsea MI. (1993a).

c — Knox, Sabatini, Canter, *Subsurface Transport and Fate Processes*, Lewis Publishers, Chelsea MI. (1993).

d — USEPA, *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

e — NDA denotes no data is available for this property.

f — MCPA = 2-Methyl-4-chlorophenoxyacetic acid

g — MCPP = 2-(2-Methyl-4-chlorophenoxy)propionic acid

h — Insoluble denotes that the compound is practically insoluble in water.

Table 7.3
Primary Contaminants in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	SWMU Designation	Reason
Acetone	9	Concentration in surface soil exceeded the soil-to-groundwater SSL
	14	Concentration in drainage ditch soil exceeded the soil-to-groundwater SSL
	59	Concentration in subsurface soil exceeded the soil-to-groundwater SSL
Aldrin	14	Concentration in drainage ditch soil and subsurface soil exceeded the soil-to-groundwater SSL
	59	Concentration in surface and subsurface soil exceeded the soil-to-groundwater SSL, concentration in surface soil exceeded the soil-to-air SSL, analyte is a COC in surface soil per the HHRA
Arsenic	9	Concentration in subsurface soil exceeded the soil-to-groundwater SSL, analyte is a COC in alluvial groundwater per the HHRA
	14	Analyte is a COC in fluvial deposits groundwater per the HHRA
	59	Concentration in surface soil exceeds both the soil-to-groundwater SSL and the background RC, analyte is COC in surface soil per the HHRA
	65	Analyte is a COC in alluvial groundwater per the HHRA
Aroclor-1260	59	Analyte is a COC in surface soil per the HHRA
Barium	9	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC
	14	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC, analyte is a COC in fluvial deposits groundwater per the HHRA
	59	Analyte is a COC in loess groundwater per the HHRA
	65	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC.
Benzene	14	Analyte is a COC in fluvial deposits groundwater per the HHRA
Benzo(a)anthracene	59	Concentration in surface soil exceeds the soil-to-groundwater SSL
BEQ[a]	59	Analyte is a COC in surface soil per the HHRA
Chloroform	9	Analyte is a COC in alluvial groundwater per the HHRA
alpha Chlordane	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, analyte is a COC in surface soil per the HHRA
gamma Chlordane	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, analyte is a COC in surface soil per the HHRA
technical Chlordane	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, concentration in surface soil exceeds the soil-to-air SSL
Chrysene	59	Concentration in surface soil exceeds the soil-to-groundwater SSL
4,4'-DDD	59	Concentration in surface aoil exceeds the soil-to-groundwater SSL

Table 7.3
Primary Contaminants in Assembly E Soil and Groundwater Samples
NSA Memphis – Millington, Tennessee

Analyte	SWMU Designation	Reason
4,4'-DDE	59	Concentration in subsurface soil exceeds the soil-to-groundwater SSL
4,4'-DDT	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL
1,2-Dichloroethene	14	Analyte is a COC in loess groundwater per the HHRA
Dieldrin	9	Concentration in surface soil exceeds the soil-to-groundwater SSL
	14	Concentration in subsurface soil and drainage ditch soil exceeds the soil-to-groundwater SSL
	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, analyte is a COC in surface soil per the HHRA
	65	Concentration in subsurface soil exceeds the soil-to-groundwater SSL
Heptachlor	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, concentration in surface soil exceeds the soil-to-air SSL, analyte is a COC in surface soil per the HHRA
Heptachlor Epoxide	59	Concentration in surface and subsurface soil exceeds the soil-to-groundwater SSL, concentration in surface soil exceeds the soil-to-air SSL, analyte is a COC in surface soil and loess groundwater per the HHRA
Lead	59	Analyte is a COC in loess groundwater per the HHRA
MCPA[b]	59	Analyte is a COC in surface soil per the HHRA
Nickel	9	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC
	14	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC
	59	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC
	65	Concentration in subsurface soil exceeds both the soil-to-groundwater SSL and the background RC
Pentachlorophenol	59	Concentration in surface soil exceeds the soil-to-groundwater SSL
Tetrachloroethene	14	Analyte is a COC in loess groundwater per the HHRA
Trichloroethene	9	Analyte is a COC in alluvial groundwater per the HHRA
	14	Analyte is a COC in loess groundwater per the HHRA
Vanadium	14	Analyte is a COC in fluvial deposits groundwater per the HHRA
	59	Analyte is a COC in loess groundwater per the HHRA

Notes:
a — BEQ = benzo(a)pyrene equivalent
b — MCPA = 2-Methyl-4-chlorophenoxyacetic acid

the maximum detected concentration of the contaminant exceeds its SSL. An inorganic contaminant is considered a threat for impacting a water-bearing zone if the maximum detected concentration of the contaminant exceeds its SSL ***and*** its background RC.

In addition to the screening assessments above, any chemical considered a COC per the HHRA is also discussed.

7.2.2 Soil-to-Air Cross-Media Transport

To evaluate the potential for soil-to-air migration of volatile contaminants, a screening approach focused on contaminants with the greatest potential to volatilize in sufficient quantities to create a human health threat in ambient air. The screening process may be summarized as follows:

Quantitative: The maximum concentrations of each SWMU's surface soil volatile contaminants were compared to soil-to-air screening levels presented in the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

Contaminants were not qualitatively screened because ambient air sampling was not part of each SWMU's RFI.

If soil concentrations did not exceed soil-to-air volatilization screening levels, it was assumed that no significant migration potential exists and that current surface soil conditions protect human health from potential inhalation exposure pathways. Other factors were considered such as type of cover (vegetation, asphalt, etc.), surface soil physical properties that might limit or enhance contaminant mobility, and physical/chemical properties of the contaminants' class (e.g., VOCs are more likely to volatilize from soil to air than SVOCs).

In addition to the screening assessments above, any chemical considered a COC per the HHRA is also discussed.

7.2.3 Groundwater-to-Surface Water Cross-Media Transport

This evaluation principally focused on determining whether constituents identified in groundwater have the potential to extend their impacts or discharge to surface water. This transport mechanism is not discussed in great detail due to the lack of water bodies at or near the SWMUs, and because it is unlikely that shallow groundwater will impact surface water, based on the soil matrix lithology.

In addition to the screening assessments above, any chemical considered a COC per the HHRA is also discussed.

7.2.4 Surface Soil-to-Sediment Cross-Media Transport

To evaluate the potential for surface soil-to-sediment erosional migration, the following approach was taken:

Qualitative: Analytical data from both soil and sediment (if sediment samples were taken) were compared to determine which chemicals were present in both media.

To evaluate the potential for sorbed contaminants in near-surface soil to migrate by erosional processes, contaminants were also identified by characteristics that would render them mobile under erosional processes such as surface water drainage and wind erosion. The most influential process by which sediments are formed involves the erosion of unvegetated surface soil that eventually collects in depositional areas. Therefore, each SWMU's topography is also used as a screening process to evaluate this transport mechanism as a migration pathway.

In addition to the screening assessments above, any chemical considered a COC per the HHRA is also discussed.

8.1 SWMU 2

This section will be inserted upon completion of the ongoing investigation.

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8.2 SWMU 9

The two SWMU 9 lagoons were used as part of the wastewater treatment system for NSA Memphis from 1969 to 1978. Although they were primarily used to treat domestic wastewater, limited amounts of industrial wastewater from aircraft maintenance also were treated. This industrial wastewater may have contained a wide variety of contaminants, including VOCs, SVOCs, and metals. The Navy has prohibited fishing at the lagoons due to their former use. Refer to Section 1.1.2 for a historical summary of activities conducted at SWMU 9.

8.2.1 Previous Investigation Results

In 1984, Geraghty and Miller collected five sediment samples from the bottom material in the two lagoons during the Confirmation Study/Verification Phase. Each sediment sample was analyzed for total cadmium, chromium, copper, nickel, and lead using SW-846 Method 1310 for Extraction Procedure Toxicity Test Method and Structural Integrity Test (EP Toxicity). No metal was detected above its method detection limit (0.01 mg/kg for cadmium and nickel and 0.1 mg/kg for chromium, copper, and lead). According to the *NACIP Confirmation Study/Verification Phase* report (Geraghty and Miller, 1985), no further investigation was warranted at SWMU 9. However, the *RCRA Facility Assessment* (ERC/EDGe, 1990b) recommended an RFI at SWMU 9 due to the lack of analytical data for the SWMU. Copies of the CS/VP report and the RFA were provided as Attachments to the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

8.2.2 RFI Characterization

RFI characterization focused on the nature and extent of contamination in the following media:

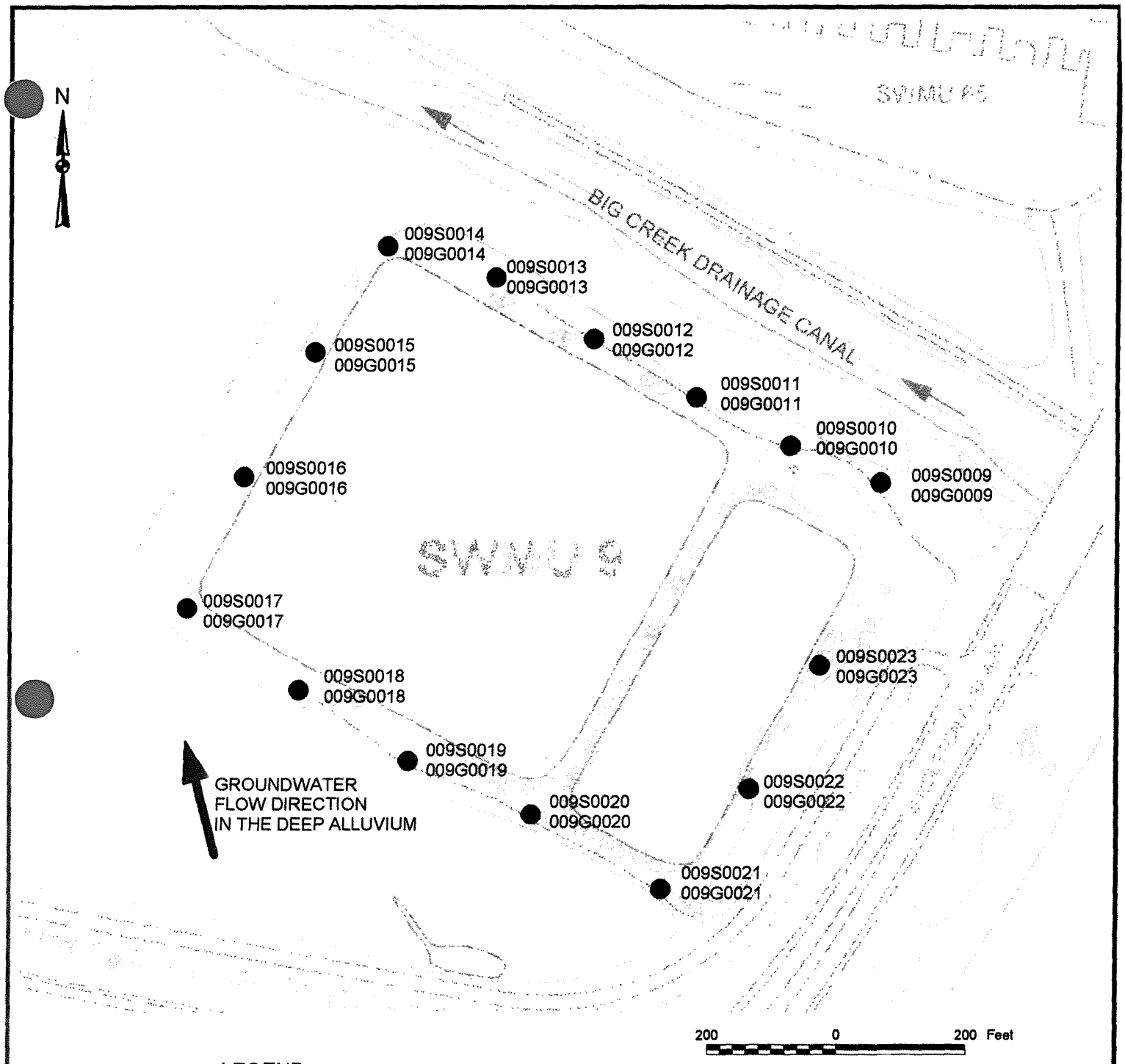
- Surface and subsurface soil along lagoon perimeters
- Groundwater near the lagoons

- Sediment within the lagoons
- Sediment and surface water in Big Creek Drainage Canal immediately north of the sewage lagoons
- Biota inhabiting the lagoons

8.2.2.1 DPT Screening Investigation

As part of the RFI characterization, a subsurface soil and groundwater screening investigation was conducted along the perimeter of the lagoons using DPT equipment operated by InSitu Technologies of Traveler's Rest, South Carolina. These sample results were used to determine the optimum placement and depth of soil borings and monitoring wells. VOCs were chosen as the indicator parameter for the DPT screening investigation, because of the small sample volume required, the ease of onsite VOC analysis, and VOCs have been the most common groundwater contaminant at NSA Memphis.

Fifteen soil samples (locations 009S0009 through 009S0023) from 8 to 10 feet bls (corresponding to just below the base of the lagoons) and 15 groundwater samples (locations 009G0009 through 009G0023) collected from the deep alluvium (at depths ranging from 42 to 52 feet bls) were analyzed for VOCs by Hydrologic's onsite mobile laboratory using SW-846 Method 8021. Figure 8.2.1 shows the DPT soil and groundwater sample locations. Four of the DPT soil samples (009S0009, 009S0014, 009S0019, and 009S0022) and four of the DPT groundwater samples (009G0009, 009G0014, 009G0015, and 009G0022) were split and submitted to an offsite laboratory (NET) for VOC confirmation analysis by SW-846 Method 8240. Although Methods 8021 (Gas Chromatograph/Electrolytic Conductivity Detector) and 8240 (Gas Chromatograph/Mass Spectrometry) both analyze for VOCs, the compound list for each method differs slightly. Refer to the analytical data in the Attachment of the *Data Validation Report — Assembly E* (E/A&H, 1997a) for a complete list of each VOC test method's analytical compounds.



LEGEND

009S0014
009G0014 — DPT SOIL AND GROUNDWATER SAMPLING LOCATION/IDENTIFICATION

SURFACE WATER FLOW DIRECTION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.2.1
DPT SOIL AND GROUNDWATER SAMPLE LOCATIONS
SWMU 9 - SEWAGE LAGOONS

8.2.2.2 Soil Borings and Monitoring Wells

The DPT investigation results indicated the presence of limited VOC contamination in deep alluvium groundwater. Based on the DPT investigation results, the optimal number, placement, and depth of soil borings and monitoring wells was determined. Four soil borings (009S01DA, 009S02DA, 009S03DA, and 009S04DA), one at each corner of the lagoons, were advanced through the upper and deep alluvium to the top of the Cockfield Formation (ranging from 46 to 72 feet bls). Groundwater monitoring wells (009G01DA, 009G02DA, 009G03DA, and 009G04DA), installed through the open borehole at each soil boring location, were screened in the basal 10 feet of the deep alluvium just above the Cockfield Formation. Figure 8.2.2 shows the soil boring and monitoring well locations.

Each soil boring/monitoring well, except for 009S03DA/009G03DA, was advanced, continuously sampled, and installed with a rotasonic drilling rig operated by Alliance Environmental of Marietta, Ohio. Alliance used an ATV drilling rig equipped with a Doodlebug carrier to advance, selectively sample, and install soil boring/monitoring well 009S03DA/009G03DA; this location was not accessible to the rotasonic drilling rig due to soft ground.

The following intervals were sampled in each soil boring: 0.5 to 2 feet, 8 to 10 feet, and 14 to 16 feet bls. To provide adequate sample volume for analysis, surface soil was collected from 0 to 2 feet bls at each location. The uppermost portion, which contained organic material, roots, grass, and gravel, was discarded, yielding an approximate surface-soil sampling interval of 0.5 to 2 feet bls. Two of the samples from the 14 to 16-foot interval (009S01DA and 009S02DA) were split as duplicates. The soil samples were submitted to NET for full-scan analysis, which consisted of VOC, SVOC, TPH-GRO, TPH-DRO, chlorinated pesticide/PCB, organophosphorus pesticide, herbicide, Appendix IX metal, and cyanide analyses. The analytical test methods used for each RFI sample are listed in Section 3 of this report. The analytical data reports in the Attachment of the *Data Validation Report — Assembly E* (E/A&H, 1997a) lists each method's compounds or elements.

Several weeks after monitoring well installation and development, the wells were purged and sampled. The groundwater samples were submitted to NET for FSA excluding TPH-GRO, since TICs from the VOC analyses would identify many of the lighter fraction hydrocarbons.

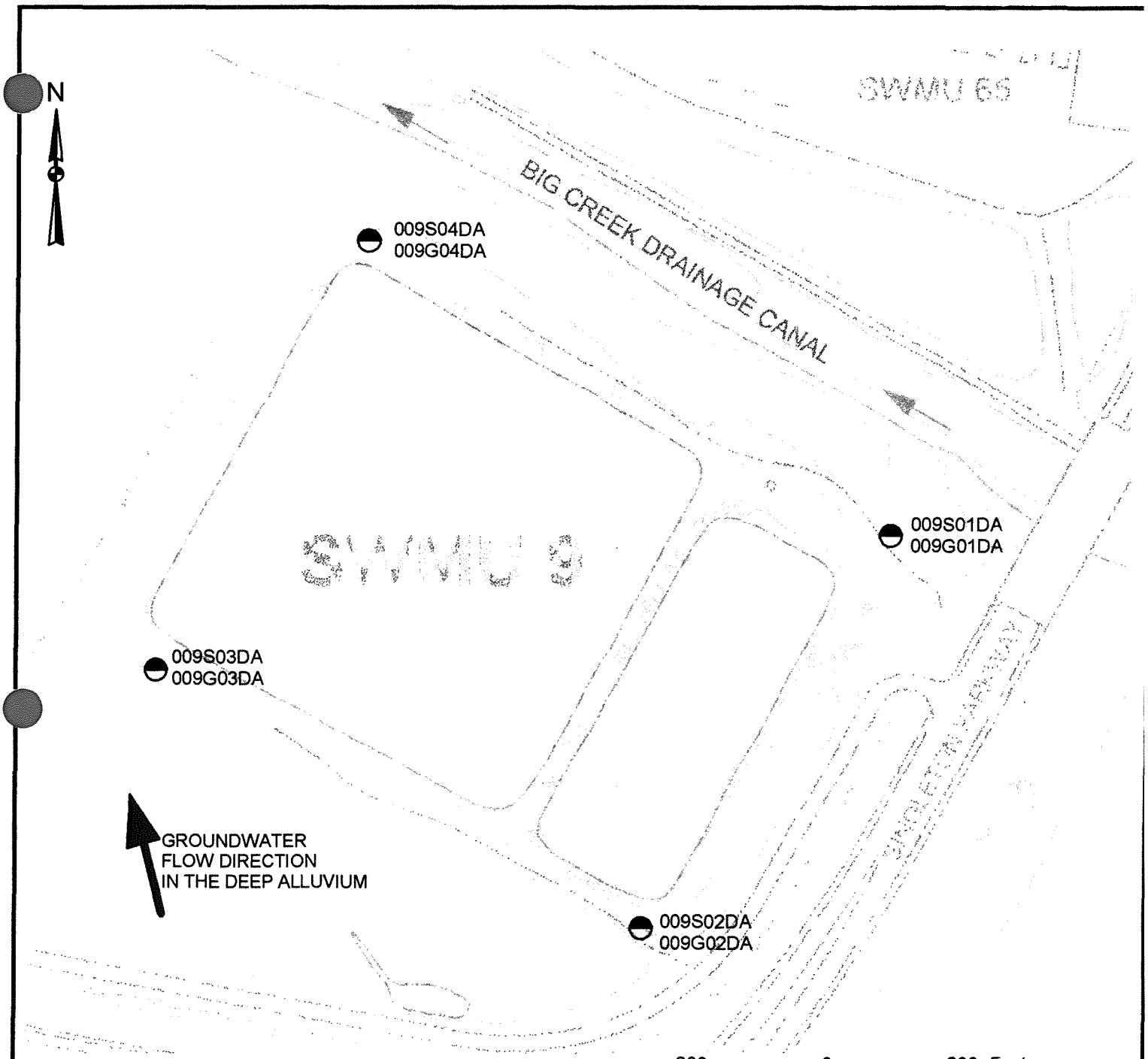
The Assembly E work plan stated that 10% of the groundwater samples collected during the Assembly E investigation would be split for duplicate analysis. Groundwater sampling at SWMU 9 was conducted concurrently with groundwater sampling at other Assembly E SWMUs, with duplicate and other QA/QC groundwater samples collected on an assembly-wide basis (i.e., 10% of the samples collected from all Assembly E SWMUs combined were split as duplicates) rather than on an individual SWMU basis. As a result, no duplicate groundwater samples were collected from SWMU 9.

8.2.2.3 Surface Soil Samples From the Lagoon Banks

To determine what constituents were present in surface soil on the lagoon banks just above the water's edge and to determine the risk associated with exposure to that soil, eight surface-soil samples (009S0001 through 009S0008) were collected from the 0- to 6-inch interval using a stainless-steel hand auger. One surface soil sample (009S0001) was split as a duplicate. The samples were submitted to NET for FSA. Figure 8.2.3 shows the surface soil sample locations.

8.2.2.4 Sediment Samples

For the purpose of this RFI Report, the samples collected from drainage pathways and lagoons are designated as "sediment samples." Those sediment samples collected from the 0- to 6-inch interval are termed "surface sediment" and those collected from the 18- to 24-inch interval are termed "subsurface sediment." Sediment samples were collected in the sewage lagoons and Big Creek Drainage Canal from locations that are generally submerged throughout the year. The following sections summarize the sediment sampling locations, procedures, and analyses.



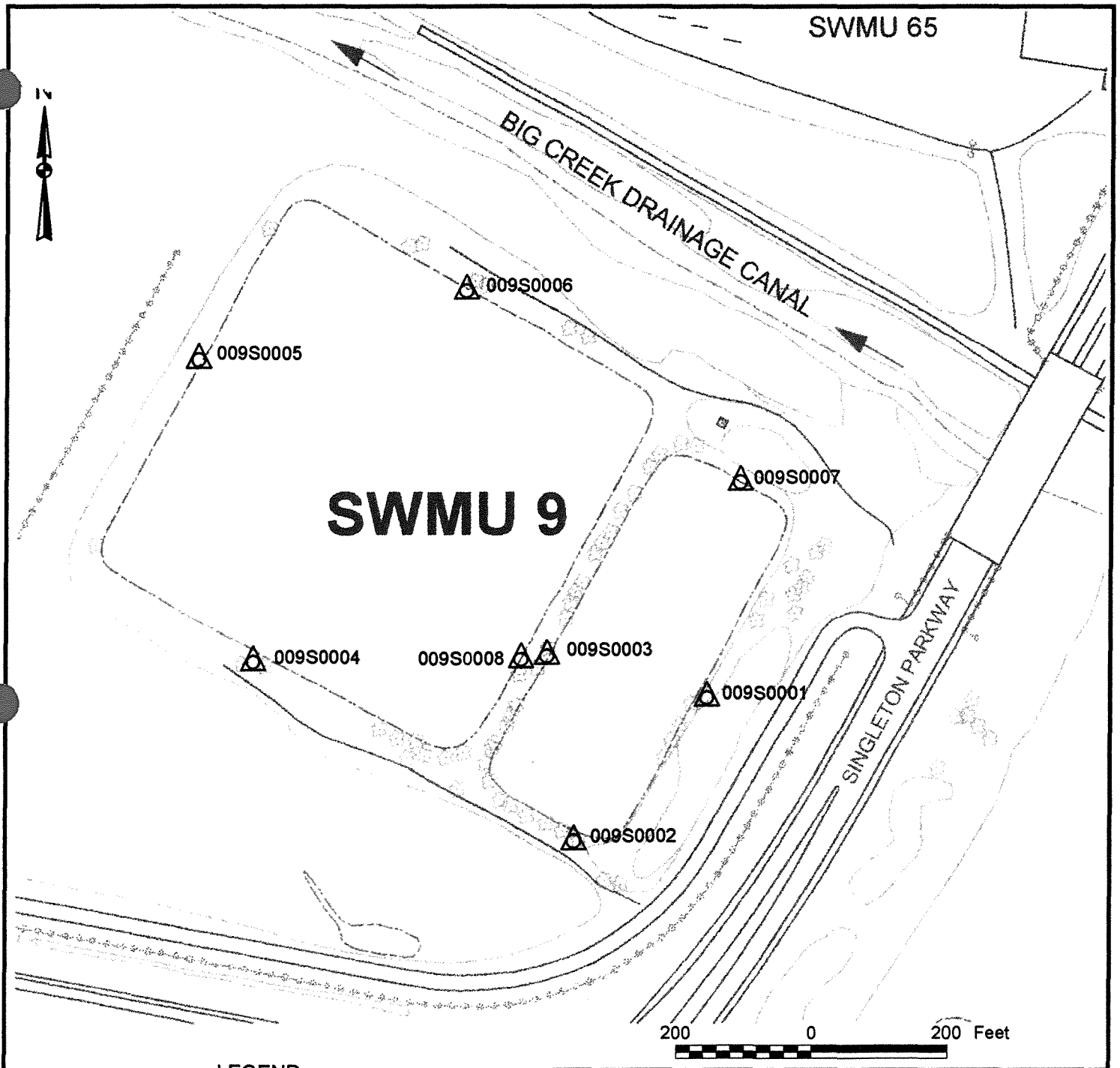
LEGEND

009S02DA
009G02DA — SOIL BORING AND MONITORING WELL LOCATION/IDENTIFICATION

SURFACE WATER FLOW DIRECTION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.2.2
SOIL BORING AND MONITORING WELL LOCATIONS
SWMU 9 - SEWAGE LAGOONS



LEGEND

009S0004 SURFACE SOIL SAMPLE LOCATION/IDENTIFICATION; SAMPLES COLLECTED FROM THE 0 TO 6-INCH INTERVAL WITH A STAINLESS-STEEL HAND AUGER.

SURFACE WATER FLOW DIRECTION

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MILLINGTON, TENNESSEE

FIGURE 8.2.3
SURFACE SOIL SAMPLE LOCATIONS
SWMU 9 - SEWAGE LAGOONS

Sediment Sampling Within the Sewage Lagoons

To determine potential contaminants present in the lagoon bottom sediments, samples were collected from the sediment in the 0- to 6-inch and the 18- to 24-inch intervals at eight locations (009M0001 through 009M0008). The sample locations were accessed with a boat and the samples were collected with a stainless-steel hand auger. Two of the 0- to 6-inch interval samples were split as duplicates. The primary and duplicate samples were submitted to the offsite laboratory (NET) for FSA. Figure 8.2.4 shows the sediment sampling locations.

Sediment Sampling in Big Creek Drainage Canal

To determine if contaminants potentially associated with SWMU 9 had affected the sediment in Big Creek Drainage Canal north of SWMU 9, sediment samples from four locations (009M0009 through 009M0012) were collected at the water's edge using a stainless-steel hand auger. At each sediment sampling location, the following intervals were sampled: 0 to 6 inches bls and 18 to 24 inches bls. One of the 0- to 6-inch interval sediment samples (009M0009) was split as a duplicate. The primary and duplicate sediment samples were submitted to NET for FSA. Figure 8.2.4 shows Big Creek Drainage Canal sediment sampling locations.

8.2.2.5 Sediment and Surface Water Sampling in Big Creek Drainage Canal

To determine if contaminants potentially associated with SWMU 9 had affected the surface water quality in Big Creek Drainage Canal north of SWMU 9, two grab surface water samples were collected. One surface water sample was collected downstream (northwest) of SWMU 9 (location 009W0001) and the second was collected upstream (northeast) of SWMU 9 (location 009W0002). The surface water sample from 009W0001 was split as a duplicate. The primary and duplicate surface water samples were submitted to NET for FSA excluding TPH-GRO, since many of the lighter fraction hydrocarbons would be identified in the TICs from the VOC analyses. Figure 8.2.4 shows the surface water sampling locations.

8.2.2.6 Biota Sampling

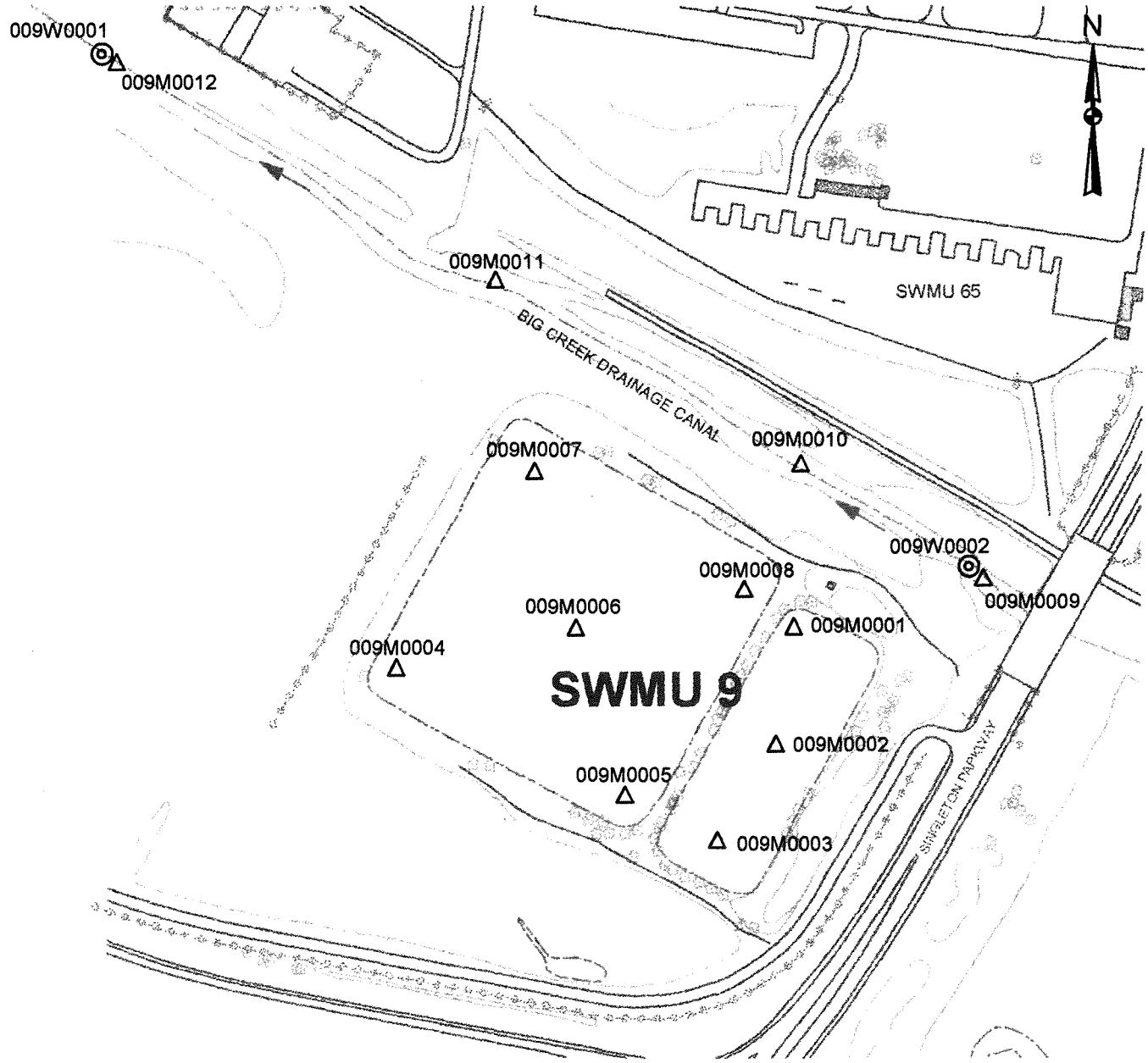
To determine the potential risk to humans that might consume fish from the sewage lagoons, a fish study was conducted at SWMU 9 from March 26 through March 28, 1996. For cost-effectiveness, trotlines were the chosen sampling device. One trotline was set in the smaller east lagoon, and two trotlines were set in the larger west lagoon. Only one species of potentially edible game fish, the black bullhead catfish *Ictalurus melas*, was caught during the study. Seven small to medium (0.25- to 1.5-pound) catfish were collected from the smaller lagoon and submitted as a composite sample designated 009J010001. Four small to medium catfish were collected from the larger lagoon and submitted as two composite samples designated 009J020001 and 009J020002. Each whole fish was frozen alive and submitted to Ceimic Corporation of Naragansett, Rhode Island, for the analysis of SVOCs (Method 8270), pesticides/PCBs (Method 8080), and TAL metals (Appendix IX Metals, 6010/7000 Series).

8.2.3 Nature and Extent of Contamination

This section summarizes the nature and extent of contamination in soil, groundwater, sediment, surface water, and fish tissue samples collected during the Assembly E SWMU 9 RFI. Additionally, the analytical results for groundwater samples collected during the April/May 1997 sampling event are included in the nature and extent of groundwater contamination section.

8.2.3.1 Nature and Extent of Soil Contamination

This section summarizes the nature and extent of contamination in SWMU 9 surface and subsurface soil samples. This discussion includes the results of the DPT subsurface soil samples, surface and subsurface soil samples collected from soil borings associated with monitoring well installation, and surface soil samples collected from the banks of the sewage lagoons. Sections 8.2.2.1, 8.2.2.2, and 8.2.2.3 provide details and rationale for sample locations and intervals sampled.



LEGEND

300 0 300 Feet

009M0004 △ SEDIMENT SAMPLE LOCATION/IDENTIFICATION; SAMPLES COLLECTED FROM THE 0 TO 6-INCH AND 18- TO 24-INCH INTERVALS WITH A STAINLESS-STEEL HAND AUGER.

009W0001 ◎ SURFACE WATER SAMPLE LOCATION/IDENTIFICATION

SURFACE WATER FLOW DIRECTION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.2.4
SEDIMENT AND SURFACE WATER SAMPLE LOCATIONS
SWMU 9 - SEWAGE LAGOONS

VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, herbicides, and Appendix IX metals were detected in surface and/or subsurface soil samples collected during the RFI. Constituents in surface soil were compared to their respective residential and industrial RBCs and SSLs. Constituents in subsurface soil samples were compared to their respective SSLs. Each detected inorganic concentration was also compared to its background RC to determine if the element occurs naturally or may be the result of SWMU 9 operations.

8.2.3.1.1 Organic Compounds in Soil Samples

VOCs in Soil

During the DPT screening investigation, no VOCs were identified in subsurface soil samples analyzed by Hydrologic's onsite laboratory by SW-846 Method 8021 or in soil samples split and submitted to NET for offsite confirmation analysis by SW-846 Method 8240. The following VOCs were detected in surface and/or subsurface soil samples:

Acetone	Ethylbenzene
2-Butanone (MEK)	Total Xylenes

Acetone was detected in most of the surface soil samples collected from the lagoon banks. However, this compound may be a laboratory artifact, based on its occurrence at similar concentrations at other SWMUs at NSA Memphis. 2-Butanone, ethylbenzene, and total xylenes were detected in soil samples collected from the borings associated with monitoring well installation. As shown in Table 8.2.1 and Figure 8.2.5, no VOC in surface soil exceeded its residential RBC. The SSL for acetone (8,000 μg/kg) was exceeded only in the hand auger surface soil sample collected from location 009S0007 (25,000 μg/kg), as shown on Figure 8.2.6. No VOC in subsurface soil exceeded its SSL.

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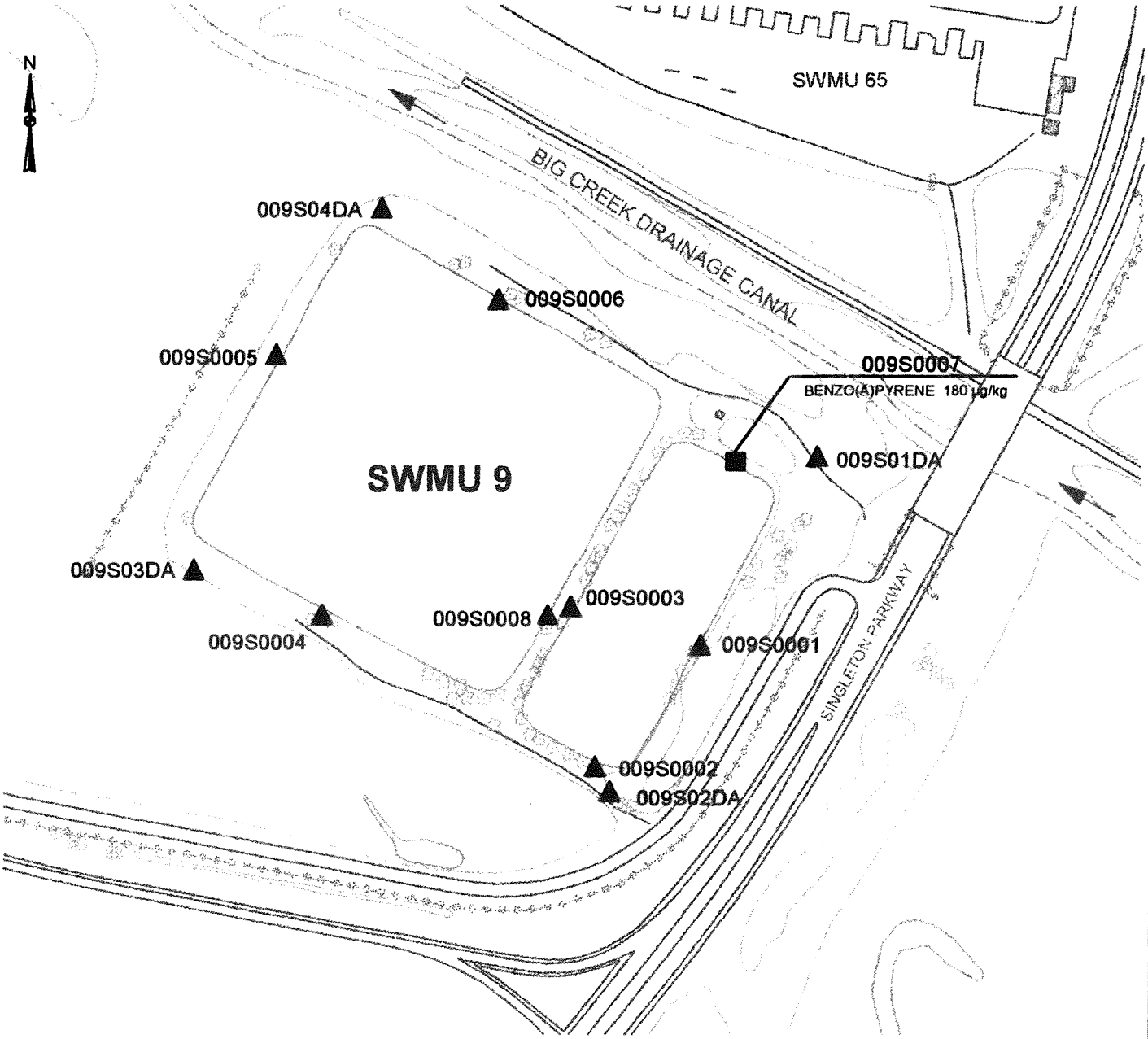


LEGEND

300 0 300 Feet

▲ NO CONSTITUENT IN SURFACE SOIL EXCEEDS THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

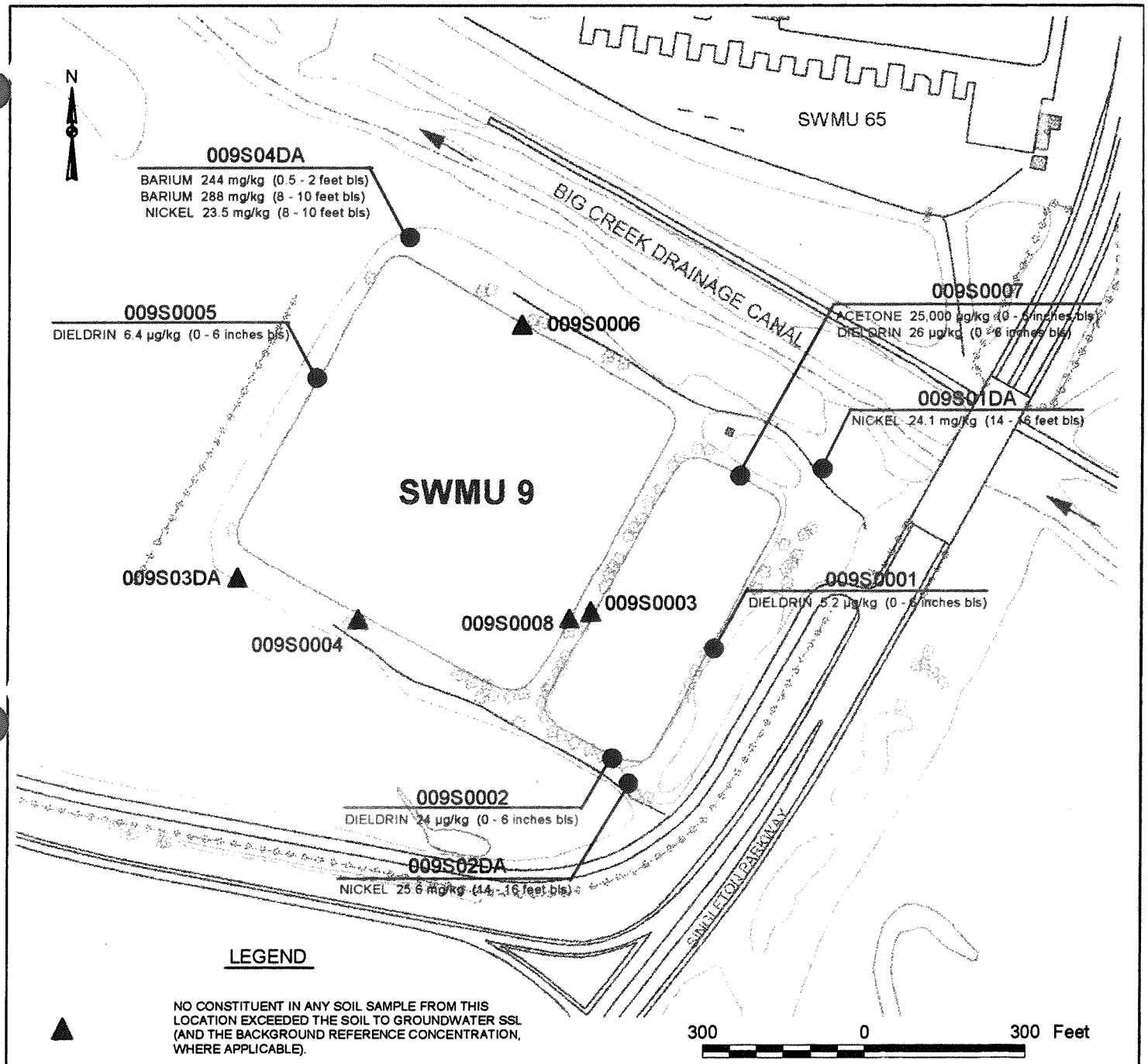
■ ONE OR MORE CONSTITUENTS IN SURFACE SOIL EXCEEDS THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION (WHERE APPLICABLE), BUT NOT THE INDUSTRIAL RBC.

009S0008 SURFACE SOIL (0 - 6") SAMPLING LOCATION; SAMPLES WERE COLLECTED FROM THE LAGOON BANKS WITH A STAINLESS-STEEL HAND AUGER.

)S02DA SOIL BORING DESIGNATION; SURFACE SOIL SAMPLES WERE COLLECTED FROM 0 TO 2 FEET BELOW LAND SURFACE WITH THE ROTASONIC DRILL RIG DURING RFI MONITORING WELL INSTALLATION.

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.2.5
RBC EXCEEDANCES IN SURFACE SOIL FROM SOIL BORINGS AND HAND AUGER SAMPLING LOCATIONS
SWMU 9 - SEWAGE LAGOONS



LEGEND

▲ NO CONSTITUENT IN ANY SOIL SAMPLE FROM THIS LOCATION EXCEEDED THE SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN A SOIL SAMPLE FROM THIS LOCATION EXCEEDED THE SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

009S02DA
NICKEL 25.6 mg/kg (14 - 16 feet bls)

THE FOLLOWING CONSTITUENT WAS DETECTED IN THE 14 TO 16 FOOT INTERVAL SAMPLE FROM SOIL BORING 009S02DA AT A CONCENTRATION THAT EXCEEDED ITS SOIL TO GROUNDWATER SSL: 25.6 mg/kg NICKEL.

009S0008	HAND AUGER SURFACE SOIL SAMPLE DESIGNATION
009S02DA	ROTASONIC SOIL BORING DESIGNATION
mg/kg	MILLIGRAMS PER KILOGRAM
µg/kg	MICROGRAMS PER KILOGRAM

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.2.6
SOIL TO GROUNDWATER SSL EXCEEDANCES IN SOIL SAMPLES FROM SOIL BORINGS AND HAND AUGER SAMPLING LOCATIONS
SWMU 9 - SEWAGE LAGOONS

Table 8.2.1
Detected Concentrations of Organic Compounds in Soil
SWMU 9 — Industrial Sewage Lagoons
(data in µg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
VOCs										
Acetone	0" - 6"	6/8	11 - 25,000	5,873	7,800,000	0	200,000,000	0	8,000	1 (009S0007)
	8' - 10'	1/4	110	110	NA[g]	NA	NA	NA	8,000	0
2-Butanone (MEK)	0.5' - 2'	1/4	1,200	1,200	47,000,000	0	1,000,000,000	0	—[h]	—
	8' - 10'	1/4	4.0	4.0	NA	NA	NA	NA	—	—
Ethylbenzene	0.5' - 2'	3/4	1 - 3	2	7,800,000	0	200,000,000	0	5,000	0
	14' - 16'	1/4	1	1	NA	NA	NA	NA	5,000	0
Xylene (total)	0.5' - 2'	3/4	7 - 16	11	160,000,000	0	1,000,000,000	0	74,000	0
	8' - 10'	1/4	3	3	NA	NA	NA	NA	74,000	0
	14' - 16'	1/4	2	2	NA	NA	NA	NA	74,000	0
SVOCs										
Benzo(a)anthracene	0 - 6"	1/8	160	160	880	0	7,800	0	700	0
Benzo(a)pyrene	0 - 6"	1/8	180	180	88	1 (009S0007)	780	0	4,000	0
Benzo(b)fluoranthene	0 - 6"	1/8	180	180	880	0	7,800	0	4,000	0
Benzo(g,h,i)perylene	0 - 6"	1/8	150	150	3,100,000[i]	0	82,000,000[i]	0	—	—
Benzo(k)fluoranthene	0 - 6"	1/8	180	180	8,800	0	78,000	0	4,000	0
Chrysene	0 - 6"	1/8	180	180	88,000	0	780,000	0	1,000	0
Fluoranthene	0 - 6"	1/8	290	290	3,100,000	0	82,000,000	0	980,000	0
Indeno(1,2,3-cd)pyrene	0 - 6"	1/8	130	130	880	0	7,800	0	35,000	0
2-Methylphenol (o-Cresol)	8' - 10'	1/4	76	76	NA	NA	NA	NA	6,000	0
Phenanthrene	0" - 6"	1/8	120	120	3,100,000[i]	0	82,000,000[i]	0	—	—
Pyrene	0" - 6"	1/8	260	260	2,300,000	0	61,000,000	0	1,400,000	0

Table 8.2.1
Detected Concentrations of Organic Compounds in Soil
SWMU 9 — Industrial Sewage Lagoons
(data in µg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Total Petroleum Hydrocarbons										
TPH - DRO	0" - 6"	6/6	7,100 - 120,000	27,750	—	—	—	—	500,000[f]	0
TPH - GRO	0" - 6"	5/6	75 - 180	135	—	—	—	—	500,000	0
	0.5' - 2'	2/4	74 - 79	77	—	—	—	—	500,000	0
Pesticides/PCBs										
Aldrin	0" - 6"	3/8	1.1 - 3	2	38	0	340	0	5	0
Aroclor-1254	0" - 6"	3/8	93 - 240	188	320	0	2,850	0	—	—
	0.5' - 2'	3/4	36 - 310	136	320	0	2,850	0	—	—
Aroclor-1260	0" - 6"	1/8	84	84	320	0	2,850	0	—	—
alpha-Chlordane	0" - 6"	1/8	1.8	1.8	1,825	0	16,352	0	2,000	0
gamma-Chlordane	0" - 6"	2/8	1.4 - 1.5	1.5	1,825	0	16,352	0	2,000	0
4,4'-DDD	0" - 6"	4/8	3.6 - 35	19	2,700	0	24,000	0	700	0
	0.5' - 2'	1/4	2.1	2.1	2,700	0	24,000	0	700	0
4,4'-DDE	0" - 6"	8/8	2 - 80	26	1,900	0	17,000	0	500	0
	0.5' - 2'	3/4	3.1 - 14	9	1,900	0	17,000	0	500	0
4,4'-DDT	0" - 6"	2/8	2.8 - 12	7.4	1,900	0	17,000	0	1,000	0
	0.5' - 2'	2/4	3.2 - 12	8	1,900	0	17,000	0	1,000	0
Dieldrin	0" - 6"	4/8	5.2 - 26	15	40	0	360	0	1	4 (009S0001, 009S0002, 009S0005, 009S0007)
Herbicides										
2,4-D	0" - 6"	4/8	10 - 22	15	780,000	0	20,000,000	0	1,700	0
2,4-DB	0" - 6"	3/8	4.4 - 84	41	630,000	0	16,000,000	0	—	—
	0.5' - 2'	2/4	5.6 - 19	12.3	630,000	0	16,000,000	0	—	—
	14' - 16'	1/4	6.3	6.3	NA	NA	NA	NA	—	—

Table 8.2.1
Detected Concentrations of Organic Compounds in Soil
SWMU 9 — Industrial Sewage Lagoons
(data in µg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Herbicides										
Dichlorprop	0" - 6"	3/8	7.6 - 32	17	NA	NA	NA	NA	—	—
	0.5' - 2'	1/4	13	13	NA	NA	NA	NA	—	—
MCPA	0" - 6"	3/8	580 - 1,200	787	39,000	0	1,000,000	0	—	—
	8' - 10'	1/4	690	690	NA	NA	NA	NA	—	—
	14' - 16'	1/4	2,900	2,900	NA	NA	NA	NA	—	—
MCPP	0" - 6"	1/8	5,100	5,100	78,000	0	2,000,000	0	—	—
2,4,5-T	0" - 6"	1/8	9	9	780,000	0	20,000,000	0	—	—
	14' - 16'	1/4	1.3	1.3	NA	NA	NA	NA	—	—
2,4,5-TP (Silvex)	14' - 16'	1/4	1.2	1.2	NA	NA	NA	NA	—	—

Notes:

a — Only primary samples are included in this table. Eight hand-auger surface-soil samples were collected from 0 to 6 inches bls in soil along the lagoon banks. One of these samples was split as a duplicate. NET analyzed the samples for VOCs, SVOCs, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide. Samples 009S0001 and 009S0008 were also analyzed for total TPH by Method 418.1. Samples 009S0002 through 009S0007 were also analyzed for TPH-GRO and TPH DRO. Twelve soil samples were collected from four soil borings associated with monitoring well installation. Four of these samples were from the 0 to 2-foot interval, four were from the 8- to 10-foot interval, and four were from the 14- to 16-foot interval. Four of the 8- to 10-foot interval samples were split as duplicates. The soil samples from soil borings were analyzed by NET for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.

b — Intervals are shown in inches and feet bls

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply for comparison to data from samples collected across the surface interval (0 to 2 feet bls).

f — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *January to June, 1996 Risk-Based Concentration Table* (USEPA, 1996a).

g — NA denotes RBC comparison is not applicable to this subsurface sample.

h — denotes RBC or SSL is not available for this analyte; therefore, no comparison can be made.

i — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.

j — No RBC or SSL exists for TPH; the TDEC soil cleanup level of 500,000 µg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

SVOCs in Soil

Detected SVOCs, primarily limited to the surface soil samples collected from the banks of the lagoons, consisted of the following constituents:

Benzo(a)anthracene	Fluoranthene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(b)fluoranthene	2-Methylphenol
Benzo(g,h,i)perylene	Phenanthrene
Benzo(k)fluoranthene	Pyrene
Chrysene	

The benzo(a)pyrene concentration in the hand auger surface soil sample from location 009S0007 (180 μg/kg) exceeded its residential RBC (88 μg/kg) but not its SSL (4,000 μg/kg). No other detected SVOC exceeded its residential RBC or SSL, as shown in Table 8.2.1.

TPH in Soil

TPH-GRO and TPH-DRO were detected in several SWMU 9 soil samples. The USEPA has not established an RBC or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers (the upper alluvium, which is lithologically similar to the loess) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface soil. As shown in Table 8.2.1, the TDEC cleanup standard was not exceeded by the total TPH concentration in any sample.

Pesticides/PCBs in Soil

The following pesticides/PCBs were detected in RFI soil samples:

Aldrin	4,4'-DDD
Aroclor-1254	4,4'-DDE
Aroclor-1260	4,4'-DDT
alpha-Chlordane	Dieldrin
gamma-Chlordane	

As shown in Table 8.2.1 and Figure 8.2.5, no detected pesticide or PCB in surface soil exceeded its respective residential or industrial RBC. The SSL for dieldrin (1 μg/kg) was exceeded at surface-soil hand-auger sampling locations 009S0001 (5.2 μg/kg), 009S0002 (24 μg/kg), 009S0005 (6.4 μg/kg) and 009S0007 (26 μg/kg), as shown on Figure 8.2.6. Dieldrin's SSL was not exceeded in any subsurface soil sample.

Although SSLs for dieldrin were exceeded in several samples, concentrations did not exceed the RC (262 μg/kg) established for dieldrin at NSA Memphis in the *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d).

Herbicides in Soil

The following herbicides were detected in RFI soil samples:

2,4-D	Dichlorprop
2,4-DB	MCPA
2,4,5-T	MCPP
2,4,5-TP (Silvex)	

As shown in Table 8.2.1, no herbicide in any surface soil sample exceeded its residential RBC. SSLs (where available) were not exceeded for any herbicide detected in individual surface or subsurface soil samples.

8.2.3.1.2 Inorganics in Soil Samples

The following inorganics were detected in RFI soil samples:

Arsenic	Lead
Barium	Nickel
Beryllium	Selenium
Cadmium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc
Cyanide	

As previously outlined, detected concentrations of inorganics have been compared to their RBCs (surface soil only), and to RCs and SSLs (all soil samples). Table 8.2.2 summarizes the inorganics detected in RFI surface and subsurface soil samples. As shown in Table 8.2.2, no inorganic in surface soil exceeded both its background RC and residential RBC. Barium and nickel concentrations exceeded both their background RC and SSL. Exceedances are discussed in the following paragraphs and plotted on Figure 8.2.6.

Barium — The barium concentration in the 0.5 to 2.0-foot interval of soil boring 009S04DA (244 mg/kg) exceeded both its RC (233.46 mg/kg) and SSL (32 mg/kg). The barium concentration in the 8- to 10-foot interval sample from the same soil boring (288 mg/kg) exceeded both its RC (265.12 mg/kg) and SSL.

Nickel — Both the RC (non-detect) and SSL (21 mg/kg) for nickel were exceeded in the following subsurface soil samples: 009S01DA (24.1 mg/kg in the 14- to 16-foot interval sample), 009S02DA (25.6 mg/kg in the 14-to 16-foot interval sample), and 009S04DA (23.5 mg/kg in the 8- to 10-foot interval sample).

8.2.3.2 Nature and Extent of Groundwater Contamination

This section summarizes the nature and extent of contamination in alluvial groundwater samples collected from the DPT sampling locations and monitoring wells. VOCs, SVOCs, TPH-DRO, and Appendix IX metals were detected in RFI groundwater samples. As discussed in Section 3, constituents in groundwater are compared to their respective RBCs for tap water and MCLs for drinking water. Inorganics in groundwater are also compared to their established background RCs to determine if they occur naturally.

Table 8.2.2
Detected Concentrations of Inorganics in Soil Samples
SWMU 9 — Industrial Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	RC[f]	RC Exceedances	SSL[g]	SSL Exceedances
Arsenic	0" - 6"	8/8	2.9 - 9.9	5	0.43	8 (009S0001, 009S0002, 009S0003, 009S0004, 009S0005, 009S0006, 009S0007, 009S0008)	3.8	4 (009S0002, 009S0005, 009S0006, 009S0007)	14.58	0	15	0
	0.5' - 2'	4/4	3.9 - 7.0	5.7	0.43	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)	3.8	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)	14.58	0	15	0
	8' - 10'	4/4	4.4 - 10.4	6.5	NA[h]	NA	NA	NA	20.32	0	15	0
	14' - 16'	4/4	3.8 - 17	8	NA	NA	NA	NA	20.32	0	15	1 (009S02DA)
Barium	0" - 6"	8/8	93.6 - 200	136	5,500	0	140,000	0	223.46	0	32	8 (009S0001, 009S0002, 009S0003, 009S0004, 009S0005, 009S0006, 009S0007, 009S0008)
	0.5' - 2'	4/4	135 - 244	167	5,500	0	140,000	0	233.46	1 (009S04DA)	32	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)
	8' - 10'	4/4	107 - 288	170	NA	NA	NA	NA	265.12	1 (009S04DA)	32	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)
	14' - 16'	4/4	108 - 197	155	NA	NA	NA	NA	265.12	0	32	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)
Beryllium	0" - 6"	8/8	0.42 - 0.85	0.58	0.15	8 (009S0001, 009S0002, 009S0003, 009S0004, 009S0005, 009S0006, 009S0007, 009S0008)	1.3	0	1	0	180	0
	0.5' - 2'	2/4	0.53 - 1	0.77	0.15	2 (009S02DA, 009S04DA)	1.3	0	1	0	180	0
	8' - 10'	1/4	0.43	0.43	NA	NA	NA	NA	1	0	180	0
	14' - 16'	1/4	0.55	0.55	NA	NA	NA	NA	1	0	180	0

Table 8.2.2
Detected Concentrations of Inorganics in Soil Samples
SWMU 9 — Industrial Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	RC[f]	RC Exceedances	SSL[g]	SSL Exceedances
Cadmium	0" - 6"	6/8	1.5 - 3.2	2.5	39	0	1,000	0	1.54	5 (009S0003, 009S0004, 009S0005, 009S0006, 009S0007)	6	0
	0.5' - 2'	4/4	1.1 - 4.0	2.2	39	0	1,000	0	1.54	2 (009S01DA, 009S04DA)	6	0
	8' - 10'	4/4	1.3 - 2.5	1.7	NA	NA	NA	NA	3.24	0	6	0
	14' - 16'	3/4	1.6 - 2.1	1.9	NA	NA	NA	NA	3.24	0	6	0
Chromium	0" - 6"	8/8	7.2 - 15	10	390	0	510	0	23.89	0	—[h]	—
	0.5' - 2'	4/4	11.4 - 13.3	12.3	390	0	510	0	23.89	0	—	—
	8' - 10'	4/4	10.7 - 17.7	13.7	NA	NA	NA	NA	28.28	0	—	—
	14' - 16'	4/4	10.3 - 16.6	13.3	NA	NA	NA	NA	28.28	0	—	—
Cobalt	0" - 6"	8/8	4 - 9.7	7	4,700	0	120,000	0	15.98	0	—	—
	0.5' - 2'	4/4	6.1 - 19.8	9.6	4,700	0	120,000	0	15.98	1 (009S04DA)	—	—
	8' - 10'	4/4	5.9 - 10.8	8.2	NA	NA	NA	NA	14.36	0	—	—
	14' - 16'	4/4	3.6 - 10.1	7.8	NA	NA	NA	NA	14.36	0	—	—
Copper	0" - 6"	8/8	9.1 - 19.6	12.6	3,100	0	82,000	0	24.19	0	—	—
	0.5' - 2'	4/4	12 - 15.9	14	3,100	0	82,000	0	24.19	0	—	—
	8' - 10'	4/4	10.9 - 18.6	13.9	NA	NA	NA	NA	32.52	0	—	—
	14' - 16'	4/4	10.3 - 19.4	15.8	NA	NA	NA	NA	32.52	0	—	—
Cyanide	0.5' - 2'	1/4	0.022	0.022	1,600	0	41,000	0	ND[i]	1 (009S02DA)	—	—

Table 8.2.2
Detected Concentrations of Inorganics in Soil Samples
SWMU 9 — Industrial Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	RC[f]	RC Exceedances	SSL[g]	SSL Exceedances
Lead	0" - 6"	8/8	8.7 - 16.3	12.4	400[h]	0	1,300[h]	0	26.03	0	—	—
	0.5' - 2'	4/4	11 - 16.9	14	400	0	1,300	0	26.03	0	—	—
	8' - 10'	4/4	7.8 - 19.7	11.9	NA	NA	NA	NA	19.8	0	—	—
	14' - 16'	4/4	9.1 - 12.4	10.7	NA	NA	NA	NA	19.8	0	—	—
Nickel	0" - 6"	6/8	7.5 - 13.8	10.2	1,600	0	41,000	0	20.62	0	21	0
	0.5' - 2'	4/4	12 - 19.1	14	1,600	0	41,000	0	20.62	0	21	0
	8' - 10'	4/4	14.2 - 23.5	16.9	NA	NA	NA	NA	ND	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)	21	1 (009S04DA)
	14' - 16'	4/4	10.5 - 25.6	19.9	NA	NA	NA	NA	ND	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)	21	2 (009S01DA, 009S02DA)
Selenium	0" - 6"	8/8	0.25 - 0.93	0.44	390	0	10,000	0	ND	8 (009S0001, 009S0002, 009S0003, 009S0004, 009S0005, 009S0006, 009S0007, 009S0008)	3	0
	0.5' - 2'	1/4	0.46	0.46	390	0	10,000	0	ND	1 (009S02DA)	3	0
	8' - 10'	1/4	0.55	0.55	NA	NA	NA	NA	ND	1 (009S01DA)	3	0

Table 8.2.2
Detected Concentrations of Inorganics in Soil Samples
SWMU 9 — Industrial Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	RC[f]	RC Exceedances	SSL[g]	SSL Exceedances
Silver	8' - 10'	1/4	0.99	0.99	NA	NA	NA	NA	ND	1 (009S03DA)	—	—
	14' - 16'	2/4	0.96 - 1.6	1.3	NA	NA	NA	NA	ND	2 (009S01DA, 009S03DA)	—	—
Tin	0" - 6"	1/8	4.7	4.7	47,000	0	1,000,000	0	33.56	0	—	—
	0.5' - 2'	4/4	22.2 - 26	24	47,000	0	1,000,000	0	33.56	0	—	—
	8' - 10'	4/4	20.7 - 29.4	24.3	NA	NA	NA	NA	ND	4 (009S01DA, 009S02DA, 009S03DA, 009S04DA)	—	—
	14' - 16'	3/4	20.2 - 32.9	26.6	NA	NA	NA	NA	ND	3 (009S01DA, 009S02DA, 009S04DA)	—	—
Vanadium	0" - 6"	8/8	13.7 - 28.8	22.1	550	0	14,000	0	45.11	0	—	—
	0.5' - 2'	4/4	21.2 - 32.6	24.9	550	0	14,000	0	45.11	0	—	—
	8' - 10'	4/4	16.4 - 26.1	22.5	NA	NA	NA	NA	43.68	0	—	—
	14' - 16'	4/4	11 - 29.4	23	NA	NA	NA	NA	43.68	0	—	—

Table 8.2.2
Detected Concentrations of Inorganics in Soil Samples
SWMU 9 — Industrial Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Frequency of Detection[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	RC[f]	RC Exceedances	SSL[g]	SSL Exceedances
Zinc	0" - 6"	8/8	29.2 - 70.1	45.1	23,000	0	610,000	0	98	0	42,000	0
	0.5' - 2'	4/4	46.1 - 56.3	49.9	23,000	0	610,000	0	98	0	42,000	0
	8' - 10'	4/4	41.6 - 80.1	52.8	NA	NA	NA	NA	109	0	42,000	0
	14' - 16'	4/4	36.8 - 67.8	56	NA	NA	NA	NA	109	0	42,000	0

Notes:

a — Only primary samples are included in this table. Eight hand-auger surface-soil samples were collected from 0 to 6 inches bls in soil along the lagoon banks. One of these samples was split as a duplicate. NET analyzed the samples for VOCs, SVOCs, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide. Samples 009S0001 and 009S0008 were also analyzed for total TPH by Method 418.1. Samples 009S0002 through 009S0007 were also analyzed for TPH-GRO and TPH-DRO. Twelve soil samples were collected from four soil borings associated with monitoring well installation. Four of these samples were from the 0 to 2-foot interval, four were from the 8- to 10-foot interval, and four were from the 14- to 16-foot interval. Four of the 8- to 10-foot interval samples were split as duplicates. The soil samples from soil borings were analyzed by NET for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.

b — Intervals are shown in inches and feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply for comparison to data from samples collected across the surface interval (0 to 2 feet bls).

f — Reference concentration (RC) is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

g — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

h — NA denotes RBC comparison is not applicable to this subsurface sample.

i — ND denotes analyte was not detected in this interval.

j — denotes RBC or SSL is not available for this analyte; therefore, no comparison can be made.

k — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 are used for comparison.

8.2.3.2.1 Organic Compounds in Groundwater Samples

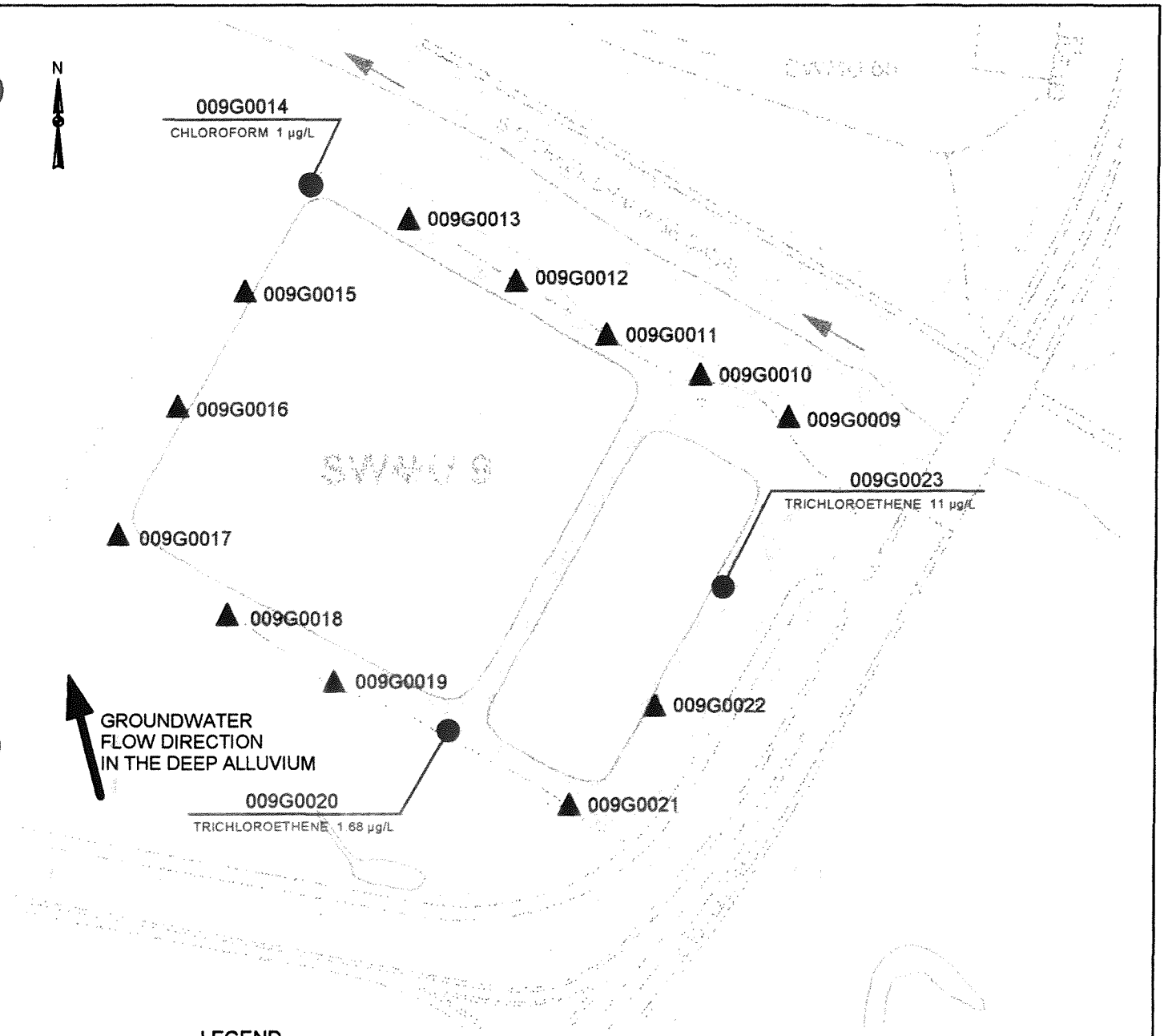
VOCs in Groundwater

During the DPT investigation of the deep alluvium groundwater at SWMU 9, only chloroform and trichloroethene were detected, as shown in Table 8.2.3 and plotted on Figure 8.2.7. Chloroform's RBC for tap water (0.15 μg/L) but not its MCL for drinking water (80 μg/L) was exceeded in the *duplicate* groundwater sample from location 009G0014 (1 μg/L); this compound was not detected in the primary sample analyzed by the onsite laboratory. Chloroform may be considered a laboratory artifact. The RBC (1.6 μg/L) and MCL (5 μg/L) for trichloroethene (TCE) were exceeded in the DPT groundwater sample from location 009G0023. At location 009G0020 (1.68 μg/L TCE), the detected concentration exceeded only the RBC. TCE, a common solvent, has been detected at other SWMUs at NSA Memphis, and may or may not be related to SWMU 9 operations. TCE was also detected in the groundwater sample collected from monitoring well 009G01DA (1 μg/L); the detected concentration did not exceed its RBC or MCL, as shown in Table 8.2.4. No other VOCs were detected in the RFI monitoring wells.

Table 8.2.3
Detected Concentrations of VOCs in DPT Groundwater Samples
SWMU 9 — Sewage Lagoons
(data in μg/L)

Analyte	DPT Sample Location	Lithologic Unit and Depth (feet bls)[a]	Onsite Laboratory Result[b]	Offsite Laboratory Result[c]	RBC - Tap Water[d]	MCL - Drinking Water[e]
chloroform	009G0014	DA[f] (45')	ND[g]	1 J[h]	0.15	80
trichloroethene (TCE)	009G0020	DA (50')	**1.68**	NA[i]	1.6	5
	009G0023	DA (47')	**11**	NA	1.6	5

Notes:
a — Fifteen deep alluvium groundwater samples were analyzed by the onsite laboratory for VOCs using SW-846 Method 8021. Of these samples, three of the groundwater samples were split and analyzed for VOCs by the offsite laboratory using SW-846 Method 8240.
b — Hydrologic, Inc. of Travelers Rest, South Carolina provided onsite laboratory services for primary samples.
c — NET of Cambridge, Massachusetts provided offsite laboratory services for confirmation samples.
d — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
e — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
f — DA denotes deep alluvium
g — ND denotes analyte not detected.
h — J denotes estimated concentration.
i — NA denotes this sample was not submitted for offsite confirmation analysis.
Bold Type denotes this concentration exceeds the RBC for tap water and/or the MCL for drinking water.



LEGEND

▲ NO VOC IN GROUNDWATER COLLECTED FROM THIS DPT SAMPLING LOCATION EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER.

● ONE OR MORE VOCs IN GROUNDWATER COLLECTED FROM THIS DPT SAMPLING LOCATION EXCEEDED THE RBC FOR TAP WATER AND/OR THE MCL FOR DRINKING WATER.

009G0023
TRICHLOROETHENE 11 µg/L

THE DPT GROUNDWATER SAMPLE FROM LOCATION 009G0023 CONTAINED THE FOLLOWING VOC THAT EXCEEDED THE RBC FOR TAP WATER AND/OR THE MCL FOR DRINKING WATER: 11 µg/L TRICHLOROETHENE.

µg/L MICROGRAMS PER LITER

NOTE: ALL DPT GROUNDWATER SAMPLES WERE COLLECTED FROM THE DEEP ALLUVIUM.

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FIGURE 8.2.7
RBC AND/OR MCL EXCEEDANCES IN
DPT GROUNDWATER SAMPLES
SWMU 9 - SEWAGE LAGOONS

Table 8.2.4
Detected Constituents in RFI Monitoring Wells
SWMU 9 — Sewage Lagoons
(data in µg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances	RC[g]	RC Exceedances
VOCs										
Trichloroethene	DA	1/4	1	1	1.6	0	5	0	—[h]	—
SVOCs										
bis(2-Ethylhexyl)phthalate (BEHP)	DA	1/4	4	4	4.8	0	—	—	—	—
TPH										
TPH - Diesel Range Organics	DA	1/4	230	230	100[i]	1 (009G03DA)	—	—	—	—
Inorganics										
Arsenic	DA	1/4	12.2	12.2	0.045	1 (009G03DA)	50	0	4.2	1 (009G03DA)
Barium	DA	4/4	250 - 806	529	2600	0	2000	0	844	0
Chromium	DA	3/4	5.3 - 26	13	180	0	100	0	69.2	0
Cobalt	DA	1/4	5.5	5.5	2200	0	—	—	27	0
Lead	DA	2/4	2 - 2.6	2.3	15[j]	0	15[j]	0	ND[k]	2 (009G01DA, 009G04DA)

Notes:

a — Only primary samples are included on this table. Four groundwater samples were collected during the initial sampling event; one from each deep alluvium monitoring well. The samples were analyzed by NET, the offsite laboratory, for VOCs, SVOCs, TPH-DRO, pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.

b — Interval refers to the aquifer present in the screened interval of the monitoring well. DA = Deep alluvium.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Risk-based concentrations (RBCs) for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels (MCLs) in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — Reference concentration (RC) is two times the mean background concentration. Analytical data from one sampling event of background middle alluvium monitoring well OBGG11MA was used to establish background concentrations. Refer to the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

h — denotes MCL or background RC is not available for this analyte; therefore, no comparison can be made.

i — No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 100 µg/L total TPH for drinking water aquifers has been substituted for the tap water RBC. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

j — Lead does not have an RBC or MCL; therefore, the USEPA treatment technique action level of 15 µg/L has been substituted for the RBC and MCL (USEPA, 1996c).

k — ND denotes analyte was not detected in the background sample used to calculate reference concentrations.

SVOCs in Groundwater

Only one SVOC, bis(2-ethylhexyl)phthalate (BEHP) was detected in groundwater at SWMU 9. As shown in Table 8.2.4, the detected BEHP concentration (4 μg/L in monitoring well 009G01DA) did not exceed its RBC (4.8 μg/L), and no MCL exists for this compound.

TPH-DRO in Groundwater

Deep alluvium groundwater samples were not tested for TPH-GRO because many of the lighter fraction hydrocarbons of interest (e.g., BTEX) are identified during the VOC analyses. TPH has no RBC or MCL; therefore, the detected concentration of TPH-DRO was compared with the 100 μg/L TDEC cleanup standard for drinking water aquifers for petroleum-contaminated sites (TDEC, 1997). As shown in Table 8.2.4 and plotted on Figure 8.2.8, the TPH-DRO concentration in monitoring well 009G03DA (230 μg/L) exceeded the TDEC drinking water cleanup standard of 100 μg/L. The water quality classification of the alluvial aquifer has not yet been established at NSA Memphis; however, the USGS stated that they are not aware of any drinking water wells completed in the alluvial aquifer in the vicinity of NSA Memphis (USGS, 1996). EnSafe is currently conducting a water use survey to establish if alluvial water wells are present in the vicinity of NSA Memphis. The results of this survey will be included in subsequent revisions to this RFI report.

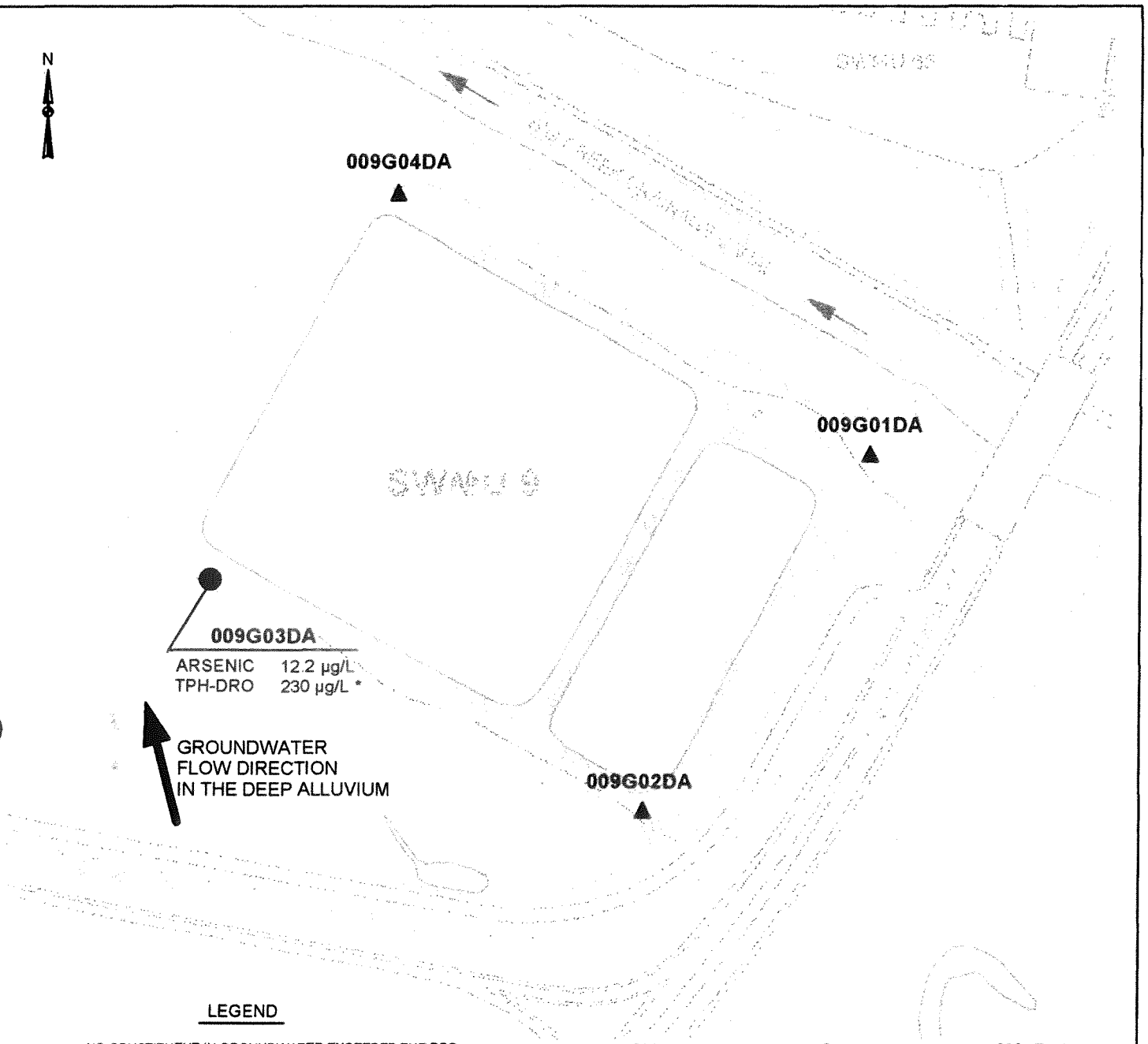
Pesticides, PCBs, and Herbicides in Groundwater

No chlorinated or organophosphorus pesticides, PCBs, or chlorinated herbicides were detected in the SWMU 9 monitoring wells, as shown in Table 8.2.4.

8.2.3.2.2 Inorganics in Groundwater Samples

The following inorganics were detected in RFI monitoring wells:

Arsenic	Cobalt
Barium	Lead
Chromium	



LEGEND

▲ NO CONSTITUENT IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

009G03DA
ARSENIC 12.2 µg/L
TPH-DRO 230 µg/L *

THE GROUNDWATER SAMPLE FROM MONITORING WELL 009G03DA CONTAINED THE FOLLOWING CONSTITUENTS THAT EXCEEDED ONE OR MORE APPLICABLE STANDARDS: 12.2 µg/L ARSENIC AND 230 µg/L TPH DIESEL-RANGE ORGANICS.

µg/L MICROGRAMS PER LITER, OR PARTS PER BILLION

* TPH-DRO CONCENTRATION EXCEEDS THE TDEC CLEANUP STANDARD OF 100 µg/L FOR TOTAL TPH IN DRINKING WATER AQUIFERS (POLICY STATEMENT FOR PETROLEUM-CONTAMINATED SITES - TDEC 1997).

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FIGURE 8.2.8
RBC AND TOTAL TPH EXCEEDANCES IN GROUNDWATER
FROM RFI MONITORING WELLS
SWMU 9 - SEWAGE LAGOONS

Table 8.2.4 compares the detected inorganic constituents in groundwater to their respective RBCs for tap water, MCLs for drinking water, and background RCs for alluvium groundwater. As shown on Figure 8.2.8, the arsenic concentration in groundwater from monitoring well 009G03DA (12.2 μg/L) exceeded both its background RC (4.2 μg/L) and the RBC for tap water (0.045 μg/L); however, the detected concentration did not exceed the MCL for drinking water (50 μg/L). No other detected inorganic in groundwater exceeded both its RC and RBC or MCL.

8.2.3.2.3 Groundwater Samples From the April/May 1997 Sampling Event

The four deep alluvium groundwater monitoring wells installed at SWMU 9 were sampled during the April/May 1997 groundwater sampling event and submitted to an offsite laboratory for analysis of VOCs, TPH, TPH-GRO, and TPH-DRO. The groundwater samples from monitoring wells 009G01DA, 009G02DA, and 009G03DA did not indicate any VOCs, TPH, TPH-GRO, or TPH-DRO. However, a duplicate sample from monitoring well 009G01DA indicated trichloroethene at a concentration of 1.0 μg/L, below its tap water RBC (1.6 μg/L) and MCL (5 μg/L), and tetrachloroethene at a concentration of 1.3 μg/L, above its tap water RBC (1.1 μg/L) but below its MCL (5 μg/L). The only compound indicated in the groundwater sample from monitoring well 009G04DA was methylene chloride at a concentration of 0.77 μg/L, below its tap water RBC (4.1 μg/L) and MCL (5 μg/L).

8.2.3.3 Nature and Extent of Sediment Contamination

Sediment samples were collected with a stainless-steel hand auger from the SWMU 9 sewage lagoon sediments and from Big Creek Drainage Canal. Sections 8.2.2.4 and 8.2.2.5 summarize the number of samples collected, depth intervals sampled, and sample locations. VOCs, SVOCs, TPH, chlorinated pesticides and PCBs, herbicides, and Appendix IX metals were detected in the sediment samples. Since the SWMU 9 sediment sample locations are generally submerged throughout the year, each detected constituent in surface sediment is compared to its USEPA SSV

(USEPA, 1995a), and the results are presented below. Subsurface sediments (18"-24"), which are not true sediments from an ecological perspective, have been compared to USEPA SSL.

8.2.3.3.1 Organic Compounds in Sediment Samples

VOCs, SVOCs, TPH, pesticides/PCBs, organophosphorus pesticides, and herbicides were detected in sediment samples from the sewage lagoons and/or Big Creek Drainage Canal (Table 8.2.5). The following paragraphs discuss detected organic compounds by parameter.

VOCs in Sediment

Acetone, chlorobenzene, and 2-butanone (methyl ethyl ketone, or MEK) were the only VOCs detected in sediment samples from the sewage lagoons. No detected VOC in surface sediment from the sewage lagoons exceeded its respective SSVor SSL, as shown in Table 8.2.5. Acetone was the only VOC detected in sediment samples from Big Creek Drainage Canal and it did not exceed its SSVor SSL, as noted in Table 8.2.6.

SVOCs in Sediment

The following SVOCs were detected in sediment samples from the sewage lagoons: BEHP, diethylphthalate, and 4-chloroaniline. The SSV for BEHP (182 μg/kg) was exceeded in the sewage lagoon surface sediment sample (0-6") from location 009M0007 with a detected concentration of 1,700 μg/kg, as shown on Figure 8.2.9. No other detected SVOC in sewage lagoon sediments exceeded its SSV, as shown in Table 8.2.5. The SSL for 4-chloroaniline (300 μg/kg) was exceeded in the subsurface sediment sample (18"-24") from location 009M0007 with a detected concentration of 1,200 μg/kg. Fluoranthene and pyrene were the two SVOCs detected in sediment samples from Big Creek Drainage Canal. Neither exceeded its SSV, as shown in Table 8.2.6.

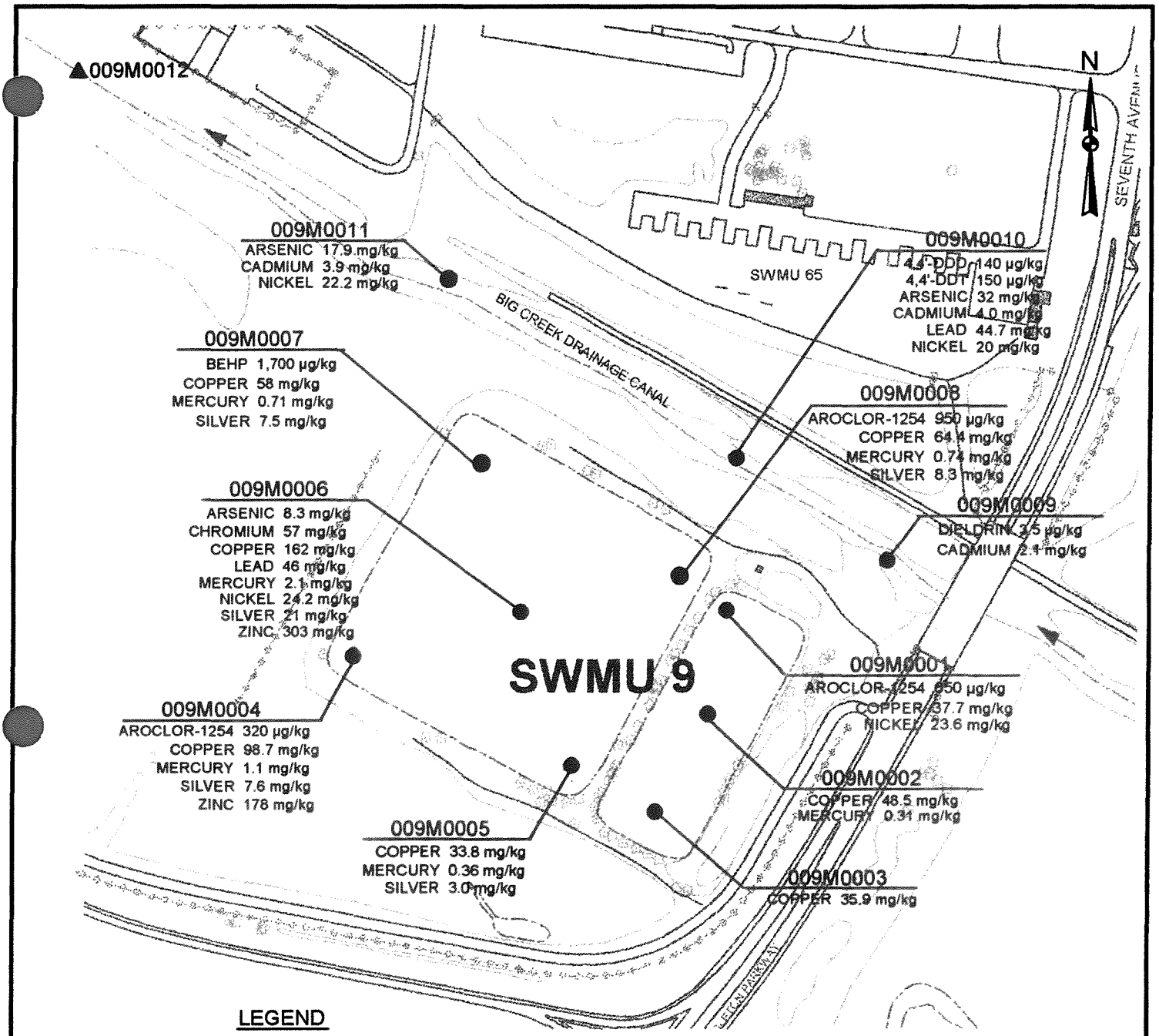

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FIGURE 8.2.9
SSV EXCEEDANCES IN SEDIMENT SAMPLES
COLLECTED FROM THE 0- TO 6-INCH INTERVAL
SWMU 9 - SEWAGE LAGOONS

Table 8.2.5
Detected Organic Compounds in Sewage Lagoon Sediment Samples
SWMU 9 — Sewage Lagoons
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	SSL	SSL Exceedances
VOCs								
Acetone	0 - 6"	3/8	1,700 - 48,000	17,467	—[f]	—	NA	NA
	18 - 24"	2/8	340 - 1,000	670	NA[g]	NA	8000	0
Chlorobenzene	18 - 24"	35802	4 - 4	4	NA	NA	600	0
2-Butanone (MEK)	0 - 6"	5/8	76 - 3,600	1,855	—	—	NA	NA
	18 - 24"	4/8	14 - 30	20	NA	NA	NA	NA
SVOCs								
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 6"	1/8	1700	1,700	182	1 (009M0007)	NA	NA
	18 - 24"	1/8	1900	1,900	NA	NA	11000	0
Diethylphthalate	18 - 24"	35802	52	52	NA	NA	110000	0
4-Chloroaniline	0 - 6"	3/8	150 - 610	350	—	—	NA	NA
	18 - 24"	3/8	48 - 1,200	435	NA	NA	300	1 (009M007)
Total Petroleum Hydrocarbons								
TPH (Method 418.1)	0 - 6"	5/8	180 - 950	470	500,000[h]	0	NA	NA
	18 - 24"	4/8	110 - 870	390	NA	N/A	500000	0
Pesticides/PCBs								
Aroclor-1254	0 - 6"	3/8	320 - 950	640	33	3 (009M0001, 009M0004, 009M0008)	NA	NA
	18 - 24"	2/8	220 - 500	360	NA	NA	NA	NA
Dieldrin	18 - 24"	1/8	6.3	6.3	NA	NA	1	1 (009M0003)
Endrin aldehyde	18 - 24"	1/8	3.3	3.3	NA	NA	400	0

Table 8.2.5
Detected Organic Compounds in Sewage Lagoon Sediment Samples
SWMU 9 — Sewage Lagoons
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	SSL	SSL Exceedances
Pesticides/PCBs								
gamma-Chlordane	18 - 24"	1/8	1.4	1.4	NA	NA	2000	0
Methoxychlor	18 - 24"	1/8	22	22	NA	NA	62000	0
4,4'-DDD	18 - 24"	1/8	9.3	9.3	NA	NA	700	0
4,4'-DDE	18 - 24"	1/8	20	20	NA	NA	500	0
4,4'-DDT	18 - 24"	1/8	4	4	NA	NA	11000	0
Herbicides								
2,4-DB	0 - 6"	1/8	0.55	0.55	—	—	NA	NA
Dalapon	0 - 6"	2/8	1.9 - 3.6	2.8	—	—	NA	NA
	18 - 24"	1/8	1.2	1.2	NA	NA	—	—
Dicamba	0 - 6"	4/8	0.93 - 2	1	—	—	NA	NA
Dichlorprop	0 - 6"	4/8	4.8 - 22	10	—	—	NA	NA
	18 - 24"	1/8	10	10	NA	NA	—	—
Dinoseb	0 - 6"	7/8	2.3 - 5.6	3.4	—	—	NA	NA
MCPP	0 - 6"	2/8	2,500 - 21,000	11,750	—	—	NA	NA
	18 - 24"	2/8	2,100 - 3,000	2,550	NA	NA	—	—

Notes:

a — Only primary samples are included in this table. Sixteen sediment samples were collected from eight sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. Two of the 0- to 6-inch interval samples were split as duplicates (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following analyses: VOCs, SVOCs, total TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX Metals and cyanide.
b — Intervals shown are in inches below land (sediment) surface.
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — SSV = Sediment Screening Value; values obtained from the *Ecological Screening Values - Ecological Risk Assessment Bulletin No. 2* (USEPA, 1995a).
f — denotes SSV is not available for this analyte; therefore, no comparison can be made.
g — NA denotes comparison is not applicable to this subsurface sample.
h — No SSV exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSV. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).
ssl — Soil Screening Level; values obtained from the *Risk Based Concentration Table, January-June 1996* (USEPA, 1996a)

Table 8.2.6
Detected Concentrations of Organic Compounds in Big Creek Drainage Canal Sediment Samples
SWMU 9 — Sewage Lagoons
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	SSL	SSL Exceedances
VOCs								
Acetone	0 - 6"	1/4	10	10	—[f]	—	NA	NA
	18 - 24"	1/4	24	24	NA[g]	NA	8000	0
SVOCs								
Fluoranthene	0 - 6"	2/4	54 - 68	61	330	NA	NA	NA
Pyrene	0 - 6"	2/4	46 - 67	57	330	NA	NA	NA
Total Petroleum Hydrocarbons								
TPH - DRO	0 - 6"	3/3	4,000 - 8,200	5,533	500,000[h]	0	NA	NA
	18 - 24"	2/3	4,200 - 4,300	4,250	500,000	0	NA	NA
Pesticides/PCBs								
4,4'-DDD	0 - 6"	1/4	140	140	3.3	1 (009M0010)	NA	NA
	18 - 24"	1/4	29	29	NA	NA	700	0
4,4'-DDT	0 - 6"	1/4	150	150	3.3	1 (009M0010)	NA	NA
	18 - 24"	1/4	29	29	NA	NA	1000	0
Dieldrin	0 - 6"	1/4	3.5	3.5	3.3	1 (009M0009)	NA	NA
Endosulfan sulfate	0 - 6"	1/4	130	130	—	—	NA	NA
	18 - 24"	1/4	25	25	NA	NA	3000	0
Herbicides								
2,4,5-TP (Silvex)	0 - 6"	1/4	1.9	1.9	—	—	NA	NA
2,4-D	18 - 24"	2/4	6.4 - 16	11. 2	NA	NA	1700	0
2,4-DB	0 - 6"	2/4	14 - 16	15	—	—	—	—
	18 - 24"	1/4	18	18	NA	NA	—	—

Table 8.2.6
Detected Concentrations of Organic Compounds in Big Creek Drainage Canal Sediment Samples
SWMU 9 — Sewage Lagoons
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	SSL	SSL Exceedances
Herbicides								
MCPA	0 - 6"	1/4	4000	4000	—	—	—	—
MCPP	0 - 6"	1/4	4100	4100	—	—	—	—

Notes:

a — Only primary samples are included in this table. Sixteen sediment samples were collected from eight sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. Two of the 0- to 6-inch interval samples were split as duplicates (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following analyses: VOCs, SVOCs, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX Metals, and cyanide. TPH analyses were conducted for samples from location 009M0009 using Method 418.1. TPH analyses for samples from locations 009M0010, 009M0011, and 009M0012 were conducted using the Modified Tennessee Method 8015 for TPH-GRO and TPH-DRO.

b — Intervals shown are in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — SSV = Sediment Screening Value; values obtained from the *Ecological Screening Values - Ecological Risk Assessment Bulletin No. 2* (USEPA, 1995a).

f — denotes SSV is not available for this analyte; therefore, no comparison can be made.

g — NA denotes comparison is not applicable to this subsurface sample.

h — No SSV exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{4} to 10^{-6} has been substituted for the SSV. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

SSL — Soil Screening Level; values obtained from the *Risk Based Concentration Table, January - June 1996* (USEPA, 1996a).

TPH in Sediment

TPH was detected in most sediment samples collected from both the sewage lagoons and Big Creek Drainage Canal. The USEPA has not established an SSV for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface sediment. Tables 8.2.5 and 8.2.6 summarize the detected TPH concentrations in sediment samples from the sewage lagoons and Big Creek Drainage Canal, respectively. As shown on the tables, no sediment sample exceeded the TDEC cleanup level for total TPH.

Pesticides/PCBs in Sediment

The following pesticides/PCBs were detected in sediment samples from the sewage lagoons:

4,4'-DDD	gamma-Chlordane
4,4'-DDE	Dieldrin
4,4'-DDT	Endrin aldehyde
Aroclor-1254	Methoxychlor

As shown in Table 8.2.5 and plotted on Figure 8.2.9, Aroclor-1254 was the only compound listed above that exceeded its SSV value. The SSV for Aroclor-1254 (33 μg/kg) was exceeded at sample locations 009M0001 (650 μg/kg), 009M0004 (320 μg/kg), and 009M0008 (950 μg/kg). However, the SSL for dieldrin (1 μg/kg) was exceeded in the subsurface sediment at sample location 009M0003 (6.6 μg/kg).

The following pesticides were detected in sediment samples from Big Creek Drainage Canal:

4,4'-DDD	Dieldrin
4,4'-DDT	Endosulfan sulfate

As shown in Table 8.2.6, the SSVs for 4,4'-DDD and 4,4'-DDT (3.3 μg/kg for both compounds) were exceeded at sample location 009M0010 (140 μg/kg of 4,4'-DDD and 150 μg/kg of 4,4'-DDT). The SSV for dieldrin (3.3 μg/kg) was exceeded at sample location 009M0009 (3.5 μg/kg). Figure 8.2.9 plots the SSV exceedances. As shown in Table 8.2.6, no SSL exceedances were detected in the Big Creek subsurface sediments.

Herbicides in Sediment

The following herbicides were detected in sediment samples collected from the sewage lagoons:

2,4-DB	Dichlorprop
Dalapon	Dinoseb
Dicamba	MCPP

The following herbicides were detected in sediment samples from Big Creek Drainage Canal:

2,4-D	MCPA
2,4-DB	MCPP
2,4,5-TP (Silvex)	

No SSVs or SSLs are available for the detected herbicides in sediment.

8.2.3.3.2 Inorganics in Sediment Samples

The following inorganics were detected in the sewage lagoon sediment samples:

Arsenic	Mercury
Barium	Nickel
Beryllium	Selenium
Cadmium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc
Lead	

The following inorganics were detected in the sediment samples collected at Big Creek Drainage Canal:

Arsenic	Lead
Barium	Nickel
Beryllium	Selenium
Cadmium	Tin
Chromium	Vanadium
Cobalt	Zinc
Copper	

Tables 8.2.7 and 8.2.8 summarize the detected inorganics from the sewage lagoons and Big Creek Drainage Canal, respectively, and compare the detected concentrations in the surface interval (0 to 6 inches bls) to USEPA SSVs. Figure 8.2.9 shows SSV exceedances. The following paragraphs discuss the inorganics in the surface sediment sampling interval that exceeded their applicable SSVs.

Sewage Lagoon Sediment Samples

Arsenic was detected in all eight surface sediment samples (0- to 6-inch interval) at concentrations ranging from 2.2 to 8.3 mg/kg. The SSV (7.24 mg/kg) was exceeded only at location 009M0006 (8.3 mg/kg).

Barium was detected in all eight surface sediment samples (0-6" interval) at concentrations ranging from 96-274 mg/kg; however, there is no SSV for this compound. Barium was also detected in 7 of the 8 subsurface sediment samples at concentrations ranging from 105 - 270 mg/kg. Both the RC (265 mg/kg) and SSL (32 mg/kg) were exceeded in the subsurface sample from location 009M007.

Table 8.2.7
Detected Concentrations of Inorganics in Sewage Lagoon Sediment Samples
SWMU 9 — Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	RC[h]	SSL[f]	SSL Exceedances
Arsenic	0 - 6"	8/8	2.2 - 8.3	4.4	7.24	1 (009M0006)	NA	NA	NA
	18 - 24"	8/8	0.67 - 13.1	5.3	NA[f]	NA	20.3	15	0
Barium	0 - 6"	8/8	96 - 274	165	—[g]	—	NA	NA	NA
	18 - 24"	7/8	105 - 270	183	NA	NA	265.1	32	1 (009M0007)
Beryllium	0 - 6"	4/8	0.4 - 0.73	0.6	—	—	NA	NA	NA
	18 - 24"	7/8	0.37 - 0.75	0.59	NA	NA	1	180	0
Cadmium	18 - 24"	1/8	2.6	2.6	NA	NA	3.24	6	0
Chromium	0 - 6"	8/8	14.1 - 57.1	28.6	52.3	1 (009M0006)	NA	NA	NA
	18 - 24"	7/8	8.8 - 31.8	17.7	NA	NA	28.3	19	1 (009M0008)
Cobalt	0 - 6"	8/8	4.8 - 11.4	7.1	—	—	NA	NA	NA
	18 - 24"	7/8	4.5 - 19.8	8.1	NA	NA	14.4	—	1 (009M0007)
Copper	0 - 6"	8/8	33.8 - 162	67	18.7	8 (009M0001, 009M0002, 009M0003, 009M0004, 009M0005, 009M0006, 009M0007, 009M0008)	NA	NA	NA
	18 - 24"	7/8	12.3 - 103	34	NA	NA	32.5	—	—
Lead	0 - 6"	8/8	13.6 - 45.7	23.7	30.2	1 (009M0006)	NA	NA	NA
	18 - 24"	8/8	9.6 - 28.4	16.9	NA	NA	19.8	400	0

Table 8.2.7
Detected Concentrations of Inorganics in Sewage Lagoon Sediment Samples
SWMU 9 — Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	RC[h]	SSL[f]	SSL Exceedances
Mercury	0 - 6"	6/8	0.31 - 2.1	0.9	0.13	6 (009M0002, 009M0004, 009M0005, 009M0006, 009M0007, 009M0008)	NA	NA	NA
	18 - 24"	4/8	0.16 - 1.5	0.8	NA	NA	0.18	3	0
Nickel	0 - 6"	2/8	23.6 - 24.2	23.9	15.9	2 (009M0001, 009M0006)	NA	NA	NA
	18 - 24"	1/8	22.6	22.6	NA	NA	—	21	1 (009M0007)
Selenium	0 - 6"	1/8	0.48	0.48	—	—	NA	NA	NA
	18 - 24"	5/8	0.31 - 0.51	0.38	NA	NA	—	3	0
Silver	0 - 6"	6/8	1.7 - 21	8	2	5 (009M0004, 009M0005, 009M0006, 009M0007, 009M0008)	NA	NA	NA
	18 - 24"	3/8	1.2 - 9.7	4.4	NA	NA	—	—	—
Tin	18 - 24"	1/8	15.1	15.1	NA	NA	—	—	—
Vanadium	0 - 6"	8/8	11.5 - 30.9	21.8	—	—	NA	NA	NA
	18 - 24"	7/8	16.3 - 34.2	23.4	NA	NA	43.4	—	—

Table 8.2.7
Detected Concentrations of Inorganics in Sewage Lagoon Sediment Samples
SWMU 9 — Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	RC[h]	SSL[i]	SSL Exceedances
Zinc	0 - 6"	8/8	72.2 - 303	133	124	2 (009M0004, 009M0006)	NA	AN	NA
	18 - 24"	7/8	33.1 - 192	80	NA	NA	109	42000	0

Notes:

a — Only primary samples are included in this table. Sixteen sediment samples were collected from eight sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. Two of the 0- to 6-inch interval samples were split as duplicates (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following SW-846 analyses: VOCs, SVOCs, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide. TPH analyses were conducted for samples from location 009M0009 using Method 418.1. TPH analyses for samples from locations 009M0010, 009M0011, and 009M0012 were conducted using the Modified Tennessee Method 8015 for TPH-GRO and TPH-DRO.

b — Intervals shown are in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — SSV = Sediment Screening Value; values obtained from the *Ecological Screening Values - Ecological Risk Assessment Bulletin No. 2* (USEPA, 1995a).

f — NA denotes SSV comparison is not applicable to this subsurface sample.

g — denotes SSV is not available for this analyte; therefore, no comparison can be made.

h — RC = Reference Concentration

I — ssl=sOIL Screening Level; values obtained from the *Risk Based Concentration Table, January - June 1996* (USEPA, 1996a).

Table 8.2.8
Detected Concentrations of Inorganics in Big Creek Drainage Canal Sediment Samples
SWMU 9 — Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	RC[f]	SSL[f]	SSL Exceedances
Arsenic	0 - 6"	3 / 4	6.1 - 32	19	7.24	2 (009M0010, 009M0011)	NA	NA	NA
	18 - 24"	2 / 4	1.6 - 28.5	15.1	NA[g]	NA	0.3	15	1 (009M001)
Barium	0 - 6"	4 / 4	50.8 - 222	136	—[g]	—	NA	NA	NA
	18 - 24"	4 / 4	34.3 - 852	244	NA	NA	265	32	1 (009M0011)
Beryllium	0 - 6"	4 / 4	0.37 - 0.72	0.55	—	—	NA	NA	NA
	18 - 24"	3 / 4	0.28 - 1.8	0.8	NA	NA	1	180	0
Cadmium	0 - 6"	4 / 4	1 - 4	3	1	3 (009M0009, 009M0010, 009M0011)	NA	NA	NA
	18 - 24"	4 / 4	1 - 7.7	3	NA	NA	3.2	6	1 (009M0011)
Chromium	0 - 6"	4 / 4	5.1 - 15.3	9.3	52.3	0	NA	NA	NA
	18 - 24"	4 / 4	1.9 - 13.8	7.4	NA	NA	28	19	0
Cobalt	0 - 6"	4 / 4	4.5 - 25.1	14.3	—	—	NA	NA	NA
	18 - 24"	4 / 4	2.3 - 64.4	18.6	NA	NA	14	—	1 (009M0011)
Copper	0 - 6"	4 / 4	6.3 - 13.2	10.9	18.7	0	NA	NA	NA
	18 - 24"	4 / 4	2.7 - 27.1	10.5	NA	NA	33	—	0
Lead	0 - 6"	4 / 4	6 - 44.7	22	30.2	1 (009M0010)	NA	NA	NA
	18 - 24"	3 / 4	5.6 - 51.6	21.8	NA	NA	20	400	0
Nickel	0 - 6"	4 / 4	5.3 - 22.2	15.2	15.9	2 (009M0010, 009M0011)	NA	NA	NA
	18 - 24"	2 / 4	6.9 - 42.8	24.9	NA	NA	—	21	1 (009M0011)
Selenium	0 - 6"	3 / 4	0.44 - 0.72	0.54	—	—	NA	NA	NA
	18 - 24"	1 / 4	0.61	0.61	NA	NA	—	3	0
Tin	0 - 6"	1 / 4	7.1 - 7.1	7.1	—	—	NA	NA	NA
	18 - 24"	1 / 4	22.6	22.6	NA	NA	—	—	—

Table 8.2.8
Detected Concentrations of Inorganics in Big Creek Drainage Canal Sediment Samples
SWMU 9 — Sewage Lagoons
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	RC[H]	SSL[I]	SSL Exceedances
Vanadium	0 - 6"	4 / 4	9.8 - 32.9	23.2	—	—	NA	NA	NA
	18 - 24"	4 / 4	6.5 - 71.2	25.2	NA	NA	43	—	0
Zinc	0 - 6"	4 / 4	23.5 - 41.7	33.5	124	0	NA	NA	NA
	18 - 24"	4 / 4	9.6 - 58.3	26.8	NA	NA	109	42000	0

Notes:

a — Only primary samples are included in this table. Sixteen sediment samples were collected from eight sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. Two of the 0- to 6-inch interval samples were split as duplicates (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following SW-846 analyses: VOCs, SVOCs, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide. TPH analyses were conducted for samples from location 009M0009 using Method 418.1. TPH analyses for samples from locations 009M0010, 009M0011, and 009M0012 were conducted using the Modified Tennessee Method 8015 for TPH-GRO and TPH-DRO.

b — Intervals shown are in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — SSV = Sediment Screening Value; values obtained from the *Ecological Screening Values - Ecological Risk Assessment Bulletin No. 2* (USEPA, 1995a).

f — NA denotes SSV comparison is not applicable to this subsurface sample.

g — denotes SSV is not available for this analyte; therefore, no comparison can be made

h — RC = Reference Concentration

I — ssl=sOIL Screening Level; values obtained from the *Risk Based Concentration Table, January - June 1996* (USEPA, 1996a).

Chromium was detected in all eight surface sediment samples, with concentrations ranging from 14.1 to 57.1 mg/kg. The SSV (52.3 mg/kg) was exceeded only at location 009M0006 (57.1 mg/kg). The RC (28.3 mg/kg) and SSL(19mg/kg) were exceeded in the subsurface sample from location 009M0008.

Copper was detected in all eight surface sediment samples, with concentrations ranging from 33.8 to 162 mg/kg. The SSV (18.7 mg/kg) was exceeded by all eight surface sediment samples.

Lead, detected in all eight surface sediment samples and all eight subsurface sediment samples at concentrations ranging from 13.6 to 45.7 mg/kg and 9.6 to 28.4 mg/kg, respectively, exceeded

its SSV (30.2 mg/kg) at only one surface sediment location: 009M0006 (45.7 mg/kg). The SSL was not exceeded.

Mercury was detected in six of eight surface sediment samples at concentrations ranging from 0.31 to 2.1 mg/kg. Mercury concentrations exceeded the SSV (0.13 mg/kg) at all six locations where it was detected: 009M0002 (0.31 mg/kg), 009M0004 (1.1 mg/kg), 009M0005 (0.36 mg/kg), 009M0006 (2.1 mg/kg), 009M0007 (0.71 mg/kg), and 009M0008 (0.74 mg/kg). Mercury was also detected in four of eight subsurface sediment samples at concentrations ranging from 0.16 to 1.5 mg/kg, but none exceeded the SSL (3 mg/kg).

Nickel, detected in two of eight surface sediment samples, exceeded its SSV (15.9 mg/kg) at both locations: 009M0001 (23.6 mg/kg) and 009M0006 (24.2 mg/kg). Nickel was also detected in one subsurface sediment sample (009M0007), at a concentration of 22.6 mg/kg exceeding its SSL(21 mg/kg).

Silver, detected in six of eight surface sediment samples, exceeded its SSV (2 mg/kg) at the following locations: 009M0004 (7.6 mg/kg), 009M0005 (3.0 mg/kg), 009M0006 (21.0 mg/kg), 009M0007 (7.5 mg/kg), and 009M0008 (8.3 mg/kg). Silver was also detected in 3 of the 8 subsurface sediments at concentrations ranging from 1.2 to 9.7 mg/kg.

Zinc, detected in all eight surface sediment samples and seven of eight subsurface samples,, exceeded its SSV (124 mg/kg) at locations 009M0004 (178 mg/kg) and 009M0006 (303 mg/kg); however, the SSL was not exceeded.

Big Creek Drainage Canal Sediment Samples

Arsenic, detected in three of the four surface sediment samples collected from Big Creek Drainage Canal at concentrations ranging from 6.1 to 32 mg/kg, exceeded its SSV (7.24 mg/kg) at the

following two surface sediment sample locations: 009M0010 (32 mg/kg) and 009M0011 (17.9 mg/kg). Arsenic was also detected in two of the four subsurface sediment samples at concentrations ranging from 1.6 to 28.5 mg/kg. The RC (20.3 mg/kg) and SSL (15 mg/kg) were exceeded at one location: 009M0011 (28.5 mg/kg).

Barium was detected in all 4 sediment samples collected at concentrations ranging from 50.8 to 222 mg/kg in the surface sediment samples and 34.3 to 852 mg/kg in the subsurface sediment samples. The RC (265.1 mg/kg) and SSL (32 mg/kg) were exceeded in one subsurface location: 009M0011 (852 mg/kg).

Cadmium was detected in all four surface samples at concentrations ranging from 1 to 4 mg/kg and in the subsurface sediment samples ranging from 1 to 7.7 mg/kg. The SSV (1 mg/kg) was exceeded in the surface sediment at locations 009M0009 (2.1 mg/kg), 009M0010 (4.0 mg/kg), and 009M0011 (3.9 mg/kg); and the RC (3.24 mg/kg) and SSL (6 mg/kg) were exceeded in the subsurface sediment sample from sample location 009M0011 (7.7 mg/kg)..

Cobalt was detected in all of the sediment samples collected, at concentrations ranging from 4.5 to 25.1 mg/kg in the surface sediment and 2.3 to 64.4 mg/kg in the subsurface sediment. The RC (14.4 mg/kg) was exceeded at one subsurface sediment location: 009M0011 (64.4 mg/kg).

Lead was detected in all four surface sediment samples, at concentrations ranging from 6 to 44.7 mg/kg, and in the subsurface sediment samples ranging from 5.6 to 51.6 mg/kg. The SSV (30.2 mg/kg) was exceeded at one surface sediment location: 009M0010 (44.7 mg/kg).

Nickel, detected in all four surface sediment samples at concentrations ranging from 5.3 to 22.2 mg/kg, exceeded its SSV of 15.9 mg/kg at two locations: 009M0010 (20 mg/kg) and 009M0011 (22.2 mg/kg). Nickel was also detected in 2 of the 4 subsurface sediment samples at

concentrations ranging from 6.9 to 42.8 mg/kg. The SSL (3 mg/kg) was exceeded at subsurface sediment location 009M0011 (42.8 mg/kg).

8.2.3.4 Nature and Extent of Surface Water Contamination

Two surface water samples were collected from Big Creek Drainage Canal— one upstream and one downstream of SWMU 9. No organic compounds were detected in either sample. Silver and barium were the only detected inorganic constituents. As shown on Table 8.2.9, neither inorganic constituent exceeded its Fresh Water Quality Standard (FWQS), RBC for tap water, or MCL for drinking water.

Table 8.2.9
Detected Concentrations of Inorganics in Surface Water Samples
SWMU 9 — Sewage Lagoons
(data in µg/L)

Analyte[a]	Number of Detections[a]	Range[b]	Mean[c]	FWQS[d]	FWQS Exceedances	RBC — Tap Water[e]	Tap Water RBC Exceedances	MCL — Drinking Water[f]	MCL Exceedances
Silver	1 / 2	3 - 3	3	4.1	0	180	0	100[g]	0
Barium	2 / 2	152 - 214	183	—[h]	—	2,600	0	2,000	0

Notes:
a — Only primary samples are included on this table. Two surface water samples were collected from Big Creek Drainage Canal; one upstream and one downstream of SWMU 9. The upstream sample (009W0001) was split as a duplicate. The samples were submitted to NET for a modified FSA, consisting of VOCs, SVOCs, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.
b — Range lower limit is the lowest detected analyte concentration.
c — Mean based on detected analyte concentrations only.
d — FWQS = Freshwater Quality Standard, specified in 40 CFR Part 131.36.
e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
g — Value shown is the USEPA secondary MCL.
h — denotes FWQS is not available for this analyte; therefore, no comparison can be made.

8.2.3.5 Nature and Extent of Biota Contamination

As outlined in Section 8.2.2, E/A&H conducted a fish study at SWMU 9. Two composite samples of the black bullhead catfish *Ictalurus melas* were collected and submitted for whole fish analysis for the following parameters: SVOCs (Method 8270), pesticides/PCBs (Method 8080), and TAL metals (Appendix IX Metals, 6010/7000 Series).

The results of the fish study were compiled in a Technical Memorandum — *SWMU 9 Sewage Lagoons, Preliminary Fish Tissue Sample Results* (E/A&H, 1996c). Table 8.2.10 provides a summary of the detected contaminants in fish tissue compared to USEPA RBCs for fish tissue (USEPA, 1996a). Sections 8.2.8 and 8.2.9 thoroughly evaluate the risk posed by biota contamination.

8.2.3.5.1 Organic Compounds in Fish Tissue Samples

As shown in Table 8.2.10, the following organic compounds were detected in the fish tissue samples at concentrations exceeding their RBCs for fish tissue consumption: 4,4'-DDE, Aroclor-1254, and Aroclor-1260. 4,4'-DDE, detected in all three composite samples at concentrations ranging from 27 to 88 μg/kg, exceeded its RBC of 9.3 μg/kg for fish tissue consumption. Aroclor-1254 exceeded its RBC (27 μg/kg) in all three composite samples, with detected concentrations ranging from 100 to 280 μg/kg. Aroclor-1260 exceeded the RBC for PCBs (0.41 μg/kg) in all three composite samples, with detected concentrations ranging from 38 to 100 μg/kg.

8.2.3.5.2 Inorganics in Fish Tissue Samples

Arsenic (0.12 mg/kg), detected only in sample 009J020002, exceeded its RBC (0.0021 mg/kg for arsenic as a carcinogen) for fish tissue consumption. As shown in Table 8.2.10, no other detected inorganic in the composite fish tissue samples exceeded its applicable RBC for fish tissue consumption.

Table 8.2.10
Detected Constituents in Fish Tissue Samples
SWMU 9 — Sewage Lagoons

	East Lagoon[a]	West Lagoon[a]		
Analyte[a]	009J010001	009J020001	009J020002	RBC - Fish Tissue[b]
SVOCs (µg/kg)				
Di-n-butylphthalate	96 J[c]	ND[d]	120 J	140,000 n[e]
Pesticides/PCBs (µg/kg)				
4,4'-DDE	**88 J**	**42 J**	**27 J**	9.3 c
Endrin	49 J	40 J	25 J	410 n
Aroclor-1254	**100 J**	**280 J**	**180 J**	27 n
Aroclor-1260	**100 J**	**79 J**	**38 J**	0.41 c
Inorganics (mg/kg)				
Aluminum	1.1 J	4.5 J	19.6 J	1,400 n
Arsenic	ND	ND	**0.03 J**	0.0021 c
Barium	8.4 J	12.8 J	28.2 J	95 n
Calcium	7,060 J	11,300 J	13,400 J	—[f]
Chromium	2.2	1	1	1,400 n
Cobalt	ND	0.05 J	0.1 J	81 n
Copper	2.2 J	1.4 J	1 J	54 n
Iron	19.3	15.4	47.8	410 n
Lead	0.05	0.14	0.31	—
Magnesium	265	325	392	—
Manganese	8.6 J	10.2 J	20.3 J	31 n
Mercury	0.09 J	0.01 J	ND	0.41 n
Nickel	1.1	0.92	ND	27 n
Potassium	2,600	2,140	2,360	—
Selenium	0.13	0.13	0.22	6.8 n
Sodium	976	1,060	1,100	—
Vanadium	0.13 J	0.17 J	0.42 J	9.5 n
Zinc	14 J	17.2 J	23.2 J	410 n

Notes:

a — One composite sample of whole fish, designated 009J010001, was collected from the smaller (east) sewage lagoon, and two composite samples of whole fish, designated 009J020001 and 009J020002, were collected from the larger (west) sewage lagoon. The samples were submitted to Ceimic Corporation of Naragansett, Rhode Island, for the analysis of SVOCs, pesticides/PCBs, and TAL metals (Appendix IX Metals, 6010/7000 Series).

b — RBC = Risk-based concentration for fish tissue consumption, based on adult exposure; values obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

c — J denotes estimated value.

d — ND denotes analyte was not detected in this sample.

e — "n" denotes RBC is based on noncarcinogenic effects, "c" denotes RBC is based on carcinogenic effects.

f — denotes RBC for tissue consumption is not available for this parameter.

Concentrations listed in **BOLD** exceed the RBC for fish tissue.

8.2.4 Human Health Risk Assessment for SWMU 9

8.2.4.1 Site Background and Investigative Approach

As discussed in Section 8.2.2, SWMU 9 was investigated to assess surface soil, subsurface soil, sediment, groundwater, surface water, and fish ingestion. The investigation focused on two former sewage lagoons. The lagoons were used as part of the NSA Memphis wastewater treatment system from 1969 to 1978 to treat domestic wastewater, including limited amounts of aircraft maintenance industrial wastewater. The industrial wastewater may have contained VOCs, SVOCs, and metals. The Navy has prohibited fishing at the lagoons due to their former use.

This risk assessment utilizes analytical results from twelve surface soil samples, eight from berms constructed of fill material (Figure 8.2.2) and four from soil borings associated with monitoring well installation (Figure 8.2.3), 22 alluvial groundwater samples from DPT samples and monitoring wells (Figure 8.2.3), two surface water samples (Figure 8.2.4), and three composite fish tissue samples. The surface soil, alluvial groundwater, surface water, and fish tissue sample designations are listed below.

• **Surface Soil**	009S000101	009S000201	009S000301	009S000401
	009S000501	009S000601	009S000701	009S000801
	00901DA02	00902DA02	00903DA02	00904DA02
• **Alluvial Groundwater**	009G01DA01	009G02DA01	009G03DA01	009G04DA01
	009G000946	009G001046	009G001150	009G001246
	009G001348	009G001547	009G001644	009G001747
	009G001852	009G001946	009G002050	009G002142
	009G002244	009G002347	009H000946	009H001445
	009H001547	009H002244		
• **Surface Water**	009W000101	009W000201		
• **Fish Tissue**	009J020001	009J020002	009J010001	

8.2.4.2 Chemicals of Potential Concern Identification

Surface Soil

Table 8.2.11 lists chemicals present in site samples (CPSS) and identifies chemicals of potential concern (COPC) in surface soil. No COPCs were identified, so soil exposure was not quantified.

Surface Water

Table 8.2.12 lists CPSS for surface water. No COPCs were identified. As a result, surface water exposure was not assessed further.

Alluvial Groundwater

As shown in Table 8.2.13 , arsenic, chloroform, and trichloroethene were identified as COPCs in alluvial groundwater.

Fish Tissue Ingestion

Table 8.2.14 lists CPSS in fish tissue and identifies the COPCs: Aroclor-1254, Aroclor-1260, 4,4'-DDE, lead, and arsenic. It should be noted that there is no RC for comparison to fish tissue data.

COPC Summary

Table 8.2.15 summarizes the COPCs and their respective exposure pathways.

Table 8.2.11
Chemicals Present in Surface Soil Samples
SWMU 9 — Sewage Lagoons

Chemical	Units (a)	Frequency of Detection	Range of Nondetects	Range of Detected Concentrations	Average Detected Concentration	Residential RBC (b)	Notes	Number Over RBC	RC(c)	Number Over RC
2,4,5-T	µg/kg	1 / 12	0.95 — 0.95	9 — 9	9	78,000	N	0	NA	NA
2,4-D	µg/kg	4 / 12	9.4 — 9.4	10 — 22	15	78,000	N	0	NA	NA
2,4-DB	µg/kg	5 / 12	9.4 — 9.5	4.4 — 84	30	63,000	N	0	NA	NA
4,4'-DDD	µg/kg	5 / 12	3.6 — 15	2.1 — 35	16	2,700	C	0	NA	NA
4,4'-DDE	µg/kg	11 / 12	4.2 — 4.2	2 — 80	22	1,900	C	0	NA	NA
4,4'-DDT	µg/kg	4 / 12	3.6 — 36	2.8 — 12	8	1,900	C	0	NA	NA
Acetone	µg/kg	6 / 12	12 — 15	11 — 25,000	5,873	780,000	N	0	NA	NA
Aldrin	µg/kg	3 / 12	1.8 — 18	1.1 — 3	2	38	C	0	NA	NA
alpha-Chlordane (Chlordane)	µg/kg	1 / 12	1.8 — 12	1.8 — 1.8	1.8	1,825	C	0	NA	NA
Aroclor-1254	µg/kg	6 / 12	37 — 190	36 — 310	162	320	C, d	0	NA	NA
Aroclor-1260	µg/kg	1 / 12	37 — 360	84 — 84	84	320	C, d	0	NA	NA
Arsenic	mg/kg	12 / 12	NA — NA	2.9 — 9.9	5.2	0.43	C	12	14.6	0
Barium	mg/kg	12 / 12	NA — NA	93.6 — 244	146	550	N	0	223	1
BEQ	µg/kg	1 / 12	360 — 420	228.8 — 228.8	229	88	C	1	565	0
Benzo(a)anthracene	µg/kg	1 / 12	360 — 420	160 — 160	160	880	C	0	NA	NA
Benzo(a)pyrene	µg/kg	1 / 12	360 — 420	180 — 180	180	88	C	1	NA	NA
Benzo(b)fluoranthene	µg/kg	1 / 12	360 — 420	180 — 180	180	880	C	0	NA	NA
Benzo(k)fluoranthene	µg/kg	1 / 12	360 — 420	180 — 180	180	8,800	C	0	NA	NA
Chrysene	µg/kg	1 / 12	360 — 420	180 — 180	180	88,000	C	0	NA	NA
Indeno(1,2,3-cd)pyrene	µg/kg	1 / 12	360 — 420	130 — 130	130	880	C	0	NA	NA
Benzo(g,h,i)perylene (Pyrene)	µg/kg	1 / 12	360 — 420	150 — 150	150	230,000	N	0	NA	NA
Beryllium	mg/kg	10 / 12	0.97 — 0.98	0.42 — 1	1	0.15	C	10	1	0
Cadmium	mg/kg	10 / 12	0.65 — 0.77	1.1 — 4	2	3.9	N	0	1.54	7
Chromium	mg/kg	12 / 12	NA — NA	7.2 — 15	11	7,800	N	0	23.9	0
Cobalt	mg/kg	11 / 11	NA — NA	4 — 19.8	8	470	N	0	16	1
Copper	mg/kg	12 / 12	NA — NA	9.1 — 19.6	13	310	N	0	24.2	0
Cyanide (Free Cyanide)	mg/kg	1 / 12	0.01 — 0.5	0.022 — 0.022	0.022	160	N	0	NA	NA
Dichlorprop (4-(2,4-Dichloro-phenoxy)butyric Acid)	µg/kg	4 / 12	9.4 — 9.4	7.6 — 32	16	63,000	C	0	NA	NA

Table 8.2.11
Chemicals Present in Surface Soil Samples
SWMU 9 — Sewage Lagoons

Chemical	Units (a)	Frequency of Detection	Range of Nondetects	Range of Detected Concentrations	Average Detected Concentration	Residential RBC (b)	Notes	Number Over RBC	RC(c)	Number Over RC
Dieldrin	µg/kg	4 / 12	3.6 — 15	5.2 — 26	15	40	C	0	262	0
Endrin aldehyde (Endrin)	µg/kg	1 / 12	3.6 — 36	18 — 18	18	2,300	N	0	NA	N
Ethylbenzene	µg/kg	3 / 12	11 — 57	1 — 3	2	780,000	n	0	NA	NA
Fluoranthene	µg/kg	1 / 12	360 — 420	290 — 290	290	310,000	N	0	NA	NA
gamma-Chlordane (Chlordane)	µg/kg	2 / 12	0.96 — 12	1.4 — 1.5	1.5	1,825	C	0	NA	NA
Lead	mg/kg	12 / 12	NA — NA	8.7 — 16.9	12.8	400	e	0	26	0
MCPA	µg/kg	3 / 12	930 — 940	580 — 1,200	787	3,900	f, N	0	NA	NA
MCPP	µg/kg	1 / 12	940 — 940	5,100 — 5,100	5,100	7,800	g, N	0	NA	NA
Nickel	mg/kg	10 / 12	6.8 — 16.8	7.5 — 19.1	11.8	160	N	0	20.6	0
Phenanthrene (Pyrene)	µg/kg	1 / 12	360 — 420	120 — 120	120	230,000	N	0	NA	NA
Pyrene	µg/kg	1 / 12	360 — 420	260 — 260	260	230,000	N	0	NA	NA
Selenium	mg/kg	9 / 12	0.48 — 0.49	0.25 — 0.93	0.44	39	N	0	NA	N
Tin	mg/kg	5 / 12	4.3 — 5.1	4.7 — 26	20	4,700	N	0	33.6	0
Vanadium	mg/kg	12 / 12	NA — NA	13.7 — 32.6	23	55	N	0	45.1	0
Xylene-Total	µg/kg	3 / 12	11 — 57	7 — 16	11	16,000,000	N	0	NA	NA
Zinc	mg/kg	12 / 12	NA — NA	29.2 — 70.1	47	2,300	N	0	98	0

Notes:

a — µg/kg denotes micrograms per kilogram soil; mg/kg denotes milligrams per kilogram soil
b — Residential risk-based concentrations (RBCs) for soil ingestion are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
c — RC- Reference Concentration (two times the mean background concentration). Refer to *Technical Memorandum-Reference Concentrations* (E/A&H, 1996a) for RC calculations
d — New RBC for PCBs based on updated slope factor from IRIS (Integrated Risk Information System).
e — Screening based on 400 mg/kg for lead in soil (USEPA, 1994c).
f — MCPA --2-methyl-4-chlorophenoxyacetic acid
g — MCPP - 2-(2-Methyl-14-chlorophenoxy)propionic acid
N — Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
C — Carcinogen
* — Identified as a contaminant of potential concern
BEQ — benzo(a)pyrene equivalent
NA — Not Applicable

Table 8.2.12
Chemicals Present in Surface Water Samples
SWMU 9 — Sewage Lagoons

Chemical	Units	Frequency of Detection	Range of Nondetected	Range of Detected Concentrations	Average Detected Concentrations	Tap Water	Notes	Number Over RBC
Silver	µg/L	1 / 4	10 — 10	3 — 3	3	18	a, n	0
Barium	µg/L	2 / 4	10 — 10	152 — 214	183	260	a, n	0

Notes:

a — Screening based on Tap Water Screening Values from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
N — Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
RBC — Risk Based Concentration
µg/L — micrograms per liter

Table 8.2.13
Chemicals Present in Alluvial Groundwater Samples
SWMU 9 — Sewage Lagoons

Chemical	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentrations	Average Detected Concentrations	Tap Water RBC	Notes	Number Over RBC	RC Alluvial	Number Over RC
*Trichloroethene	μg/L	3 / 18	10 — 10	1 — 11	4.6	1.6	a, c	2	NA	NA
BEHP	μg/L	1 / 18	10 — 10	4 — 4	4	4.8	a, c	0	NA	NA
*Chloroform	μg/L	1 / 18	10 — 10	1 — 1	1	0.15	a, c	1	NA	NA
Lead	μg/L	2 / 4	2 — 2	2 — 2.6	2	15	e	0	NA	NA
*Arsenic	μg/L	1 / 4	2 — 2	12 — 12	12	0.045	a, c, x	1	4.20	1
Barium	μg/L	4 / 4	NA — NA	250 — 806	529	260	a, n	3	844	0
Chromium	μg/L	3 / 4	5 — 5	5.3 — 26	13	3700	a, n	1	69.2	0
Cobalt	μg/L	1 / 4	4 — 4	5.5 — 5.5	5.5	220	a, n	0	27	0

Notes:

*	—	Identified as a chemical of potential concern
a	—	Screening based on Tap Water Screening Values from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
BEHP	—	bis(2-Ethylhexyl)-phthalate
c	—	Carcinogen
e	—	Screening based on 15 μg/L of lead in groundwater (USEPA, 1996c).
NA	—	Not applicable
n	—	Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
RBC	—	Risk Based Concentration
RC	—	Reference concentration; background concentration (E/A&H, 1996a).
μg/L	—	micrograms per liter of water
x	—	Maximum Contaminant Limit for Arsenic is 50 μg/L (USEPA, 1996c).

Table 8.2.14
Chemicals Present in Fish Tissue Samples
SWMU 9 — Sewage Lagoons

		East Lagoon	West Lagoon				
Chemical	**Units**	**009J010001**	**009J020001**	**009J020002**	**Max -West Lagoon**	**RBC**	**N/C**
* 4,4-DDE	µg/kg	88 J	42 J	27 J	42	9.3	c
Aluminum	mg/kg	1.1 J	4.5 J	19.6 J	81.1	1400	n
* Aroclor -1254	µg/kg	100 J	280 J	180 J	280	1.6	c
* Aroclor-1260	µg/kg	100 J	79 J	38 J	79	1.6	c
* Arsenic	mg/kg	ND	ND	0.03 J	0.03	0.0021	c
Barium	mg/kg	8.4 J	12.8 J	28.2 J	28.2	95	n
Calcium	mg/kg	7060 J	11300 J	13400 J	65900	NA	NA
Chromium	mg/kg	2.2	1	1	6.1	1400	n
Cobalt	mg/kg	ND	0.05 J	0.1 J	0.43	81	n
Copper	mg/kg	2.2 J	1.4 J	1 J	8.2	54	n
Di-n-Butylphthalate	µg/kg	96 J	ND	120 J	120	14000	n
Endrin	µg/kg	49 J	40 J	25 J	40	410	n
Iron	mg/kg	19.3	15.4	47.8	47.8	410	n
* Lead	mg/kg	0.05	0.14	0.31	0.31	NA	c
Magnesium	mg/kg	265	325	392	392	NA	NA
Manganese	mg/kg	8.6 J	10.2 J	20.3 J	20.3	31	n
Mercury	mg/kg	0.09 J	0.01 J	ND	0.04	0.41	n
Nickel	mg/kg	1.1	0.92	ND	5.4	27	n
Potassium	mg/kg	2600	2140	2360	2360	NA	NA
Selenium	mg/kg	0.13	0.13	0.22	0.22	6.8	n
Sodium	mg/kg	976	1060	1100	1100	NA	NA
Vanadium	mg/kg	0.13 J	0.17 J	0.42 J	0.42	9.5	n
Zinc	mg/kg	14 J	17.2 J	23.2 J	23.2	410	n

Notes:

Max — Maximum concentration reported in West Lagoon fish tissue samples 009J020001 or 009J02C002. Sample 009J010001 was collected from the East Lagoon.
NA — Not applicable
RBC — Risk-based concentration for tissue consumption excerpted from the *Risk-Based Concetration Table* (USEPA, 1998).
n — RBC based on noncarcinogenic effects.
c — RBC based on carcinogenic effects.
J — Estimated value
* — Chemical of Potential Concern
Calcium, iron, magnesium, potassium, and sodium were estimated as essential nutrients.
mg/kg — milligram per kilogram
µg/kg — micrograms per kilogram

Table 8.2.15
Summary of Chemicals of Potential Concern Identified
SWMU 9 — Sewage Lagoons

COPC	Surface Soil	Surface Water	Alluvial Groundwater	Fish Tissue Ingestion
Aroclor-1254	—	—	—	X
Aroclor-1260	—	—	—	X
Arsenic	—	—	X	X
Chloroform	—	—	X	—
4,4'-DDE	—	—	—	X
Lead	—	—	—	X
Trichloroethene	—	—	X	—

8.2.4.3 Exposure Assessment

Exposure Setting

SWMU 9's exposure setting consists of two former sewage lagoons. The east lagoon covers approximately 3.2 acres, and the west lagoon covers approximately 9.1 acres. No residential or industrial activity is expected in the future. Although never officially allowed, fishing has occurred in the past. Signs prohibited fishing have been posted at the access points to the lagoons.

Potential Exposed Populations

Current Residents

No residences are present at SWMU 9.

Current Site Workers

Maintenance workers mow this site infrequently.

Hypothetical Site Residents

It is assumed that residents could live at this site, but this is unlikely. The Navy plans to retain this property, and there are no plans for residential use.

Future Site Workers

The Navy plans to retain this property, and future site workers will be exposed to the site.

Trespassers

It is assumed that adolescent trespassers may visit this site.

Exposure Pathways

Table 8.2.16 lists potentially exposed populations and possible pathways. Potentially exposed populations include hypothetical residents, future workers, construction workers, and adolescent trespassers. Exposure pathways for hypothetical residents include water ingestion, and subsistence fish ingestion. The only exposure pathways for future workers groundwater ingestion and inhalation of VOCs in groundwater. The only exposure pathway for construction workers is subsurface soil which will be described in detail in the Risk Uncertainty Section 8.2.4.7. Adolescent trespassers' were addressed assuming they would ingest fish tissue.

Exposure Point Concentrations

The exposure point concentration (EPC) was set to the maximum reported concentration for each COPC.

Alluvial Groundwater

No groundwater plumes were clearly defined in this RFI; therefore, EPCs are the maximum reported concentrations.

Table 8.2.16
Exposure Pathways Summary
SWMU 9 — Sewage Lagoons

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Hypothetical Residents			
	Air, inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 9, no significant VOC concentrations were identified at this site.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure that than which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater, ingestion of contaminants during potable or general use	Yes	Based on Tennessee law, it is assumed that all groundwater is a potential source of drinking water. At present, a basewide system supplies drinking water
	Goundwater, inhalation of VOCs from the groundwater	Yes	VOCs were identified in this HHRA as COPCs at SWMU 9
	Soil, incidental ingestion	No	This exposure pathway was considered, but no COPCs were identified.
	Soil, dermal contact	No	This exposure pathway was considered, but no COPCs were identified.
	Sediment, incidental ingestion	No	Sediment at the site is completely submerged under water.
	Sediment, dermal contact	No	Sediment at the site is completely submerged under water.
	Fish Ingestion	Yes	It is assumed that hypothetical residents would ingest fish on a subsistence basis.
Future Workers			
	Air, inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 9, no significant VOC concentrations were identified at this site.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater, ingestion of contaminants during potable or general use	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water, but at the present a basewide system supplies drinking water
	Groundwater, inhalation of VOCs from the groundwater	Yes	VOCs were identified as COPCs at SWMU 9.
	Soil, incidental ingestion	No	This exposure pathway was considered, but no COPCs were identified.

Table 8.2.16
Exposure Pathways Summary
SWMU 9 — Sewage Lagoons

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Soil, dermal contact	No	This exposure pathway was considered, but no COPCs were identified.
	Sediment, incidental ingestion	No	Sediment at the site is completely submerged under water.
	Sediment, dermal contact	No	Sediment at the site is completely submerged under water.
	Fish ingestion	No	It is assumed that workers will not ingest fish
Construction Workers			
	Air, inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 9, no significant VOC concentrations were identified at this site.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater, ingestion of contaminants during potable or general use	No	Based on Tennessee law, it is assumed that all groundwater is a potential source of drinking water, but at present, a basewide system supplies drinking water
	Groundwater, inhalation of VOCs from the groundwater	No	There are no significant VOCs identified as COPC at SWMU 9.
	Soil, incidental ingestion	Yes (Qualified)	It is assumed that workers will exposed to sub-surface soils. This is discussed in the Risk Uncertainty Section 8.2.10.6.
	Soil, dermal contact	Yes (Qualified)	It is assumed that workers will be dermally exposed to subsurface soil.
	Sediment, incidental ingestion	No	Sediment is completely submerged under water.
	Sediment, dermal contact	No	Sediment is completely submerged under water.
	Fish ingestion	No	It is assumed that workers will not ingest fish
Adolescent Trespassers			
	Soil, incidental ingestion	No	This exposure pathway was considered, but no COPCs were identified.
	Soil, dermal contact	No	This exposure pathway was considered, but no COPCs were identified.
	Sediment, incidental ingestion	No	Sediment is completely submerged under water.
	Sediment, dermal contact	No	Sediment is completely submerged under water.
	Fish ingestion	Yes	It is possible that trespassers will ingest fish.

Fish Ingestion

Table 8.2.17 presents EPC estimates of fish ingested by humans. Each reported concentration was used as the EPC for the east lagoon. The maximum concentrations in the west lagoon fish tissue composite samples were used as EPCs.

Five sediment samples were collected from the west lagoon and three samples were collected from the east lagoon. Although DDE is a COPC in fish tissue, it was detected in only one of eight samples in the 18-to-24-inch interval bls. It was not detected in any samples at the 0-to-6 inch interval bls. Another fish tissue COPC, Aroclor-1254 was detected in only three of eight samples in the 18-to-24-inch interval bls; however, this compound was not detected in the 0-to-6 inch interval sediment samples. The origin of the PCBs and DDE in the fish is not fully known since these compounds were not detected in any 0-to-6-inch bls interval sediment samples. The lagoons were not stocked with fish from an outside source, so it is possible that contaminants present in the sediment at concentrations below detection limits bioaccumulated in the fish.

Lead and arsenic were detected in all sediment samples, except for one sample in the 18-to-24-inch interval bls. Table 8.2.17 also lists the concentrations of the fish tissue COPCs in the lagoon sediment and surface water from the nearby Big Creek Drainage Canal, and the surface soil RC lead and arsenic. The concentrations are for comparison to determine the possible source of some of the inorganic COPCs. It is possible that lead and arsenic are natural in origin based on their presence in soil which surrounds the lagoon.

Table 8.2.17
Exposure Point Concentration Estimates for Pond 1 and 2
Ingestion of Fish Tissue at SWMU 9 NSA Memphis

	Fish Tissue Concs.			Sediment Detections				Max.	Surface	
	EPC	EPC	Max.					Surface	Water	
	East		Sediment			East		Water	Freq. of	Soil
	Lagoon	West Lagoon	Conc.	East Lagoon	West Lagoon	Lagoon	West Lagoon	Conc.	Detection	RC
Chemical	mg/kg	mg/kg	mg/kg	D 0-6"	D 0-6"	D 18-24"	D 18-24"	mg/L		mg/kg
4,4-DDE	0.088	0.042	0.02	ND	ND	ND	1/8	ND	0/4	NA
Aroclor-1254	0.1	0.28	0.95	1/3	ND	ND	2/5	ND	0/4	NA
Aroclor-1260	0.1	0.079	0.084	ND	ND	ND	ND	ND	ND	NA
Lead	0.05	0.31	45.7	3/3	5/5	3/3	5/5	ND	0/4	26
Arsenic	ND	0.03	13.1	3/3	5/5	3/3	5/5	ND	0/4	14.6

Notes:
EPC — Exposure Point Concentration
Max. — Maximum
D — Depth
NA — Not Available
ND — Not Detected
mg/kg — milligrams per kilogram
mg/L — micrograms per liter
RC — Reference Concentrations

8.2.4.4 Quantification of Exposure

The Technical Memorandum on HHRA (E/A&H, 1997e) listed human exposure quantifications for soil and groundwater exposures. The assumptions and formulas used for fish ingestion exposures are listed below.

Fish Ingestion

Exposure was estimated by calculating the RME (Reasonable Maximum Exposure) Chronic Daily Intake (CDI) using the exposure assumptions presented in Table 8.2.18 and Equations 1 and 2. Table 8.2.18 lists intake assumptions for resident children and adults and trespasser children and adolescents. Equation 1 estimates chronic daily intake for fish ingestion. Equation 2 shows the adjustment to the Lifetime-Weighted-Average (LWA) for trespassers. The remaining steps for risk and hazard estimations are detailed in the HHRA memorandum.

Equation 1 $$CDI_{FI}(mg/kg\text{-}day) = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

CDI	=	Chronic Daily Intake (mg/kg-day)
C	=	Concentration in Fish Tissue (mg/kg)
IR	=	Tissue ingestion rate (kg/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (yr)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)

The RME scenario assumes that residents consume 54 grams of fish 350 days per year for 30 years. Trespasser exposure frequency assumes that a child and/or adolescent ingests 145 grams of fish at a frequency of 52 days per year. It is assumed that the trespasser is exposed as an adolescent four years and as a child for six years. A central tendency (CT) exposure scenario will be discussed in the risk uncertainty section.

Equation 2 $$LWA = \frac{IR_{child} \times EF_{child} \times ED_{child}}{BW_{child}} + \frac{IR_{adolescent} \times EF_{adolescent} \times ED_{adolescent}}{BW_{Adolescent}}$$

Table 8.2.18
RME Assumptions for Fish Tissue
SWMU 9 — Sewage Lagoons

Parameter	Abbreviation	Resident (subsistence) Adult	Resident (subsistence) Child	Trespasser Adolescent	Units
Exposure Frequency	EF	350	350	52	days/yr
Exposure duration	ED	24	6	4	yr
Ingestion	IR	0.054	0.054	0.145	kg/day
Oral SF	SFo	Chemical Specific		Chemical Specific	kg-day/mg
Oral RfD	RfDo	Chemical-Specific		Chemical-Specific	mg/kg-day
Body weight	BW	70	15	45	kg
Averaging Time (carcinogen)	ATc	25550	25550	25550	days
Averaging Time (Noncarcinogen)	ATn	8760	2190	1460	days

Notes:
USEPA's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure were used to develop the exposure assumptions above (USEPA, 1993a).
The EF of 52 days per year was selected as a conservative estimated based on 1 day per weekend.

8.2.4.5 Toxicity Assessment

Toxicity assessment terms and methods are discussed in the Technical Memorandum on HHRA (E/A&H, 1997e). The USEPA has established a classification system for rating the potential carcinogenicity of environmental contaminants based on the weight of scientific evidence. The cancer classes are described below. Cancer weight-of-evidence class "A" (human carcinogens) means that human toxicological data have shown a proven correlation between exposure and the onset of cancer. The B1 classification indicates some human exposure studies have implicated the compound as a probable carcinogen. Weight-of-evidence class B2 indicates a possible human carcinogen, a description based on positive laboratory animal data (for carcinogenicity) in the absence of human data. Weight-of-evidence class C identifies possible human carcinogens, and class D indicates a compound not classifiable with respect to its carcinogenic potential. The USEPA has established slope factors (SF) for carcinogenic compounds as a "plausible upper-bound estimate of the probability of a response (cancer) per unit intake of a chemical over a lifetime" (RAGS, Part A). In addition to potential carcinogenic effects, most substances also can produce other toxic responses at doses greater than experimentally derived threshold concentrations. The

USEPA has derived Reference Dose (RfD) values for these substances. A chronic RfD is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure concentration for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime." These toxicological values are used in risk formulae to assess the upper-bound level of cancer risk and noncancer hazard associated with exposure to a given concentration of contaminant listed in Table 8.2.19. Toxicological profiles of identified COPCs are presented below.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg-day as the RfD for arsenic based on a No-Observed-Adverse-Effect Level (NOAEL) of 0.0008 mg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans (as shown in IRIS). Inhalation of these materials are shown to cause cancer in humans (as shown in IRIS). Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the SF to 1.5 kg-day/mg. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date 9/1/95), the critical effect of this chemical is hyper pigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Table 8.2.19
Toxicologial Reference Information
for Chemicals of Potential Concern
SWMU 9
NSA Memphis RFI

Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Oral Slope Factor (kg/mg-day)		Inhalation Slope Factor (kg/mg-day)		Weight of Evidence	Tumor Type
Arsenic	0.0003	a	M	hyperpigmentation	3	ND			ND	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	ND				ND	ND			ND	7.3	a			B2	mutagen
Beryllium	0.005	a	L	microscopic organ changes	100	ND			ND	4.3	a	8.4	a	B2	osteosarcoma
Cadmium (food)	0.001	a	H	proteinuria	10	ND			ND	ND		6.3	a	B1	lung
Cadmium (water)	0.0005	a	H	proteinuria	10	ND			ND	ND		6.3	a	B1	lung
Chloroform	0.01	a	M/L	fatty cysts in liver	1000	ND			ND	0.0061	a	2.3E-05 ((ug/cm3)-1	a	B2	hepatocellular carcinoma
Chloromethane	0.257		H	hepatotoxicity	300	0.257	H	hepatotoxicity	ND	0.012	b	0.0063	b	C	kidney tumors
4,4'-DDE	ND				ND	ND			ND	0.034	a	ND		B2	liver
Lead	ND				ND	ND			ND	ND		ND		B2	various
PCB Aroclor-1254	2E-05	a	NA		ND	ND			ND	2		ND		B2	hepatocellular carcinoma
PCB Aroclor-1260	ND				ND	ND			ND	2		ND		B2	hepatocellular carcinoma
Trichloroethene	0.006	e	NA	NA	NA	0.006			ND	0.011	f	0.006	e	B2	forestomach tumors in mice

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information
H High
M Medium
L Low

Chloroform, a halogenated hydrocarbon, has been used as a fumigant and an additive to suppress the fire hazard of carbon disulfide, as well as having a low capacity for insect control. Volatile and gaseous anesthetics such as chloroform are sometimes used to produce general anesthesia. This contaminant is the primary chlorinated hydrocarbon produced during chlorination of drinking water, and is commonly present at low concentrations in most drinking water supplies. This compound depresses all CNS function in descending order from the cortex to the medulla. Additional target organs include the liver, heart, and kidney. Chloroform exposure to the heart sensitizes the muscle to arrhythmias, as do many halogenated hydrocarbons. This action could interfere with digitalis glycosides or a pacemaker in the form of premature or uncontrolled beats. Chloroform is a class B2 carcinogen, and USEPA set the oral SF and inhalation SF to 0.0061 and 0.0805 $(mg/kg\text{-}day)^{-1}$, respectively. The oral RfD is 0.01 mg/kg-day (Dreisbach et al., 1987).

DDT, or ***1,1,1-trichloro-2,2-bis-(p-chlorophynyl)ethane***, was one of the most widely used chemicals for controlling agricultural insect pests and insects that carry diseases such as malaria and typhus. Technical DDT is primarily a mixture of three forms (p,p'-DDT, o,p'-DDT, and o,o'-DDT); all are white, crystalline, tasteless, and almost odorless solids. DDT is anthropogenic in origin and its presence in the environment is due to past production and application. Some DDT can be photo-oxidized in air and on surface soils, but the compound tends to bind to certain types of soil. ***DDE (1,1-dichloro-2,2-bis [p-chlorophenyl] ethylene)*** and ***DDD (1,1-dichloro-2,2-bis [p-chlorophenyl] ethane)*** are found in small amounts as contaminants in technical grade DDT. DDD has had some use as a pesticide and also as a treatment for adrenal gland cancer. The use of DDD, DDE, and DDT is banned in the United States (ATSDR, 1992).

With acute exposure to high doses of DDT, the nervous system appears to be the major target in both humans and experimental animals (Herr and Tilson, 1987; Hayes, 1982). Information on health effects in humans following acute inhalation exposure to DDD or DDE is limited (ATSDR, 1992). Chronic exposure of experimental animals to DDT is associated with tremors

and general hyperirritability (NCI, 1978; Rossi et al., 1977). In male and female mice, a single oral dose of between 32 to 237 mg DDT/kg caused the death of all the mice (Bathe et al., 1976; Kashyap et al., 1977; Tomatis et al., 1972). There is evidence of mild to severe hepatic effects in experimental animals as a result of acute, subchronic, or chronic oral administration of DDT (Pasha, 1981).

Epidemiological evidence is inconclusive for establishing, with reasonable certainty, if DDT is a human carcinogen. Evidence exists from animal studies to consider DDT, DDE, and DDD probable human carcinogens based on USEPA's B2 classification (IRIS, 1996). For example, DDT is carcinogenic in most strains of mice tested (Innes et al., 1969; Thorpe and Walker, 1973; Tomatis et al., 1972; Kashyap et al., 1977; Shabad et al., 1973). In a few studies, it was carcinogenic in rats (Cabral et al., 1982b; Rossi et al., 1977). However, several other rat studies reported negative results (Legator et al., 1973; Palmer et al., 1973; Cameron and Cheng, 1951; Shivapurkar et al., 1986), as did most of those on hamsters (Agthe et al., 1970; Cabral et al., 1982a; Graillot et al., 1975), and the one study on monkeys (Adamson and Sieber, 1979, 1983).

One area of uncertainty is the significance of liver tumors in certain strains of mice and the appropriateness of extrapolating this information to humans. Several studies in rats, mice and hamsters have been conducted to determine the potential carcinogenicity of DDD and DDE. A chronic feeding study in mice has shown DDE to produce liver tumors at doses of 19 to 34 mg/kg-day for 124 weeks (NCI 1978; Tomatis et al., 1974a). A similar study produced liver tumors in hamsters given DDE for 40 mg/kg-day for 124 weeks (Rossi et al., 1983). However, DDE did not induce significant tumor frequencies in rats given 12 to 42 mg/kg/day for 78 weeks (NCI, 1978). DDD induced liver tumors and lung adenomas in CF-1 mice (Tomatis et al., 1974a) and thyroid follicular cell tumors in Fischer-344 rats (NCI, 1978), but was not tumor producing in B6C3F1 mice (NCI, 1978).

The oral SF for DDD, DDE, and DDT are 2.4E-01, 3.4E-01, and 3.4E-01 kg-day/mg, respectively. DDT's inhalation SF equals 3.4E-01 kg-day/mg. An oral RfD of 5E-04 has been issued for DDT (IRIS, 1996).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, USEPA has set an action level for residential soil to be 400 mg/kg (USEPA, 1994c). An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead accumulates in fat tissue and affects the brain, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate; sometimes the lead is attached to binding sites, and sometimes lead is free flowing. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al, 1986).

PCB Aroclors are a group of chlorinated hydrocarbons (such as Aroclors-1248, 1254, and 1260) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al., 1986; Dreisbach, et al., 1987). USEPA classified PCB Aroclors as group B2 carcinogens, primarily based on animal data. As listed in IRIS (search date 6/29/95), the basis for the classification is hepatocellular carcinomas in three strains of rats and two strains of mice and inadequate, yet suggestive, evidence of excess risk of liver cancer in humans by ingestion and inhalation or dermal contact. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. USEPA set 2.0 kg-day/mg as the oral SF for PCB Aroclors, and the RfD was set to 0.00007 mg/kg/day for Aroclor-1260 and 0.00002 mg/kg-day for Aroclor-1254.

Trichloroethene is a mobile, volatile liquid which has the characteristic odor of chloroform. Inhalation, intravenous, and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhaling high concentrations causes narcosis and anesthesia. This compound targets the liver and other organs. TCE is a B2 carcinogen, and the oral SF and inhalation SF have been set by USEPA to 0.011 and 0.006 $(mg/kg\text{-}day)^{-1}$, respectively. USEPA also set the oral RfD to 0.006 mg/kg-day (Dreisbach et al., 1987).

8.2.4.6 Risk Characterization

Risk and hazard were estimated for hypothetical site residents, future workers, and trespassers. Exposure pathways for hypothetical residents included alluvial groundwater ingestion and fish ingestion. Exposure pathways for future workers included alluvial groundwater ingestion and inhalation of VOCs in groundwater. The exposure pathway included for site trespassers is fish ingestion.

TDEC assumes all groundwater is potential drinking water. Consequently, hypothetical future site residents and hypothetical nonresidential site worker receptors were assumed to use alluvial groundwater for drinking water. Carcinogenic risk and HQ estimates are presented in Tables 8.2.20 and 8.2.21.

Fish ingestion exposure risk/hazard estimates are presented in Tables 8.2.22 and 8.2.23. Fish ingestion scenarios include hypothetical resident subsistence and RME (Reasonable Maximum Exposure) to trespassers for both lagoons.

Exposure pathways are first discussed below for hypothetical residents, followed by a discussion of the site worker scenario, and finally a discussion of a trespasser scenario.

Table 8.2.20
Risk Estimates
Ingestion of Alluvial Groundwater
SWMU 9
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Oral RfD (mg/kg-day)**	**Oral SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
Arsenic	0.012	0.0003	1.5	1.1	2.6	2.7E-04	0.39	6.3E-05
Chloroform	0.001	0.01	0.0061	0.003	0.01	9.1E-08	0.0010	2.1E-08
Trichloroethene	0.011	0.006	0.011	0.050	0.12	1.8E-06	0.018	4.2E-07
Cumulative HI or ILCR				1	3	3.E-04	0.4	6.E-05

Table 8.2.21
Risk Estimates
Inhalation and Dermal Contact Exposure to VOCs in Alluvial Groundwater
SWMU 9
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Inhalation RfD (mg/kg-day)**	**Inhalation SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
Chloroform	0.001	0.01	0.0805	0.0027	0.0064	1.2E-06	0.0010	2.8E-07
Trichloroethene	0.011	0.006	0.006	0.050	0.117	9.8E-07	0.018	2.3E-07
Cumulative HI or ILCR				0.05	0.1	2.E-06	0.02	5.E-07

Notes:

EPC = Exposure point concentration
RfD = Reference Dose; the oral RfD was applied when no inhalation RfD was available
SF = Slope Factor
HQ = Hazard quotient
ILCR = Incremental excess lifetime cancer risk
HI = Hazard index
NA = Not applicable
LWA = Lifetime weighted average

Table 8.2.22
RME Risk Estimates for Ingestion of Fish Tissue from East Lagoon
SWMU 9 — Sewage Lagoons

				Hypothetical Site Resident (Subsistence)			Potential Future Trespasser		
Chemical	EPC	Oral RfD mg/kg-day	Oral SF kg-day/mg	Adult HQ	Child HQ	LWA ILCR	Adolescent HQ	Child HQ	LWA ILCR
4,4-DDE	0.088	NA	0.34	NA	NA	1.6E-05	NA	NA	4.3E-06
Aroclor-1254	0.1	NA	2.0	NA	NA	1.1E-04	NA	NA	2.9E-05
Aroclor-1260	0.1	2.00E-05	2.0	3.7	17.3	1.1E-04	2.3	6.89	2.9E-05
			Sum	**4**	**17**	**2E-04**	**2**	**7**	**6E-05**

Notes:
RME — Reasonable Maximum Exposure
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
kg-day/mg — kilograms day per milligram
mg/kg — milligrams per kilograms
mg/kg-day — milligrams per kilogram per day
HQ — Hazard Quotient
NA — Not Applicable

Table 8.2.23
RME Risk Estimates for Ingestion of Fish Tissue from West Lagoon
SWMU 9 — Sewage Lagoons

				Hypothetical Site Resident (Subsistence)			Potential Future Trespasser		
Chemical	EPC	Oral RfD mg/kg-day	Oral SF kg-day/mg	Adult HQ	Child HQ	LWA ILCR	Adolescent HQ	Child HQ	LWA ILCR
4,4-DDE	0.042	NA	0.34			7.8E-06			2.1E-06
Aroclor-1254	0.28	NA	2.0	NA	NA	3.1E-04	NA	NA	8.1E-05
Aroclor-1260	0.079	2.00E-05	2.0	2.9	13.6	8.7E-05	1.8	5.44	2.3E-05
Arsenic	0.03	0.0003	1.5	0.1	0.3	2.5E-05	0.0	0.14	6.5E-06
			Sum	**3**	**14**	**4E-04**	**2**	**6**	**1E-04**

Notes:
RME — Reasonable Maximum Exposure
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
kg-day/mg — kilogram day per milligram
mg/kg — milligrams per kilograms
mg/kg-day — milligrams per kilogram per day
HQ — Hazard Quotient
NA — Not Applicable

Hypothetical Site Residents

Figure 8.2.10 shows the total residential risk from all exposure pathways at SWMU 9. Figure 8.2.10 yields qualitative information, showing which exposure pathways contribute the most to total risk, and which COPCs have the largest individual chemical risk contribution. However, chemicals that contribute a relatively small amount of risk cannot be easily distinguished in this figure. The COPCs present at SWMU 9 are shown in the key below the figure. The largest risk contributions come from fish and groundwater ingestion. The estimated risk for fish ingestion in Figure 8.2.10 is based on the maximum reported contaminant concentration of the two lagoons. Figure 8.2.11 shows risk associated with individual chemical from all exposure pathways. PCBs (Aroclor-1254 [42.6%] and Aroclor-1260 [15.1%]) and arsenic (40.8%) are the major risk contributors. Figure 8.2.12 shows the hazard index for children for all exposure pathways. Figure 8.2.13 is similar to Figure 8.2.10 in its qualitative nature. The individual pathways are discussed below.

Alluvial Groundwater

Based on the projected RME, the ingestion-related ILCR from groundwater was estimated to be 3E-4 (as shown in Table 8.2.20), while inhalation ILCR was estimated to be 2E-6 (as shown in Table 8.2.21). The ingestion HI for adults and child residential receptors were estimated to be 1 and 3, respectively under a RME scenario. As shown in Table 8.2.21, inhalation HIs were less than 1.0. Arsenic was the primary contributor to both the ILCR and HI, which exceed acceptable limits.

Fish Ingestion

East Lagoon

Based on the RME subsistence exposure scenario, the ILCR estimate for the east lagoon is 2E-4, as shown in Table 8.2.22. The major risk contributors are PCBs and 4,4'-DDE. The

East lagoon's HI estimates for adults and children are 4 and 17, respectively. PCBs are the major hazard contributors. The ILCR and HI exceed acceptable limits.

West Lagoon

Based on the RME subsistence exposure scenario, the ILCR for west lagoon is 4E-4, as shown in Table 8.2.23. The major risk contributors are PCBs, arsenic, and 4,4'-DDE. The west lagoon's HI estimates for adults and children are 3 and 14, respectively. PCBs are the major hazard contributors. The ILCR and HI exceed acceptable limits.

Future Site Workers

Figure 8.2.14 shows the total from all exposure pathways at SWMU 9. The presence of arsenic in groundwater accounted for more than 98% of the total risk for future site workers.

Alluvial Groundwater

The projected ingestion-related ILCR from groundwater was 6E-5; and the HI was estimated to be 0.4. Inhalation ILCR was 3E-7, and inhalation HI was less than 1.0. Arsenic was the largest contributor to both the ILCR and HIs. No acceptable limits were exceeded for this exposure pathway.

Trespassers

Fish Ingestion

East Lagoon

For the east lagoon, the LWA ILCR (weighted average for children and adolescents) is estimated to be 6E-5 (as shown in Table 8.2.22). The HI for child and adolescents are 7 and 2, respectively. PCBs are the major risk and hazard contributors. The acceptable limit for the HI was exceeded for this exposure pathway.

Figure 8.2.10 SWMU 9 Residential Risk Estimates

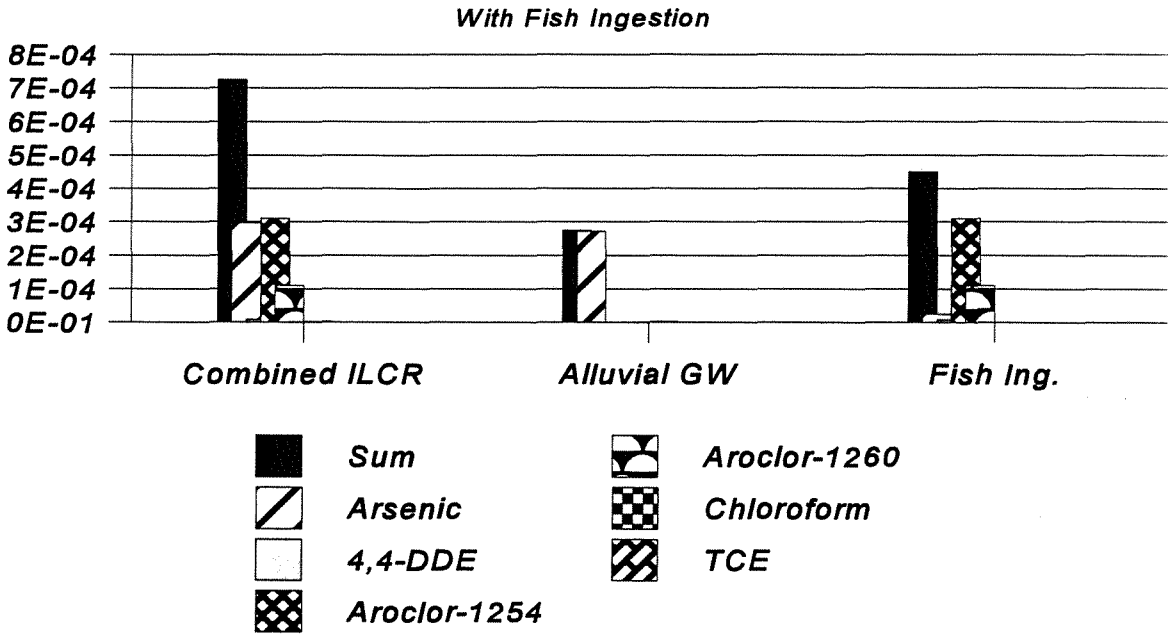

Figure 8.2.11 SWMU 9 Residential Risk Contributors Including Fish Ingestion

Risk Estimates are 1E-5 Times Value Shown

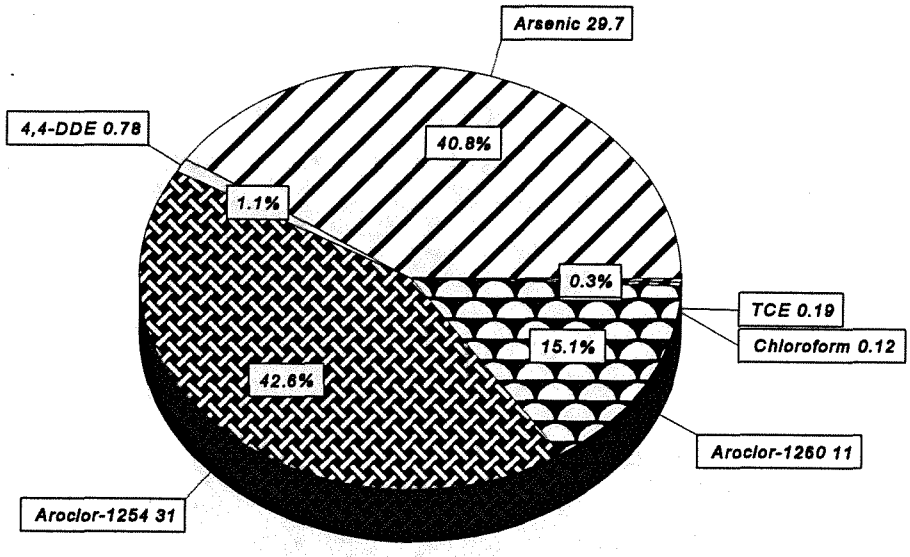

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Figure 8.2.12 SWMU 9 Residential Child Hazard Index Estimates

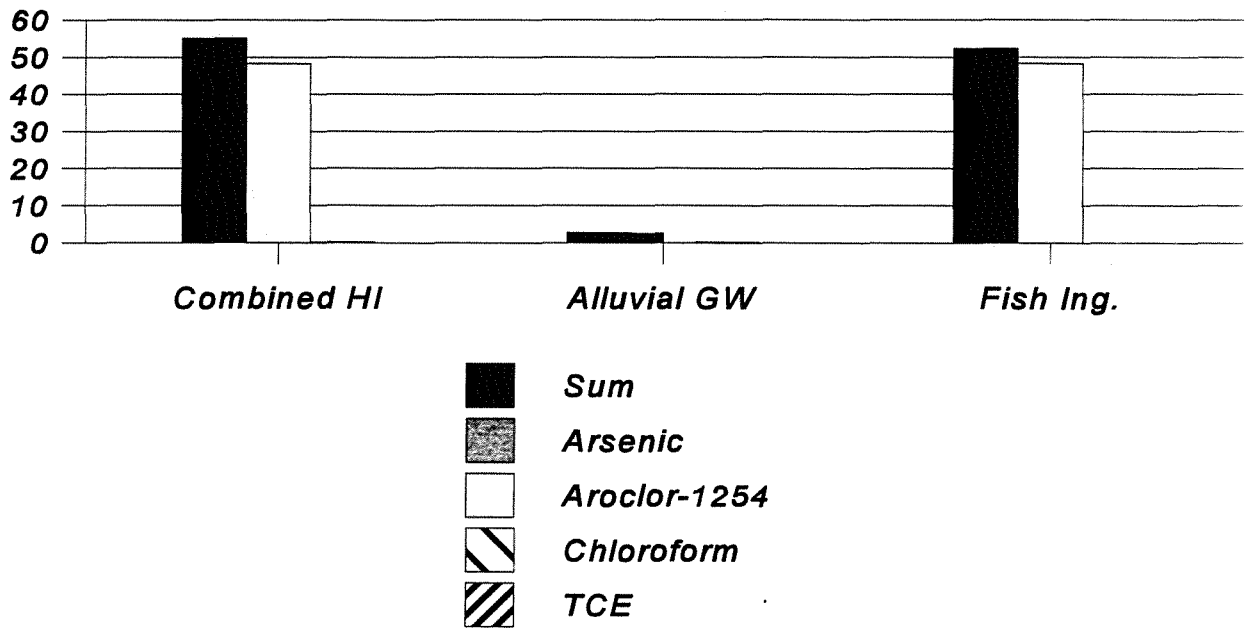

Figure 8.2.13 SWMU 9 Child Hazard Contributors Including Fish Ingestion

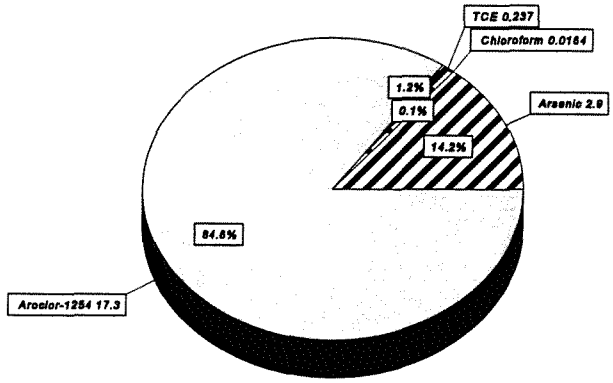

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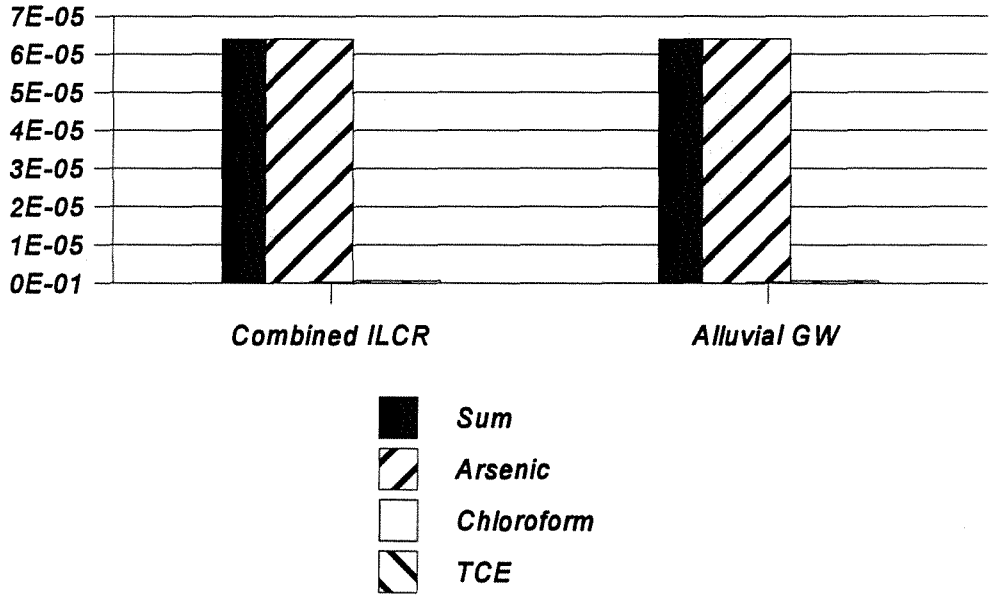
Figure 8.2.14 SWMU 9 Industrial Risk Estimates



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West Lagoon

For the west lagoon, the LWA ILCR is estimated to be 1E-4 (as shown in Table 8.2.23). The HI for children and adolescents are 6 and 2, respectively. PCBs were the major risk and hazard contributors. The acceptable limits for the ILCR and HI were exceeded for this exposure pathway.

COCs Identified

As described in the Technical Memorandum on HHRA, COCs were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In Assembly E HHRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative HI above 1.0, if its individual ILCR exceeds 1E-6 or its HQ exceeds 0.1.

Hypothetical Site Residents

Alluvial Groundwater

Arsenic, chloroform, and trichloroethene were identified as COCs for the hypothetical site resident scenario based on contributions to risk/hazard.

Fish Ingestion

East Lagoon

COCs identified are 4,4'-DDE, Aroclor-1254, and Aroclor-1260.

West Lagoon

COCs identified are 4,4'-DDE, Aroclor-1254, Aroclor-1260, and arsenic. Arsenic has no comparative reference, and it is likely to be natural in origin.

Future Site Workers

Alluvial Groundwater

No risk- or hazard-based COCs were identified for the future site worker scenario.

Trespassers

Fish Ingestion

East Lagoon

COCs identified were 4,4'-DDE, Aroclor-1254, and Aroclor-1260.

West Lagoon

COCs identified were 4,4'-DDE, Aroclor-1254, Aroclor-1260, and arsenic. Arsenic has no comparative reference, and it is may be natural in origin.

8.2.4.7 Risk Uncertainty

Several parameters contribute to risk assessment uncertainty or variability including:

- Future exposure settings and exposure pathways are unknown
- Toxicological uncertainty in the determination of SFs and RfDs
- EPC estimation
- Human exposure quantification
- Elimination of some CPSSs that could result in overestimations or underestimations

Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection process due to the highly conservative assumptions (i.e., future residential use) when assessing potential future and current exposure.

Alluvial Groundwater

Groundwater is not currently used at SWMU 9 for potable or industrial purposes. NSA Memphis has a system supplying drinking and process water and it is to remain in operation under the current reuse plan. As a result, groundwater use would not be expected under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Fish Ingestion

Although it is possible that someone would ingest fish for subsistence from these lagoons, it is improbable. Currently fishing is not allowed, and it is a policy that NSA Memphis Security enforces.

Subsurface Soil

One uncertainty for this site is the possibility of heavy construction. This HHRA addresses that possibility here. Construction projects generally require less than seven years to complete, and RAGS defines chronic exposure as seven years or more.

Default site workers assumptions were modified in accordance with USEPA Region IV and TDEC recommendations:

Exposure Duration	=	0.5 year (1 year was used for carcinogens)
Exposure Frequency	=	120 days/year
Ingestion Rate	=	340 mg/day

The modified ingestion rate is based on the time-weighted average, assuming a worker would be exposed to a hole in the ground, incidentally ingesting 480 mg/day (RBCA/ASTM) for 0.5 year, and 200 mg/day for 0.5 year. The weighted average is 340 mg/day.

Assuming a soil concentration of 1 mg/kg, this results in the following intake multipliers:

Ingestion Hazard Multiplier = 1.6E-06

Ingestion ILCR Multiplier = 1.28E-08

Residential RBCs for noncarcinogens and carcinogens can be related to construction worker RBCs using the following multipliers:

Noncarcinogens = 8.0 * RBC_N (res) = RBC_N (constr)

Carcinogens = 68.63 * RBC_C (res) = RBC_C (constr)

A screening level assessment was performed for SWMU 9 subsurface soil, and as shown in Table 8.2.24, no COPCs were identified for this land use scenario.

Table 8.2.24
Construction Worker Scenario
SWMU 9 — Sewage Lagoons

Chemical	MAX µg/kg	RBC res µg/kg	RBC const µg/kg	NOTE	RC µg/kg
2-Butanone (MEK)	4	47,000,000	376,000,000.00	N	NA
2-Methylphenol (o-Cresol)	76	3,900,000	31,200,000.00	N	NA
Acetone	110	7,800,000	62,400,000.00	N	NA
Arsenic	10,400	430	29,500.00	C	20,320
Barium	288,000	5,500,000	44,000,000.00	N	265,120
Beryllium	0430	150	10,300.00	C	1,000
Cadmium	2,500	39,000	312,000.00	N	3,240
Chromium	17,700	390,000	3,120,000.00	N	28,280

Table 8.2.24
Construction Worker Scenario
SWMU 9 — Sewage Lagoons

Chemical	MAX µg/kg	RBC res µg/kg	RBC const µg/kg	NOTE	RC µg/kg
Cobalt	10,800	4,700,000	37,600,000.00	N	14,360
Copper	18,600	3,100,000	24,800,000.00	N	32,520
Lead	19,700	400,000	1,300,000.00	a	19,800
MCPA	690	39,000	312,000.00	N	NA
Nickel	23,500	1,600,000	12,800,000.00	N	NA
Selenium	550	390,000	3,120,000.00	N	NA
Silver	990	390,000	3,120,000.00	N	NA
Tin	29,400	47,000,000	376,000,000.00	N	NA
Vanadium	26,100	550,000	4,400,000.00	N	43,680
Xylene (total)	3	160,000,000	1,280,000,000.00	N	NA
Zinc	80,100	23,000,000	184,000,000.00	N	109,000

Notes:
MAX — Maximum reported concentration in subsurface soil
RBC res — Screening based on Residential Soil Ingestion (USEPA, 1996a).
RBC const — Screening based on construction worker soil ingestion as per RBCA/ASTM guidance
RC — reference concentration
NA — Not applicable/not available
N — Noncarcinogen
C — Carcinogen
a — industrial cleanup goals used at other federal facilities

Toxicological Uncertainty

Alluvial Groundwater

Arsenic has been demonstrated to be carcinogenic in humans primarily through inhalation and not through incidental water ingestion. Arsenic causes squamous cell carcinoma (blackfoot disease) through ingestion; because it is treatable, EPA has a policy of tolerance to 1E-3 cancer risk. As a result, the potential risk may be overestimated.

Fish Ingestion

COCs included 4,4-DDE, Aroclor-1254, Aroclor-1260, and arsenic. DDE, and Aroclor-1254 have "B2" cancer ratings which indicates that they cause cancer in animals but have not been demonstrated to cause cancer in humans (IRIS, 1995). This may overestimate the potential cancer risk from exposure to these compounds.

Whole fish samples were analyzed to provide a conservative estimate of potential risk using a limited number of samples. The COCs identified would accumulate in the liver and skin rather than in the fish filets, which is the portion that people consume. This may overestimate the potential human risk/hazard.

Determination of Exposure Point Concentrations

Based on RAGS and the methods discussed in the Technical Memorandum on HHRA (E/A&H, 1997e), EPCs are used to estimate CDI. The uncertainties associated with EPCs primarily stem from their statistical determination (UCLs) or imposition of maximum concentrations.

Alluvial Groundwater

EPCs were the maximum concentrations detected. Arsenic was detected in only one of four samples; as a result, exposure was likely overestimated, since it was detected in only one sample. Chloroform was detected in one of 18 samples, and trichloroethene was detected in 2 of 18. Using the maximum concentrations to represent the exposure area would likely overestimate risk. Risk estimates were overestimated where these COPCs were reported as nondetects.

Fish Ingestion

The EPCs were based on the maximum detected concentrations in the fish and this overestimates the exposure. A larger number of fish collected could have resulted in a smaller EPC. Composite samples of whole raw fish were collected from each lagoon. Contaminants tend to bioconcentrate in skin and liver; as a result, risk may be overestimated because most people eat the filets and not the whole fish.

Frequency of Detection and Spatial Distribution

Alluvial Groundwater

Arsenic was detected in one of four wells. This frequency of detection (25%) indicates that arsenic may not be widespread. As a result, exposure was likely overestimated. Arsenic's concentration (12 mg/L) does not exceed the MCL (50 mg/L). Chloroform was detected in one of 18 samples and the frequency of detection indicates it is not widespread. TCE was detected in three of 18 samples.

Fish Ingestion

The east lagoon composite sample consisted of seven fish. The two west lagoon composite samples consisted of four fish. Several of these fish were quite small (five of the total fish weighted approximately one-quarter pound) and contained Aroclor-1254 and DDE which bioaccumulate. Larger fish would likely bioaccumulate larger quantities of these chemicals over time. Four of the fish weighed between 1 to 1.5 pounds. As a result, it is uncertain if these samples underestimated or overestimated the risk to human ingestion.

Quantification of Risk/Hazard

As indicated by the discussions above, uncertainty is inherent during the risk assessment process. In addition, many site-specific factors affecting the uncertainty of this assessment would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of variability and uncertainty are discussed below.

Alluvial Groundwater

As a measure of variability, CT analysis was performed for groundwater. Exposure assumptions were modified to reflect the 50th rather than the 95th percentile, and the EPCs were not modified. In accordance with *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure-Draft* (USEPA, 1993a), the exposure duration of site residents

was reduced from 30 to nine years, two years for child exposure, and seven years for adult exposure. Exposure frequency was reduced from 350 to 234 days for site residents and from 250 to 219 days for site workers. The drinking water ingestion rate for an adult was reduced from 2 to 1.4 liters per day, and exposure to groundwater was reduced by 25% to account for other water sources.

Under a residential RME scenario, the ILCR was estimated to be 3E-4, but drops to 3E-5 under a CT exposure scenario. Under a RME residential scenario, the HI for adults and children were estimated to be 1 and 3, respectively, but these values dropped to 0.1 and 0.4 under a CT exposure scenario. No COCs would be identified when using the CT exposure assumptions.

Fish Ingestion

There were no eliminated chemicals in the fish tissues within 10% of their respective RBC. As a result, it is likely that risk was not increased with the elimination of these chemicals from fish tissues. Composite samples increase the variability of determining the EPC. This variability may increase or decrease the EPC.

CT exposure frequency analysis was performed on hypothetical residents and potential trespassers. Exposure frequency drops from the RME of 350 to 234 (CT) days per year. Exposure duration drops from 30 years to 9 years. Using this less frequent exposure scenario for the east lagoon, LWA risk drops from 2E-4 to 6E-6, child hazard drops from 17 to 1, and trespasser LWA risk drops from 6E-5 to 2E-6. For the west lagoon CT exposure, LWA risk drops from 5E-4 to 1E-5, child hazard drops from 14 to 4, and trespasser LWA drops from 1E-4 to 3E-6. As a result lowering the exposure frequency from the RME to the CT significantly lowers the risk/hazard potential.

8.2.4.8 Risk Summary

Tables 8.2.25 lists the sum of all exposure pathways. Numbers in **bold** indicate the risk or hazard has exceeded acceptable limits. These exceedances included alluvial groundwater exposure for hypothetical residents (adults and children), fish ingestion for hypothetical residents (adult and children), and fish ingestion for trespassers (adolescents and children).

8.2.4.9 Remedial Goal Options

Table 8.2.26 lists RGOs for arsenic, chloroform, and trichloroethene in groundwater under a LWA ILCR, adult hazard, and child hazard with a RME exposure frequency. If the exposure frequency was decreased to a CT exposure frequency scenario, no COCs would be identified.

The remediation of the fish tissue COCs would require removal of the fish and possibly the sediment in the lagoons. No RGOs are listed for fish removal.

Table 8.2.25
Sum of All Exposure Pathways
SWMU 9 — Sewage Lagoons

	Future Site Residents			Future Site Workers		Current and Future Site Trespassers		
Medium and Exposure Pathway	**Adult HI**	**Child HI**	**LWA ILCR**	**Worker HI**	**Worker ILCR**	**Adolescent HI**	**Child HI**	**LWA ILCR**
Alluvial Groundwater- Ingestion	**1**	**3**	**3E-04**	0.4	6E-05	NA	NA	NA
Alluvial Groundwater- Inhalation	**0.05**	**0.1**	**2E-6**	0.02	5E-7	NA	NA	NA
Sum of Groundwater	***1***	***3***	***3E-04***	***0.4***	***6E-05***	***NA***	***NA***	***NA***
Fish Tissue: East Lagoon - Ingestion	**3.7**	**17.3**	**2E-04**	NA	NA	**2.3**	**6.9**	6E-05
Fish Tissue: West Lagoon - Ingestion	**3**	**14**	**4E-04**	NA	NA	**1.8**	**5.6**	**1.1E-04**

Notes:
HI — Hazard Index
ILCR — Incremental Lifetime Cancer Risk
NA — Not Applicable
LWA — Lifetime Weighted Average

Table 8.2.26
Residential Remedial Goal Options for COCs in Alluvial Groundwater
SWMU 9 — Sewage Lagoons

	EPC	RBC	RC	MCL	Risk LWA at 10-6	Risk LWA at 10-5	Risk LWA at 10-4	Child Hazard at 0.1	Child Hazard at 1	Child Hazard at 3
Chemical	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Arsenic	12	0.045	4.2	50	0.045	0.45	4.482	0.47	4.69	14.08
Chloroform	1	0.15	NA	100	0.78	7.8	78	7.8	78	780
Trichloroethene	11	1.6	NA	5	3.9	39	390	4.7	47	470

Notes:
COC — Chemical of Concern
LWA — Lifetime Weighted Average
MCL — Maximum Contaminant Limit
RBC — Risk Based Concentration
RC — Reference concentration
μg/L — micrograms per liter
NA — not applicable

8.2.5 Ecological Risk Assessment

8.2.5.1 Introduction

The terrestrial and aquatic ecosystems associated with SWMU 9 are the focus of this ecological risk assessment (ERA). This assessment considers soil, sediment, and fish tissue contaminant concentrations and distributions, media-specific physicochemical conditions, and exposure pathways which could result in unacceptable levels of exposure to ecological receptors now or in the future.

8.2.5.2 Problem Formulation

Site Description

SWMU 9 consists of two sewage lagoons on the southern boundary of the NSA Memphis Southside. The larger western lagoon has a surface area of approximately 400,000 square feet and the smaller eastern lagoon, approximately 141,000 square feet (Figure 1-3). The lagoons were used as part of the wastewater treatment system for NSA Memphis from 1969 to 1978. Although primarily domestic wastewater was treated, limited amounts of industrial wastewater from aircraft maintenance also were treated. Historical information indicates that discharge from the lagoons into Big Creek Drainage Canal occurred. Section 1.1.2 of this report provides a site map and discusses the site in detail.

Ecosystem at Risk

The ecosystem associated with SWMU 9 consists of upland, open water, and riparian habitats. The upland area surrounding the lagoons is made up of bottomland hardwoods and shrubby understory that may support a variety of terrestrial species such as cottontail rabbits, squirrels, raccoons, robins, hawks, and other similar species. Terrestrial invertebrates such as earthworms and other insects are also expected to be present. In addition to supporting fish and benthic invertebrates, the ponds offer riparian and open-water habitats which could provide cover and foraging areas for species such as the belted kingfisher and beaver.

Ecological Chemicals of Potential Concern

Previous sections of this report (Section 1.1.2) discuss past activities at SWMU 9 that may have impacted the surrounding ecosystem. COCs resulting from these activities have been identified and quantified according to USEPA methods and protocols for analyses of soil, groundwater, surface water, and sediment.

Eight sediment samples were collected in the lagoons and four in the adjacent Big Creek Drainage Canal to determine if a risk to ecological receptors exists. In sediment, analytes were selected as ecological chemicals of potential concern (ECPCs) if the maximum concentration detected either: (1) exceeded the USEPA Region IV SSV (USEPA, 1995a), (2) exceeded the most conservative effects level found in literature, or (3) if neither benchmark was available (Table 8.2.27).

Three composite fish samples were also collected from the lagoons; one from Lagoon 1 and two from Lagoon 2. Analytical results from the composite fish samples are presented in Table 8.2.28. Only one species of fish, the black bullhead catfish *(Ictalurus melas)* was caught during the study.

Soil contaminants were identified from the sampling data generated during the RFI and are discussed in detail in Section 8.2.3. For ecological risk, only the results from surficial soil (0 to 1 foot bls) are addressed and are presented in Table 8.2.29. It is presumed, even considering root development in the lower strata, that most biological effects will be limited to the upper zone. Although groundwater has been monitored, water table depth (approximately 10 to 12 feet bls) within SWMU 9 precludes assessing ecological impacts from this medium.

Table 8.2.27
Summary of Organic and Inorganic Constituents in Sediments Exceeding the SSV
SWMU 9 — Sewage Lagoons

Analyte	Number of Samples	Number of Detections	Range of Concentrations	Sediment Screening Value	HQ	ECPC
Organics (μg/kg) East Lagoon						
DDD	6	1	9.3	3.3	3	Yes
DDE	6	1	20	3.3	6	Yes
DDT	6	1	4	3.3	1	Yes
Dieldrin	6	1	6.3	3.3	2	Yes
Organics (μg/kg) West Lagoon						
DDE	10	1	73	3.3	22	Yes
Inorganics (mg/kg) East Lagoon						
Arsenic	6	1	13.1	7.24	2	Yes
Copper	6	3	35.9 - 48.5	18.1	3	Yes
Mercury	6	1	0.13	0.13	1	Yes
Nickel	6	1	23.6	15.9	2	Yes
Inorganics (mg/kg) West Lagoon						
Arsenic	10	2	8.3 - 12.5	7.24	2	Yes
Cadmium	10	1	2.6	1	2	Yes
Chromium	10	1	57.1	52.3	1	Yes
Copper	10	8	33.8 - 162	18.7	9	Yes
Lead	10	2	41.2 - 45.7	30.2	2	Yes
Mercury	10	9	0.36 - 2.1	0.13	2	Yes
Nickel	10	4	16.7 - 24.2	15.9	2	Yes
Silver	10	7	2.4 - 21.0	2	11	Yes
Zinc	10	4	131.0 - 303.0	124	2	Yes

Notes:
ECPC — Ecological Chemical of Potential Concern
HQ — Hazard Quotient

Table 8.2.28
Fish Tissue Contaminant Concentrations (wet weight)
SWMU 9 — Sewage Lagoons

Analyte	Number of Samples	Number of Detections	Range of Concentrations
Organics (μg/kg)			
Di-n-Butylphthalate	3	2	96 J - 120 J
DDE	3	3	27 - 88
Endrin	3	3	25 - 49
Aroclor-1254	3	3	100 - 280
Aroclor-1260	3	3	38 J - 100 J
Inorganics (mg/kg)			
Arsenic	3	1	0.03
Aluminum	3	3	1.1 - 19.6
Barium	3	3	8.4 - 28.2
Chromium	3	3	1 - 2.2
Copper	3	3	1 - 2.2
Cobalt	3	2	0.05 - 0.1
Iron	3	3	15.4 - 47.8
Lead	3	3	0.05 - 0.31
Manganese	3	3	8.6 - 20.3
Mercury	3	2	0.01 - 0.09
Nickel	3	2	0.92 - 1.1
Selenium	3	3	0.13 - 0.22
Vanadium	3	3	0.13 - 0.42
Zinc	3	3	14 - 23.2

Note:
J — Estimated

Table 8.2.29
SWMU 9 — Sewage Lagoons
Organic and Inorganic Constituents in Surface Soil

Analyte	Number of Samples	Number of Detections	Range of Concentrations	Mean	RC	ECPC
Organics (μg/kg)						
Acetone	8	6	11 - 25,000	5,873	NA	Yes
Benzo(a)anthracene	8	1	160	160	NA	Yes
Benzo(a)pyrene	8	1	180	180	NA	Yes
Benzo(b)fluoranthene	8	1	180	180	NA	Yes
Benzo(g,h,i)perylene	8	1	150	150	NA	Yes
Benzo(k)fluoranthene	8	1	180	180	NA	Yes
Chrysene	8	1	180	180	NA	Yes
Fluoranthene	8	1	290	290	NA	Yes
Indeno(1,2,3-cd)pyrene	8	1	130	130	NA	Yes
Phenanthrene	8	1	120	120	NA	Yes
Pyrene	8	1	260	260	NA	Yes
Aldrin	8	3	1.1 - 3	2	NA	Yes
Aroclor-1254	8	3	93 -240	188	NA	Yes
Aroclor-1260	8	1	84	84	NA	Yes
alpha-Chlordane	8	1	1.8	1.8	NA	Yes
gamma-Chlordane	8	2	1.4 - 1.5	1.5	NA	Yes
4,4'-DDD	8	4	3.6 - 35	19	NA	Yes
4,4'-DDE	8	8	2 - 80	26	NA	Yes
4,4'-DDT	8	2	2.8 - 12	7.4	NA	Yes
Dieldrin	8	4	5.2 - 26	15	NA	Yes
2,4-D	8	4	10 - 22	15	NA	Yes
2,4-DB	8	3	4.4 - 84	41	NA	Yes
Dichlorprop	8	3	7.6 - 32	17	NA	Yes
MCPA	8	3	580 - 1,200	787	NA	Yes
MCPP	8	1	5,100	5,100	NA	Yes
2,4,5-T	8	1	9	9	NA	Yes

Table 8.2.29
SWMU 9 — Sewage Lagoons
Organic and Inorganic Constituents in Surface Soil

Analyte	Number of Samples	Number of Detections	Range of Concentrations	Mean	RC	ECPC
Inorganics (mg/kg)						
Arsenic	8	8	2.9 - 9.9	5	14.58	No
Barium	8	8	9.3 - 200	136	223.46	No
Beryllium	8	8	0.42 - 0.85	0.58	1	Yes
Cadmium	8	6	1.5 - 3.2	2.5	1.54	Yes
Chromium	8	8	7.2 - 15	10	23.89	No
Cobalt	8	8	4 - 9.7	7	15.98	No
Copper	8	8	9.1 - 19.6	12.6	24.19	No
Lead	8	8	8.7 - 16.3	12.4	26.03	No
Nickel	8	6	7.5 - 13.8	10.2	20.62	No
Selenium	8	8	0.25 - 0.93	0.44	ND	Yes
Tin	8	1	4.7	4.7	35.56	No
Vanadium	8	8	13.7 - 28.8	22.1	45.11	No
Zinc	8	8	29.2 - 70.1	45.1	98	No

Notes:
ECPC — Ecological Chemical of Potential Concern.
RC — Reference concentration. Refer to *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a).
ND — Not Detected in background samples.
Mean — Mean based on detected analyte concentrations only.
NA — Not available.

Inorganic parameters in site surface soil exceeding the RC, or not detected in background samples, are identified as Ecological Chemicals of Potential Concern (ECPCs). Any constituent detected in less than five percent of the samples was not considered an ECPC. Any organic constituent detected in greater than five percent of the samples was considered an ECPC.

General Stressor Characteristics

Metals

In general, heavy metals adversely affect survival, growth, reproduction, development, and metabolism of both terrestrial and aquatic invertebrate species, but effects are substantially

modified by physical, chemical, and biological variables. Most heavy metals do not biomagnify. In contact tests with terrestrial earthworms, the order of toxicity for heavy metals, from most toxic to least toxic, was copper > zinc > nickel = cadmium > lead.

Organics

PAHs vary by molecular weight. With increasing molecular weight, aqueous solubility decreases and the log K_{ow} increases, suggesting increased solubility in fats, a decrease in resistance to oxidation and reduction, and a decrease in vapor pressure (Eisler, 1987). Accordingly, PAHs of different molecular weight vary substantially in their behavior and distribution in the environment and in their biological effects. In water, PAHs either evaporate, disperse into the water column, become incorporated into sediments, or undergo degradative processes such a photo oxidation, chemical oxidation, and biological transformation by bacteria and animals (Neff, 1979).

Organochlorine pesticides have been used extensively in the U.S. since the 1940s. They appear to be ubiquitous in the environment being found in surface waters, sediments and biological tissues. They are readily absorbed by warm-blooded species and degradatory products are frequently more toxic than the parent form. Food chain biomagnification is usually low, except in some marine mammals. In soil invertebrates, organochlorine pesticides can accumulate to concentrations higher that those in the surrounding soil, and residues may in turn be ingested by birds and other animals feeding on earthworms (Beyer and Gish, 1980). Most environmental effects studies have been directed at mammals and birds.

PCBs are distributed worldwide with measurable concentrations recorded in fishery and wildlife resources from numerous locations (Eisler, 1986). They are known to bioaccumulate and to biomagnify within the food chain and to elicit biological effects such as death, birth defects, tumors, and a wasting syndrome. In terrestrial environments, PCBs are rapidly metabolized from the soil into the terrestrial food chain (McKee, 1992). Subsoil-dwelling organisms may directly absorb PCBs and food chain transfer to lower-level vertebrate species may occur.

8.2.5.3 Conceptual Model

Pathways and Exposure Scenarios

Terrestrial Wildlife

For terrestrial wildlife species, exposure would include direct dermal contact, ingestion of soil particles, and food-chain transfer. Small mammals could contact contaminated soil if the area is used as a migratory corridor or if animals burrow into it. The contact time, and thus exposure, will be limited when animals are crossing the area, but could be lengthy if burrows are established. Dermal contact by small reptiles and amphibians would be similar to that for mammals. For insect populations, direct exposure to ground-dwelling species could provide a link for contaminant transfer to higher-level predators.

The assessment endpoint selected for terrestrial wildlife is the maintenance of well-balanced terrestrial wildlife populations and communities that are present at the site. As a measure of the assessment endpoint selected, results of laboratory toxicity studies in literature that relate the oral dose of a contaminant with adverse response to growth, reproduction, or survival were used. Selected representative wildlife species and their exposure factors are listed below. These species (or an equivalent) are likely to occur within the SWMU 9 boundary. The information regarding each list species was derived from the studies presented in USEPA's *Wildlife Exposure Factors Handbook, Volume I* (USEPA, 1993b).

The **Eastern cottontail rabbit (*Sylvilagus floridanus*)** is found in a variety of habitats that contain weedy shrubs and perennial grasses and thick, short, woody vegetation that provide escape sites, similar to the conditions are present in the upland areas surrounding the SWMU 9 lagoons. During the growing season, rabbits consume herbaceous plants and during the winter, they eat woody vines, shrubs, and trees. Home ranges in an given area tend to overlap, especially in fall and winter when rabbits search for areas offering a combination of food and cover. Home ranges are smaller when thick vegetation provides abundant food and larger in those habitats with less

food. Home ranges also are smaller during severe winter weather than at other times. Overall, the rabbit's home range can vary from 0.8 to 7.5 hectares depending on climatic conditions.

The **short-tailed shrew (*Blarina brevicauda*)** nests under the ground and maintains underground runaways, usually in the top 10 cm of soil, but sometimes as deep as 50 cm. Shrews are common in areas with abundant vegetative cover and need cool, moist habitats. The shrew is primarily carnivorous, with a diet consisting mostly of insects, earthworms, slugs, and snails but shrews also consume plants, fungi, millipedes, arachnids, and small mammals. Home ranges of the shrew can vary from 0.03 to 2.2 ha depending on prey densities.

The **American robin (*Turdus migratorius*)** nest in the northern United States and Canada and winter in the Gulf Coast States. Robins require access to fresh water, protected nesting sites, and productive foraging areas. Most foraging is on the ground in open areas, along habitat edges, or the edges of streams as well as in shrubs and lower branches of trees. Their diet consists of ground-dwelling invertebrates, fruit, and foliage-dwelling insects in shrubs and trees. The mean foraging home range for the robin is between 0.15 to 0.18 ha.

The **red-tailed hawk (*Buteo jamaicensis*)** in this region are likely to be year-round resident. Red-tailed hawks are territorial throughout the year, including winter and are found in various habitats ranging from woodlands, wetlands, pastures, and prairies to deserts. Trees or other elevated sites for nesting and perching are important requirements for breeding territories and can determine which habitats are used in a particular area. Hawks consume small mammals, including mice, shrews, voles, rabbits, and squirrels are important prey, but depending on availability, their diet may also include birds, snakes, lizards, and large insects. Home range size can vary from a few hundred hectares to over 1,500 hectares, depending on the habitat.

The **belted kingfisher (*Ceryle alcyon*)** requires suitable nesting sites and adequate nearby fishing. During spring and early summer, belted kingfishers defend a territory that includes both their nest

site and their foraging area. By autumn, each bird (including the young of the year) only defends its individual feeding territory. The breeding territories (length of waterline protected) can be more than twice as long as the fall and winter feeding territories, and stream territories tend to be longer than those on lakes. Foraging territory size is inversely related to prey abundance. Kingfishers generally feed on small fish that swim near the surface or in shallow water. The mean average territory size for the kingfisher is between 1.03 to 2.19 kilometers of shoreline.

Biotransfer Assessment

To assess biotransfer of contaminants along food chains based on surface soil exposure, a total potential dietary exposure (PDE) has been modeled for representative wildlife species within SWMU 9. PDEs are calculated based on predicted concentrations of the ECPC in food items that the species would consume, the amount of soil it would ingest, the relative amount of different food items in its diet, body weight, and food ingestion rate. The wildlife contaminant exposure model for surface soil is presented in Table 8.2.30.

The concentrations of ECPCs in food items are estimated based upon literature-reported bioaccumulation factors (BAFs), which are a ratio of the ECPC concentration in dietary items to the concentration in soil. The BAFs reported for avian and mammalian species are reported ratios of ECPCs in the tissue of the animals to the concentrations of ECPCs in their diets. BAFs for selected contaminant and species are presented in Appendix G of this report. The site foraging factor (SFF) allows for consideration of the frequency of feeding in the site area by estimating the acreage of the site relative to the receptors feeding range and by considering the fraction of the year the receptor would be exposed to site contaminants. The SSF is calculated by dividing the species specific home range by the site acreage. Species specific exposure parameters are provided in Appendix G of this report.

Table 8.2.30
Contaminant Exposure Model for Surface Soil to Terrestrial Receptors
SWMU 9 — Sewage Lagoons

Food Contaminant Concentration (mg/kg)	=	BAF[1] X Soil Contaminant Concentration (mg/kg)
Soil Exposure (SE)	=	(% of diet as soil) X Soil Contaminant Concentration (mg/kg)
PDE (mg/contaminant / kg BW/day)	=	$\frac{[P_1 \times T_1 + P_2 \times T_2 + \ldots P_n \times T_n + SE] \times IR_{diet} \times SFF]}{BW}$

Where:

P_n = percent of diet composed of food item N
T_n = tissue concentration in food item N (mg/kg), (Food Contaminant Concentration)
IR_{diet} = food ingestion rate of receptor (kg of food per day)
SFF = site foraging factor (cannot exceed 1)
BW = receptor body weight (kg)
1 = BAF from Appendix G
PDE = Potential Dietary Exposure

To assess biotransfer of contaminants along food chains from aquatic to terrestrial species, a dietary exposure model similar to that used for soil exposure was used. The model, presented in Table 8.2.31, uses the maximum fish tissue contaminant concentration to determine a dietary exposure to a fish-eating bird. The dietary model reflects literature information on the ingestion rate, body weight, and percent time spent foraging at the site by a belted kingfisher.

Table 8.2.31
Contaminant Exposure Model for Fish Tissue Consumption by a Fish-eating Bird at SWMU 9

PDE (mg contaminant / kg BW/day)	=	$\frac{T \times IR_{diet} \times Ct}{BW}$

Notes:
T — Fraction time spent onsite (unitless, assuming 1.0)
Ct — Concentration in tissue (reported in mg/kg)
IR — Ingestion rate (0.017 kg/day from Nagy, 1987)
BW — Body weight (0.15 kg from USEPA, 1993b)
PDE — Potential Dietary Exposure

Aquatic Wildlife

Contact/interface with water and sediment is a potential pathway, therefore fish living in the lagoons were considered as an assessment endpoint for evaluating the aquatic community health. As a measure of the assessment endpoint selected, results of literature studies that relate the body burden of a contaminant with an adverse response to growth, reproduction, or survival were used.

8.2.5.4 Ecological Effects Assessment

Terrestrial Wildlife

Potential adverse effects associated with the identified ECPCs to bird and mammal species are based on food uptake potential. Available toxicity reference values (TRVs) were determined for each measurement endpoint species selected. The TRV relates the dose of a respective ECPC in an oral exposure with an adverse effect. The lethal TRV has been determined to be one-fifth of the lowest reported LD_{50} value (concentration of a contaminant at which half of the exposed test population die) for the most closely related test species. One-fifth of an oral LD_{50} value is considered to be protective of lethal effects for 99.9% of individuals in a test population (USEPA, 1986). It is assumed that this level of risk to individuals within terrestrial wildlife populations across SWMU 9 is acceptable.

A sublethal TRV is also identified, representing a threshold for sublethal effects. Sublethal effects are defined as those that impair or prevent reproduction, growth, or survival. The sublethal TRV reflects the assessment endpoint chosen as the basis for establishing risk.

Effects are predicted quantitatively by dividing the PDE by a TRV. This produces a HQ which represents the potential risk to a species by that contaminant. For a cumulative assessment of risk posed by all contaminants, HQs are added to produce a HI.

Aquatic Wildlife

To determine if contaminant concentrations detected in fish, whole-body samples were at levels that may be chronically affecting fish within the lagoon, tissue levels have been compared to available critical effects data in the literature. When tissue concentrations exceeded a critical effects level then it was assumed that chronic impacts to fish have occurred or are occurring.

8.2.5.5 Risk Characterization

Terrestrial Wildlife

The hazard indices produced for surface soil exposure by terrestrial receptors are presented in Figure 8.2.15, and calculations are provided in Appendix G of this report. Except for the shrew, HIs for all species were below the effects level of 1.0. The sublethal HI for the shrew was 1.62.

Aroclor-1260, detected in one surface soil sample, was the primary constituent responsible for the elevated sublethal HI for the representative species. Based on the limited spatial distribution, however, exposure to Aroclor-1260 should not be a concern.

Dietary exposure risk to terrestrial species in the uplands around SWMU 9 is very low when compared to effects levels. Biotransfer of contaminants up the food chain will not be a concern as they are not at concentrations indicative of accumulation. Low soil concentrations and limited distribution of contaminants will limit the incidental ingestion risk to acceptable concentrations for bird and mammal species which might forage in the area. The hazard indices produced for fish tissue exposure to the belted kingfisher, a terrestrial receptor, are presented in Table 8.2.32. The HIs were based on maximum concentrations from both lagoons. Only exposure to DDE, in fish tissue, represents a potential risk to the belted kingfisher. DDE's sublethal HQ value of 3.3 was primarily responsible for the sublethal HI of 4.5.

Aquatic Wildlife

Limited information was available concerning tissue concentrations necessary to produce physiological impacts in fish. A recent publication by Beyers et al., (Eds., 1996) provides

information on fish tissue concentrations "toxic effects thresholds" for polychlorinated biphenyls, endrin, selenium, and mercury. These "toxic effects thresholds" are not to be considered as criteria, but as general levels that can be used for comparative purposes. Table 8.2.33 presents a summary of contaminant concentrations in tissue that may cause adverse effects or changes in response, by fish.

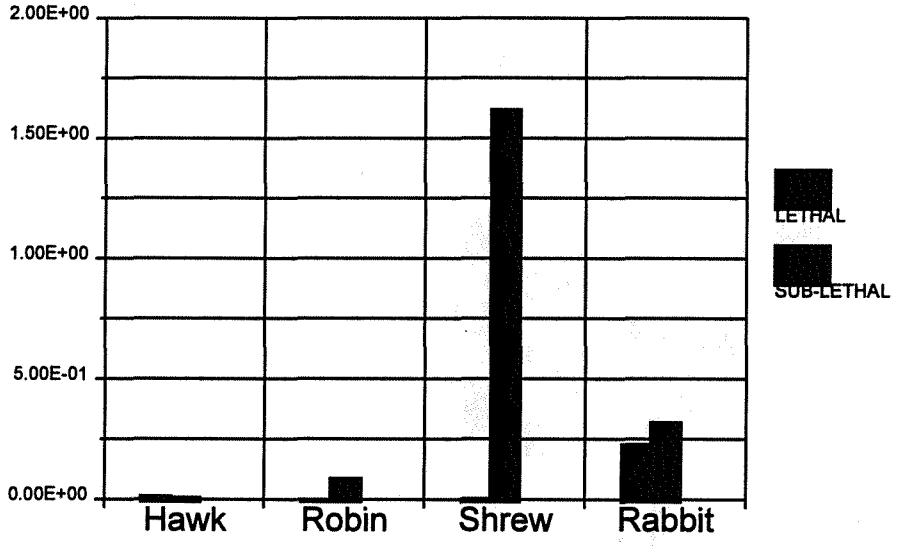
Based on tissue concentrations observed at SWMU 9, no impacts to fishery populations are expected from PCB, endrin, mercury, or selenium contamination. All detected concentrations were well below the lowest effects threshold concentrations presented in the literature.

No risk prediction can be made for the other contaminants detected in fish tissue at SWMU 9. For comparison purposes only, fish tissue concentrations at SWMU 9 are presented in relation to other studies. For this report, cited fresh (wet) weight values have been converted to dry weights by assuming 75% moisture (Lemly, 1996).

The maximum SWMU 9 chromium tissue concentration (13.7 mg/kg dry weight) was above those reported by Hall et al., (1978) where individual concentrations for several species ranged from 0.4 and 2.4 mg Cr/kg. The SWMU 9 concentration was below concentrations found by other investigators; Papadopoulo and Dassimati (1977), 97 mg/kg Cr in scales of selected species, and Mearns and Young (1977) where up to 100 mg/kg Cr+6 were detected in speckled sanddab intestines.

The maximum lead concentration at SWMU 9 (1.3 mg/kg, dry weight) has been compared to several studies. Schmitt et al. (1984) detected whole body lead burdens of 36 to 72 mg/kg in fish from the Big River, Missouri, near a ruptured mine tailings pond dam. Lowe et al.'s (1985) study found lead to 26.8 mg/kg in whole Mozambique tilapia from Honolulu in 1979. The significance of lead residue in fish is unknown, and merits additional research (Eisler, 1988).

Figure 8.2.15
Surface Soil Wildlife Hazard Indices



Notes:

HI = Hazard Index Sum of all HQs ($HQ_1+HQ_2+...HQ_3$)

Lethal Effects = One-fifth of an oral LD50 value is considered to be protective of lethal effects for 99.9% of individuals in a test population (USEPA, 1986)

Sublethal Effects = Impair or prevent reproduction, growth, or survival.

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Table 8.2.32
Risk Values for Dietary Exposure of Contaminated Fish to Belted Kingfisher

Analyte	Max Conc. (mg/kg)	PDE	TRV_{SL}	TRV_L	HQ_{SL}	HQ_L
Aluminum	19.6	2.22	109.7	NA	0.02	NC
Arsenic	0.03	0.0034	5.1	12.8	0.0007	0.0003
Chromium[a]	2.2	0.249	1.0	5.0	0.249	0.0498
Copper[b]	2.2	0.249	47.0	61.7	0.0053	0.0040
Lead	0.31	0.0351	1.13	11.30	0.0311	0.0031
Manganese[c]	20.3	2.30	997	NA	0.0023	NC
Mercury[d]	0.09	0.0102	0.45	0.90	0.0227	0.0113
Nickel[e]	1.1	0.125	77.4	107.0	0.0016	0.0012
Selenium[f]	0.22	0.0249	0.4	0.8	0.06	0.031
Aroclor-1254	0.280	0.0317	0.18	1.8	0.176	0.018
DDE[g]	0.088	.010	0.003	0.028	**3.3**	0.36
Di-n-butylphthalate	0.120	0.0136	0.11	1.10	0.124	0.012
Endrin	0.049	0.0056	0.01	0.10	0.55	0.055
HI =					4.5	0.54

Notes:
a — Effects levels based on chromium as $CrK(so_4)_2$.
b — Effects levels based on copper as copper oxide.
c — Effects levels based on manganese as Mn_3O_4.
d — Effects levels based on mercury as mercuric-chloride.
e — Effects levels based on nickel as nickel sulfate.
f — Effects levels based on selenium as selanomethio-nine.
g — Effects levels based on DDT and metabolite data.
PDE — Potential Dietary Exposure based derived from model - Table 8.2.9.5.
TRV — Threshold Risk Value.
SL — Sublethal (chronic)
L — Lethal (acute)
NA — Not available
NC — Not calculated
Bold numbers indicate elevated risk potentials.

Table 8.2.33
Summary of Contaminant Concentrations in Fish at which Adverse and Chronic Effects May Occur

Parameter	Response	Species	Organ	Effects	SWMU 9 Max
PCB	Lethality	Fish	Whole-Body	>100 mg/kg	0.28 mg/kg
	Growth			>50 mg/kg	
	Reproduction			>100 mg/kg	
	Fedmal			>50 mg/kg	
	Progeny				
	Disease			mg/kg range	
	Cellular Changes			High μg/kg to low mg/kg	
	Biochemical Changes			High μg/kg to low mg/kg	
Endrin	Lethality	Gizzard Shad[1]	Blood	10 mg/kg	0.049 mg/kg
		Channel Catfish[2]	Blood	30 mg/kg	
Mercury	On-set of mortality	Walleye[3]	Brain	3-6 mg/kg	0.56 mg/kg
	emaciation		Liver	6-14 mg/kg	
	(-) locomotion activity		Muscle	5-8 mg/kg	
	(-) coordination		Brain	15-40 mg/kg	
	(-) appetite		Liver	18-50 mg/kg	
	(+) mortality		Muscle	15-45 mg/kg	
	(-) growth	Rainbow trout[4]	Muscle	12-23 mg/kg	
	Darkened skin	Rainbow trout[5]	Whole-body	30-35 mg/kg	
	(-) appetite	Rainbow trout[4]	Whole-body	10-30 mg/kg	
	(-) growth				
	(-) diet	Rainbow trout[6]	Brain	16-30 mg/kg	
	(-) activity		Liver	26-68 mg/kg	
	(-) growth		Muscle	20-28 mg/kg	
	mortality	Brook Trout[7]	Whole-body	24 mg/kg	
Selenium	mortality of juveniles and reproduction failure	Fish	Whole-body	4 mg/kg	0.89 mg/kg
	Reduced growth	Fathead Minnow[8]	Whole-body	5 mg/kg	
	Reproduction failure	Fathead minnow[9]	Whole-body	16 mg/kg	
	Mortality	Bluegill sunfish[11]	Whole-body	5 mg/kg	
	Reproduction failure	Bluegill sunfish[12]	Whole-body	19 mg/kg	

Notes:
1 — Brungs and Mount, 1967
2 — Mount et al., 1966
3 — Scherer et al., 1975
4 — Wobeser, 1975
5 — Rodgers and Beamish, 1982
6 — Matida et al., 1971
7 — McKim et al., 1976
8 — Ogle and Knight 1989
9 — Schultz and Hernanatz 1990
10 — Saiki et al. 1992
11 — USFWS, 1990
12 — Coyle et al., 1993
An increase is indicated by (+); a decrease is indicated by (-).

Schmitt and Brumbaugh (1990) provided information on U.S. nationwide zinc whole body tissue concentrations in freshwater fish species. They reported the geometric mean, 85th percentile, and maximum values as 86.8 mg/kg, 128.8 mg/kg, and 473.6 mg/kg, respectively. As with lead, wet weight to dry weight conversion was necessary. The maximum zinc concentration at SWMU 9 was 99.9 mg/kg, suggesting that zinc contamination may be important. As with many of the other contaminants, actual physiological impacts to fish from the observed concentrations is unknown.

Big Creek Drainage Canal

No significant SSV exceedances (see Tables 8.2.6 and 8.2.8) were found for the four samples collected from Big Creek Drainage Canal. Also, all water contaminant concentrations were below established USEPA Water Quality Standards. No risk to aquatic receptors is predicted from contamination in Big Creek Drainage Canal.

Risk Summary

Terrestrial Wildlife

The maximum soil concentration for Aroclor-1260 resulted in a predicted potential sublethal risk to the short-tailed shrew. Aroclor-1260 produced a sublethal HQ of 1.35 for the shrew which contributed to the cumulative HI of 1.62 (Appendix G). Overall PCB risk is low since only one of the eight surface soil samples detected Aroclor-1260. Risk to shrew populations found across the site will be negligible. All other HQs and HIs for surface soil concentrations were below the risk threshold level of 1.0. No lethal or sublethal effects are predicted for other wildlife species at SWMU 9.

The dietary exposure model for fish tissue consumption by the belted kingfisher predicted a limited risk from pesticide contamination. The sublethal HI was 4.5, indicating some risk to piscivorous (fish-eating) birds. It must be noted that the model used to estimate the dietary exposure is

extremely conservative and based on assumptions, actual feeding habits may be different than those use in the model. No lethal risk to the belted kingfisher was predicted.

Aquatic Wildlife

No impacts to aquatic species from contamination found in the lagoons, or in the segment of Big Creek Drainage Canal near SWMU 9, is predicted. Fish tissue concentrations within the lagoons were well below the lowest effects threshold concentrations presented in the literature. Based on tissue concentrations observed at SWMU 9, no impacts to fishery populations are expected from PCB, endrin, mercury, or selenium contamination and none is expected from other constituents found in the lagoons.

8.2.5.6 Uncertainty

- Field sampling design (sample locations selected) may lend itself to uncertainties based on the subjective decisions that are necessary and unavoidable. This uncertainty may result in either an over- or under-estimation of risk.

- Analytical uncertainties exist based on field and laboratory methods employed, but quantification of these is impossible.

- Synergistic or antagonistic relations between contaminants cannot be accounted for, especially when methods employing contaminant-specific benchmark comparisons are used.

- A lack of criteria or screening values for many chemicals compounds the uncertainty for screening level assessments. This uncertainty could create an underestimation of risk.

- Toxicological effects studies may be different at individual versus community levels.

- Extrapolation of literature-generated effects levels to indigenous species and communities may not be appropriate.

- Use of maximum fish tissue concentrations may overestimate risk potentials to piscivorous species.

8.2.6 Fate and Transport Assessment

This section evaluates the specific transport processes for site constituents at SWMU 9. The primary contaminants discussed in the fate and transport evaluation are:

- Those constituents that are defined as COCs per the HHRA

- Any organic contaminant which exceeds its soil to groundwater SSL and any inorganic contaminant which exceeds both its soil to groundwater SSL and RC

- Any VOC that exceeds the SSL for soil-to-air transport

In addition, transport processes for constituents other than those designated as COCs are discussed when they are in multiple environmental media, or have the potential to migrate to other media.

As outlined in Section 8.2, SWMU 9 consists of two sewage lagoons on the southern boundary of the Southside of NSA Memphis, approximately 175 feet south of Big Creek Drainage Canal and 200 feet west of the South Gate. The lagoons are bordered by woods and Big Creek Drainage Canal to the north and woods to the south, east and west. The land surrounding the lagoons slopes away on all sides for a short distance, with surface water draining generally west before entering Big Creek Drainage Canal. The two lagoons were used as part of the wastewater treatment system

for NSA Memphis from 1969 to 1978, when NSA Memphis connected its sewer system to the City of Millington sewage treatment system.

SWMU 9 COCs include:

- ***acetone*** and ***dieldrin***, which exceeded their soil-to-groundwater SSLs in soil samples
- ***barium*** and ***nickel***, which exceeded their respective background RCs and soil-to-groundwater SSLs in soil samples
- ***arsenic***, ***chloroform***, and ***trichloroethene***, which are COCs in alluvium groundwater per the HHRA

Two potential cross-transport mechanisms which were evaluated for SWMU 9 are soil-to-groundwater and soil-to-sediment. Surface soil analytical data indicate that VOCs are not of concern at SWMU 9; therefore, the soil-to-air cross-media transport process was not evaluated. Also, the absence of a groundwater-to-surface-water mechanism eliminates this process from being evaluated. The following sections outline the two potential cross-transport mechanisms at SWMU 9.

8.2.6.1 Soil-to-Groundwater Cross-Media Transport

Six constituents (arsenic, barium, chromium, cobalt, lead, and TPH-DRO) were detected in both soil and deep alluvium groundwater at SWMU 9. Of these constituents, only barium exceeded both its background RC and its SSL for soil-to-groundwater transfer. Based on the fact that the majority of constituents found in both soil and groundwater are inorganics, and only one inorganic in both media exceeded both its background RC and SSL, it is unlikely that vertical migration of these contaminants resulted in groundwater impact.

SWMU 9 contaminants that exhibit the potential for soil-to-groundwater transport, based on comparison of soil concentrations to the groundwater protection soil screening criteria, are the VOC acetone, the pesticide dieldrin, and the inorganics barium and nickel.

Acetone, detected in six surface soil samples locations at concentrations ranging from 11 to 25,000 μg/kg, exceeded its 8,000 μg/kg SSL at one location. Although acetone was also detected in subsurface soil samples, detected concentrations in this interval were well below its soil to groundwater SSL of 8,000 μg/kg. Acetone was not detected in SWMU 9 groundwater during the initial sampling event in April 1996. Although the conservative screening process indicates the potential for isolated soil-to-groundwater migration of acetone, widespread impacts to the shallow aquifer are not expected.

Dieldrin, detected in four surface soil samples at concentrations ranging from 5.2 to 26 μg/kg, exceeded its SSL (1 μg/kg) at each location where it was detected. No dieldrin was detected in subsurface soil samples. Dieldrin's presence in SWMU 9 soil samples may be attributed to aerial applications throughout NSA Memphis during the 1950s and 1960s. The potential for dieldrin to migrate to groundwater is not likely due to its low solubility, vapor pressure, and Henry's law constant; therefore, it is anticipated to be immobile and persistent in the environment, not readily diffusing into groundwater. This is evident by its absence in SWMU 9 groundwater.

Barium and nickel each exceeded their respective soil to groundwater SSLs as well as their background RCs in subsurface soil samples. Nickel was not detected in groundwater during the April 1996 sampling event; therefore, it may not be a soil to groundwater migration concern. Barium was detected in deep alluvium groundwater, but this constituent is not a COC per the HHRA. Although arsenic was detected in both surface and subsurface soil samples at concentrations that did not exceed both its RC and SSL, it was detected in deep alluvium groundwater at concentrations exceeding the RBC for tap water but not the MCL for drinking

water, and HHRA results indicate it is a COC. Widespread impact to alluvium groundwater by arsenic, barium, and nickel is not expected based on the relative immobility of these constituents in groundwater, as they typically adhere to solids and do not readily diffuse into groundwater.

The VOCs chloroform and trichloroethene were both detected in deep alluvium groundwater. Chloroform's RBC for tap water, but not its MCL for drinking water, was exceeded in a duplicate groundwater sample; this compound was not detected in the primary sample analyzed by the onsite laboratory. Chloroform may be considered a laboratory artifact. The RBC and the MCL for trichloroethene were exceeded in one groundwater sample location. Trichloroethene, a common solvent, has been detected at other SWMUs at NSA Memphis, and may or may not be related to SWMU 9 operations. Neither chloroform or trichloroethene were detected in SWMU 9 soil or sediment samples. Widespread impacts to the underlying aquifer are not expected due to the absence of these constituents in soil.

8.2.6.2 Soil-to-Sediment Cross-Media Transport

For this discussion, contaminants which were detected in near-surface soil were evaluated to determine their potential for transport by erosional processes, which form sediments. Drainage patterns and topography at SWMU 9 were also examined to see if site features would support contaminant transport.

Contaminants detected in surface soil consist of VOCs, SVOCs, chlorinated pesticides/PCBs, herbicides, and inorganics. Only the VOC acetone and the pesticide dieldrin are considered to be COCs in SWMU 9 surface soil, based on exceeding soil to groundwater SSLs. VOCs have a limited tendency to adsorb to solids and are more likely to volatilize to the atmosphere or leach to groundwater before moving with soil particles. In general, SVOCs, pesticides, and PCBs tend to sorb to soil particles and are relatively immobile in the environment, leading to a likelihood of greater persistence, but lower mobility in the environment than VOCs. Herbicides can leach from

soil particles to groundwater and tend to be mobile in both soil and groundwater. Therefore, herbicides are expected to be moderately mobile in groundwater with some retention in soil. Inorganic chemicals do not degrade, but may change chemical form or speciation in the environment. Like pesticides and SVOCs, inorganics tend to sorb to soil particles, which renders them immobile.

Contaminants detected in sediment samples from Big Creek Drainage Canal consist of VOCs, SVOCs, chlorinated pesticides, TPH-DRO, herbicides, and inorganics. Of these contaminants, only the pesticides — 4,4'-DDD, 4,4'-DDT, and dieldrin — and the inorganics — arsenic, cadmium, lead, and nickel — exceeded their respective SSVs. Contaminants found in both surface soil samples and Big Creek Drainage Canal sediment samples include one VOC — acetone —, TPH-DRO, three pesticides — 4,4'-DDD, 4,4'-DDT, and dieldrin —, four herbicides — 2,4-D, 2,4-DB, MCPA, MCPP —, two SVOCs — fluoranthene, pyrene —, and the inorganics — arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, tin, vanadium, and zinc.

All sediment concentrations are along the same order of magnitude as the contaminant concentrations detected in surface soil samples. It may not be possible to solely attribute sediment sample contamination with SWMU 9 activities due to the length of Big Creek Drainage Canal and the many outfalls into Big Creek Drainage Canal from other NSA Memphis locations and from other sources (primarily agricultural) upstream of NSA Memphis.

Surface water samples collected from Big Creek Drainage Canal were analyzed for organic compounds and inorganics. No organic compounds were detected in the surface water samples, and silver and barium were the only detected inorganics. Due to the absence of organic contamination and the presence of only two inorganics in surface water samples, constituents in

SWMU 9 soil and sediment do not appear to contribute to surface water contamination in Big Creek Drainage Canal.

8.2.7 Conclusions and Recommendations

The following conclusions are presented based on the findings of the RFI:

- RFI soil samples contained VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides and PCBs, herbicides, and Appendix IX metals. No TPH, PCB, or herbicide exceeded a screening value. Exceedances for VOCs, SVOCs, chlorinated pesticides, and Appendix IX metals are provided below.

  - One VOC — acetone — exceeded its soil-to-groundwater SSL in one hand-auger surface soil sample from the north side of the east sewage lagoon.

  - One SVOC — benzo(a)pyrene — exceeded its residential RBC in one hand-auger surface soil sample from the bank of the north side of the east sewage lagoon.

  - One pesticide — dieldrin — exceeded its soil-to-groundwater SSL in four hand-auger surface soil samples from the lagoons' banks.

  - Two metals — barium and nickel — exceeded screening values. The barium concentrations in the 0.5- to 2-foot and 8- to 10-foot intervals of one soil boring exceeded both the RC and SSL. Both the RC and SSL for nickel were exceeded by three subsurface soil samples of three separate soil borings (8- to 10-foot or 14-to 16-foot intervals).

- VOCs, SVOCs, TPH-DRO, and Appendix IX metals were detected in RFI groundwater samples. No SVOCs exceeded a screening value. Exceedances for VOCs, TPH-DRO, and Appendix IX metals are provided below.

  — Trichloroethene's tap-water RBC and MCL were exceeded in one deep alluvium DPT groundwater sample. The tap-water RBC, but not the MCL, was exceeded in a second deep alluvium DPT groundwater sample.

  — The TPH-DRO concentration in one deep alluvium groundwater sample from a monitoring well exceeded its TDEC cleanup standard for total TPH in drinking water aquifers. The deep alluvium has not been classified as drinking water or nondrinking water, so the most conservative TDEC cleanup standard was used for comparison.

  — Arsenic exceeded both its background RC and tap water RBC in one deep alluvium groundwater sample from a monitoring well. The detected concentrations did not exceed the MCL for arsenic.

- During the April/May 1997 groundwater sampling event, a duplicate sample from one deep alluvium groundwater sample indicated trichloroethene below its tap water RBC and MCL, and tetrachloroethene above its tap water RBC but below its MCL.

- VOCs, SVOCs, TPH, chlorinated pesticides, PCBs, herbicides, and Appendix IX metals were detected in sediment samples from the sewage lagoon sediments and Big Creek Drainage Canal. SSVs were exceeded by SVOCs, pesticides, and nine Appendix IX metals, as summarized below.

— One SVOC — BEHP — exceeded its SSV in one surface sediment sample from the west sewage lagoon.

— Three pesticides — 4,4'-DDD, 4,4'-DDT, and dieldrin — exceeded their SSVs. The SSVs for 4,4'-DDD and 4,4'-DDT were exceeded by one surface sediment sample from Big Creek Drainage Canal north of SWMU 9. The SSV for dieldrin was exceeded in one surface sediment sample from Big Creek Drainage Canal northeast (upstream) of SWMU 9.

— One PCB — Aroclor-1254 — exceeded its SSV in three surface sediment samples from the sewage lagoons; two exceedances were from the west lagoon and one exceedance was from the east lagoon.

— Nine Appendix IX metals — arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc — exceeded their SSVs in one or more surface sediment samples from the sewage lagoons or Big Creek Drainage Canal. Arsenic's SSV was exceeded in one surface sediment sample from the west lagoon, and two surface sediment samples from Big Creek Drainage Canal north and northwest (downstream) of SWMU 9. Cadmium's SSV was exceeded in three of four Big Creek Drainage Canal surface sediment samples. Chromium's SSV was exceeded in one surface sediment sample from the west lagoon. Copper's SSV was exceeded by all eight surface sediment samples collected from the sewage lagoons. Lead's SSV was exceeded by one surface sediment sample from the west sewage lagoon, and one Big Creek Drainage Canal surface sediment sample northeast (upstream) of SWMU 9. Mercury's SSV was exceeded in six of eight surface sediment samples from the sewage lagoons. Nickel's SSV was exceeded by two surface sediment samples from the sewage lagoons two surface sediment samples

from Big Creek Drainage Canal. Silver's SSV was exceeded in five sewage lagoon surface sediment samples. Zinc's SSV was exceeded by two surface sediment samples from the west lagoon.

- No organic compounds were identified in the two surface water samples from Big Creek Drainage Canal. The only detected inorganics — barium and silver — did not exceed their respective FWQSs.

- One SVOC, two pesticides, two PCBs, and eighteen inorganics were detected in the three composite fish tissue samples collected from the sewage lagoons. 4,4'-DDD, Aroclor-1254, and Aroclor-1260 exceeded their respective RBCs for fish tissue consumption in all three samples. The arsenic concentration in one sample exceeded its RBC for fish tissue consumption.

- The HHRA calculated the risk and hazard posed by soil, groundwater, sediment, and fish tissue contaminants at SWMU 9. The findings were as follows:

  — No COPCs were identified in soil, so soil exposure was not quantified.

  — The HHRA assumes that alluvial groundwater will be used as a drinking water source. However, the alluvial aquifer has not been classified as a source of potable water. No alluvial drinking water wells are present at NSA Memphis and a public water supply is readily available. The HHRA evaluated the ingestion route of exposure for alluvial groundwater contaminants for two scenarios: the hypothetical site resident and the site worker. The HHRA identified arsenic, chloroform, and trichloroethene as COCs in alluvial groundwater. The cumulative ILCR for the hypothetical site resident was 3E-04, exceeding USEPA's upper-bound risk level of 1E-04. The calculated HIs for the hypothetical adult and child residents were

1 and 3, meeting or exceeding USEPA's target HI of 1. The cumulative ILCR and HI for the site worker were 6E-05 and 0.4, respectively, which do not exceed USEPA's acceptable risk level or target HI.

— Two exposure scenarios were evaluated for fish consumption: the hypothetical site resident and the future site trespasser. Risk was evaluated separately for the east and west lagoons. The HHRA identified 4,4'-DDE, Aroclor-1254, and Aroclor-1260 as COCs for fish ingested from the East Lagoon and 4,4'-DDE, Aroclor-1254, Aroclor-1260, and arsenic as COCs for fish ingested from the West Lagoon. For the east lagoon, the hypothetical site resident's ILCR was 2E-04, which exceeds USEPA's acceptable ILCR of 1E-04. The calculated HIs for the hypothetical adult and child residents were 4 and 17, which both exceed USEPA's target HI of 1. The ILCR for the future site trespasser was 6E-05, which does not exceed USEPA's acceptable ILCR of 1E-04. However, the calculated HIs for the future adolescent and child site trespassers were 2 and 7 which both exceed USEPA's target HI of 1. For the west lagoon, the hypothetical site resident's ILCR was 4E-04, which exceeds USEPA's acceptable ILCR of 1E-04. The calculated HIs for the hypothetical adult and child residents were 3 and 14, which both exceed USEPA's target HI of 1. The ILCR for the future site trespasser was 1E-04, which equals USEPA's acceptable ILCR of 1E-04. However, the calculated HIs for the future adolescent and child site trespassers were 2 and 6 which both exceed USEPA's target HI of 1.

- The ERA determined no lethal or sublethal effects were predicted for terrestrial wildlife species at SWMU 9, except for the short-tailed shrew. Aroclor-1260 produced a sublethal HQ of 1.35, which contributed to the cumulative HI of 1.62 for this species (risk threshold is 1.0). The dietary exposure model for fish tissue consumption by the belted kingfisher predicted a limited risk from pesticide contamination. The sublethal HI was 4.5, indicating

some risk to piscivorous birds. No impacts to aquatic species from contamination found in lagoon sediment or Big Creek Drainage Canal is predicted.

- The fate and transport discussion evaluated the soil-to-groundwater and soil-to sediment cross-media transport mechanisms. It determined that acetone, dieldrin, barium, and nickel were the SWMU 9 contaminants that exhibit the potential for soil-to-groundwater transport. Widespread impact to the alluvial aquifer by acetone is not expected; this compound was detected only in soil samples. Acetone was not detected in SWMU 9 groundwater during the April 1996 or April/May 1997 sampling events. Dieldrin, also detected only in soil, is expected to be immobile and persistent in the environment, not readily diffusing to groundwater. Dieldrin was absent in SWMU 9 groundwater samples collected during the initial April 1996 sampling event. Widespread impact to alluvial groundwater by barium and nickel are not expected, based on the relative immobility of these constituents. The VOCs chloroform and trichloroethene were both detected in deep alluvium groundwater, but neither compound was detected in SWMU 9 soil or sediment. Widespread impacts to the underlying aquifer are not expected due to the absence of chloroform and trichloroethene in soil.

The following recommendations are presented based on the findings of the RFI:

- Based on previous detections in DPT and monitoring well groundwater samples, conduct annual sampling and analysis of all SWMU 9 monitoring wells for VOCs, TPH-GRO, and TPH-DRO to verify the presence of these contaminants and determine whether their concentrations are increasing.

- Continue the ban on fishing at the lagoons.

- Assess the TCE in SWMU 9 groundwater during the SWMU 2 investigation.

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8.3 SWMU 14

SWMU 14, a flat, grass-covered area on the NSA Memphis Southside, is the former site of Building S-140, several related former buildings and structures, and the Seventh Avenue and Polaris Drive drainage ditches west and south of the site, respectively. The grass covering SWMU 14 is regularly mowed to maintain lawn-like conditions. According to engineering plans of the building obtained from Public Works, four smaller structures were associated with Building S-140: a gear locker (Building S-275), a mobile building along the eastern edge of the site (Building S-1602), a prefabricated metal storage building southeast of Building S-140 used as a paint locker (Building S-351), and SWMU 46, a hazardous waste accumulation point northeast of the building. Building S-140 was demolished along with all associated buildings and structures in 1985. Figure 1.4 shows the locations of the previous buildings and structures.

Building S-140 housed a paint spray booth, paint removing area, and paint washdown area, which were associated with training Navy personnel in various painting-related processes from 1943 until 1985. According to building diagrams, two drainage systems were associated with painting activities at S-140. One was in the central portion of the building near the paint spray booths and water wash pits; the other was in the northern portion near the interior washdown area and work table.

Navy records indicate paint-related wastes generated by the paint spray booth and water wash pits collected in two floor drains which emptied into two 1,885-gallon sump pits. Paint waste and sludge from these sumps were most likely removed on an as-needed basis, and any overflow was discharged directly to the Seventh Avenue ditch until 1980. After 1980, the flow from the paint booth and washdown area was redirected to a paint separator/sump in the building's mechanical room, while overflow was discharged to the sanitary sewer. The paint waste and sludge likely contained chromium, lead, and various hydrocarbons and paint solvents including mineral spirits, toluene, and phenols.

Wastes generated by the paint washdown area and work tables were discharged to an unidentified drain line exiting the building's east side. In 1968, these wastes were diverted to an interceptor/separator installed beneath the north end of a sidewalk immediately east of the building (Figure 1.4). According to construction diagrams, this interceptor was 3.5 x 5 feet across with the deepest portion of the bottom 4.5 feet bls. Discharge from the interceptor was directed to the sanitary sewer line to the north.

A former outdoor wash basin adjacent to Building S-140's south side consisted of a 36 x 40-foot concrete slab surrounded by a 6-inch berm. According to sewer modification diagrams, the drain in this basin once discharged to the Polaris Drive drainage ditch south of SWMU 14 until it was diverted to the sanitary sewer in 1980. A small discharge pipe still visible in the Polaris Drive ditch has been included in the SWMU 14 RFI.

SWMU 46 is a former hazardous waste accumulation point near the north end of a paved area east of Building S-140. According to Navy records, it was used for less-than-90-day storage of drummed hazardous waste, including waste paint and thinners, from 1980 until its demolition in 1985. Although SWMU 46 is in Assembly G, it does not require a separate investigation, because it is in the SWMU 14 study area. Assembly G SWMUs are former hazardous waste accumulation points that require a confirmatory investigation.

8.3.1 Previous Investigation Results

In July 1995, E/A&H conducted a geophysical survey of SWMU 14 in an attempt to verify the approximate location of the former building and subsurface structures (E/A&H, 1995c). Geophysical anomalies due to disturbed soil or metal objects were plotted on a map, and proposed sample locations were chosen after results were reviewed. The geophysical survey showed one moderate anomaly at SWMU 14 near where the outdoor wash basin was previously located. The rest of the surveyed area was anomaly-free, indicating the sumps and separators may have been

removed during building demolition. A linear feature along the site's eastern survey boundary may be an abandoned potable water line that supplied water to the adjacent property when it was a trailer park.

8.3.2 RFI Characterization

RFI characterization focused on the nature and extent of contamination in the following media:

- Surface and subsurface soil near the former SWMU 14 buildings and structures
- Surface and near-surface soil in the Polaris Drive drainage ditch near the small outfall from the former outdoor wash basin
- Loess and fluvial deposits groundwater
- Seventh Avenue drainage ditch sediment

8.3.2.1 DPT Screening Investigation

As part of RFI characterization, a preliminary screening investigation was conducted at SWMU 14 using DPT equipment operated by InSitu Technologies of Travelers Rest, South Carolina. The screening investigation, conducted from November 7 to 19, 1995, focused on the location of the former waste-receiving interceptor/separator and its associated piping on Building S-140's northeast corner. The results of the DPT investigation were used to determine the optimum placement and depth of soil borings and monitoring wells.

Based on the anticipated site contaminants — paint, paint waste, paint thinners, and solvents — VOCs were chosen as the indicator parameter. Figure 8.3.1 shows the DPT sample locations which were chosen for the following reasons:

- Five of the sample locations were positioned around the former waste receiving structures near the northeast corner of the former location of Building S-140. These locations were: 014S0005/014G0005, 014S0010/014G0010, 014S0011/014G0011, 014S0012/014G0012, and 014S0014/014G0014.

- One sample location (014S0012/014G0012) was positioned near SWMU 46.

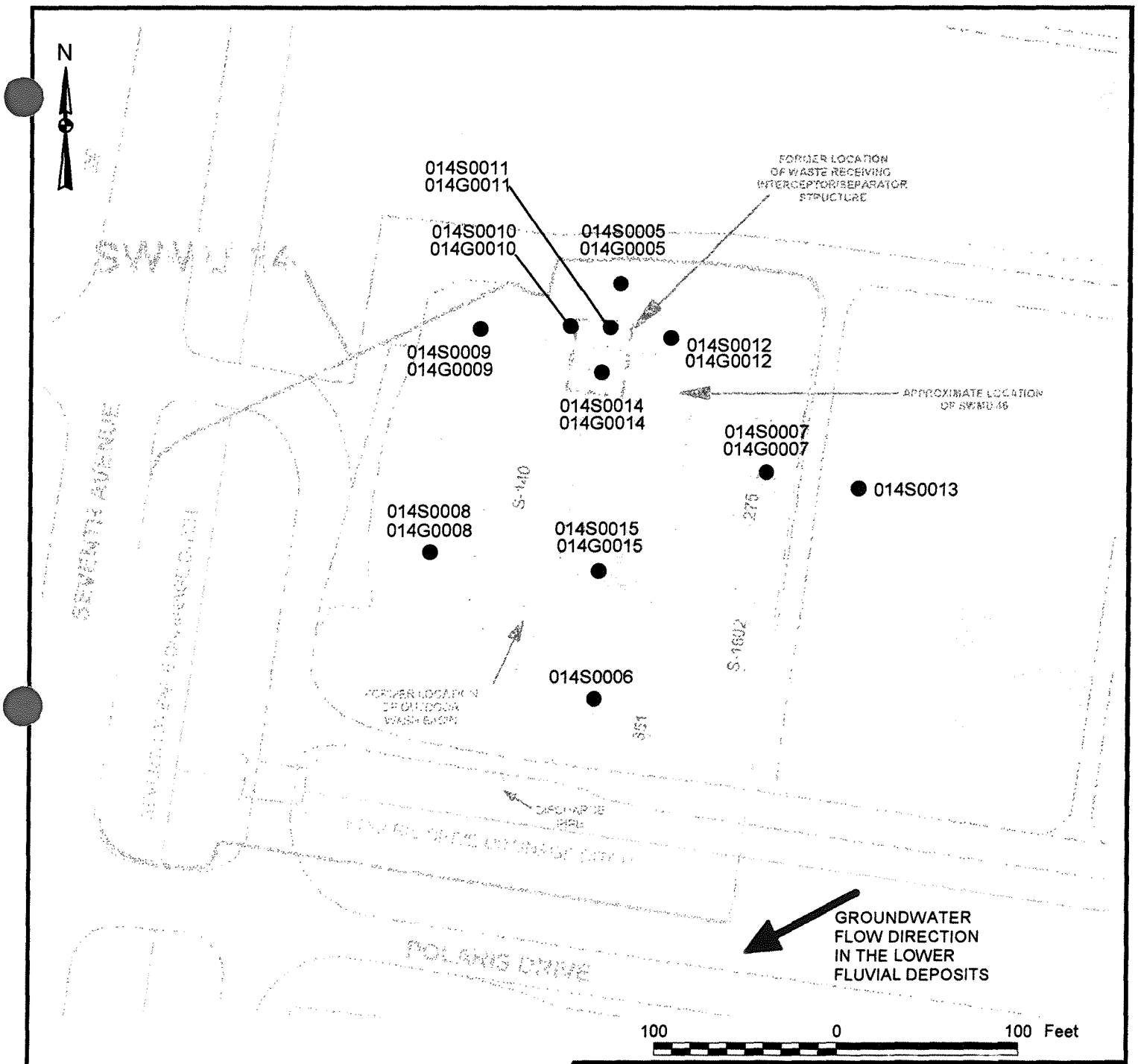
- Two sample locations were placed near the former locations of Buildings S-351 and S-275. Location 014S0006/014G0006 was positioned near the former location of Building S-351, the former paint locker; location 014S0007/014G0007 was placed near Building S-275, the former gear locker.

- Two sample locations were positioned to assess the potential migration of contaminants from Building S-140 to the Seventh Avenue ditch: 014S0008/014G0008 and 014S0009/014G0009.

- An "unbiased" sample location (014S0015/014G0015) was placed southeast of former Building S-140.

- During the DPT investigation, an additional sampling location was added to assess the migration of chlorinated solvents in groundwater east of location 014G0007, where chlorinated solvents were detected by the onsite laboratory. The additional location was 014S0013/014G0013.

Eleven soil samples were collected from 5 to 7 feet bls at locations 014S0005 through 014S0015. These DPT soil and groundwater sampling locations are shown on Figure 8.3.1. Groundwater



LEGEND

014S0008
014G0008 — DPT SOIL AND GROUNDWATER SAMPLING LOCATION

FORMER BUILDING OR FEATURE

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.1
DPT SOIL AND GROUNDWATER SAMPLE LOCATIONS
SWMU 14 - BUILDING S-140 AND
SEVENTH AVENUE DRAINAGE DITCH

samples were collected from the loess (between 9 and 12 feet bls) and fluvial deposits (between 36 and 45 feet bls) at each location with the following exceptions:

- No loess groundwater samples were collected from locations 014S0006, 014S0013, and 014S0015, because no groundwater entered the hydrocone groundwater sampler. As outlined in the RFI work plan, soil samples were collected from 11 to 13 feet bls at these locations (just above the anticipated soil-water interface) to provide analytical data for the interval near the shallow water table.

- No fluvial deposits DPT groundwater samples could be collected from locations 014G0006 and 014G0013, because no groundwater entered the hydrocone groundwater sampler.

The DPT soil and groundwater samples were transported directly to Hydrologic's onsite mobile laboratory for VOC analyses using SW-846 Method 8021. As specified in the *Assembly E Site Investigation Plans* (E/A&H, 1995a) 25% of the DPT soil and groundwater samples were split and submitted to the offsite laboratory (NET) for confirmation analysis by SW-846 Method 8240. The results of the confirmation samples are discussed in Sections 8.3.3.1 and 8.3.4.1.

Confirmation Samples

- Four 5- to 7-foot interval soil samples
  - 014S0005
  - 014S0009
  - 014S0010
  - 014S0012

- One 11- to 13-foot interval soil sample (014S0015)

- One loess groundwater sample (014G0010)

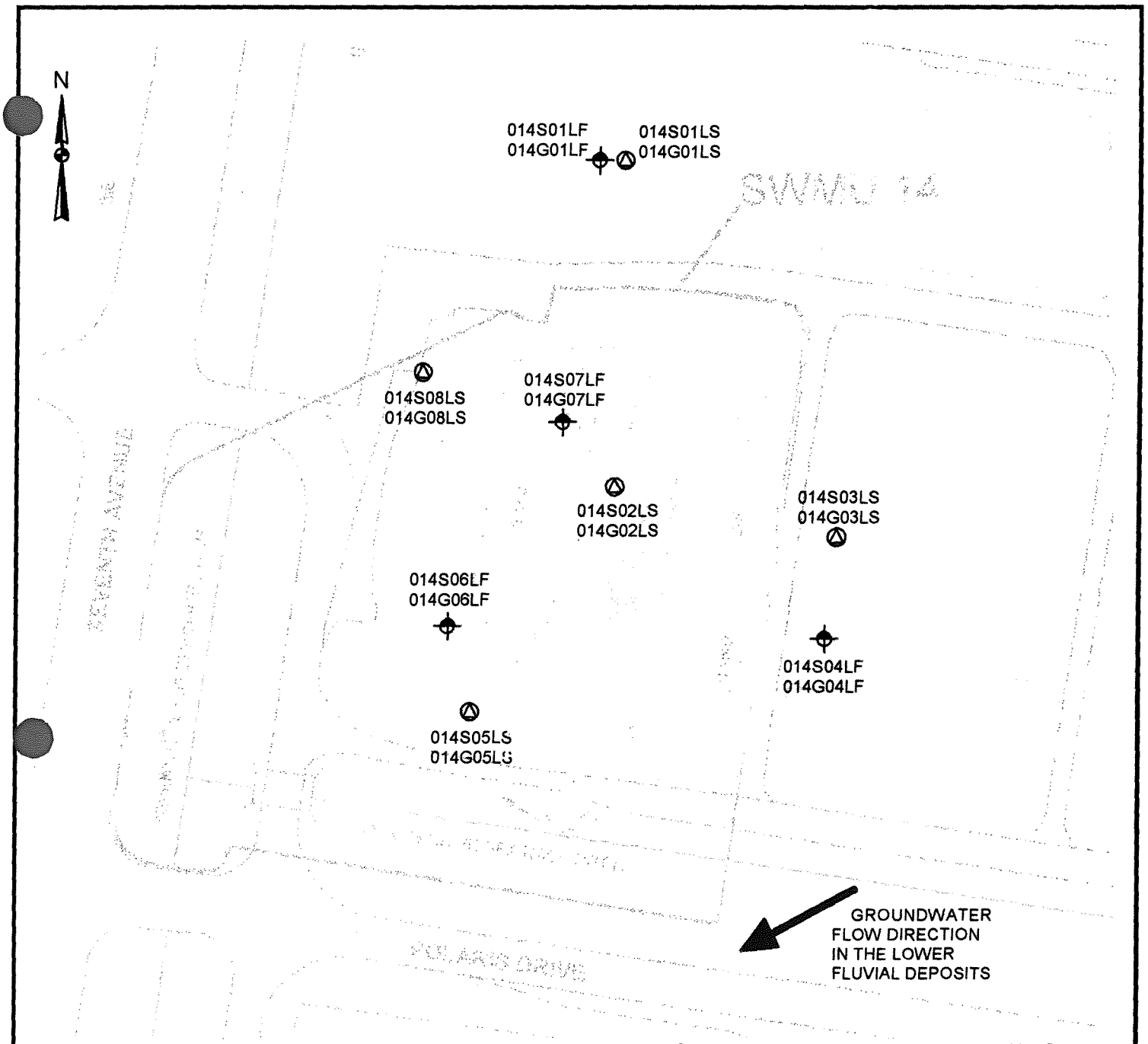
- Three fluvial deposits groundwater samples
  - 014G0007
  - 014G0008
  - 014G0011

Although Methods 8021 (Gas Chromatograph/Electrolytic Conductivity Detector) and 8240 (Gas Chromatograph/Mass Spectrometry) both analyze for VOCs, the compound lists differ slightly. Refer to the analytical data in the Attachment of the *Data Validation Report — Assembly E* (E/A&H, 1997a) for a complete list of analytical compounds for each VOC test method.

8.3.2.2 Soil Boring and Monitoring Wells

Based on the DPT investigation results, the optimal number, placement, and depth of the RFI soil borings and groundwater monitoring wells were determined. The soil borings and monitoring wells were placed to adequately characterize the nature and extent of chlorinated solvent contamination in groundwater that was identified during the DPT screening investigation, and to provide a geologic cross section of SWMU 14 loess and fluvial deposits. Figure 8.3.2 shows the soil boring and monitoring well locations.

Five soil borings (014S01LS, 014S02LS, 014S03LS, 014S05LS, and 014S08LS) were advanced to a depth of 20 feet bls in the loess (20.4 feet bls for soil boring 014S01LS). Corresponding loess groundwater monitoring wells were installed in the open boreholes, with screened intervals ranging from 10 to 20 feet bls (10.4 to 20.4 feet bls for monitoring well 014G04LS). Soil boring/monitoring well 014S02LS/014G02LS was placed near the area where the highest chlorinated solvent contamination was identified during the DPT screening investigation. The



LEGEND

014S08LS
014G08LS — LOESS SOIL BORING/MONITORING WELL LOCATION AND DESIGNATION

014S06LF
014G06LF — LOWER FLUVIAL DEPOSITS SOIL BORING/MONITORING WELL LOCATION AND DESIGNATION

FORMER BUILDING OR FEATURE

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FIGURE 8.3.2
SOIL BORING AND MONITORING WELL LOCATIONS
SWMU 14 - BUILDING S-140 AND
SEVENTH AVENUE DRAINAGE DITCH

remainder of the soil borings/monitoring wells were placed around this area to define the lateral extent of chlorinated solvent contamination in the loess.

Four soil borings (014S01LF, 014S04LF, 014S06LF, and 014S07LF) were advanced through the loess and fluvial deposits to the top of the Cockfield Formation, encountered at depths ranging from 47 to 50 feet bls. The corresponding lower fluvial deposits groundwater monitoring wells (014G01LF, 014G04LF, 014G06LF, and 014G07LF) were generally screened in the basal 10 feet of the lower fluvial deposits just above the Cockfield Formation, encountered at depths ranging from 47 to 49 feet bls. These wells were placed to surround the area at which the highest concentrations of chlorinated solvents were identified during DPT screening to determine if the solvents had migrated from the loess to the underlying fluvial deposits.

The following intervals were sampled in each soil boring: 0.5 to 2 feet, 4 to 6 feet, and 8 to 10 feet bls. In order to obtain enough sample volume for analysis, the surface soil samples were collected from 0 to 2 feet bls at each location; however, the uppermost portion of each surface soil sample, which contained organic material, roots, grass, gravel, and brick fragments, was discarded, yielding an approximate surface soil sample interval of 0.5 to 2 feet bls. In accordance with the RFI work plan, 10% of the soil samples were split as duplicates: one 4- to 6-foot interval sample from location 014S05LS and three 8- to 10-foot interval samples from locations 014S01LS, 014S02LS, and 014S03LS. The primary and duplicate soil samples were submitted to NET for FSA. Table 3.1 lists the analytical test methods used for each soil sample, and the Attachment of the *Data Validation Report — Assembly E* (E/A&H, 1997a) lists reported analytes for each test method.

The monitoring wells were purged and sampled in April 1996, several weeks after monitoring well installation and development. All groundwater samples were submitted to NET for FSA excluding TPH-GRO, since TICs from the VOC analyses would identify many of the lighter fraction

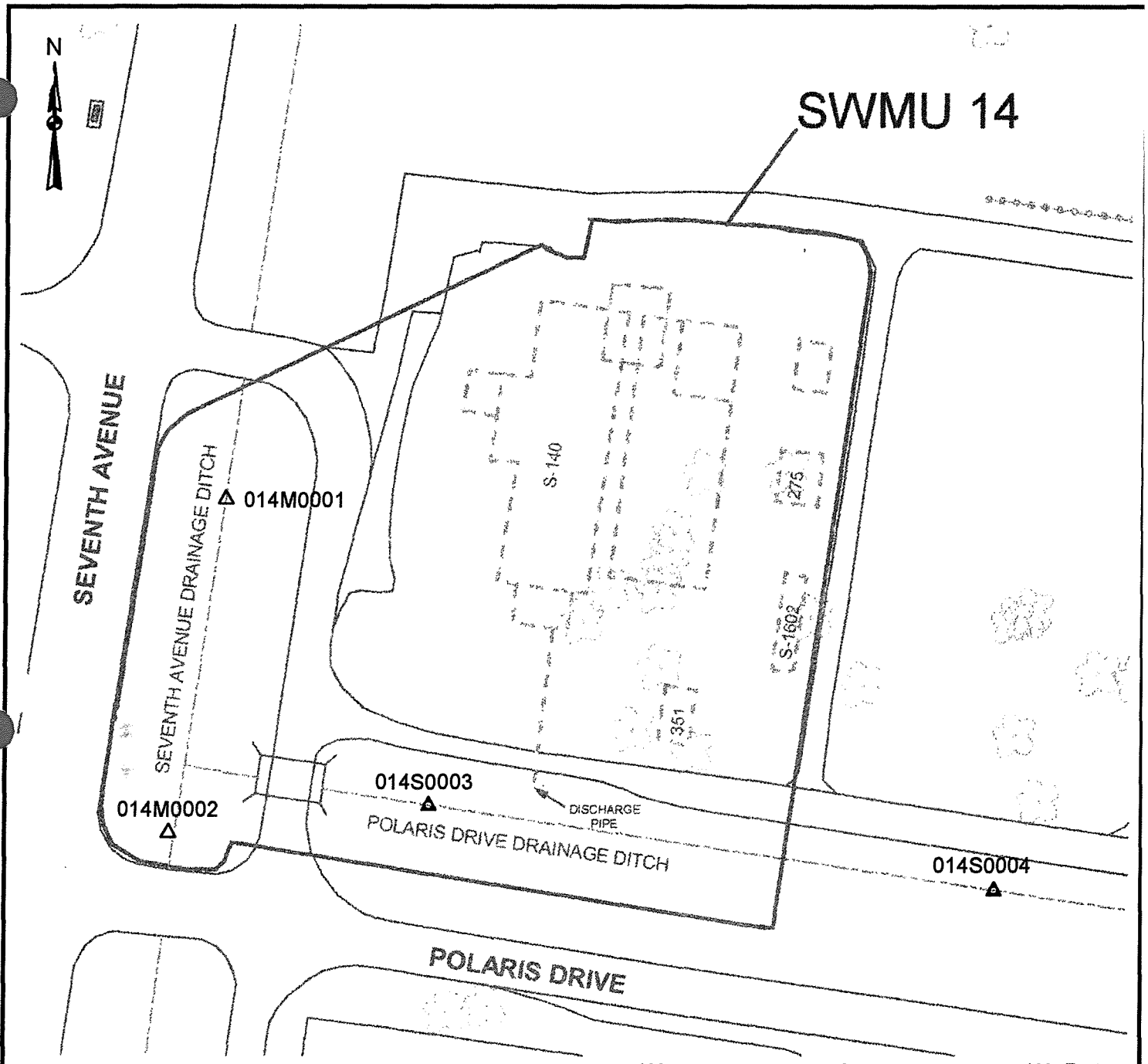
hydrocarbons, if present. The Assembly E work plan stated that 10% of the groundwater samples collected during the Assembly E investigation would be split for duplicate analysis. Groundwater was sampled at SWMU 14 at the same time as groundwater sampling at other Assembly E SWMUs, with duplicate and other QA/QC groundwater samples collected assembly-wide rather from individual SWMUs, i.e., 10% of the samples collected from all Assembly E SWMUs were split as duplicates. One SWMU 14 lower fluvial deposits groundwater sample (014G01LF) was split as a duplicate during assembly-wide sampling.

8.3.2.3 Soil and Sediment Samples from Drainage Ditches

Soil and sediment samples were collected from the drainage ditches west and south of SWMU 14 to determine the presence of any residual contaminants associated with past SWMU 14 operations. The soil and sediment samples were collected with a stainless-steel hand auger from the surface interval (0 to 6 inches bls) and from 18 to 24 inches bls at each sampling location. Sediment samples were collected from the Seventh Avenue drainage ditch from two locations (014M0001 and 014M0002). The *Assembly E Site Investigation Plans* (E/A&H, 1995a) originally proposed the collection of sediment samples from two locations in the Polaris Drive drainage ditch; however, this ditch is primarily lined with concrete. Samples were collected in the ditch above the concrete lining near the outfall (location 014S0003) and upgradient of the outfall (location 014S0004). Since these samples were collected in the upper portion of the ditch that rarely is submerged, they were designated as soil samples and evaluated accordingly. Figure 8.3.3 shows soil and sediment sample locations. The surface sediment sample from location 014M0001 was split as a duplicate in accordance with the RFI work plan. The primary and duplicate sediment and soil samples were submitted to NET for FSA.

8.3.3 Nature and Extent of Contamination

The following sections describe the nature and extent of contamination in soil, groundwater, and sediment samples collected during the Assembly E SWMU 14 RFI.



LEGEND

014M0002 — SEVENTH AVENUE DRAINAGE DITCH SEDIMENT SAMPLE LOCATION AND DESIGNATION

014S0003 — POLARIS DRIVE DRAINAGE DITCH SOIL SAMPLE LOCATION AND DESIGNATION

FORMER BUILDING OR FEATURE

NOTE: THE FOLLOWING INTERVALS WERE SAMPLED AT EACH DRAINAGE DITCH SAMPLING LOCATION: 0 TO 6 INCHES AND 18 TO 24 INCHES BELOW LAND SURFACE.

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.3
SOIL AND SEDIMENT SAMPLE LOCATIONS
FROM DRAINAGE DITCHES
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

8.3.3.1 Nature and Extent of Soil Contamination

This section summarizes the nature and extent of contamination in SWMU 14 surface and subsurface soil samples. This discussion includes the results of the DPT subsurface soil samples, surface and subsurface soil samples from soil borings associated with monitoring well installation, and surface and subsurface soil samples from the Polaris Drive drainage ditch south of SWMU 14. The following subsections provide details and rationale for sample locations and intervals sampled.

VOCs, SVOCs, TPH, pesticides/PCBs, herbicides, and Appendix IX metals were detected in surface and/or subsurface soil samples collected during the RFI. Each analyte detected in surface soil was compared to its respective residential RBC, industrial RBC, and SSL or RC. Each detected inorganic concentration was also compared to its established RC to determine if the element occurs naturally or may be related to former SWMU 14 operations.

8.3.3.1.1 Organic Compounds in Soil Samples

VOCs, SVOCs, chlorinated pesticides/PCBs, and herbicides were detected in soil samples. The following sections discuss the detected organic compound concentrations by parameter.

VOCs in DPT Soil Samples

Tetrachloroethene (PCE) was the only VOC identified in the DPT subsurface soil samples analyzed by the onsite laboratory (Method 8021). It was present in the 5- to 7-foot interval samples from locations 014S0007 and 014S0013 (1.51 μg/kg and 2.04 μg/kg, respectively). The detected concentrations did not exceed the SSL (40 μg/kg). Acetone, 2-butanone (MEK), and toluene were detected in several split samples submitted to the offsite laboratory for confirmation analysis. As shown in Table 8.3.1, no detected concentration exceeded its applicable SSL (where available).

Note that the analyte list for Method 8021 used for onsite analyses does not include acetone and 2-butanone; however, Method 8240, used by the offsite laboratory, does analyze for these compounds. Although acetone and 2-butanone are common laboratory artifacts, both are constituents of paint removers and solvents and therefore cannot be solely attributed to laboratory contamination.

Table 8.3.1
Detected Concentrations of VOCs in DPT Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Sample Location[a]	Interval[b]	Onsite Lab Result[c]	Offsite Lab Result[d]	SSL[e]
2-Butanone	014S0009	5 - 7'	DNA[f]	4	—[g]
Acetone	014S0005	5 - 7'	DNA	340	8,000
	014S0009	5 - 7'	DNA	250	
	014S0010	5 - 7'	DNA	410	
	014S0012	5 - 7'	DNA	920	
	014S0015	11 - 13'	DNA	36	
Tetrachloroethene	014S0007	5 - 7'	1.51	NA[h]	40
	014S0013	5 - 7'	2.04	NA	
Toluene	014S0009	5 - 7'	ND[i]	1	5,000

Notes:

a — Fourteen soil samples were collected from the loess during the DPT screening investigation. Eleven samples were from the 5- to 7-foot interval, and three samples were from the 11- to 13-foot interval (where a loess groundwater sample could not be collected). The samples were analyzed by the onsite laboratory for VOCs by SW-846 Method 8021. Five of the soil samples were split and submitted for offsite laboratory confirmation analysis by SW-846 Method 8240.

b — Intervals shown are in feet below land surface.

c — Hydrologic, Inc., of Travelers Rest, South Carolina, provided onsite laboratory services for primary samples.

d — NET of Cambridge, Massachusetts, provided offsite laboratory services for confirmation analysis.

e — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — DNA denotes the analytical test method used does not analyze for this compound.

g — denotes SSL value is not available for this analyte; therefore, no comparison can be made.

h — NA denotes sample was not split for confirmation analysis; therefore, it was not analyzed by the offsite laboratory.

i — ND denotes analyte was not detected.

VOCs in Soil Samples

The following VOCs were detected in surface and/or subsurface soil samples from the Polaris Drive drainage ditch and from soil borings associated with monitoring well installation:

2-Butanone (MEK)	PCE
4-Methyl-2-Pentanone (MIBK)	Trichloroethene (TCE)
Acetone	Xylenes

Tables 8.3.2 and 8.3.3 summarize detected concentrations of organic compounds, including VOCs, for soil samples collected from the Polaris Drive drainage ditch and soil samples from soil borings. As shown on these tables, no detected VOC in surface soil exceeded its residential RBC. Acetone was the only VOC to exceed its applicable SSL in surface or subsurface soil. Although present at both soil sampling locations in the Polaris Drive drainage ditch, it exceeded its SSL (8,000 μg/kg) only in the surface soil (0 to 6 inches bls) sample collected from location 014S0004 (16,000 μg/kg).

SVOCs in Soil Samples

The following SVOCs were detected in soil samples from the Polaris Drive drainage ditch and soil borings associated with monitoring well installation:

2-Methylnaphthalene	Carbazole
Acenaphthene	Chrysene
Acenaphthylene	Di-n-octyl phthalate
Anthracene	Dibenz(a,h)anthracene
Benzo(a)anthracene	Dibenzofuran
Benzo(a)pyrene	Fluoranthene
Benzo(b)fluoranthene	Fluorene
Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene	Naphthalene
bis(2-Ethylhexyl)phthalate (BEHP)	Phenanthrene
Butylbenzylphthalate	Pyrene

Table 8.3.2
Detected Concentrations of Organic Compounds in Polaris Drive Drainage Ditch Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
VOCs										
2-Butanone (MEK)	0 - 6"	1/2	1,500	1,500	47,000,000	0	1,000,000,000	0	—[g]	—
4-Methyl-2-Pentanone (MIBK)	0 - 6"	1/2	170	170	6,300,000	0	160,000,000	0	—	—
Acetone	0 - 6"	1/2	16,000	16,000	7,800,000	0	200,000,000	0	8,000	1 (014S0004)
	18 - 24"	2/2	46 - 5,600	2,823	NA[h]	NA	NA	NA	8,000	0
Xylene (Total)	0 - 6"	1/2	18	18	160,000,000	0	1,000,000,000	0	74,000	0
SVOCs										
Benzo(a)anthracene	0 - 6"	1/2	70	70	880	0	7,800	0	700	0
Benzo(a)pyrene	0 - 6"	2/2	59 - 120	90	88	1 (014S0004)	780	0	4,000	0
	18 - 24"	1/2	56	56	NA	NA	NA	NA	4,000	0
Benzo(b)fluoranthene	0 - 6"	2/2	54 - 120	87	880	0	7,800	0	4,000	0
	18 - 24"	1/2	50	50	NA	NA	NA	NA	4,000	0
Benzo(g,h,i)perylene	0 - 6"	2/2	57 - 89	73	3,100,000[i]	0	82,000,000[i]	0	—	—
Benzo(k)fluoranthene	0 - 6"	2/2	53 - 110	82	8,800	0	78,000	0	4,000	0
	18 - 24"	1/2	50	50	NA	NA	NA	NA	4,000	0
bis(2-Ethylhexyl)phthalate (BEHP)	18 - 24"	1/2	10,000	10,000	NA	NA	NA	NA	11,000	0
Butylbenzylphthalate	0 - 6"	2/2	50 - 74	62	16,000,000	0	410,000,000	0	68,000	0
	18 - 24"	1/2	270	270	NA	NA	NA	NA	68,000	0
Chrysene	0 - 6"	2/2	56 - 110	83	88,000	0	780,000	0	1,000	0
	18 - 24"	1/2	57	57	NA	NA	NA	NA	1,000	0
Fluoranthene	0 - 6"	2/2	51 - 75	63	3,100,000	0	82,000,000	0	980,000	0
	18 - 24"	1/2	58	58	NA	NA	NA	NA	980,000	0
Indeno(1,2,3-cd)pyrene	0 - 6"	2/2	44 - 74	59	880	0	7,800	0	35,000	0

Table 8.3.2
Detected Concentrations of Organic Compounds in Polaris Drive Drainage Ditch Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
SVOCs										
Naphthalene	18 - 24"	1/2	380	380	NA	NA	NA	NA	30,000	0
Pyrene	0 - 6"	2/2	51 - 92	72	2,300,000	0	61,000,000	0	1,400,000	0
	18 - 24"	1/2	62	62	NA	NA	NA	NA	1,400,000	0
Total Petroleum Hydrocarbons										
TPH-DRO	0 - 6"	2/2	8,300 - 12,000	10,150	—	—	—	—	500,000[g]	0
	18 - 24"	2/2	7,700 - 10,000	8,850	NA	NA	NA	NA	500,000	0
TPH-GRO	0 - 6"	2/2	85 - 110	98	—	—	—	—	500,000	0
	18 - 24"	1/2	66	66	NA	NA	NA	NA	500,000	0
Total TPH	0 - 6"	2/2	8,385 - 12,110	10,248	—	—	—	—	500,000	0
	18 - 24"	2/2	7,785 - 10,066	8,926	NA	NA	NA	NA	500,000	0
Pesticides/PCBs										
4,4'-DDD	0 - 6"	1/2	24	24	2,700	0	24,000	0	700	0
	18 - 24"	1/2	9	9	NA	NA	NA	NA	700	0
4,4'-DDE	0 - 6"	1/2	21	21	1,900	0	17,000	0	500	0
	18 - 24"	2/2	2.2 - 7.5	4.9	NA	NA	NA	NA	500	0
4,4'-DDT	0 - 6"	1/2	28	28	1,900	0	17,000	0	1,000	0
	18 - 24"	1/2	3	3	NA	NA	NA	NA	1,000	0
Aldrin	0 - 6"	2/2	5.7 - 6	6	38	0	340	0	5	2 (014S0003, 014S0004)
	18 - 24"	2/2	1.7 - 2.2	2	NA	NA	NA	NA	5	0
Dieldrin	0 - 6"	2/2	24 - 39	32	40	0	360	0	1	2 (014S0003, 014S0004)
	18 - 24"	2/2	5.1 - 20	13	NA	NA	NA	NA	1	2 (014S0003, 014S0004)

Table 8.3.2
Detected Concentrations of Organic Compounds in Polaris Drive Drainage Ditch Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Herbicides										
2,4-DB	0 - 6"	2/2	44 - 51	48	630,000	0	16,000,000	0	—	—
	18 - 24"	1/2	7.5	7.5	NA	NA	NA	NA	—	—
MCPP	0 - 6"	2/2	1,900 - 3,000	2,450	78,000	0	2,000,000	0	—	—
	18 - 24"	2/2	570 - 2,200	1,385	NA	NA	NA	NA	—	—

Notes:

a — Four soil samples were collected with a stainless-steel hand auger from two locations in the Polaris Drive drainage ditch south of SWMU 14. The 0- to 6-inch interval and the 18- to 24-inch interval were sampled at each location. The samples were analyzed by the offsite laboratory for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.
b — Intervals shown are in inches below land surface
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply for comparison to data from samples collected across the surface interval.
f — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
g — denotes RBC or SSL is not available for this analyte; therefore, no comparison can be made.
h — NA denotes RBC comparison is not applicable for this subsurface sample.
i — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene, which does not have RBCs.
j — No RBC or SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

Table 8.3.3
Detected Concentrations of Organic Compounds in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[a]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
VOCs										
4-Methyl-2-Pentanone (MIBK)	8 - 10'	1/8	1	1	NA[g]	NA	NA	NA	—[h]	—
Acetone	0 - 2'	2/8	14 - 69	42	7,800,000	0	200,000,000	0	8,000	0
	4 - 6'	4/8	6 - 47	19	NA	NA	NA	NA	8,000	0
	8 - 10'	3/8	3 - 5	4	NA	NA	NA	NA	8,000	0
Tetrachloroethene (PCE)	0 - 2'	1/8	2	2	12,000	0	110,000	0	40	0
	4 - 6'	1/8	8	8	NA	NA	NA	NA	40	0
	8 - 10'	1/8	23	23	NA	NA	NA	NA	40	0
Trichloroethene (TCE)	4 - 6'	1/8	3	3	NA	NA	NA	NA	20	0
	8 - 10'	1/8	19	19	NA	NA	NA	NA	20	0
Xylene (Total)	0 - 2'	1/8	3	3	160,000,000	0	1,000,000,000	0	74,000	0
	4 - 6'	3/8	2 - 3	3	NA	NA	NA	NA	74,000	0
	8 - 10'	1/8	1	1	NA	NA	NA	NA	74,000	0
SVOCs										
2-Methylnaphthalene	0 - 2'	1/8	120	120	3,100,000[i]	0	82,000,000[i]	0	300,000	0
Acenaphthene	0 - 2'	1/8	98	98	4,700,000	0	120,000,000	0	200,000	0
Acenaphthylene	0 - 2'	1/8	59	59	3,100,000[i]	0	82,000,000[i]	0	—	—
Anthracene	0 - 2'	2/8	53 - 380	217	23,000,000	0	610,000,000	0	4,300,000	0
	4 - 6'	1/8	44	44	NA	NA	NA	NA	4,300,000	0
Benzo(a)anthracene	0 - 2'	4/8	47 - 560	201	880	0	7,800	0	700	0
	4 - 6'	1/8	84	84	NA	NA	NA	NA	700	0

Table 8.3.3
Detected Concentrations of Organic Compounds in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[a]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
SVOCs										
Benzo(a)pyrene	0 - 2'	4/8	62 - 560	213	88	3 (014S02LS, 014S03LS, 014S04LF)	780	0	4,000	0
	4 - 6'	1/8	65	65	NA	NA	NA	NA	4,000	0
Benzo(b)fluoranthene	0 - 2'	4/8	63 - 550	213	880	0	7,800	0	4,000	0
	4 - 6'	1/8	58	58	NA	NA	NA	NA	4,000	0
Benzo(g,h,i)perylene	0 - 2'	4/8	59 - 420	182	3,100,000[b]	0	82,000,000[b]	0	—	—
	4 - 6'	1/8	44	44	NA	NA	NA	NA	—	—
Benzo(k)fluoranthene	0 - 2'	4/8	51 - 480	190	8,800	0	78,000	0	4,000	0
	4 - 6'	1/8	61	61	NA	NA	NA	NA	4,000	0
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 2'	5/8	44 - 2,000	717	46,000	0	410,000	0	11,000	0
	4 - 6'	1/8	68	68	NA	NA	NA	NA	11,000	0
Butylbenzylphthalate	0 - 2'	2/8	120 - 450	285	16,000,000	0	410,000,000	0	68,000	0
Carbazole	0 - 2'	1/8	230	230	32,000	0	290,000	0	500	0
Chrysene	0 - 2'	4/8	60 - 620	225	88,000	0	780,000	0	1,000	0
	4 - 6'	1/8	77	77	NA	NA	NA	NA	1,000	0
Di-n-octyl phthalate	4 - 6'	1/8	450	450	NA	NA	NA	NA	1,000,000,000	0
Dibenz(a,h)anthracene	0 - 2'	2/8	40 - 130	85	88	1 (014S04LF)	780	0	11,000	0
Dibenzofuran	0 - 2'	1/8	190	190	310,000	0	8,200,000	0	120,000	0
Fluoranthene	0 - 2'	4/8	55 - 1,500	466	3,100,000	0	82,000,000	0	980,000	0
	4 - 6'	1/8	210	210	NA	NA	NA	NA	980,000	0
Fluorene	0 - 2'	1/8	260	260	3,100,000	0	82,000,000	0	160,000	0
Indeno(1,2,3-cd)pyrene	0 - 2'	4/8	48 - 360	146	880	0	7,800	0	35,000	0
Naphthalene	0 - 2'	1/8	390	390	3,100,000	0	82,000,000	0	30,000	0

Table 8.3.3
Detected Concentrations of Organic Compounds in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[a]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
SVOCs										
Phenanthrene	0 - 2'	2/8	250 - 1,500	875	3,100,000[g]	0	82,000,000[g]	0	—	—
	4 - 6'	1/8	220	220	NA	NA	NA	NA	—	—
Pyrene	0 - 2'	4/8	62 - 1,200	391	2,300,000	0	61,000,000	0	1,400,000	0
	4 - 6'	1/8	190	190	NA	NA	NA	NA	1,400,000	0
Total Petroleum Hydrocarbons										
TPH-DRO	0 - 2'	1/8	31,000	31,000	—	—	—	—	500,000[h]	0
TPH-GRO	0 - 2'	1/8	200	200	—	—	—	—	500,000	0
	4 - 6'	1/8	140	140	NA	NA	NA	NA	500,000	0
	8 - 10'	2/8	97 - 170	134	NA	NA	NA	NA	500,000	0
Total TPH	0 - 2'	2/8	200 - 31,000	15,600	—	—	—	—	500,000	0
	4 - 6'	1/8	140	140	NA	NA	NA	NA	500,000	0
	8 - 10'	2/8	97 - 170	134	NA	NA	NA	NA	500,000	0
Pesticides/PCBs										
4,4'-DDE	0 - 2'	6/8	2.8 - 49	18	1,900	0	17,000	0	500	0
4,4'-DDT	0 - 2'	5/8	4.8 - 71	32	1,900	0	17,000	0	1,000	0
Aldrin	0 - 2'	2/8	1.2 - 8.4	4.8	38	0	340	0	5	1 (014S04LF)
alpha-Chlordane	0 - 2'	4/8	1.6 - 26	8.2	1,825	0	16,352	0	2,000	0
Aroclor-1260	0 - 2'	1/8	31	31	320[i]	0	2,850[i]	0	—	—
Dieldrin	0 - 2'	7/8	6.2 - 91	30	40	2 (014S02LS, 014S04LF)	360	0	1	7 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S06LF, 014S07LF, 014S08LS)
gamma-Chlordane	0 - 2'	3/8	1.1 - 22	9	1,825	0	16,352	0	2,000	0
Heptachlor epoxide	0 - 2'	3/8	1.1 - 6.6	3.6	70	0	630	0	30	0
Technical Chlordane	0 - 2'	1/8	160	160	1,825	0	16,352	0	2,000	0

Table 8.3.3
Detected Concentrations of Organic Compounds in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[a]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Herbicides										
2,4,5-TP (Silvex)	0 - 2'	1/8	24	24	630,000	0	16,000,000	0	—	—
2,4-D	0 - 2'	1/8	9.8	9.8	780,000	0	20,000,000	0	1,700	0
2,4-DB	4 - 6'	1/8	160	160	NA	NA	NA	NA	—	—
Dichlorprop	0 - 2'	1/8	4.8	4.8	—	—	—	—	—	—
Dinoseb	8 - 10'	1/8	2.6	2.6	NA	NA	NA	NA	—	—
MCPA	0 - 2'	1/8	1,100	1,100	39,000	0	1,000,000	0	—	—
MCPP	0 - 2'	1/8	5,800	5,800	78,000	0	2,000,000	0	—	—
	4 - 6'	2/8	2,200 - 4,600	3,400	NA	NA	NA	NA	—	—
	8 - 10'	1/8	5,900	5,900	NA	NA	NA	NA	—	—

Notes:

a — Twenty-four soil samples were collected from eight soil boring locations. The samples were collected from 0 to 2 feet, 4 to 6 feet, and 8 to 10 feet below land surface and analyzed for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.

b — Intervals shown are in feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs apply only for comparison to data from samples collected across the surface interval.

f — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

g — denotes RBC or SSL is not available for this analyte; therefore, no comparison can be made.

h — NA denotes RBC comparison is not applicable for this subsurface sample.

i — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.

j — The RBCs for naphthalene were used as a surrogate for 2-methylnaphthalene and acenaphthalene which do not have RBCs.

k — No RBC or SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

l — The slope factor for PCBs was updated in IRIS in October 1996. Consequently, the RBCs were recalculated using this updated information.

Tables 8.3.2 and 8.3.3 summarize the detected SVOC concentrations in Polaris Drive drainage ditch samples and soil samples from soil borings associated with monitoring well installation. Figure 8.3.4 plots SVOC concentrations in surface soil that exceeded their respective RBCs. As shown in the tables, no detected SVOC in surface soil exceeded its industrial RBC, and no detected SVOC in any soil sample exceeded its SSL. However, the following two SVOCs exceeded their residential RBCs:

Benzo(a)pyrene's residential RBC (88 μg/kg) was exceeded in one surface soil sample from the Polaris Drive ditch (014S0004, 120 μg/kg) and in three surface soil samples from soil borings associated with monitoring well installation: 014S02LS (100 μg/kg), 014S03LS (130 μg/kg), and 014S04LF (560 μg/kg).

Dibenz(a,h)anthracene's residential RBC (88 μg/kg) was exceeded in the surface soil sample from soil boring 014S04LF (130 μg/kg).

TPH in Soil Samples

TPH-GRO and TPH-DRO were detected in many SWMU 14 soil samples. The USEPA has not established an RBC or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers (i.e., the loess) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface soil. As shown in Tables 8.3.2 and 8.3.3, the TDEC cleanup standard was not exceeded by the total TPH concentration in any sample.

Pesticides/PCBs in Soil Samples

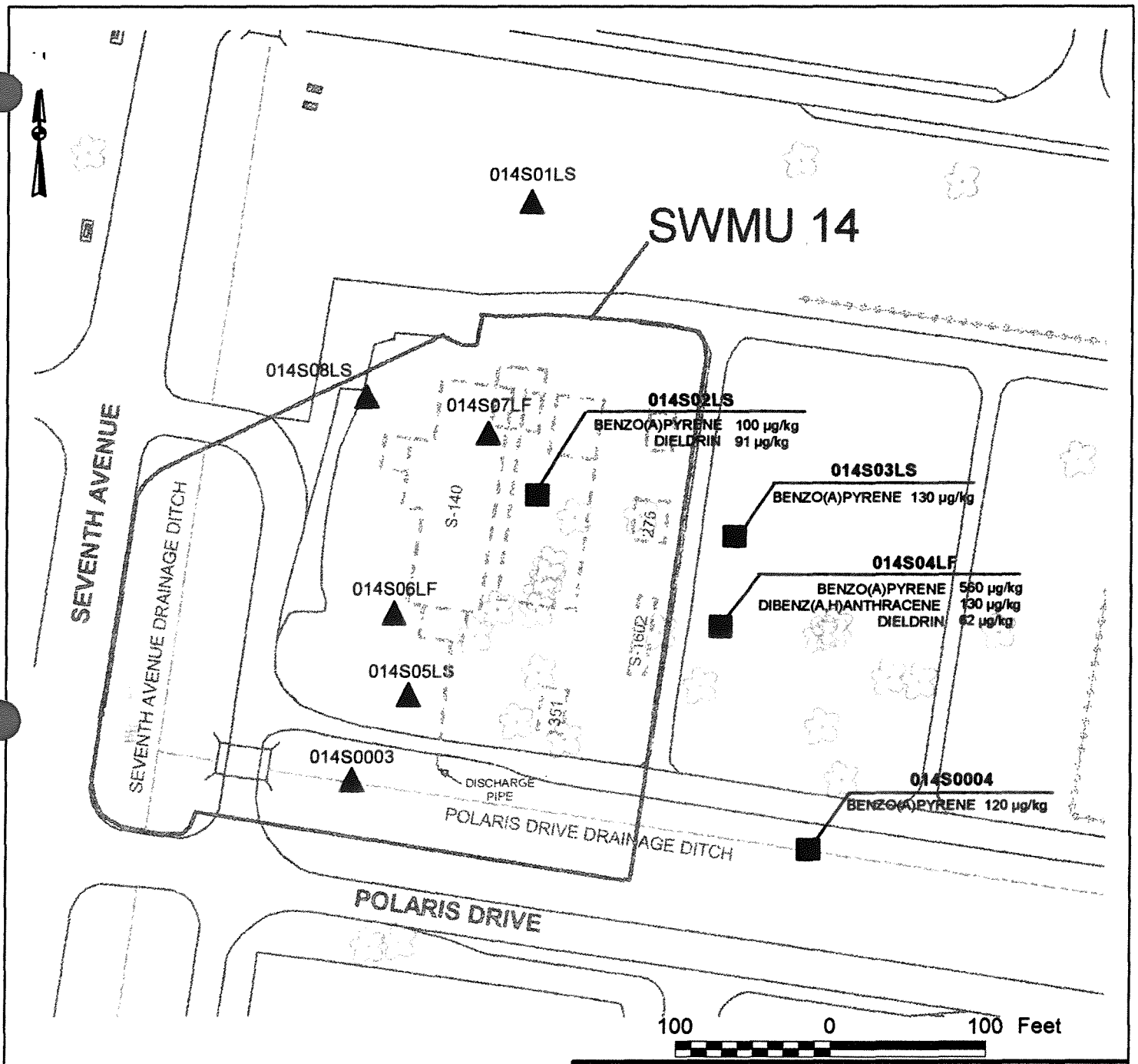
The following pesticides/PCBs were detected in soil samples from the Polaris Drive drainage ditch and soil borings associated with monitoring well installation:

4,4'-DDD	alpha-Chlordane
4,4'-DDE	gamma-Chlordane
4,4'-DDT	Dieldrin
Aldrin	Heptachlor epoxide
Aroclor-1260	Technical chlordane

As shown in Tables 8.3.2 and 8.3.3, no PCB exceeded its respective residential RBC or SSL, and no pesticide exceeded its respective industrial RBC. Aldrin and dieldrin were the only pesticides that exceeded their applicable residential RBCs and/or SSLs, as summarized below. Figure 8.3.4 plots the surface soil RBC exceedances, and Figure 8.3.5 plots the SSL exceedances in both surface and subsurface soil samples.

Aldrin's SSL (5 μg/kg) was exceeded in the 0- to 6-inch interval surface soil samples from the Polaris Drive drainage ditch (014S0003 [6 μg/kg] and 014S0004 [5.7 μg/kg]), and the 0.5- to 2-foot interval surface soil sample from soil boring 014S04LF (8.4 μg/kg).

Dieldrin's residential RBC (40 μg/kg) was exceeded in surface soil samples from the following soil boring locations: 014S02LS (91 μg/kg) and 014S04LF (62 μg/kg). Figure 8.3.4 plots the RBC exceedances for dieldrin. Dieldrin's SSL value (1 μg/kg) was exceeded in both intervals of the two Polaris Drive drainage ditch sampling locations. The 0- to 6-inch interval samples from locations 014S0003 and 014S0004 were 39 μg/kg and 24 μg/kg; the 18- to 24-inch interval samples exhibited concentrations of 20 μg/kg and 5.1 μg/kg. The SSL was also exceeded in surface soil (0.5- to 2-foot interval) from seven of the eight soil boring locations: 014S01LS (14 μg/kg), 014S02LS (91 μg/kg), 014S03LS (6.5 μg/kg), 014S04LF (62 μg/kg), 014S06LF (11 μg/kg), 014S07LF (6.2 μg/kg), and 014S08LS (16 μg/kg). No detected dieldrin concentration in surface soil exceeded its RC (262 μg/kg) established in the *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d).



LEGEND

▲ NO CONSTITUENT IN SURFACE SOIL EXCEEDED THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

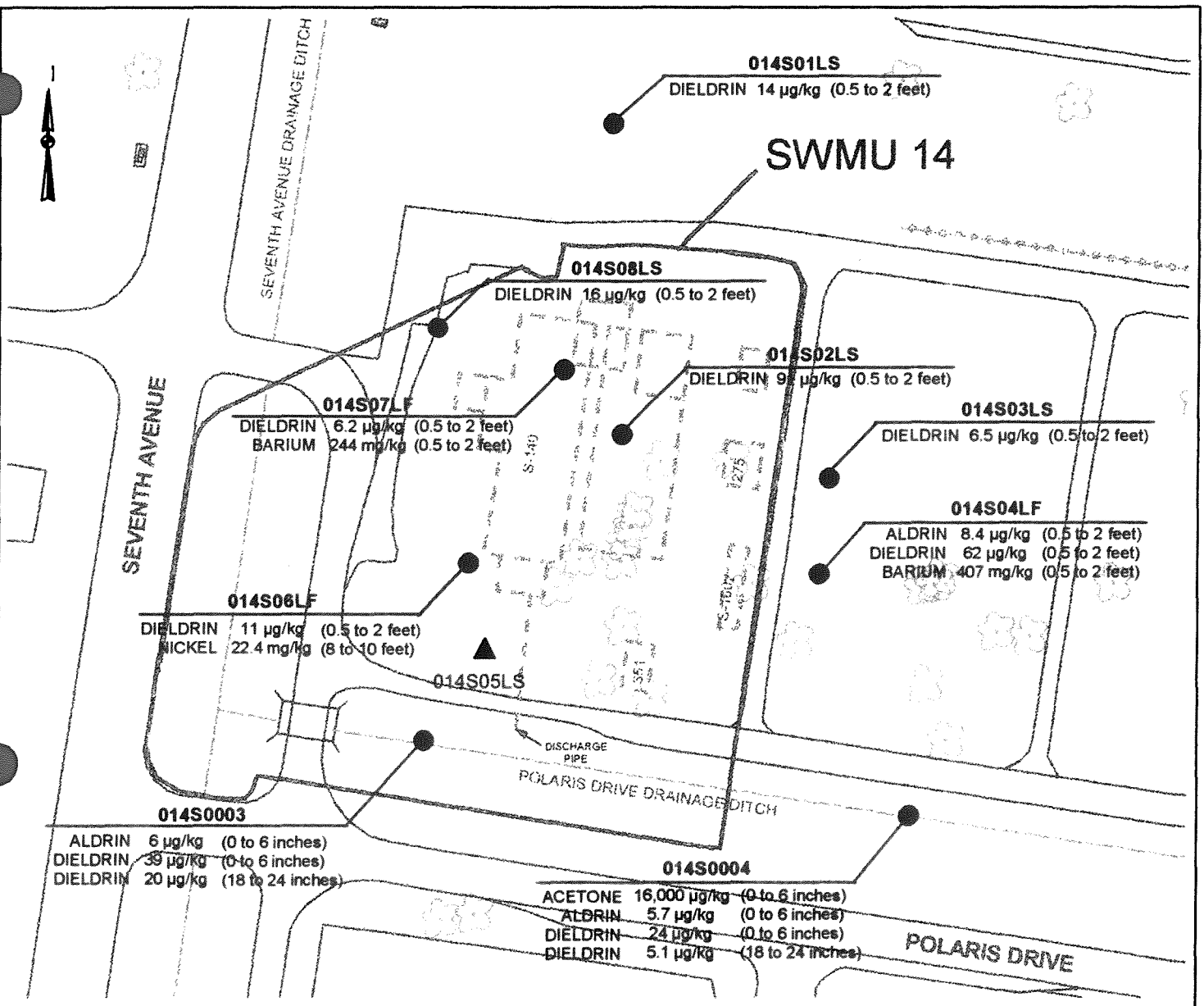
■ ONE OR MORE CONSTITUENTS IN SURFACE SOIL EXCEEDED THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

014S0003 — SURFACE SOIL (0 - 6") SAMPLE DESIGNATION; SAMPLE COLLECTED FROM THE POLARIS DRIVE DRAINAGE DITCH

I4S02LS — SURFACE SOIL (0 .5 - 2') SAMPLE DESIGNATION; SAMPLE COLLECTED WITH THE ROTASONIC DRILLING RIG AT MONITORING WELL LOCATIONS

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.4
RBC EXCEEDANCES IN SURFACE SOIL SAMPLES
SWMU 14 - BUILDING S-140 AND
SEVENTH AVENUE DITCH



LEGEND

▲ NO CONSTITUENT IN ANY SOIL SAMPLE FROM THIS SOIL BORING EXCEEDED ITS SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN A SOIL SAMPLE FROM THIS SOIL BORING EXCEEDED ITS SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

014S06LF

DIELDRIN 11 µg/kg (0.5 to 2 feet)
NICKEL 22.4 mg/kg (8 to 10 feet)

THE FOLLOWING CONSTITUENTS IN SOIL SAMPLES FROM SOIL BORING 014S06LF EXCEEDED THEIR RESPECTIVE SSLs (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE): 11 µg/kg DIELDRIN IN THE SAMPLE FROM 0.5 TO 2 FEET BELOW LAND SURFACE, AND 22.4 mg/kg NICKEL IN THE SAMPLE FROM 8 TO 10 FEET BELOW LAND SURFACE.

µg/kg MICROGRAMS PER KILOGRAM

mg/kg MILLIGRAMS PER KILOGRAM

100 0 100 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.5
SOIL TO GROUNDWATER SSL EXCEEDANCES IN SOIL BORING AND POLARIS DRIVE DRAINAGE DITCH SOIL SAMPLES
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

Herbicides in Soil

The following herbicides were detected in soil samples from the Polaris Drive drainage ditch and soil borings associated with monitoring well installation:

2,4-D	Dinoseb
2,4-DB	MCPA
2,4,5-TP (Silvex)	MCPP
Dichlorprop	

As shown in Tables 8.3.2 and 8.3.3, no herbicide in any surface soil sample exceeded its residential RBC. None of the herbicides detected in RFI samples exceeded available SSLs.

8.3.3.1.2 Inorganics in Soil Samples

The following inorganics were detected in RFI soil samples:

Antimony	Lead
Arsenic	Mercury
Barium	Nickel
Beryllium	Selenium
Cadmium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc

Tables 8.3.4 and 8.3.5 summarize the inorganics in the surface and subsurface soil samples collected from the Polaris Drive drainage ditch and soil borings associated with monitoring well installation, respectively. As shown in these tables, barium was the only inorganic in surface soil to exceed both its background RC and residential RBC or SSL. Nickel was the only inorganic in subsurface soil to exceed both its background RC and SSL. Figure 8.3.4 plots the inorganic concentrations in surface soil that exceeded both the RC and RBC. Figure 8.3.5 plots inorganic concentrations in surface and subsurface soil that exceeded both the RC and SSL. The exceedances for these analytes are discussed in the following paragraphs.

Table 8.3.4
Detected Concentrations of Inorganics in Polaris Drive Drainage Ditch Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	Reference Concentration[g]	RC[f] Exceedances
Arsenic	0 - 6"	2/2	6.7 - 10.6	8.7	0.43	2 (014S0003, 014S0004)	3.8	2 (014S0003, 014S0004)	15	0	14.58	0
	18 - 24"	2/2	7.8 - 7.9	7.9	NA[h]	NA	NA	NA	15	0	20.32	0
Barium	0 - 6"	2/2	118 - 141	130	5,500	0	140,000	0	32	2 (014S0003, 014S0004)	223.46	0
	18 - 24"	2/2	152 - 153	153	NA	NA	NA	NA	32	2 (014S0003, 014S0004)	265.12	0
Beryllium	0 - 6"	2/2	0.4 - 0.56	0.5	0.15	2 (014S0003, 014S0004)	1.3	0	180	0	1	0
	18 - 24"	2/2	0.44 - 0.48	0.46	NA	NA	NA	NA	180	0	1	0
Cadmium	0 - 6"	2/2	2.3 - 3.7	3	39	0	1,000	0	6	0	1.54	2 (014S0003, 014S0004)
	18 - 24"	2/2	2.5 - 2.6	2.6	NA	NA	NA	NA	6	0	3.24	0
Chromium	0 - 6"	2/2	10 - 24.2	17	390[i]	0	10,000[i]	0	—[i]	—	23.89	1 (014S0003)
	18 - 24"	2/2	10 - 12	11	NA	NA	NA	NA	—	—	28.28	0
Cobalt	0 - 6"	2/2	6.3 - 8.9	7.6	4,700	0	120,000	0	—	—	15.98	0
	18 - 24"	2/2	7.5 - 8.8	8.2	NA	NA	NA	NA	—	—	14.36	0
Copper	0 - 6"	2/2	15.7 - 17.9	16.8	3,100	0	82,000	0	—	—	24.19	0
	18 - 24"	2/2	14 - 17.1	16	NA	NA	NA	NA	—	—	32.52	0
Lead	0 - 6"	2/2	46.8 - 60.3	53.6	400[i]	0	1,300[i]	0	—	—	26.03	2 (014S0003, 014S0004)
	18 - 24"	2/2	19.8 - 52.7	36.3	NA	NA	NA	NA	—	—	19.8	1 (014S0004)
Nickel	0 - 6"	2/2	11.7 - 15.9	13.8	1,600	0	41,000	0	21	0	20.62	0
	18 - 24"	2/2	15.5 - 17.4	16.5	NA	NA	NA	NA	21	0	ND[h]	2 (014S0003, 014S0004)
Selenium	0 - 6"	2/2	0.31 - 0.54	0.43	390	0	10,000	0	3	0	ND	2 (014S0003, 014S0004)
	18 - 24"	2/2	0.32 - 0.34	0.33	NA	NA	NA	NA	3	0	ND	2 (014S0003, 014S0004)

Table 8.3.4
Detected Concentrations of Inorganics in Polaris Drive Drainage Ditch Soil Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	Reference Concentration[g]	RC[f] Exceedances
Vanadium	0 - 6"	2/2	17.5 - 28.7	23.1	550	0	14,000	0	—	—	45.1	0
	18 - 24"	2/2	19.9 - 20.9	20.4	NA	NA	NA	NA	—	—	43.68	0
Zinc	0 - 6"	2/2	102 - 121	112	23,000	0	610,000	0	42,000	0	98	2 (014S0003, 014S0004)
	18 - 24"	2/2	48.8 - 60.8	54.8	NA	NA	NA	NA	42,000	0	109	0

Notes:

a — Four soil samples were collected with a stainless-steel hand auger from two locations in the Polaris Drive drainage ditch south of SWMU 14. The 0- to 6-inch interval and the 18- to 24-inch interval were sampled. The samples were analyzed by the offsite laboratory for VOCs, SVOCs, TPH-gasoline, TPH-diesel, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.

b — Intervals shown are in inches below land surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply for comparison to data from samples collected across the surface interval.

f — Reference concentration is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

g — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

h — NA denotes RBC comparison is not applicable for this subsurface sample.

i — denotes SSL is not available for this analyte; therefore, no comparison can be made.

j — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 are used for comparison (USEPA, 1994c).

k — ND denotes indicated analyte was not detected in background samples.

l — The RBCs for chromium VI were used as a conservative estimate of risk. Based on past site activities, it is unlikely that the total chromium concentrations reported are comprised of hexavalent chromium, and as such, the SSL for chromium VI was not used.

Table 8.3.5
Detected Concentrations of Inorganics in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[c]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[g]	SSL Exceedances	Reference Concentration[f]	RC[f] Exceedances
Antimony	4 - 6'	2/8	12.3 - 13.8	13.1	NA[h]	NA	NA	NA	—[i]	—	ND[j]	2 (014S05LS, 014S06LF)
	8 - 10'	1/8	8.7	8.7	NA	NA	NA	NA	—	—	ND	1 (014S07LF)
Arsenic	0 - 2'	8/8	5.3 - 9	7	0.43	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)	3.8	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)	15	0	14.58	0
	4 - 6'	8/8	1.8 - 11.3	4.5	NA	NA	NA	NA	15	0	20.32	0
	8 - 10'	8/8	3.2 - 12.5	7.8	NA	NA	NA	NA	15	0	20.32	0
Barium	0 - 2'	8/8	108 - 407	202	5,500	0	140,000	0	32	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)	223.46	2 (014S04LF, 014S07LF)
	4 - 6'	8/8	109 - 208	166	NA	NA	NA	NA	32	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)	265.12	0
	8 - 10'	8/8	103 - 203	143	NA	NA	NA	NA	32	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)	265.12	0
Cadmium	0 - 2'	8/8	1.8 - 3.4	2.4	39	0	1,000	0	6	0	1.54	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)
	4 - 6'	8/8	1.6 - 3.7	2.4	NA	NA	NA	NA	6	0	3.24	1 (014S04LF)
	8 - 10'	8/8	1.6 - 3.6	2.6	NA	NA	NA	NA	6	0	3.24	3 (014S02LS, 014S05LS, 014S08LS)

Table 8.3.5
Detected Concentrations of Inorganics in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[c]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[g]	SSL Exceedances	Reference Concentration[f]	RC[f] Exceedances
Chromium	0 - 2'	8/8	9.5 - 21.1	13.8	390	0	10,000	0	—	—	23.89	0
	4 - 6'	8/8	11 - 16.9	14	NA	NA	NA	NA	—	—	28.28	0
	8 - 10'	8/8	8.8 - 13.4	11.2	NA	NA	NA	NA	—	—	28.28	0
Cobalt	0 - 2'	8/8	4.7 - 19.4	9.2	4,700	0	120,000	0	—	—	15.98	2 (014S03LS, 014S04LF)
	4 - 6'	8/8	3.1 - 6.6	4.9	NA	NA	NA	NA	—	—	14.36	0
	8 - 10'	8/8	5.4 - 8.4	7.1	NA	NA	NA	NA	—	—	14.36	0
Copper	0 - 2'	8/8	12.7 - 24.3	16.3	3,100	0	82,000	0	—	—	24.19	1 (014S03LS)
	4 - 6'	8/8	12.7 - 17.7	14.9	NA	NA	NA	NA	—	—	32.52	0
	8 - 10'	8/8	14.9 - 20	18	NA	NA	NA	NA	—	—	32.52	0
Lead	0 - 2'	8/8	9.7 - 84.9	49.8	400[f]	0	1,300[f]	0	—	—	26.03	6 (014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S08LS)
	4 - 6'	8/8	9.7 - 22.1	14.8	NA	NA	NA	NA	—	—	19.8	2 (014S07LF, 014S08LS)
	8 - 10'	8/8	7.9 - 13	11	NA	NA	NA	NA	—	—	19.8	0
Mercury	0 - 2'	1/8	0.14	0.14	23	0	610	0	3	0	0.46	0
Nickel	0 - 2'	8/8	9.7 - 20.6	14.3	1,600	0	41,000	0	21	0	20.62	0
	4 - 6'	8/8	10.6 - 18.2	13.8	NA	NA	NA	NA	21	0	ND	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)
	8 - 10'	8/8	14.7 - 22.4	17.8	NA	NA	NA	NA	21	1 (014S06LF)	ND	8 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S06LF, 014S07LF, 014S08LS)
Selenium	0 - 2'	1/8	0.61	0.61	390	0	10,000	0	3	0	ND	1 (014S05LS)
Silver	4 - 6'	2/8	0.96 - 4.2	2.6	NA	NA	NA	NA	—	—	ND	2 (014S03LS, 014S05LS)

Table 8.3.5
Detected Concentrations of Inorganics in Soil Samples From Soil Borings Associated With Monitoring Well Installation
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[c]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[g]	SSL Exceedances	Reference Concentration[f]	RC[f] Exceedances
Tin	0 - 2'	5/8	29.3 - 46.2	33.9	47,000	0	1,000,000	0	—	—	33.56	1 (014S05LS)
	4 - 6'	5/8	19.2 - 37.8	29.1	NA	NA	NA	NA	—	—	ND	5 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S08LS)
	8 - 10'	6/8	23.3 - 53.3	34.1	NA	NA	NA	NA	—	—	ND	6 (014S01LS, 014S02LS, 014S03LS, 014S04LF, 014S05LS, 014S08LS)
Vanadium	0 - 2'	8/8	17.8 - 32.1	22.1	550	0	14,000	0	—	—	45.1	0
	4 - 6'	8/8	15.6 - 26.2	19.8	NA	NA	NA	NA	—	—	43.68	0
	8 - 10'	8/8	16.9 - 26.5	21.2	NA	NA	NA	NA	—	—	43.68	0
Zinc	0 - 2'	8/8	45.7 - 113	72	23,000	0	610,000	0	42,000	0	98	1 (014S08LS)
	4 - 6'	8/8	50.9 - 121	66	NA	NA	NA	NA	42,000	0	109	1 (014S08LS)
	8 - 10'	8/8	37.8 - 62.6	54.6	NA	NA	NA	NA	42,000	0	109	0

Notes:

a — Twenty-four soil samples were collected from eight soil boring locations. The samples were collected from 0 to 2 feet, 4 to 6 feet, and 8 to 10 feet below land surface and analyzed for VOCs, SVOCs, TPH-gasoline, TPH-diesel, chlorinated pesticides/PCBs, organophosphorus pesticides, Appendix IX metals, and cyanide.

b — Intervals shown are in feet below land surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs apply only for comparison to data from samples collected across the surface interval.

f — Reference concentration is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

g — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

h — NA denotes RBC comparison is not applicable for this subsurface sample.

i — ND denotes the indicated analyte was not detected in background samples.

j — denotes SSL is not available for this analyte; therefore, no comparison can be made.

k — The RBCs for chromium VI were used as a conservative estimate of risk. Based on past site activities, it is unlikely that the total chromium concentrations reported are comprised of hexavalent chromium, and as such, the SSL for chromium VI was not used.

l — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 are used for comparison.

Barium's background RC (223.46 mg/kg) and SSL (32 mg/kg) were exceeded for surface soil samples collected from the following soil boring locations: 014S04LF (407 mg/kg) and 014S07LF (244 mg/kg).

Nickel's background RC (non-detect) and SSL (21 mg/kg) was exceeded in the 8 to 10-foot interval sample from soil boring 014S06LF (22.4 mg/kg).

8.3.3.2 Nature and Extent of Groundwater Contamination

As previously mentioned in Section 3, constituents in groundwater are compared with their respective RBCs for tap water and MCLs for drinking water. Detected concentrations of inorganics in groundwater are also compared to their established background RCs to determine if they occur naturally or may be attributed to former operations at SWMU 14.

8.3.3.2.1 Organic Compounds in Groundwater Samples

VOCs in DPT Groundwater Samples

The following VOCs were identified in DPT groundwater samples collected from SWMU 14:

Benzene	PCE
cis-1,2-Dichloroethene	TCE

Table 8.3.6 summarizes the detected concentrations of VOCs in DPT groundwater and compares them to their RBCs for tap water and MCLs for drinking water. Figure 8.3.6 presents the detected VOCs in DPT groundwater and shows which exceeded their RBCs and/or MCLs. The following discusses RBC and MCL exceedances by compound.

Benzene's tap water RBC (0.36 μg/L) was exceeded by the fluvial deposits confirmation groundwater sample from location 014G0011 (5 μg/L). The detected benzene concentration in this sample equaled its MCL.

Table 8.3.6
Detected Concentrations of VOCs in DPT Groundwater Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/L)

Analyte[a]	Sample Location	Interval[b]	Onsite Laboratory Result[b]	Offsite Laboratory Result[c]	RBC - Tap Water[d]	MCL - Drinking Water[e]
benzene	014G0011	UF (43')	ND[f]	**5**	0.36	5
cis-1,2-dichloroethene	014G0005	LS (12')	3.2	NA[g]	61	70
	014G0007	LS (11')	20.1	NA	61	70
	014G0012	LS (11')	5.79	NA	61	70
TCE	014G0005	LS (12')	**4.44**	NA	1.6	5
	014G0007	LS (11')	**285**	NA		
	014G0008	LS (11')	**3.09**	NA		
	014G0009	LS (11')	**41.2**	NA		
	014G0010	LS (11')	1.4	1		
	014G0011	LS (10')	**39.2**	NA		
	014G0012	LS (11')	**10.6**	NA		
	014G0012	UF (39')	**5.31**	NA		
	014G0014	UF (37')	**3.45**	NA		
	014G0015	UF (43')	1.35	NA		
PCE	014G0007	LS (11')	**230**	NA	1.1	5
	014G0007	UF (43')	ND	1		

Notes:

a — Nine loess and nine upper fluvial deposits groundwater samples were analyzed for VOCs by the onsite laboratory using Method 8021. Of these samples, one loess and three upper fluvial deposits groundwater samples were split and analyzed for VOCs by the offsite laboratory using SW-846 Method 8240.

b — Interval shown is the unit from which the groundwater sample was collected. LS = loess; UF = upper fluvial deposits.

c — Hydrologic, Inc. of Travelers Rest, South Carolina, provided onsite laboratory services for primary samples.

c — NET of Cambridge, Massachusetts provided offsite laboratory services for confirmation samples.

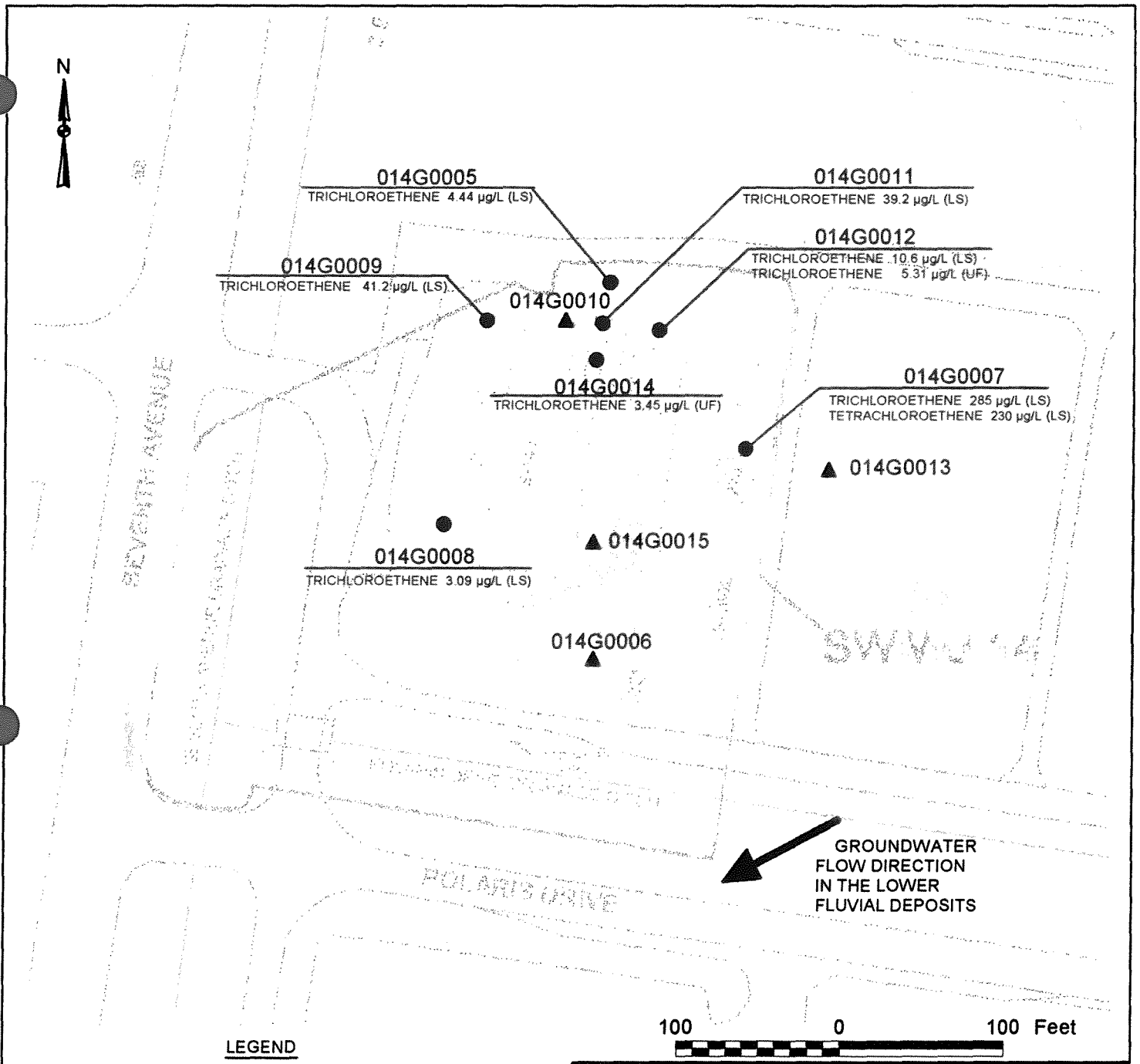
d — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

e — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

f — ND denotes analyte was not detected by the onsite laboratory.

g — NA denotes this sample was not submitted for offsite laboratory confirmation analysis.

Bold Type denotes this concentration exceeds the RBC for tap water.
Bold Type and Underline denotes this concentration exceeds both the RBC for tap water and the MCL for drinking water.



LEGEND

▲ NO VOC IN DPT GROUNDWATER SAMPLE EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER.

● ONE OR MORE VOCs IN DPT GROUNDWATER EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER.

014G0005
TRICHLOROETHENE 4.4 µg/L (LS)

THE LOESS GROUNDWATER SAMPLE FROM DPT SAMPLING LOCATION 014G0005 CONTAINED THE FOLLOWING VOC THAT EXCEEDED THE RBC FOR TAP WATER AND/OR THE MCL FOR DRINKING WATER: 4.4 µg/L TRICHLOROETHENE.

(LS) LOESS
(UF) UPPER FLUVIAL DEPOSITS

NOTE: DPT GROUNDWATER SAMPLES WERE ANALYZED FOR VOCS ONLY BY THE ONSITE LABORATORY USING METHOD 8021.

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.6
RBC AND/OR MCL EXCEEDANCES FOR VOCs
IN DPT GROUNDWATER SAMPLES
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

TCE's tap water RBC (1.6 μg/L) and/or MCL (5 μg/L) were exceeded by six loess groundwater samples and two upper fluvial deposits groundwater samples. The tap water RBC, but not the MCL, was exceeded at loess groundwater sampling locations 014G0005 (4.44 μg/L) and 014G0008 (3.09 μg/L). Locations where loess groundwater samples exceeded both the tap water RBC and MCL were: 014G0007 (285 μg/L), 014G0009 (41.2 μg/L), 014G0011 (39.2 μg/L), 014G0012 (10.6 μg/L). The upper fluvial deposits groundwater sample from location 014G0014 (3.45 μg/L) exceeded the tap water RBC, but not the MCL; the upper fluvial deposits sample from location 014G0012 (5.31 μg/L) exceeded both the tap water RBC and MCL.

PCE's tap water RBC (1.1 μg/L) and MCL (5 μg/L) were exceeded at loess groundwater sample location 014G0007 at a concentration of 230 μg/L.

VOCs in Groundwater Samples from Monitoring Wells

The VOCs detected in groundwater samples from monitoring wells were 1,2-dichloroethene, PCE and TCE; these compounds were detected only in loess groundwater. Table 8.3.7 summarizes the VOC concentrations and compares them to their respective RBCs for tap water and MCLs for drinking water. Figure 8.3.7 plots concentrations that exceeded their RBC or MCL values. Exceedances are discussed by compound below.

TCE's tap water RBC (1.6 μg/L) and MCL (5 μg/L) were exceeded in loess groundwater sample 014G02LS at a concentration of 120 μg/L.

PCE's tap water RBC (1.1 μg/L) and MCL (5 μg/L) were also exceeded at location 014G02LS by a concentration of 150 μg/L.

Table 8.3.7
Detected Concentrations of Organic Compounds in Groundwater Samples from Monitoring Wells
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean Concentration[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances
VOCs								
1,2-Dichloroethene (total)	LS	1/5	13	13	55	0	70[g]	0
PCE	LS	1/5	150	150	1.1	1 (014G02LS)	5	1 (014G02LS)
TCE	LS	1/5	120	120	1.6	1 (014G02LS)	5	1 (014G02LS)
SVOCs								
Diethylphthalate	LS	1/5	1	1	29,000	0	—[h]	—
TPH								
TPH - DRO	LF	1/4	140	140	100[i]	1 (014G01LF)	—	—

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from five loess monitoring wells and four lower fluvial monitoring wells and analyzed at an offsite laboratory for VOCs, SVOCs, TPH-DRO, pesticides/PBCs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.

b — Interval shown is the lithologic unit in the screened interval of the monitoring well. LS = loess groundwater, LF = lower fluvial deposits groundwater.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

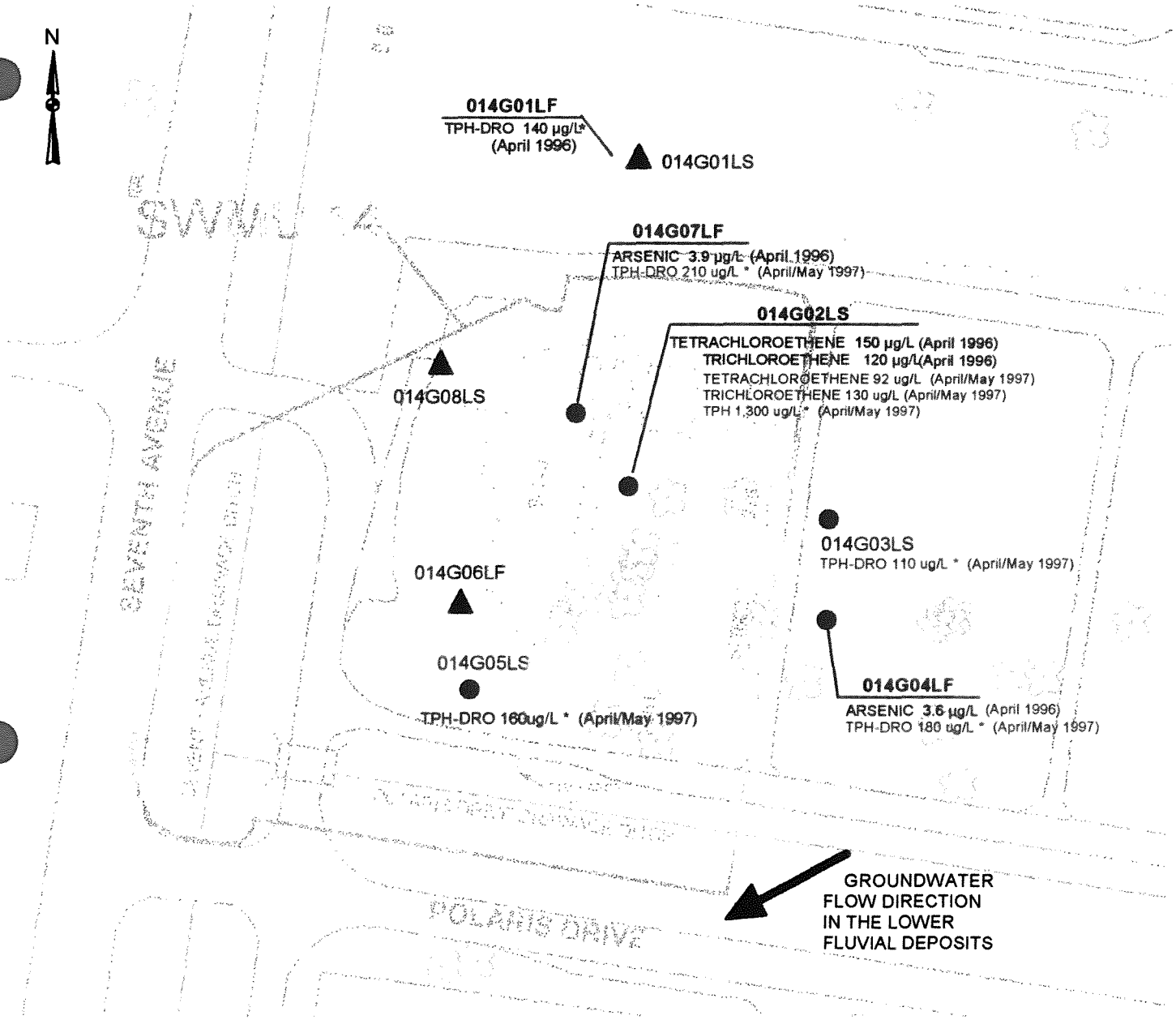
e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — The MCL for cis-1,2 dichloroethene is the most conservative of the 1,2-dichloroethene isomers and was therefore chosen as the MCL for 1,2-dichloroethene (total).

h — denotes MCL is not available for this analyte; therefore, no comparison can be made.

i — No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers has been substituted for the RBC for tap water. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).



LEGEND

▲ NO GROUNDWATER CONSTITUENTS EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

● ONE OR MORE GROUNDWATER CONSTITUENTS EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

014G04LF
ARSENIC 3.6 µg/L — THE GROUNDWATER SAMPLE FROM MONITORING WELL 014G04LF CONTAINED THE FOLLOWING CONSTITUENT THAT EXCEEDED ONE OR MORE APPLICABLE STANDARDS: 3.6 µg/L ARSENIC.

* THE DETECTED CONCENTRATION OF TPH-DRO OR TPH EXCEEDED THE TDEC CLEANUP STANDARD OF 100 µg/L FOR TOTAL TPH IN DRINKING WATER AQUIFERS (TDEC, 1997)

LS LOESS MONITORING WELL

LF LOWER FLUVIAL DEPOSITS MONITORING WELL

100 0 100 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.7
RBC, MCL, AND/OR TOTAL TPH EXCEEDANCES IN GROUNDWATER SAMPLES FROM MONITORING WELLS
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

8.3.3.2.2 Inorganic Compounds in Groundwater Samples

Arsenic exceeded both its background RC (3.5 μg/L) and its tap-water RBC (0.045 μg/L) in lower fluvial deposits groundwater samples from monitoring wells 014G04LF (3.6 μg/L) and 014G07LF (3.9 μg/L), as shown on Figure 8.3.7 and Table 8.3.8. However, the detected concentrations did not exceed the MCL for drinking water (50 μg/L). No other detected inorganic in groundwater exceeded both its RC and RBC or MCL.

8.3.3.2.3 Groundwater Samples From the April/May 1997 Sampling Event

The five loess and four lower fluvial deposits groundwater monitoring wells installed at SWMU 14 were sampled during the April/May 1997 groundwater sampling event and submitted to an offsite laboratory for analysis of VOCs, TPH, TPH-GRO, and TPH-DRO.

The VOCs detected in groundwater samples from monitoring wells were PCE and TCE. Additionally, the one SWMU 14 duplicate sample, from loess monitoring well 014G02LS, identified the VOC 1,2-dichloroethene at a concentration of 30 μg/L which was below both its tap water RBC (55 μg/L) and MCL (70 μg/L). Table 8.3.9 summarizes the VOC concentrations and compares them to their respective RBCs for tap water and MCLs for drinking water. Figure 8.3.7 plots concentrations that exceeded their RBC or MCL values. Exceedances are discussed by compound below.

TCE's tap water RBC (1.6 μg/L) and MCL (5 μg/L) were exceeded in loess groundwater sample 014G02LS at a concentration of 130 μg/L.

PCE's tap water RBC (1.1 μg/L) and MCL (5 μg/L) were also exceeded at location 014G02LS by a concentration of 92 μg/L.

Table 8.3.8
Detected Concentrations of Inorganics in Groundwater Samples from Monitoring Wells
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean Concentration[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances	Reference Concentration[g]	RC[g] Exceedances
Arsenic	LF	3/4	2.8 - 3.9	3.4	0.045	3 (014G01LF, 014G04LF, 014G07LF)	50	0	3.5	2 (014G04LF, 014G07LF)
Barium	LS	5/5	126 - 215	159	2,600	0	2,000	0	442	0
	LF	4/4	422 - 638	549	2,600	0	2,000	0	232	4 (014G01LF, 014G04LF, 014G06LF, 014G07LF)
Chromium	LS	4/5	6.9 - 23.8	16.3	180[h]	0	100	0	239	0
	LF	3/4	10.9 - 72	34	180	0	100	0	39.8	1 (014G01LF)
Lead	LS	5/5	2.3 - 10.2	5.1	15[i]	0	15[i]	0	17.5	0
	LF	3/4	3.4 - 15	8	15	0	15	0	6.6	1 (014G01LF)
Nickel	LS	1/5	27.1	27.1	730	0	100	0	173.5	0
	LF	1/4	42.1	42.1	730	0	100	0	33.4	1 (014G01LF)
Tin	LF	1/4	48	48	22,000	0	NA[j]	NA	ND[k]	1 (014G01LF)
Vanadium	LF	1/4	54	54	260	0	NA	NA	17.4	1 (014G01LF)
Zinc	LF	1/4	315	315	11,000	0	5,000	0	39.8	1 (014G01LF)

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from five loess monitoring wells and four lower fluvial monitoring wells and analyzed by the offsite laboratory for VOCs, SVOCs, TPH-DRO, pesticides/PBCs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.
b — Interval shown is the lithologic unit within the screened interval of the monitoring well. LS = loess groundwater; LF = lower fluvial deposits groundwater
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
g — Reference concentration is two times the mean background concentration. Analytical data from two sampling events of 4 loess monitoring wells and 13 fluvial monitoring wells were used to establish background concentrations. Refer to *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.
h — The RBCs for chromium VI were selected because they are the most conservative risk value.
i — Lead does not have an RBC or MCL; therefore, the USEPA treatment technique action level of 15 μg/L has been substituted for the RBC and MCL (USEPA, 1996c).
j — NA denotes risk-based data or background reference concentrations are not available for this analyte; therefore, no comparison can be made.
k — ND denotes the indicated analyte was not detected in the background samples.

Table 8.3.9
Compounds Identified During the April/May 1997 Groundwater Monitoring Well Sampling Event
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean Concentration[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances
VOCs								
PCE	LS	1/5	92	92	1.1	1 (014G02LS)	5	1 (014G02LS)
TCE	LS	2/5	0.65 — 130	65	1.6	1 (014G02LS)	5	1 (014G02LS)
TCE	LF	1/4	1.3	1.3	1.6	0	5	0
Total Petroleum Hydrocarbons								
TPH	LS	1/5	1,300	1,300	100[g]	1 (014G02LS)	—[h]	—
TPH-GRO	LS	1/5	42	42	100[g]	0	—	—
TPH-DRO	LS	2/5	110 — 160	135	100[g]	2 (014G03LS, 014G05LS)	—	—
TPH-DRO	LF	2/4	180 — 210	195	100[g]	2 (014G04LF, 014G07LF)	—	—

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from five loess monitoring wells and four lower fluvial monitoring wells and analyzed at an offsite laboratory for VOCs, TPH, TPH-DRO, and TPH-GRO.

b — Interval shown is the lithologic unit in the screened interval of the monitoring well. LS = loess groundwater, LF = lower fluvial deposits groundwater.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers has been substituted for the RBC for tap water. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

h — denotes MCL is not available for this analyte; therefore, no comparison can be made.

The detected concentrations of TPH, TPH-DRO, and TPH-GRO were compared to the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers. Exceedances of this standard were indicated in loess monitoring wells 014G02LS, 014G03LS, and 014G05LS, and lower fluvial deposits wells 014G04LF and 014G07LF. Table 8.3.9 summarizes the TPH concentrations and compares them to the TDEC standard. Figure 8.3.7 plots concentrations that exceeded the TDEC standard.

8.3.3.3 Nature and Extent of Sediment Contamination

Sediment samples from the Seventh Avenue drainage ditch west of SWMU 14 were collected using a stainless-steel hand auger. As outlined in Section 8.3.2.3, the sediment samples were collected from two intervals (0 to 6 inches bls and 18 to 24 inches bls) at two locations (014M0001 and 014M0002). SVOCs, TPH, chlorinated pesticides, herbicides, and Appendix IX metals were detected in Seventh Avenue drainage ditch sediment samples. Detected analytes in surface sediment are compared to their respective USEPA SSVs and, because the sediment sample locations are seasonally exposed, their USEPA soil RBCs and soil-to-groundwater SSLs. Detected analytes in subsurface sediment are compared to their respective USEPA SSLs only, since the SSVs and RBCs do not apply to subsurface samples. Surface and subsurface soil RCs are also compared to detected concentrations of inorganics in surface and subsurface sediment.

8.3.3.3.1 Organic Compounds in Sediment Samples

SVOCs, TPH, pesticides, and herbicides were detected in sediment samples from the Seventh Avenue drainage ditch. The organic compounds detected in sediment samples that exceeded their respective SSVs, soil RBCs, or soil-to-groundwater SSLs are discussed below.

SVOCs in Sediment

The SVOCs detected in sediment samples from the Seventh Avenue drainage ditch were as follows:

Benzo(a)anthracene	Chrysene
Benzo(a)pyrene	Di-n-butylphthalate
Benzo(b)fluoranthene	Dibenz(a,h)anthracene
Benzo(g,h,i)perylene	Fluoranthene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene
BEHP	Phenanthrene
Butylbenzylphthalate	Pyrene

Table 8.3.10 summarizes the SVOCs detected in surface (0 to 6-inch interval) and subsurface (18- to 24-inch interval) sediment samples and compares them to their applicable screening levels. The following SVOCs exceeded their SSV or residential soil RBC: benzo(a)pyrene, BEHP, chrysene, fluoranthene, and pyrene. No SVOC exceeded its respective soil-to-groundwater SSL. Figures 8.3.8 and 8.3.9 plot SSV and RBC exceedances in surface sediment samples, respectively, and the exceedances are discussed by compound below.

Benzo(a)pyrene's SSV (330 μg/kg) was equaled by the concentration in the surface sediment sample from location 014M0001. The detected concentration exceeded the residential soil RBC (88 μg/kg), but not the industrial soil RBC (780 μg/kg).

BEHP's SSV (182 μg/kg) was exceeded by the surface sediment sample from location 014M0001 (2,300 μg/kg). The detected concentration did not exceed the residential soil RBC (46,000 μg/kg).

The SSV of 330 μg/kg for *chrysene, fluoranthene, and pyrene* was exceeded by the surface sediment sample from location 014M0001, with detected concentrations of 370 μg/kg, 550 μg/kg, and 400 μg/kg, respectively. These concentrations did not exceed their respective residential soil RBCs (88,000, 3,100,000, and 2,300,000, respectively).

4,4'-DDE's SSV (3.3 μg/kg) was exceeded in the surface sediment sample from location 014M0002 (23 μg/kg). The detected concentration did not exceed its soil-to-groundwater SSL (500 μg/kg).

4,4'-DDT's SSV (3.3 μg/kg) and soil-to-groundwater SSL (1,000 μg/kg) were exceeded in the surface sediment sample from location 014M0001 (1,900 μg/kg).

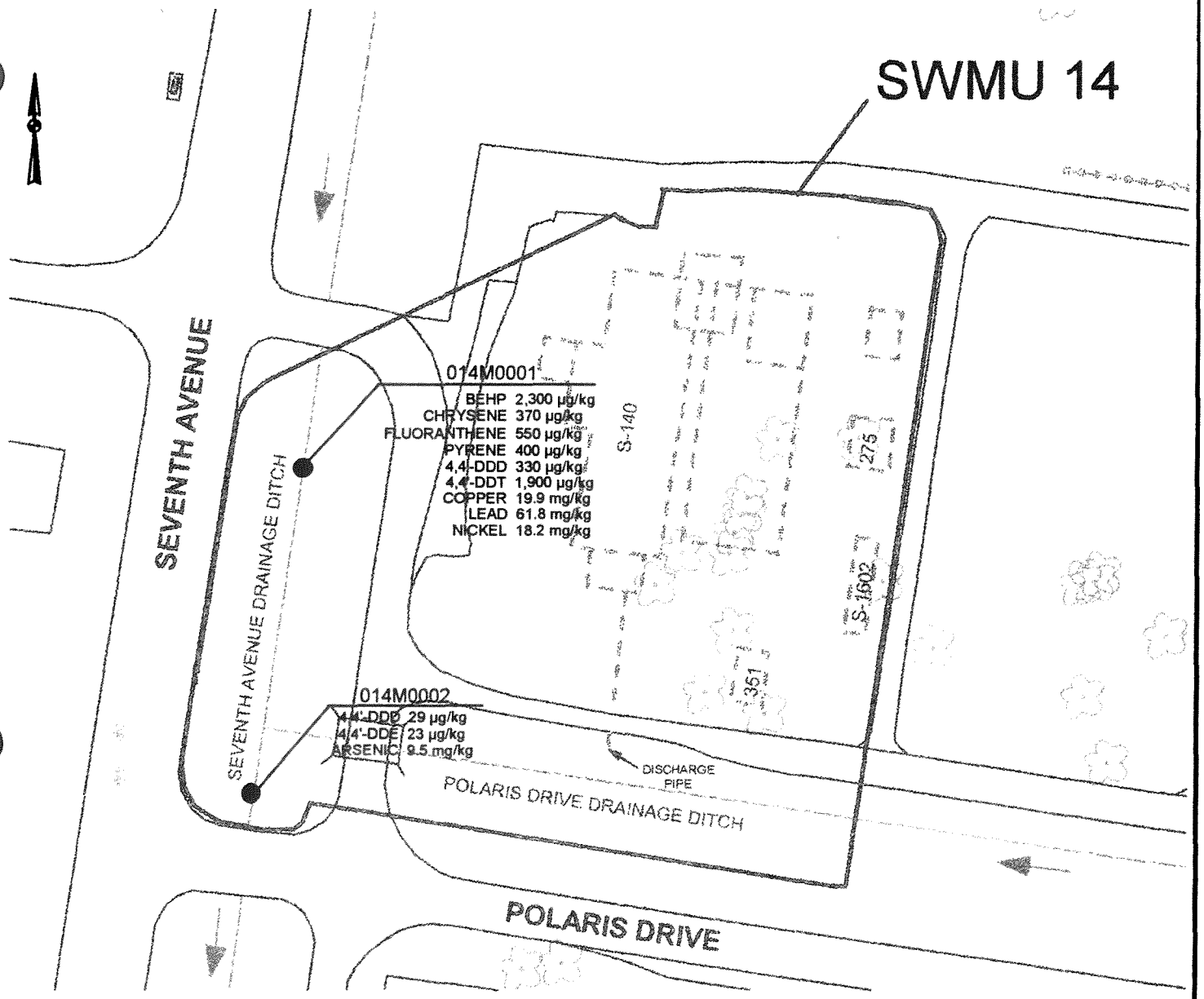
Dieldrin's soil-to-groundwater SSL (1 μg/kg) was exceeded in the subsurface sediment sample from location 014M0002 (24 μg/kg).

Herbicides in Sediment

Dinoseb and 2,4-DB were the only herbicides detected in sediment samples collected from the Seventh Avenue drainage ditch. Of these two compounds, only 2,4-DB was detected in surface sediment; it did not exceed its residential soil RBC (630,000 μg/kg), and no SSV or soil-to-groundwater SSL is available for this compound.

TPH in Sediment

Total TPH was detected at both sediment sampling locations in the Seventh Avenue ditch; concentrations ranged from 120 to 320 μg/kg. The USEPA has not established an RBC or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers (i.e., the loess) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface sediment. As shown in Table 8.3.10, the detected TPH concentrations did not exceed the TDEC cleanup standard.



LEGEND

● ONE OR MORE DETECTED CONSTITUENTS IN SURFACE SEDIMENT EXCEEDED ITS USEPA SEDIMENT SCREENING VALUE.

014M0002	
4,4'-DDD	29 µg/kg
4,4'-DDE	23 µg/kg
ARSENIC	9.5 mg/kg

THE SURFACE SEDIMENT SAMPLE FROM LOCATION 014M0002 CONTAINED THE FOLLOWING CONSTITUENTS THAT EXCEEDED THEIR USEPA SEDIMENT SCREENING VALUES: 29 µg/kg 4,4'-DDD, 23 µg/kg 4,4'-DDE, AND 9.5 mg/kg ARSENIC.

µg/kg MICROGRAMS PER KILOGRAM

mg/kg MILLIGRAMS PER KILOGRAM

← DRAINAGE DITCH SURFACE WATER FLOW DIRECTION

100 0 100 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
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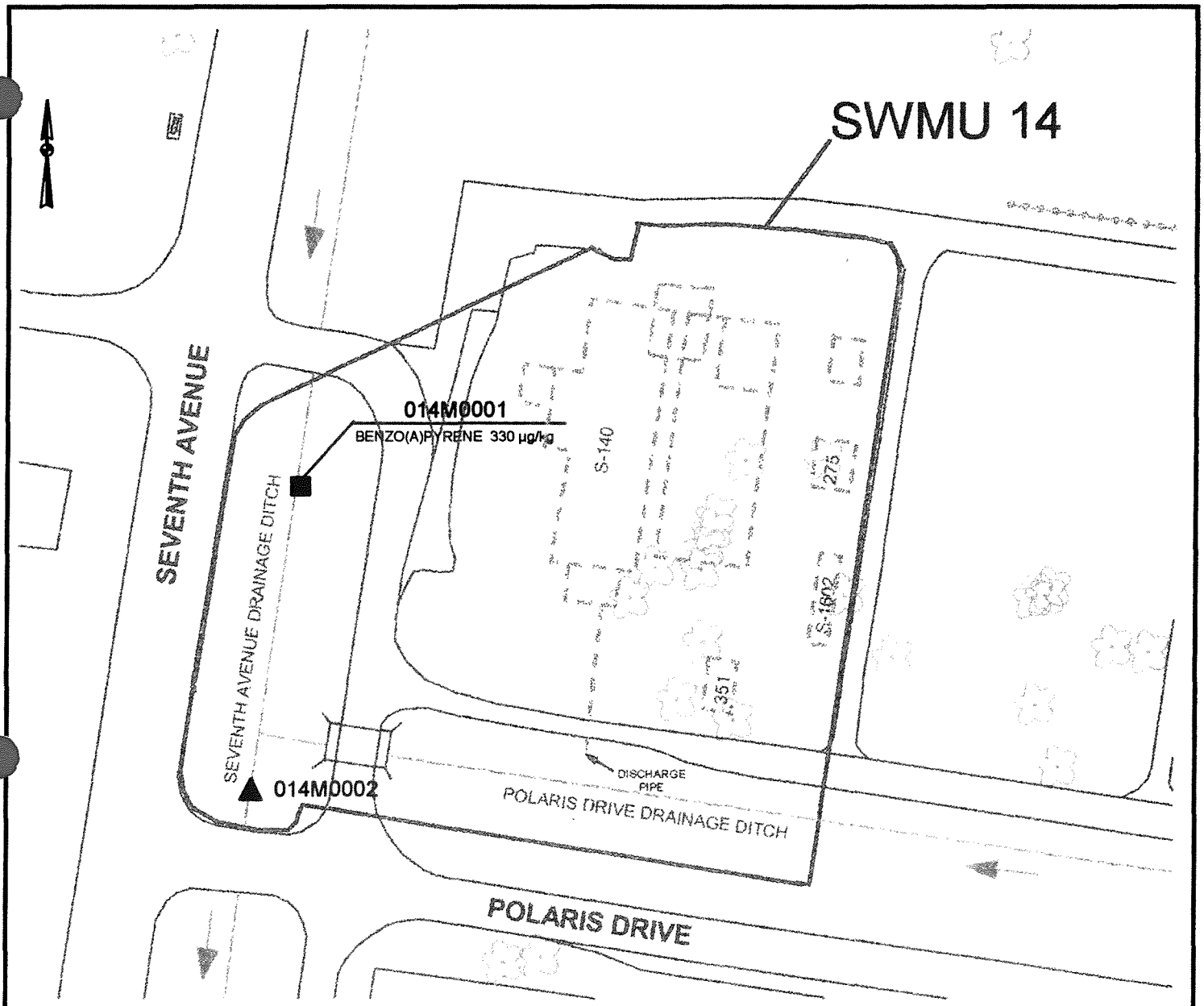
FIGURE 8.3.8
SSV EXCEEDANCES IN SEVENTH AVENUE DRAINAGE DITCH
SEDIMENT SAMPLES (0- TO 6-INCH INTERVAL)
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH



LEGEND

▲ NO DETECTED CONSTITUENT IN SURFACE SEDIMENT EXCEEDED ITS RESIDENTIAL OR INDUSTRIAL RISK-BASED CONCENTRATION (RBC) FOR SOIL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

■ ONE OR MORE DETECTED CONSTITUENTS IN SURFACE SEDIMENT EXCEEDED ITS RBC FOR RESIDENTIAL SOIL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE), BUT NOT ITS RBC FOR INDUSTRIAL SOIL.

014M0001
BENZO(A)PYRENE 330 µg/kg

THE SURFACE SEDIMENT SAMPLE FROM LOCATION 014M0001 CONTAINED THE FOLLOWING CONTAMINANT THAT EXCEEDED AN RBC FOR SOIL: 330 µg/kg BENZO(A)PYRENE, WHICH EXCEEDED ITS RBC FOR RESIDENTIAL SOIL, BUT NOT ITS RBC FOR INDUSTRIAL SOIL.

µg/kg MICROGRAMS PER KILOGRAM

DRAINAGE DITCH SURFACE WATER FLOW DIRECTION

100 0 100 Feet

RCRA FACILITY INVESTIGATION
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MILLINGTON, TENNESSEE

FIGURE 8.3.9
RBC EXCEEDANCES IN SEVENTH AVENUE DRAINAGE DITCH SEDIMENT SAMPLES (0- TO 6-INCH INTERVAL)
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

Table 8.3.10
Detected Concentrations of Organic Compounds in Seventh Avenue Drainage Ditch Sediment Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
SVOCs												
Benzo(a)anthracene	0 - 6"	½	260	260	330	0	880	0	7,800	0	700	0
	18 - 24"	½	150	150	NA[g]	NA	NA	NA	NA	NA	700	0
Benzo(a)pyrene	0 - 6"	½	330	330	330	0	88	1 (014M0001)	780	0	4,000	0
	18 - 24"	½	170	170	NA	NA	NA	NA	NA	NA	4,000	0
Benzo(b)fluoranthene	0 - 6"	½	380	380	—[h]	—	880	0	7,800	0	4,000	0
	18 - 24"	2/2	50 - 190	120	NA	NA	NA	NA	NA	NA	4,000	0
Benzo(g,h,i)perylene	0 - 6"	½	150	150	—	—	3,100,000[i]	0	82,000,000[i]	0	—	—
	18 - 24"	½	47	47	NA	NA	NA	NA	NA	NA	—	—
Benzo(k)fluoranthene	0 - 6"	½	320	320	—	—	8,800	0	78,000	0	4,000	0
	18 - 24"	½	160	160	NA	NA	NA	NA	NA	NA	4,000	0
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 6"	½	2,300	2,300	182	1 (014M0001)	46,000	0	410,000	0	11,000	0
	18 - 24"	½	950	950	NA	NA	NA	NA	NA	NA	11,000	0
Butylbenzylphthalate	0 - 6"	½	190	190	—	—	16,000,000	0	410,000,000	0	68,000	0
	18 - 24"	2/2	83 - 140	112	NA	NA	NA	NA	NA	NA	68,000	0
Chrysene	0 - 6"	½	370	370	330	1 (014M0001)	88,000	0	780,000	0	1,000	0
	18 - 24"	2/2	47 - 190	119	NA	NA	NA	NA	NA	NA	1,000	0
Di-n-butylphthalate	0 - 6"	½	73	73	—	—	7,800,000	0	200,000,000	0	—	—
	18 - 24"	½	74	74	NA	NA	NA	NA	NA	NA	—	—
Dibenz(a,h)anthracene	0 - 6"	½	61	61	330	0	88	0	780	0	11,000	0

Table 8.3.10
Detected Concentrations of Organic Compounds in Seventh Avenue Drainage Ditch Sediment Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
SVOCs												
Fluoranthene	0 - 6"	2/2	55 - 550	303	330	1 (014M0001)	3,100,000	0	82,000,000	0	980,000	0
	18 - 24"	2/2	59 - 290	175	NA	NA	NA	NA	NA	NA	980,000	0
Indeno(1,2,3-cd)pyrene	0 - 6"	½	150	150	—	—	880	0	7,800	0	35,000	0
	18 - 24"	½	71	71	NA	NA	NA	NA	NA	NA	35,000	0
Phenanthrene	0 - 6"	½	230	230	330	0	3,100,000[g]	0	82,000,000[g]	0	—	—
	18 - 24"	½	110	110	NA	NA	NA	NA	NA	NA	—	—
Pyrene	0 - 6"	2/2	46 - 400	223	330	1 (014M0001)	2,300,000	0	61,000,000	0	1,400,000	0
	18 - 24"	2/2	46 - 230	138	NA	NA	NA	NA	NA	NA	1,400,000	0
Total Petroleum Hydrocarbons												
Total TPH (Method 418.1)	0 - 6"	2/2	300 - 320	310	500,000[g]	0	—	—	—	—	—	—
	18 - 24"	½	120	120	500,000	0	NA	NA	NA	NA	—	—
Pesticides												
4,4'-DDD	0 - 6"	2/2	29 - 330	180	3.3	2 (014M0001, 014M0002)	2,700	0	24,000	0	700	0
	18 - 24"	½	40	40	NA	NA	NA	NA	NA	NA	700	0
4,4'-DDE	0 - 6"	½	23	23	3.3	1 (014M0002)	1,900	0	17,000	0	500	0
	18 - 24"	2/2	49 - 62	56	NA	NA	NA	NA	NA	NA	500	0
4,4'-DDT	0 - 6"	½	1,900	1,900	3.3	1 (014M0001)	1,900	0	17,000	0	1,000	1 (014M0001)
	18 - 24"	½	140	140	NA	NA	NA	NA	NA	NA	1,000	0
Dieldrin	18 - 24"	½	24	24	NA	NA	NA	NA	NA	NA	1	1 (014M0002)
gamma-Chlordane	18 - 24"	½	16	16	NA	NA	NA	NA	NA	NA	2,000	0

Table 8.3.10
Detected Concentrations of Organic Compounds in Seventh Avenue Drainage Ditch Sediment Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Herbicides												
2,4-DB	0 - 6"	½	10	10	—	—	630,000	0	16,000,000	0	—	—
	18 - 24"	2/2	5.5 - 18	12	NA	NA	NA	NA	NA	NA	—	—
Dinoseb	18 - 24"	½	2.8	3	NA	NA	NA	NA	NA	NA	—	—

Notes:

a — Only primary samples are included in this table. Four sediment samples were collected from two sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. One of the 0- to 6-inch interval samples was split as a duplicate (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following SW-846 analyses: VOCs, SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.

b — Intervals shown are in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — SSV = Sediment Screening Value; values obtained from the *Screening Values for Hazardous Waste Sites* (USEPA, 1992b).

f — Residential and industrial screening values (RBC-Res., RBC-Ind.) and SSL values are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to data from samples collected from the surface interval while SSLs are applicable to both the surface and subsurface intervals.

g — NA denotes SSV or RBC is not applicable to this subsurface sample.

h — denotes SSV, RBC, or SSL is not available for this analyte; therefore, no comparison can be made.

i — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.

j — No SSV, RBC, or SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSV. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

Pesticides in Sediment

The following pesticides were detected in sediment samples from the Seventh Avenue drainage ditch:

gamma-Chlordane	4,4'-DDT
4,4'-DDD	Dieldrin
4,4'-DDE	

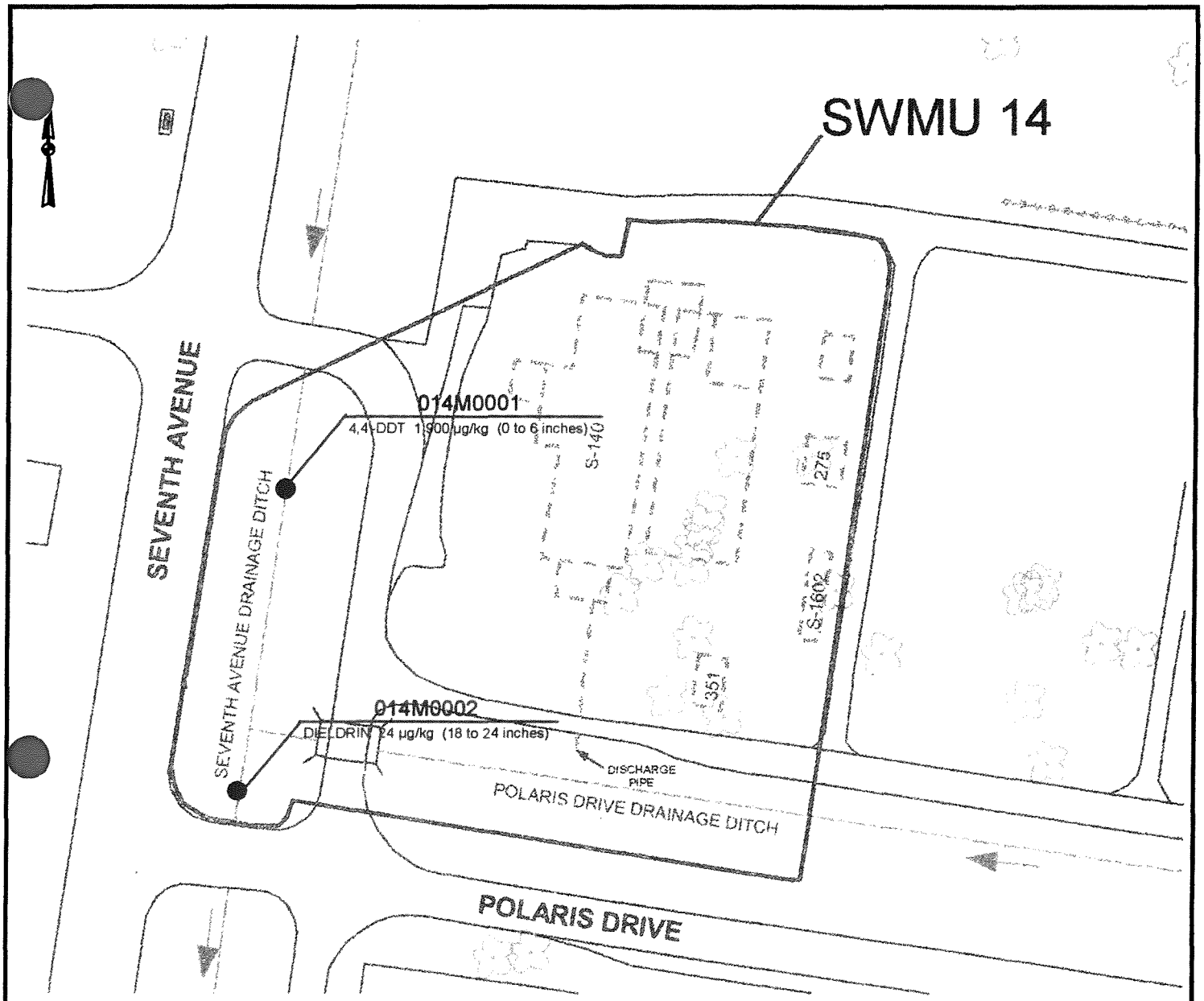
SSVs were exceeded for 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT in surface sediment samples. No detected pesticide in surface sediment exceeded its respective residential soil RBC. Soil-to-groundwater SSLs were exceeded for 4,4'-DDT in surface sediment and dieldrin in subsurface sediment. Table 8.3.10 summarizes the detected pesticide concentrations, and Figures 8.3.8 and 8.3.10 plot the SSV and soil-to-groundwater SSL exceedances, respectively. Exceedances are discussed by analyte below.

4,4'-DDD concentrations in the surface sediment samples from locations 014M0001 (330 μg/kg) and 014M0002 (29 μg/kg) exceeded the SSV (3.3 μg/kg), but not the soil-to-groundwater SSL (700 μg/kg).

8.3.3.3.2 Inorganics in Sediment Samples

The following inorganics were detected in the Seventh Avenue drainage ditch sediment samples:

Arsenic	Lead
Barium	Nickel
Beryllium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc



LEGEND

100 0 100 Feet

ONE OR MORE CONSTITUENTS IN A SEDIMENT SAMPLE FROM THIS LOCATION EXCEEDED ITS SOIL TO GROUNDWATER SSL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

014M0002
DIELDRIN 24 µg/kg (18 to 24 inches)

THE FOLLOWING CONSTITUENT IN A SEDIMENT SAMPLE FROM LOCATION 014M0002 EXCEEDED ITS SOIL-TO-GROUNDWATER SSL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE): 24 µg/kg DIELDRIN IN THE SAMPLE FROM 18 TO 24 INCHES BELOW LAND SURFACE.

kg MICROGRAMS PER KILOGRAM

DRAINAGE DITCH SURFACE WATER FLOW DIRECTION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
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FIGURE 8.3.10
SOIL TO GROUNDWATER SSL EXCEEDANCES IN SEVENTH AVENUE DRAINAGE DITCH SEDIMENT SAMPLES
SWMU 14 - BUILDING S-140 AND SEVENTH AVENUE DITCH

Table 8.3.11 summarizes the detected inorganics from the Seventh Avenue drainage ditch sediment samples and compares the detected concentrations in the surface interval (0 to 6 inches bls) with USEPA SSVs, soil RBCs, soil-to-groundwater SSLs, and soil RCs. As shown on Table 8.3.11, SSVs were exceeded by the following inorganics: arsenic, copper, lead, and nickel. Figure 8.3.8 shows the SSV exceedances for inorganics in sediment. No inorganic in sediment exceeded both its RC and soil RBC, and no detected inorganic in surface or subsurface sediment exceeded both its RC and soil-to-groundwater SSL. The following paragraphs discuss the SSV exceedances in surface sediment samples.

Arsenic's SSV (7.24 mg/kg) was exceeded by the surface sediment sample from location 014M0002 (9.5 mg/kg).

Copper's SSV (18.7 mg/kg) was exceeded by the surface sediment sample from location 014M0001 (19.9 mg/kg).

Lead's SSV (30.2 mg/kg) was exceeded by the surface sediment sample from location 014M0001 (61.8 mg/kg). This concentration did not exceed the USEPA residential soil screening value (400 mg/kg) (USEPA, 1994c).

Nickel's SSV (15.9 mg/kg) was exceeded by the surface sediment sample from location 014M0001 (18.2 mg/kg).

Table 8.3.11
Detected Concentrations of Inorganics in Seventh Avenue Drainage Ditch Sediment Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	Soil RC[g]	RC Exceedances
Arsenic	0 - 6"	2/2	4.1 - 9.5	6.8	7.24	1 (014M0002)	0.43	2 (014M0001, 014M0002)	3.8	2 (014M0001, 014M0002)	15	0	14.58	0
	18 - 24"	2/2	3.9 - 6.7	5.3	NA[h]	NA	NA	NA	NA	NA	15	0	20.32	0
Barium	0 - 6"	2/2	105 - 119	112	—[h]	—	5,500	0	140,000	0	32	2 (014M0001, 014M0002)	223.46	0
	18 - 24"	2/2	97 - 144	121	NA	NA	NA	NA	NA	NA	32	2 (014M0001, 014M0002)	265.12	0
Beryllium	0 - 6"	2/2	0.41 - 0.49	0.45	—	—	0.15	2 (014M0001, 014M0002)	1.3	0	180	0	1	0
	18 - 24"	2/2	0.41 - 0.53	0.47	NA	NA	NA	NA	NA	NA	180	0	1	0
Chromium	0 - 6"	2/2	9.9 - 19.5	14.7	52.3	0	390	0	10,000	0	—	—	23.89	0
	18 - 24"	2/2	9.1 - 15.6	12.4	NA	NA	NA	NA	NA	NA	—	—	28.28	0
Cobalt	0 - 6"	2/2	7.9 - 9.1	8.5	—	—	4,700	0	120,000	0	—	—	15.98	0
	18 - 24"	2/2	8.8 - 9.6	9.2	NA	NA	NA	NA	NA	NA	—	—	14.36	0
Copper	0 - 6"	2/2	14 - 19.9	17	18.7	1 (014M0001)	3,100	0	82,000	0	—	—	24.19	0
	18 - 24"	2/2	18 - 19.4	19	NA	NA	NA	NA	NA	NA	—	—	32.52	0
Lead	0 - 6"	2/2	15 - 61.8	38	30.2	1 (014M0001)	400[i]	0	1,300[i]	0	—	—	26.03	1 (014M0001)
	18 - 24"	2/2	12 - 29	20	NA	NA	NA	NA	NA	NA	—	—	19.8	1 (014M0002)
Nickel	0 - 6"	2/2	8.9 - 18.2	13.6	15.9	1 (014M0001)	1,600	0	41,000	0	21	0	20.62	0
	18 - 24"	½	8.2	8.2	NA	NA	NA	NA	NA	NA	21	0	ND	1 (014M0002)
Silver	18 - 24"	½	1.1	1.1	NA	NA	NA	NA	NA	NA	—	—	ND	1 (014M0002)

Table 8.3.11
Detected Concentrations of Inorganics in Seventh Avenue Drainage Ditch Sediment Samples
SWMU 14 — Building S-140 and Seventh Avenue Drainage Ditch
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	Soil RC[g]	RC Exceedances
Tin	18 - 24"	2/2	7.3 - 7.4	7.4	NA	NA	NA	NA	NA	NA	—	—	ND	2 (014M0001, 014M0002)
Vanadium	0 - 6"	2/2	19 - 23.1	21	—	—	550	0	14,000	0	—	—	45.1	0
	18 - 24"	2/2	18 - 24.9	21	NA	NA	NA	NA	NA	NA	—	—	43.68	0
Zinc	0 - 6"	2/2	50 - 84.8	68	124	0	23,000	0	610,000	0	42000	0	98	0
	18 - 24"	2/2	42 - 54.6	48	NA	NA	NA	NA	NA	NA	42000	0	109	0

Notes:

a — Only primary samples are included in this table. Four sediment samples were collected from two sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. One of the 0- to 6-inch interval samples was split as a duplicate (Attachment 1 of the *Data Validation Report — Assembly E* [E/A&H, 1997a] provides the duplicate sample analytical results). The sediment samples were submitted to NET for the following SW-846 analyses: VOCs, SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide.

b — Depth is in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — SSV = Sediment Screening Value; values obtained from the *Screening Values for Hazardous Waste Sites* (USEPA, 1992b).

f — Residential and industrial screening values (RBC-Res., RBC-Ind.) And SSL values are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to data from samples collected from the 0- to 6-inch interval.

g — NA denotes SSV or RBC comparison is not applicable to this subsurface sample.

h — denotes SSV, RBC, or SSL is not available for this analyte; therefore, no comparison can be made.

i — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 are used for comparison (USEPA, 1994c).

8.3.4 Human Health Risk Assessment for SWMU 14

8.3.4.1 Site Background and Investigative Approach

The SWMU 14 human health risk assessment (HHRA) analyzes the potential adverse effects on actual or hypothetical human receptors that could arise from exposures to hazardous substances released from SWMU 14 if no remedial actions are taken to reduce the extent of present environmental contamination. SWMU 14 is previously presented in Figure 1.4, and a site description and history is in Section 1.1.3. The former Building S-140 (demolished in 1985) contained a paint spray booth, a paint removing area, and a paint wash-down area used to train Navy personnel in painting-related processes from 1943 to 1985. Four smaller structures were used in conjunction with the painting training. Before 1980, overflow from sumps inside Building S-140 may have discharged in the Seventh Avenue Ditch. This overflow contained chromium, lead, various hydrocarbons, and solvents including toluene and phenols. Table 3.1, previously presented, lists samples and analytical methods for surface soil, sediment, fluvial deposits groundwater, and loess groundwater. Samples used in the HHRA are listed below:

- Surface soil — 014S000301 014S000401 014S01LS02 014S02LS02 014S03LS02 014S04LF02 014S05LS02 014S06LF02 014S07LF02 014S08LS02

- Partially exposed sediment — 014M000101 014M000201

- Loess groundwater — 014G01LS01 014G02LS01 014G03LS01 014G05LS01 014G08LS01 014G000512 014G000711 014G000811 14G000911 014G001110 014G001211 014G001411 014H001411

- Fluvial deposits groundwater — 014G01LF01 014G04LF01 014G06LF01 014G07LF01 014G000545 014G000840 014G000943 014G001043 014G001239 014G001437 014G001543 014H000743 014H000840 014H001143

8.3.4.2 Identification of Chemicals of Potential Concern

Chemicals of potential concern (COPCs) were identified in accordance with RAGS (USEPA, 1995b) and using the methods outlined in the Technical Memorandum on HHRA (E/A&H, 1997e).

Surface Soil

Table 8.3.12 lists chemicals present in site samples (CPSSs) in surface soil and identifies COPCs, which are labeled with asterisks. Benzo(a)pyrene equivalents (BEQs) were the only COPCs identified in SWMU 14 surface soil.

Sediment

Sediment samples were assumed to be exposed for approximately eight months per year. For screening purposes, sediment samples were compared to residential soil RBCs in accordance with *Supplemental Guidance to RAGS, Bulletin 1, Data Collection and Evaluation* (USEPA, 1995b). Table 8.3.13 lists CPSSs in sediment and identifies COPCs, which are labeled with asterisks. COPCs identified in sediment included arsenic, beryllium, and BEQ.

Loess Groundwater

Table 8.3.14 lists CPSSs in loess groundwater and identifies COPCs, which are labeled with asterisks. Tetrachloroethene (PCE), 1,2-dichloroethene, and trichloroethene (TCE) were the only COPCs identified in the loess groundwater at SWMU 14.

Table 8.3.12
Chemicals Present in Surface Soil Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
2,4,5-TP -Silvex	µg/kg	1/10	0.95---0.95	24---24	24	63,000	a, n		NA	NA
2,4-D	µg/kg	1/10	9.4---9.6	9.8---9.8	9.8	78,000	a, n		NA	NA
2,4-DB	µg/kg	2/10	9.5---9.7	44---51	48	63,000	a, n		NA	NA
2-Butanone - MEK	µg/kg	1/10	12---15	1,500---1,500	1,500	4,700,000	a, n		NA	NA
2-Methylnaphthalene (Naphthalene)	µg/kg	1/10	410---460	120---120	120	310,000	a, n		NA	NA
4,4'-DDD	µg/kg	1/10	4.1---22	24---24	24	2,700	a, c		NA	NA
4,4'-DDE	µg/kg	7/10	4.3---22	2.8---49	18	1,900	a, c		NA	NA
4,4'-DDT	µg/kg	6/10	4.3---22	4.8---71	31	1,900	a, c		NA	NA
4-Methyl-2-Pentanone (MIBK)	µg/kg	1/10	12---15	170---170	170	630,000	a, n		NA	NA
Acenaphthene	µg/kg	1/10	410---460	98---98	98	470,000	a, n		NA	NA
Acenaphthylene (Acenaphthene)	µg/kg	1/10	410---460	59---59	59	470,000	a, n		NA	NA
Acetone	µg/kg	3/10	12---25	14---16,000	5,361	780,000	a, n		NA	NA
Aldrin	µg/kg	4/10	2---10	1.2---8.4	5.3	38	a, c		NA	NA
alpha-Chlordane (Chlordane)	µg/kg	4/10	2.1---16	1.6---26	8	1,825	a, c		NA	NA
Anthracene	µg/kg	2/10	410---460	53---380	217	2,300,000	a, n		NA	NA
Aroclor-1260	µg/kg	1/10	42---230	31---31	31	320	f, a, c		NA	NA
Arsenic	mg/kg	10/10	---	5.3---10.6	7.4	0.43	a, c	10	14.58	
Barium	mg/kg	10/10	---	108---407	188	550	a, n		265.1	1
* BEQ	µg/kg	6/10	410---430	64.99---806.42	265.6	88	a, c	4	565	1
Benzo(g,h,i)perylene (pyrene)	µg/kg	6/10	410---430	57---420	146	230,000	a, n		NA	NA
Beryllium	mg/kg	2/10	0.98---1	0.4---0.56	0.5	0.15	a, c	2	1	
bis(2-Ethylhexyl)phthalate-BEHP	µg/kg	5/10	430---1500	44---2,000	717	46,000	a, c		NA	NA
Butylbenzylphthalate	µg/kg	4/10	410---430	30---450	174	1,600,000	a, n		NA	NA
Cadmium	mg/kg	10/10	---	1.8---3.7	2.5	3.9	a, n		1.54	10
Carbazole	µg/kg	1/10	410---460	230---230	230.00	32,000	a, c		NA	NA
Chromium	mg/kg	10/10	---	9.5---24.2	14	7800	a, n		23.89	1

Table 8.3.12
Chemicals Present in Surface Soil Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
Cobalt	mg/kg	10/10	---	4.7---19.4	8.9	470	a, n		15.98	2
Copper	mg/kg	10/10	---	12.7---24.3	16.4	310	a, n		24.19	1
Dibenzofuran	µg/kg	1/10	410---460	190---190	190	31,000	a, n		NA	NA
Dichlorprop (4-(2,4-Dichlorophenoxy)butyric Acid)	µg/kg	1/10	9.4---9.7	4.8---4.8	4.8	63,000	a, c		NA	NA
Dieldrin	µg/kg	9/10	4.3---4.3	6.2---91	30	40	a, e	2	262	
Fluoranthene	µg/kg	6/10	410---430	51---1,500	332	310,000	a, n		NA	NA
Fluorene	µg/kg	1/10	410---460	260---260	260	310,000	a, n		NA	NA
gamma-Chlordane (Chlordane)	µg/kg	3/10	2.1---19	1.1---22	9	1,825	a, c		NA	NA
Heptachlor epoxide	µg/kg	3/10	2---11	1.1---6.6	3.6	70	a, c		NA	NA
Indeno(1,2,3-cd)pyrene	µg/kg	6/10	410---430	44---360	117	880	a, c		NA	NA
Lead	mg/kg	10/10	---	9.7---84.9	51	400	e		26.03	8
MCPA	µg/kg	1/10	930---960	1,100---1,100	1,100	3,900	b, a, n		NA	NA
MCPP	µg/kg	3/10	940---960	1,900---5,800	3567	7,800	d, a, n		NA	NA
Mercury	mg/kg	1/10	0.12---0.13	0.14---0.14	0.1	2.3	a, n		0.46	
Naphthalene	µg/kg	1/10	410---460	390---390	390	310,000	a, n		NA	NA
Nickel	mg/kg	10/10	---	9.7---20.6	14	160	a, n		20.62	
Phenanthrene (Pyrene)	µg/kg	2/10	410---460	250---1,500	875	230,000	a, n		NA	NA
Pyrene	µg/kg	6/10	410---430	51---1,200	285	230,000	a, n		NA	NA
Selenium	mg/kg	3/10	0.49---0.51	0.31---0.61	0.5	39	a, n		NA	NA
Tetrachloroethene	µg/kg	1/10	12---70	2---2	2	12,000	a, c		NA	NA
Tin	mg/kg	5/10	5.2---44.8	29.3---46.2	33.9	4,700	a, n		33.56	1
Vanadium	mg/kg	10/10	---	17.5---32.1	22.3	55	a, n		45.11	

Table 8.3.12
Chemicals Present in Surface Soil Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
Xylene (Total)	µg/kg	2/10	12—15	3—18	10.5	16,000,000	a, n		NA	NA
Zinc	mg/kg	10/10	---	45.7—121	79.8	2,300	a, n		98	3

Notes:

( )	—	Surrogate used
*	—	Identified as a chemical of potential concern
a	—	Screening based on *Risk Based Concentration Table, January to June 1996* (USEPA, 1996a)
BEQ	—	Benzo(a)pyrene equivalent
b	—	MCPA -- 2-Methyl-4-chlorophenoxyacetic acid
c	—	Carcinogen
d	—	MCPP -- 2-(2-Methyl-14-chlorophenoxy)propionic acid
mg/kg	—	milligrams per kilogram
mg/kg	—	micrograms per kilogram
e	—	Screening based on 400 mg/kg lead in soil in accordance with USEPA's OSWER Directive 9355.4-2 (USEPA, 1994c)
f	—	The slope factor for PCBs was updated in IRIS in October 1996. Consequently, the RBC was recalculated using the updated information.
n	—	Noncarcinogen; RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA	—	Not applicable
RBC	—	Risk-based concentration
RC	—	Reference concentration; two times the mean background concentration (E/A&H, 1996a)

Table 8.3.13
Chemicals Present in Partially Exposed Sediment Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC
2,4-DB	µg/kg	1/2	9.3 — 9.3	10 — 10	10	63,000	a, n	
4,4'-DDD	µg/kg	2/2	---	29 — 330	180	2,700	a, c	
4,4'-DDE	µg/kg	1/2	500 — 500	23 — 23	23	1,900	a, c	
4,4'-DDT	µg/kg	1/2	44 — 44	1,900 — 1,900	1900	1,900	a, c	
* Arsenic	mg/kg	2/2	---	4.1 — 9.5	6.8	0.43	a, c	2
Barium	mg/kg	2/2	---	105 — 119	112	550	a, n	
* BEQ	µg/kg	1/2	440 — 440	473.2 — 473.2	473.2	88	a, c	1
Benzo(g,h,i)perylene (Pyrene)	µg/kg	1/2	440 — 440	150 — 150	150	230,000	a, n	
* Beryllium	mg/kg	2/2	---	0.41 — 0.49	0.45	0.15	a, c	2
bis(2-Ethylhexyl)phthalate -BEHP	µg/kg	1/2	440 — 440	2,300 — 2,300	2,300	46,000	a, c	
Butylbenzylphthalate	µg/kg	1/2	440 — 440	190 — 190	190	1,600,000	a, n	
Chromium	mg/kg	2/2	---	9.9 — 19.5	14.7	7,800	a, n	
Cobalt	mg/kg	2/2	---	7.9 — 9.1	8.5	470	a, n	
Copper	mg/kg	2/2	---	14.2 — 19.9	17.1	310	a, n	
Di-n-butylphthalate	µg/kg	1/2	440 — 440	73 — 73	73	780,000	a, n	
Fluoranthene	µg/kg	2/2	---	55 — 550	303	310,000	a, n	
Lead	mg/kg	2/2	---	14.9 — 61.8	38.4	400	b	
Nickel	mg/kg	2/2	---	8.9 — 18.2	13.6	160	a, n	
Phenanthrene (Pyrene)	µg/kg	1/2	440 — 440	230 — 230	230	230,000	a, n	
Pyrene	µg/kg	2/2	---	46 — 400	223	230,000	a, n	

Table 8.3.13
Chemicals Present in Partially Exposed Sediment Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC
Vanadium	mg/kg	2/2	—	19.4 — 23.1	21.3	55	a, n	
Zinc	mg/kg	2/2	—	50.4 — 84.8	67.6	2,300	a, n	

Notes:

( )	—	Surrogate used
*	—	Identified as a chemical of potential concern
a	—	Screening based on *Risk Based Concentration Table, January to June 1996* (USEPA, 1996a)
b	—	Screening based on 400 mg/kg of lead in soil, in accordance with USEPA's OSWER Directive 9355.4-2 (USEPA, 1994c)
BEQ	—	Benzo(a)pyrene equivalent
c	—	Carcinogen
n	—	Noncarcinogen; RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
RBC	—	Risk Based Concentration
mg/kg	—	milligrams per kilogram
mg/kg	—	micrograms per kilogram

Table 8.3.14
Chemicals Present in Loess Groundwater Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
* 1,2-Dichloroethene-total	μg/L	1/13	10 — 10	13 — 13	13	5.5	a, n	1	NA	NA
* cis-1,2-dichloroethene	μg/L	3/13	10 — 10	3.2 — 20.1	9.7	5.5	a, n	2	NA	NA
Barium	μg/L	5/5	—	126 — 215	159	260	a, n		442	
Chromium	μg/L	4/5	5 — 5	6.9 — 23.8	16.3	3700	a, n		239	
Diethylphthalate	μg/L	1/5	10 — 10	1 — 1	1	2,900	a, n		NA	NA
Lead	μg/L	5/5	—	2.3 — 10.2	5.1	15	b		17.5	
Nickel	μg/L	1/5	25 — 25	27.1 — 27.1	27.1	73	a, n		173.5	
* Tetrachloroethene	μg/L	2/13	10 — 10	150 — 230	190	1.1	a, c, d	2	NA	NA
* Trichloroethene	μg/L	8/13	10 — 10	1 — 285	63.1	1.6	a, c, d	7	NA	NA

Notes:

*	—	Identified as a chemical of potential concern
a	—	Screening based on tap water ingestion *Risk Based Concentration Table, January to June 1996* (USEPA, 1996a)
b	—	Screening based on treatment technique action level of 15 mg/L of lead in groundwater (USEPA, 1996c)
c	—	Carcinogen
d	—	MCL is 5 mg/L (USEPA, 1996c)
n	—	Noncarcinogen; RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA	—	Not Applicable
RBC	—	Risk Based Concentration
RC	—	Reference Concentration; two-times the mean background concentration (E/A&H, 1996a)
μg/L	—	micrograms per liter

Fluvial Deposits Groundwater

Table 8.3.15 lists CPSSs in fluvial deposits groundwater and identifies COPCs, which are labeled with asterisks. COPCs identified in the fluvial deposits groundwater were arsenic, barium, benzene, trichloroethene, and vanadium.

8.3.4.3 Exposure Assessment

Exposure Setting

SWMU 14 is a flat, grass covered area on the Southside of NSA Memphis. Drainage ditches are located to the south and west of the site. The eastern portion of the site has a small stand of trees, several sidewalks, and a large open field that was once used as a trailer park. Residential property is at the far east end of this open field. The site is relatively flat with no obvious direction for surface-water runoff. However, runoff likely discharges as sheet flow to the Seventh Avenue ditch to the west and a smaller ditch to the south. These ditches, which discharge into Big Creek Drainage Canal, are partially concrete-lined.

Potential Exposed Populations

There are currently no plans for residential or worker reuse scenarios. However, this HHRA assesses hypothetical residential and industrial site worker scenarios as well as construction worker, maintenance worker, and adolescent site trespasser scenarios.

Exposure Pathways

Table 8.3.16 summarizes exposure pathways and receptors for current and future land use and justifies including or excluding various exposure pathways.

Surface Soil

Exposure pathways include incidental soil ingestion and dermal contact. Uniform exposure was assumed for all sample locations.

Table 8.3.15
Chemicals Present in Fluvial Deposits Groundwater Samples
NSA Memphis — SWMU 14
Millington, TN

Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Tap Water RBC	Notes	Number Over RBC	RC	Number Over RC
* Benzene	µg/L	1 / 12	10 — 14	5 — 5	5	0.36	a, b, c	1	NA	NA
* Trichloroethene	µg/L	3 / 12	10 — 14	1.35 — 5.31	3.37	1.6	a, c, d	2	NA	NA
Tetrachloroethene	µg/L	1 / 12	10 — 14	1 — 1	1	1.1	a, c		NA	NA
* Arsenic	µg/L	3 / 4	2 — 2	2.8 — 3.9	3.4	0.045	a, c, e	3	3.5	1
* Barium	µg/L	4 / 4	—	422 — 638	549	260	a, n, f	4	232	4
Chromium	µg/L	3 / 4	5 — 5	10.9 — 72	34	7800	a, n	0	39.8	1
Lead	µg/L	3 / 4	2 — 2	3.4 — 15	7.5	15	g	0	6.6	1
Nickel	µg/L	1 / 4	25 — 25	42.1 — 42.1	42.1	73	a, n	0	33.4	1
Tin	µg/L	1 / 4	45 — 45	48 — 48	48	2,200	a, n	0	NA	NA
* Vanadium	µg/L	1 / 4	7.5 — 16.9	54 — 54	54	26	a, n	1	17.4	1
Zinc	µg/L	1 / 4	33.3 — 54.8	315 — 315	315	1,100	a, n	0	39.8	1

Notes:

*	—	Identified as a chemical of potential concern
a	—	Screening based on *Risk Based Concentration Table, January to June 1996* (USEPA, 1996a)
b	—	Benzene's MCL is 5 mg/L (USEPA, 1996a)
c	—	Carcinogen
d	—	Trichloroethene's MCL is 50 mg/L (USEPA, 1996a)
e	—	Arsenic's MCL is 50 mg/L (USEPA, 1996a)
f	—	Barium's MCL is 2000 mg/L (USEPA, 1996a)
g	—	Screening based on treatment technique action level of 15 mg/L lead in groundwater (USEPA, 1996c)
n	—	Noncarcinogen; RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA	—	Not Applicable
RBC	—	Risk Based Concentration
RC	—	Reference Concentration; two-times the mean background concentration (E/A&H, 1996a)
mg/L	—	micrograms per liter

Sediment

Exposure pathways include incidental sediment ingestion and dermal contact. Sediment samples were collected from partially exposed drainage ditches near Seventh Avenue as described in Section 8.3.2.3. Sediment was estimated to be exposed eight months of the year, and was analyzed as surface soil in this HHRA. Uniform exposure was assumed for all sample locations.

Loess Groundwater

Exposure pathways include water ingestion and inhalation of VOCs. Uniform exposure was assumed for all sample locations.

Fluvial Deposits Groundwater

The only exposure pathway is water ingestion. Uniform exposure was assumed for all sample locations.

Table 8.3.16
Exposure Pathways Summary — SWMU 14
NSA Memphis
Millington, TN

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
		Current Land Uses	
Current Site Workers	**Air — Inhalation of gaseous contaminants emanating from soil**	**No**	**No significant VOC concentrations were reported in surface soil.**
	Air — Inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater — Ingestion of contaminants during potable or general use	**No**	**Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis.**
	Groundwater — Inhalation of volatilized groundwater contaminants	No	Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis.
	Soil — Incidental ingestion	**No (Qualified)**	**Future land use assessment is considered protective of current receptors.**
	Soil - Dermal Contact	No (Qualified)	Future land use assessment is considered protective of current receptors.

Table 8.3.16
Exposure Pathways Summary — SWMU 14
NSA Memphis
Millington, TN

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Maintenance Worker and Site Trespasser	Air — Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soil.
	Air — Inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater — Ingestion of contaminants during potable or general use	No	Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis.
	Groundwater — Inhalation of volatilized contaminants during domestic use	No	Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis.
	Soil — Incidental ingestion	No (Qualified)	Future land use assessment is considered protective of current receptors.
	Soil — Dermal contact	No (Qualified)	Future land use assessment is considered protective of current receptors.
	Sediment - Incidental ingestion	Yes	COPCs were identified based on the screening process described in Section 8.3.6.3.
	Sediment - Dermal contact	Yes	COPCs were identified based on the screening process described in Section 8.3.6.3
	Future Land Use		
Future Site Residents (Child and Adult) and Future Site Worker	Air — Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soil.
	Air — Inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater — Ingestion of contaminants during potable or general use	Yes	COPCs were identified based on the screening process described in Section 8.3.6.2.
	Groundwater — Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified based on the screening process described in Section 8.3.6.2.
	Soil — Incidental ingestion	Yes	COPCs were identified based on the screening process described in Section 8.3.6.2.
	Soil — Dermal contact	Yes	COPCs were identified based on the screening process described in Section 8.3.6.2.

Table 8.3.16
Exposure Pathways Summary — SWMU 14
NSA Memphis
Millington, TN

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Construction Worker	Air — Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in subsurface soil.
	Air — Inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Groundwater — Ingestion of contaminants during potable or general use	No	Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis, nor are they expected to be in the future.
	Groundwater — Inhalation of volatilized groundwater contaminants	No	Loess and fluvial deposits groundwater are not currently used as a source of potable or nonresidential water at NSA Memphis, nor are they expected to be in the future.
	Soil — Incidental ingestion	Yes	Construction worker RBCs were calculated based on recommendations from TDEC and USEPA Region IV and were used in a screening level assessment as described in Section 8.3.4.6.
	Soil — Dermal Contact	No	Construction worker RBCs were calculated as described in Section 8.3.4.6.

Exposure Point Concentrations

When more than 10 surface soil samples were analyzed, 95% Upper Confidence Levels (UCLs) were calculated as described in the Technical Memorandum on HHRA (E/A&H, 1997e). The lesser of the maximum reported concentrations or the calculated UCLs were used as the EPC (Exposure Point Concentrations) for each COPC. Subsurface soils are assessed in the fate and transport assessment in Section 8.3.6, and in the construction worker scenario in Section 8.3.4.6.

Surface Soil

BEQ was the only COPC identified for surface soil. The BEQ EPC was determined by calculating the UCL of 0.399 mg/kg. The log-transformed mean concentration of 10 samples was

5.16 mg/kg, the standard deviation was 0.7 and the H-statistic was 2.53. The maximum reported concentration of BEQ was 0.806 mg/kg.

Partially Exposed Sediment

Maximum concentrations were used as EPCs, which were previously presented in Table 8.3.13.

Loess Groundwater

Maximum concentrations were used as EPCs, which were previously presented in Table 8.3.14.

Fluvial Deposits Groundwater

The following were identified as COPCs in fluvial deposits groundwater: arsenic, barium, benzene, trichloroethene, and vanadium. Arsenic and barium were reported at concentrations less than their corresponding MCLs. Trichloroethene and benzene were reported at concentrations meeting or exceeding their MCLs. An MCL does not exist for vanadium. The maximum concentrations reported for these COPCs were used as EPCs and are previously presented in Table 8.3.15.

Quantification of Exposure

Exposure was quantified as discussed in the Technical Memorandum on HHRA (E/A&H, 1997e). In accordance with the memorandum, intake calculations were incorporated into risk estimates, and chronic daily intake is not presented separately.

Sediment pathways were developed separately from other media. Sediments were evaluated using a typical site worker scenario, an adolescent trespasser scenario, and a maintenance worker scenario. Sediments collected for analysis were obtained from a drainage ditch, which was assumed to remain dry for approximately 8 months, or 67% of the year. Therefore, the multipliers used to calculate risk and hazard for the typical site worker and the adolescent

trespasser, described in the Technical Memorandum on HHRA (E/A&H, 1997e), were modified by a factor of 0.67 to account for the time when the sediments are submerged, limiting workers' and trespassers' exposure. The modifying factor of 0.67 was also included in multiplier for the maintenance worker scenario, which also used a modifying factor of 0.208 to account for an exposure rate of 52 days per year rather than 250 days per year.

8.3.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in the Technical Memorandum on HHRA (E/A&H, 1997e). Table 8.3.17 presents toxicological references for COPCs identified at SWMU 14. Toxicological profiles for SWMU 14 COPCs are also presented.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg-day (micrograms per kilogram per day) as the RfD for arsenic based on a NOAEL (No-Observed-Adverse-Effect-Level) of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 kg-day/mg oral SF for arsenic. As listed in IRIS (search date 9/1/95), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (Integrated Research Information System-search date 9/1/95), the

Table 8.3.17
Toxicological Reference Information
for Chemicals of Potential Concern
SWMU 14
NSA Memphis RFI

	Non-Carcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Oral Slope Factor (kg-day/mg)		Inhalation Slope Factor (kg-day/mg)		Weight of Evidence	Tumor Type
Arsenic	0.0003	a	M	hyperpigmentation	3	ND	ND	ND	ND	1.5	a	15.1	a	A	various
Barium	0.07	a	M	increased blood pressure	3	ND	ND	ND	ND	ND		ND		D	
Benzene	NA	a	NA	NA	NA	NA	NA	NA	NA	0.029	a	0.029	a	A	nonlymphocytic leukemia
Benzo(a)pyrene Equivalents (BEQ)	ND		NA		ND	ND	ND	ND	ND	7.3	a	6.1	c	B2	mutagen
Beryllium	0.005	a	L	microscopic organ changes	100	ND	ND	ND	ND	4.3	a	8.4	a	B2	osteosarcoma
cis-1,2-Dichloroethene	0.01	a	NA	NA	NA	NA	NA	NA	NA	NA		NA		D	
Tetrachloroethene	0.01	a	M		1000	ND	ND	ND	ND	0.052	b	0.00203	b	C-B2	
Trichloroethene	0.006	b	NA		ND	ND	ND	ND	ND	0.011	c	0.006	b	B2	liver tumors
Vanadium	0.007	a	NA	unclear	100	ND	ND	ND	ND	ND		ND		D	

Notes:

a Integrated Risk Information System (IRIS)
b EPA NCEA - Cincinnati (provisional)
c Withdrawn from IRIS/HEAST
NA Not applicable or not available
ND Not determined due to lack of information
L Low confidence
M Medium confidence

critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Barium is used in various alloys, paints, soap, and manufacturing processes. Barium sulfate, which is used to aid x-ray diagnosis, is relatively abundant in nature and is present in plant and animal tissue. Brazil nuts contain 3 to 4 mg per gram of nuts. The fatal absorbed dose of barium is approximately 1000 mg (for humans). Assuming an absorption efficiency of 5% for barium, 20,000 mg ingested barium could be fatal. Major toxic effects of this element are muscle stimulation, central nervous system effects, and effects on the heart. The major critical effect is increased blood pressure. USEPA determined the oral RfD and inhalation RfD to be 0.07 and 1.43E-4 mg/kg-day, respectively (Dreisbach, et al., 1987) (Klaassen, et al., 1986), based on a medium confidence level. The oral uncertainty factor for barium is 3 and the oral modifying factor is 1. Barium has been issued a carcinogenic weight-of-evidence classification of "D."

Benzene is a VOC which has been associated with leukemia. This chemical has been used as a solvent in coal tar naphtha, rubber, and plastic cement. USEPA lists benzene as a group A carcinogen. In large doses, benzene depresses the central nervous system (CNS), and chronic exposure depresses bone marrow. The oral SF for benzene was set by USEPA as 2.9E-2 $(mg/kg\text{-}day)^{-1}$; an oral RfD has not been set. Occupational inhalation exposure to benzene is acceptable by the Occupational Safety and Health Administration (OSHA) at concentrations of 3.25 milligrams per cubic meter $(mg/m)^3$ or 1 ppm in air (Dreisbach et al; 1987; NIOSH, 1990).

Beryllium exposure via the inhalation route can inflame the lungs, a condition known as acute beryllium disease, as a result of short-term exposure to high concentrations. Removal from exposure reverses the symptoms. Chronic exposure to much lower concentrations of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with

symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined an NOAEL of 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. Human epidemiology studies of beryllium are inadequate. As listed in IRIS (search date 6/28/95), classification is based on beryllium being shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. An inhalation SF of 8.4 kg-day/mg and an oral SF of 4.3 kg-day/mg have been set by USEPA. As listed in IRIS, the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

1,2-Dichloroethene is a halogenated hydrocarbon associated with toxicity to the mucous membrane, skin, lung, cornea (irritation), and liver. This compound is less toxic than its alkane counterparts, and is neither mutagenic nor carcinogenic. There is no USEPA carcinogenicity listing for this compound (Dreisbach et al., 1987). However, the RfDo has been set to 1E-02 mg/kg-day for the cis-isomer, and at 2E-02 mg/kg-day for the trans- isomer by USEPA (HEAST and IRIS, 1996).

Polyaromatic hydrocarbons were assessed in accordance with Supplemental Guidance to RAGS *Bulletin 3, Toxicity Assessment* (USEPA, 1995b) using toxic equivalency factors (TEFs) and include the following COPCs:

Benzo(a)anthracene	TEF=0.1
Benzo(b)fluoranthene	TEF=0.1
Dibenz(a,h)anthracene	TEF=1.0

Benzo(k)fluoranthene	TEF=0.01
Benzo(a)pyrene	TEF=1.0
Indeno(1,2,3-cd)pyrene	TEF=0.1
Chrysene	TEF=0.001

Some PAHs are toxic to the liver, kidney, and blood. However, toxic effects of the PAHs above have not been well-established, aside from their mutagenic properties. RfDs are not available for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene (BAP), having an oral SF of 7.3 kg-day/mg.

TEFs, multipliers determined by USEPA that are applied to the detected concentrations, are used to estimate excess cancer risk for chemicals with similar mutagenic properties. Most PAHs have been classified as carcinogens based on animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC Table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS (search date 6/28/95), the BAP is classified B2 based on insufficient human data specifically linking it to a carcinogenic effect. BAP has produced positive results in numerous genotoxicity assays in which various exposure routes were examined. The B2 classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen.

As listed in IRIS, the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is based on data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells and transformed mammalian cells in culture. Equivocal results have been

found in a lung adenoma assay in mice. Benzo(k)fluoranthene is also mutagenic in bacteria assays (Klaassen et al., 1986).

As listed in IRIS, the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is based on data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells and transformed mammalian cells in culture. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen et al., 1986).

Tetrachloroethene (PCE) has been uwed as a solvent in industry and occurs as a volatile chemical in other chlorinated hydrocarbons. Tetrachloroethene exposure can result in long-lasting narcosis with delayed onset and damage to the liver and kidneys. The principal manifestations of overexposure to this halogenated hydrocarbon are coma, jaundice, oliguria, and irritation of the eyes and nose followed by headache and nausea. Cyanosis and CNS depression progressing to coma appear one to four hours after the short-term exposure. Liver and kidney damage after apparent recovery or after repeated exposures cause acute symptoms such as nausea, vomiting, abdominal pain, jaundice, oliguria, and uremia. PCE exposure via the inhalation and/or skin absorption exposure pathways could result in headache, tremor, dizziness, peripheral paresthesia, hypesthesia or anesthesia. PCE is a carcinogen, but is currently under review by USEPA; it is classified as a B2-C carcinogen. The oral RfD has been set at 0.01 mg/kg-day, and the oral SF and inhalation SF have been set at 0.052 and 0.0023 kg-day/mg, respectively, by USEPA (Dreisbach et al., 1987). An oral RfD uncertainty factor of 1000 has been issued for PCE as well as a modifying factor of 1 (IRIS, 1996).

Trichloroethene is a volatile liquid with the characteristic odor of chloroform. Inhalation, intravenous, and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhaling high concentrations causes narcosis and anesthesia. TCE targets the liver and other organs. TCE is a B2 carcinogen, and the oral SF and inhalation SF have been set by USEPA at 0.011 and 0.006 kg-day/mg, respectively. USEPA set the oral RfD at 0.006 mg/kg-day (Dreisbach et al., 1987).

Vanadium is not readily absorbed through the skin or oral ingestion and is a ubiquitous element. It is also a by-product of petroleum refining. Vanadium is soluble in fats and oils (Klaassen et al., 1986). Municipal water supplies contain 0.001 to 0.006 mg/L. The target organ is unclear, and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg in a daily dose. The oral RfD set by USEPA is 0.007 mg/kg-day.

8.3.4.5 Risk Characterization

Exposure to SWMU 14 surface soil and groundwater was assessed using future residential and industrial site worker scenarios. For each scenario, these exposure pathways were evaluated:

- incidental surface soil ingestion
- dermal contact with surface soil
- ingestion of loess groundwater
- inhalation of VOCs in loess groundwater
- ingestion of fluvial deposits groundwater

Exposure to SWMU 14 sediment was assessed using an industrial site worker, a maintenance worker, and an adolescent site trespasser scenario. For each scenario, these exposure pathways were evaluated:

- incidental sediment ingestion
- dermal contact with sediment

TDEC assumes all groundwater is potential drinking water. Consequently, loess and fluvial deposits groundwater were assumed to be used as drinking water sources. Tables 8.3.18 and 8.3.19 present the estimated ILCRs and HQs associated with the incidental ingestion of and dermal contact with surface soil, respectively. Tables 8.3.20 and 8.3.21 present the estimated ILCRs and HQs associated with the incidental ingestion of and dermal contact with sediment, respectively. ILCR and HQ for groundwater exposure scenarios are presented in Tables 8.3.22, 8.3.23, 8.3.24, and 8.3.25.

Table 8.3.18
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Ingestion of Surface Soil at SWMU 14
NSA Memphis Assembly E
Millington, TN

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC mg/kg**	**Oral RfD mg/kg-day**	**Oral SF kg-day/mg**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
BEQ	0.399	NA	7.3	NA	NA	4.6E-06	NA	5.1E-07

Notes:

BEQ	—	Benzo(a)pyrene equivalent	mg/kg-day	—	milligrams per kilogram per day
HQ	—	Hazard Quotient	NA	—	Not applicable
ILCR	—	Incremental Lifetime Excess Cancer Risk	RfD	—	Reference Dose
LWA	—	Lifetime Weighted Average	SF	—	Slope Factor
kg-day/mg	—	kilograms per day per milligram	EPC	—	Exposure Point Concentration
mg/kg	—	milligrams per kilogram			

Table 8.3.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Exposure to Surface Soil at SWMU 14
NSA Memphis Assembly E
Millington, TN

					Site Resident			*Site Worker*	
					Adult	*Child*	*LWA*	*Adult*	
	EPC mg/kg	**Oral RfD mg/kg-day**	**Oral SF kg-day/mg**	**Dermal Adjustment Factor**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
BEQ	0.399	NA	7.3	0.5	NA	NA	2.1E-06	NA	8.4E-07

Notes:
BEQ — Benzo(a)pyrene equivalent
HQ — Hazard Quotient
ILCR — Incremental Lifetime Excess Cancer Risk
LWA — Lifetime Weighted Average
kg-day/mg — kilograms per day per milligram
mg/kg — milligrams per kilogram
mg/kg-day — milligrams per kilogram per day
NA — Not applicable
RfD — Reference Dose
SF — Slope Factor
EPC — Exposure Point Concentration

Table 8.3.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Ingestion of Partially Exposed Sediments at SWMU 14
NSA Memphis Assembly E
Millington, TN

				Site Worker		*Maintenance Worker*		*Site Trespasser*	
				Adult		*Adult*		*Adolescent*	
Chemical	**EPC mg/kg**	**Oral RfD mg/kg-day**	**Oral SF kg-day/mg**	**HQ**	**ILCR**	**HQ**	**ILCR**	**HQ**	**ILCR**
Arsenic	9.5	0.0003	1.5	0.010	1.7E-06	0.0022	3.5E-07	0.0067	4.3E-07
BEQ	0.4732	NA	7.3	NA	4.1E-07	NA	8.5E-08	NA	1.0E-07
Beryllium	0.49	0.005	4.3	0.000032	2.5E-07	0.0000067	5.2E-08	0.000021	6.4E-08
Cumulative HI or ILCR:				0.01	2E-06	0.002	5E-07	0.007	6E-07

Notes:
BEQ — Benzo(a)pyrene equivalent
HQ — Hazard Quotient
ILCR — Incremental Lifetime Excess Cancer Risk
LWA — Lifetime Weighted Average
kg-day/mg — kilograms per day per milligram
mg/kg — milligrams per kilogram
mg/kg-day — milligrams per kilogram per day
NA — Not applicable
RfD — Reference Dose
SF — Slope Factor
EPC — Exposure Point Concentration

Table 8.3.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact with Partially Exposed Sediments at SWMU 14
NSA Memphis Assembly E
Millington, TN

					Site Worker		*Maintenance Worker*		*Site Trespasser*	
					Adult		*Adult*		*Adolescent*	
	EPC		**Oral RfD**	**Oral SF**						
Chemical	**mg/kg**	**DAF**	**mg/kg-day**	**kg-day/mg**	**HQ**	**ILCR**	**HQ**	**ILCR**	**HQ**	**ILCR**
Arsenic	9.5	0.2	0.0003	1.5	0.0043	6.8E-07	0.00089	1.4E-07	0.0014	8.8E-08
BEQ	0.4732	0.5	NA	7.3	NA	6.6E-07	NA	1.4E-07	NA	8.6E-08
Beryllium	0.49	0.2	0.005	4.3	0.000013	1.0E-07	0.0000028	2.1E-08	0.0000043	1.3E-08
Cumulative HI or ILCR:					0.004	1E-06	0.0009	3E-07	0.001	2E-07

Notes:

BEQ — Benzo(a)pyrene equivalent
HQ — Hazard Quotient
ILCR — Incremental Lifetime Excess Cancer Risk
SF — Slope Factor
kg-day/mg — kilograms per day per milligram
mg/kg — milligrams per kilogram
mg/kg-day — milligrams per kilogram per day
NA — Not Applicable
RfD — Reference Dose
EPC — Exposure Point Concentration
DAF — Dermal Adjustment Factor

Table 8.3.22
Risk Estimates
Ingestion of Loess Groundwater
SWMU 14
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Oral RfD (mg/kg-day)**	**Oral SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
cis-1,2-Dichloroethene	0.0201	0.01	NA	0.055	0.13	NA	0.020	NA
Tetrachloroethene	0.23	0.01	0.052	0.630	1.5	1.8E-04	0.225	4.2E-05
Trichloroethene	0.285	0.006	0.011	1.302	3.04	4.7E-05	0.465	1.1E-05
Cumulative HI or ILCR				2	5	2.E-04	0.7	5.E-05

Table 8.3.23
Risk Estimates
Inhalation and Dermal Contact Exposure to VOCs in Loess Groundwater
SWMU 14
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Inhalation RfD (mg/kg-day)**	**Inhalation SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
cis-1,2-Dichloroethene	0.0201	0.01	NA	0.0551	0.1284	NA	0.020	NA
Tetrachloroethene	0.23	0.01	0.00203	0.6302	1.4697	7.0E-06	0.225	1.6E-06
Trichloroethene	0.285	0.006	0.006	1.302	3.035	2.5E-05	0.465	6.0E-06
Cumulative HI or ILCR				2	5	3.E-05	0.7	8.E-06

Notes:

EPC = Exposure point concentration
RfD = Reference Dose; the oral RfD was applied when no inhalation RfD was available
SF = Slope Factor
HQ = Hazard quotient
ILCR = Incremental excess lifetime cancer risk
HI = Hazard index
NA = Not applicable
LWA = Lifetime weighted average

Table 8.3.24
Risk Estimates
Ingestion of Fluvial Deposits Groundwater
SWMU 14
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Oral RfD (mg/kg-day)**	**Oral SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
Arsenic	0.004	0.0003	1.5	0.4	0.9	8.9E-05	0.13	2.1E-05
Barium	0.638	0.07	NA	0.2	0.6	NA	0.09	NA
Vanadium	0.054	0.007	NA	0.2	0.5	NA	0.08	NA
Benzene	0.005	NA	0.029	NA	NA	2.2E-06	NA	5.1E-07
Trichloroethene	0.00531	0.006	0.011	0.024	0.06	8.7E-07	0.009	2.0E-07
Cumulative HI or ILCR				0.9	2	9.E-05	0.3	2.E-05

Table 8.3.25
Risk Estimates
Inhalation and Dermal Contact Exposure to VOCs in Fluvial Deposits Groundwater
SWMU 14
NSA Memphis RFI

				Site Resident			*Site Worker*	
				Adult	*Child*	*LWA*	*Adult*	
Chemical	**EPC (mg/L)**	**Inhalation RfD (mg/kg-day)**	**Inhalation SF (kg-day/mg)**	**HQ**	**HQ**	**ILCR**	**HQ**	**ILCR**
Benzene	0.005	0.00171	0.029	0.0801	0.1868	2.2E-06	0.0286	5.1E-07
Trichloroethene	0.00531	0.006	0.006	0.024	0.057	4.7E-07	0.009	1.1E-07
Cumulative HI or ILCR				0.1	0.2	3.E-06	0.04	6.E-07

Notes:

EPC = Exposure point concentration
RfD = Reference Dose; the oral RfD was applied when no inhalation RfD was available
SF = Slope Factor
HQ = Hazard quotient
ILCR = Incremental excess lifetime cancer risk
HI = Hazard index
NA = Not applicable
LWA = Lifetime weighted average

Hypothetical Site Residents

In accordance with RAGS, risks to site residents were evaluated for carcinogens using the lifetime weighted average. Noncarcinogenic risk, or hazard, was estimated separately to address child and adult exposure. As shown in Figure 8.3.11, the sum of soil, loess groundwater, fluvial deposits groundwater, and sediment risk estimates was greater than 2.5E-04. The loess groundwater exposure pathway generated the greatest source of risk with an ILCR of 2E-04. The fluvial deposits groundwater exposure pathway ILCR was 9E-05. As shown in Figure 8.3.12, arsenic and tetrachloroethane were the primary contributors to carcinogenic risk in SWMU 14. Figure 8.3.13 shows the contribution from each exposure pathway to the child HI. The loess groundwater exposure pathway HI, 10, is the primary contributor to the cumulative HI of 10.

Surface Soil

The estimated ILCR for surface soil ingestion at SWMU 14 (based on adult and child lifetime weighted average) is 5E-06. The dermal pathway ILCR estimate is 8E-07. Carcinogenic PAHs (as BEQs) are the sole contributors to the ILCR for each pathway. Noncarcinogenic COPCs were not identified in surface soil at SWMU 14; therefore, HQs were not calculated for surface soil.

Loess Groundwater

The projected ingestion-related LWA ILCR estimate for loess groundwater at SWMU 14 is 2E-04. HIs for the ingestion pathway were estimated to be 2 and 5 for adults and children, respectively. The inhalation-related LWA ILCR estimate is 3E-05, and the inhalation HIs for adults and children, were 2 and 5, respectively. Tetrachloroethene and trichloroethene are the main contributors for HI and ILCR, with 1,2-dichloroethene also contributing to the HI.

Fluvial Deposits Groundwater

The projected ingestion-related ILCR LWA for fluvial deposits groundwater at SWMU 14 is 9E-05. Arsenic, benzene, and tetrachloroethene were contributors for this pathway. The HIs for

Figure 8.3.11 SWMU 14 Residential Risk Estimates

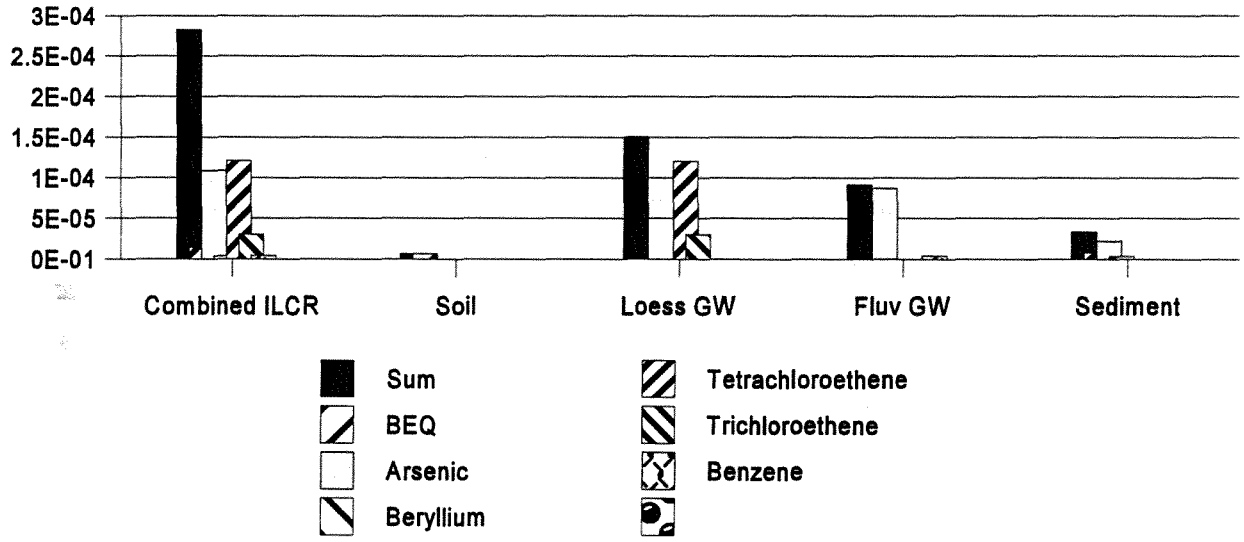

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Figure 8.3.12 SWMU 14 Residential Risk Contributors

Risk Estimates are 1E-5 Times Value Shown

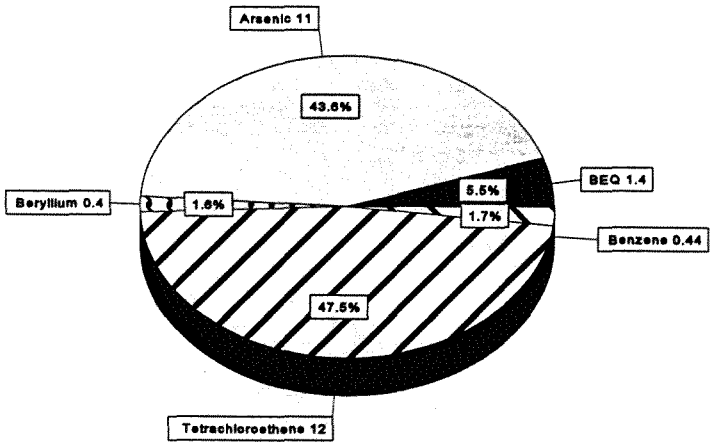

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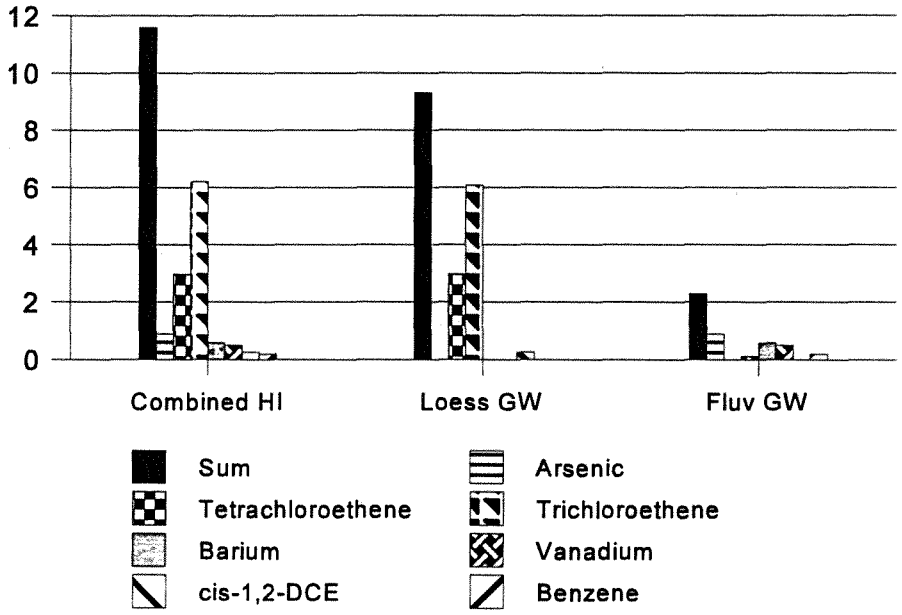
Figure 8.2.13 SWMU 14 Residential Child Hazard Index Estimates



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adult and child residential receptors were estimated to be 0.9 and 2, respectively. Arsenic, vanadium, and barium were the primary contributors to the HI. The inhalation ILCR estimate for fluvial deposits groundwater is 3E-06. Inhalation HIs for adult and child residents are 0.1 and 0.2, respectively. Benzene and tetrachloroethene are the only contributors to inhalation ILCR and HI.

Hypothetical Site Workers

Figure 8.3.14 presents the industrial risk estimates for each pathway. Loess and fluvial deposits groundwater are the primary risk exposure pathways at SWMU 14. Figure 8.3.15 shows the percentage of contribution from individual COPCs to the estimated risk. Arsenic, tetrachloroethene, and trichloroethene are the major contributors to ILCR estimates for site workers at SWMU 14. Figure 8.3.16 shows individual COPC contributors to the industrial exposure HI as well as cumulative values.

Surface Soil

Site worker ILCRs estimates are 5E-07 and 8E-07 for the ingestion and dermal contact pathways, respectively, with carcinogenic PAHs (as BEQs) as the only contributor to ILCR for each pathway. There were no noncarcinogenic COPCs reported in surface soil.

Sediment

Site worker ILCR estimates are 2E-06 and 1E-06 for the ingestion and dermal contact pathways, respectively. Carcinogenic PAHs (as BEQs), arsenic, and beryllium were the contributors to the ILCR. The HI estimate for soil ingestion is 0.01. The HI estimate for dermal exposure is 0.004.

Groundwater

Exposure to groundwater was evaluated under both residential and industrial (site worker) land use scenarios. For noncarcinogenic chemicals evaluated for hypothetical site residents, HQs were computed separately to address children and adults.

Loess Groundwater

Ingestion-related ILCR from loess groundwater is 5E-05, and the HI is 0.7. The projected inhalation of volatiles ILCR is 8E-06, and the HI is 0.7. Arsenic is the primary contributor to ingestion risk and hazard.

Fluvial Deposits Groundwater

The ILCR estimate for ingestion of fluvial deposits groundwater is 2E-05, and the HI is 0.3. The ILCR estimate for inhalation of volatiles is 6E-07, and the HI is 0.04. Benzene and tetrachloroethene are the contributors to ILCR and HI estimates for this exposure pathway.

Maintenance Worker

Sediment

For the maintenance worker scenario, as described in Section 8.3.4.3, the worker was assumed to be exposed to site chemicals 52 days per year while providing lawn care, which would occur in the eight months that sediment is assumed to be exposed. The estimated ILCR for the maintenance worker via ingestion of partially exposed sediments is 5E-07. The estimated HI is 0.002. The estimated ILCR via dermal exposure is 3E-07, and the HI is 0.0009.

Site Trespasser

Sediment

For the adolescent site trespasser scenario (as described in Section 8.3.4.3 and in the Technical Memorandum on HHRA [E/A&H, 1997e]) assumptions included an exposure duration of

Figure 8.3.14 Industrial Risk Estimates

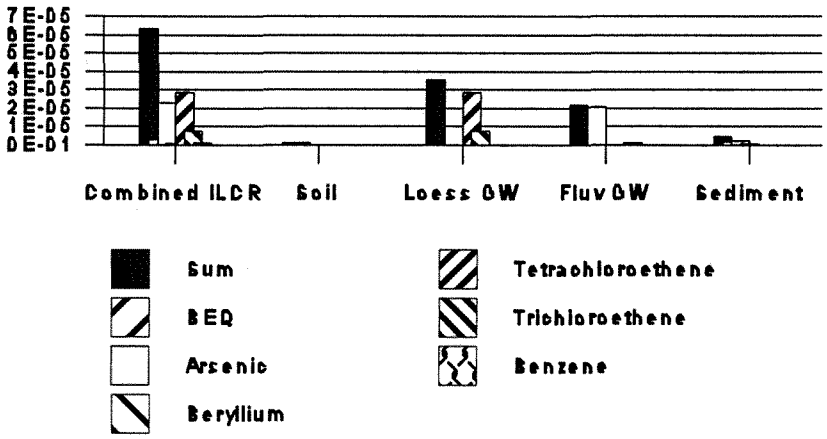

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Figure 8.3.15 SWMU 14 Industrial Risk Contributors 1

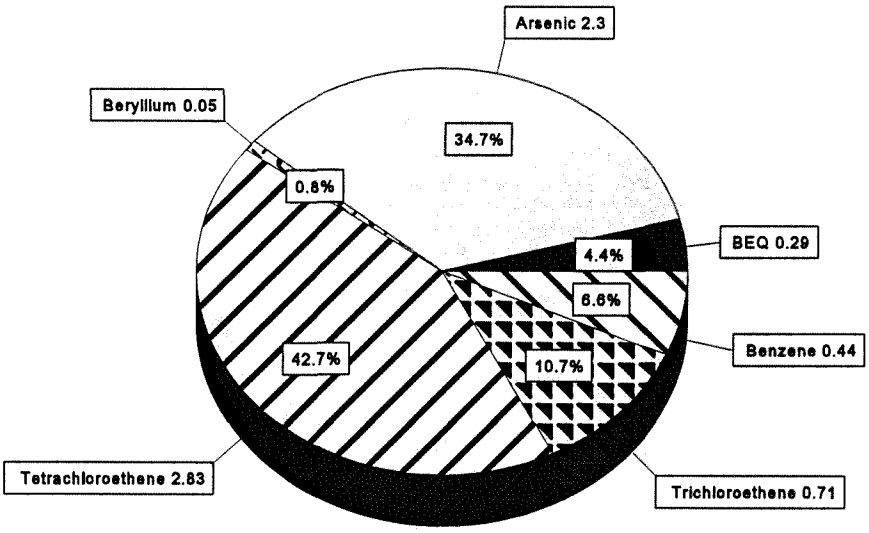

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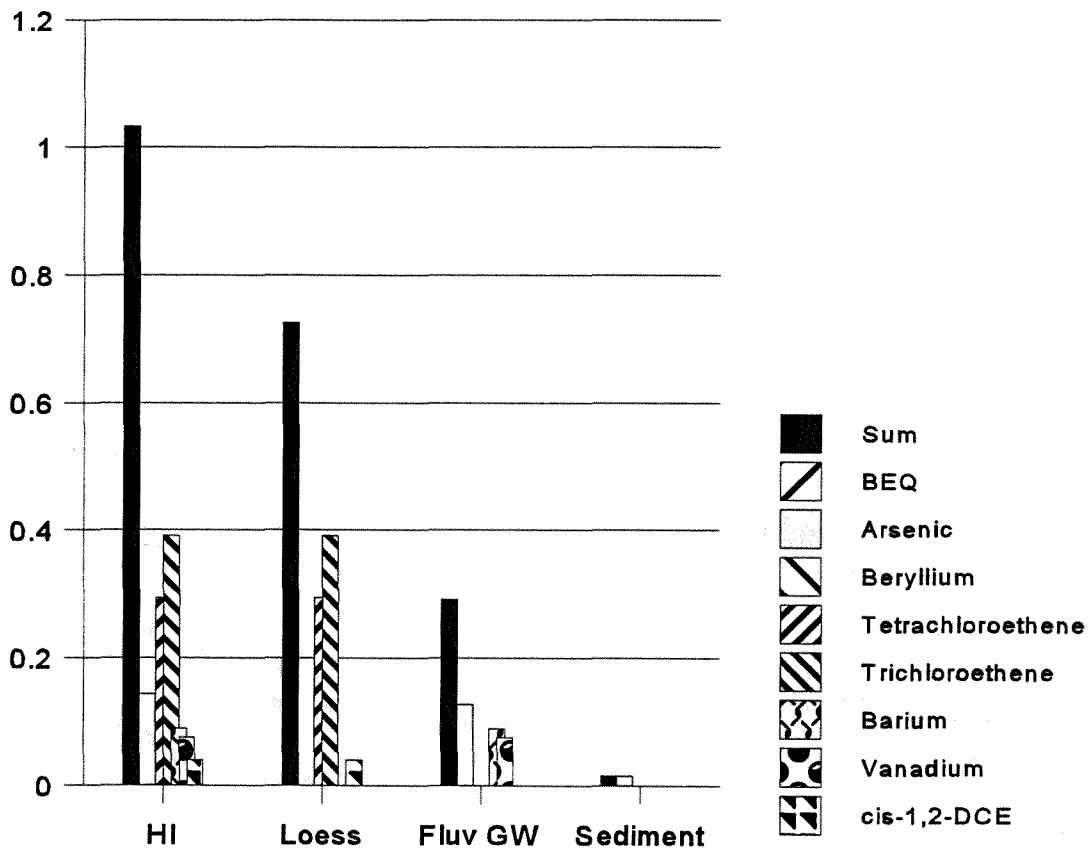
Figure 8.3.16 SWMU 14 Worker Hazard Index Estimates



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10 years, a body weight of 45 kg, and an exposure frequency of 52 days per year. The adolescent trespasser exposure multiplier was also adjusted for the fraction of time per year when SWMU 14 sediment is exposed (eight months per year). The estimated ILCR via ingestion is 6E-07, and the HI is 0.007. The estimated ILCR via dermal exposure is 2E-07, and the HI is 0.001.

COCs Identified

As described in the Technical Memorandum on HHRA, COCs were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In Assembly E HHRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative HI above 1.0, if its individual ILCR exceeds 1E-6 or its HQ exceeds 0.1. The COC selection algorithm provides a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process.

Hypothetical Site Residents

Surface Soil

No risk- or hazard-based COCs were identified for the hypothetical site resident scenario.

Loess Groundwater

1,2-Dichloroethene, tetrachloroethene and trichloroethene were identified as COCs for this scenario based on their contribution to risk and hazard.

Fluvial Deposits Groundwater

Arsenic, benzene, vanadium, and barium were identified as COCs for this scenario based on their contribution to hazard, assuming an UCL (95%) exposure frequency.

Hypothetical Site Workers

Surface Soil

No risk or hazard-based COCs were identified for the hypothetical site worker scenario.

Sediments

No risk or hazard-based COCs were identified for the hypothetical site worker scenario.

Loess Groundwater

No COCs were identified for this scenario based on their contribution to risk and hazard.

Fluvial Deposits Groundwater

No COCs were identified for this scenario based on their contribution to risk and hazard.

Maintenance Worker

Sediment

No COCs were identified for this scenario based on their contribution to risk and hazard.

Site Trespasser

Sediment

No COCs were identified for this scenario based on their contribution to risk and hazard.

Summary Risk Mapping

In addition to the standard tabular presentation of risk estimates in Section 8.3.4.5, point estimate maps were plotted for loess and fluvial deposits groundwater to clarify the spatial distribution for risk managers. As an extension of conventional data presentation, excess cancer risk and hazard estimates were calculated for each sample location. Point estimates of risk and hazard were developed for both residential and industrial land use scenarios for relative comparison. These

point risk estimates and corresponding maps exclude DPT samples, which were collected to determine appropriate placement of the samples presented in the summary figures and tables.

Tables were generated to present risk estimates for each COC at each sample location using the ratio of the reported concentration to the corresponding RGO and risk estimate used to develop the RGO. For example, the residential RGO for tetrachloroethene is 1.24 mg/L when estimated at 1E-06 risk for an LWA residential receptor. A loess groundwater tetrachloroethene concentration of 150 mg/L would result in a risk estimate of 1.2E-04. This method incorporates both incidental ingestion and dermal contact exposure pathways, the basis for calculating RGOs. These tables are presented in Section 8.3.4.9

COCs were not detected at all sample locations, as discussed in Section 8.3.2. However, concentrations were assumed to be present in site samples slightly below sample quantitation limits, when COCs were reported as nondetects. As discussed in the Technical Memorandum on HHRA (E/A&H, 1997e), the assumed concentration for a specific organic COC equals either one-half of the lowest reported hit or one-half the reported sample quantitation limit. Using one-half the lowest reported hit accounts for any elevated sample quantitation limits that could bias risk estimates and overestimate risk by using some other assumed concentration. Assumed concentrations for inorganics equal one-half of the reported sample quantitation limit. After estimating risk for each COC and each sample location, risk estimate were summed to provide cumulative risk estimates for each sample location and land-use scenario. Individual hazard estimates were established as well as cumulative hazard estimates for each COC and each sample location.

ArcView, a graphical data presentation and geographic information system software package, was used to plot risk and hazard estimates on maps of NSA Memphis. The risk or hazard for individual locations was plotted using corresponding northing and easting data. All graphical

presentations of risk and corresponding tables are based on RME assumptions and RGOs presented in Section 8.3.4.8. Figures were developed for a residential land use scenario only. Point estimates for an industrial land use scenario are shown in corresponding tables in Section 8.3.4.9.

Risk and hazard point mapping is useful for determining whether hot spots (or isolated areas of gross contamination) exist within an otherwise unimpacted area and in identifying areas where remedial activities would be more effective. This information is important because heterogeneous contaminant concentrations can affect the manner in which receptors are exposed to the affected media. As discussed earlier, it is sometimes appropriate to estimate the FI/FC from the contaminated source in computing CDI. Point maps allow for visual analysis of risk and hazard distributions and facilitate estimation of the extent of hot spots relative to the overall site area. These maps also support preliminary scoping of remedial requirements as well as assessment of potential cleanup alternatives in the CMS.

Cumulative risk maps could be misleading when different chemicals contribute to elevated risk estimates in a cluster of sample locations. Such an area could appear to be a hot spot, when chemicals with different toxicology were reported at each location. For this reason, it is important to support the figures with tables showing individual chemical concentrations along with risk and hazard estimates. These tables are sorted by sample location and also show cumulative values for each location.

Figures presented in this report are approximations which include many uncertainties. Loess and fluvial deposits groundwater are not currently used for potable purposes at NSA Memphis, nor are they expected to be in the future; therefore groundwater exposure pathways are not likely to be completed. Point estimates shown in tables and figures below would overestimate risk and hazard for the groundwater pathways. The numerous uncertainties in risk and hazard estimates presented in tables and figures below should be considered by risk management when making

decisions regarding the potential for exposure to site media. If an exposure pathway will not be completed, that pathway poses no risk.

8.3.4.6 Risk Uncertainty

Several parameters contribute to risk assessment uncertainty including:

- Future exposure settings and exposure pathways are unknown
- Toxicological uncertainty in the determination of SFs and RfDs
- EPC estimation
- Human exposure quantification
- Elimination of some CPSSs

Fate and transport uncertainties are addressed in Section 8.3.6.

Exposure Setting and Exposure Pathways

Surface Soil

Currently there are no future re-use plans for SWMU 14, but a residential re-use is highly unlikely. Therefore a residential re-use scenario is likely to overestimate exposure, which could result in overestimates in projected risk/hazard values.

Subsurface Soil

Construction work generally requires less than one year to complete a project, and chronic exposure is typically seven years or more. The current site worker scenario used in this assessment assumes 25-year exposure. Therefore, future worker assessment is considered to be protective of both current site use and future construction/maintenance exposure scenarios for surface soil. The future site resident scenario assumed existing buildings would be removed and

replaced with dwellings. In addition, the future site residents and workers were assumed to use the onsite underlying aquifers as a source of drinking water.

USEPA Region IV and TDEC recommend the construction worker scenario be assessed using default worker assumptions, with the following exceptions:

Exposure Duration = 0.5 year (one year was used as recommended when estimating ILCR)
Exposure Frequency = 120 days/year
Ingestion Rate = 340 mg/day (modified as discussed below)

The modified ingestion rate is based on the time-weighted average, assuming a worker would be exposed to a hole in the ground, incidentally ingesting 480 mg/day (RBCA/ASTM) for 0.5 year, and 200 mg/day for 0.5 year (USEPA, 1995b). The weighted average is 340 mg/day. Intake multipliers were calculated in accordance with RAGS as discussed in the Technical Memorandum on HHRA.

Assuming a soil concentration of 1 mg/kg and applying the modified exposure assumptions presented above, this results in the following intake multipliers:

- Ingestion Hazard Multiplier = 1.6E-06
- Ingestion ILCR Multiplier = 1.28E-08

As presented in the Technical Memorandum on HHRA the residential intake multipliers are:

- Ingestion Hazard Multiplier = 1.28E-07
- Ingestion ILCR Multiplier = 1.57E-09

RBCs were calculated by USEPA Region III using similar multipliers. The following equation can be used to calculate the RBC for a site resident exposed to soil:

$$RBC = \frac{\text{Target Risk Goal}}{\text{Ingestion Hazard Multiplier x Slope Factor}}$$

For example, the slope factor for arsenic is 1.5 kg-day/mg. Using arsenic as an example with a target risk goal of 1E-6 and the residential multiplier for carcinogens shown above, the RBC would equal approximately 0.43 mg/kg, the same value shown in USEPA Region III's RBC tables. Applying the multiplier for the construction worker scenario results in an RBC for a construction worker scenario approximately equal to 134 mg/kg, which is shown in Table 8.3.26.

Because a linear relationship exists between the two land use scenarios, residential RBCs for noncarcinogens and carcinogens can be related to construction worker RBCs using the following multipliers:

- Noncarcinogens = 8 * RBC_N (residential) = RBC_N (construction worker)
- Carcinogens = 68.63 * RBC_C (residential) = RBC_C (construction worker)

For example, the arsenic RBC which is based on carcinogenicity, is 0.43 mg/kg. Multiplying this value by 68.63 results in the construction worker RBC of 29.5 mg/kg shown in Table 8.3.26. Similar calculations were performed for noncarcinogens, and a screening level assessment was performed for SWMU 14 subsurface soil by comparing all chemicals reported in subsurface soil to construction worker RBCs.

Table 8.3.26
Construction Worker Scenario
SWMU 14
NSA Memphis

Chemical	MAX µg/kg	RBC res µg/kg	RBC const µg/kg	NOTE	RC µg/kg
2,4-DB	160	630,000	5,040,000	N	NA
4-Methyl-2-Pentanone (MIBK)	1	6,300,000	50,400,000	N	NA
Acetone	47	7,800,000	62,400,000	N	NA
Anthracene	44	23,000,000	184,000,000	N	NA
Antimony	13,800	31,000	248,000	N	NA
Arsenic	12,500	430	29,511	C	20,320
Barium	208,000	5,500,000	44,000,000	N	265,120
Benzo(a)anthracene	84	880	60,394	C	NA
Benzo(a)pyrene	65	88	6,039	C	NA
Benzo(b)fluoranthene	58	880	60,394	C	NA
Benzo(g,h,i)perylene	44	3,100,000	24,800,000	N, a	NA
Benzo(k)fluoranthene	61	8,800	603,944	C	NA
bis(2-Ethylhexyl)phthalate (BEHP)	68	46,000	3,156,980	C	NA
Cadmium	3,700	39,000	312,000	N	3,240
Chromium	16,900	390,000	3,120,000	N	28,280
Chrysene	77	88,000	6,039,440	C	NA
Cobalt	8,400	4,700,000	37,600,000	N	14,360
Copper	20,000	3,100,000	24,800,000	N	32,520
Di-n-octyl phthalate	450	1,600,000	12,800,000	N	NA
Dinoseb	2.6	78,000	624,000	N	NA
Fluoranthene	210	3,100,000	24,800,000	N	NA
Lead	22,100	400,000	400,000	b	19,800
MCPP	5,900	78,000	624,000	N	NA
Nickel	22,400	1,600,000	12,800,000	N	NA
Phenanthrene	220	3,100,000	24,800,000	N, a	NA
Pyrene	190	2,300,000	18,400,000	N	NA
Silver	4,200	390,000	3,120,000	N	NA
Tetrachloroethene (PCE)	23	12,000	823,560	C	NA
Tin	53,300	47,000,000	376,000,000	N	NA
Trichloroethene (TCE)	19	58,000	3,980,540	C	NA
Vanadium	26,500	550,000	4,400,000	N	43,680
Xylene (Total)	3	160,000,000	1,280,000,000	N	NA
Zinc	121,000	23,000,000	184,000,000	N	109,000

Notes:

MAX - Maximum reported concentration in subsurface soil

RBC res - Screening based on USEPA's 1998 Risk-Based Concentration tables (USEPA, 1998)

RBC const - Screening based on construction worker soil ingestion as per RBCA/ASTM guidance

RC - NASP reference concentration

NA - Not applicable/not available

N - Noncarcinogen

C - Carcinogen

a - Fluoranthene used as surrogate

b - industrial cleanup goals used at other federal facilities

Sediment

Sediment was hypothetically treated as surface soil in RBC comparisons. Such comparisons could overestimate or underestimate potential risk and hazard values. However, separate assumptions were determined to provide reasonable maximum exposure scenarios. Sediment was assumed to be exposed eight months of the year. Scenarios included a typical site worker, maintenance worker, and a site trespasser scenario. Any of these scenarios could overestimate or underestimate exposure, depending on how long sediments are actually exposed.

Loess and Fluvial Deposits Groundwater

Loess and fluvial deposits groundwater are not currently used at SWMU 14 or NSA Memphis for potable or industrial purposes. NSA Memphis has a system that supplies drinking and process water from the Memphis aquifer. This system is to remain in operation under the current reuse plan. As a result, shallow groundwater use would not be expected under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed.

Toxicological Uncertainty

Surface Soil

BEQ has a "B2" cancer rating which indicates that it causes cancer in animals but has not been demonstrated to cause cancer in humans. This may overestimate the cancer risk from exposure to BEQ.

Sediment

Arsenic was assessed as a carcinogen, and arsenic ILCR was a primary contributor to risk estimates for sediment exposure pathways. USEPA evaluated the cancer potency of arsenic based on certain studies from the literature. Limitations in these studies and the methods used by USEPA would result in overestimates of arsenic risk. For example, arsenic's MCL is 50 mg/L

(USEPA, 1996c). Yet, exposure to drinking water with 50 mg/L arsenic would equate with unacceptable risk. The technology-based method used to calculate the MCL for arsenic is not the same as risk-based methods used to assess risk.

USEPA derived the oral SF from a Taiwanese study of human exposures to groundwater containing arsenic (Tseng et al., 1968). The assumptions used by USEPA to derive the SF may have underestimated dietary exposure to arsenic (Yost et al., 1994). More recent water intake values were available for the Taiwanese population. These values are higher than the historical data used by USEPA. Using higher water intake values would reduce the expected cancer potency. In addition, toxic effects of arsenic could have been exacerbated because the study population was reportedly undernourished and many had chronic liver disease (Hsueh et al., 1995).

The calculation method USEPA used to determine the SF may also have overestimated the cancer-causing potential of arsenic. A linear dose response curve was assumed by USEPA, and the dose-response curve for arsenic may be sublinear (Loehr et al., 1989). In 1989, the USEPA Science Advisory Board concluded that, "at dose levels below 200-250 micrograms arsenic per day there is a possible detoxification mechanism that may substantially reduce cancer risk from the levels USEPA has calculated using a linear-quadratic model fit to the Tseng data."

The Tseng study was based on water ingestion, and many studies indicate arsenic is more bioavailable from water than soil. Ingesting arsenic in soil may not elicit toxic responses, while the same amount of arsenic ingested from groundwater may be toxic (ATSDR, 1992). Relative bioavailabilities of arsenic in soil to arsenic in groundwater range from 20% to 78% (Freeman et al., 1993, 1994).

USEPA determined that risk-based concentrations for arsenic should be multiplied by 10 to account for the uncertainty in arsenic's carcinogenicity (USEPA, 1988). For example, a risk-based concentration of 0.001 mg/L would be changed to 0.01 mg/L. In addition, the mean relative bioavailability of 78% is recommended by USEPA to address arsenic in soil. In summary, a risk-based concentration of 1 mg/kg would be modified (e.g., 1/0.78 = 1.282 mg/kg) to approximately 1.28 mg/kg. The 1.28 mg/kg concentration in soil would also be adjusted to account for the uncertainty in arsenic's SF, resulting in an adjusted value of 12.8 mg/kg. The relative bioavailability factor would not be applicable to groundwater concentrations, so a risk-based groundwater concentration of 0.001 mg/L would be modified to 0.01 mg/L. Therefore, risk and hazard estimates are potentially overestimates.

Loess Groundwater

TCE and PCE have "B2" cancer ratings which indicates that they cause cancer in animals but have not been demonstrated to cause cancer in humans. This may overestimate the cancer risk from exposure to these compounds.

Fluvial Deposits Groundwater

Arsenic is carcinogenic in humans, and has been shown to cause squamous cell carcinoma or blackfoot disease. USEPA's policy regarding arsenic is discussed above. Vanadium's primary entrance pathway is inhalation and it is not readily absorbed through the skin or via oral ingestion. It appears to pose little danger through water ingestion. Barium's toxic effects include muscle stimulation, central nervous system effects, and increased blood pressure. The cumulative effect of these compounds is not known.

Determination of Exposure Point Concentrations

EPCs are used to estimate CDI. The uncertainty associated with EPCs primarily stems from their statistical determination (UCLs) or imposition of maximum concentrations. Use of the maximum is highly conservative and generally overestimates exposure.

Surface Soil

The UCL was determined to be the EPC for BEQ. The primary uncertainty in using the UCL is in the statistical determination, which could overestimate exposure.

Sediments

Only two samples were collected and the maximum concentration was used to estimate the EPC. As a result, the EPC may be overestimated, which indicates that exposure may be overestimated.

Loess Groundwater

The tetrachloroethene, 1,2-dichloroethene, and trichloroethene EPCs were the maximum reported concentrations. As a result, exposure estimates may be overestimated, because these chemicals were reported as nondetects at some locations.

Fluvial Deposits Groundwater

EPCs were based on maximum concentrations, which tend to overestimate exposure as mentioned above.

Frequency of Detection and Spatial Distribution

Surface Soil

BEQs were detected in 6 of 10 surface soil samples analyzed. Uniform exposure was assumed, which could potentially overestimate risk or hazard estimates.

Sediment

Only two sediment samples were collected. BEQs were reported in only one sample, while arsenic and beryllium were reported in both samples. Sediment was assumed to be exposed only eight months of the year, which could overestimate or underestimate actual exposure depending on rainfall.

Loess Groundwater

Tetrachloroethene and trichloroethene were present in only one of five samples, which could indicate a hot spot. Hence, assuming uniform exposure could overestimate risk and hazard estimates.

Fluvial Deposits Groundwater

Arsenic was detected in three of four samples, barium in all four samples, and vanadium in one of four samples. By assuming a uniform concentration exposure for arsenic and vanadium may be overestimated, since each chemical was not detected in all samples.

Imposing the maximum reported concentration overestimates exposure because low detection frequency compounds are not distributed equally across the site.

Quantification of Risk/Hazard

As indicated by the discussions above, uncertainty is inherent during the risk assessment process. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of variability and uncertainty are discussed below.

Surface Soil

Although future land use at this site is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely overestimate risk and/or hazard. The RME assumptions were used to calculate the risk/hazard estimations to soil exposure. The RME is based on the 95th percentile, which tends to overestimate the risk/hazard.

Sediment

A site worker, maintenance worker, and site trespasser scenario were determined for SWMU 14 sediment exposure. In these scenarios, sediment was only assumed to be exposed for eight months of the year. The maintenance worker and site trespasser scenarios both assumed a 52-day exposure frequency, which reduces uncertainty stemming from using a 250-day exposure frequency. However, as stated before, exposure could be overestimated or underestimated, depending on how long sediments are actually exposed.

Sediments were not compared to soil reference concentrations in this HHRA. However, if they were compared, none of the COPCs were detected above soil RCs; hence, risk and hazard estimates may be overestimated.

Loess and Fluvial Deposits Groundwater

As a measure of variability, CT analysis was performed for loess and fluvial deposits groundwater. Exposure assumptions were modified to reflect the 50th percentile rather than the 95th, and EPCs were not modified. In accordance with *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure-Draft* (USEPA, 1993a), the exposure duration of site residents was reduced from 30 to nine years, two years for child exposure, and seven years for adult exposure. Exposure frequency was reduced from 350 to 234 for site residents and from 250 to 219 for site workers. The drinking water ingestion rate for an

adult was reduced from 2 to 1.4 liters per day, and exposure to groundwater was reduced by 25% to account for other water sources. Using the CT assumptions above, adult and child residential intakes would reduce to 60% and 50% of the RME values. Site workers' intake would be reduced to 35% of the RME value. Risk estimates would be proportionately reduced.

Summary Risk Mapping

As stated earlier, figures presented in this report are approximations which include many uncertainties. For example, shallow groundwater is not currently used at SWMU 14 for potable or industrial purposes. NSA Memphis has an existing system that supplies drinking and process water from a deeper groundwater source and according to the current reuse plan it is to remain in operation. As a result, shallow groundwater use would not be expected under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future. In addition, risk figures for SWMU 14 correspond to a residential scenario based on a child's exposure. The current land use is not expected to change under the current reuse plan. Hence, risk figures tend to show risk and hazard as overestimates.

Risk figures are inherently graphical representations of the risk and hazard estimates from this report. Hence, all previous examples of uncertainty discussed in Section 8.3.4.6 also apply to the risk figures.

8.3.4.7 Risk Summary

Risk estimates for all exposure pathways evaluated are summarized in Table 8.3.27, including chemical-specific as well as multi pathway risk estimates.

Table 8.3.27
Summary Risk Estimates
All Exposure Pathways
SWMU 14 — NSA Memphis

	Future Site Residents			Current and Future Site Workers		Current and Future Maintenance Workers		Current and Future Site Trespassers
	Adult	Child	LWA	Adult		Adult		Adult
Medium and Exposure Pathway	**HI**	**HI**	**ILCR**	**HI**	**ILCR**	**HI**	**ILCR**	**HI**	**ILCR**
Soil — Incidental Ingestion	NA	NA	5e-06	NA	5e-07	NA	NA	NA	NA
Soil — Dermal Contact	NA	NA	2e-06	NA	8e-07	NA	NA	NA	NA
Sum of Soil	*NA*	*NA*	*7e-06*	*NA*	*1e-06*	*NA*	*NA*	*NA*	*NA*
Sediment — Incidental Ingestion	NA	NA	NA	0.01	2e-06	0.002	5e-07	0.007	6e-07
Sediment — Dermal Contact	NA	NA	NA	0.004	1e-06	0.0009	3e-07	0.001	2e-07
Sum of Sediment	*NA*	*NA*	*NA*	*0.01*	*3e-06*	*0.003*	*8e-07*	*0.008*	*8e-07*
Loess Groundwater — Ingestion	2	5	2e-04	0.7	5e-05	NA	NA	NA	NA
Loess Groundwater — Inhalation of VOCs	2	5	3e-05	0.7	8e-06	NA	NA	NA	NA
Sum of Loess Groundwater	*4*	*10*	*2e-04*	*1.4*	*6e-05*	*NA*	*NA*	*NA*	*NA*
Sum of Soil, Sediment, and Loess Groundwater	*4*	*10*	*2e-04*	*1.4*	*6e-05*	*0.003*	*8e-07*	*0.008*	*8e-07*
Fluvial Deposits Groundwater — Ingestion	0.9	2	9e-05	0.3	2e-05	NA	NA	NA	NA
Fluvial Deposits Groundwater — Inhalation	0.1	0.2	3e-06	0.04	6e-07	NA	NA	NA	NA
Sum of Soil, Sediment, and Fluvial Deposits Groundwater	*1*	*2*	*1e-04*	*0.3*	*3e-05*	*0.003*	*8e-07*	*0.008*	*8e-07*

Notes:
ILCR — Incremental lifetime excess cancer risk
HI — Hazard Index
NA — Not applicable
LWA — Lifetime weighted average

8.3.4.8 Remedial Goal Options

Surface Soil

No COCs were identified for soil exposure pathways; therefore, RGOs were not calculated.

Sediments

No COCs were identified for sediment exposure pathways; therefore, RGOs were not calculated.

Loess Groundwater

RGOs were calculated for 1,2-dichloroethene, tetrachloroethene, and trichloroethene. Table 8.3.28 presents RGOs for LWA ILCR and HI for a child's exposure. Although these chemicals were not identified as COCs for an industrial exposure pathway, RGOs for the site worker are presented for a relative comparison.

Fluvial Deposits Groundwater

RGOs were calculated for arsenic, benzene, vanadium, and barium. Table 8.3.29 presents RGOs for a child's hazard exposure. Although these chemicals were not identified as COCs for an industrial exposure pathway, RGOs for the site worker are presented for a relative comparison.

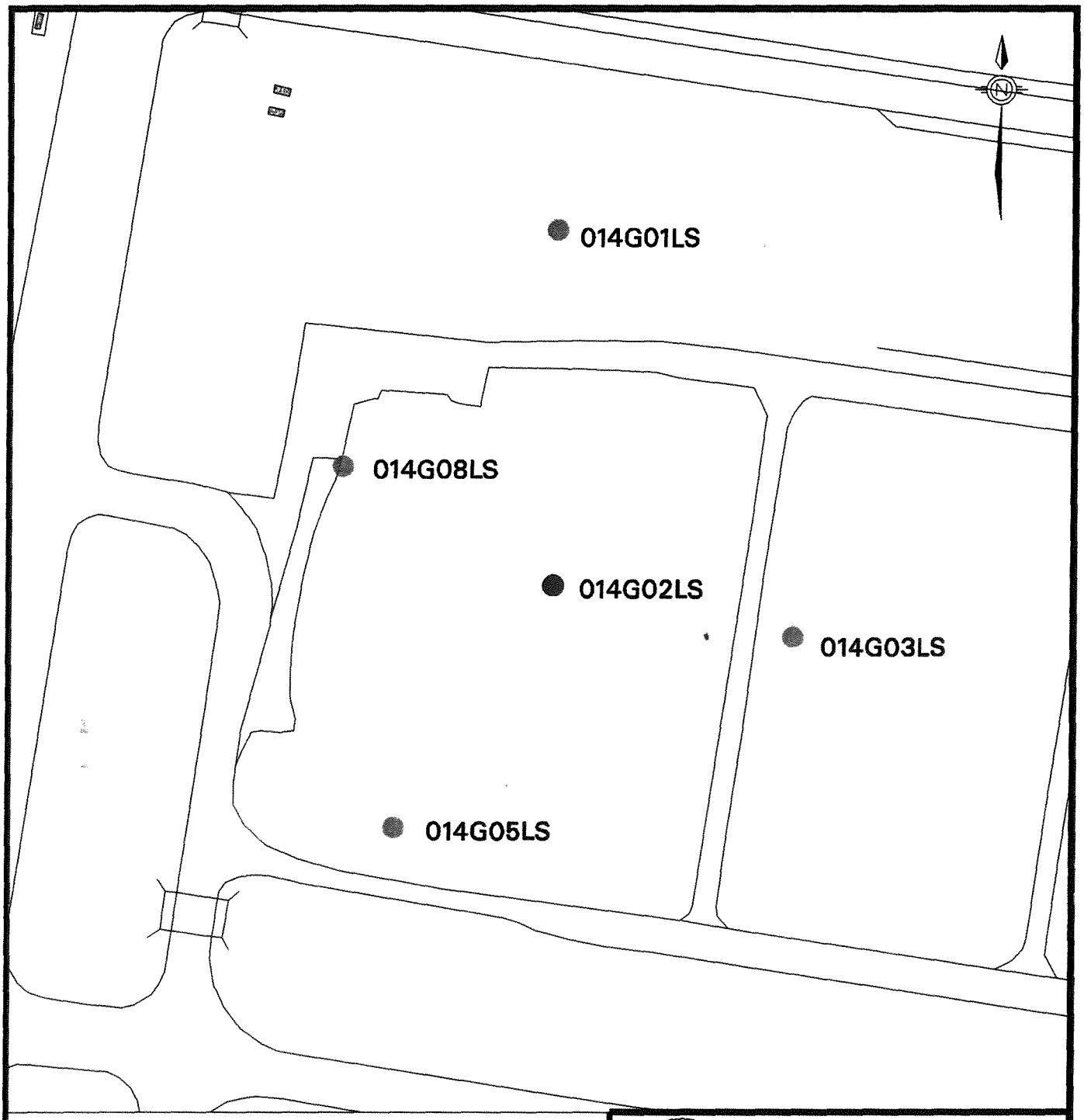
8.3.4.9 Summary Risk Figures

Risk figures were developed for loess groundwater risk, and loess and fluvial deposits groundwater hazard. As previously discussed, figures were developed only for a residential land use scenario, based on a child receptor for the presented risk and hazard estimates. However, estimates assuming industrial land use are provided in corresponding tables.

Table 8.3.30 presents individual and cumulative risk and hazard estimates for loess groundwater sorted by sample location, which are presented graphically in Figures 8.3.17 and 8.3.18, respectively. Tetrachloroethene and trichloroethene were the only contributors to loess

groundwater risk and hazard. Tetrachloroethene and trichloroethene were only reported in sample 014G02LS01, where each chemical exceeded the target residential LWA ILCR of 1E-06 and the child HQ of 1. However, an assumed concentration was used for samples in which neither chemical was detected, as described in the Technical Memorandum on HHRA (E/A&H, 1997e). Individual ILCR estimates exceeded the target residential LWA ILCR of 1E-06 at all samples where the assumed concentration was used. The target cumulative risk estimate of 1E-04 and target child HI of 1 was only exceeded for the residential scenario at sample 014G02LS01. Tetrachloroethene and trichloroethene also exceeded the target ILCR of 1E-06 for the site worker in sample 014G02LS01, although cumulative ILCR was not exceeded in any samples for the site worker scenario.

Table 8.3.31 shows individual and cumulative hazard estimates for fluvial deposits groundwater by sample location. A graphical presentation of the cumulative hazard estimates is shown in Figure 8.3.19. Arsenic, barium, and vanadium were contributors to cumulative hazard estimates in SWMU 14 fluvial deposits groundwater. None of these chemicals exceeded the individual target HQ of 1. However, the target HI of 1 for cumulative effects was exceeded at samples 014G01LF01, 014G04LF01, and 014G07LF01 for the residential child receptor. None of the chemicals attributed to a cumulative hazard above the target HI of 1 for the site worker scenario.



LEGEND - RISK VALUES

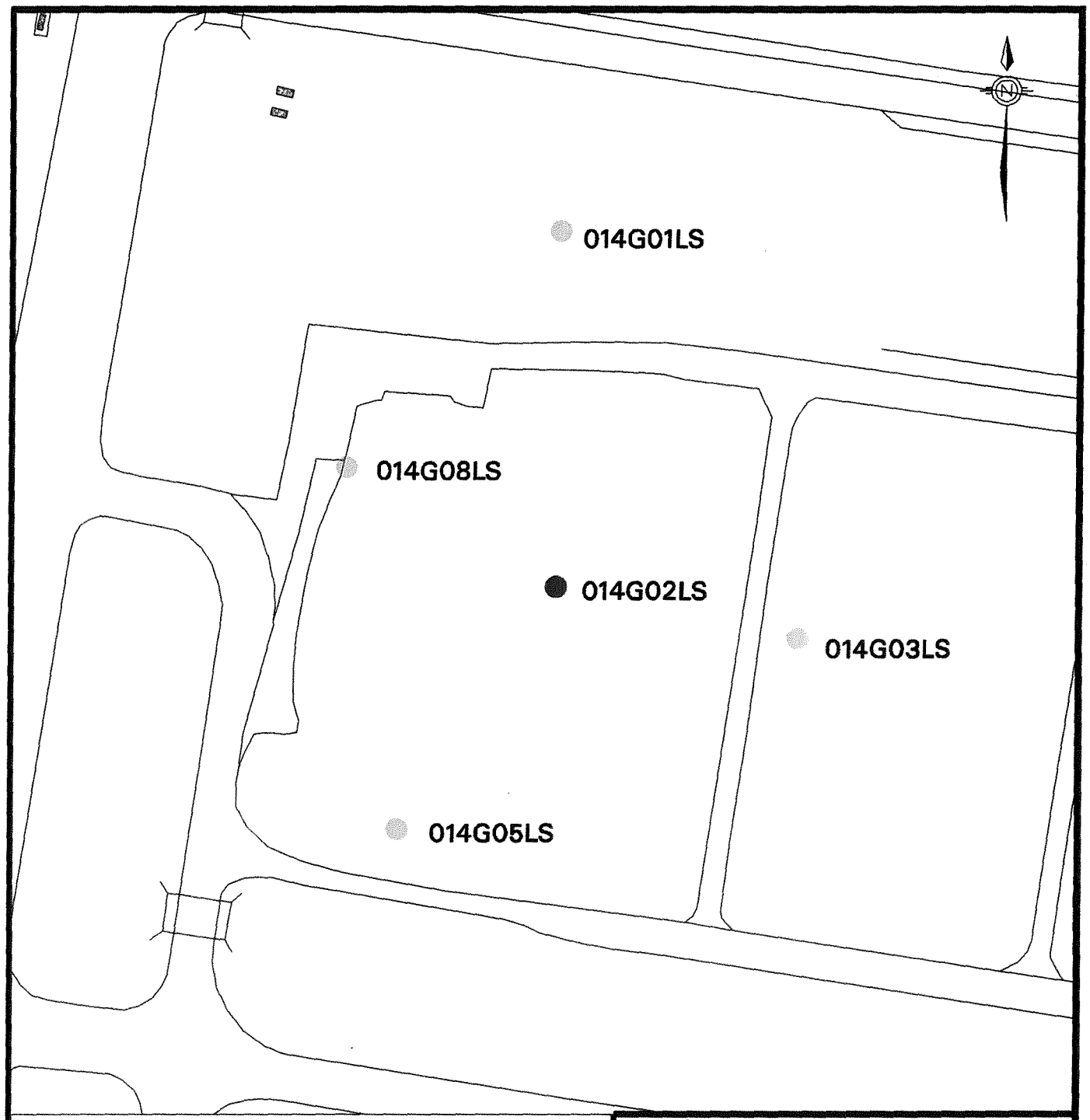
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 140

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.17
CUMULATIVE RISK
IN LOESS GROUNDWATER
SWMU 14

AML: /home/ths2/memphis_dir/site_dir/assem_a/risk_cumu.ai



LEGEND - HAZARD VALUES

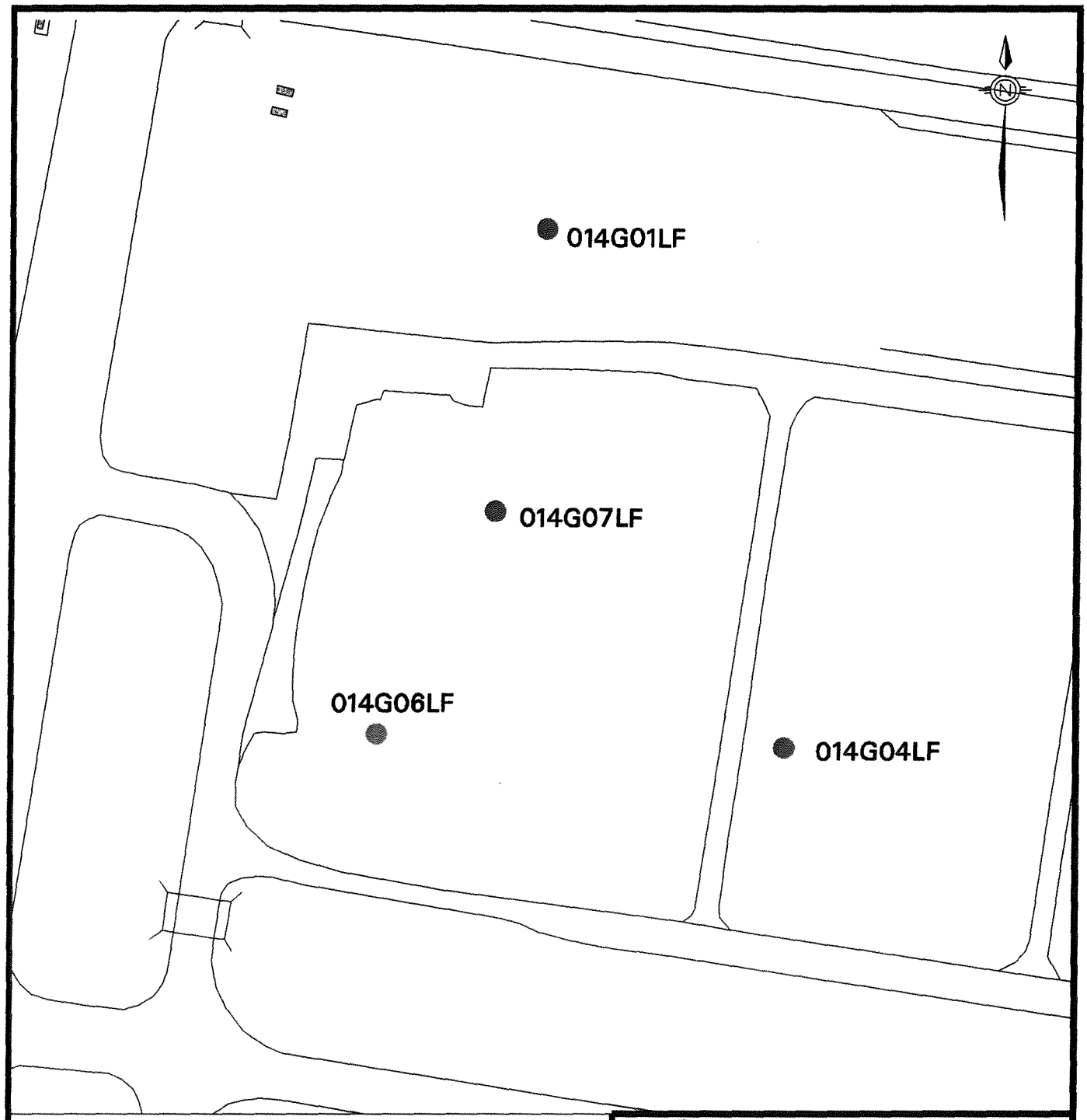
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 140

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.18
CUMULATIVE HAZARD
IN LOESS GROUNDWATER
SWMU 14

AMIL: /home/ks2/memphis_dir/site_dir/assem_e/risk_assess



LEGEND - HAZARD VALUES

- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 140

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.3.19
CUMULATIVE HAZARD
IN FLUVIAL DEPOSITS GROUNDWATER
SWMU 14

AML: /home/ks2/memphis_dirfata_dirjasem_a/risk_assess

Table 8.3.28
Remedial Goal Options for Loess Groundwater COCs at SWMU 14
NSA Memphis – Assembly E
Millington, TN

	Site Resident						Site Worker					
Chemical	LWA ILCR 1E-06 µg/L	LWA ILCR 1E-05 µg/L	LWA ILCR 1E-04 µg/L	Child Hazard at 0.1 µg/L	Child Hazard at 1 µg/L	Child Hazard at 3 µg/L	Adult ILCR 1E-06 µg/L	Adult ILCR 1E-05 µg/L	Adult ILCR 1E-04 µg/L	Adult Hazard at 0.1 µg/L	Adult Hazard at 1 µg/L	Adult Hazard at 3 µg/L
Tetrachloroethene	1.24	12.44	124.44	7.82	78.21	234.64	5.34	53.4	534	75	750	2250
cis-1,2-Dichloroethene	NA	NA	NA	7.8	78	780	NA	NA	NA	51.1	511	5110
Trichloroethene	3.96	39.55	395.51	4.69	46.93	140.79	16.9	169	1690	30	300	900

Notes:
ILCR - Incremental Lifetime Excess Cancer Risk
LWA - Lifetime Weighted Average
µg/L - micrograms per liter

Table 8.3.29
Remedial Goal Options for Fluvial Deposits Groundwater COCs at SWMU 14
NSA Memphis – Assembly E
Millington, TN

	Site Resident			Site Worker		
Chemical	Child Hazard at 0.1 µg/L	Child Hazard at 1 µg/L	Child Hazard at 3 µg/L	Adult Hazard at 0.1 µg/L	Adult Hazard at 1 µg/L	Adult Hazard at 3 µg/L
Arsenic	0.5	4.7	14.1	3.07	30.7	92.1
Barium	110	1095	3285	708.9	7089	21267
Benzene	2.7	27	270	17.5	175	1750
Vanadium	11	110	329	67.5	675	2025

Notes:

Table 8.3.30 Risk and Hazard Estimates for COCs per Sampling Location
Loess Groundwater
SWMU 14
NSA Memphis

Sample ID	Result µg/L	VQUAL	Chemical	Assumed Concentration µg/L	EPC µg/L	Residential Child HQ	Residential LWA ILCR	Industrial Site Worker HQ	Industrial Site Worker ILCR
014G01LS01	10	U	Tetrachloroethene	5	5	0.064	4.0E-06	0.0067	9.4E-07
	10	U	Trichloroethene	5	5	0.11	1.3E-06	0.017	3.0E-07
					Summary:	0.2	5E-06	0.02	1E-06
014G02LS01	150		Tetrachloroethene	5	150	1.9	1.2E-04	0.20	2.8E-05
	120		Trichloroethene	5	120	2.6	3.0E-05	0.40	7.1E-06
					Summary:	4	2E-04	0.6	4E-05
014G03LS01	10	U	Tetrachloroethene	5	5	0.064	4.0E-06	0.0067	9.4E-07
	10	U	Trichloroethene	5	5	0.11	1.3E-06	0.017	3.0E-07
					Summary:	0.2	5E-06	0.02	1E-06
014G05LS01	10	U	Tetrachloroethene	5	5	0.064	4.0E-06	0.0067	9.4E-07
	10	U	Trichloroethene	5	5	0.11	1.3E-06	0.017	3.0E-07
					Summary:	0.2	5E-06	0.02	1E-06
014G08LS01	10	U	Tetrachloroethene	5	5	0.064	4.0E-06	0.0067	9.4E-07
	10	U	Trichloroethene	5	5	0.11	1.3E-06	0.017	3.0E-07
					Summary:	0.2	5E-06	0.02	1E-06

Notes:
VQUAL - Validation qualifier
EPC - Exposure Point Concentration
LWA - Lifetime Weighted Average
HQ - Hazard Quotient
ILCR - Incremental Lifetime Excess Cancer Risk
U - The material was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
µg/L - micrograms per liter

Table 8.3.31 Risk and Hazard Estimates for COCs per Sampling Location
Fluvial Deposits Groundwater
SWMU 14
NSA Memphis

Sample ID	Result µg/L	VQUAL	Chemical	Assumed Concentration µg/L	EPC µg/L	Residential Child HQ	Industrial Site Worker HQ
014G01LF01	2.8	J	Arsenic	1	2.8	0.60	0.091
	568		Barium	211	568	0.52	0.080
	54		Vanadium	3.75	54	0.49	0.08
					Summary:	1.6	0.25
014G04LF01	3.6	J	Arsenic	1	3.6	0.77	0.12
	422		Barium	211	422	0.39	0.060
	12.2	U	Vanadium	3.75	3.75	0.03	0.006
					Summary:	1.2	0.18
014G06LF01	2	UJ	Arsenic	1	1	0.21	0.032
	638		Barium	211	638	0.58	0.090
	16.9	U	Vanadium	3.75	3.75	0.03	0.006
					Summary:	0.8	0.13
014G07LF01	3.9	J	Arsenic	1	3.9	0.83	0.127
	569		Barium	211	569	0.52	0.080
	7.5	U	Vanadium	3.75	3.75	0.03	0.006
					Summary:	1.4	0.21

Notes:
VQUAL - Validation qualifier
EPC - Exposure Point Concentration
LWA - Lifetime Weighted Average
HQ - Hazard Quotient
ILCR - Incremental Lifetime Excess Cancer Risk
U - The material was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
J - The associated numerical value is an estimated quantity.
µg/L - micrograms per liter

8.3.5 Ecological Risk Assessment

8.3.5.1 Introduction

The focus of the SWMU 14 ERA is the terrestrial ecosystem associated with the site since other habitat types are not present. This assessment considers surface soil contaminant concentrations and distributions and exposure pathways which could result in unacceptable levels of exposure to terrestrial ecological receptors now or in the future. Potential aquatic risks associated with the adjacent Seventh Avenue ditch are discussed in the ERA for SWMU 38 (Industrial Drainage Ditches — Southside). The approach to this assessment is based on *Risk Assessment Guidance for Superfund Volume II — Environmental Evaluation Manual* (USEPA, 1989a) and *Framework for Ecological Risk Assessment* (USEPA, 1992a).

8.3.5.2 Problem Formulation

Site Description

The ecological features at SWMU 14 are minimal. The site is a large, level, grass-covered lot with a few trees. The grass is mowed regularly to maintain lawn-like conditions. Section 1.1.3 discussed the site in detail; Figure 1.4 provided a site map. To the east and south of the site are drainage ditches associated with SWMU 38, the Industrial Drainage Ditches/Southside.

Ecosystem at Risk

Based on visual observations, no quality habitat is available at SWMU 14. The grass fields at the site and surrounding area could be used by terrestrial receptors such as passerine birds and/or small mammals as foraging areas, but their occurrence would most likely be transient or opportunistic or would otherwise include a much larger and diverse home range than available at SWMU 14, therefore the exposure potential for any sensitive receptor is not considered significant. No viable terrestrial community exists within SWMU 14. With limited habitat and lack of terrestrial receptors, the SWMU 14 area does not warrant a preliminary ecological risk assessment.

8.3.6 Fate and Transport Assessment

This section evaluates the specific transport processes for site constituents at SWMU 14. The primary contaminants discussed in the fate and transport evaluation are:

- Those constituents defined as COCs per the HHRA.
- Any organic contaminant exceeding its soil to groundwater SSL, and any organic contaminant exceeding both its SSL and RC.
- Any VOC exceeding the soil-to-air transport SSL.

In addition, transport processes for constituents other than those designated as COCs are discussed when those constituents are in multiple environmental media, or may migrate to other media.

SWMU 14 is currently a flat, grass-covered area on the NSA Memphis Southside; drainage ditches are to its south (Polaris Drive ditch) and west (Seventh Avenue ditch). The eastern portion of the site has a small stand of trees, several sidewalks, and a large open field. Residential property is at the far east end of this open field.

The site is relatively flat with no obvious direction for surface water runoff. It is likely that all runoff discharges as sheet flow to the Seventh Avenue drainage ditch to the west and the Polaris Drive drainage ditch to the south. Both ditches ultimately discharge to Big Creek Drainage Canal, approximately 2,750 feet south of SWMU 14. The Seventh Avenue drainage ditch is also a part of SWMU 38 (Southside Drainage Ditches). A significant portion of the Seventh Avenue ditch is upgradient and north of SWMU 14. Both ditches are along major streets on the NSA Memphis Southside, with surface water runoff from the roadways likely entering these ditches. Therefore,

it is not probable that contaminants in Seventh Avenue ditch sediment or Polaris Drive ditch surface soil samples are solely a result of SWMU 14 activities.

SWMU 14 COCs include:

- ***Acetone***, ***aldrin***, and ***dieldrin***, which exceeded their respective soil-to-groundwater SSLs.
- ***Barium*** and ***nickel***, which exceeded both their respective soil-to-groundwater SSLs and their background RCs.
- ***Tetrachloroethene***, ***trichloroethene***, and ***1,2-dichloroethene***, which are considered COCs in loess groundwater per the HHRA.
- ***Arsenic***, ***barium***, ***vanadium***, and ***benzene***, which are considered COCs in fluvial deposits groundwater per the HHRA.

Two potential cross-transport mechanisms are evaluated for SWMU 14: soil-to-groundwater and soil-to-sediment. Migration of surface soil constituents to sediment by surface water erosion is less significant at SWMU 14 than at other Assembly E SWMUs because the site is covered with grass and generally flat. Soil-to-air cross-media transport is not discussed, since the lack of significant VOC contamination in surface soil renders this transport mechanism unimportant. Since no surface water bodies are near SWMU 14, groundwater-to-surface-water transport is also not discussed. The following sections outline the two potential cross-transport mechanisms at SWMU 14.

8.3.6.1 Soil-to-Groundwater Cross-Media Transport

Eleven constituents — tetrachloroethene, trichloroethene, TPH-DRO, arsenic, barium, chromium, lead, nickel, tin, vanadium, and zinc — were detected in both soil and groundwater at SWMU 14. Tetrachloroethene and trichloroethene, determined to be COCs in loess groundwater per the HHRA, are expected to be relatively mobile in groundwater due to their high solubility in water and high vapor pressure; however, they are expected to attenuate relatively quickly. Benzene and 1,2-dichloroethene were also determined to be COCs in fluvial deposits or loess groundwater per the HHRA. These two constituents were only detected in groundwater and were not detected in soil samples at SWMU 14. Like other VOCs, these compounds are also relatively mobile in groundwater. Widespread impact to the underlying aquifer from these VOCs is not expected due to the relatively low concentrations, or absence of the compound, in soil.

Acetone, aldrin, and dieldrin were detected in soil at concentrations exceeding their respective soil-to-groundwater SSLs. The conservative screening process indicates the potential for isolated soil-to-groundwater migration of these compounds. They were detected at higher concentrations than other detected soil constituents. However, they were not detected in loess or fluvial deposits groundwater during the April 1996 sampling event; thus, widespread impact to groundwater has not been indicated.

Dieldrin's presence in SWMU 14 soil samples may be attributed to aerial applications throughout NSA Memphis during the 1950s and 1960s. The potential for aldrin and dieldrin to migrate to groundwater is not likely due to its low solubility, vapor pressure, and Henry's law constant; therefore, it is expected to be immobile and persistent in the environment, not readily diffusing into groundwater.

Of the inorganics detected in both soil and groundwater, only barium and nickel exceeded both their respective soil-to-groundwater SSLs and background RCs. Widespread impact to loess and

fluvial deposits groundwater by barium and nickel is not expected because they are relatively immobile in groundwater, typically adhere to solids, and do not readily diffuse into groundwater.

8.3.6.2 Soil-to-Sediment Cross-Media Transport

Contaminants present in both surface soil from the SWMU 14 soil borings and sediment samples from the Seventh Avenue drainage ditch west of SWMU 14 include 13 SVOCs, 3 pesticides, and 10 inorganics, as summarized below.

SVOCs: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, BEHP, butylbenzylphthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene

Pesticides: 4,4'-DDE, 4,4'-DDT, and dieldrin

Inorganics: Arsenic, barium, chromium, cobalt, copper, lead, nickel, tin, vanadium, and zinc.

As previously outlined, a significant portion of the Seventh Avenue drainage ditch running north-south on the west side of SWMU 14 is included in SWMU 38; therefore, it may not be possible to attribute these sediment sample results solely to SWMU 14 activities. Most SVOCs detected in sediment are typical constituents of vehicle emissions and asphalt road materials. Also, as described earlier, because SWMU 14 is relatively flat and covered with vegetation, there is no obvious water runoff pathway at SWMU 14.

The contaminant classes in sediment samples are relatively immobile in soil and diffuse only slightly to groundwater. They tend to adhere to soil particles and would only be transported by erosional processes which move soil particles.

8.3.7 Conclusions and Recommendations

The following conclusions are presented based on the findings of the RFI:

- RFI soil samples contained VOCs, SVOCs, TPH, pesticides, PCBs, herbicides, and Appendix IX metals. No PCB or herbicide exceeded a screening value. Exceedances for VOCs, SVOCs, pesticides, and Appendix IX metals are provided below.

  — The only VOC to exceed a screening value was acetone (a common laboratory artifact). Its SSL was exceeded in one surface soil sample from the Polaris Drive drainage ditch.

  — The only SVOCs that exceeded screening values were benzo(a)pyrene and dibenz(a,h)anthracene, which exceeded their residential RBCs only. Benzo(a)pyrene exceeded its residential RBC in one surface soil sample from the Polaris Drive ditch and three surface soil samples from soil borings. Dibenz(a,h)anthracene exceeded its residential RBC in one surface soil sample from a soil boring.

  — The only pesticides that exceeded screening values were aldrin and dieldrin. Aldrin's SSL was exceeded in both surface soil samples from the Polaris Drive drainage ditch and one surface soil sample from a soil boring. Dieldrin's RBC was exceeded in surface soil samples from two soil borings. Dieldrin's SSL was exceeded in the 0- to 6-inch and 18- to 24-inch intervals of the two Polaris Drive drainage ditch samples, and in surface soil samples from seven of eight soil borings. However, the detected dieldrin concentrations did not exceed their background RC established for NSA Memphis.

— Barium and nickel were the only Appendix IX metals that exceeded both their RCs and SSLs; both the RC and residential RBC were not exceeded by any detected inorganic. Barium's background RC and SSL were exceeded in surface soil samples from two soil borings. Nickel's background RC and SSL was exceeded in one 8- to 10-foot interval sample from a soil boring.

- RFI groundwater samples contained VOCs, SVOCs, TPH-DRO, and Appendix IX metals. No SVOCs, pesticides, PCBs, or herbicides were detected in groundwater. Exceedances for VOCs, TPH-DRO, and Appendix IX metals are provided below.

— Benzene's tap water RBC was exceeded by one fluvial deposits DPT confirmation groundwater sample analyzed by the offsite laboratory; the detected concentration in this sample equaled its MCL. TCE's tap water RBC and drinking water MCL were exceeded by four loess DPT groundwater samples, one upper fluvial deposits DPT groundwater sample, and one loess monitoring well sample. The RBC, but not the MCL, was exceeded in two loess DPT groundwater samples and one upper fluvial deposits DPT groundwater sample. PCE's RBC and MCL were exceeded by one loess DPT groundwater sample and one loess monitoring well groundwater sample.

— The TPH-DRO concentration in one lower fluvial deposits monitoring well groundwater sample exceeded its TDEC cleanup standard of 100 μg/L for drinking water aquifers.

— Arsenic exceeded both its background RC and tap water RBC in two lower fluvial deposits monitoring well groundwater samples. The detected concentrations did not exceed the MCL for arsenic.

- Groundwater samples were collected from five loess and four lower fluvial deposits groundwater monitoring wells at SWMU 14 during the April/May 1997 sampling event and analyzed for VOCs, TPH, TPH-DRO, and TPH-GRO. Exceedances of applicable standards are provided below:

  — TCE's RBC and MCL were exceeded by one loess groundwater sample. PCE's RBC and MCL were exceeded by one loess groundwater sample. The TPH, TPH-GRO, and/or TPH-DRO concentrations in three loess groundwater samples and two lower fluvial deposits samples exceeded the TDEC groundwater cleanup level for total TPH in drinking water aquifers.

- SVOCs, TPH, pesticides, herbicides, and Appendix IX metals were detected in sediment samples from the Seventh Avenue drainage ditch. SSVs were exceeded for BEHP, chrysene, fluoranthene, pyrene, 4,4'-DDE, 4,4'-DDT, arsenic, copper, lead, and nickel in one surface sediment sample each. 4,4'-DDD's SSV was exceeded in both surface sediment samples. Since the Seventh Avenue drainage ditch sediment samples are intermittently exposed, they were also compared to soil RBCs and SSLs. The soil RC and the industrial soil RBC for arsenic were exceeded by both surface sediment samples. The soil RC and residential soil RBC were exceeded by the beryllium concentration in both surface sediment samples. The residential soil RBC was exceeded by benzo(a)pyrene in one surface sediment sample. Soil-to-groundwater SSLs were exceeded only by dieldrin in one 18- to 24-inch interval sediment sample from the Seventh Avenue drainage ditch.

- The HHRA calculated the risk and hazard posed by soil, sediment, and groundwater contaminants at SWMU 14. The findings are as follows:

- Two exposure scenarios were evaluated for soil contaminants: the hypothetical site resident and the hypothetical site worker. No COCs were identified in surface soil.

- Three exposure scenarios were evaluated for sediment contaminants: the site worker, the maintenance worker, and the adolescent trespasser. No COCs were identified in sediment.

- The HHRA assumes that both loess and fluvial deposits groundwater will be used as a drinking water source; however, the loess will likely never be used as a potable water source at NSA Memphis due to its low yield and poor aesthetic water quality. No fluvial deposits drinking water wells are present at NSA Memphis and a public water supply is readily available. The HHRA evaluations of loess and fluvial deposits groundwater contaminants are as follows:

Loess: The HHRA evaluated both the inhalation and ingestion routes of exposure for loess groundwater contaminants for three scenarios: the adult site resident, the child site resident, and the site worker. The HHRA identified 1,2-dichloroethene, tetrachloroethene, and trichloroethene as COCs in loess groundwater. The cumulative HIs for the ingestion pathway for the adult site resident, child site resident, and site worker are 2, 5, and 0.7. The calculated HIs for the adult and child site residents exceed USEPA's target HI of 1, but the HI for the site worker does not exceed the target HI. The calculated ILCR for the ingestion pathway for site residents is 2E-04, which exceeds USEPA's upper-bound risk level of 1E-04. The ILCR for the ingestion pathway for site workers is 5E-05, which does not exceed USEPA's acceptable ILCR.

Fluvial Deposits: The HHRA evaluated both the inhalation and ingestion routes of exposure for fluvial deposits groundwater contaminants for three scenarios: the hypothetical adult site resident, the hypothetical child site resident, and site worker. The HHRA identified the following COCs in fluvial deposits groundwater: arsenic, barium, benzene, and vanadium. The calculated HIs for adult site residents and site workers were 0.9 and 0.3, respectively, which do not exceed USEPA's target HI of 1. The calculated HI for the child site resident was 2, which exceeds the USEPA target HI. ILCRs for hypothetical site residents and site workers were 9E-05 and 2E-05, neither of which exceeds USEPA's acceptable ILCR of 1E-04.

- Based on the ERA, it has been determined that no quality habitat is available at SWMU 14, which has no viable terrestrial community.

- The fate and transport discussion evaluated the soil-to-groundwater and soil-to sediment cross-media transport mechanisms. The evaluation concluded that TCE and PCE, detected in both soil and groundwater samples, are anticipated to be relatively mobile due to their high solubility and vapor pressure; however, they are expected to attenuate rather quickly. Aldrin and dieldrin, detected in soil only, are expected to be immobile and not likely to diffuse to groundwater due to their physical and chemical properties. Because the portion of the Seventh Avenue drainage ditch west of SWMU 14 is included in SWMU 38 (Southside drainage ditches), the SVOCs, pesticides, and inorganics detected in both soil and sediment samples cannot be attributed solely to SWMU 14 activities. Most of the SVOCs in the Seventh Avenue drainage ditch sediment are typical constituents of vehicle emissions and asphalt road materials; both may emanate from Seventh Avenue, the main street of the NSA Memphis Southside.

The following recommendation is presented based on the findings of the RFI:

- Remediation of PCE and TCE in loess groundwater should be evaluated in a Corrective Measures Study. At a minimum, all site monitoring wells should be analyzed for VOCs on an annual basis and for remedial design parameters, including those needed to evaluate natural attenuation.

8.4 SWMU 38

SWMU 38 is made up of the Miscellaneous Ditches in Industrial Areas at NSA Memphis. Only the ditches on the Southside of NSA Memphis were studied during the Assembly E RFI; the Northside ditches were investigated in 1995 during the Assembly B RFI; results were reported in the *Assembly B RFI Report* (E/A&H, 1996d). In general, the Southside drainage ditches slope downward 1% to 3% to the west, eventually draining into Big Creek Drainage Canal in the southwest corner of NSA Memphis. Water stages in the ditches may vary as much as several feet during storm events. Southside drainage ditches receive influent from surface runoff and storm sewers, and once received wastewater discharges from floor drains in industrial buildings on the NSA Memphis Southside. The original design of many buildings at NSA Memphis (circa 1943) included floor drains which discharged to storm sewers, storm sewer drains, and drainage ditches. As buildings were remodeled and replaced, these drains were eliminated or re-routed to the sanitary sewer. Until 1980, when most of these drains were replaced, it is reported that various substances, including solvents, degreasers, oils, and paints, may have been discharged to the drainage ditches. Most wastes entering the drainage ditches would have been transported downstream with flow. However, due to their relative immobility, contaminants such as metals can potentially accumulate in soil and sediments near the outfalls and in areas where flow is slow. SWMU 38 (Southside) is depicted in Figure 8.4.1.

8.4.1 Previous Investigations

Western Perimeter Ditch PCB Screening (Southside)

During a routine inspection of the Building S-183 performed by the NSA Memphis Public Works Office (PWO), paint residue was observed in the parking lot storm sewer inlet that drains the paved area associated with Building 183 and discharges into SWMU 38. The PWO cleaned out the storm drain and associated trap of any paint and residue and collected a waste disposal characterization sample. They submitted it to Environmental Testing and Consulting Inc. (ETC), in Memphis, Tennessee, for the following analyses: Toxicity Characteristic Leaching Procedure

(TCLP) metals, SVOCs, VOCs, pesticides, and herbicides; VOCs, and PCBs. DynCorp, the operator of the paint shop, collected a surface sediment sample from around the outfall of the parking lot storm drain that discharges into SWMU 38 and submitted it to ETC for the same analyses. Contaminants detected in the disposal characterization sample submitted by the PWO and the outfall sediment sample submitted by DynCorp are summarized in Table 8.4.1. Based on the waste characterization profile, the paint residue was disposed of according to applicable regulations as hazardous waste. The only notable detection was the PCB Aroclor-1260 detected in the outfall sample at a concentration of 114,000 μg/kg.

Table 8.4.1
Western Perimeter Ditch Area
NSA Memphis PWO and DynCorp Sample Analytical Results

Analyte	Units	TCLP Limit	PWO Result	DynCorp Result
Arsenic - TCLP	mg/L	5	0.275	<0.250
Barium - TCLP	mg/L	100	0.855	1.48
Cadmium - TCLP	mg/L	1	0.02	0.02
Lead - TCLP	mg/L	5	10.3	<0.225
Pentachlorophenol - TCLP	mg/L	100	0.459	ND
Acetone	μg/kg	NA	46 J	ND
Benzene	μg/kg	NA	2.7 J	ND
Ethylbenzene	μg/kg	NA	193	ND
Toluene	μg/kg	NA	173	ND
Xylenes	μg/kg	NA	1,490	ND
Aroclor-1260 (PCB)	μg/kg	NA	ND	114,000

Notes:
NA — Not applicable
ND — Not detected

1000 0 1000 2000 Feet

LEGEND

38SM0012 ● SEDIMENT SAMPLE LOCATION AND DESIGNATION

SOLID WASTE MANAGEMENT UNIT (SWMU) 38

SURFACE WATER FLOW DIRECTION IN SWMU 38 DRAINAGE DITCH

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MILLINGTON, TENNESSEE

FIGURE 8.4.1
SEDIMENT SAMPLE LOCATIONS
SWMU 38 - SOUTHSIDE DRAINAGE DITCHES

To further define the nature and extent of PCBs in this area, E/A&H personnel conducted onsite immunoassay (see Table 8.4.2 footnotes) PCB soil screening in the western perimeter ditch area on August 22, 1996. Nine samples were collected from three different areas, all associated with the storm drain system in the area north and west of Building S-183. Sample 38SM002701 was collected in an attempt to replicate the sample previously collected by DynCorp in which PCBs were detected. Sample locations are presented in Figure 8.4.2; screening results are presented in Table 8.4.2. Screening results did not indicate PCB contamination in the western perimeter ditch, but did indicate the presence of PCBs in sediment samples collected from an open ditch that receives storm water runoff from the containment area west of Building S-75 (samples 38SM002001 [1 to 5 mg/kg PCBs] and 38SM002201 [5 to 10 mg/kg PCBs]).

Aliquots of two screening samples (38SM002201 and 38SM002701) were submitted to NET for confirmation analysis according to USEPA SW-846 Method 8080 for PCBs. The confirmation samples were labeled 38SM002501 and 38SM002601 and were aliquots of screening samples 38SM002701 and 38SM002201, respectively (see Figure 8.4.2). Aroclor-1260 was detected in samples 38SM002501 and 38SM002601 at concentrations of 1,900 μg/kg and 270 μg/kg, respectively.

Table 8.4.2
PCB Soil Screening Sample Descriptions
Western Perimeter Ditch Area— SWMU 38

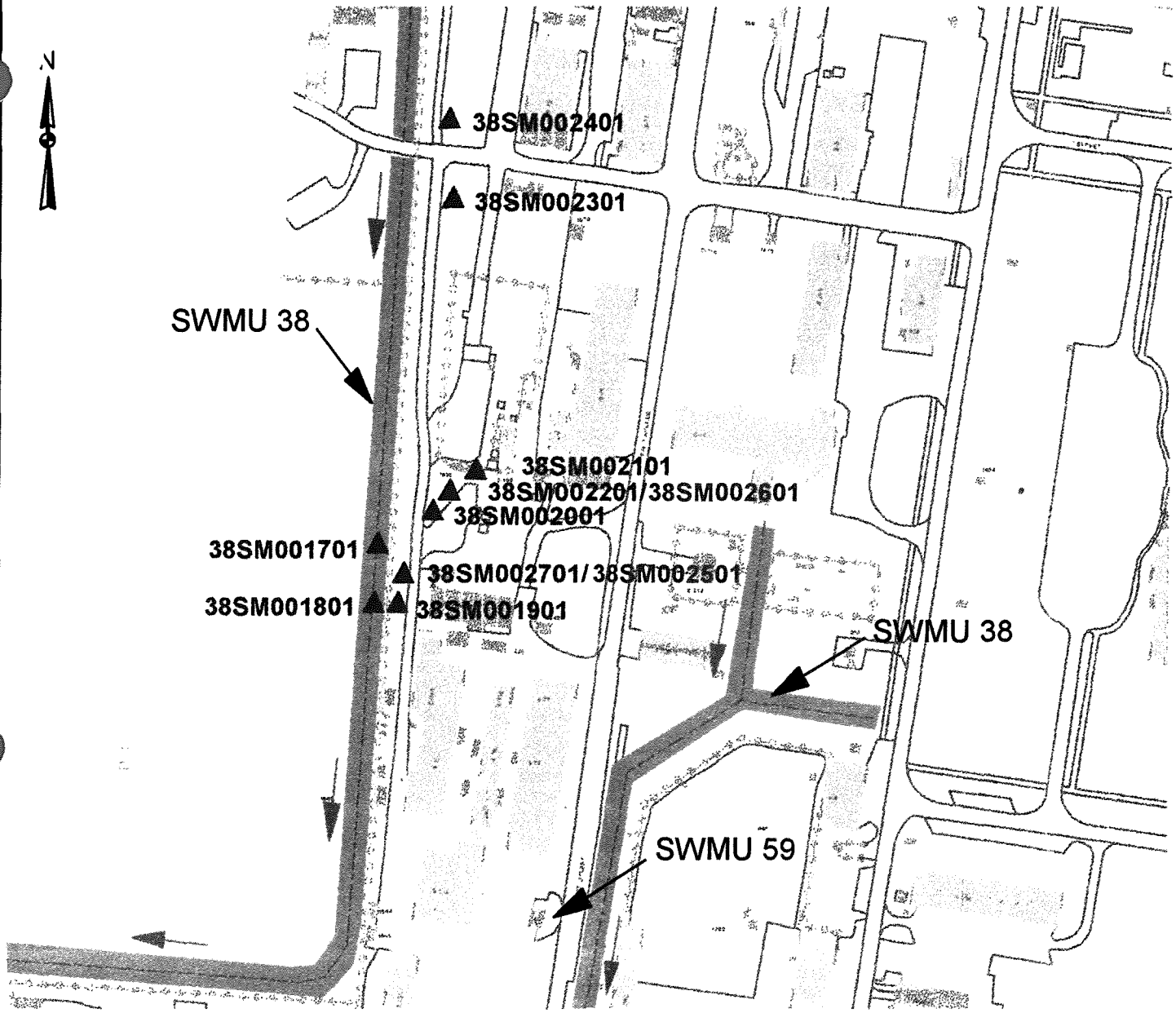
	Sample ID	Photovac Reading	Concentration Range (mg/kg)	Sample Location
Calibration Standards [a]	NC[b]	0.91	0	NA[c]
	1 ppm	0.73	1	NA
	5 ppm	0.34	5	NA
	10 ppm	0.26	10	NA
	50 ppm	0.02	50	NA

Table 8.4.2
PCB Soil Screening Sample Descriptions
Western Perimeter Ditch Area— SWMU 38

	Sample ID	Photovac Reading	Concentration Range (mg/kg)	Sample Location
Western Perimeter Ditch	038S002701	0.94	0	Storm water outfall
	038S001701	0.91	0	Ditch sediment 20 feet upstream of outfall
	038S001801	0.96	0	Ditch sediment 20 feet downstream of outfall
	038S001901	0.89	0 to 1	Ditch bank downstream of outfall in an area with stressed vegetation
Upper Ditch (North of S-183)	038S002001	0.62	1 to 5	Adjacent to opening of upstream culvert
	038S002101	0.82	0 to 1	Adjacent to opening of downstream culvert
	038S002201	0.28	5 to 10	Outfall drain from the containment area
Stormwater Outfalls (Northwest of S-75)	038S002301	0.85	0 to 1	Southern outfall west of Building S-75
	038S002401	0.88	0 to 1	Northern outfall west of Building S-75

Notes:
a — The EnSys RISc Test System is a semi-quantitative PCB testing kit. Analysis consisted of adding standards, samples, and color-change reagents to test tubes coated with a PCB-specific chemical. The PCB concentration in the sample was determined by comparing its color intensity to a standard. The PCB concentration is inversely proportional to color intensity; the lighter the sample's color development, the higher the PCB concentration. The colorimetric measurement was made by comparing samples to standards representing different concentrations using the Photovac, a differential photometer.
b — NC denotes no concentration.
c — NA denotes same location is not applicable.

In accordance with *Guidance on Preliminary Risk Evaluations (PREs) for the Purpose of Reaching a Finding of Suitability to Lease* (USEPA, 1994e), a PRE was conducted for the western perimeter ditch area on the Southside based on PCB analytical results for the confirmation sample 38SM002501 and analytical results from SWMU 38 RFI samples 38SM000101, 38SM000201, and 38SM000301, all collected from the subject area (see Figure 8.4.1). Because the ditch area is a network of widely separated drainage pathways, the samples collected during the investigation do not represent one contiguous land surface. To compensate for this characteristic of the study area, an individual PRE based on a residential risk scenario was conducted on each sample. The PREs indicated that no ILCR exceeded 1 x 10^{-4}, the USEPA threshold for restriction of land use. Nonresidential risk was not estimated because it would be less than that estimated for site residents. No noncarcinogenic COPCs were identified in the samples used for this PRE. Tables 8.4.3 through 8.4.5 below present the PRE data and results.



LEGEND

200 0 200 Feet

38SM002501 ▲ SEDIMENT SAMPLE LOCATION AND DESIGNATION; SAMPLE WAS ANALYZED ONSITE USING THE ENSYS PCB SCREENING METHOD.

38SM002201/38SM002601 ▲ PRIMARY / CONFIRMATION SEDIMENT SAMPLE LOCATION AND DESIGNATION; PRIMARY SAMPLES WERE ANALYZED ONSITE USING THE ENSYS PCB SCREENING METHOD. CONFIRMATION SAMPLES WERE SUBMITTED TO AN OFFSITE LABORATORY FOR PCB ANALYSIS BY SW-846 METHOD 8080.

SWMU 38 DRAINAGE DITCH LOCATION, WITH ARROW INDICATING SURFACE WATER FLOW DIRECTION

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MILLINGTON, TENNESSEE

FIGURE 8.4.2
SEDIMENT SAMPLE LOCATIONS FOR
ONSITE PCB SCREENING
SWMU 38 - SOUTHSIDE DRAINAGE DITCHES

Table 8.4.3
Western Perimeter Ditch Area
Identification of COPCs Soil (μg/kg)

Chemical	Residential RBC	Carcinogen/ Noncarcinogen	RC	Reported Concentrations (detections only**) 38MS000101	38MS000201	38MS002501	38MS000301
Acetone	780,000	n	NA	13	21	NS	150
Aldrin	38	c	NA	ND	3.9	NS	ND
Anthracene	2,300,000	n	NA	38	ND	NS	ND
Arsenic	430	c	20,320	19,000	3,200	NS	3,600
BEHP	46,000	c	NA	100	120	NS	ND
Barium	550,000	n	265,120	122,000	75,000	NS	131,000
BEQ	88	c	NA	172	124	NS	ND
Benzo(a)pyrene	88	c	NA	130	96	NS	ND
Benzo(a)anthracene	880	c	NA	88	77	NS	ND
Benzo(b)fluoranthene	880	c	NA	240	140	NS	ND
Benzo(k)fluoranthene	8,800	c	NA	190	120	NS	ND
Chrysene	88,000	c	NA	170	120	NS	ND
Indeno(123-cd)pyrene	880	c	NA	69	51	NS	ND
Benzo(g,h,i)perylene	2,300,000	a	NA	68	58	NS	ND
Beryllium	150	c	1,004	480	320	NS	460
Cadmium	3,900	n	3,240	1,800	1,600	NS	920
Chromium	39,000	n	28,280	9,800	7,400	NS	10,000
Cobalt	470,000	n	14,360	5,100	4,500	NS	6,500
Copper	310,000	n	32,520	13,700	10,000	NS	12,000
technical-Chlordane	1,825	c	NA	ND	240	NS	ND
DDD	2,700	c	NA	ND	280	NS	5.5
DDE	1,900	c	NA	ND	79	NS	8.6
DDT	1,900	c	NA	5.6	280	NS	ND
Dieldrin	40	c,f	262	450	28	NS	ND
Dinoseb	7,800	n	NA	12	ND	NS	ND
Endrin	2,300	n	NA	ND	6.2	NS	ND
Endrin aldehyde	2,300	e	NA	ND	ND	NS	2.2
Ethylbenzene	780,000	n	NA	1	ND	NS	ND
Fluoranthene	310,000	n	NA	220	150	NS	ND
Heptachlor	70	c	NA	ND	3.4	NS	ND
Lead	400,000	b	19,800	96,900	12,200	NS	9,200
MCPA	3,900	n	NA	2,100	ND	NS	ND
MCPP	7,800	n	NA	ND	4,100	NS	8,600
Methyl Ethyl Ketone (MEK)	4,700,000	n	NA	ND	ND	NS	21
Nickel	160,000	n	NA	7,200	7,600	NS	11,900
PCB Aroclor-1260	320	c,d	NA	52	ND	114,000/1,900	34
Phenanthrene	230,000	a	NA	58	51	NS	ND
Pyrene	230,000	n	NA	200	140	NS	ND
Selenium	39,000	n	176	530	270	NS	ND
2,4,5-TP (Silvex)	63,000	n	NA	ND	2.5	NS	ND

Table 8.4.3
Western Perimeter Ditch Area
Identification of COPCs Soil (μg/kg)

Chemical	Residential RBC	Carcinogen/ Noncarcinogen	RC	Reported Concentrations (detections only**) 38MS000101	38MS000201	38MS002501	38MS000301
Vanadium	55,000	n	43,680	16,600	10,500	NS	16,500
Zinc	2,300,000	n	109,000	85,100	59,200	NS	46,100

Notes:
** — Estimated concentrations (i.e., "J" qualified data) were considered hits.
a — The RBC for pyrene was used as a surrogate (USEPA, 1996a).
b — The USEPA action level for lead in soil was used as the RBC (USEPA, 1994c).
c — Carcinogen
d — Calculated in accordance with USEPA Region III's guidance based on the new slope factor of 2.0 kg-day/mg
e — The RBC for endrin was used as a surrogate (USEPA, 1996a).
f — Dieldrin was reported at an average concentration of 131 micrograms per kilogram in the *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d).
n — Noncarcinogen
NA — Not applicable/ not available
RBC — Risk-based concentration from the *Risk Based Concentration Table, January to June 1996* (USEPA, 1996a); in accordance with USEPA Region IV's Supplemental Guidance to RAGS Bulletin 1, RBCs were conservatively adjusted to reflect a hazard quotient of 0.1 (USEPA, 1995b).
RC — Background reference concentrations excerpted from the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a).
BEHP — Bis(2-Ethylhexyl)phthalate
MCPA — 2-Methyl-4-chlorophenoxyacetic acid
MCPP — 2-(2-Methyl-14-chlorophenoxy)propionic acid; eliminated as a COPC because it would be the only contributor to the hazard index, which would be below 1.0.
ND — Not detected.
NS — Not sampled for this analyte.

Table 8.4.4
Western Perimeter Ditch Area
Benzo(a)pyrene Equivalent Concentrations (BEQ*) (mg/kg)

Chemical	TEF	38SM000101 Reported Concentration**	38SM000101 Equivalent Concentration**	38SM000201 Reported Concentration**	38SM000201 Equivalent Concentration**
Benzo(a)pyrene	1	130	130	96	96
Benzo(a)anthracene	0.1	88	8.8	77	7.7
Benzo(b)fluoranthene	0.1	240	24	140	14
Benzo(k)fluoranthene	0.01	190	1.9	120	1.2
Chrysene	0.001	170	0.17	120	0.12
Indeno(123-cd)pyrene	0.1	69	6.9	51	5.1
			BEQ =171.77		BEQ =124.12

Notes:
* — BEQ was calculated in accordance with *Supplemental Guidance to RAGS, Bulletin 2* (USEPA, 1995b).
** — All concentrations are in micrograms per kilogram
TEF — Toxicity equivalence factor

Table 8.4.5
Western Perimeter Ditch Area
Preliminary Risk Evaluation — Carcinogens

Chemical	Residential Risk Ratio			
	38SM000101	38SM000201	38SM002501*	38SM000301**
BEQ	2.0E-06	1.4E-06	NA	NA
Dieldrin	1.1E-05	NA	NA	NA
PCB Aroclor-1260	NA	NA	5.9E-06	NA
SUM	1E-05	1E-06	6E-06	NA

Notes:
* — Calculation of soil risk was based on the maximum reported concentration of 1.9 mg/kg; if the 114 mg/kg concentration reported by DynCorp was used the risk estimate would be approximately 4E-4. It was not used because it could not be reproduced through resampling.
** — No chemicals of potential concern were identified in sample 38SM000301.
NA — Not applicable/not available

8.4.2 RFI Characterization

RFI characterization focused on the nature and extent of contamination in the drainage ditch sediments on the Southside of NSA Memphis. Between September 27 and October 4, 1995, E/A&H collected 32 sediment samples from two intervals at 16 locations (38SM0001 through 38SM0016), as outlined in the *Assembly E Site Investigation Plans* (E/A&H, 1995a). For the purposes of this RFI report, the Assembly E samples collected from drainage pathways are designated "sediment samples." Those sediment samples collected from the 0 to 6-inch interval are termed "surface sediment," and those collected from the 18- to 24-inch interval are termed "subsurface sediment." All SWMU 38 sediment sample locations were in areas of very shallow water or in dry areas along the water's edge. Specifically, sediment samples were collected from SWMU 38 primary and secondary drainage ditches on the Southside. The 10-digit sample identification system represented the following:

38S	—	SWMU 38 Southside
M	—	sediment
0001	—	sample location 1
01 or 02	—	sample collected from 0 to 6-inch or 18- to 24-inch interval

Sediment Sampling Rationale

Surface sediment samples were collected to characterize recently deposited contaminants. Subsurface sediment samples were collected to characterize contaminants from past releases or that may have migrated down through the sediments. Figure 8.4.1 above shows the sediment sample locations.

The sample locations were selected to ensure that each branch leading to the main channel of the drainage system would be characterized. Two of the sediment sample locations (38SM0001 and 38SM0007) were positioned at the upper (northern) end of the eastern and western portions of the SWMU 38 drainage ditches to provide upstream sediment concentrations that should theoretically be least affected by industrial influences (Figure 8.4.1). The remaining samples were collected in the main channel downstream of each confluence to determine if contaminants had been transported by discharge or runoff into these ditches from the upstream sites.

The sediment samples were collected with a stainless steel hand auger using the sediment sampling procedures outlined in Section 3.5 of this report, and submitted to the offsite laboratory (NET) for FSA with the following exceptions:

- Four 0 to 6-inch interval samples and three 18- to 24-inch interval samples were analyzed for TPH by Method 418.1, rather than TPH-GRO and TPH-DRO as outlined in the work plan. These four samples were from locations 38SM0004, 38SM0005, 38SM0006, and 38SM0007. TPH was not analyzed in the 38SM0004 sample collected from the 18- to 24-inch depth interval.

Most of the sediment sample locations are intermittently submerged; therefore, the sediments have many of the exposure characteristics of soil. Therefore, as outlined in Section 4.1.3, the following evaluations were made of detected organic and inorganic constituents in the sediment samples:

- Surface sediment sample concentrations were compared to USEPA SSVs, residential and industrial soil RBCs, SSLs, and surface soil background RCs (inorganic compounds only).

- Subsurface sediment samples were compared to USEPA SSLs and subsurface soil background RCs (inorganic compounds only).

When comparing SWMU 38 inorganic compounds to SSLs and/or RBCs, an exceedance was not considered significant unless the surface or subsurface soil background RC was also exceeded. However, because there are no sediment background RCs for NSA Memphis, any inorganic concentrations exceeding applicable SSVs were considered significant.

At some sample locations, it was difficult to collect a discrete subsurface sediment sample from the 18- to 24-inch interval because standing water deeper than 1 to 2 inches was present causing the auger hole to fill with loose sediment; in these cases, samples were collected directly from the bank at the water line. Characteristics of the medium sampled in these situations were not expected to differ drastically from those of bed sediment, as both are submerged with the same frequency and are potentially impacted by ditch sediments.

8.4.3 Nature and Extent of Sediment Contamination

The following sections summarize the organic and inorganic compounds detected in SWMU 38 surface and subsurface sediment samples.

8.4.3.1 Organic Compounds in Sediment

VOCs, SVOCs, TPH, pesticides, PCBs, and herbicides were detected in SWMU 38 sediment samples. The following sections discuss the detected organic compound concentrations by parameter. Table 8.4.6 summarizes the organic compounds detected in sediment and compares the surface sediment detections to SSVs and residential and industrial soil RBCs. Table 8.4.7

compares surface and subsurface sediment detections to soil-to-groundwater SSLs. Sample locations of the exceedances are listed in the appropriate table column next to the number of exceedances. Figure 8.4.3 depicts the SSV exceedances in surface sediment samples; Figure 8.4.4 depicts the soil RBC exceedances in surface sediment samples; and, Figure 8.4.5 depicts soil-to-groundwater SSL exceedances in surface and subsurface sediment samples.

VOCs

The following VOCs were detected in surface and/or subsurface sediment samples from the SWMU 38 Southside drainage ditches:

Acetone	Methylene chloride
2-Butanone (MEK)	Toluene
Ethylbenzene	

As shown in Table 8.4.6, no SSV is available for any of the detected VOCs. The residential and industrial RBCs were not exceeded by any detected VOC in surface sediment samples. Table 8.4.7 shows that no soil-to-groundwater SSLs were exceeded by any detected VOC in surface or subsurface sediment samples.

SVOCs

The following SVOCs were detected in SWMU 38 Southside drainage ditch sediment samples:

Acenaphthene	Dibenz(a,h)anthracene
Anthracene	Dibenzofuran
Benzo(a)anthracene	Fluoranthene
Benzo(b)fluoranthene	Fluorene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(g,h,i)perylene	2-Methylnaphthalene
Benzo(a)pyrene	4-Methylphenol
bis(2-Ethylhexyl)phthalate (BEHP)	Naphthalene
Butylbenzylphthalate	4-Nitrophenol
Carbazole	Phenanthrene
Chrysene	Pyrene

LEGEND

▲ NO DETECTED CONSTITUENT IN SEDIMENT EXCEEDS ITS USEPA SEDIMENT SCREENING VALUE.

● ONE OR MORE DETECTED CONSTITUENTS IN SEDIMENT EXCEEDS ITS USEPA SEDIMENT SCREENING VALUE.

38SM0015
DIELDRIN 20 µg/kg
CADMIUM 2.8 mg/kg

THE USEPA SEDIMENT SCREENING VALUE WAS EXCEEDED BY THE FOLLOWING CONSTITUENT CONCENTRATIONS IN THE SURFACE SEDIMENT (0 TO 6-INCH INTERVAL) SAMPLE FROM LOCATION 38SM0015: 20 µg/kg DIELDRIN AND 2.8 mg/kg CADMIUM.

mg/kg MILLIGRAMS PER KILOGRAM

µg/kg MICROGRAMS PER KILOGRAM

SURFACE WATER FLOW DIRECTION IN THE SWMU 38 DRAINAGE DITCH

1000 0 1000 2000 Feet

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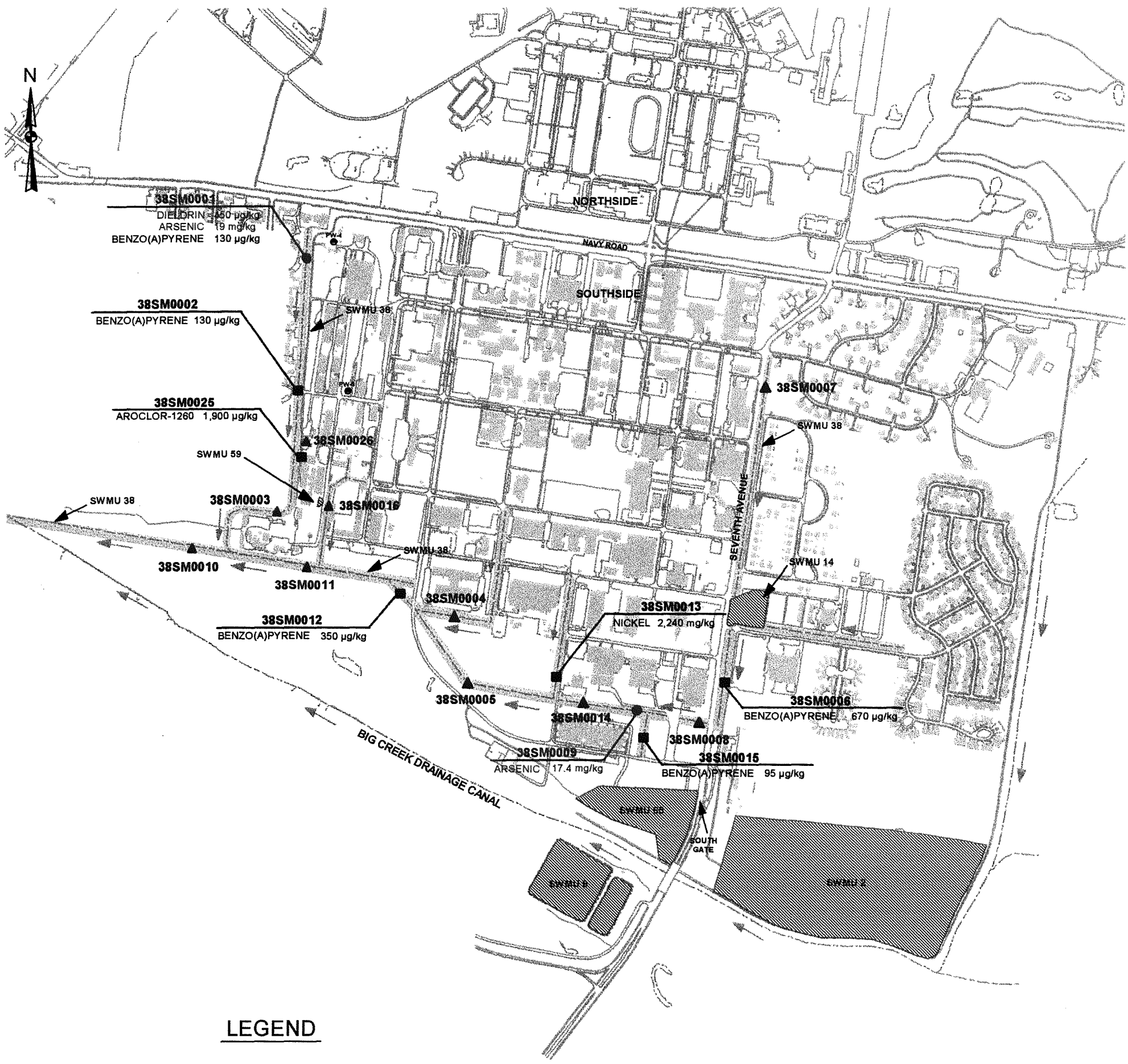
FIGURE 8.4.3
SSV EXCEEDANCES IN SEDIMENT SAMPLES COLLECTED FROM THE 0- TO 6-INCH INTERVAL
SWMU 38 - SOUTHSIDE DRAINAGE DITCHES



LEGEND

▲ NO DETECTED CONSTITUENT IN THIS SURFACE SEDIMENT SAMPLE EXCEEDED THE USEPA RESIDENTIAL RISK-BASED CONCENTRATION FOR SOIL AND THE BACKGROUND REFERENCE CONCENTRATION FOR SURFACE SOIL, WHERE APPLICABLE.

■ ONE OR MORE DETECTED CONSTITUENTS IN THIS SURFACE SEDIMENT SAMPLE EXCEEDED THE USEPA RESIDENTIAL RISK-BASED CONCENTRATION FOR SOIL AND THE BACKGROUND REFERENCE CONCENTRATION FOR SURFACE SOIL, WHERE APPLICABLE, BUT DID NOT EXCEED THE INDUSTRIAL RISK-BASED CONCENTRATION FOR SOIL.

● ONE OR MORE DETECTED CONSTITUENTS IN THIS SURFACE SEDIMENT SAMPLE EXCEEDED ITS USEPA INDUSTRIAL RISK-BASED CONCENTRATION FOR SOIL AND ITS BACKGROUND REFERENCE CONCENTRATION FOR SURFACE SOIL, WHERE APPLICABLE.

1000 0 1000 2000 Feet

38SM0015

DIELDRIN	450 µg/kg
ARSENIC	19 mg/kg
BENZO(A)PYRENE	130 µg/kg

THE FOLLOWING CONSTITUENTS IN SURFACE SEDIMENT EXCEEDED USEPA RISK-BASED CONCENTRATIONS FOR SOIL (AND BACKGROUND REFERENCE CONCENTRATIONS FOR SURFACE SOIL, WHERE APPLICABLE): 450 µg/kg DIELDRIN AND 19 mg/kg ARSENIC, WHICH EXCEEDED THE INDUSTRIAL SOIL RBC (ARSENIC ALSO EXCEEDED ITS BACKGROUND REFERENCE CONCENTRATION), AND 130 µg/kg BENZO(A)PYRENE, WHICH EXCEEDED THE RESIDENTIAL, BUT NOT THE INDUSTRIAL, SOIL RBC.

mg/kg MILLIGRAMS PER KILOGRAM

µg/kg MICROGRAMS PER KILOGRAM

SURFACE WATER FLOW DIRECTION IN THE SWMU 38 DRAINAGE DITCH

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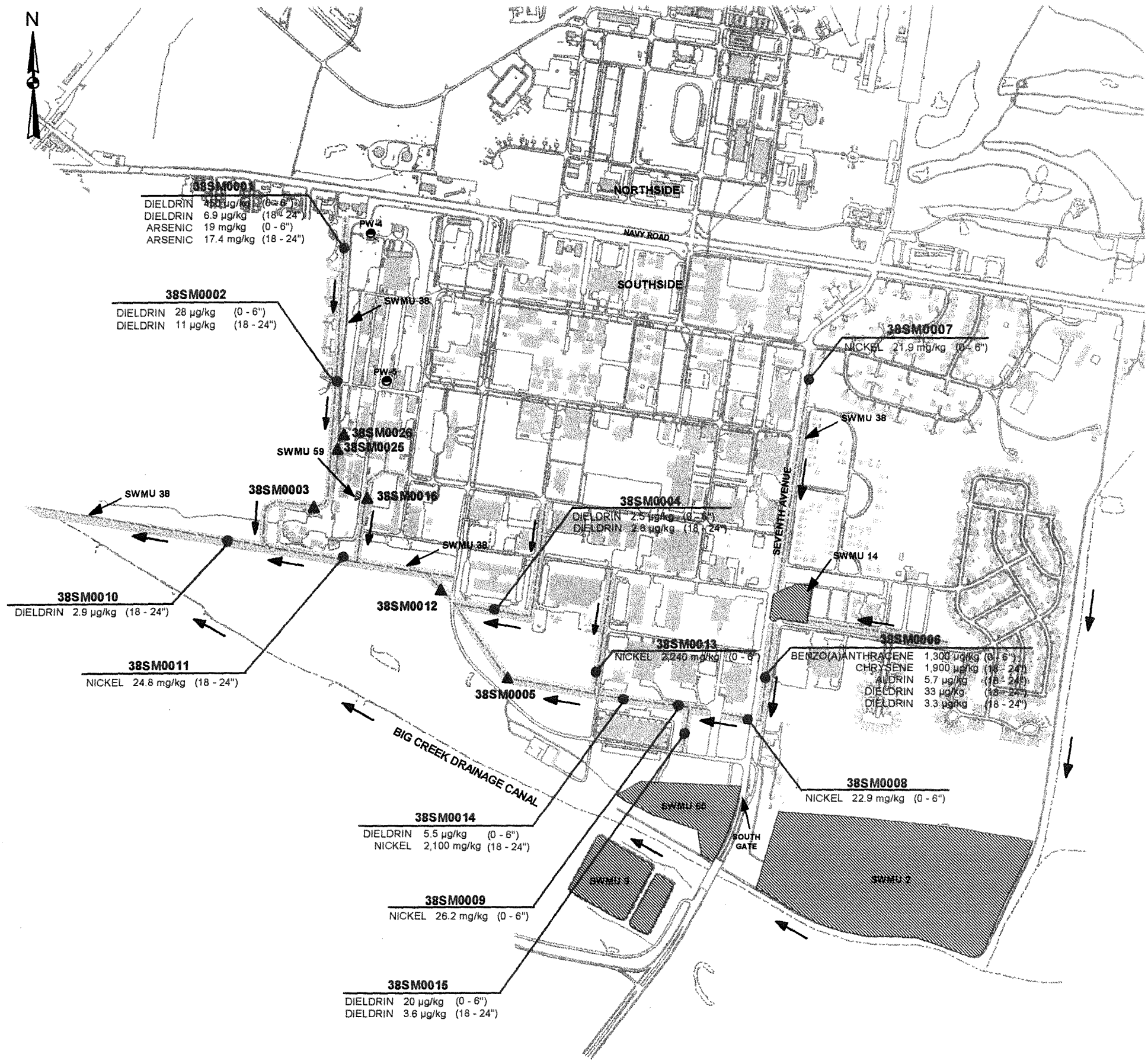
FIGURE 8.4.4
SOIL RBC EXCEEDANCES IN SEDIMENT SAMPLES COLLECTED FROM THE 0- TO 6-INCH INTERVAL
SWMU 38 - SOUTHSIDE DRAINAGE DITCHES



LEGEND

▲ NO DETECTED CONSTITUENT IN SURFACE OR SUBSURFACE SEDIMENT FROM THIS SAMPLING LOCATION EXCEEDED ITS SOIL-TO-GROUNDWATER SSL AND BACKGROUND REFERENCE CONCENTRATION FOR SOIL, WHERE APPLICABLE.

● ONE OR MORE DETECTED CONSTITUENTS IN SURFACE OR SUBSURFACE SEDIMENT FROM THIS SAMPLING LOCATION EXCEEDED ITS SOIL-TO-GROUNDWATER SSL AND BACKGROUND REFERENCE CONCENTRATION FOR SOIL, WHERE APPLICABLE.

1000 0 1000 2000 Feet

38SM0014
DIELDRIN 5.5 µg/kg (0 - 6")
NICKEL 2,110 mg/kg 18 - 24")

THE FOLLOWING CONSTITUENTS IN SEDIMENT FROM SAMPLING LOCATION 38SM0014 EXCEEDED THEIR SOIL-TO-GROUNWATER SSL AND BACKGROUND REFERENCE CONCENTRATION FOR SOIL (WHERE APPLICABLE): 5.5 µg/kg DIELDRIN IN THE 0- TO 6-INCH INTERVAL SAMPLE, AND 2,110 mg/mg NICKEL IN THE 18- TO 24-INCH INTERVAL SAMPLE.

mg/kg MILLIGRAMS PER KILOGRAM

µg/kg MICROGRAMS PER KILOGRAM

SURFACE WATER FLOW DIRECTION IN THE SWMU 38 DRAINAGE DITCH

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NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.4.5
SOIL-TO-GROUNDWATER SSL EXCEEDANCES IN SEDIMENT SAMPLES
SWMU 38 - SOUTHSIDE DRAINAGE DITCHES

Table 8.4.6
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSVs and RBCs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC - Res. Exceedances	Industrial Soil RBC[f]	RBC - Ind. Exceedances
VOCs										
Acetone	0 - 6"	13/16	13 - 240	93	–	–	7,800,000	0	200,000,000	0
	18 - 24"	13/16	11 - 260	101	NA	NA	NA	NA	NA	NA
2-Butanone (MEK)	0 - 6"	3/16	21 - 24	23	–	–	47,000,000	0	1,000,000,000	0
	18 - 24"	3/16	10 - 49	31	NA	NA	NA	NA	NA	NA
Ethylbenzene	0 - 6"	1/16	1	1	–	–	7,800,000	0	200,000,000	0
	18 - 24"	2/16	1	1	NA	NA	NA	NA	NA	NA
Methylene chloride	0 - 6"	2/16	1 - 2	2	–	–	85,000	0	760,000	0
	18 - 24"	2/16	1 - 2	2	NA	NA	NA	NA	NA	NA
Toluene	0 - 6"	1/16	2	2	–	–	16,000,000	0	410,000,000	0
	18 - 24"	3/16	1 - 2	2	NA	NA	NA	NA	NA	NA
SVOCs										
Acenaphthene	18 - 24"	2/16	45 - 110	78	NA	NA	NA	NA	NA	NA
Anthracene	0 - 6"	2/16	38 - 180	109	330	0	23,000,000	0	610,000,000	0
	18 - 24"	3/16	140 - 200	170	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0 - 6"	7/16	42 - 430	145	330	1 (38SM0006)	880	0	7,800	0
	18 - 24"	3/16	270 - 1,300	667	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0 - 6"	7/16	53 - 690	228	–	–	880	0	7,800	0
	18 - 24"	4/16	50 - 2,500	930	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	0 - 6"	7/16	61 - 560	204	–	–	8,800	0	78,000	0
	18 - 24"	4/16	56 - 1,900	712	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	0 - 6"	7/16	52 - 540	148	–	–	3,100,000[g]	0	82,000,000[g]	0
	18 - 24"	3/16	190 - 1,900	823	NA	NA	NA	NA	NA	NA

Table 8.4.6
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSVs and RBCs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC - Res. Exceedances	Industrial Soil RBC[f]	RBC - Ind. Exceedances
SVOCs										
Benzo(a)pyrene	0 - 6"	8/16	47 - 670	192	330	2 (38SM0006, 38SM0012)	88	5 (38SM0001, 38SM0002, 38SM0006, 38SM0012, 38SM0015)	780	0
	18 - 24"	4/16	48 - 2,500	947	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 6"	9/16	45 - 1,400	228	182	1 (38SM0006)	46,000	0	410,000	0
	18 - 24"	9/16	44 - 280	108	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	0 - 6"	1/16	320	320	–	–	16,000,000	0	410,000,000	0
Carbazole	18 - 24"	1/16	150	150	NA	NA	NA	NA	NA	NA
Chrysene	0 - 6"	7/16	75 - 930	272	330	2 (38SM0006, 38SM0012)	88,000	0	780,000	0
	18 - 24"	4/16	50 - 1,900	778	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	0 - 6"	1/16	61	61	330	0	88	0	780	0
	18 - 24"	3/16	62 - 690	287	NA	NA	NA	NA	NA	NA
Dibenzofuran	18 - 24"	1/16	57	57	NA	NA	NA	NA	NA	NA
Fluoranthene	0 - 6"	7/16	66 - 750	230	330	1 (38SM0006)	3,100,000	0	82,000,000	0
	18 - 24"	5/16	68 - 1,600	485	NA	NA	NA	NA	NA	NA
Fluorene	0 - 6"	1/16	78	78	330	0	3,100,000	0	82,000,000	0
	18 - 24"	3/16	81 - 86	84	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0 - 6"	7/16	43 - 340	106	–	–	880	0	7,800	0
	18 - 24"	3/16	170 - 1,600	707	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	0 - 6"	1/16	40	40	330	0	3,100,000[h]	0	82,000,000[h]	0
	18 - 24"	1/16	46	46	NA	NA	NA	NA	NA	NA
4-Methylphenol (p-Cresol)	0 - 6"	1/16	45	45	–	–	390,000	0	10,000,000	0
Naphthalene	18 - 24"	1/16	94	94	NA	NA	NA	NA	NA	NA
4-Nitrophenol	18 - 24"	1/16	66	66	NA	NA	NA	NA	NA	NA

Table 8.4.6
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSVs and RBCs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC - Res. Exceedances	Industrial Soil RBC[f]	RBC - Ind. Exceedances
SVOCs										
Phenanthrene	0 - 6"	5/16	51 - 400	168	330	1 (38SM0012)	3,100,000[g]	0	82,000,000[g]	0
	18 - 24"	3/16	440 - 930	607	NA	NA	NA	NA	NA	NA
Pyrene	0 - 6"	7/16	80 - 1,300	416	330	2 (38SM0006, 38SM0012)	2,300,000	0	61,000,000	0
	18 - 24"	4/16	73 - 1,700	926	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons										
TPH - DRO	0 - 6"	2/12	5,700 - 59,000	32,350	–	–	–	–	–	–
	18 - 24"	3/12	6,400 - 99,000	63,133	–	–	–	–	–	–
TPH - GRO	0 - 6"	1/12	100	100	–	–	–	–	–	–
Total TPH (TPH-GRO + TPH-DRO)	0 - 6"	3/12	100 - 59,000	21,600	500,000[g]	0	–	–	–	–
	18 - 24"	3/12	6,400 - 99,000	63,133	500,000[g]	0	–	–	–	–
TPH (Method 418.1)	0 - 6"	1/4	780	780	500,000[g]	0	–	–	–	–
	18 - 24"	1/3	410	410	500,000[g]	0	–	–	–	–
Pesticides/PCBs										
Aldrin	0 - 6"	7/16	1.3 - 4.4	2.5	–	–	38	0	340	0
	18 - 24"	4/16	1.3 - 5.7	2.7	NA	NA	NA	NA	NA	NA
Aroclor-1260	0 - 6"	5/18	34 - 1,900	509	33.0	5 (38SM0001, 38SM0003, 38SM0016, 38SM0025, 38SM0026)	320[g]	1 (38SM0025)	2,850[g]	0
	18 - 24"	1/16	42	42	NA	NA	NA	NA	NA	NA
Technical Chlordane	0 - 6"	1/16	240	240	1.7	–	1,825	NA	16,352	NA
	18 - 24"	1/16	100	100	NA	NA	NA	NA	NA	NA
alpha-Chlordane	0 - 6"	2/16	2.1 - 72	37	1.7	–	1,825	0	16,352	0
	18 - 24"	1/16	1.6	1.6	NA	NA	NA	NA	NA	NA

Table 8.4.6
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSVs and RBCs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC - Res. Exceedances	Industrial Soil RBC[f]	RBC - Ind. Exceedances
Pesticides/PCBs										
gamma-Chlordane	0 - 6"	3/16	1.7 - 74	27	1.7	–	1,825	0	16,352	0
	18 - 24"	2/16	1.9 - 11	6	NA	NA	NA	NA	NA	NA
4,4'-DDD	0 - 6"	10/16	2.9 - 280	55	3.3	9 (38SM0002, 38SM0003, 38SM0004, 38SM0006, 38SM0007, 38SM0010, 38SM0012, 38SM0014, 38SM0016)	2,700	0	24,000	0
	18 - 24"	7/16	2.5 - 85	22	NA	NA	NA	NA	NA	NA
4,4'-DDE	0 - 6"	10/16	2.8 - 110	26	3.3	9 (38SM0002, 38SM0003, 38SM0004, 38SM0006, 38SM0007, 38SM0010, 38SM0012, 38SM0014, 38SM0016)	1,900	0	17,000	0
	18 - 24"	6/16	2.5 - 30	12	NA	NA	NA	NA	NA	NA
4,4'-DDT	0 - 6"	4/16	5.6 - 520	208	3.3	4 (38SM0001, 38SM0002, 38SM0004, 38SM0006)	1,900	0	17,000	0
	18 - 24"	2/16	3.8 - 97	50	NA	NA	NA	NA	NA	NA
Dieldrin	0 - 6"	6/16	2.5 - 450	90	3.3	5 (38SM0001, 38SM0002, 38SM0006, 38SM0014, 38SM0015)	40	1 (38SM0001)	360	1 (38SM0001)
	18 - 24"	6/16	2.8 - 11	5	NA	NA	NA	NA	NA	NA
Endrin	0 - 6"	1/16	6.2	6.2	3.3	1 (38SM0002)	23,000	0	610,000	0
	18 - 24"	1/16	2.2	2.2	NA	NA	NA	NA	NA	NA
Endrin aldehyde	0 - 6"	1/16	2.2	2.2	3.3[h]	0	23,000[h]	0	610,000	0
Heptachlor	0 - 6"	1/16	3.4	3.4	–	–	140	0	1,300	0
	18 - 24"	1/16	1.6	1.6	NA	NA	NA	NA	NA	NA

Table 8.4.6
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSVs and RBCs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC - Res. Exceedances	Industrial Soil RBC[f]	RBC - Ind. Exceedances
Herbicides										
2,4-D	0 - 6"	2/16	19 - 49	34	–	–	780,000	0	20,000,000	0
	18 - 24"	3/16	9.9 - 45	26	NA	NA	NA	NA	NA	NA
2,4-DB	0 - 6"	1/16	25	25	–	–	630,000	0	16,000,000	0
	18 - 24"	1/16	23	23	NA	NA	NA	NA	NA	NA
Dinoseb	0 - 6"	1/16	12	12	–	–	78,000	0	2,000,000	0
	18 - 24"	2/16	3.5 - 10	7	NA	NA	NA	NA	NA	NA
MCPA	0 - 6"	5/16	930 - 4,100	2,066	–	–	39,000	0	1,000,000	0
	18 - 24"	4/16	3,700 - 5,100	4,250	NA	NA	NA	NA	NA	NA
MCPP	0 - 6"	4/16	1,100 - 8,600	4,775	–	–	78,000	0	2,000,000	0
	18 - 24"	6/16	3,000 - 8,700	5,717	NA	NA	NA	NA	NA	NA
2,4,5-T	18 - 24"	1/16	19	19	NA	NA	NA	NA	NA	NA
2,4,5-TP (Silvex)	0 - 6"	1/16	2.5	2.5	–	–	630,000	0	16,000,000	0

Notes:

a — Interval shown is in inches bls.
b — Thirty-two sediment samples were collected from 16 sample locations (38SM0001 through 38SM0016) from the following intervals: 0 to 6 inches bls and 18 to 24 inches bls. Of these, three from the 0- to 6-inch interval were split as duplicates. Two additional surface sediment samples (locations 38SM0025 and 38SM0026) were collected during a separate Southside investigation and are included in this table, bringing the total number of samples to 34; these two additional samples were analyzed only for PCBs.
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — SSV = Sediment Screening Values; values obtained from the *Screening Values for Hazardous Waste Sites* (USEPA, 1995b).
f — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs apply only for comparison to data from surface sediment samples.
g — The RBCs for fluoranthene were used for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.
h — The RBCs for naphthalene were used for 2-methylnaphthalene, which does not have RBCs.
i — No RBC or SSV exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for non-drinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSV. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).
j — The slope factor for PCBs was updated in IRIS in October 1996. Consequently, the RBC was recalculated using the updated information.
k — The RBCs for endrin were used for endrin aldehyde, which does not have RBCs.
– — RBC or SSV is not available for this analyte; therefore, no comparison can be made.
NA — Comparison is not applicable for this subsurface sediment sample.

Table 8.4.7
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSLs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSL[e]	SSL Exceedances
VOCs						
Acetone	0 - 6"	13/16	13 - 240	93	8,000	0
	18 - 24"	13/16	11 - 260	101	8,000	0
2-Butanone (MEK)	0 - 6"	3/16	21 - 24	23	–[f]	–
	18 - 24"	3/16	10 - 49	31	–	–
Ethylbenzene	0 - 6"	1/16	1	1	5,000	0
	18 - 24"	2/16	1	1	5,000	0
Methylene chloride	0 - 6"	2/16	1 - 2	2	10	0
	18 - 24"	2/16	1 - 2	2	10	0
Toluene	0 - 6"	1/16	2	2	5,000	0
	18 - 24"	3/16	1 - 2	2	5,000	0
SVOCs						
Acenaphthene	18 - 24"	2/16	45 - 110	78	200,000	0
Anthracene	0 - 6"	2/16	38 - 180	109	4,300,000	0
	18 - 24"	3/16	140 - 200	170	4,300,000	0
Benzo(a)anthracene	0 - 6"	7/16	42 - 430	145	700	0
	18 - 24"	3/16	270 - 1,300	667	700	1 (38SM0006)
Benzo(b)fluoranthene	0 - 6"	7/16	53 - 690	228	4,000	0
	18 - 24"	4/16	50 - 2,500	930	4,000	0
Benzo(k)fluoranthene	0 - 6"	7/16	61 - 560	204	4,000	0
	18 - 24"	4/16	56 - 1,900	712	4,000	0
Benzo(g,h,i)perylene	0 - 6"	7/16	52 - 540	148	–	–
	18 - 24"	3/16	190 - 1,900	823	–	–
Benzo(a)pyrene	0 - 6"	8/16	47 - 670	192	4,000	0
	18 - 24"	4/16	48 - 2,500	947	4,000	0
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 6"	9/16	45 - 1,400	228	11,000	0
	18 - 24"	9/16	44 - 280	108	11,000	0
Butylbenzylphthalate	0 - 6"	1/16	320	320	68,000	0
Carbazole	18 - 24"	1/16	150	150	500	0
Chrysene	0 - 6"	7/16	75 - 930	272	1,000	0
	18 - 24"	4/16	50 - 1,900	778	1,000	1 (38SM0006)
Dibenz(a,h)anthracene	0 - 6"	1/16	61	61	11,000	0
	18 - 24"	3/16	62 - 690	287	11,000	0
Dibenzofuran	18 - 24"	1/16	57	57	120,000	0
Fluoranthene	0 - 6"	7/16	66 - 750	230	980,000	0
	18 - 24"	5/16	68 - 1,600	485	980,000	0

Table 8.4.7
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSLs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSL[e]	SSL Exceedances
SVOCs						
Fluorene	0 - 6"	1/16	78	78	160,000	0
	18 - 24"	3/16	81 - 86	84	160,000	0
Indeno(1,2,3-cd)pyrene	0 - 6"	7/16	43 - 340	106	35,000	0
	18 - 24"	3/16	170 - 1,600	707	35,000	0
2-Methylnaphthalene	0 - 6"	1/16	40	40	–	–
	18 - 24"	1/16	46	46	–	–
4-Methylphenol (p-Cresol)	0 - 6"	1/16	45	45	–	–
Naphthalene	18 - 24"	1/16	94	94	30,000	0
4-Nitrophenol	18 - 24"	1/16	66	66	–	–
Phenanthrene	0 - 6"	5/16	51 - 400	168	–	–
	18 - 24"	3/16	440 - 930	607	–	–
Pyrene	0 - 6"	7/16	80 - 1,300	416	1,400,000	0
	18 - 24"	4/16	73 - 1,700	926	1,400,000	0
Total Petroleum Hydrocarbons						
TPH - DRO	0 - 6"	2/12	5,700 - 59,000	32,350	–	–
	18 - 24"	3/12	6,400 - 99,000	63,133	–	–
TPH - GRO	0 - 6"	1/12	100	100	–	–
Total TPH (TPH-GRO + TPH-DRO)	0 - 6"	3/12	100 - 59,000	21,600	500,000[f]	0
	18 - 24"	3/12	6,400 - 99,000	63,133	500,000[f]	0
TPH (Method 418.1)	0 - 6"	1/4	780	780	500,000[f]	0
	18 - 24"	1/3	410	410	500,000[f]	0
Pesticides/PCBs						
Aldrin	0 - 6"	7/16	1.3 - 4.4	2.5	5	0
	18 - 24"	4/16	1.3 - 5.7	2.7	5	1 (38SM0006)
Aroclor-1260	0 - 6"	5/18	34 - 1,900	509	–	–
	18 - 24"	1/16	42	42	–	–
Technical Chlordane	0 - 6"	1/16	240	240	2,000	0
	18 - 24"	1/16	100	100	2,000	0
alpha-Chlordane	0 - 6"	2/16	2.1 - 72	37	2,000	0
	18 - 24"	1/16	1.6	1.6	2,000	0
gamma-Chlordane	0 - 6"	3/16	1.7 - 74	27	2,000	0
	18 - 24"	2/16	1.9 - 11	6	2,000	0
4,4'-DDD	0 - 6"	10/16	2.9 - 280	55	700	0
	18 - 24"	7/16	2.5 - 85	22	700	0
4,4'-DDE	0 - 6"	10/16	2.8 - 110	26	500	0
	18 - 24"	6/16	2.5 - 30	12	500	0

Table 8.4.7
Detected Concentrations of Organic Compounds in Sediment Samples Compared to SSLs
SWMU 38 — Southside Drainage Ditches
(data in μg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSL[e]	SSL Exceedances
Pesticides/PCBs						
4,4'-DDT	0 - 6"	4/16	5.6 - 520	208	1,000	0
	18 - 24"	2/16	3.8 - 97	50	1,000	0
Dieldrin	0 - 6"	6/16	2.5 - 450	90	1	6 (38SM0001, 38SM0002, 38SM0004, 38SM0006, 38SM0014, 38SM0015)
	18 - 24"	6/16	2.8 - 11	5	1	6 (38SM0001, 38SM0002, 38SM0004, 38SM0006, 38SM0010, 38SM0015)
Endrin	0 - 6"	1/16	6.2	6.2	400	0
	18 - 24"	1/16	2.2	2.2	400	0
Endrin aldehyde	0 - 6"	1/16	2.2	2.2	–	–
Heptachlor	0 - 6"	1/16	3.4	3.4	60	0
	18 - 24"	1/16	1.6	1.6	60	0
Herbicides						
2,4-D	0 - 6"	2/16	19 - 49	34	1,700	0
	18 - 24"	3/16	9.9 - 45	26	1,700	0
2,4-DB	0 - 6"	1/16	25	25	–	–
	18 - 24"	1/16	23	23	–	–
Dinoseb	0 - 6"	1/16	12	12	–	–
	18 - 24"	2/16	3.5 - 10	7	–	–
MCPA	0 - 6"	5/16	930 - 4,100	2,066	–	–
	18 - 24"	4/16	3,700 - 5,100	4,250	–	–
MCPP	0 - 6"	4/16	1,100 - 8,600	4,775	–	–
	18 - 24"	6/16	3,000 - 8,700	5,717	–	–
2,4,5-T	18 - 24"	1/16	19	19	–	–
2,4,5-TP (Silvex)	0 - 6"	1/16	2.5	2.5	–	–

Notes:

a — Interval shown is in inches bls.

b — Thirty-two sediment samples were collected from 16 sample locations (38SM0001 through 38SM0016) from the following intervals: 0 to 6 inches bls and 18 to 24 inches bls. Of these, three from the 0- to 6-inch interval were split as duplicates. Two additional surface sediment samples (locations 38SM0025 and 38SM0026) were collected during a separate Southside investigation and are included in this table, bringing the total number of samples to 34; these two additional samples were analyzed only for PCBs.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Sediment Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — No SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

– — RBC or SSL is not available for this analyte; therefore, no comparison can be made.

The following SVOCs exceeded SSVs in surface sediment: benzo(a)anthracene, benzo(a)pyrene, BEHP, chrysene, fluoranthene, phenanthrene, and pyrene. Residential RBCs were exceeded by benzo(a)pyrene only. No industrial RBCs were exceeded. SSLs were exceeded by the SVOCs benzo(a)anthracene and chrysene. The following discusses the exceedances for each SVOC.

Benzo(a)anthracene's SSV (330 μg/kg) was exceeded in the surface sediment sample from location 38SM0006 (430 μg/kg), while the SSL for benzo(a)anthracene (700 μg/kg) was exceeded in the subsurface sediment from sample location 38SM0006 (1,300 μg/kg). Benzo(a)anthracene concentrations did not exceed the RBCs in any sample.

Benzo(a)pyrene's SSV (330 μg/kg) was exceeded in two surface sediment samples from locations 38SM0006 (670 μg/kg) and 39SM0012 (350 μg/kg). The residential RBC (88 μg/kg) was exceeded in five surface sediment samples from locations 38SM0001 (130 μg/kg), 38SM0002 (96 μg/kg), 38SM0006 (670 μg/kg), 38SM0012 (350 μg/kg), and 38SM0015 (95 μg/kg). Benzo(a)pyrene concentrations did not exceed the SSL in any sample.

BEHP's SSV (182 μg/kg) was exceeded in the surface sediment sample from location 38SM0006 (1,400 μg/kg). BEHP concentrations did not exceed the RBC or SSL values in any sample.

Chrysene's SSV (330 μg/kg) was exceeded in two surface sediment samples from locations 38SM0006 (930 μg/kg) and 38SM0012 (440 μg/kg). Chrysene's SSL (1,000 μg/kg) was exceeded in the subsurface sample from location 38SM0006 (1,900 μg/kg). There were no RBC exceedances for chrysene.

Fluoranthene's SSV (330 μg/kg) was exceeded in the surface sediment sample from location 348SM0006 (750 μg/kg). Fluoranthene concentrations did not exceed the RBC or SSL values in any sample.

Phenanthrene's SSV (330 μg/kg) was exceeded in the surface sediment sample from location 348SM0012 (400 μg/kg). Phenanthrene concentrations did not exceed the RBC or SSL values in any sample.

Pyrene's SSV (330 μg/kg) was exceeded in two surface sediment samples from locations 348SM0006 (1,300 μg/kg) and 38SM0012 (1,000 μg/kg). Pyrene concentrations did not exceed the RBC or SSL value in any sample.

TPH

TPH-DRO, TPH-GRO (TN Modified Method 8015), and TPH (Method 418.1) were detected in one or more surface and subsurface sediment samples. USEPA has not established an RBC, SSV, or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers (i.e., the loess) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface sediment. Total TPH for samples analyzed by the TN Modifier Method 8015 consists of the sum of the GRO and DRO concentrations in each sample. Total TPH for Method 418.1 consists of the reported concentration. As shown in Tables 8.4.6 and 8.4.7, the TDEC cleanup level was not exceeded by the total TPH concentration in any sample.

Pesticides/PCBs

The following pesticides/PCBS were detected in surface and/or subsurface sediment samples collected from the SWMU 38 Southside drainage ditches:

Aldrin	4,4'-DDT
Technical Chlordane	Dieldrin
alpha-Chlordane	Endrin
gamma-Chlordane	Endrin aldehyde
4,4'-DDD	Heptachlor
4,4'-DDE	Aroclor-1260

SSVs were exceeded by one or more detected concentrations of the following pesticides and PCBs in surface sediment: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endrin, and Aroclor-1260. The residential and industrial RBC was exceeded for the pesticide, dieldrin only. The residential, but not the industrial, RBC was exceeded by the PCB Aroclor-1260. SSLs were exceeded by one or more detected concentrations of the pesticides aldrin and dieldrin.

Aldrin's SSL (5 μg/kg) was exceeded in one subsurface sediment sample from location 38SM0006 (5.7 μg/kg). Aldrin concentrations did not exceed the RBC or SSL values in any sample.

4,4'-DDD's SSV (3.3 μg/kg) was exceeded in nine surface sediment samples from locations 38SM0002 (280 μg/kg), 38SM0003 (5.5 μg/kg), 38SM0004 (5 μg/kg), 38SM0006 (170 μg/kg), 38SM0007 (11 μg/kg), 38SM0010 (5.7 μg/kg), 38SM0012 (11 μg/kg), 38SM0014 (6.8 μg/kg), and 38SM0016 (56 μg/kg). 4,4'-DDD concentrations did not exceed the RBC or SSL values in any sample.

4,4'-DDE's SSV (3.3 μg/kg) was exceeded in nine surface sediment samples from locations 38SM0002 (79 μg/kg), 38SM0003 (8.6 μg/kg), 38SM0004 (10 μg/kg), 38SM0006 (110 μg/kg), 38SM0007 (5 μg/kg), 38SM0010 (5.8 μg/kg), 38SM0012 (9.8 μg/kg), 38SM0014 (8 μg/kg), and 38SM0016 (23 μg/kg). 4,4'-DDE concentrations did not exceed the RBC or SSL values in any sample.

4,4'-DDT's SSV (3.3 μg/kg) was exceeded in four surface sediment samples from locations 38SM0001 (5.6 μg/kg), 38SM0002 (280 μg/kg), 38SM0004 (28 μg/kg), and 38SM0006 (520 μg/kg). 4,4'-DDT concentrations did not exceed the RBC or SSL values in any sample.

Dieldrin's SSV (3.3 μg/kg) was exceeded in five surface sediment samples from locations 38SM0001 (450 μg/kg), 38SM0002 (28 μg/kg), 38SM0006 (33 μg/kg), 38SM0014 (5.5 μg/kg),

and 38SM0015 (20 μg/kg). Additionally, dieldrin's residential RBC (40 μg/kg) and industrial RBC (360 μg/kg) were exceeded in the surface sediment sample from location 38SM0001 (450 μg/kg). Dieldrin's SSL (1 μg/kg) was exceeded in six surface sediment samples collected from the 0 to 6-inch interval and six subsurface sediment samples collected from the 18- to 24-inch interval. The samples in which dieldrin exceeded its SSL included surface samples from locations 38SM0001 (450 μg/kg), 38SM0002 (28 μg/kg), 38SM0004 (2.5 μg/kg), 38SM0006 (33 μg/kg), 38SM0014 (5.5 μg/kg), and 38SM0015 (20 μg/kg), and subsurface samples from locations 38SM0001 (6.9 μg/kg), 38SM0002 (11 μg/kg), 38SM0004 (2.8 μg/kg), 38SM0006 (3.3 μg/kg), 38SM0010 (2.9 μg/kg), and 38SM0015 (3.6 μg/kg).

Endrin's SSV (3.3 μg/kg) was exceeded in the surface sediment sample from location 38SM0002 (6.2 μg/kg). Endrin concentrations did not exceed the RBC or SSL values in any sample.

Aroclor-1260's SSV (33 μg/kg) was exceeded in five surface sediment samples from locations 38SM0001 (52 μg/kg), 38SM0003 (34 μg/kg), 38SM0016 (290 μg/kg), 38SM0025 (1,900 μg/kg), and 38SM0026 (270 μg/kg). Additionally, the residential RBC for Aroclor-1260 (320 μg/kg) was exceeded at surface sediment sample location 38SM0025 (1,900 μg/kg). No PCBs were detected exceeding their respective industrial RBC or SSL values.

Herbicides

The following herbicides were detected in surface and/or subsurface sediment samples collected from the SWMU 38 Southside drainage ditches:

2,4-D	MCPP
2,4-DB	2,4,5-T
Dinoseb	2,4,5-TP (Silvex)
MCPA	

No SSVs exist for the detected herbicides. RBCs or SSLs (where available) by any detected herbicide concentration were not exceeded in surface and/or subsurface sediment.

8.4.3.2 Inorganic Compounds in Sediment

The following inorganic compounds were detected in surface and/or subsurface sediment samples collected from the SWMU 38 Southside drainage ditches:

Antimony	Copper
Arsenic	Lead
Barium	Nickel
Beryllium	Selenium
Cadmium	Vanadium
Chromium	Zinc
Cobalt	

Tables 8.4.8 and 8.4.9 summarize the inorganics detected in sediment samples and compare them to SSVs, residential and industrial soil RBCs, soil RCs, and soil-to-groundwater SSLs. Because no sediment background RCs are available for the NSA Memphis Southside, any inorganic concentrations exceeding applicable SSVs were considered significant and are discussed. When comparing SWMU 38 inorganics to SSLs and RBCs, an exceedance was not considered significant and was not discussed, unless the surface or subsurface soil background RC was also exceeded. Figure 8.4.3 plots the SSV exceedances in surface sediment samples. Figure 8.4.4 plots surface sediment sample concentrations that exceeded both the soil RBC and soil RC. Figure 8.4.5 plots surface and subsurface sediment sample concentrations that exceeded both soil-to-groundwater SSL and soil RBC. The inorganic exceedances are discussed below.

Antimony's SSV (12 mg/kg) was exceeded in one surface sediment sample at sample location 38SM0008 (15.8 mg/kg). This same sample was the only sediment sample to exceed antimony's RC (non-detect). No antimony concentrations exceeded the SSL.

Table 8.4.8
Detected Concentrations of Inorganics in Sediment Samples Compared to SSVs, RBCs, and RCs
SWMU 38 — Miscellaneous Industrial Drainage Ditches — Southside
(data in mg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	RC[g]	RC Exceedances
Antimony	0 - 6"	1/16	15.8	15.8	12	1 (38SM0008)	31	0	820	0	ND	1 (38SM0008)
Arsenic	0 - 6"	16/16	2.8 - 19	8	7.24	7 (38SM0001, 38SM0007, 38SM0009, 38SM0011, 38SM0013, 38SM0014, 38SM0016)	0.43	16 (38SM0001, 38SM0002, 38SM0003, 38SM0004, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	3.8	12 (38SM0001, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	14.58	2 (38SM0001, 38SM0009)
	18 - 24"	16/16	2.6 - 18.8	8.3	NA	NA	NA	NA	NA	NA	20.32	0
Barium	0 - 6"	16/16	75 - 212	140	–	–	5,500	0	140,000	0	223.46	0
	18 - 24"	16/16	45.4 - 219	132	NA	NA	NA	NA	NA	NA	265.12	0
Beryllium	0 - 6"	15/16	0.32 - 0.81	0.53	–	–	0.15	15 (38SM0001, 38SM0002, 38SM0003, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	1.3	0	1	0
	18 - 24"	16/16	0.28 - 0.69	0.47	NA	NA	NA	NA	NA	NA	1.004	0
Cadmium	0 - 6"	16/16	0.92 - 5.3	2.3	1	15 (38SM0001, 38SM0002, 38SM0004, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	39	0	1,000	0	1.54	11 (38SM0001, 38SM0002, 38SM0007, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)
	18 - 24"	14/16	0.83 - 3.2	2	NA	NA	NA	NA	NA	NA	3.24	0

Table 8.4.8
Detected Concentrations of Inorganics in Sediment Samples Compared to SSVs, RBCs, and RCs
SWMU 38 — Miscellaneous Industrial Drainage Ditches — Southside
(data in mg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	RC[g]	RC Exceedances
Chromium	0 - 6"	16/16	7.4 - 18.3	11.9	52.3	0	390	0	10,000	0	23.89	0
	18 - 24"	16/16	6.3 - 12.6	10.7	NA	NA	NA	NA	NA	NA	28.28	0
Cobalt	0 - 6"	16/16	4.5 - 10	7	–	–	4,700	0	120,000	0	15.98	0
	18 - 24"	16/16	2.9 - 9.5	6.9	NA	NA	NA	NA	NA	NA	14.36	0
Copper	0 - 6"	16/16	9.4 - 2,250	155	18.7	2 (38SM0013, 38SM0016)	3,100	0	82,000	0	24.19	2 (38SM0013, 38SM0016)
	18 - 24"	16/16	10 - 2,160	148	NA	NA	NA	NA	NA	NA	32.52	1 (38SM0014)
Lead	0 - 6"	16/16	9.2 - 96.9	20.5	30.2	2 (38SM0001, 38SM0016)	400[h]	0	1,300[h]	0	26.03	2 (38SM0001, 38SM0016)
	18 - 24"	16/16	8.3 - 20.1	13.6	NA	NA	NA	NA	NA	NA	19.8	1 (38SM0016)
Nickel	0 - 6"	16/16	7.2 - 2,240	154	15.9	7 (38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0013, 38SM0016)	1,600	1 (38SM0013)	41,000	0	20.62	4 (38SM0007, 38SM0008, 38SM0009, 38SM0013)
	18 - 24"	16/16	9.3 - 2,110	146	NA	NA	NA	NA	NA	NA	ND	16 (38SM0001 through 38SM0016)
Selenium	0 - 6"	4/16	0.27 - 0.53	0.39	–	–	390	0	10,000	0	ND	4 (38SM0001, 38SM0002, 38SM0004, 38SM0016)
	18 - 24"	3/16	0.28 - 0.37	0.33	NA	NA	NA	NA	NA	NA	ND	3 (38SM0004, 38SM0005, 38SM0016)
Vanadium	0 - 6"	16/16	10.5 - 35.2	21.1	–	–	550	0	14,000	0	45.11	0
	18 - 24"	16/16	13.5 - 23.6	19	NA	NA	NA	NA	NA	NA	43.68	0

Table 8.4.8
Detected Concentrations of Inorganics in Sediment Samples Compared to SSVs, RBCs, and RCs
SWMU 38 — Miscellaneous Industrial Drainage Ditches — Southside
(data in mg/kg)

Analyte	Interval[a]	Number of Detections[b]	Range[c]	Mean[d]	SSV[e]	SSV Exceedances	Residential Soil RBC[f]	RBC-Res. Exceedances	Industrial Soil RBC[f]	RBC-Ind. Exceedances	RC[g]	RC Exceedances
Zinc	0 - 6"	16/16	41.2 - 115	62	124	0	23,000	0	610,000	0	98	1 (38SM0016)
	18 - 24"	16/16	37.5 - 68.6	53.1	NA	NA	NA	NA	NA	NA	109	0

Notes:

a — Interval shown is in inches below land surface.
b — Thirty-two sediment samples were collected from 16 sample locations (38SM0001 through 38SM0016) from the following intervals: 0 to 6 inches bls and 18 to 24 inches bls. Of these, three from the 0- to 6-inch interval were split as duplicates.
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — SSV = Sediment Screening Values; values obtained from the *Screening Values for Hazardous Waste Sites* (USEPA, 1995b).
f — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs apply only for comparison to data from samples collected across the surface interval.
g — Reference Concentration (RC) is two times the mean background concentration established for 13 background surface samples collected throughout NSA Memphis. Refer to *Technical Memorandum – Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.
h — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 are used for comparison (USEPA, 1994c).
ND — Analyte was not detected in background soil samples.
NA — Comparison is not applicable to this subsurface sediment sample.
– — RBC or SSL is not available for this analyte; therefore, no comparison can be made.

Table 8.4.9
Detected Concentrations of Inorganics in Sediment Samples Compared to SSLs and RCs
SWMU 38 — Miscellaneous Industrial Drainage Ditches — Southside
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSL[e]	SSL Exceedances	RC[f]	RC Exceedances
Antimony	0 - 6"	1/16	15.8	15.8	–	–	ND	1 (38SM000801)
Arsenic	0 - 6"	16/16	2.8 - 19	8	15	2 (38SM0001, 38SM0009)	14.58	2 (38SM0001, 38SM0009)
	18 - 24"	16/16	2.6 - 18.8	8.3	15	2 (38SM0001, 38SM0011)	20.32	0
Barium	0 - 6"	16/16	75 - 212	140	32	16 (38SM0001, 38SM0002, 38SM0003, 38SM0004, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	223.46	0
	18 - 24"	16/16	45.4 - 219	132	32	16 (38SM0001, 38SM0002, 38SM0003, 38SM0004, 38SM0005, 38SM0006, 38SM0007, 38SM0008, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)	265.12	0
Beryllium	0 - 6"	15/16	0.32 - 0.81	0.53	180	0	1	0
	18 - 24"	16/16	0.28 - 0.69	0.47	180	0	1.004	0
Cadmium	0 - 6"	16/16	0.92 - 5.3	2.3	6	0	1.54	11 (38SM0001, 38SM0002, 38SM0007, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, 38SM0016)
	18 - 24"	14/16	0.83 - 3.2	2	6	0	3.24	0
Chromium	0 - 6"	16/16	7.4 - 18.3	11.9	–	–	23.89	0
	18 - 24"	16/16	6.3 - 12.6	10.7	–	–	28.28	0
Cobalt	0 - 6"	16/16	4.5 - 10	7	–	–	15.98	0
	18 - 24"	16/16	2.9 - 9.5	6.9	–	–	14.36	0

Table 8.4.9
Detected Concentrations of Inorganics in Sediment Samples Compared to SSLs and RCs
SWMU 38 — Miscellaneous Industrial Drainage Ditches — Southside
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	SSL[e]	SSL Exceedances	RC[f]	RC Exceedances
Copper	0 - 6"	16/16	9.4 - 2,250	155	–	–	24.19	2 (38SM0013, 38SM0016)
	18 - 24"	16/16	10 - 2,160	148	–	–	32.52	1 (38SM0014)
Lead	0 - 6"	16/16	9.2 - 96.9	20.5	–	–	26.03	2 (38SM0001, 38SM0016)
	18 - 24"	16/16	8.3 - 20.1	13.6	–	–	19.8	1 (38SM0016)
Nickel	0 - 6"	16/16	7.2 - 2,240	154	21	4 (38SM0007, 38SM0008, 38SM0009, 38SM0013)	20.62	4 (38SM0007, 38SM0008, 38SM0009, 38SM0013)
	18 - 24"	16/16	9.3 - 2,110	146	21	2 (38SM0011, 38SM0014)	ND	16 (38SM0001 through 38SM0016)
Selenium	0 - 6"	4/16	0.27 - 0.53	0.39	3	0	ND	4 (38SM0001, 38SM0002, 38SM0004, 38SM0016)
	18 - 24"	3/16	0.28 - 0.37	0.33	3	0	ND	3 (38SM0004, 38SM0005, 38SM0016)
Vanadium	0 - 6"	16/16	10.5 - 35.2	21.1	–	–	45.11	0
	18 - 24"	16/16	13.5 - 23.6	19	–	–	43.68	0
Zinc	0 - 6"	16/16	41.2 - 115	62	42,000	0	98	1 (38SM0016)
	18 - 24"	16/16	37.5 - 68.6	53.1	42,000	0	109	0

Notes:

a — Interval shown is in inches below land surface.
b — Thirty-two sediment samples were collected from 16 sample locations (38SM0001 through 38SM0016) from the following intervals: 0 to 6 inches bls and 18 to 24 inches bls. Of these, three from the 0- to 6-inch interval were split as duplicates.
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — Sediment Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
f — Reference concentration is two times the mean background concentration established for 13 background surface soil samples collected throughout NSA Memphis. Refer to *Technical Memorandum – Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.
– — SSL is not available for this analyte; therefore, no comparison can be made.
ND — Analyte was not detected in background soil samples.
NA — Comparison is not applicable to this subsurface sediment sample.

Arsenic's SSV (7.24 mg/kg) was exceeded in seven surface sediment sampling collected from sampling locations 38SM0001 (19 mg/kg), 38SM0007 (11.5 mg/kg), 38SM0009 (17.4 mg/kg), 38SM0011 (11.5 mg/kg), 38SM0013 (12 mg/kg), 38SM0014 (9.9 mg/kg), and 38SM0016 (13.1 mg/kg). Arsenic's surface soil RC (14.58 mg/kg), residential RBC (0.43 mg/kg), industrial RBC (3.8 mg/kg), and SSL (15 mg/kg) were exceeded in two surface sediment samples from locations 38SM0001 and 38SM0009.

Cadmium's SSV (1 mg/kg) was exceeded in 15 surface sediment samples: 38SM0001 (1.8 mg/kg), 38SM0002 (1.6 mg/kg), 38SM0004 (1.3 mg/kg), 38SM0005 (1.2 mg/kg), 38SM0006 (1.4 mg/kg), 38SM0007 (2.8 mg/kg), 38SM0008 (1.2 mg/kg), 38SM0009 (2.7 mg/kg), 38SM0010 (2.2 mg/kg), 38SM0011 (2.1 mg/kg), 38SM0012 (1.9 mg/kg), 38SM0013 (4.6 mg/kg), 38SM0014 (2.6 mg/kg), 38SM0015 (2.8 mg/kg), 38SM0016 (5.3 g/kg). Cadmium's RC (non-detect) was exceeded in 11 surface sediment samples: 38SM0001, 38SM0002, 38SM0007, 38SM0009, 38SM0010, 38SM0011, 38SM0012, 38SM0013, 38SM0014, 38SM0015, and 38SM0016. No cadmium concentrations exceeded the RBCs.

Copper's SSV (18.7 mg/kg) was exceeded in surface sediment collected from sample locations 38SM0013 (2,250 mg/kg) and 38SM0016 (27.1 mg/kg). These same two samples also exceeded copper's surface RC (24.19 mg/kg). Copper's subsurface RC (32.52 mg/kg) was exceeded in subsurface sediment sample 038SM0014 (2,160 mg/kg). No copper concentrations exceeded the RBCs.

Lead's SSV (30.2 mg/kg) was exceeded in surface sediment collected from sample locations 38SM0001 (96.9 mg/kg) and 38SM0016 (39.4 mg/kg). These same two samples also exceeded lead's surface RC (26.03 mg/kg). Lead's subsurface RC (19.8 mg/kg) was exceeded in subsurface sediment sample 038SM0016 (20.1). No lead concentrations exceeded the RBCs.

Nickel's SSV (15.9 mg/kg) was exceeded in seven surface sediment samples from sampling locations 38SM0007 (21.9 mg/kg), 38SM0008 (22.9 mg/kg), 38SM0009 (26.2 mg/kg), 38SM0010 (16.1 mg/kg), 38SM0011 (18.8 mg/kg), 38SM0013 (2,240 mg/kg), and 38SM0016 (17.5 mg/kg). The surface soil RC (20.62) and the residential RBC for nickel (1,600 mg/kg) were exceeded at 38SM0013 (2,240 mg/kg). There were four exceedances of the surface soil RC and the SSL (21 mg/kg) in surface sediment samples 38SM0007, 38SM0008, 38SM0009, 38SM0013 and two exceedances of the subsurface soil RC (nondetect [ND]) and the SSL in subsurface sediment samples 38SM0011 (24.8 mg/kg) and 38SM0014 (2,110 mg/kg).

8.4.3.3 SWMU 38 Follow Up Sediment Sampling Summary

During the 1996 investigation at SWMU 38, sediment samples collected from two locations exhibited anomalous concentrations of copper and nickel. Because these detections were isolated, additional sediment samples were collected to confirm the presence of these inorganics. In June 1997, EnSafe personnel collected sediment samples both upstream and downstream from sample locations 38SM0013 and 38SM0014 and submitted them for copper and nickel analysis.

Sample Location 38SM0013

In the area of 38SM0013, two samples were collected upstream, two samples from downstream, and one from the same location. As shown in Table 8.4.10, the copper and nickel concentrations in the 1997 samples were approximately 100 times lower than the original concentrations, indicating an erroneous value. Due to the extreme difference between the original sample (38SM001301) and the follow up sample (38SM003001), as well as the concentrations detected both upstream and downstream during the follow up sampling, the original values are considered inaccurate and will not be used during the assessment of SWMU 38.

Table 8.4.10
1997 Resampling of Sample Location 38SM0013

Sample ID	Location	Parameter	Result (mg/kg)
38SM001301	Original sample	Copper	2,250
		Nickel	2,240
38SM002801	100 ft. upstream	Copper	20.3
		Nickel	20.1
38SM002901	50 ft. upstream	Copper	20.2
		Nickel	24.2
38SM003001	Duplication of original sample location	Copper	19.3
		Nickel	20.1
38SM003101	50 ft. downstream	Copper	19.0
		Nickel	22.2
38SM003201	100 ft. downstream	Copper	19.1
		Nickel	25.7

Sample Location 38SM0014

As with sample location 38SM0013, additional samples were collected both upstream and downstream of sample location 38SM0014, from the same sample interval. The samples collected were submitted for both copper and nickel analysis to determine if the original sample data was accurate, or an anomalous. As shown in Table 8.4.11, the values for copper and nickel detected during the 1997 follow up sampling are approximately 100 times lower in the upstream and downstream samples, as well as the sample collected from the original sample location (38SM0014). Based on this information, the original values are considered inaccurate and will not be used during the assessment of SWMU 38.

Table 8.4.11
1997 Resampling of Sample Location 38SM0014

Sample ID	Location	Parameter	Result (mg/kg)
38SM001402	Original sample	Copper	2,160
		Nickel	2,110
38SM003502	50 ft. upstream	Copper	19.3
		Nickel	20.1
38SM003402	Duplicate of original sample location	Copper	17.8
		Nickel	19.2
38SM003302	50 ft. downstream	Copper	15.6
		Nickel	15.6

8.4.4 Human Health Risk Assessment for SWMU 38

8.4.4.1 Site Background and Investigative Approach

The SWMU 38 HHRA addresses potential adverse effects on actual or hypothetical human receptors potentially exposed to hazardous substances released from SWMU 38. It was assumed that samples collected during the investigation represent the baseline extent of current environmental contamination.

This HHRA for SWMU 38, which limited in scope to sediment, includes most of the open ditches on the NSA Memphis Southside. SWMU 38 ditches are used to drain the north and south sides of NSA Memphis; however, only the ditches on the Southside of NSA Memphis are included in this investigation. Northside ditches were included in the *Assembly B RFI Report* (E/A&H, 1996d). The Southside drainage ditches receive influent from surface runoff, storm sewers, and formerly, wastewater discharges from various industrial buildings on the NSA Memphis Southside.

The locations of the SWMU 38 primary and secondary drainage ditches were illustrated on Figure 8.4.1. The general topography of the Southside of NSA Memphis consists of a subtle downward slope of 1% to 3% to the west. The ditches comprising SWMU 38 drain to Big Creek Drainage Canal in the southwest corner of NSA Memphis. Water stages in the ditches, which may vary as much as several feet during storm events, appear to have eroded bank soil in several areas, as described in Section 1.1.4.

SWMU 38 sediment is submerged for approximately four months per year based on visual observations. To assess potential excess human health risks, sediment exposure was assumed to be similar to that generally assumed for soil exposure, in accordance with Supplemental Guidance to RAGS *Bulletin 3, Exposure Assessment* (USEPA, 1995b). Sample locations are scattered throughout the Southside of NSA Memphis, so risk estimates were developed for each sample

location. The 18 sediment samples used in this HHRA were: 038M000101 through 038M001601, 038M002501, and 038M002601.

8.4.4.2 Identification of Chemicals of Potential Concern

COPCs were identified using the methods outlined in Supplemental Guidance to RAGS *Bulletin 1, Data Collection and Evaluation* (USEPA, 1995b) and the Technical Memorandum on HHRA (E/A&H, 1997e). In accordance with USEPA guidance, sediment data collected from locations which were not submerged for a portion of the year were compared to soil RBCs and soil RCs to identify sediment COPCs.

Table 8.4.12 lists CPSSs and identifies the following sediment COPCs: antimony, PCB Aroclor-1260, arsenic, BEQs, cadmium, copper, dieldrin, MCPA, MCPP, and nickel. Table 8.4.13 shows the BEQs concentrations and BEQs for each sample location used in this HHRA.

8.4.4.3 Exposure Assessment

Exposure Setting

SWMU 38 drainage ditches on the Southside are not submerged year-round, so exposure would be to sediment and surface water in these ditches. Human exposure to surface water would be negligible, and sediments would act as a sink for contaminants. Consequently, this HHRA addresses sediment exposure. Section 8.4.5, the ecological risk assessment, addresses other receptors' exposure to SWMU 38 surface water, while Section 1.1.4 describes the various ditches and includes a site figure.

Table 8.4.12
Chemicals Present in SWMU 38 Sediment
NSA Memphis Assembly E RFI

	Chemical	Units	Frequency of Detection	Range of Nondetected Concentrations	Range of Detected Concentrations	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
	Acetone	µg/kg	13 / 17	11 - 79	13 - 240	93.3	780,000	a, N		NA	
	Aldrin	µg/kg	7 / 17	2 - 21	1.3 - 4.4	2.46	38	a, C		NA	
	alpha-Chlordane (Chlordane)	µg/kg	2 / 17	1.9 - 9.7	2.1 - 72	37.1	490	a, C		NA	
	Anthracene	µg/kg	2 / 17	380 - 2200	38 - 180	109	2,300,000	a, N		NA	
*	Antimony	mg/kg	1 / 17	11.2 - 14.9	15.8 - 15.8	15.8	3.1	a, N	1	NA	1
*	Aroclor 1260	µg/kg	5 / 18	38 - 190	34 - 1900	509	320	a, C, e	1	NA	
*	Arsenic	mg/kg	16 / 17	-	2.8 - 19	8.19	0.43	a, C	16	14.58	2
	Barium	mg/kg	16 / 17	-	75 - 212	140	550	a, N		223.46	
*	BEQ	µg/kg	8 / 17	380 - 2200	61.2 - 853	155	88	a, C	6	NA	
	Benzo(a)anthracene	µg/kg	7 / 17	420 - 490	42 - 430	145	880	a, C		NA	
*	*Benzo(a)pyrene*	µg/kg	8 / 17	420 - 490	47 - 670	192	88	a, C	5	NA	
	Benzo(b)fluoranthene	µg/kg	7 / 17	420 - 490	53 - 690	228	880	a, C		NA	
	Benzo (k)fluoranthene	µg/kg	7 / 17	420 - 490	61 - 560	204	8,800	a, C		NA	
	Chrysene	µg/kg	7 / 17	420 - 490	75 - 930	272	88,000	a, C		NA	
	Dibenz(a,h)anthracene	µg/kg	1 / 17	380 - 2200	61 - 61	61	88	a, C		NA	
	Indeno(1,2,3-cd)pyrene	µg/kg	7 / 17	420 - 490	43 - 340	106	880	a, C		NA	
	Benzo (g,h,i)perylene	µg/kg	7 / 17	420 - 490	52 - 540	148	23,000	a, N		NA	
	Beryllium	mg/kg	15 / 17	0.26 - 0.26	0.32 - 0.81	0.529	0.15	a, C	15	1	
	Bis(2-ethylhexyl)phthalate (BEHP)	µg/kg	9 / 17	390 - 490	45 - 1400	228	46,000	a, C		NA	
	Butylbenzylphthalate	µg/kg	1 / 17	380 - 490	320 - 320	320	1,600,000	a, N		NA	
*	Cadmium	mg/kg	16 / 17	-	0.92 - 5.3	2.28	3.9	a, N	2	1.54	11
	Chromium	mg/kg	16 / 17	-	7.4 - 18.3	11.9	39	a, N		23.89	
	Cobalt	mg/kg	16 / 17	-	4.5 - 10	7.39	470	a, N		15.98	
*	Copper	mg/kg	16 / 17	-	9.4 - 2250	155	310	a, N	1	24.19	2
	2,4,5-TP - Silvex	µg/kg	1 / 17	0.95 - 0.95	2.5 - 2.5	2.5	63,000	a, N		NA	
	2,4-D	µg/kg	2 / 17	8 - 9.4	19 - 49	34	78,000	a, N		NA	
	2,4-DB	µg/kg	1 / 17	9.5 - 9.5	25 - 25	25	63,000	a, N		NA	
	2-Butanone (MEK)	µg/kg	3 / 17	11 - 15	21 - 24	22.7	4,700,000	a, N		NA	
	2-Methylnaphthalene (Naphthalene)	µg/kg	1 / 17	380 - 2200	40 - 40	40	310,000	a, N		NA	
	4,4'-DDD	µg/kg	10 / 17	3.8 - 4.9	2.9 - 280	55.4	2,700	a, C		NA	
	4,4'-DDE	µg/kg	10 / 17	3.8 - 4.9	2.8 - 110	26.2	1,900	a, C		NA	
	4,4'-DDT	µg/kg	4 / 17	3.8 - 42	5.6 - 520	208.4	1,900	a, C		NA	
	4-Methylphenol	µg/kg	1 / 17	380 - 2200	45 - 45	45	39,000	a, N		NA	
*	Dieldrin	µg/kg	6 / 17	4.3 - 42	2.5 - 450	89.8	40	a, C	1	NA	
	Dinoseb	µg/kg	1 / 17	4.7 - 4.7	12 - 12	12	7,800	a, N		NA	
	Endrin	µg/kg	1 / 17	3.8 - 42	6.2 - 6.2	6.2	2,300	a, N		NA	
	Endrinaldehyde	µg/kg	1 / 17	3.8 - 42	2.2 - 2.2	2.2	2,300	a, N		NA	
	Ethylbenzene	µg/kg	1 / 17	11 - 15	1 - 1	1	780,000	a, N		NA	
	Fluoranthene	µg/kg	7 / 17	420 - 490	66 - 750	230	310,000	a, N		NA	
	Fluorene	µg/kg	1 / 17	380 - 2200	78 - 78	78	310,000	a, N		NA	
	gamma-Chlordane (Chlordane)	µg/kg	3 / 17	1.9 - 4.4	1.7 - 7.4	27.3	490	a, C		NA	
	Heptachlor	µg/kg	1 / 17	3.8 - 42	3.4 - 3.4	3.4	140	a, C		NA	
	Lead	mg/kg	16 / 17	-	9.2 - 96.9	20.5	400	d		26.03	2
*	MCPA	µg/kg	5 / 17	930 - 940	930 - 4100	2066	3,900	a, N	1	NA	
*	MCPP	µg/kg	4 / 17	940 - 940	1100 - 8600	4775	7,800	a, N	1	NA	
	Methylene Chloride	µg/kg	2 / 17	11 - 15	1 - 2	1.5	85,000	a, C		NA	
*	Nickel	mg/kg	16 / 17	-	7.2 - 2240	154	160	a, N	1	20.62	4
	Phenanthrene	µg/kg	5 / 17	420 - 490	51 - 400	168	230,000	a, N		NA	
	Pyrene	µg/kg	7 / 17	420 - 490	80 - 1300	416	230,000	a, N		NA	
	Selenium	mg/kg	4 / 17	0.22 - 0.3	0.27 - 0.53	0.39	39	a, N		NA	
	Technical Chlordane	µg/kg	1 / 17	38 - 640	240 - 240	240	490	a, C		NA	
	Toluene	µg/kg	1 / 17	11 - 15	2 - 2	2	1,600,000	a, N		NA	
	Vanadium	mg/kg	16 / 17	-	10.5 - 35.2	21.1	55	a, N		45.11	
	Zinc	mg/kg	16 / 17	-	41.2 - 115	61.9	2,300	a, N		98	1

Notes:
( ) Surrogate used
* - Identified as a chemical of potential concern
a - Screening based on USEPA's 1998 Risk-Based Concentration tables (USEPA, 1998)
b - Screening based on 400 mg/kg of lead in soil, in accordance with USEPA's OSWER Directive 9355.4-2 (USEPA 1994)
C - Carcinogen
N - Noncarcinogen; RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
BEQ - Benzo(a)pyrene equivalent
RBC - Risk Based Concentration
mg/kg - milligrams per kilogram
µg/kg - micrograms per kilogram

Table 8.4.13
SWMU 38 Benzo(a)pyrene Equivalent Concentrations
NSA Memphis Assembly E RFI

		Sample Designations								
BEQ Component	**TEF**	**38SM000101**	**38SM000201**	**38SM000301**	**38SM000401**	**38SM000501**	**38SM000601**	**38SM000701**	**38SM000801**	**38SM000901**
Detected Concentrations										
Benzo(a)anthracene	0.1	88	77				430	42		
Benzo(a)pyrene	1	130	96				670	86		
Benzo(b)fluoranthene	0.1	240	140				690	53		
Benzo(k)fluoranthene	0.01	190	120				560	62		
Chrysene	0.001	170	120				930	76		
Dibenz(a,h)anthracene	1									
Indeno(123-cd)pyrene	0.1	69	51				340	43		
Equivalent Concentrations (a)										
Benzo(a)anthracene	0.1	8.8	7.7	2.1	2.1	2.1	43	4.2	2.1	2.1
Benzo(a)pyrene	1	130	96	23.5	23.5	23.5	670	86	23.5	23.5
Benzo(b)fluoranthene	0.1	24	14	2.65	2.65	2.65	69	5.3	2.65	2.65
Benzo(k)fluoranthene	0.01	1.9	1.2	0.305	0.305	0.305	5.6	0.62	0.305	0.305
Chrysene	0.001	0.17	0.12	0.0375	0.0375	0.0375	0.93	0.076	0.0375	0.0375
Dibenz(a,h)anthracene	1	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
Indeno(123-cd)pyrene	0.1	6.9	5.1	2.15	2.15	2.15	34	4.3	2.15	2.15
BEQs		**202.27**	**154.62**	**61.24**	**61.24**	**61.24**	**853.03**	**131.00**	**61.24**	**61.24**

Table 8.4.13 (continued)
SWMU 38 Benzo(a)pyrene Equivalent Concentrations
NSA Memphis Assembly E RFI

BEQ Component	TEF	38SM001001	38SM001101	38SM001201	38SM001301	38SM001401	38SM001501	38SM001601	38SS002501	38SS002601
Detected Concentrations										
Benzo(a)anthracene	0.1			250		51	77		NS	NS
Benzo(a)pyrene	1	47		350		64	95		NS	NS
Benzo(b)fluoranthene	0.1			340		55	79		NS	NS
Benzo(k)fluoranthene	0.01			350		61	82		NS	NS
Chrysene	0.001			440		75	95		NS	NS
Dibenz(a,h)anthracene	1			61					NS	NS
Indeno(123-cd)pyrene	0.1			120		46	72		NS	NS
Equivalent Concentrations (a)										
Benzo(a)anthracene	0.1	2.1	2.1	25	2.1	5.1	7.7	2.1	NS	NS
Benzo(a)pyrene	1	47	23.5	350	23.5	64	95	23.5	NS	NS
Benzo(b)fluoranthene	0.1	2.65	2.65	34	2.65	5.5	7.9	2.65	NS	NS
Benzo(k)fluoranthene	0.01	0.305	0.305	3.5	0.305	0.61	0.82	0.305	NS	NS
Chrysene	0.001	0.0375	0.0375	0.44	0.0375	0.075	0.095	0.0375	NS	NS
Dibenz(a,h)anthracene	1	30.5	30.5	61	30.5	30.5	30.5	30.5	NS	NS
Indeno(123-cd)pyrene	0.1	2.15	2.15	12	2.15	4.6	7.2	2.15	NS	NS
BEQs		**84.74**	**61.24**	**485.94**	**61.24**	**110.39**	**149.22**	**61.24**	**NS**	**NS**

Notes:

a = Equivalent concentrations include assumed concentrations, as described in Section 8.4.4 text.
NS = Not sampled/not analyzed
TEF = Toxicity equivalence factor
BEQs = Sum benzo(a)pyrene equivalents concentration

Potential Exposed Populations

Two populations would be expected to be exposed to SWMU 38 sediment — site workers and site trespassers. Current land use would be limited to maintenance workers or groundskeepers, assuming a site worker would be exposed to sediment once per week for 25 years. Corresponding multipliers presented in the Technical Memorandum on HHRA were adjusted from an exposure frequency of 250 days per year to 52 days per year to address the maintenance worker/groundskeeper potentially exposed to SWMU 38 sediment.

Because NSA Memphis is part of BRAC, future site use cannot be determined with absolute certainty. However, the Southside is being retained by the Navy. Therefore, conservative assumptions were used to account for any reasonable future use. Future land use is unlikely to change, but could include maintenance workers and site trespassers, who were assumed to contact SWMU 38 sediment once per week for 10 years as an adolescent. The default site worker scenario was included as a relative comparison. All SWMU 38 intake estimates were modified multiplying by 0.67 to account for the four months SWMU 38 sediment would be submerged.

Exposure Pathways

Table 8.4.14 summarizes exposure pathways and receptors for current and future land use and justifies including or excluding various exposure pathways. Exposure pathways include incidental sediment ingestion and dermal contact. Sediment samples were collected from partially exposed drainage ditches as described in Section 1.1.4. As previously discussed, sediment was estimated to be exposed eight months of the year, and was analyzed as surface soil in this HHRA. Uniform exposure was assumed for all sample locations.

Table 8.4.14
SWMU 38 Exposure Pathways Summary
NSA Memphis, Assembly E RFI

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Current Land Uses		
Current Site Users/Maintenance	Air — Inhalation of gaseous contaminants emanating from soil	No	SWMU 38 does not include soil or groundwater.
	Air — Inhalation of chemicals entrained in fugitive dust	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Ingestion of contaminants during potable or general use	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Inhalation of volatilized groundwater contaminants	No	SWMU 38 does not include soil or groundwater.
	Soil — Incidental ingestion	No	SWMU 38 does not include soil or groundwater.
	Soil — Dermal contact	No	SWMU 38 does not include soil or groundwater.
	Sediment — Incidental ingestion	Yes	Risk estimates for sediment exposure pathways are presented in Table 8.4.15.
	Sediment — Dermal contact	Yes	Risk estimates for sediment exposure pathways are presented in Table 8.4.15.
	Surface Water — Incidental ingestion	No	Sediments would act as a sink for contaminants, so sediment exposure was the focus of the HHRA.
	Future Land Uses		
Future Site Construction Worker	Air — Inhalation of gaseous contaminants emanating from soil	No	SWMU 38 does not include soil or groundwater.
	Air — Inhalation of chemicals entrained in fugitive dust	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Ingestion of contaminants during potable or general use	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Inhalation of volatilized groundwater contaminants	No	SWMU 38 does not include soil or groundwater.

Table 8.4.14
SWMU 38 Exposure Pathways Summary
NSA Memphis, Assembly E RFI

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Future Land Uses		
Future Site Construction Worker (continued)	Subsurface Soil — Incidental Ingestion	No	SWMU 38 does not include soil or groundwater.
	Subsurface Soil — Dermal contact	No	SWMU 38 does not include soil or groundwater.
	Surface Water — Incidental ingestion	No	Sediments would act as a sink for contaminants, so sediment exposure was the focus of the HHRA.
Future Site Residents (child and Adult) and Future Site Worker	Air — Inhalation of gaseous contaminants emanating from soil	No	SWMU 38 does not include soil or groundwater.
	Air — Inhalation of chemicals entrained in fugitive dust	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Ingestion of contaminants during potable or general use	No	SWMU 38 does not include soil or groundwater.
	Groundwater — Inhalation of volatilized contaminants during domestic use	No	SWMU 38 does not include soil or groundwater.
	Soil — Incidental ingestion	No	SWMU 38 does not include soil or groundwater.
	Soil — Dermal contact	No	SWMU 38 does not include soil or groundwater.
	Sediment — Incidental ingestion	No (Qualified)	Risk estimates for typical site workers' sediment exposure are presented in Table 8.4.15 for comparison only.
	Sediment — Dermal contact	No (Qualified)	Risk estimates for typical site workers' sediment exposure are presented in Table 8.4.15 for comparison only.
	Surface Water — Incidental Ingestion	No	Sediments would act as a sink for contaminants, so sediment exposure was the focus of the HHRA.
	Wild game or domestic animals — Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited at SWMU 38.
	Fruits and vegetables — Ingestion of plant tissues grown in media	No	SWMU 38 does not include soil or groundwater.

Exposure Point Concentrations

When more than 10 surface soil samples are analyzed, 95% UCLs are typically calculated as described in the Technical Memorandum on HHRA. However, SWMU 38 ditches span the Southside of NSA Memphis, and as a result, risk estimates would not represent all locations. Therefore, risk was estimated for each COPC at each sample location.

Subsurface sediment, those collected from deeper than 12 inches, are assessed in the fate and transport discussion (Section 8.4.6).

Quantification of Exposure

Exposure was quantified per the Technical Memorandum on HHRA and modified as discussed in this section. Intake calculations were incorporated into risk estimates and chronic daily intake is not presented separately.

As previously discussed, sediment samples were evaluated using a typical site worker scenario, an adolescent trespasser scenario, and a maintenance worker scenario. Sediments collected for analysis were obtained from drainage ditches assumed to remain dry for approximately 8 months, or 67% of the year. Therefore, the multipliers used to calculate risk and hazard for the typical site worker and the adolescent trespasser, as described in the Technical Memorandum on HHRA, were modified by a factor of 0.67 to account for the time when the sediments are submerged, limiting workers' and trespassers' exposure. The modifying factor of 0.67 was also included in the multiplier for the maintenance worker scenario, and an additional modifying factor of 0.208 was used to account for an exposure rate of 52 days per year rather than 250 days per year.

To make it possible to calculate risk estimates for each COPC at each sample location, risk-based concentrations were calculated that include both incidental ingestion and dermal contact exposure pathways in accordance with USEPA's Supplemental Guidance to RAGS *Bulletin 5, Development*

of Risk-Based Remedial Goal Options (RGOs) for each COPC. RGOs were used to calculate risk by using the ratio of RGO/target risk or hazard to reported concentration/risk or hazard estimate. RGOs are presented in Table 8.4.15, and the equation used to calculate risk and hazard estimates is shown below.

$$\text{Risk or hazard estimate} = \frac{\text{(target risk or hazard) x (reported concentration)}}{\text{RGO}}$$

Table 8.4.15
SWMU 38 Risk-Based RGOs for Sediment
Including the Incidental Ingestion and Dermal Contact Exposure Pathways
NSA Memphis, Assembly E RFI

	Default Site Worker		Maintenance Worker		Adolescent Trespasser	
COPC	HI = 1.0	ILCR = 1E-6	HI = 1.0	ILCR = 1E-6	HI = 1.0	ILCR = 1E-6
Antimony	579.9	NA	2,788	NA	1,049	NA
PCB Aroclor-1260	NA	1.08	NA	5.21	NA	6.07
Arsenic	434.7	2.7	2090	13	786	12.23
BEQs	NA	0.297	NA	1.43	NA	1.664
Cadmium	724.8	NA	3,485	NA	1,311	NA
Copper	57,986	NA	278,778	NA	104,852	NA
Dieldrin	38.7	0.135	186.1	0.651	86.8	0.759
MCPA	387.1	NA	1,861	NA	868	NA
MCPP	774.2	NA	3,722	NA	1,736	NA
Nickel	28,993	NA	139389	NA	52,426	NA

Notes:
NA — Not applicable
HI — Hazard Index
ILCR — Incremental lifetime excess cancer risk

8.4.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in the Technical Memorandum on HHRA. The toxicological profile paragraphs below present toxicological references for COPCs identified at SWMU 38. This information is summarized in Table 8.4.16.

Antimony, which belongs to the same periodic group as arsenic, is absorbed slowly through the gastrointestinal tract, which is the target of this element. Another target is the blood, where antimony concentrates. Due to frequent industrial use, the primary exposure route for antimony to the general population is food. Antimony is also a common air pollutant from industrial emissions. USEPA has not classified antimony as a carcinogen, and the Oral RfD is 0.0004 mg/kg-day (Klaassen et al., 1986). The oral RfD is based on a LOAEL of 0.35 mg/kg-day, an uncertainty factor of 1000, and a modifying factor of 1 (IRIS, 1995).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen et al., 1986). USEPA determined 0.0003 mg/kg-day as the RfD for arsenic based on a No Observed Adverse Effect Level (NOAEL) of 0.0008 mg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 kg-day/mg oral SF for arsenic. As listed in IRIS (search date 9/1/95), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk

Table 8.4.16
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 38
NSA Memphis Assembly E RFI

	Non-Carcinogenic Toxicity Data									Carcinogenic Toxicity Data					
Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Oral Slope Factor (kg-day/mg)		Inhalation Slope Factor (kg-day/mg)		Weight of Evidence	Tumor Type
Antimony	0.0004	a	Low	whole body/blood increased mortality	1000	ND			ND	ND		ND		D	
Arsenic	0.0003	a	Medium	hyperpigmentation	3	ND			ND	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	ND				ND	ND			ND	7.3	a			B2	mutagen
Cadmium (food)	0.001	a	High	proteinuria	10	ND			ND	ND		6.3	a	B1	lung
Cadmium (water)	0.0005	a	High	proteinuria	10	ND			ND	ND		6.3	a	B1	lung
Copper	0.04	b	NA	NA	ND	ND			ND	ND		ND		D	
Dieldrin	5E-05	a	Medium	liver lesions	100	ND			ND	16	a	16.1	a	B2	hepatoma
MCPA	0.0005	a	Medium	liver and kidney toxicity	300	ND			ND	ND		ND		D	
MCPP	0.001	a	Medium	liver and kidney toxicity	3000	ND			ND	ND		ND		D	
PCB Aroclor-1260	ND				ND	ND			ND	2		ND		B2	hepatocellular carcinoma
Nickel	0.02	a	Medium	decreased body and organ weight	300	ND			ND	ND		ND		D	

a = Integrated Risk Information System (IRIS)
b = EPA - NCEA Regional Support provisional value
NA = Not applicable or not available
ND = Not determined due to lack of information

contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (Integrated Research Information System-search date 9/1/95), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

PCB Aroclors are a group of chlorinated hydrocarbons (such as Aroclors-1248, 1254, and 1260) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen et al., 1986; Dreisbach et al., 1987). USEPA classified PCB Aroclors as group B2 carcinogens, primarily based on animal data. As listed in IRIS, the classification is based on hepatocellular carcinomas in three strains of rats and two strains of mice and inadequate, yet suggestive, evidence of excess risk of liver cancer in humans by ingestion and inhalation or dermal contact. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. In October 1996, USEPA changed the oral slope factor to 2.0 kg-day/mg for food ingestion.

Polyaromatic hydrocarbons were assessed in accordance with Supplemental Guidance to RAGS *Bulletin 3, Toxicity Assessment* (USEPA, 1995b) using toxic equivalency factors (TEFs) and include the following COPCs:

Benzo(a)anthracene	TEF=0.1
Benzo(b)fluoranthene	TEF=0.1
Dibenz(a,h)anthracene	TEF=1.0
Benzo(k)fluoranthene	TEF=0.01
Benzo(a)pyrene	TEF=1.0
Indeno(1,2,3-cd)pyrene	TEF=0.1
Chrysene	TEF=0.001

Some PAHs are toxic to the liver, kidney, and blood. However, toxic effects of the PAHs above have not been well-established, aside from their mutagenic properties. RfDs are not available for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene (BAP), having an oral SF of 7.3 kg-day/mg.

TEFs, multipliers determined by USEPA that are applied to the detected concentrations, are used to estimate excess cancer risk for chemicals with similar mutagenic properties. Most PAHs have been classified as carcinogens based on animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC Table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS (search date 6/28/95), BAP is classified B2 based on insufficient human data specifically linking it to a carcinogenic effect. BAP has produced positive results in numerous genotoxicity assays in which various exposure routes were examined. The B2 classification reflects a weight-of-evidence judgment of the likelihood that BAP is a human carcinogen.

As listed in IRIS, the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is based on data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells and transformed mammalian cells in culture. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is also mutagenic in bacteria assays (Klaassen et al., 1986).

Cadmium can upset the stomach, leading to vomiting and diarrhea in acute exposure; acute inhalation of cadmium-containing dust can irritate the lungs. Chronic exposure to cadmium, either via inhalation or ingestion, has been shown to cause kidney damage (including kidney stones), emphysema, and high blood pressure. Other tissues reportedly injured by cadmium exposure in animals and humans include the lungs, testes, liver, immune system, blood, and the nervous system (Klaassen et al., 1986). An oral RfD of 0.001 mg/kg-day has been determined by USEPA, based on human studies (food) involving chronic exposure in which significant increased protein was found in the urine. A separate oral RfD for water has been determined by USEPA to be 0.0005 mg/kg-day. For inhalation exposure, cadmium has been classified by USEPA as a group B1, or probable human carcinogen, based on limited evidence from epidemiological studies in which an excess risk of lung cancer was observed in cadmium smelter workers. As listed in IRIS (search date 6/28/95), the classification is based on limited evidence from occupational epidemiologic studies consistent across investigations and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven rat and mice studies where cadmium salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. There is sufficient evidence of increased risk of lung cancer in rats and mice exposed to cadmium via inhalation. Seven studies in which cadmium was administered orally to rats and mice have shown no evidence of carcinogenic response following exposure via this route. As listed in IRIS, the critical effect of cadmium is proteinuria. The uncertainty factor was 10 and the modifying factor was 1. The uncertainty factor was 10 and the modifying factor was 1.

Copper is a nutritionally essential element, necessary for many of the body's enzymes. In the past, lead pipes and solder were used for residential water pipes, and resulting lead concentrations in drinking water exceeded USEPA guidelines. Copper has been used to replace water pipes in residences due to its lower toxicity to man. Short-term exposure to copper can result in anemia (the lack of iron), the breakdown of red blood cells, and liver and kidney lesions. The target

organs for copper are the liver, kidney, and red blood cell. Vitamin C reduces copper uptake from the gut, and other substances can also influence copper uptake. Copper fumes can cause metal fume fever (Klaassen et al., 1986). As listed in IRIS (search date 6/28/95), the D classification is based on no human data, inadequate animal data from assays of copper compounds, and equivocal mutagenicity data. The USEPA RfD is 0.0371 mg/kg/day, which is 2.6 mg/day for the average adult (70 kg). In typical vitamin supplements, 2 mg/day is the approximate dose (NRC, 1989).

Dieldrin is a polycyclic chlorinated pesticide. Short-term exposure to high doses of dieldrin causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the dieldrin source is removed. Dieldrin is classified as a B2 carcinogen by USEPA; the oral SF, inhalation SF, and oral RfD were set to 16 kg-day/mg, 16.1 kg-day/mg, and 0.00005 mg/kg-day, respectively (Dreisbach et al., 1987).

MCPA, 2-methyl-4-chlorophenoxyacetic acid, is a pesticide with a no effect level of 0.15 mg/kg-day. USEPA's oral RfD is 5E-4 mg/kg-day, and the critical effect listed in IRIS is toxicity to the kidney and liver. The uncertainty and modifying factors are 300 and 1, respectively, and the confidence in the RfD is medium (IRIS, 1996).

MCPP, 2-(2-methyl-14-chlorophenoxy) propionic acid, is a pesticide which has been shown to cause increased kidney weights in rats when they are exposed under the conditions in the critical study. Based on the critical study in IRIS, USEPA determined the oral RfD to be 0.001 mg/kg-day, with an uncertainty factor of 3000. USEPA's confidence in the oral RfD is medium (IRIS, 1996).

Nickel is an essential nutrient; a five microgram dose is typical of supplemental vitamins. USEPA set the oral RfD to 0.02 mg/kg-day (IRIS, 1996). Chronic exposure of rats to nickel caused decreased body and organ weights. For a chronically exposed individual, nickel salts would affect the gastro-intestinal system, and would also target the liver and kidney. This element has been shown to be a sensitizer, an element that can produce allergic reactions. Sensitization of skin to nickel dust has been shown to occur in industry (Dreisbach, et al., 1987).

8.4.4.5 Risk Characterization

As previously discussed, exposure to SWMU 38 sediment was assessed using the maintenance worker, adolescent trespasser, and default site worker land use scenarios. Risk estimates for the default site worker would not be applicable to sediment and were included for a relative comparison only because default site worker assumptions would overestimate exposure to SWMU 38 sediment. Incidental sediment ingestion and dermal contact pathways were evaluated for each land use scenario. Risk was estimated for each COPC reported at each sample location, as shown in Table 8.4.17.

Maintenance Worker

For the maintenance worker scenario, as described in Section 8.4.4.3, the worker was assumed to be exposed to site chemicals 52 days per year while providing lawn care, which would occur in the eight months that sediment is assumed to be exposed.

Site Trespasser

For the adolescent site trespasser scenario, assumptions included an exposure duration of 10 years, a body weight of 45 kg, and an exposure frequency of 52 days per year. The adolescent trespasser exposure multiplier was also adjusted for the fraction of time per year when SWMU 38 sediment is exposed (eight months per year).

Table 8.4.17
Risk Estimates for SWMU 38 Sediment
NSA Memphis Assembly E RFI

Sample ID	Chemical	Reported Concentration (mg/kg)	Risk Estimates: Default Site Worker HI	Default Site Worker ILCR	Maintenance Worker HI	Maintenance Worker ILCR	Adolescent Trespasser HI	Adolescent Trespasser ILCR
38SM000101								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	0.052	NA	3.21E-08	NA	6.69E-09	NA	5.74E-09
	Arsenic	19	0.029283	4.71E-06	0.0060909	9.79E-07	0.0161959	1.04E-06
	BEQ	0.202	NA	4.56E-07	NA	9.48E-08	NA	8.14E-08
	Cadmium	1.8	0.001664	NA	0.0003461	NA	0.0009202	NA
	Copper	13.7	0.000158	NA	3.293E-05	NA	8.754E-05	NA
	Dieldrin	0.45	0.007789	2.23E-06	0.0016201	4.63E-07	0.0034735	3.97E-07
	MCPA	2.1	0.003635	NA	0.000756	NA	0.0016214	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	7.2	0.000166	NA	3.461E-05	NA	9.202E-05	NA
	Sum		0.042695	7.42E-06	0.0088806	1.54E-06	0.0223906	1.53E-06
38SM000201								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	3.2	0.004932	7.93E-07	0.0010258	1.65E-07	0.0027277	1.75E-07
	BEQ	0.155	NA	3.48E-07	NA	7.24E-08	NA	6.23E-08
	Cadmium	1.6	0.001479	NA	0.0003076	NA	0.0008179	NA
	Copper	10	0.000116	NA	2.403E-05	NA	6.39E-05	NA
	Dieldrin	0.028	0.000485	1.39E-07	0.0001008	2.88E-08	0.0002161	2.47E-08
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	4.1	0.003548	NA	0.000738	NA	0.0015828	NA
	Nickel	7.6	0.000176	NA	3.653E-05	NA	9.713E-05	NA
	Sum		0.010735	1.28E-06	0.0022328	2.66E-07	0.0055057	2.62E-07
38SM000301								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	0.034	NA	2.10E-08	NA	4.37E-09	NA	3.75E-09
	Arsenic	3.6	0.005548	8.92E-07	0.0011541	1.86E-07	0.0030687	1.97E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	0.92	0.00085	NA	0.0001769	NA	0.0004703	NA
	Copper	12	0.000139	NA	2.884E-05	NA	7.668E-05	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	8.6	0.007442	NA	0.001548	NA	0.0033201	NA
	Nickel	11.9	0.000275	NA	5.72E-05	NA	0.0001521	NA
	Sum		0.014255	1.05E-06	0.002965	2.19E-07	0.0070879	2.26E-07
38SM000401								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	2.8	0.004315	6.94E-07	0.0008976	1.44E-07	0.0023868	1.53E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	1.3	0.001202	NA	0.0002499	NA	0.0006646	NA
	Copper	14.4	0.000166	NA	3.461E-05	NA	9.202E-05	NA
	Dieldrin	0.0025	4.3E-05	1.24E-08	9.001E-06	2.57E-09	1.93E-05	2.21E-09
	MCPA	0.93	0.00161	NA	0.0003348	NA	0.0007181	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	9.7	0.000224	NA	4.662E-05	NA	0.000124	NA
	Sum		0.007561	8.44E-07	0.0015726	1.76E-07	0.0040047	1.80E-07

Table 8.4.17
Risk Estimates for SWMU 38 Sediment
NSA Memphis Assembly E RFI

Sample ID	Chemical	Reported Concentration (mg/kg)	Risk Estimates: Default Site Worker HI	Default Site Worker ILCR	Maintenance Worker HI	Maintenance Worker ILCR	Adolescent Trespasser HI	Adolescent Trespasser ILCR
38SM000501								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	4.5	0.006935	1.12E-06	0.0014426	2.32E-07	0.0038359	2.47E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	1.2	0.001109	NA	0.0002307	NA	0.0006135	NA
	Copper	15.8	0.000183	NA	3.797E-05	NA	0.000101	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	15.1	0.000349	NA	7.258E-05	NA	0.000193	NA
	Sum		0.008576	1.25E-06	0.0017839	2.61E-07	0.0047433	2.71E-07
38SM000601								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	5.2	0.008014	1.29E-06	0.001667	2.68E-07	0.0044326	2.85E-07
	BEQ	0.853	NA	1.92E-06	NA	4.00E-07	NA	3.43E-07
	Cadmium	1.4	0.001294	NA	0.0002692	NA	0.0007157	NA
	Copper	12.6	0.000146	NA	3.028E-05	NA	8.051E-05	NA
	Dieldrin	0.033	0.000571	1.63E-07	0.0001188	3.40E-08	0.0002547	2.91E-08
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	8.8	0.000203	NA	4.23E-05	NA	0.0001125	NA
	Sum		0.010229	3.37E-06	0.0021276	7.02E-07	0.005596	6.57E-07
38SM000701								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	11.5	0.017724	2.85E-06	0.0036866	5.93E-07	0.0098028	6.30E-07
	BEQ	0.131	NA	2.95E-07	NA	6.14E-08	NA	5.27E-08
	Cadmium	2.8	0.002588	NA	0.0005384	NA	0.0014314	NA
	Copper	18.7	0.000216	NA	4.494E-05	NA	0.0001195	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	4.1	0.007096	NA	0.001476	NA	0.0031656	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	21.9	0.000506	NA	0.0001053	NA	0.0002799	NA
	Sum		0.028131	3.14E-06	0.0058512	6.54E-07	0.0147992	6.83E-07
38SM000801								
	Antimony	15.8	0.018256	NA	0.0037973	NA	0.0100963	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	4.1	0.006319	1.02E-06	0.0013144	2.11E-07	0.0034949	2.25E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	1.2	0.001109	NA	0.0002307	NA	0.0006135	NA
	Copper	18	0.000208	NA	4.326E-05	NA	0.000115	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	2	0.003462	NA	0.00072	NA	0.0015442	NA
	MCPP	5.3	0.004586	NA	0.000954	NA	0.0020461	NA
	Nickel	22.9	0.000529	NA	0.0001101	NA	0.0002927	NA
	Sum		0.034469	1.15E-06	0.0071697	2.40E-07	0.0182027	2.49E-07

Table 8.4.17
Risk Estimates for SWMU 38 Sediment
NSA Memphis Assembly E RFI

			Risk Estimates					
		Reported Concentration	Default Site Worker		Maintenance Worker		Adolescent Trespasser	
Sample ID	Chemical	(mg/kg)	HI	ILCR	HI	ILCR	HI	ILCR
38SM000901								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	17.4	0.026817	4.31E-06	0.005578	8.97E-07	0.0148321	9.53E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	2.7	0.002496	NA	0.0005191	NA	0.0013803	NA
	Copper	15.8	0.000183	NA	3.797E-05	NA	0.000101	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	1.1	0.000952	NA	0.000198	NA	0.0004247	NA
	Nickel	26.2	0.000605	NA	0.0001259	NA	0.0003348	NA
	Sum		0.031053	4.45E-06	0.006459	9.25E-07	0.0170728	9.78E-07
38SM001001								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	4.2	0.006473	1.04E-06	0.0013464	2.16E-07	0.0035802	2.30E-07
	BEQ	0.085	NA	1.91E-07	NA	3.97E-08	NA	3.41E-08
	Cadmium	2.2	0.002034	NA	0.000423	NA	0.0011247	NA
	Copper	12.8	0.000148	NA	3.076E-05	NA	8.179E-05	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	16.1	0.000372	NA	7.739E-05	NA	0.0002058	NA
	Sum		0.009027	1.23E-06	0.0018776	2.56E-07	0.0049924	2.64E-07
38SM001101								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	11.5	0.017724	2.85E-06	0.0036866	5.93E-07	0.0098028	6.30E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	2.1	0.001941	NA	0.0004038	NA	0.0010736	NA
	Copper	18	0.000208	NA	4.326E-05	NA	0.000115	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	1.2	0.002077	NA	0.000432	NA	0.0009265	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	18.8	0.000434	NA	9.037E-05	NA	0.0002403	NA
	Sum		0.022385	2.99E-06	0.004656	6.21E-07	0.0121582	6.55E-07
38SM001201								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	3.5	0.005394	8.67E-07	0.001122	1.80E-07	0.0029835	1.92E-07
	BEQ	0.486	NA	1.09E-06	NA	2.28E-07	NA	1.96E-07
	Cadmium	1.9	0.001756	NA	0.0003653	NA	0.0009713	NA
	Copper	9.4	0.000109	NA	2.259E-05	NA	6.007E-05	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	12.7	0.000293	NA	6.104E-05	NA	0.0001623	NA
	Sum		0.007553	1.96E-06	0.001571	4.08E-07	0.0041771	3.87E-07

Table 8.4.17
Risk Estimates for SWMU 38 Sediment
NSA Memphis Assembly E RFI

Sample ID	Chemical	Reported Concentration (mg/kg)	Risk Estimates: Default Site Worker HI	Default Site Worker ILCR	Maintenance Worker HI	Maintenance Worker ILCR	Adolescent Trespasser HI	Adolescent Trespasser ILCR
38SM001301								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	12	0.018495	2.97E-06	0.0038469	6.18E-07	0.010229	6.57E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	4.6	0.004252	NA	0.0008844	NA	0.0023516	NA
	Copper	2250	0.025998	NA	0.0054075	NA	0.0143775	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	2240	0.051764	NA	0.010767	NA	0.0286271	NA
	Sum		0.100509	3.11E-06	0.0209058	6.47E-07	0.0555852	6.82E-07
38SM001401								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	9.9	0.015258	2.45E-06	0.0031737	5.10E-07	0.0084389	5.42E-07
	BEQ	0.110	NA	2.49E-07	NA	5.17E-08	NA	4.44E-08
	Cadmium	2.6	0.002403	NA	0.0004999	NA	0.0013292	NA
	Copper	15.1	0.000174	NA	3.629E-05	NA	9.649E-05	NA
	Dieldrin	0.0055	9.5E-05	2.72E-08	1.98E-05	5.66E-09	4.245E-05	4.86E-09
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	13.5	0.000312	NA	6.489E-05	NA	0.0001725	NA
	Sum		0.018243	2.73E-06	0.0037946	5.68E-07	0.0100796	5.92E-07
38SM001501								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	ND	NA	NA	NA	NA	NA	NA
	Arsenic	5.5	0.008477	1.36E-06	0.0017632	2.83E-07	0.0046883	3.01E-07
	BEQ	0.149	NA	3.36E-07	NA	6.99E-08	NA	6.01E-08
	Cadmium	2.8	0.002588	NA	0.0005384	NA	0.0014314	NA
	Copper	14.7	0.00017	NA	3.533E-05	NA	9.393E-05	NA
	Dieldrin	0.02	0.000346	9.90E-08	7.2E-05	2.06E-08	0.0001544	1.77E-08
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	13.1	0.000303	NA	6.297E-05	NA	0.0001674	NA
	Sum		0.011884	1.80E-06	0.0024718	3.74E-07	0.0065354	3.79E-07
38SM001601								
	Antimony	ND	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	0.29	NA	1.79E-07	NA	3.73E-08	NA	3.20E-08
	Arsenic	13.1	0.02019	3.25E-06	0.0041995	6.75E-07	0.0111667	7.18E-07
	BEQ	0.061	NA	1.38E-07	NA	2.87E-08	NA	2.47E-08
	Cadmium	5.3	0.004899	NA	0.001019	NA	0.0027094	NA
	Copper	27.1	0.000313	NA	6.513E-05	NA	0.0001732	NA
	Dieldrin	ND	NA	NA	NA	NA	NA	NA
	MCPA	ND	NA	NA	NA	NA	NA	NA
	MCPP	ND	NA	NA	NA	NA	NA	NA
	Nickel	17.5	0.000404	NA	8.412E-05	NA	0.0002236	NA
	Sum		0.025807	3.56E-06	0.0053678	7.41E-07	0.0142729	7.74E-07

Table 8.4.17
Risk Estimates for SWMU 38 Sediment
NSA Memphis Assembly E RFI

Sample ID	Chemical	Reported Concentration (mg/kg)	Risk Estimates: Default Site Worker HI	Default Site Worker ILCR	Maintenance Worker HI	Maintenance Worker ILCR	Adolescent Trespasser HI	Adolescent Trespasser ILCR
38SM002501								
	Antimony	NS	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	1.9	NA	1.17E-06	NA	2.44E-07	NA	2.10E-07
	Arsenic	NS	NA	NA	NA	NA	NA	NA
	BEQ	NS	NA	NA	NA	NA	NA	NA
	Cadmium	NS	NA	NA	NA	NA	NA	NA
	Copper	NS	NA	NA	NA	NA	NA	NA
	Dieldrin	NS	NA	NA	NA	NA	NA	NA
	MCPA	NS	NA	NA	NA	NA	NA	NA
	MCPP	NS	NA	NA	NA	NA	NA	NA
	Nickel	NS	NA	NA	NA	NA	NA	NA
	Sum		NA	1.17E-06	NA	2.44E-07	NA	2.10E-07
38SM002601								
	Antimony	NS	NA	NA	NA	NA	NA	NA
	PCB Aroclor-1260	0.27	NA	1.67E-07	NA	3.47E-08	NA	2.98E-08
	Arsenic	NS	NA	NA	NA	NA	NA	NA
	BEQ	NS	NA	NA	NA	NA	NA	NA
	Cadmium	NS	NA	NA	NA	NA	NA	NA
	Copper	NS	NA	NA	NA	NA	NA	NA
	Dieldrin	NS	NA	NA	NA	NA	NA	NA
	MCPA	NS	NA	NA	NA	NA	NA	NA
	MCPP	NS	NA	NA	NA	NA	NA	NA
	Nickel	NS	NA	NA	NA	NA	NA	NA
	Sum		NA	1.67E-07	NA	3.47E-08	NA	2.98E-08

Notes:

ND = Not detected
NS = Not sampled/not analyzed
NA = Not applicable
HI = Hazard index
ILCR = Incremental lifetime excess cancer risk
BEQ = Benzo(a)pyrene equivalent concentration
MCPA = 2-Methyl-4-chlorophenoxyacetic acid
MCPP = 2-(2-Methyl-14-chlorophenoxy)propionic acid

COCs Identified

As described in the Technical Memorandum on HHRA, COCs were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In Assembly E HHRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative HI above 1.0, if its individual ILCR exceeds 1E-6 or its HQ exceeds 0.1.

As shown in Table 8.4.17, no COCs were identified in SWMU 38 sediment.

8.4.4.6 Risk Uncertainty

Several parameters contribute to risk assessment uncertainty including:

- Unknown future exposure settings and exposure pathways
- Toxicological uncertainty in the determination of SFs and RfDs
- EPC estimation
- Human exposure quantification
- Elimination of some CPSSs

Fate and transport uncertainties are addressed in Section 8.4.6.

Data Quality

Most analytical data for environmental samples have inherent variability. This is a function of the matrix characteristics and heterogeneity, and the precision and accuracy of sampling, preparation, and analysis methods employed. Although data are typically considered to be exact values, they are in reality the laboratory's best estimate within a range defined by method control limits. As a result, reported concentrations for any chemical can underestimate or overestimate actual concentrations. The *Data Validation Report — Assembly E* (E/A&H, 1997a) presents and evaluates the Assembly E analytical data.

Exposure Setting and Exposure Pathways

Sediment was treated as surface soil in RBC comparisons. Such comparisons could overestimate or underestimate potential risk and hazard values. However, separate assumptions were determined to provide reasonable maximum exposure scenarios. Sediment was assumed to be exposed eight months of the year. Scenarios included a typical site worker, maintenance worker, and a site trespasser scenario. Any of these scenarios could overestimate or underestimate exposure, depending on the duration sediments are submerged, as well as the duration and frequency of human exposure.

Identification of COPCs

Comparison to Reference Concentrations (Background)

Because the intent of the HHRA is to estimate the excess cancer risk or health hazard posed by COPCs, site data were compared to RCs in the RFI for NSA Memphis subsequent to comparison to risk-based screening values. Additional uncertainty is introduced by a comparison of site data to nonspecific screening reference data. Although the RCs are specific to NSA Memphis, they are not SWMU-specific. The limited number of background samples and sample locations at NSA Memphis increases the uncertainty because a larger data set more adequately accounts for natural variability in media composition. Comparison of soil RCs to sediment which are assessed as soils increases the uncertainty because conditions at background locations are dissimilar to those at SWMU 38.

Dieldrin

The *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d) stated that dieldrin was detected at NSA Memphis at relatively insignificant concentrations. Dieldrin was used extensively in the 1950s and 1960s, and was applied aerially as a pesticide at NSA Memphis during that time period. Dieldrin was also used in the pest control trade with chlordane for general subterranean termite control. As stated in the

memorandum, "this finding indicates that dieldrin levels found at each SWMU do not necessitate remedial action in the absence of other significant carcinogenic risk contributors." The average background dieldrin concentration reported in the memorandum is 0.131 mg/kg; two-times the mean is 0.262 mg/kg. Therefore, the background risk posed by dieldrin should be considered when making risk-management decisions.

Toxicological Uncertainty

The uncertainty of toxicological values from the IRIS and HEAST databases (provided by USEPA) are summarized in Table 8.4.16. The uncertainty factors assigned to these values account for acute to chronic dose extrapolation, study inadequacies, and sensitive subpopulations, among other factors. Although uncertainty factors for a specific compound may be 1,000 or higher, these safety factors are applied by USEPA to conservatively bias the overall assessment of risk/hazard toward human health concerns. In the presence of such uncertainty, USEPA and the risk assessor are obligated to make conservative assumptions so the chance is very small for the actual health risk to be greater than what is determined through the risk assessment process. On the other hand, the process is not to yield overly conservative risk values that have no basis in actual conditions. This balance was kept in mind in developing exposure assumptions and pathways and in interpreting data and guidance for this HHRA.

USEPA determined BEQs to have a B2 cancer rating, which indicates they cause cancer in animals but have not been demonstrated to cause cancer in humans. BEQs are known mutagens. However, there is some uncertainty in assuming BEQs would cause the proliferation of cells caused in laboratory test organisms. BEQs are composed of seven carcinogenic PAHs: benzo(a)pyrene, benzo(a)anthracene, dibenz(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(123-cd)pyrene, and chrysene. Concentrations reported for benzo(a)anthracene, dibenz(a,h)anthracene, indeno(123-cd)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene did not exceed corresponding soil screening values. Because

the mechanism of action is similar for the seven carcinogenic PAHs, all seven carcinogenic PAHs were used to calculate BEQs.

Arsenic was assessed as a carcinogen, and arsenic ILCR was a primary contributor to risk estimates for sediment exposure pathways. USEPA evaluated the cancer potency of arsenic based on certain studies from the literature. Limitations in these studies and the methods used by USEPA would result in overestimates of arsenic risk. For example, arsenic's MCL is 50 mg/L (USEPA, 1996c). Yet, exposure to drinking water with 50 mg/L arsenic would equate with unacceptable risk. The technology-based method used to calculate the MCL for arsenic is not the same as risk-based methods used to assess risk.

USEPA derived the oral SF from a Taiwanese study of human exposures to groundwater containing arsenic (Tseng et al., 1968). The assumptions used by USEPA to derive the SF may have underestimated dietary exposure to arsenic (Yost et al., 1994). More recent water intake values were available for the Taiwanese population. These values are higher than the historical data used by USEPA. Using higher water intake values would reduce the expected cancer potency. In addition, toxic effects of arsenic could have been exacerbated because the study population was reportedly undernourished and many had chronic liver disease (Hsueh et al., 1995).

The calculation method USEPA used to determine the SF may also have overestimated the cancer-causing potential of arsenic. A linear dose response curve was assumed by USEPA, and the dose-response curve for arsenic may be sublinear (Loehr et al., 1989). In 1989, the USEPA Science Advisory Board concluded that, "...at dose levels below 200-250 micrograms arsenic per day there is a possible detoxification mechanism that may substantially reduce cancer risk from the levels USEPA has calculated using a linear-quadratic model fit to the Tseng data."

The Tseng study was based on water ingestion, and many studies indicate arsenic is more bioavailable from water than soil. Ingesting arsenic in soil may not elicit toxic responses, while the same amount of arsenic ingested from groundwater may be toxic (ATSDR, 1992). Relative bioavailabilities of arsenic in soil to arsenic in groundwater range from 20% to 78% (Freeman et al., 1993, 1994).

USEPA determined that risk-based concentrations for arsenic should be multiplied by 10 to account for the uncertainty in arsenic's carcinogenicity (USEPA, 1988). For example, a risk-based concentration of 0.001 mg/L would be changed to 0.01 mg/L. In addition, the mean relative bioavailability of 78% is recommended by USEPA to address arsenic in soil. In summary, a risk-based concentration of 1 mg/kg would be modified (e.g., 1/0.78 = 1.282 mg/kg) to approximately 1.28 mg/kg. The 1.28 mg/kg concentration in soil would also be adjusted to account for the uncertainty in arsenic's SF, resulting in an adjusted value of 12.8 mg/kg. The relative bioavailability factor would not be applicable to groundwater concentrations, so a risk-based groundwater concentration of 0.001 mg/L would be modified to 0.01 mg/L. Therefore, risk and hazard estimates are potentially overestimates.

Determination of Exposure Point Concentrations

EPCs are used to estimate intake. The uncertainty associated with EPCs primarily stems from their statistical determination (UCLs) or imposition of maximum concentrations. Use of the maximum reported concentration is highly conservative, can grossly overestimate exposure, and is not generally recommended by RAGS. The potential for variability between different sample locations would be very high because the samples are widely distributed across the Southside of NSA Memphis. SWMU 38 sediment risk estimates were calculated for each COPC at each sample location to limit this potential source of variability in the risk estimates.

Frequency of Detection and Spatial Distribution

Risk estimates shown in Table 8.4.17 were calculated only for chemicals detected, which accounts for the frequency of detection. Spatial distribution is also a component of Table 8.4.17 because cumulative risk estimates are sorted by sample location.

Quantification of Risk/Hazard

As indicated by the discussions above, uncertainty is inherent during the risk assessment process. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of variability and uncertainty are discussed below.

Site worker, maintenance worker, and site trespasser scenarios were determined for SWMU 38 sediment exposure. In these scenarios, sediment was only assumed to be exposed for eight months of the year. The maintenance worker and site trespasser scenarios both were assessed assuming a 52-day exposure frequency, reducing the typical 250-day exposure frequency. However, exposure could be overestimated or underestimated, depending on the duration sediments are actually submerged.

8.4.4.7 Risk Summary

Exposure to SWMU 38 sediment was assessed using maintenance worker, adolescent trespasser, and default site worker land use scenarios. Risk estimates for the default site worker would not be applicable to sediment and were included for a relative comparison only. Incidental sediment ingestion and dermal contact pathways were evaluated for each land use scenario. Risk was estimated for each COPC reported at each sample location. No COCs were identified for SWMU 38 sediment exposure pathways for any of the three land use scenarios assessed.

8.4.5 Ecological Risk Assessment

8.4.5.1 Introduction

This ERA focuses specifically on the aquatic and riparian ecosystem associated with SWMU 38, the Southside Industrial Drainage Ditches. This assessment considers sediment contaminant concentrations and distributions, physicochemical conditions, and exposure pathways which could result in unacceptable levels of exposure to ecological receptors now or in the future. The approach to this assessment is based on *Risk Assessment Guidance for Superfund Volume II — Environmental Evaluation Manual* (USEPA, 1989a) and *Framework for Ecological Risk Assessment* (USEPA, 1992a).

8.4.5.2 Problem Formulation

Site Description

The majority of NSA Memphis Southside has been heavily developed, displacing most of the natural habitats capable of supporting significant species diversity and/or richness. In addition to the overall absence of natural habitats, the high levels of human activity (foot and vehicular traffic, etc.) also reduce the attractiveness and accessibility of most of NSA Memphis as suitable habitat for plant or animal species.

The portions of the SWMU 38 drainage ditches addressed in this report are within the southwest quadrant of NSA Memphis. The southside ditch system receives water from surface runoff and storm sewers, and reportedly has previously received floor drain discharges from various industrial buildings. The system consists of three main branches: flowing north-to-south are two parallel ditches approximately 3,800 feet apart and 3,000 feet in length draining the western and eastern portions of its service areas. The southern end of the eastern ditch curves due west and forms the third branch, the larger southern ditch flowing east-to-west. After meandering approximately 4,800 feet west, this ditch intersects the southern end of the western ditch and ultimately discharges into Big Creek Drainage Canal (see Figure 8.4.1). Several smaller,

secondary ditches are present along the southern and eastern branch to facilitate drainage of outlying areas. Habitat and biota surveys were conducted concurrently with site sediment sampling to evaluate the presence and exposure potential of ecological receptors associated with the SWMU 38 ditches.

Based on the observed topography of the ditches, flow in the eastern and western ditches is expected only in direct response to precipitation runoff and the topography is such that shallow pools form periodically in portions of the ditches. This lack of a constant water source prohibits a sustainable aquatic ecosystem to develop. Except in a few areas, the SWMU 38 ditches have either a cement or hard clay-sediment bottom which do not provide the cover and/or food requirements for aquatic organisms.

Eastern Ditch — The eastern ditch is a deep-cut, cement-lined ditch along the west side of a four-lane road, Seventh Avenue. This eastern branch of SWMU 38 is in a completely developed portion of NSA Memphis, surrounded by buildings, roads, parking lots, and maintained grassy fields and medians. Numerous large culverts are also present along its run south from G Street to its confluence with the southern ditch, including a massive culvert beneath Seventh Avenue. From north to south, this branch is represented by sediment samples 038S0007, 038S0006, and 038S0008.

Southern Ditch — The habitat along the entire southern branch is the most diverse. At its origins west of Seventh Avenue, the ditch is narrow, cement-lined and devoid of marginal vegetation (other than grass), but as it enters into the undisturbed wooded area between Fifth and Third avenues, the ditch appears to have a natural bottom and a less maintained shoreline overgrown with herbaceous vegetation. As the ditch continues west through the culvert beneath Third Avenue, it goes beyond NSA Memphis fenceline and into a densely wooded area. The ditch widens, becoming more stream-like and less channelized. The fence and steep banks, which reach

heights of over 30 feet, limit human access, thus prohibiting the level of maintenance observed in the other portions of the ditches. These undisturbed riparian areas are dominated by mature trees and thick undergrowth. As it flows west, the channel is joined by the western branch of SWMU 38 and widens further and the shallow water reveals a hard-clay bottom. As the total amount of water carried by this ditch increases, the high-water marks along the shore rise significantly, indicated that during heavy storm events, the water in the ditch rises nearly 10 feet. This periodic flooding keeps the bottom clean of debris and loose sediments. From east to west, the sediment samples representing the southern branch of SWMU 38 are 038S0008, 038S0009, 038S0014, 038S0005, 038S0012, 038S0011 and 038S0010.

Four smaller tributaries to the southern ditch are also present. These range in length from 300 to 1,000 feet and drain some interior areas not connected to the stormsewer system. Nearly identical to one another, the ecological characteristics associated with these secondary ditches are much like the eastern ditch, having a cement lining and grassy banks. From east to west, these are represented by sediment samples 038S00015, 038S00013, 038S0004, and 038S0016.

Western Branch — The western branch is similar to the eastern branch since it too is a narrow, predominantly dry drainageway. During rain events, it flows from Navy Road south along the NSA Memphis boundary to its confluence with the southern branch. A narrow fringe of herbaceous and scrub vegetation exists along the central and lower portions, but these are adjacent to the distributional warehouses and various industrial facilities, a off-site recreational park, and off-base housing. With these surroundings and the quality of habitat observed, this ditch doesn't offer adequate cover and foraging habitat for receptors to be present. From north to south, the western branch is represented by sediment samples 038S0001, 038S0002, and 038S0003.

Potential Receptors

The southern portions of SWMU 38 are the only areas which may be regularly accessible to terrestrial species such as raccoons or opossums for drinking water. Resident birds also have access to the remote and vegetated drainage ditches for cover and drinking water. Although no aquatic or benthic species were observed during the initial habitat and biota surveys, a subsequent visit during a warmer season did reveal that after a period of frequent rainfall, the southern portion of SWMU 38 between Third and Fifth avenues did support small, isolated communities of aquatic biota (small fish). These more natural and remote ditches would be expected to support larger communities of aquatic wildlife, but this potential is greatly reduced by occasional devegetation and flow maintenance by NSA Memphis grounds keeping personnel and/or the scouring from flash flooding which occurs during heavy rainfall.

8.4.5.3 Risk Characterization

VOCs, SVOCs, metals, pesticides, and herbicides were detected in the drainage-ditch sediment. Although some contaminant concentrations in the ditches exceed SSV values, the lack of suitable habitat for sediment- or surface water-dwelling organisms limits the exposure potential. The habitat and biota survey revealed that the ditches do not have sufficient annual water flow or forage/cover features to support significant communities of aquatic biota.

In addition, the drainage ditch system provides minimal life requisites for terrestrial vertebrate species. Although access is possible, no evidence of mammalian species in the area of the drainage ditches was noted during the habitat and biota survey. A lack of suitable habitat, significant human activity, and lack of vegetation in the general area of NSA Memphis may account for this.

Furthermore, sediment contamination appears to be limited to the onsite reaches of the drainage ditches and is not a likely source to downstream receptors. At sample location 38SM0010, the

most downstream of the SWMU 38 samples, the overall level of contamination was the lowest, with no SVOCs detected; only cadmium and nickel exceeded their SSVs. Pesticides were also detected at sample location 38SM0010, but at concentrations lower than the upstream samples. These data indicate that contaminants are confined to the upper reaches of SWMU 38, have a low migration potential, and most likely will not impact downgradient receptors.

A small portion of the ditches onsite did appear to support seasonal populations of aquatic biota (small fish/insects). However, this intermittent habitat is relatively small and the ambient conditions defined during this assessment would likely allow it to reoccur each year, therefore the low concentrations of constituents detected in the associated sediment samples are not expected to pose a significant ecological risk.

8.4.5.4 ERA Summary

It is recommended that no further ecological study be conducted on the SWMU 38 drainage ditches. Quality habitat is limited to a small portion of the site and contaminant concentrations do not appear to represent a single source. Runoff characteristics across the area most likely will remain the same.

8.4.6 Fate and Transport Assessment

The migration pathway for constituents detected at SWMU 38 is predominantly soil to sediment, with transport within the ditches occurring during high water events. No contaminant detected at SWMU 38 exceeded its SSL for soil-to-air transport; therefore, this pathway is not discussed. Also, since all samples collected from SWMU 38 Southside drainage ditches were sediment samples, the groundwater-to-surface water pathway is not relevant. The soil-to-groundwater migration pathway is mitigated by the fact that contaminants in drainage ditch surface soil are migrating with the flow of water during drainage, limiting the potential for leaching through the soil column to groundwater.

8.4.6.1 Soil-to-Sediment Cross-Media Transport

Thirty-two sediment samples collected from two intervals (0 to 6 inches and 18 to 24 inches bls) at 16 SWMU 38 locations were analyzed and the results compared to SSVs. SSVs were exceeded by seven SVOCs [benzo(a)anthracene, benzo(a)pyrene, BEHP, chrysene, fluoranthene, phenanthrene, pyrene]; one PCB (Aroclor-1260); five pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, and endrin); and six inorganics (antimony, arsenic, cadmium, copper, lead, and nickel). Most of these contaminants have a strong tendency to sorb to soil particles and are relatively immobile in the environment. Transport is more likely to occur in their solid rather than their dissolved phase. Also, these contaminants are generally persistent in the environment and do not degrade readily.

Surface water runoff and numerous Southside outfalls discharge into SWMU 38 drainage ditches. The original design of many buildings at NSA Memphis (circa 1943) included floor drains which discharged to storm sewers, storm sewer drains, and drainage ditches. As buildings were remodeled and replaced, these drains were eliminated or re-routed to the sanitary sewer. Until 1980, when most of these drains were replaced, it is reported that various substances, including solvents, degreasers, oils, and paints, may have been discharged to the drainage ditches. Most wastes discharged into the drainage ditches prior to 1980 would have been transported downstream during high flow events. Therefore, it may not be possible to locate where contamination in the drainage ditches evolved from. Due to the relative immobility of the contaminants, most residual contamination is most likely concentrated nearest the outfalls.

SWMU 38 transects the Southside of NSA Memphis. The drainage pathways are generally adjacent to streets; therefore, the potential exists for contact with surface water and sediment by the general population. South of NSA Memphis, the potential also exists for similar contact due to unrestricted access to Big Creek Drainage Canal, into which the drainage ditches ultimately discharge. Other potential receptors include two production wells PW-4 and PW-5

(see Figure 8.4.1). However, it is unlikely that these wells will be impacted by SWMU 38 contaminants since they are both screened at depths greater than 1,400 feet and topographically upgradient of the majority of the SWMU 38 Southside drainage ditches.

8.4.7 Conclusions and Recommendations

Based on information gathered during this RFI, the following conclusions are presented:

- VOCs, SVOCs, TPH, pesticides/PCBs, herbicides, and metals have been identified in the sediment samples collected from drainage ditches that comprise SWMU 38. Due to the nature and configuration of the drainage ditches and their proximity to several SWMUs, there are multiple "contaminant sources that cannot readily be identified." Analytical data indicate organic compounds were more frequently detected in the surface sediment interval, with a decreasing detection frequency and contaminant concentration gradient with depth. The pesticides DDD, DDE, DDT, and dieldrin were frequently detected in surface sediment samples; these compounds are most likely present in site sediments due to pesticide applications throughout NSA Memphis and are transported to the drainage ditch system in site runoff during rainfall events.

- The HHRA evaluated the risk and hazard posed by sediment contaminants by using three hypothetical reasonable maximum exposure scenarios: the maintenance worker, the site worker, and the child (adolescent) trespasser. Because each sample represented a certain portion of the widely separated drainage ditch system, each sample was assessed independently in the HHRA. Incidental ingestion and dermal contact exposure pathways were used to address potential future sediment exposure. COCs were identified for various exposure scenarios to determine whether they exceeded an excess cancer risk of 1E-4 or a hazard index of 1. The HHRA concluded these thresholds were not exceeded

for any exposure scenario. Based on the HHRA, the property consisting of the Southside Industrial Drainage Ditches is suitable for reuse in either industrial or residential scenarios.

- The ERA recommended that no further ecological study be conducted on the SWMU 38 drainage ditches. Quality habitat is limited to a small portion of the site and contaminant concentrations do not appear to represent a single source. Runoff characteristics across the area most likely will remain the same.

- The fate and transport discussion determined the migration pathway for SWMU 38 constituents is predominantly soil-to-sediment, and transport during high water events within the drainage ditches. The soil-to-groundwater migration pathway is mitigated by the fact that contaminants in surface sediment in the drainage ditches are migrating with the flow of water during drainage, limiting the potential for leaching through the soil column to groundwater. Due to the relative immobility of the contaminants, most residual contamination is most likely concentrated nearest the outfalls and areas where water flow is slow. The drainage pathways are mainly adjacent to streets; therefore, the potential exists for contact with surface water and sediment by the general population. Away from NSA Memphis, the potential also exists for similar contact due to unrestricted access to Big Creek Drainage Canal, into which the drainage ditches ultimately discharge. Other potential receptors include two production wells PW-4 and PW-5. However, it is unlikely that these wells will be impacted by SWMU 38 contaminants since they are both screened at depths greater than 1,400 feet.

Based on information gathered during this RFI, the following recommendations are presented:

- No further action is recommended for SWMU 38.

8.5 SWMU 59 – Pesticide Storage Facility

SWMU 59 consists of Building S-335, the Pesticide Storage Facility (commonly referred to as the Old Pesticide Shop) and the grassy area immediately adjacent to the building. Building S-335 is a wood-framed, sheet-metal exterior structure. A small grassy area adjacent to the north, east, and south sides of the building separates it from First Avenue on the east. An asphalt parking lot is north, west, and south of Building S-335 and its adjacent grassy area. Figure 1.5 shows SWMU 59 and its surrounding features.

The SWMU 59 area slopes gently to the east, with runoff flowing toward a storm drain northeast of the building in the grassy area. This storm drain conveys the water southeast under First Street to an outfall in the SWMU 38 secondary drainage ditch along the east side of First Street. SWMU 38 then conveys runoff approximately 1,800 feet south to Big Creek Drainage Canal. Any storm runoff which does not enter the storm drain northeast of the building would move across the parking lot as sheet flow to First Street, where it would travel south to Big Creek Drainage Canal.

8.5.1 Previous Investigation Results

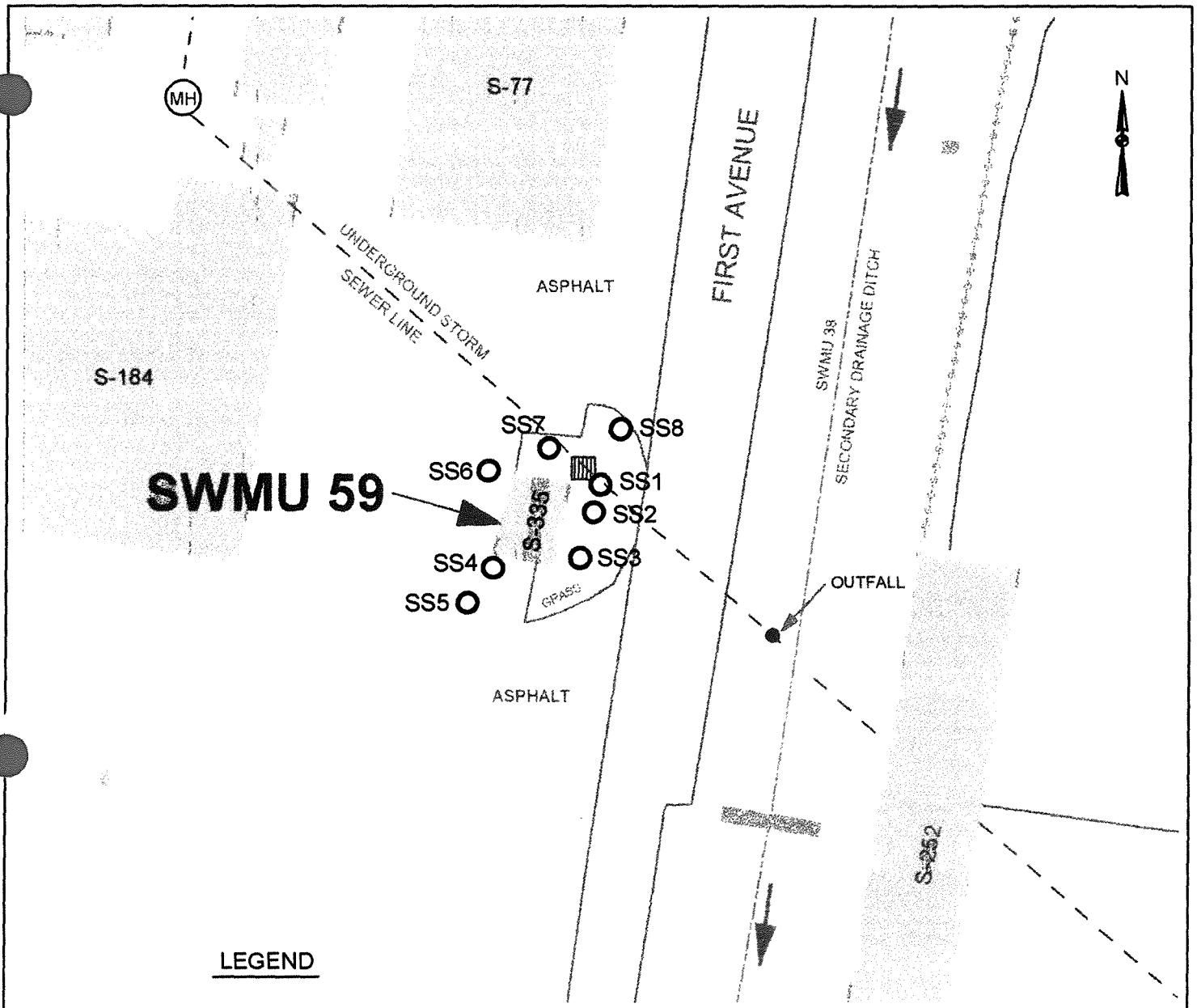
According to the *RCRA Facility Assessment* (RFA) (ERC/EDGe, 1990b), the exact age of Building S-335 is unknown. It is estimated to be approximately 40 years old. The building was used to store pesticides and fertilizers used throughout NSA Memphis. Pesticides reported to have been stored at the building included chlordane, dieldrin, and DDT, and arsenic, a common component of early pesticide formulations. SWMU 59 was flooded in 1974 and again in 1987; water marks from flooding are present on the walls inside the building approximately 2.5 feet above the floor.

According to the *Visual Site Inspection Report* (ERC/EDGe, 1990a), a water line leak was observed during a 1990 site visit by the Navy, with clear water trickling from beneath the building and saturating the ground on the building's east side. A pesticide odor near the building's window was also noted.

According to the *Draft Final RCRA Facility Investigation Work Plan for Naval Air Station Memphis* (SOUTHDIV, 1990), an inspection of Building S-335 in 1990 indicated the building had not been cleaned up following the flood damage, and the doors were locked. The report also stated that the building was scheduled for demolition in 1990.

In 1990 an RFI was conducted at SWMU 59 because the Navy planned to demolish Building S-335 and needed to generate data for project planning issues, including worker health and safety and demolition waste disposal. The RFI consisted of collecting 16 shallow soil samples from eight boring locations (SS1 to SS8) surrounding Building S-335 and 30 wipe samples from the building's interior surfaces. Figure 8.5.1 shows the soil sample locations. Soil samples were collected with a stainless-steel hand auger from 0 to 1 foot bls (upper interval) and 1 to 2 feet bls (lower interval) at all eight boring locations. The soil samples and wipe samples were analyzed for chlordane, DDT and related isomers, dieldrin, and arsenic. The results of the RFI were compiled in the *RCRA Facility Investigation Report, NAS Memphis Site No. 59 (Building No. S-335, Former Pesticide Storage Facility), NAS Memphis* (ERC/EnSafe, 1990). According to the report, chlorinated pesticides and arsenic were identified in shallow (0 to 2 feet bls) soil surrounding the building and on surfaces inside the building.

The analytical results from the 1990 SWMU 59 RFI soil samples were compared to values listed in the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). Surface soil sample results were compared to residential and industrial RBC soil ingestion concentrations and soil-to-groundwater SSL concentrations. Soil sample results from the subsurface interval were compared to the SSLs only, because RBCs do not apply to subsurface soil. Detected inorganics were also compared to their established RCs to determine if the element occurs naturally or may be the result of SWMU 59 operations. The calculations for the RCs are provided in the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a). As shown in Table 8.5.1, the following constituents exceeded one or more applicable values: chlordane, dieldrin, and arsenic. The exceedances are discussed in the following paragraphs.



LEGEND

SS2 — 1990 RFI SOIL SAMPLE LOCATION AND DESIGNATION

UNDERGROUND STORM SEWER LINE

STORM DRAIN

MH — MANHOLE

SWMU 38 SECONDARY DRAINAGE DITCH, WITH ARROW INDICATING SURFACE WATER FLOW DIRECTION

50 0 50 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.5.1
1990 RFI SOIL SAMPLE LOCATIONS
SWMU 59 - S-335 OLD PESTICIDE SHOP

TE: 1990 RFI SOIL SAMPLES WERE COLLECTED WITH A STAINLESS-EEL HAND AUGER FROM 0 TO 1 FOOT AND 1 TO 2 FEET BELOW LAND SURFACE.

Table 8.5.1
Analytical Summary of 1990 RFI Soil Samples

Sample Location and Interval (feet bls)[a]	Arsenic (mg/kg)	DDT (µg/kg)	DDD (µg/kg)	DDE (µg/kg)	Dieldrin (µg/kg)	Chlordane (µg/kg)
SS1 (0-1')	**33**	ND[b]	ND	25	35.8	**2,602**
SS1 (1-2')	17.5	10	ND	4	4.7	267
SS2 (0-1')	8.5	ND	ND	41	**41.6**	**2,391**
SS2 (1-2')	6	9	312	2	42.8	202
SS3 (0-1')	14.5	ND	ND	230	**260**	**279,719**
SS3 (1-2')	7.25	ND	ND	ND	4.9	9,949
SS4 (0-1')	9	ND	ND	ND	ND	**22,180**
SS4 (1-2')	7	ND	ND	ND	ND	5,014
SS5 (0-1')	10.5	ND	ND	ND	23.7	**5,793**
SS5 (1-2')	13	ND	ND	ND	18	407
SS6 (0-1')	8.5	ND	ND	ND	ND	1,231
SS6 (1-2')	10.5	ND	ND	ND	ND	398
SS7 (0-1')	8.25	ND	ND	ND	20.1	**5,667**
SS7 (1-2')	6.5	ND	ND	ND	ND	1,323
SS8 (0-1')	7	ND	ND	13	26.2	801
SS8 (1-2')	7	ND	ND	5	7.8	20
RBCs, SSLs, and Background RCs						
RBC[c] - Residential	0.43	1,900	2,700	1,900	40	1,825
RBC[c] - Industrial	3.8	17,000	24,000	17,000	360	16,352
SSL[c]	15	1,000	700	500	1	2,000
RC[d] (0-1') / RC (> 1')	14.58/20.32	NA[e]	NA	NA	NA	NA

Notes:
a — feet bls = feet below land surface
b — ND denotes the analyte was not detected below the practical quantitation limit in this sample.
c — RBCs and SSLs were obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a) and the 1998 update.
d — RC = reference concentration (2 x the mean background concentration). RCs were established for inorganics in surface (0 to 1 foot bls) and subsurface (> 1 foot bls) soil throughout NSA Memphis; refer to the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for reference concentration calculations.
e — NA denotes a background RC is not available for this organic compound.

Concentrations in surface soil that exceeded their residential soil RBC (and background RC, where applicable) are shown in **bold print**.

Chlordane's residential soil RBC (1,825 µg/kg) was exceeded in upper interval samples from locations SS1, SS2, SS3, SS4, SS5, and SS7, while the industrial soil RBC (16,352 µg/kg) was exceeded in the upper interval samples from locations SS3 and SS4. The soil-to-groundwater SSL for chlordane (2,000 µg/kg) was exceeded by upper interval samples from locations SS1, SS2,

SS3, SS4, SS5, and SS7. Lower interval soil samples from locations SS3 and SS4 also exceeded the soil-to-groundwater SSL.

Dieldrin's residential RBC (40 μg/kg) was exceeded in the upper interval soil samples from locations SS2 and SS3, while the industrial RBC for dieldrin (360 μg/kg) was not exceeded by any upper interval soil sample. The soil-to-groundwater SSL for dieldrin (1 μg/kg) was exceeded by six upper interval samples and five lower interval sample.

Arsenic's surface soil RC (14.58 mg/kg) and industrial soil RBC (3.8 mg/kg for arsenic as a carcinogen) were both exceeded by the upper interval soil sample from location SS1. The arsenic concentration at this location also exceeded its RC and SSL (15 mg/kg). No other detected concentration of arsenic exceeded both its RC and soil RBC, or RC and SSL.

The wipe samples collected during the 1990 RFI identified the following contaminants on surfaces inside the building: 4,4'-DDE, 4,4'-DDT, chlordane, dieldrin, and arsenic. Results of the wipe samples were provided in the *Assembly E Site Investigation Plans* (E/A&H, 1995a).

On June 8, 1995, E/A&H representatives inspected the site. The building had not been demolished, had not been cleaned, and was still locked. A chlorinated pesticide odor was evident near the window and door.

According to Navy personnel, employees associated with the SWMU 59 pesticide operation are no longer employed at NSA Memphis or involved in the aforementioned activities. Therefore, no definitive information is available regarding the former operating procedures at SWMU 59.

8.5.2 RFI Characterization

The focus of the RFI characterization was on the nature and extent of contamination in the following media:

- Surface and subsurface soil near Building S-335
- Groundwater in the loess and fluvial deposits

8.5.2.1 DPT Screening Investigation

As part of the RFI characterization, a preliminary screening investigation was conducted at SWMU 59 using DPT Geoprobe equipment operated by ProTech Inc. of Baton Rouge, Louisiana. The DPT screening investigation was conducted on October 27 and 28, 1995. Chlorinated pesticides/PCBs and VOCs were chosen as the DPT screening investigation indicator parameters because:

- The 1990 RFI confirmed the presence of pesticides in shallow soil surrounding Building S-335.

- Many of these pesticides were commonly formulated with a hydrocarbon carrier, such as xylene, which contained VOCs.

The DPT investigation focused on the area immediately surrounding Building S-335, especially the adjacent grassy area, where the highest chlordane concentrations were detected in shallow soil during the 1990 RFI. Ten DPT soil sample locations (059S0001 through 059S0010) were selected, and samples were collected from three depth intervals at each location (Figure 8.5.2). The following intervals were sampled: 0 to 2 feet bls (exclusive of any grass or asphalt), 3 to 5 feet bls, and 9 to 11 feet bls. Three of the surface soil samples (locations 059S0002, 059S0003, and 059S0004) were split as duplicates. The soil samples were submitted to an offsite laboratory

(NET) for analysis of VOCs (SW-846 Method 8240) and chlorinated pesticides/PCBs (SW-846 Method 8080).

One additional sample was collected during the DPT screening investigation – an upper fluvial deposits groundwater sample (059G0002) from 39 to 40 feet bls at DPT soil sample location 059S0002. Due to the limited volume of groundwater that could be collected with the DPT equipment, the groundwater sample was submitted to NET for VOC analysis only (SW-846 Method 8240). The borehole was immediately grouted to land surface following groundwater sample collection.

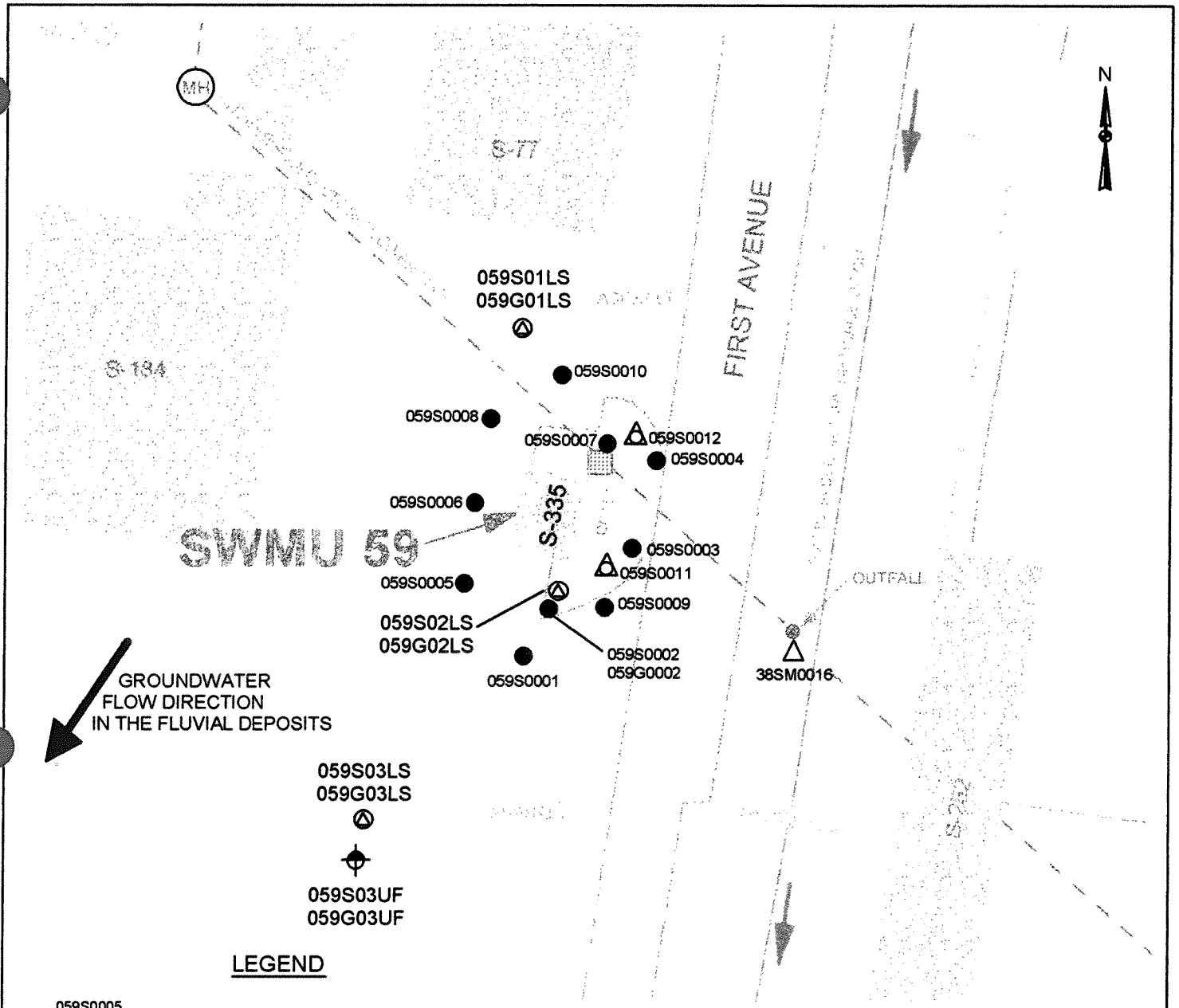
The NSA Memphis BCT reviewed the DPT results to determine the optimal number, placement, and depth of the SWMU 59 soil borings and groundwater monitoring wells.

8.5.2.2 Hand-Auger Surface Soil Investigation

Since the highest pesticide concentrations detected during the 1990 RFI were in the grassy area next to Building S-335, this area was chosen for surface soil sampling to provide information for an evaluation of the potential ecological and human health effects. On October 12, 1995, E/A&H collected two surface soil samples from 0 to 6 inches bls on the north (location 059S0012) and south (location 059S0011) sides of the grassy area. The surface soil samples were collected with a stainless-steel hand auger. A duplicate sample was collected at location 059S0011. The hand auger samples were submitted to NET for FSA. Figure 8.5.2 shows the hand-auger surface soil sample locations.

8.5.2.3 Soil Boring and Monitoring Well Investigation

Based on the 1990 RFI and 1995 DPT screening results, the NSA Memphis BCT selected three locations for advancing soil borings and installing groundwater wells. Each soil boring/monitoring well was advanced, continuously sampled, and installed with a rotasonic



LEGEND

059S0005 ●	DPT SAMPLE LOCATION AND DESIGNATION
059S0011 △	HAND-AUGER SURFACE SOIL SAMPLE LOCATION AND DESIGNATION
059S02LS 059G02LS	LOESS SOIL BORING AND MONITORING WELL LOCATION AND DESIGNATION
059S03UF 059G03UF	UPPER FLUVIAL DEPOSITS SOIL BORING AND MONITORING WELL LOCATION AND DESIGNATION
38SM0016 △	SWMU 38 SEDIMENT SAMPLE LOCATION
▒	STORM DRAIN
	UNDERGROUND STORM SEWER LINE

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FIGURE 8.5.2
DPT, HAND AUGER, SOIL BORING, AND
MONITORING WELL LOCATIONS
SWMU 59 - S-335 OLD PESTICIDE SHOP

drilling rig operated by Alliance Environmental of Marietta, Ohio. Figure 8.5.2 shows the soil boring and monitoring well locations.

Based on the anticipated groundwater flow direction (southwest, toward Big Creek Drainage Canal), one soil boring/monitoring well (059S01LS/059G01LS) was placed upgradient (north) of Building S-335. Soil boring/monitoring well 059S02LS/059G02LS was placed in the grassy area near Building S-335's door, where pesticides were identified in soil samples from the 1990 RFI and 1995 DPT screening investigation. A soil boring/monitoring well pair (059S03LS/059G03LS and 059S03UF/059G03UF) was placed downgradient (southwest) of SWMU 59.

Loess soil borings 059S01LS, 059S02LS, and 059S03LS were advanced to 20 feet bls and soil samples from each of the three borings were collected at three intervals. Loess soil boring 059S02LS was sampled from 0 to 2 feet bls, 4 to 6 feet bls, and 10 to 12 feet bls, as outlined in the *Assembly E Site Investigation Plans* (E/A&H, 1995a). Loess soil boring 059S01LS was sampled from 1 to 2 feet bls, 6 to 8 feet bls, and 10 to 12 feet bls; the 0- to 1-foot interval sample was not included because it consisted of asphalt, and the 6- to 8-foot interval, rather than the 4- to 6-foot interval, was sampled due to poor sample recovery in the 4- to 6-foot interval. Loess soil boring 059S03LS was sampled from 1 to 2 feet bls, 4 to 6 feet bls, and 10 to 12 feet bls; the 0- to 1-foot interval was not included because it consisted of asphalt. The sample from the 10- to 12-foot interval of location 059S03LS was split as a duplicate. The soil boring samples listed above were submitted to NET for FSA. Upper fluvial deposits soil boring 059S03UF, collocated with soil boring 059S03LS, was advanced to 56 feet bls and no soil samples were collected for chemical analysis.

As outlined in the *Assembly E Site Investigation Plans* (E/A&H, 1995a), soil samples were collected for physical and chemical design parameters analysis from each water-bearing unit encountered during the SWMU 59 RFI. Shelby tube soil samples were collected for physical

design parameters analysis (e.g., geotechnical testing) from the 13- to 15-foot bls interval of boring 059S03LS and the 41- to 43-foot bls interval of boring 059S03UF. Soil samples collected for chemical design parameters analysis were the 10- to 12-foot bls interval of boring 059S03LS and the 43- to 45-foot bls interval of boring 059S03UF. Samples for chemical design parameters analysis were submitted to NET, and samples for physical design parameters analysis were submitted to Tri-State Testing Services of Memphis, Tennessee.

Loess groundwater monitoring wells 059G01LS, 059G02LS, and 059G03LS were installed through open boreholes 059S01LS, 059S02LS, and 059S03LS and screened from 10 to 20 feet bls. Upper fluvial deposits monitoring well 059G03UF was installed through open borehole 059S03UF and screened from 44 to 54 feet bls. Several weeks after monitoring well installation and development, the wells were purged and sampled. A duplicate groundwater sample was collected from upper fluvial deposits monitoring well 059G03UF. The groundwater samples were submitted to NET for FSA excluding TPH-GRO, because many of the lighter fraction hydrocarbons of interest would be identified from the TICs of the VOC analyses.

8.5.3 Nature and Extent of Contamination

The following sections summarize the nature and extent of contamination in soil and groundwater samples collected during the Assembly E SWMU 59 RFI.

8.5.3.1 Nature and Extent of Soil Contamination

This section summarizes the nature and extent of contamination in surface and subsurface soil samples collected at SWMU 59 during the Assembly E RFI. This discussion includes the results of the DPT surface and subsurface soil samples, hand auger surface soil samples, and surface and subsurface soil samples collected from soil borings associated with monitoring well installation. For comparison purposes, the 0- to 2-foot bls DPT samples, 0- to 6-inch bls hand auger samples, and the 0- to 2-foot or 1- to 2-foot bls soil boring samples were considered surface soil.

Constituents in surface and subsurface soil samples are compared to the screening values discussed in Section 8.5.1.

8.5.3.1.1 Organic Compounds in Soil Samples

VOCs, SVOCs, TPH, chlorinated pesticides, PCBs, and herbicides were detected in the SWMU 59 soil samples. Tables 8.5.2, 8.5.3, and 8.5.4 summarize the organic compounds detected in the DPT samples, hand auger samples, and soil boring samples, respectively. The following sections detail the detected organic compounds by parameter.

VOCs in Soil

The following VOCs were identified in DPT, hand auger, or soil boring samples:

2-Butanone (MEK)	Methylene chloride
4-Methyl-2-Pentanone (MIBK)	Tetrachloroethene (PCE)
Acetone	Toluene
Carbon disulfide	Xylene
Ethylbenzene	

As shown in Tables 8.5.2, 8.5.3, and 8.5.4, no detected VOC in any surface soil sample exceeded its respective residential RBC value. The only VOC in soil that exceeded its soil-to-groundwater SSL was acetone in the 3- to 5-foot interval sample from DPT location 059S0009 (detected concentration = 8,600 μg/kg, SSL = 8,000 μg/kg). Figure 8.5.3 shows the SSL exceedance.

SVOCs in Soil

The DPT soil samples were not analyzed for SVOCs. The following SVOCs were detected in hand auger or soil boring samples:

Anthracene	Carbazole
Benzo(a)anthracene	Chrysene

Benzo(a)pyrene	Dibenz(a,h)anthracene
Benzo(b)fluoranthene	Fluoranthene
Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene	Pentachlorophenol
bis(2-Ethylhexyl)phthalate (BEHP)	Phenanthrene
Butylbenzylphthalate	Pyrene

The following SVOCs exceeded one or more screening values: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and pentachlorophenol. Figure 8.5.3 plots the soil-to-groundwater SSL exceedances, and Figure 8.5.4 plots the RBC exceedances. The following paragraphs discuss the exceedances by compound.

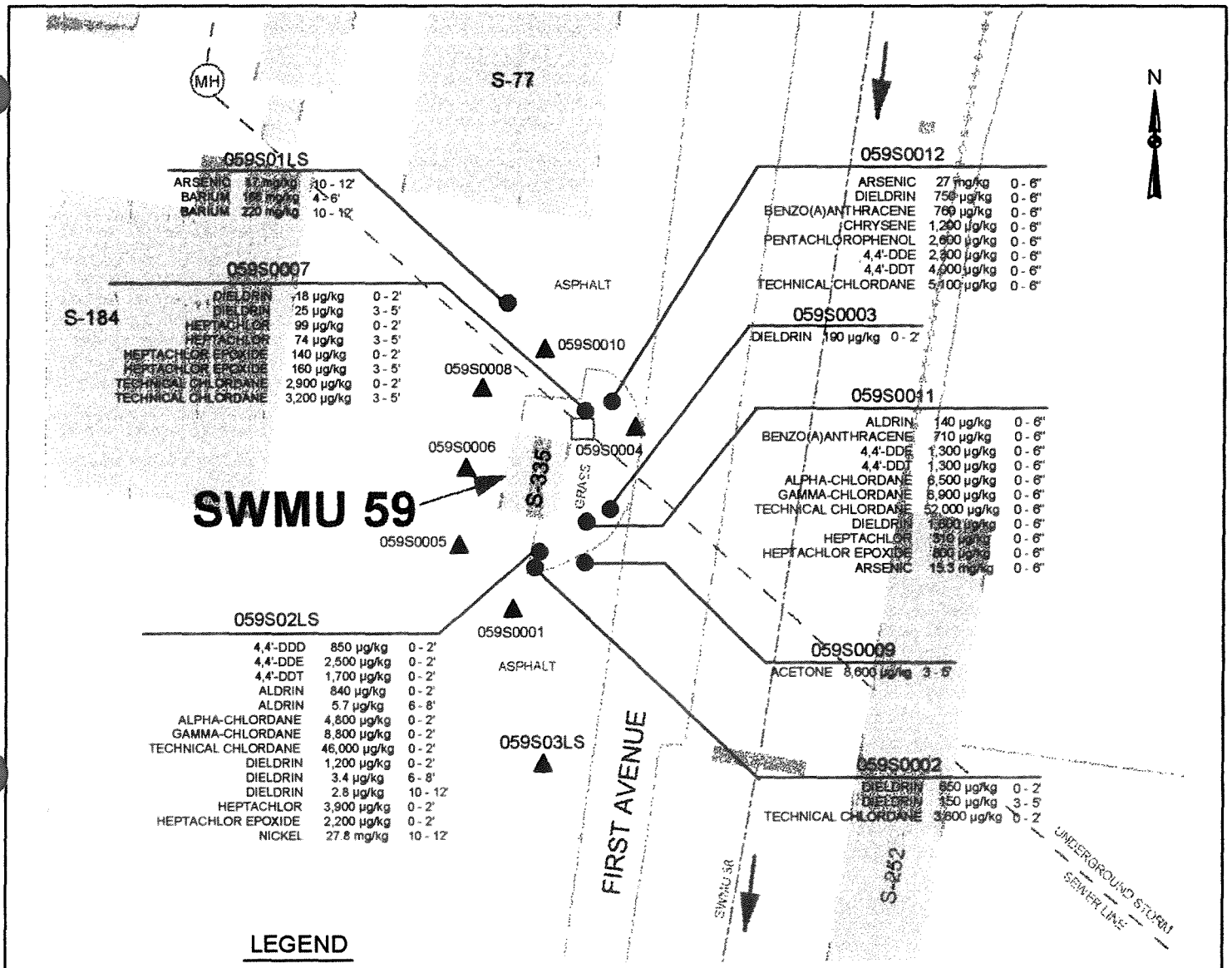
Benzo(a)anthracene's SSL (700 μg/kg) was exceeded at hand auger surface soil sample locations 059S0011 (710 μg/kg) and 059S0012 (760 μg/kg).

Benzo(a)pyrene's residential soil RBC (88 μg/kg) was exceeded by the hand auger surface soil sample from location 059S0011 (780 μg/kg) and the surface soil sample from soil boring 059S02LS (280 μg/kg). The residential and industrial RBC (780 μg/kg) were exceeded by the hand auger surface soil sample from location 059S0012 (950 μg/kg).

Benzo(b)fluoranthene's residential soil RBC (880 μg/kg) was exceeded by the detected concentration in the surface soil sample from hand auger location 059S0012 (1,200 μg/kg).

Chrysene's SSL (1,000 μg/kg) was exceeded by the detected concentration in the hand auger surface soil sample from location 059S0012 (1,200 μg/kg).

Pentachlorophenol's SSL (200 μg/kg) was exceeded by the concentration in the hand auger surface soil sample from location 059S0012 (2,600 μg/kg).



LEGEND

▲ NO CONSTITUENT IN ANY SOIL SAMPLE FROM THIS LOCATION EXCEEDED ITS SOIL-TO-GROUNDWATER SSL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN A SOIL SAMPLE FROM THIS LOCATION EXCEEDED ITS SOIL-TO-GROUNDWATER SSL (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

50 0 50 Feet

059S0002

DIELDRIN	650 µg/kg	0 - 2'
DIELDRIN	150 µg/kg	3 - 5'
TECHNICAL CHLORDANE	3,600 µg/kg	0 - 2'

THE FOLLOWING CONSTITUENTS IN SOIL SAMPLES FROM LOCATION 059S0002 EXCEEDED THEIR RESPECTIVE SSLs (AND BACKGROUND REFERENCE CONCENTRATIONS, WHERE APPLICABLE): 650 µg/kg DIELDRIN IN THE 0- TO 2-FOOT INTERVAL SAMPLE, 150 µg/kg DIELDRIN IN THE 3 TO 5-FOOT INTERVAL SAMPLE, AND 3,600 µg/kg TECHNICAL CHLORDANE IN THE 0- TO 2-FOOT INTERVAL SAMPLE.

mg/kg MILLIGRAMS PER KILOGRAM

µg/kg MICROGRAMS PER KILOGRAM

NOTE:

ALL SOIL BORING SAMPLES AND HAND AUGER SAMPLES 059S0011 AND 059S0012 WERE ANALYZED FOR VOCs, SVOCs, TPH-GRO, TPH-DRO, CHLORINATED PESTICIDES/PCBs, ORGANOPHOSPHORUS PESTICIDES, HERBICIDES, APPENDIX IX METALS, AND CYANIDE. SOIL SAMPLES 059S0001 THROUGH 059S0010 WERE ANALYZED FOR VOCs AND CHLORINATED PESTICIDES/PCBs ONLY.

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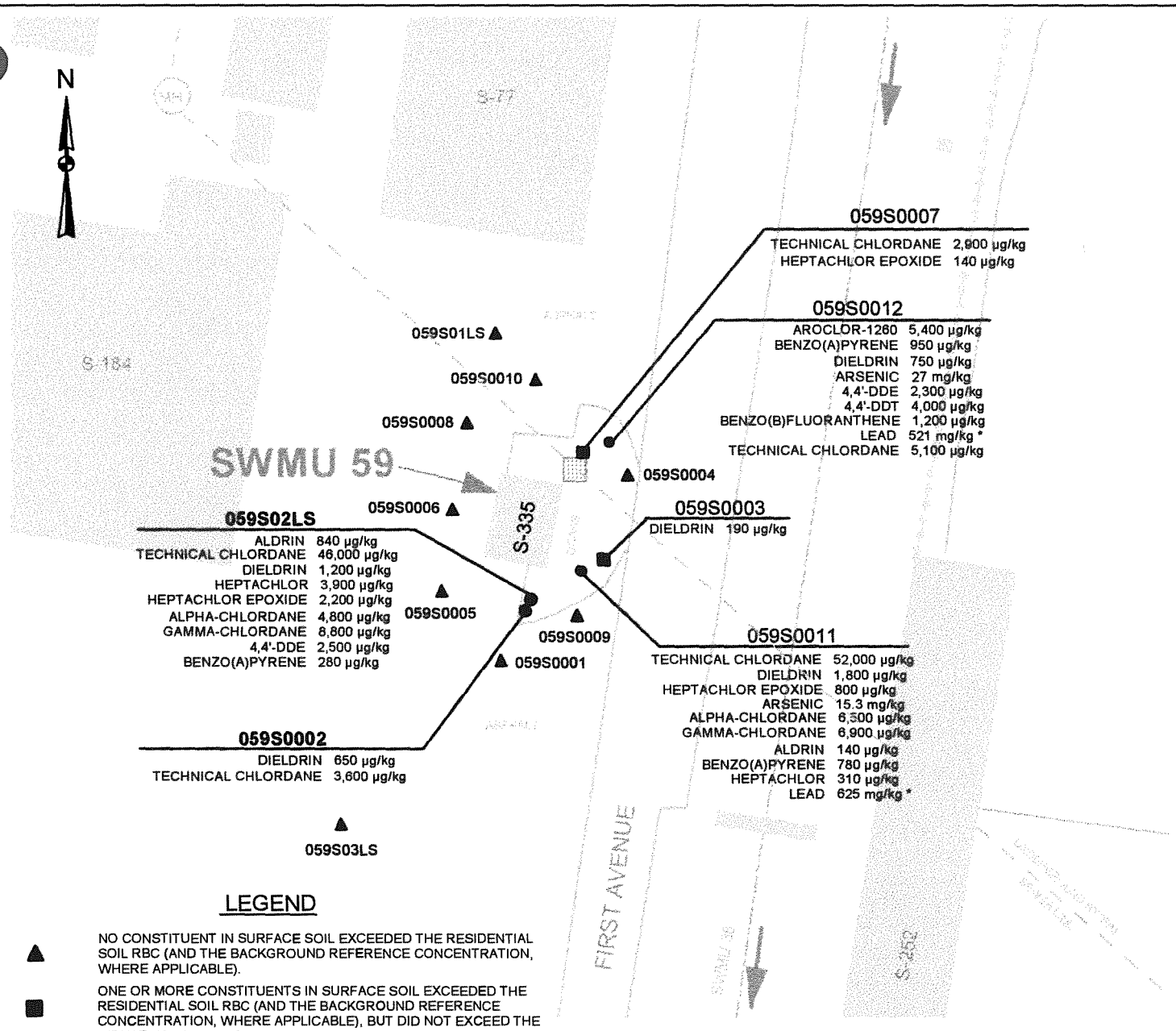
FIGURE 8.5.3
SOIL-TO-GROUNDWATER SSL EXCEEDANCES IN SOIL SAMPLES FROM DPT, HAND AUGER, AND SOIL BORING LOCATIONS
SWMU 59 - S-335 OLD PESTICIDE SHOP



LEGEND

▲ NO CONSTITUENT IN SURFACE SOIL EXCEEDED THE RESIDENTIAL SOIL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

■ ONE OR MORE CONSTITUENTS IN SURFACE SOIL EXCEEDED THE RESIDENTIAL SOIL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE), BUT DID NOT EXCEED THE INDUSTRIAL SOIL RBC.

● ONE OR MORE CONSTITUENTS IN SURFACE SOIL EXCEEDED THE INDUSTRIAL SOIL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

50 0 50 Feet

059S0002

DIELDRIN 650 µg/kg
TECHNICAL CHLORDANE 3,600 µg/kg

THE SURFACE SOIL SAMPLE FROM SAMPLING LOCATION 059S0002 CONTAINED THE FOLLOWING CONTAMINANTS THAT EXCEEDED SOIL RBCs: 650 µg/kg DIELDRIN, WHICH EXCEEDED ITS INDUSTRIAL SOIL RBC, AND 3,600 µg/kg TECHNICAL CHLORDANE, WHICH EXCEEDED ITS RESIDENTIAL SOIL RBC ONLY.

mg/kg MILLIGRAMS PER KILOGRAM
µg/kg MICROGRAMS PER KILOGRAM

NOTES:

** NO RBC IS AVAILABLE FOR LEAD; THE USEPA RESIDENTIAL AND INDUSTRIAL LEAD CLEANUP GOALS OF 400 mg/kg AND 1,300 mg/kg WERE USED FOR COMPARISON (OSWER DIRECTIVE 9355.4-12).*

ALL SOIL BORING SAMPLES AND HAND AUGER SAMPLES 059S0011 AND 059S0012 WERE ANALYZED FOR VOCs, SVOCs, TPH-GRO, TPH-DRO, CHLORINATED PESTICIDES/PCBs, ORGANOPHOSPHORUS PESTICIDES, HERBICIDES, APPENDIX IX METALS, AND CYANIDE. DPT SOIL SAMPLES 059S0001 THROUGH 059S0010 WERE ANALYZED FOR VOCs AND CHLORINATED PESTICIDES/PCBs ONLY.

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FIGURE 8.5.4
RBC EXCEEDANCES IN SURFACE SOIL SAMPLES FROM DPT, HAND AUGER, AND SOIL BORING LOCATIONS
SWMU 59 - S-335 OLD PESTICIDE SHOP

Table 8.5.2
Detected Concentrations of VOCs and Pesticides in DPT Soil Samples
SWMU 59 — S-335 Old Pesticide Shop
(data in µg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
VOCs										
2-Butanone (MEK)	3 - 5	3/10	22 - 37	29	NA[f]	NA	NA	NA	–[g]	–
	9 - 11	4/10	7 - 1,100	284	NA	NA	NA	NA	–	–
4-Methyl-2-Pentanone (MIBK)	3 - 5	1/10	1	1	NA	NA	NA	NA	–	–
Acetone	0 - 2	5/10	700 - 7,200	3,292	7,800,000	0	200,000,000	0	8,000	0
	3 - 5	5/10	320 - 8,600	3,160	NA	NA	NA	NA	8,000	1 (059S0009)
	9 - 11	5/10	370 - 6,400	2,598	NA	NA	NA	NA	8,000	0
Carbon disulfide	0 - 2	1/10	2	2	7,800,000	0	200,000,000	0	14,000	0
Ethylbenzene	0 - 2	2/10	1 - 2	2	7,800,000	0	200,000,000	0	5,000	0
	3 - 5	1/10	1	1	NA	NA	NA	NA	5,000	0
Methylene chloride	0 - 2	1/10	3	3	85,000	0	760,000	0	10	0
	3 - 5	2/10	3 - 4	4	NA	NA	NA	NA	10	0
	9 - 11	2/10	1 - 2	2	NA	NA	NA	NA	10	0
Tetrachloroethene (PCE)	0 - 2	1/10	6	6	12,000	0	110,000	0	40	0
Xylene (total)	0 - 2	2/10	7 - 9	8	160,000,000	0	1,000,000,000	0	74,000	0
Pesticides/PCBs										
Aldrin	3 - 5	1/10	1.2	1.2	NA	NA	NA	NA	5	0
alpha-Chlordane	0 - 2	3/10	19 - 430	273	1,825	0	16,352	0	2,000	0
	3 - 5	2/10	93 - 410	252	NA	NA	NA	NA	2,000	0
	9 - 11	1/10	1.2	1.2	NA	NA	NA	NA	2,000	0
Aroclor-1260	0 - 2	1/10	210	210	320[h]	0	2,850[h]	0	–	–
4,4'-DDD	0 - 2	2/10	92 - 160	126	2,700	0	24,000	0	700	0
	3 - 5	2/10	14 - 16	15	NA	NA	NA	NA	700	0
4,4'-DDE	0 - 2	5/10	39 - 340	163	1,900	0	17,000	0	500	0
	3 - 5	3/10	29 - 58	45	NA	NA	NA	NA	500	0
4,4'-DDT	0 - 2	4/10	25 - 180	109	1,900	0	17,000	0	1,000	0
	3 - 5	3/10	8.2 - 47	30	NA	NA	NA	NA	1,000	0

Table 8.5.2
Detected Concentrations of VOCs and Pesticides in DPT Soil Samples
SWMU 59 — S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
Pesticides/PCBs										
Dieldrin	0 - 2	3/10	18 - 650	286	40	2 (059S0002, 059S0003)	360	1 (059S0002)	1	3 (059S0002, 059S0003, 059S0007)
	3 - 5	2/10	25 - 150	88	NA	NA	NA	NA	10	2 (059S0002, 059S0007)
Endrin aldehyde	0 - 2	1/10	58	58	23,000	0	610,000	0	–	–
gamma-Chlordane	0 - 2	3/10	22 - 490	311	1,825	0	16,352	0	2,000	0
	3 - 5	2/10	90 - 480	285	NA	NA	NA	NA	2,000	0
	9 - 11	1/10	1.3	1.3	NA	NA	NA	NA	2,000	0
Heptachlor	0 - 2	1/10	99	99	140	0	1,300	0	60	1 (059S0007)
	3 - 5	1/10	74	74	NA	NA	NA	NA	60	1 (059S0007)
Heptachlor epoxide	0 - 2	1/10	140	140	70	1 (059S0007)	630	0	30	1 (059S0007)
	3 - 5	1/10	160	160	NA	NA	NA	NA	30	1 (059S0007)
Technical Chlordane	0 - 2	2/10	2,900 - 3,600	3,250	1,825	2 (059S0002, 059S0007)	16,352	0	2,000	2 (059S0002, 059S0007)
	3 - 5	2/10	730 - 3,200	1,965	NA	NA	NA	NA	2,000	1 (059S0007)

Notes:

a — Thirty primary samples were collected from 10 DPT sampling locations. The following intervals were sampled: 0 to 2 feet, 3 to 5 feet, and 9 to 11 feet. Three of the 0 to 2-foot interval samples were split as duplicates. All samples were submitted to NET for VOC and pesticide/PCB analyses. The surface soil interval for DPT locations collected in the grassy area (059S0002, 059S0003, 059S0004, and 059S0007) was approximately 0.5 to 2 feet bls after grass, roots, and rocks were removed. The surface soil interval for DPT locations on asphalt (059S0001, 059S0005, 059S0006, 059S0008, 059S0009, and 059S0010) was approximately 1 to 2 feet bls, exclusive of asphalt.

b — Interval shown is in feet below land surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial soil screening values (RBC-Res., RBC-Ind.) and soil-to-groundwater soil screening levels (SSLs) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to surface soil samples; SSLs apply to both surface and subsurface soil samples.

f — NA denotes RBC comparison is not applicable for this subsurface sample.

g — denotes SSL is not available for this analyte; therefore, no comparison can be made.

h — The residential and industrial RBC's for PCBs were obtained from the *Integrated Risk Information System* (IRIS 1996).

Table 8.5.3
Detected Concentrations of Organic Compounds in Hand Auger Surface Soil Samples
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
VOCs										
Toluene	0 - 6"	2/2	8 - 9	9	16,000,000	0	410,000,000	0	5,000	0
SVOCs										
Benzo(a)anthracene	0 - 6"	2/2	710 - 760	735	880	0	7,800	0	700	2 (059S0011, 059S0012)
Benzo(a)pyrene	0 - 6"	2/2	780 - 950	865	88	2 (059S0011, 059S0012)	780	1 (059S0012)	4,000	0
Benzo(b)fluoranthene	0 - 6"	2/2	840 - 1,200	1,020	880	1 (059S0012)	7,800	0	4,000	0
Benzo(g,h,i)perylene	0 - 6"	2/2	520 - 570	545	3,100,000[f]	0	82,000,000[f]	0	–[g]	–
Benzo(k)fluoranthene	0 - 6"	2/2	800 - 1,100	950	8,800	0	78,000	0	4,000	0
Chrysene	0 - 6"	2/2	880 - 1,200	1,040	88,000	0	780,000	0	1,000	1 (059S0012)
Fluoranthene	0 - 6"	2/2	1,100 - 1,200	1,150	3,100,000	0	82,000,000	0	980,000	0
Indeno(1,2,3-cd)pyrene	0 - 6"	2/2	480 - 490	485	880	0	7,800	0	35,000	0
Pentachlorophenol	0 - 6"	1/2	2,600	2,600	5,300	0	48,000	0	200	1 (059S0012)
Phenanthrene	0 - 6"	2/2	500 - 560	530	3,100,000[f]	0	82,000,000[f]	0	–	–
Pyrene	0 - 6"	2/2	910 - 990	950	2,300,000	0	61,000,000	0	1,400,000	0
Total Petroleum Hydrocarbons										
TPH - DRO	0 - 6"	2/2	51,000 - 78,000	64,500	–	–	–	–	500,000[h]	0
TPH - GRO	0 - 6"	2/2	140 - 200	170	–	–	–	–	500,000[h]	0
Total TPH (TPH-DRO + TPH-GRO)	0 - 6"	2/2	51,140 - 78,200	64,670	–	–	–	–	500,000[h]	0
Pesticides/PCBs										
Aldrin	0 - 6"	1/2	140	140	38	1 (059S0011)	340	0	5	1 (059S0011)
Aroclor-1260	0 - 6"	1/2	5,400	5,400	320[i]	1 (059S0012)	2,850[i]	1 (059S0012)	–	–
alpha-Chlordane	0 - 6"	2/2	860 - 6,500	3,680	1,825	1 (059S0011)	16,352	0	2,000	1 (059S0011)

Table 8.5.3
Detected Concentrations of Organic Compounds in Hand Auger Surface Soil Samples
SWMU 59 – S-335 Old Pesticide Shop
(data in µg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
Pesticides/PCBs										
gamma-Chlordane	0 - 6"	2/2	790 - 6,900	3,845	1,825	1 (059S0011)	16,352	0	2,000	1 (059S0011)
Technical Chlordane	0 - 6"	2/2	5,100 - 52,000	28,550	1,825	2 (059S0011, 059S0012)	16,352	1 (059S0011)	2,000	2 (059S0011, 059S0012)
4,4'-DDD	0 - 6"	1/2	700	700	2,700	0	24,000	0	700	0
4,4'-DDE	0 - 6"	2/2	1,300 - 2,300	1,800	1,900	1 (059S0012)	17,000	0	500	2 (059S0011, 059S0012)
4,4'-DDT	0 - 6"	2/2	1,300 - 4,000	2,650	1,900	1 (059S0012)	17,000	0	1,000	2 (059S0011, 059S0012)
Dieldrin	0 - 6"	2/2	750 - 1,800	1,275	40	2 (059S0011, 059S0012)	360	2 (059S0011, 059S0012)	1	2 (059S0011, 059S0012)
Endrin aldehyde	0 - 6"	1/2	260	260	23,000	0	610,000	0	–	–
Heptachlor	0 - 6"	1/2	310	310	140	1 (059S0011)	1,300	0	60	1 (059S0011)
Heptachlor epoxide	0 - 6"	1/2	800	800	70	1 (059S0011)	630	1 (059S0011)	30	1 (059S0011)
Herbicides										
2,4-D	0 - 6"	2/2	25	25	780,000	0	20,000,000	0	1,700	0
Dichlorprop	0 - 6"	1/2	5.7	5.7	–	–	–	–	–	–
MCPA	0 - 6"	1/2	6,500	6,500	39,000	0	1,000,000	0	–	–

Notes:

a — Two surface soil samples were collected from 0 to 6 inches bls. One sample was split as a duplicate. All hand/auger surface soil samples were submitted to NET for the following analyses: VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval shown is in inches below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) and soil-to-groundwater soil screening levels (SSLs) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.

g — denotes risk-based data not available for this analyte; therefore, no comparison can be made.

h — The TDEC soil cleanup level of 500,000 µg/kg for non-drinking water aquifers and soil permeabilities ranging from 10^{-4} to 10^{-6} has been used for the SSL. The total TPH cleanup level is from *TDEC Policy Statement for Petroleum Contaminated Sites* (TDEC Memorandum, February 14, 1997).

i — The residential and industrial RBC's for PCBs were obtained from the *Integrated Risk Information System* (IRIS 1996).

Table 8.5.4
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
VOCs										
2-Butanone (MEK)	1 - 2	1/3	7	7	47,000,000	0	1,000,000,000	0	–[f]	–
	4 - 8	2/3	8 - 11	10	NA[g]	NA	NA	NA	–	–
Acetone	0 - 2	3/3	5 - 43	18	7,800,000	0	200,000,000	0	8,000	0
	4 - 8	3/3	6 - 47	29	NA	NA	NA	NA	8,000	0
	10 - 12	2/3	7 - 30	19	NA	NA	NA	NA	8,000	0
Carbon disulfide	1 - 2	1/3	2	2	7,800,000	0	200,000,000	0	14,000	0
SVOCs										
Anthracene	0 - 2	1/3	47	47	23,000,000	0	610,000,000	0	4,300,000	0
	10 - 12	1/3	58	58	NA	NA	NA	NA	4,300,000	0
Benzo(a)anthracene	0 - 2	1/3	220	220	880	0	7,800	0	700	0
	10 - 12	1/3	240	240	NA	NA	NA	NA	700	0
Benzo(a)pyrene	0 - 2	1/3	280	280	88	1 (059S02LS)	780	0	4,000	0
	10 - 12	1/3	320	320	NA	NA	NA	NA	4,000	0
Benzo(b)fluoranthene	0 - 2	1/3	300	300	880	0	7,800	0	4,000	0
	10 - 12	1/3	360	360	NA	NA	NA	NA	4,000	0
Benzo(g,h,i)perylene	0 - 2	1/3	150	150	3,100,000[h]	0	82,000,000[h]	0	–	–
	10 - 12	1/3	190	190	NA	NA	NA	NA	–	–
Benzo(k)fluoranthene	0 - 2	1/3	330	330	8,800	0	78,000	0	4,000	0
	10 - 12	1/3	340	340	NA	NA	NA	NA	4,000	0
bis(2-Ethylhexyl)phthalate (BEHP)	0 - 2	1/3	320	320	46,000	0	410,000	0	11,000	0
	4 - 6	1/3	380	380	NA	NA	NA	NA	11,000	0
	10 - 12	3/3	46 - 220	135	NA	NA	NA	NA	11,000	0
Butylbenzylphthalate	10 - 12	1/3	64	64	NA	NA	NA	NA	68,000	0

Table 8.5.4
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
SVOCs										
Carbazole	10 - 12	1/3	42	42	NA	NA	NA	NA	500	0
Chrysene	0 - 2	1/3	240	240	88,000	0	780,000	0	1,000	0
	10 - 12	1/3	280	280	NA	NA	NA	NA	1,000	0
Dibenz(a,h)anthracene	0 - 2	1/3	49	49	88	0	780	0	11,000	0
	10 - 12	1/3	63	63	NA	NA	NA	NA	11,000	0
Fluoranthene	0 - 2	1/3	330	330	3,100,000	0	82,000,000	0	980,000	0
	10 - 12	1/3	370	370	NA	NA	NA	NA	980,000	0
Indeno(1,2,3-cd)pyrene	0 - 2	1/3	130	130	880	0	7,800	0	35,000	0
	10 - 12	1/3	170	170	NA	NA	NA	NA	35,000	0
Phenanthrene	0 - 2	1/3	150	150	3,100,000[h]	0	82,000,000[h]	0	–	–
	10 - 12	1/3	220	220	NA	NA	NA	NA	–	–
Pyrene	0 - 2	1/3	200	200	2,300,000	0	61,000,000	0	1,400,000	0
	10 - 12	1/3	230	230	NA	NA	NA	NA	1,400,000	0
Total Petroleum Hydrocarbons										
TPH - DRO	0 - 2	3/3	12,000 - 69,000	32,333	–	–	–	–	500,000[f]	0
	4 - 6	1/3	7,200	7,200	–	–	–	–	500,000[f]	0
TPH - GRO	4 - 6	1/3	69	69	–	–	–	–	500,000[f]	0
Total TPH (TPH-GRO + TPH-DRO)	0 - 2	3/3	12,000 - 69,000	32,333	–	–	–	–	500,000[f]	0
	4 - 6	1/3	7,269	7,269	–	–	–	–	500,000[f]	0
Pesticides/PCBs										
4,4'-DDD	0 - 2	2/3	4.8 - 850	427	2,700	0	24,000	0	700	1 (059S02LS)
4,4'-DDE	0 - 2	2/3	12 - 2,500	1,256	1,900	1 (059S02LS)	17,000	0	500	1 (059S02LS)
	4 - 6	1/3	3.9	3.9	NA	NA	NA	NA	500	0

Table 8.5.4
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
Pesticides/PCBs										
4,4'-DDT	0 - 2	2/3	7.2 - 1,700	854	1,900	0	17,000	0	1,000	1 (059S02LS)
Aldrin	0 - 2	1/3	840	840	38	1 (059S02LS)	340	1 (059S02LS)	5	1 (059S02LS)
	4 - 6	1/3	5.7	5.7	NA	NA	NA	NA	5	1 (059S02LS)
	10 - 12	1/3	3.1	3.1	NA	NA	NA	NA	5	0
alpha-Chlordane	0 - 2	1/3	4,800	4,800	1,825	1 (059S02LS)	16,352	0	2,000	1 (059S02LS)
	4 - 6	1/3	26	26	NA	NA	NA	NA	2,000	0
	10 - 12	1/3	15	15	NA	NA	NA	NA	2,000	0
Dieldrin	0 - 2	1/3	1,200	1,200	40	1 (059S02LS)	360	1 (059S02LS)	10	1 (059S02LS)
	4 - 6	1/3	3.4	3.4	NA	NA	NA	NA	10	1 (059S02LS)
	10 - 12	1/3	2.8	2.8	NA	NA	NA	NA	10	1 (059S02LS)
gamma-Chlordane	0 - 2	1/3	8,800	8,800	1,825	1 (059S02LS)	16,352	0	2,000	1 (059S02LS)
	4 - 6	1/3	52	52	NA	NA	NA	NA	2,000	0
	10 - 12	1/3	26	26	NA	NA	NA	NA	2,000	0
Heptachlor	0 - 2	1/3	3,900	3,900	140	1 (059S02LS)	1,300	1 (059S02LS)	60	1 (059S02LS)
	4 - 6	1/3	26	26	NA	NA	NA	NA	60	0
	10 - 12	1/3	11	11	NA	NA	NA	NA	60	0
Heptachlor epoxide	0 - 2	1/3	2,200	2,200	70	1 (059S02LS)	630	1 (059S02LS)	30	1 (059S02LS)
	4 - 6	1/3	12	12	NA	NA	NA	NA	30	0
	10 - 12	1/3	8	8	NA	NA	NA	NA	30	0
Technical Chlordane	0 - 2	1/3	46,000	46,000	1,825	1 (059S02LS)	16,352	1 (059S02LS)	2,000	1 (059S02LS)
	4 - 6	1/3	250	250	NA	NA	NA	NA	2,000	0
	10 - 12	1/3	140	140	NA	NA	NA	NA	2,000	0

Table 8.5.4
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[e]	SSL Exceedances
Herbicides										
2,4,5-T	0 - 2	1/3	1.5	1.5	780,000	0	20,000,000	0	–	–
	4 - 6	1/3	1	1	NA	NA	NA	NA	–	–
2,4-D	0 - 2	2/3	12 - 18	15	780,000	0	20,000,000	0	1,700	0
2,4-DB	0 - 2	1/3	16	16	630,000	0	16,000,000	0	–	–
	10 - 12	1/3	6.4	6.4	NA	NA	NA	NA	–	–
Dicamba	0 - 2	1/3	12	12	2,300,000	0	61,000,000	0	–	–
Dinoseb	1 - 2	1/3	3	3	78,000	0	2,000,000	0	–	–
	4 - 6	1/3	7	7	NA	NA	NA	NA	–	–
	10 - 12	2/3	2.5	2.5	NA	NA	NA	NA	–	–

Notes:

a — Nine soil samples were collected; three from each loess soil boring location. The surface sample interval was 1 to 2 feet bls (exclusive of asphalt) for soil borings 059S01LS and 059S03LS, and 0 to 2 feet for soil boring 059S02LS. Subsurface soil samples were collected from soil boring 059S01LS from the 6 to 8 feet bls (due to poor sample recovery in the 4- to 6-foot interval) and 10 to 12 feet bls intervals. Subsurface soil samples were collected from the 4 to 6-foot and 10- to 12-foot intervals at soil boring locations 059S02LS and 059S03LS. One of the 10- to 12-foot interval soil samples was split for duplicate analysis. The samples were analyzed by NET for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval shown is in feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) and soil-to-groundwater soil screening levels (SSLs) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to surface soil samples; SSLs apply to both surface and subsurface soil samples.

f — denotes risk-based data not available for this analyte; therefore, no comparison can be made.

g — NA denotes RBC comparison is not applicable for this subsurface sample.

h — The RBCs for fluoranthene were used as a surrogate for benzo(g,h,i)perylene and phenanthrene, which do not have RBCs.

i — No RBC or SSL exists for TPH. The TDEC soil cleanup level of 500,000 μg/kg for non-drinking water aquifers and soil permeabilities ranging from 10^{-4} to 10^{-6} has been used for the SSL. The total TPH cleanup level is from *TDEC Policy Statement for Petroleum Contaminated Sites* (TDEC Memorandum, February 14, 1997).

TPH in Soil

The DPT soil samples were not analyzed for TPH. TPH-GRO and TPH-DRO were detected in several SWMU 59 hand auger or soil boring samples. The USEPA has not established an RBC or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg (TDEC, 1997) for total TPH in non-drinking water aquifers (e.g., the loess groundwater throughout NSA Memphis) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec has been compared to total TPH concentrations in surface and subsurface soil samples. As shown in Tables 8.5.3 and 8.5.4, the TDEC cleanup standard was not exceeded by any sample's total TPH concentration.

Pesticides/PCBs in Soil

The following pesticides were detected in SWMU 59 DPT, hand auger, or soil boring samples:

Aldrin	4,4'-DDT
alpha-Chlordane	Dieldrin
gamma-Chlordane	Endrin aldehyde
Technical chlordane	Heptachlor
4,4'-DDD	Heptachlor epoxide
4,4'-DDE	

Each of these pesticides, except for endrin aldehyde, exceeded one or more of their applicable screening values for soil. Tables 8.5.2, 8.5.3, and 8.5.4 summarize the pesticides detected in the DPT surface and subsurface soil samples, hand auger surface soil samples, and surface and subsurface soil samples from soil borings, respectively. Figure 8.5.3 shows the pesticides in surface and subsurface soil that exceeded their SSLs, and Figure 8.5.4 shows the pesticides in surface soil that exceeded their RBCs. The following paragraphs discuss the pesticides that exceeded one or more comparison values.

Aldrin's residential RBC (38 μg/kg) and SSL (5 μg/kg) were exceeded by surface soil samples from hand auger location 059S0011 (140 μg/kg) and soil boring 059S02LS (840 μg/kg). The industrial RBC (340 μg/kg) was also exceeded by the surface soil sample from soil boring 059S02LS (840 μg/kg). The SSL was also exceeded in the 4- to 6-foot bls soil sample from soil boring 059S02LS (5.7 μg/kg).

Alpha-chlordane concentrations in surface soil samples from hand auger location 059S0011 (6,500 μg/kg) and soil boring 059S02LS (4,800 μg/kg) exceeded the residential RBC for chlordane (1,825 μg/kg). The surface soil samples from hand auger location 059S0011 and soil boring 059S02LS also exceeded the SSL (2,000 μg/kg) for chlordane.

Gamma-chlordane concentrations in surface soil samples from hand auger location 059S0011 (6,900 μg/kg) and soil boring 059S02LS (8,800 μg/kg) exceeded the residential RBC (1,825 μg/kg) for chlordane. The concentrations in surface soil samples from hand auger location 059S0011 and soil boring 059S02LS also exceeded the SSL (2,000 μg/kg) for chlordane.

Technical chlordane concentrations in surface soil samples from DPT locations 059S0002 (3,600 μg/kg) and 059S0007 (2,900 μg/kg), hand auger locations 059S0011 (52,000 μg/kg) and 059S0012 (5,100 μg/kg), and soil boring 059S02LS (46,000 μg/kg) exceeded the residential RBC (1,825 μg/kg) and SSL (2,000 μg/kg) for chlordane. The industrial RBC for chlordane (16,352 μg/kg) was also exceeded by the surface soil samples from hand auger location 059S0011 and soil boring 059S02LS. The SSL for chlordane was also exceeded by the technical chlordane concentration in the 3- to 5-foot bls subsurface soil sample from DPT location 059S0007 (3,200 μg/kg).

4,4'-DDD's SSL (700 μg/kg) was exceeded by the surface soil sample from soil boring 059S02LS (850 μg/kg).

4,4'-DDE's residential RBC (1,900 μg/kg) and SSL (500 μg/kg) were exceeded by surface soil samples from hand auger location 059S0012 (2,300 μg/kg) and soil boring 059S02LS (2,500 μg/kg). The hand auger surface soil sample from location 059S0011 (1,300 μg/kg) also exceeded the SSL.

4,4'-DDT's residential RBC (1,900 μg/kg) and SSL (1,000 μg/kg) were exceeded by the surface soil sample from hand auger location 059S0012 (4,000 μg/kg). The surface soil samples from hand auger location 059S0011 (1,300 μg/kg) and soil boring 059S02LS (1,700 μg/kg) also exceeded the SSL.

Dieldrin's residential RBC (40 μg/kg) and SSL (1 μg/kg) were exceeded in surface soil samples from DPT locations 059S0002 (650 μg/kg) and 059S0003 (190 μg/kg), hand auger locations 059S0011 (1,800 μg/kg) and 059S0012 (750 μg/kg), and soil boring location 059S02LS (1,200 μg/kg). The surface soil samples from DPT location 059S0002, hand auger locations 059S0011 and 059S0012, and soil boring 059S02LS also exceeded the industrial RBC (360 μg/kg). The SSL was also exceeded by the surface soil sample from DPT location 059S0007 (18 μg/kg), the 3- to 5-foot bls subsurface soil samples from DPT locations 059S0002 (150 μg/kg) and 059S0007 (25 μg/kg), and the 4- to 6-foot bls (3.4 μg/kg) and 10- to 12-foot bls interval (2.8 μg/kg) soil samples from soil boring 059S02LS.

Heptachlor's residential RBC (140 μg/kg) and SSL (60 μg/kg) were exceeded in surface soil samples from hand auger location 059S0011 (310 μg/kg) and soil boring 059S02LS (3,900 μg/kg). The industrial RBC (1,300 μg/kg) was also exceeded by the surface soil sample from soil boring 059S02LS. The SSL was exceeded by the surface soil sample (99 μg/kg) and 3- to 5-foot bls subsurface soil sample (74 μg/kg) from DPT location 059S0007.

Heptachlor epoxide's residential RBC (70 μg/kg) and SSL (30 μg/kg) were both exceeded in surface soil samples from DPT location 059S0007 (140 μg/kg), hand auger location 059S0011 (800 μg/kg), and soil boring 059S02LS (2,200 μg/kg). The industrial RBC (630 μg/kg) was also exceeded by the surface soil samples from hand auger location 059S0011 and soil boring 059S02LS. The SSL was also exceeded in 3- to 5-foot bls soil sample from DPT location 059S0007 (160 μg/kg).

The only PCB detected in SWMU 59 soil samples was Aroclor-1260. Detected concentrations of Aroclor-1260 in the hand auger surface soil sample from location 059S0012 (5,400 μg/kg) exceeded both the residential and industrial RBCs (320 μg/kg and 2,850 μg/kg, respectively).

Herbicides in Soil

The DPT soil samples were not analyzed for herbicides. The following herbicides were detected in hand auger or soil boring samples:

2,4-D	Dichlorprop
2,4-DB	Dinoseb
2,4,5-T	MCPA
Dicamba	

Herbicide concentrations in soil samples did not exceed either the residential RBCs or SSLs (where available). Tables 8.5.3 and 8.5.4 summarize the herbicides detected in soil from the hand auger and soil boring samples, respectively.

8.5.3.1.2 Inorganics in Soil Samples

The DPT soil samples were not analyzed for inorganics. The following inorganics were detected in hand auger or soil boring samples:

Arsenic	Mercury
Barium	Nickel
Beryllium	Selenium
Cadmium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc
Lead	

Tables 8.5.5 and 8.5.6 summarize the detected inorganics in hand auger and soil boring samples collected during the RFI. As shown on the tables, the only inorganics that exceeded both their RCs and RBCs or SSLs were arsenic, lead, and nickel. Figure 8.5.3 shows the inorganics in exceedance of their RCs and SSLs and Figure 8.5.4 shows the inorganics in exceedance of their RCs and RBCs. Exceedances are discussed by analyte in the following paragraphs.

Arsenic's surface soil RC (14.58 mg/kg), residential RBC (0.43 mg/kg), industrial RBC (3.8 mg/kg), and SSL (15 mg/kg) all were exceeded in surface soil samples from hand auger locations 059S0011 (15.3 mg/kg) and 059S0012 (27 mg/kg).

Lead, which has no RBC or SSL, was compared to its surface soil RC (26.03 mg/kg) and the USEPA residential and industrial soil cleanup goals of 400 mg/kg and 1,300 mg/kg (USEPA, 1994c). Concentrations of lead in surface soil samples from hand auger locations 059S0011 (625 mg/kg) and 059S0012 (521 mg/kg) exceeded both the surface soil RC and the USEPA residential soil cleanup goal.

Nickel's subsurface RC (nondetect) and SSL (21 mg/kg) were both exceeded in the 10- to 12-foot bls soil sample from soil boring location 059S02LS (27.8 mg/kg).

8.5.3.2 Nature and Extent of Groundwater Contamination

As discussed in Section 4, groundwater sample results were compared to the tap water RBCs (USEPA, 1996a) and the MCLs listed in *Drinking Water Regulations and Health Advisories* (USEPA, 1996c). Inorganics detected in groundwater are also compared to the RCs established in the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a). The one DPT groundwater sample was only analyzed for VOCs. The groundwater samples from monitoring wells were analyzed for FSA.

8.5.3.2.1 Organic Compounds in Groundwater Samples

VOCs, SVOCs, TPH-DRO, and pesticides were detected in the Assembly E SWMU 59 groundwater samples. The following sections summarize the detected concentrations by parameter.

VOCs in Groundwater

No VOCs were detected in the one DPT groundwater sample. Acetone, the only VOC identified in monitoring wells during the RFI, was detected in loess monitoring well 059G01LS (93 μg/L). This concentration did not exceed the tap water RBC (3,700 μg/L), and no MCL is available for this compound. Table 8.5.7 summarizes the VOC detections in groundwater samples from monitoring wells.

SVOCs in Groundwater

Two SVOCs were detected in loess monitoring wells, bis(2-Ethylhexyl)phthalate (BEHP) in well 059G01LS (1 μg/L) and diethylphthalate in well 059G03LS (3 μg/L); however, neither SVOC exceeded its tap water RBC, and no MCL is available for either compound. Table 8.5.7 summarizes the detected SVOC concentrations in groundwater samples.

Table 8.5.5
Detected Concentrations of Inorganics in Hand Auger Surface Soil Samples
SWMU 59 – S-335 Old Pesticide Shop
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	Reference Concentration[f]	RC Exceedances	SSL[e]	SSL Exceedances
Arsenic	0 - 6"	2/2	15.3 - 27	21	0.43	2 (059S0011, 059S0012)	3.8	2 (059S0011, 059S0012)	14.58	2 (059S0011, 059S0012)	15	2 (059S0011, 059S0012)
Barium	0 - 6"	2/2	95.2 - 147	121	5,500	0	140,000	0	223.46	0	32	2 (059S0011, 059S0012)
Beryllium	0 - 6"	2/2	0.55 - 0.6	0.6	0.15	2 (059S0011, 059S0012)	1.3	0	1.0	0	180	0
Cadmium	0 - 6"	2/2	1.6 - 2.3	2	39	0	1,000	0	1.54	2 (059S0011, 059S0012)	6	0
Chromium	0 - 6"	2/2	23.2 - 40	32	390	0	10,000	0	23.89	1 (059S0011)	–[g]	–
Cobalt	0 - 6"	2/2	6.5 - 6.9	6.7	4,700	0	120,000	0	15.98	0	–	–
Copper	0 - 6"	2/2	46.2 - 73.5	59.9	3,100	0	82,000	0	24.19	2 (059S0011, 059S0012)	–	–
Lead	0 - 6"	2/2	521 - 625	573	400[h]	2 (059S0011, 059S0012)	1,300[h]	0	26.03	2 (059S0011, 059S0012)	–	–
Mercury	0 - 6"	2/2	0.35 - 0.54	0.45	23	0	610	0	0.46	1 (059S0011)	3	0
Nickel	0 - 6"	2/2	5.3 - 6.3	5.8	1,600	0	41,000	0	20.62	0	21	0
Tin	0 - 6"	1/2	7.9	7.9	47,000	0	1,000,000	0	33.56	0	–	–
Vanadium	0 - 6"	2/2	21.9 - 23.1	22.5	550	0	14,000	0	45.11	0	–	–
Zinc	0 - 6"	2/2	285 - 326	306	23000	0	610,000	0	98	2 (059S0011, 059S0012)	42,000	0

Notes:

a — Two hand-auger surface soil samples were collected from 0 to 6 inches below land surface. One of the samples was split as a duplicate. The samples were analyzed by the offsite laboratory for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval shown is in inches below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) and soil-to-groundwater soil screening levels (SSLs) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Reference concentration (RC) is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to the *Technical Memorandum – Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

g — denotes SSL is not available for this analyte; therefore, no comparison can be made.

h — No RBC exists for lead; the soil screening values for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 (USEPA 1994c) are used for comparison.

Table 8.5.6
Detected Concentrations of Inorganics in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	Reference Concentration[f]	RC Exceedances	SSL[e]	SSL Exceedances
Arsenic	0 - 2	3/3	3.3 - 9.7	6.7	0.43	3 (059S01LS, 059S02LS, 059S03LS)	3.8	2 (059S02LS, 059S03LS)	14.58	0	15	0
	4 - 8	3/3	6 - 10.4	8	NA[g]	NA	NA	NA	20.32	0	15	0
	10 - 12	3/3	6.8 - 17.2	12.3	NA	NA	NA	NA	20.32	0	15	1 (059S01LS)
Barium	0 - 2	3/3	62.4 - 113	89	5,500	0	140,000	0	223.46	0	32	3 (059S01LS, 059S02LS, 059S03LS)
	4 - 8	3/3	81.5 - 166	110	NA	NA	NA	NA	265.12	0	32	3 (059S01LS, 059S02LS, 059S03LS)
	10 - 12	3/3	63.5 - 220	157	NA	NA	NA	NA	265.12	0	32	3 (059S01LS, 059S02LS, 059S03LS)
Beryllium	0 - 2	3/3	0.43 - 0.52	0.48	0.15	3 (059S01LS, 059S02LS, 059S03LS)	1.3	0	1.0	0	180	0
	4 - 8	3/3	0.42 - 0.56	0.50	NA	NA	NA	NA	1.0	0	180	0
	10 - 12	3/3	0.35 - 0.68	0.56	NA	NA	NA	NA	1.0	0	180	0
Cadmium	0 - 2	3/3	1.0 - 1.8	1.4	39	0	1,000	0	1.54	1 (059S02LS)	6	0
	4 - 8	3/3	1.1 - 1.6	1.4	NA	NA	NA	NA	3.24	0	6	0
	10 - 12	3/3	0.84 - 2.3	1.7	NA	NA	NA	NA	3.24	0	6	0
Chromium	0 - 2	3/3	9.8 - 15.3	12.1	390	0	10,000	0	23.89	0	–[h]	–
	4 - 8	3/3	6.3 - 12.8	9.9	NA	NA	NA	NA	28.28	0	–	–
	10 - 12	3/3	9 - 17.3	13	NA	NA	NA	NA	28.28	0	–	–
Cobalt	0 - 2	3/3	6.2 - 9.8	7.7	4,700	0	120,000	0	15.98	0	–	–
	4 - 8	3/3	7 - 8.8	8	NA	NA	NA	NA	14.36	0	–	–
	10 - 12	3/3	6.6 - 12	10	NA	NA	NA	NA	14.36	0	–	–

Table 8.5.6
Detected Concentrations of Inorganics in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	Reference Concentration[f]	RC Exceedances	SSL[e]	SSL Exceedances
Copper	1 - 2	1/3	25.1	25.1	3,100	0	82,000	0	24.19	1 (059S02LS)	–	–
	4 - 6	1/3	20.2	20.2	NA	NA	NA	NA	32.52	0	–	–
	10 - 12	1/3	22.6	22.6	NA	NA	NA	NA	32.52	0	–	–
Lead	0 - 2	3/3	12.3 - 151	89	400[f]	0	1,300[f]	0	26.03	2 (059S01LS, 059S02LS)	–	–
	4 - 8	3/3	11.1 - 14.8	13.1	NA	NA	NA	NA	19.8	0	–	–
	10 - 12	4/4	8.3 - 14.8	11.8	NA	NA	NA	NA	19.8	0	–	–
Nickel	0 - 2	3/3	9.4 - 14.6	11.6	1,600	0	41,000	0	20.62	0	21	0
	4 - 8	3/3	10.2 - 14.6	13.0	NA	NA	NA	NA	ND[f]	3 (059S01LS, 059S02LS, 059S03LS)	21	0
	10 - 12	3/3	12.2 - 27.8	19.4	NA	NA	NA	NA	ND[f]	3 (059S01LS, 059S02LS, 059S03LS)	21	1 (059S02LS)
Selenium	0 - 2	2/3	0.31 - 0.32	0.32	390	0	10,000	0	ND[f]	2 (059S02LS, 059S03LS)	3	0
	4 - 8	2/3	0.31 - 0.38	0.35	NA	NA	NA	NA	ND[f]	2 (059S01LS, 059S02LS)	3	0
	10 - 12	2/3	0.26 - 0.35	0.31	NA	NA	NA	NA	ND[f]	2 (059S01LS, 059S03LS)	3	0
Silver	1 - 2	1/3	4	4	390	0	10,000	0	2.05	1 (059S03LS)	–	–
Tin	0 - 2	3/3	21.7 - 27.9	25.5	47000	0	1,000,000	0	33.56	0	–	–
	4 - 8	3/3	17.8 - 31.4	25.0	NA	NA	NA	NA	ND	3 (059S01LS, 059S02LS, 059S03LS)	–	–
	10 - 12	3/3	21.2 - 33	27	NA	NA	NA	NA	ND	3 (059S01LS, 059S02LS, 059S03LS)	–	–
Vanadium	0 - 2	3/3	16.6 - 27.3	21.2	550	0	14,000	0	45.11	0	–	–
	4 - 8	3/3	18 - 27	23	NA	NA	NA	NA	43.68	0	–	–
	10 - 12	3/3	17 - 29.1	24	NA	NA	NA	NA	43.68	0	–	–

Table 8.5.6
Detected Concentrations of Inorganics in Soil Samples from Soil Borings
SWMU 59 – S-335 Old Pesticide Shop
(data in mg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	Reference Concentration[f]	RC Exceedances	SSL[e]	SSL Exceedances
Zinc	0 - 2	2/3	49.5 - 102	76	23000	0	610,000	0	98	1 (059S02LS)	42,000	0
	4 - 8	3/3	38.3 - 58.8	51.3	NA	NA	NA	NA	109	0	42,000	0
	10 - 12	3/3	40.5 - 79.9	62.2	NA	NA	NA	NA	109	0	42,000	0

Notes:

a — Nine soil samples were collected; three from each loess soil boring location. The surface sample interval was 1 to 2 feet bls (exclusive of asphalt) for soil borings 059S01LS and 059S03LS, and 0 to 2 feet for soil boring 059S02LS. Subsurface soil samples were collected from soil boring 059S01LS from the 6 to 8 feet bls (due to poor sample recovery in the 4- to 6-foot interval) and 10 to 12 feet bls intervals. Subsurface soil samples were collected from the 4 to 6-foot and 10- to 12-foot intervals at soil boring locations 059S02LS and 059S03LS. One of the 10- to 12-foot interval soil samples was split for duplicate analysis. The samples were analyzed by NET for VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval shown in feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) and soil-to-groundwater soil screening levels (SSLs) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to surface soil samples; SSLs apply to both surface and subsurface soil samples.

f — Reference concentration (RC) is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to the *Technical Memorandum – Reference Concentrations* (E/A&H 1996a) for background reference concentration calculations.

g — NA denotes RBC comparison is not applicable for this subsurface sample.

h — denotes risk-based data not available for this analyte; therefore, no comparison can be made.

i — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from OSWER Directive 9355.4-12 (USEPA 1994c) are used for comparison.

j — ND denotes the indicated analyte was not detected in background samples.

Table 8.5.7
Detected Concentrations of Organic Compounds in Groundwater Samples from Monitoring Wells
SWMU 59 – Building S-335 Old Pesticide Shop
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances
VOCs								
Acetone	LS	1/3	93	93	3,700	0	--[g]	--
SVOCs								
Bis(2-ethylhexyl)phthalate (BEHP)	LS	1/3	1	1	4.8	0	--	--
Diethylphthalate	LS	1/3	3	3	29,000	0	--	--
Total Petroleum Hydrocarbons								
TPH - DRO	LS	1/3	160	160	100[h]	1 (059G02LS)	--	--
Pesticides								
alpha-Chlordane	LS	1/3	0.085	0.085	0.192	0	2	0
gamma-Chlordane	LS	1/3	0.12	0.12	0.192	0	2	0
Technical chlordane	LS	1/3	1.1	1.1	0.192	1 (059G02LS)	2	0
Dieldrin	LS	1/3	0.052	0.052	0.0042	1 (059G02LS)	--	--
Heptachlor	LS	1/3	0.069	0.069	0.0023	1 (059G02LS)	0.4	0
Heptachlor epoxide	LS	1/3	0.19	0.19	0.0012	1 (059G02LS)	0.2	0

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from three loess monitoring wells and one upper fluvial deposits monitoring well and analyzed by NET for VOCs, SVOCs, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval refers to the lithologic unit within the screened interval of the monitoring well. LS = loess groundwater. No organic compounds were detected in the upper fluvial deposits groundwater sample.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Tap water RBCs obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels (MCLs) in drinking water obtained from *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — denotes MCL is not available for this analyte; therefore, no comparison can be made.

h — No RBC or MCL exists for TPH. The TDEC groundwater cleanup standard of 100 μg/L for drinking water aquifers has been used for comparison. The TDEC cleanup standard is from *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

TPH-DRO in Groundwater

As previously mentioned, monitoring well samples were not tested for TPH-GRO because many of the lighter fraction hydrocarbons of interest would be identified in the TICs from the VOC analyses. No tap water RBC or MCL is available for TPH; therefore, the TDEC cleanup standard of 100 μg/L for drinking water (TDEC, 1997) was compared to detected concentrations of TPH-DRO in groundwater samples from monitoring wells.

As shown on Table 8.5.7, TPH-DRO was detected in only one loess monitoring well at a concentration of 160 μg/L (059G02LS), which exceeds the TDEC cleanup standard for total TPH in drinking water.

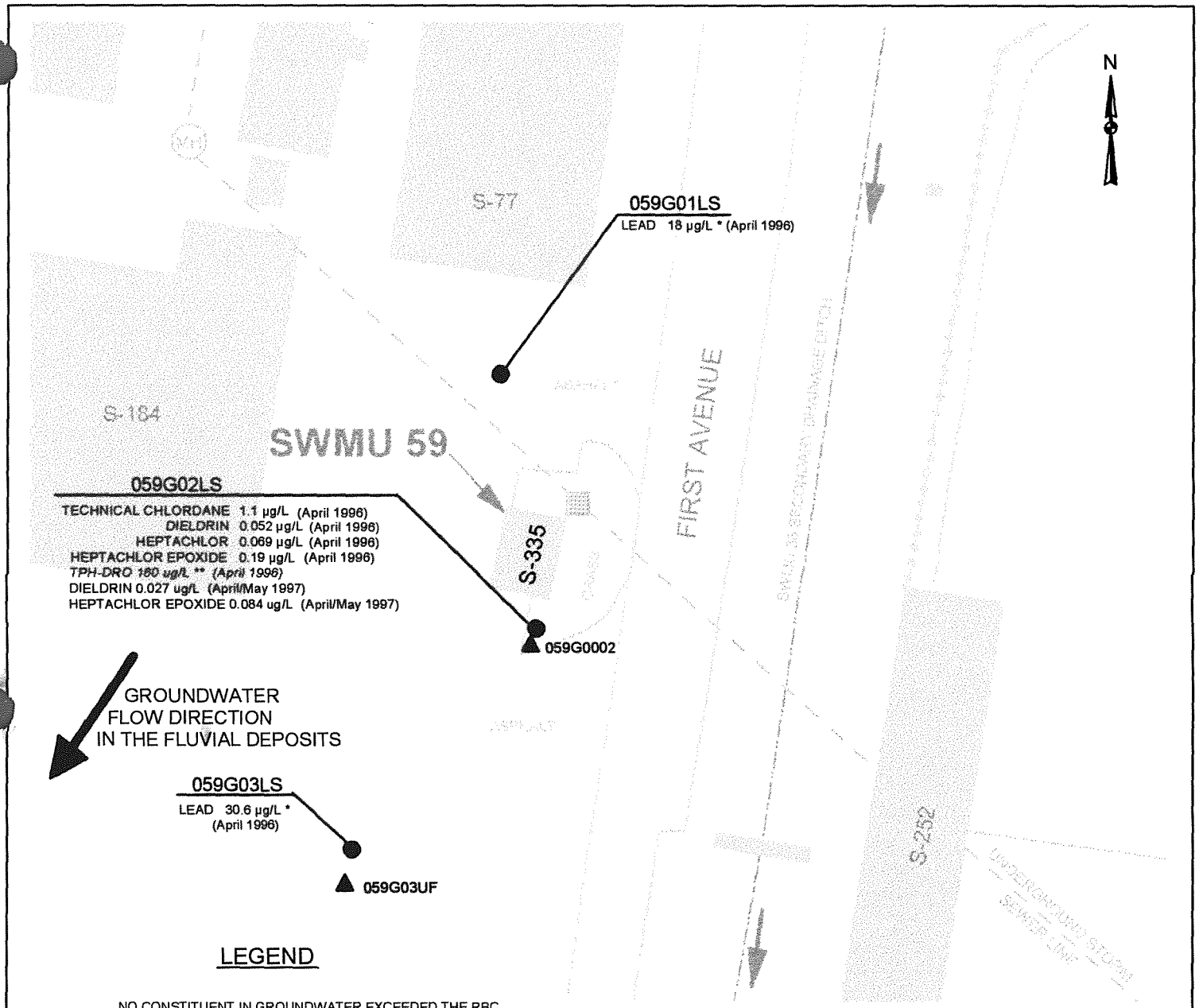
Pesticides, PCBs, and Herbicides in Groundwater

No PCBs, organophosphorus pesticides, or herbicides were detected in monitoring well samples. The following chlorinated pesticides were detected in monitoring well samples:

alpha-Chlordane	Dieldrin
gamma-Chlordane	Heptachlor
Technical chlordane	Heptachlor epoxide

As shown on Table 8.5.7, several of the detected pesticides exceeded their tap water RBCs in loess monitoring well 059G02LS; however, none of the pesticides exceeded its MCL, where one was available. Figure 8.5.5 plots the tap water RBC exceedances. The following summarizes the pesticides that exceeded their tap water RBC.

The *technical chlordane* concentration in the groundwater sample from loess monitoring well 059G02LS (1.1 μg/L) exceeded the tap water RBC for chlordane (0.192 μg/L), but not the MCL for chlordane (2 μg/L).



LEGEND

▲ NO CONSTITUENT IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

059G0002 DPT GROUNDWATER SAMPLE DESIGNATION

059G03LS MONITORING WELL GROUNDWATER SAMPLE DESIGNATION

059G03LS
LEAD 30.6 µg/L *
THE GROUNDWATER SAMPLE FROM MONITORING WELL 059G03LS CONTAINED THE FOLLOWING CONSTITUENT THAT EXCEEDED ONE OR MORE APPLICABLE COMPARISON VALUES: 30.6 µg/L LEAD.

µg/L MICROGRAMS PER LITER

NOTES:

** NO RBC IS AVAILABLE FOR LEAD; THE USEPA TREATMENT TECHNIQUE ACTION LEVEL OF 15 µg/L IS USED FOR COMPARISON (USEPA DRINKING WATER REGULATIONS AND HEALTH ADVISORIES, OCTOBER 1996).*

*** TPH-DRO CONCENTRATION EXCEEDS THE TDEC CLEANUP STANDARD OF 100 ug/L FOR TOTAL TPH IN DRINKING WATER AQUIFERS (TDEC, 1997).*

50 0 50 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.5.5
RBC AND TOTAL TPH EXCEEDANCES
IN GROUNDWATER SAMPLES
SWMU 59 - S-335 OLD PESTICIDE SHOP

Dieldrin's tap water RBC (0.0042 μg/L) was exceeded by the detected dieldrin concentration in the groundwater sample from loess monitoring well 059G02LS (0.052 μg/L). No MCL is available for dieldrin.

Heptachlor's tap water RBC (0.0023 μg/L) was exceeded in the groundwater sample from loess monitoring well 059G02LS (0.069 μg/L). The MCL (0.4 μg/L) was not exceeded.

Heptachlor epoxide's tap water RBC (0.0012 μg/L) was exceeded in the groundwater sample from loess monitoring well 059G02LS (0.19 μg/L). The MCL (0.2 μg/L) was not exceeded.

8.5.3.2.2 Inorganics in Groundwater Samples

The following inorganics were detected in monitoring well samples:

Arsenic	Mercury
Barium	Nickel
Beryllium	Tin
Chromium	Vanadium
Cobalt	Zinc
Lead	

No inorganic was detected in groundwater that exceeded both its RC and tap water RBC or MCL for drinking water. However, lead, which does not have a tap water RBC or MCL, was screened by comparing concentrations to its RC and the USEPA TTAL (15 μg/L). Lead concentrations in groundwater samples from loess monitoring wells 059G01LS (18 μg/L) and 059G03LS (30.6 μg/L) exceeded both the loess groundwater RC (17.5 μg/L) and the TTAL. Table 8.5.8 summarizes the inorganic constituents detected in groundwater samples and Figure 8.5.5 plots the lead concentrations that exceeded both the RC and TTAL.

Table 8.5.8
Detected Concentrations of Inorganics in Groundwater Samples from Monitoring Wells
SWMU 59 – S-335 Old Pesticide Shop
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances	Reference Concentration[g]	RC Exceedances
Arsenic	LS	3/3	2.3 - 7.2	4.2	0.045	3 (059G01LS, 059G02LS, 059G03LS)	50	0	7.32	0
Barium	LS	3/3	263 - 463	390	2,600	0	2,000	0	442	2 (059G01LS, 059G03LS)
	UF	1/1	203	203	2,600	0	2,000	0	232	0
Beryllium	LS	1/3	1.3	1.3	0.016	1 (059G03LS)	4	0	1.3	0
Chromium	LS	3/3	27.2 - 42.2	35.3	180	0	100	0	239	0
	UF	1/1	11.1	11.1	180	0	100	0	39.8	0
Cobalt	LS	3/3	13.6 - 37.7	27.5	2,200	0	–[h]	–	17.8	2 (059G01LS, 059G03LS)
Lead	LS	3/3	16.5 - 30.6	21.7	15[i]	3 (059G01LS, 059G02LS, 059G03LS)	–	–	17.5	2 (059G01LS, 059G03LS)
Mercury	LS	1/3	0.21	0.21	11	0	2	0	0.24	0
Nickel	LS	3/3	43.6 - 55.2	50.6	730	0	100	0	173.5	0
Tin	LS	1/3	64.7	64.7	22,000	0	–	–	ND[j]	1 (059G03LS)
Vanadium	LS	3/3	14.9 - 46.8	27	260	0	–	–	40.9	1 (059G03LS)
Zinc	LS	3/3	51.2 - 128	79	11,000	0	5,000	0	154.6	0

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from three loess monitoring wells and one upper fluvial monitoring well and analyzed by NET for VOCs, SVOCs, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval refers to the lithologic unit within the screened interval of the monitoring well. LS = loess groundwater; UF = upper fluvial deposits groundwater.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Tap water RBCs obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels (MCLs) in drinking water obtained from *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — Reference concentration (RC) is two times the mean background concentration. Analytical data from two sampling events of 4 loess monitoring wells and 13 fluvial monitoring wells were used to establish background concentrations. Refer to the *Technical Memorandum – Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

h — denotes risk-based data or background reference concentrations are not available for this analyte; therefore, no comparison can be made.

i — Lead does not have an RBC or MCL; therefore, the USEPA treatment technique action level of 15 μg/L has been substituted for screening purposes (USEPA, 1996c).

j — ND denotes the indicated analyte was not detected in the background samples.

8.5.3.2.3 Groundwater Samples From the April/May 1997 Sampling Event

The three loess and one upper fluvial deposits groundwater monitoring wells installed at SWMU 59 were sampled during the April/May 1997 groundwater sampling event and submitted to an offsite laboratory for analysis of chlorinated pesticides/PCBs and VOCs.

The only VOC detected in groundwater samples from SWMU 59 monitoring wells was methylene chloride in loess well 059G03LS at a concentration of 1.0 μg/L, which was below both its tap water RBC (4.1 μg/L) and MCL (5 μg/L).

No PCBs were identified in any of the groundwater samples and the only chlorinated pesticides detected were in loess well 059G02LS. The groundwater sample from loess well 059G02LS indicated dieldrin at a concentration of 0.027 μg/L, which was above its tap water RBC (0.0042 μg/L), and heptachlor epoxide at a concentration of 0.084 μg/L, which was above its tap water RBC (0.0012 μg/L) but below its MCL (0.2 μg/L). No MCL is available for dieldrin. Figure 8.5.5 plots the tap water RBC exceedances.

8.5.3.3 Nature and Extent of Sediment Contamination

As part of the SWMU 38 RFI, two sediment samples were collected southeast of SWMU 59 near the outfall of the underground storm sewer line leading from the grassy area adjacent to Building S-335 to the SWMU 38 secondary drainage ditch. The sediment samples were collected from the 0- to 6-inch interval and the 18- to 24-inch interval at SWMU 38 sample location 38SM0016 (refer to Figure 8.4.1 within the tabbed section for SWMU 38 [Section 8]). The sediment samples were collected with a stainless-steel hand auger and analyzed by NET for FSA.

As outlined in the SWMU 38 RFI (Section 8.4), SSVs were exceeded by the following analytes in the surface sediment sample from location 38SM0016: Aroclor-1260, 4,4'-DDD, 4,4'-DDE,

arsenic, cadmium, copper, lead, and nickel. The SSV exceedances are plotted on Figure 8.4.2 (Section 8.4). The SSV exceedances are listed below, along with their applicable SSV values.

Analyte	Concentration	SSV
Aroclor-1260	290 μg/kg	33 μg/kg
4,4'-DDD	56 μg/kg	3.3 μg/kg
4,4'-DDE	23 μg/kg	3.3 μg/kg
Cadmium	5.3 mg/kg	1 mg/kg
Copper	27.1 mg/kg	18.7 mg/kg
Lead	39.4 mg/kg	30.2 mg/kg
Nickel	17.5 mg/kg	15.9 mg/kg

No contaminant in the surface sediment sample from location 38SM0016 exceeded both the RC for surface soil and the residential RBC or SSL, as shown on Figure 8.4.3 in the SWMU 38 RFI (Section 8.4). No contaminant in subsurface sediment exceeded both the RC for subsurface soil and the SSL, as shown on Figure 8.4.4 in the SWMU 38 RFI (Section 8.4).

Concentrations in surface and subsurface sediment from location 38SM0016 do not definitively indicate storm water runoff from SWMU 59 is responsible for the detected concentrations in the SWMU 38 sediment drainage ditch, nor do the sediment samples collected downstream of SWMU 59 (locations 38SM0011 and 38SM0010). No sediment samples were collected in the secondary drainage ditch upstream (north) of location 38SM0016. Note that other sediment samples from the SWMU 38 drainage ditches upgradient (north) of SWMU 59 exhibit higher concentrations of 4,4'-DDD (location 38SM0002, 280 μg/kg), 4,4'-DDE (location 38SM0002, 79 μg/kg), Aroclor-1260 (location 38SM0025, 1,900 μg/kg), or lead (location 38SM0001, 96.9 mg/kg) than were detected in sample 38SM0016.

8.5.4 Human Health Risk Assessment for SWMU 59

8.5.4.1 Site Background and Investigative Approach

SWMU 59 consists of Building S-335 and the surrounding area. This human health risk assessment (HHRA) uses analytical data from 15 surface soil samples, three loess groundwater samples, one DPT fluvial deposits groundwater sample, and one fluvial deposits groundwater monitoring well sample. Soil and groundwater samples used in this HHRA are listed below. A Voluntary Corrective Action Work Plan has been prepared for SWMU 59 and specifies the removal of Building S-335, the asphalt flooring, and contaminated soil under the building and in the grassy area surrounding the building.

- **Surface Soil** 059S000102 059S000202 059S000302 059S000402 059S000502 059S000602 059S000702 059S000802 059S000902 059S001002 059S001102 059S001202 059S01LS02 059S02LS02 059S03LS02
- **Loess Groundwater** 059G01LS01 059G02LS01 059G03LS01
- **Fluvial Groundwater** 059G03UF01 059S0002 (DPT)

8.5.4.2 COPC Identification

Surface Soil

Table 8.5.9 lists chemicals present in site samples (CPSSs) in surface soil with chemicals of potential concern (COPCs) labeled with an asterisk. COPCs are any chemical that exceed RBCs and where applicable RCs. COPCs in surface soil at SWMU 59 include 4,4'-DDE, 4,4'-DDT, aldrin, alpha-chlordane, Aroclor-1260, arsenic, BEQ, gamma-chlordane, dieldrin, heptachlor, heptachlor epoxide, lead, and 2-methyl-4-chlorophenoxyacetic acid (MCPA).

Table 8.5.9
Chemicals Present in Surface Soil Samples
SWMU 59 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetects	Range of Detected Concentration	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
2,4,5-T	µg/kg	1/5	0.95 — 1.1	1.5 — 1.5	2	78,000	a, n	0	NA	NA
2,4-D	µg/kg	4/5	9.4 — 9.4	12 — 25	20	78,000	a, n	0	NA	NA
2,4-DB	µg/kg	1/5	9.5 — 11	16 — 16	16	63,000	a, n	0	NA	NA
2-Butanone -MEK	µg/kg	1/15	11 — 1,600	7 — 7	7	4,700,000	a, n	0	NA	NA
4,4'-DDD	µg/kg	5/15	4.2 — 410	4.8 — 850	361	2,700	a, c	0	NA	NA
* 4,4'-DDE	µg/kg	9/15	4.2 — 200	12 — 2,500	769	1,900	a, c	2	NA	NA
* 4,4'-DDT	µg/kg	8/15	4.2 — 200	7.2 — 4,000	930	1,900	a, c	1	NA	NA
Acetone	µg/kg	8/15	12 — 22,000	5 — 7,200	2,064	780,000	a, n	0	NA	NA
* Aldrin	µg/kg	2/15	2 — 200	140 — 840	490	38	a, c	2	NA	NA
* alpha-Chlordane (Chlordane)	µg/kg	6/15	2 — 100	19 — 6,500	2,163	1,825	a, c	1	NA	NA
Anthracene	µg/kg	1/5	390 — 4,400	47 — 47	47	2,300,000	a, n	0	NA	NA
* Aroclor-1260	µg/kg	2/15	39 — 2,200	210 — 5,400	2,805	320	a, c, f	1	NA	NA
* Arsenic	mg/kg	5/5	NA — NA	3.3 — 27	13	0.43	a, c	2	14.58	2
Barium	mg/kg	5/5	NA — NA	62.4 — 147	102	550	a, n	0	223.46	0
0 BEQ	µg/kg	3/5	390 — 420	397.3 — 1,231	881	88	a, c	3	565	1
Benzo(a)pyrene	µg/kg	3/5	390 — 420	280 — 950	670	88	a, c	3	NA	NA
Benzo(a)anthracene	µg/kg	3/5	390 — 420	220 — 760	563	880	a, c	0	NA	NA
Benzo(b)fluoranthene	µg/kg	3/5	390 — 420	300 — 1,200	780	880	a, c	1	NA	NA
Benzo(k)fluoranthene	µg/kg	3/5	390 — 420	330 — 1,100	743	8,800	a, c	0	NA	NA
Dibenz(a,h)anthracene	µg/kg	1/5	390 — 4,400	49 — 49	49	88	a, c	0	NA	NA
Indeno(1,2,3-c,d)pyrene	µg/kg	3/5	390 — 420	130 — 490	367	880	a, c	0	NA	NA
Benzo(g,h,i)perylene (Pyrene)	µg/kg	3/5	390 — 420	150 — 570	413	230,000	a, c	0	NA	NA
Beryllium	mg/kg	5/5	NA — NA	0.43 — 0.6	0.52	0.15	a, c	5	1	0
bis(2-Ethylhexyl)phthalate-BEHP	µg/kg	1/5	390 — 4,400	320 — 320	320	46,000	a, c	0	NA	NA
Cadmium	mg/kg	5/5	NA — NA	1 — 2.3	2	4	a, n	0	1.54	3
Carbon disulfide	µg/kg	2/15	11 — 1,600	2 — 2	2	780,000	a, n	0	NA	NA
Chromium	mg/kg	5/5	NA — NA	9.8 — 40	20	7,800	a, n	0	23.89	1
Cobalt	mg/kg	5/5	NA — NA	6.2 — 9.8	7.3	470	a, n	0	15.98	0

Table 8.5.9
Chemicals Present in Surface Soil Samples
SWMU 59 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetects	Range of Detected Concentration	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
Copper	mg/kg	3/5	9.5 — 15.4	25.1 — 73.5	48.3	310	a, n	0	24.19	3
Dicamba	µg/kg	1/5	0.94 — 1	12 — 12	12	230,000	a, n	0	NA	NA
Dichlorprop (4-(2,4-Dichloro-phenoxy)butyric Acid)	µg/kg	1/5	9.3 — 9.4	5.7 — 5.7	5.7	63,000	a, n	0	NA	NA
* Dieldrin	µg/kg	6/15	3.9 — 200	18 — 1,800	768	40	a, c	5	262	4
Dinoseb	µg/kg	1/5	4.6 — 5.3	3 — 3	3	7,800	a, n	0	NA	NA
Endrin aldehyde (Endrin)	µg/kg	2/15	3.9 — 410	58 — 260	159	2,300	a, n	0	NA	NA
Ethylbenzene	µg/kg	2/15	12 — 1,600	1 — 2	2	780,000	a, n	0	NA	NA
Fluoranthene	µg/kg	3/5	390 — 420	330 — 1,200	877	310,000	a, n	0	NA	NA
* gamma-Chlordane (Chlordane)	µg/kg	6/15	2 — 100	22 — 8,800	2904	1,825	a, c	3	NA	NA
* Heptachlor	µg/kg	3/15	2 — 200	99 — 3,900	1436	140	a, c	2	NA	NA
* Heptachlor epoxide	µg/kg	3/15	2 — 200	140 — 2,200	1047	70	a, c	2	NA	NA
* Lead	mg/kg	5/5	NA — NA	12.3 — 625	283	400	b	2	26.03	4
* MCPA	µg/kg	1/5	920 — 1,000	6,500 — 6,500	6,500	3,900	a, n	1	NA	NA
Mercury	mg/kg	2/5	0.11 — 0.13	0.35 — 0.54	0.45	2.3	a, n	0	0.46	1
Methylene Chloride	µg/kg	1/15	11 — 1,600	3 — 3	3	85,000	a, c	0	NA	NA
Nickel	mg/kg	5/5	NA — NA	5.3 — 14.6	9.3	160	a, n	0	20.62	0
Pentachlorophenol	µg/kg	1/5	980 — 11,000	2,600 — 2,600	2,600	5,300	a, c	0	NA	NA
Phenanthrene (Pyrene)	µg/kg	3/5	390 — 420	150 — 560	403	230,000	a, n	0	NA	NA
Pyrene	µg/kg	3/5	390 — 420	200 — 990	700	230,000	a, n	0	NA	NA
Selenium	µg/kg	2/5	0.23 — 0.26	0.31 — 0.32	0.32	39	a, n	0	NA	NA
Silver	mg/kg	1/5	0.69 — 0.79	4 — 4	4	39	a, n	0	2.05	1
Tetrachloroethene	µg/kg	1/15	12 — 1,600	6 — 6	6	12,000	a, c	0	NA	NA
Tin	mg/kg	4/5	4.8 — 5	7.9 — 27.9	21.1	4,700	a, n	0	33.56	0
Toluene	µg/kg	2/15	11 — 1,600	8 — 9	9	1,600,000	a, n	0	NA	NA
Vanadium	mg/kg	5/5	NA — NA	16.6 — 27.3	21.7	55	a, n	0	45.11	0

Table 8.5.9
Chemicals Present in Surface Soil Samples
SWMU 59 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetects	Range of Detected Concentration	Average Detected Concentration	Residential RBC	Notes	Number Over RBC	RC	Number Over RC
Xylene -Total	µg/kg	2/15	12 — 1,600	7 — 9	8	16,000,000	a, n	0	NA	NA
Zinc	mg/kg	4/5	23.7 — 23.7	49.5 — 326	191	2,300	a, n	0	98	3

Notes:

( )	—	Surrogate used
*	—	Identified as a chemical of potential concern
a	—	Screening based on *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a)
b	—	Screening based on 400 mg/kg of lead in soil (USEPA, 1994c)
BEQ	—	Benzo(a)pyrene Equivalent
c	—	Carcinogen
MCPA	—	2-methyl-4-chlorophenoxyacetic acid
n	—	Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA	—	Not Applicable
RC	—	Reference concentration from *Technical Memorandum - Reference Concentrations* (E/A&H, 1996a)
RBC	—	Risk Based Concentration

Loess Groundwater

Table 8.5.10 lists CPSS in loess groundwater with COPCs labeled with an asterisk. COPCs in loess groundwater at SWMU 59 include barium, dieldrin, heptachlor, heptachlor epoxide, lead, and vanadium. It should be noted that both chlordane isomers, barium, heptachlor, and heptachlor epoxide are below their respective MCLs.

Fluvial Deposits Groundwater

Table 8.5.11 lists CPSSs in fluvial deposits groundwater. There are no COPCs identified in fluvial deposits groundwater at SWMU 59.

8.5.4.3 Exposure Assessment

Exposure Setting

SWMU 59 is approximately 2,000 feet east of the nearest offsite residence and 80 feet south and east of the nearest NSA Memphis personnel at Buildings S-184 and S-77. The storm water from SWMU 59 discharges into SWMU 38, which in turn, discharges into Big Creek Drainage Canal approximately 1,400 feet south of Building S-335. Big Creek Drainage Canal may serve as a food and water source for various animals. SWMU 38 is made up of drainage ways in populated areas of NSA Memphis; therefore, personnel may contact surface water and sediment in these ditches (See Section 1.1.4). Off of NSA Memphis, the general public may contact surface water and sediment due to unrestricted access to Big Creek Drainage Canal. According to NSA Memphis personnel, no fishing or swimming occurs in Big Creek Drainage Canal, but children may play near this stream.

Potential Exposed Populations

Potential exposed populations are assumed to be hypothetical area residents and future site workers. The future use of this property is unknown, but it is likely to be used for commercial/industrial purposes. There are no plans for residential use.

Table 8.5.10
Chemicals Present in Loess Groundwater Samples
SWMU 59 NSA Memphis

Chemical		Frequency of Detection	Range of Nondetects	Range of Detected Concentration	Average Detected Concentration	Tap Water RBC	Notes	Number Over RBC	RC	Number Over RC
Acetone	µg/L	1/3	10 — 10	93 — 93	93	370	a, n	0	NA	NA
alpha-Chlordane (Chlordane)	µg/L	1/3	0.05 — 0.05	0.085 — 0.085	0.085	0.19	a, c, x	0	NA	NA
Arsenic	µg/L	3/3	NA — NA	2.3 — 7.2	4.2	0.045	a, c	3	7.32	0
* Barium	µg/L	3/3	NA — NA	263 — 463	390	260	a, n, t	3	442	2
Beryllium	µg/L	1/3	1 — 1	1.3 — 1.3	1.3	0.016	a, c	1	1.3	0
bis(2-Ethylhexyl)-phthalate-BEHP	µg/L	1/3	10 — 10	1 — 1	1	5	a, c	0	NA	NA
Chromium	µg/L	3/3	NA — NA	27.2 — 42.2	35.3	3700	a, n	3	239	0
Cobalt	µg/L	3/3	NA — NA	13.6 — 37.7	27.5	220	a, n	0	17.8	2
* Dieldrin	µg/L	1/3	0.1 — 0.1	0.052 — 0.052	0.052	0.0042	a, c	1	NA	NA
Diethylphthalate	µg/L	1/3	10 — 10	3 — 3	3	2,900	a, n	0	NA	NA
gamma-Chlordane (Chlordane)	µg/L	1/3	0.05 — 0.05	0.12 — 0.12	0.12	0.19	a, c, x	0	NA	NA
* Heptachlor	µg/L	1/3	0.05 — 0.05	0.069 — 0.069	0.069	0.0023	a, c, z	1	NA	NA
* Heptachlor epoxide	µg/L	1/3	0.05 — 0.05	0.19 — 0.19	0.19	0.0012	a, c, y	1	NA	NA
* Lead	µg/L	3/3	NA — NA	16.5 — 30.6	21.7	15	b	3	17.5	2
Mercury	µg/L	1/3	0.2 — 0.2	0.21 — 0.21	0.21	1.1	a, n	0	0.24	0
Nickel	µg/L	3/3	NA — NA	43.6 — 55.2	50.6	73	a, n	0	173.5	0
Tin	µg/L	1/3	45 — 45	64.7 — 64.7	64.7	2,200	a, n	0	NA	NA
* Vanadium	µg/L	3/3	NA — NA	14.9 — 46.8	27	26	a, n	1	40.9	1
Zinc	µg/L	3/3	NA — NA	51.2 — 128	79	1,100	a, n	0	154.6	0

Notes:
* — Identified as a chemical of potential concern
a — Screening based on *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a)
b — Screening based on treatment technique action level of 15 µg/L of lead in groundwater (USEPA, 1994c)
c — Carcinogen
n — Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA — Not Applicable
RC — Reference Concentration from *Technical Memorandum - Reference Concentrations* (E/A&H, 1996a)
RBC — Risk Based Concentration
ug/L — micrograms per liter of water
t — MCLS is 2000 mg/L (USEPA, 1994c)
x — MCLS is 2 mg/L (USEPA, 1994c)
y — MCLS is 0.2 mg/L (USEPA, 1994c)
z — MCLS is 0.4 mg/L (USEPA, 1994c)

Table 8.5.11
Chemicals Present in Fluvial Deposits Groundwater Samples
SWMU 59 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetects	Range of Detected Concentration	Average Detected Concentration	Tap Water RBC	Notes	Number Over RBC	RC	Number Over RC
Barium	µg/L	1/1	NA --- NA	203 --- 203	203	260	a, n	0	232	0
Chromium (III)	µg/L	1/1	NA --- NA	11.1 --- 11.1	11.1	3700	a, n	0	39.8	0

Notes:
* — Identified as a chemical of potential concern
a — Screening based on tap water RBCs from *Risk -Based Concentration Table, January to June 1996* (USEPA, 1996a)
n — Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
RC — Reference concentration from *Technical Memorandum - Reference Concentration* (E/A&H, 1996a).
RBC — Risk Based Concentration
mg/L — micrograms per liter of water

Exposure Pathways

Soil

Soil exposure pathways include incidental soil ingestion and dermal exposure for hypothetical residents and site workers. Table 8.5.12 lists exposure pathways, media, and land use assumptions.

Loess Groundwater

It is unlikely that the loess groundwater exposure pathway will be completed since there is an existing drinking water supply system at NSA Memphis. However, in this HHRA, it is assumed that hypothetical residents and future site workers could be exposed to chemicals via ingestion of groundwater. Inhalation of VOCs from groundwater was not considered a viable exposure pathway since significant VOC quantities were not identified. Uniform exposure at all sample locations with the exposure point concentration (EPC) set equal to the maximum detected concentration was assumed for all groundwater sample locations. This is quite conservative since groundwater is not used as a source for drinking water.

Table 8.5.12
Exposure Pathways Summary — SWMU 59
NSA Memphis Millington, Tennessee

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Hypothetical Residents			
	Air, inhalation of gaseous contaminants emanating from soil	No	No significant VOCs were identified in the RFI.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Shallow groundwater, ingestion of contaminants during potable or general use	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base-wide system supplies drinking water
	Shallow groundwater, inhalation of VOCs from the groundwater	No	There were no significant VOCs identified in the RFI.
	Soil, incidental ingestion	Yes	It is assumed that hypothetical residents would ingest incidental amounts of soil
	Soil, dermal contact	Yes	It is assumed that hypothetical residents would be dermally exposed to soil

Table 8.5.12
Exposure Pathways Summary — SWMU 59
NSA Memphis Millington, Tennessee

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Hypothetical Residents			
	Sediment, Incidental ingestion	No	No sediment is present
	Sediment, Dermal contact	No	No sediment is present
Hypothetical Site Workers			
	Air, inhalation of gaseous contaminants emanating from soil	No	No significant VOCs were identified in the RFI
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Shallow groundwater, ingestion of contaminants during potable or general use	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Shallow groundwater, inhalation of VOCs from the groundwater	No	There were no significant VOCs identified in the RFI.
	Soil, incidental ingestion	Yes	It is assumed that worker will ingest incidental amount of soil
	Soil, dermal contact	Yes	It is assumed that workers would be dermally exposed to soil
	Sediment, incidental ingestion	No	No sediment is present
	Sediment, dermal contact	No	No sediment is present
Construction Worker			
	Air, inhalation of gaseous contaminants emanating from soil	No	No significant amount of VOCs were identified in this HHRA.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Based on Tennessee law, it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Shallow groundwater, inhalation of VOCs from the groundwater	No	There were no significant VOCs identified in the RFI.
	Soil, incidental ingestion	Yes (Qualified)	It is assumed that a construction worker will ingest incidental amount of subsurface soil. This is discussed in the uncertainty Section 8.5.4.6.
	Soil, dermal contact	Yes (Qualified)	It is assumed that construction workers would be dermally exposed to subsurface soil. This is discussed in the Uncertainty Section 8.5.4.6.

Fluvial Deposits Groundwater

No COPCs were identified in fluvial deposits groundwater.

Exposure Point Concentrations

When more than 10 surface soil samples were analyzed, 95% Upper Confidence Levels (UCLs) were calculated. In accordance with USEPA Region IV's recommendations and Supplemental Guidance to RAGS (USEPA, 1995b), the lesser of the maximum reported concentration or the calculated UCL was the EPC for each COPC.

Soil

Table 8.5.13 lists the EPC estimates for the soil COPCs with a statistical analysis for each compound. All 15 soil samples were analyzed for pesticides and PCBs, but only five were analyzed for metals, VOCs, and SVOCs. The maximum concentrations were used as the EPC for all COPCs, except for aldrin and Aroclor-1260. The calculated UCL was used for the EPC for aldrin and Aroclor-1260. The fraction ingested/fraction contaminated (FI/FC) term was used to adjust the exposure based on the actual contaminated area. The development of each FI/FC term per COPC is discussed in the Spatial Distribution and Frequency of Detection in the Uncertainty Section (Section 8.5.4.6), which includes tables showing risk estimates without the FI/FC adjustment for comparison.

Loess Groundwater

Three loess groundwater samples were collected, and the EPC estimate was set equal to the maximum reported concentrations.

Table 8.5.13
Statistical Analysis of COPCs
Soil Surface Samples at SWMU 59 NSA Memphis

		Natural Log Transformed			95% UCL	MAX	EPC	EPC
COPC	n	mean	SD	H-stat	µg/kg	µg/kg	µg/kg	mg/kg
4,4'-DDE	15	3.56	2.78	6.13	161,049	2,500	2,500	2.5
4,4'-DDT	15	3.20	2.83	6.23	149,910	4,000	4,000	4.0
Aldrin	15	1.38	1.84	4.26	175.9	840	175.9	0.176
Alpha-Chlordane	15	3.01	3.20	6.98	1,321,225	6500	6500	6.5
Arsenic	5	NA	NA	NA	NA	27,000	27,000	27.0
Aroclor-1260	15	3.50	1.54	3.68	488.9	5,400	488.9	0.489
BEQ	5	NA	NA	NA	NA	1,231	1,231	1.2
Dieldrin	15	2.79	2.87	6.31	127,595	1,800	1,800	1.8
gamma-Chlordane	15	2.66	3.62	7.84	19,604,760	8,800	8,800	8.8
Heptachlor	15	1.24	2.66	5.89	7,937	3,900	3,900	3.9
Heptachlor epoxide	15	1.29	2.72	6.00	11,395	2,200	2,200	2.2
MCPA	5	NA	NA	NA	NA	6,500	6,500	6.5

Notes:
COPC — Chemical of Potential Concern
EPC — Exposure Point Concentration
H-stat — parameter from the H-stat statistical method
MAX — Maximum detected concentration
n — number of samples
NA — Not Applicable
SD — Standard Deviation

8.5.4.4 Toxicity Assessment

The USEPA has established a classification system for rating the potential carcinogenicity of environmental contaminants based on the weight of scientific evidence. The cancer classes are described below. Cancer weight-of-evidence class "A" (human carcinogens) means that human toxicological data have shown a proven correlation between exposure and the onset of cancer (in varying forms). The "B1" classification indicates some human exposure studies have implicated the compound as a probable carcinogen. Weight-of-evidence class "B2" indicates a possible human carcinogen, a description based on positive laboratory animal data (for carcinogenicity) in the absence of human data. Weight-of-evidence class "C" identifies possible human carcinogens,

and class "D" indicates a compound not classifiable with respect to its carcinogenic potential. Also the USEPA has established slope factors (SF) for carcinogenic compounds, which are defined as a "plausible upper-bound estimate of the probability of a response (cancer) per unit intake of a chemical over a lifetime" (USEPA, 1991b).

In addition to potential carcinogenic effects, most substances can also produce other toxic responses at doses greater than experimentally derived threshold concentrations. For these substances, the USEPA has established Reference Dose (RfD) values. A chronic RfD is defined as "... estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure concentration for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime." These toxicological values are used in risk formulae to assess the upper-bound level of cancer risk and noncancer hazard associated with exposure to a given contaminant concentration. Toxicological profiles of COPCs identified at SWMU 59 are presented below. Table 8.5.14 lists the SF and RfD values used in risk/hazard calculations.

Aldrin is a man-made insecticide widely used by farmers from the 1950s to the early 1970s. Aldrin was also used to treat soil and to kill termites. The main effects of short-term exposure of aldrin are headaches, dizziness, irritability, loss of appetite, nausea, muscle twitching, convulsions, and loss of consciousness and death. Most symptoms disappear with time after removal from exposure. The effects of long-term exposure to humans have not been clearly demonstrated. Aldrin fed to mice has caused liver cancer.

There is inconclusive evidence in humans, but more evidence in animals, that aldrin exposure of a pregnant mother may be associated with harm to the fetus. Aldrin is absorbed into the blood from the gastrointestinal tract, through the skin, or by inhalation. The percentage of an oral dose absorbed has not been accurately determined because of the enterohepatic circulation system. In

Table 8.5.14
Slope Factors and Reference Doses for COPCs at SWMU 59
NSA Memphis

COPC	RfD mg/kg-day	SF kg-day/mg	Cancer Class	Target Organ	Effect
Aldrin	0.00003	17.0	B2	Neuromuscular	Short-term exposure to high doses causes headaches, dizziness, irritability, loss of appetite, nausea, muscle twitching, convulsions, and loss of consciousness and death. The long-term exposure effects to humans have not been clearly demonstrated.
Aroclor-1260	0.00002	2.0	B2	Liver	Eye and lung irritation, loss of appetite, liver enlargement, rashes, decreased birth weight in heavily exposed mothers
Arsenic	0.0003	1.5	A	Skin, bladder, lung, CNS, and cardiovascular system	Soil ingestion can lead to skin cancer; water ingestion may lead to cancer in liver, kidney, lung, and bladder. Lung cancer can result from inhalation.
Barium	0.07	NA	---	Neuromuscular, CNS, and cardiovascular	Muscle stimulation, CNS, and heart effects
BEQ	NA	7.3	B2	Liver, kidney, and blood.	Some PAHs are toxic to the liver, kidney, and blood. The family of BEQ isomers has been shown to produce cancer in several species.
Alpha-chlordane	0.00006	1.3	B2	Neuromuscular	Short-term exposure to high doses of dieldrin causes tremors and convulsions; chronic exposure can cause emotional and neuromuscular disturbances
Gamma-chlordane	0.00006	1.3	B2	Neuromuscular	Short-term exposure to high doses of dieldrin causes tremors and convulsions; chronic exposure can cause emotional and neuromuscular disturbances.
4,4'-DDE	NA	0.34	B2	Liver	Liver Cancer
4,4-DDT	NA	0.34	B2	Liver	Liver Cancer
Dieldrin	0.00005	16	B2	Neuromuscular	Short-term exposure to high doses of dieldrin causes tremors and convulsions; chronic exposure can cause emotional and neuromuscular disturbances
Heptachlor	0.0005	4.5	B2	See chlordane; component of the insecticide chlordane	
Heptachlor epoxide	0.000013	9.1	B2	See chlordane; component of the insecticide chlordane	

Table 8.5.14
Slope Factors and Reference Doses for COPCs at SWMU 59
NSA Memphis

COPC	RfD mg/kg-day	SF kg-day/mg	Cancer Class	Target Organ	Effect
Lead	NA	NA	B2	No SF or RfD due to lead's properties	Effects are difficult to predict, but according to OSWER the cutoff effect is 400 mg/kg.
MCPA	0.0005	NA	-----	Inconclusive studies indicate it may be is a neurotoxin	Exposure can cause headaches, dizziness, nausea, vomiting, abdominal pains, diarrhea, respiratory complications, aching, and tender muscles, myotonia, weakness, and fatigue.
Vanadium	0.0005	NA	-----	Target organ is unclear	The primary focus of toxicological information is inhalation of vanadium dust.

Notes:
kg-day/mg — kilogram day per milligram
mg/kg-day — milligram per kilogram day
CNS — Central Nervous System

humans, 20% to 50% of inhaled aldrin is retained, and approximately 8% of a dermal dose of aldrin is absorbed (5 days). Aldrin, which rapidly converts to the epoxide dieldrin, is rarely found in the blood or tissues, because it is excreted primarily in the feces via the bile. In humans and animals, urinary excretion is minor. An oral reference dose for aldrin has been determined to be 3.00E-05 mg/kg-day based on a LOAEL of 0.5 ppm and an uncertainty factor of 1,000 in a hepatic effects study on rats. The modifying factor is 1. The cancar oral SF is 17.0 kg-day/mg, while the inhalation SF is 17.1 kg-day/mg (IRIS, 1996).

Arsenic exposure via the ingestion route darkens and hardens the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg-day as the RfD for arsenic based on a NOAEL of 0.0008 mg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans (as shown in IRIS). Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the SF at 1.5 kg-day/mg. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date 9/1/95), the critical effect of this chemical is hyper pigmentation, keratosis, and possibly vascular complications. The uncertainty factor is 3, while the modifying factor is 1.

Barium is used in various alloys, paints, soap, and manufacturing processes. Barium sulfate is used to aid x-ray diagnosis. This element is relatively abundant in nature and present in plant and animal tissue. Brazil nuts contain 3 to 4 mg of barium per gram. The fatal absorbed dose of

barium is approximately 1,000 mg for humans. Assuming an absorption efficiency of 5% for barium, 20,000 mg of ingested barium could be fatal. Major toxic effects are muscle stimulation, central nervous system effects, and effects on the heart. The major critical effect is increased blood pressure. USEPA has determined the oral RfD and inhalation RfD to be 0.07 and 1.43E-4 mg/kg-day, respectively (Dreisbach, et al., 1987) (Klaassen, et al., 1986), based on a medium confidence level. The oral uncertainty factor for barium is 3 and the oral modifying factor is 1. Barium has been issued a carcinogenic weight-of-evidence classification of "D".

Chlordane is a polycyclic chlorinated pesticide. Acute exposure to high doses of chlordane causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the source is removed (Dreisbach et al., 1987). USEPA has established an oral RfD of 6E-5 mg/kg-day and an oral SF of 1.3 kg-day/mg for chlordane.

DDT, or ***1,1,1-trichloro-2,2-bis-(p-chlorophynyl)ethane***, has been one of the most widely used chemicals for controlling agricultural pests and insects that carry diseases such as malaria and typhus. Technical DDT is primarily a mixture of three forms (p,p'-DDT, o,p'-DDT, and o,o'-DDT); all are white, crystalline, tasteless, and almost odorless solids. DDT is anthropogenic; its presence in the environment is due to past production and application. Some DDT can be photo-oxidized in air and on surface soils, but the compound tends to bind to certain types of soil.

DDE (1,1-dichloro-2,2-bis [p-chlorophenyl] ethylene) and ***DDD (1,1-dichloro-2,2-bis [p-chlorophenyl] ethane)*** are present in small amounts as contaminants in technical grade DDT. DDD has had some use as a pesticide and as a treatment for adrenal gland cancer. The use of DDD, DDE, and DDT was banned in the United States (ATSDR, 1992).

With acute exposure to high doses of DDT, the nervous system appears to be the major target in both humans and experimental animals (Herr and Tilson, 1987; Hayes, 1982). Information on health effects in humans following acute inhalation exposure to DDD or DDE is limited (ATSDR, 1992). Chronic exposure of experimental animals to DDT is associated with tremors and general hyperirritability (NCI, 1978; Rossi et al., 1977). In male and female mice, a single oral dose between 32 to 237 to mg DDT/kg caused death of all the mice (Bathe et al., 1976; Kashyap et al., 1977; Tomatis et al., 1972). There is evidence of mild to severe hepatic effects in experimental animals as a result of acute, subchronic, or chronic oral administration of DDT (Pasha, 1981).

Epidemiological evidence is inconclusive for establishing, with reasonable certainty, if DDT is a human carcinogen. Evidence exists from animal studies to consider DDT, DDE, and DDD probable human carcinogens based on USEPA's B2 classification (IRIS, 1996). For example, DDT is carcinogenic in most strains of mice tested (Innes et al., 1969; Thorpe and Walker, 1973; Tomatis et al., 1972; Kashyap et al., 1977; Shabad et al., 1973) and in a few studies, it was carcinogenic in rats (Cabral et al., 1982b; Rossi et al., 1977). However, several other rat studies reported negative results (Legator et al., 1973; Palmer et al., 1973; Cameron and Cheng, 1951; Shivapurkar et al., 1986), as did most of the studies on hamsters (Agthe et al., 1970; Cabral et al., 1982a; Graillot et al., 1975), and the one study on monkeys (Adamson and Sieber, 1979, 1983).

One area of uncertainty is the significance of liver tumors in certain strains of mice and the appropriateness of extrapolating this significance to humans. Several studies in rats, mice and hamsters have been conducted to determine the potential carcinogenicity of DDD and DDE. A chronic feeding study in mice has shown DDE to produce liver tumors at doses of 19 to 34 mg/kg/day for 124 weeks (NCI 1978; Tomatis et al., 1974a). A similar study produced liver tumors in hamsters given 40 mg/kg-day DDE for 124 weeks (Rossi et al., 1983). However, DDE did not induce significant tumor frequencies in rats given 12 to 42 mg/kg/day for 78 weeks

(NCI, 1978). DDD induced liver tumors and lung adenomas in CF-1 mice (Tomatis et al., 1974a) and thyroid follicular cell tumors in Fischer-344 rats (NCI, 1978) but it was not tumor producing in B6C3F1 mice (NCI, 1978).

The oral SF for DDD, DDE, and DDT are 2.4E-01, 3.4E-01, and 3.4E-01 kg-day/mg, respectively. DDT's inhalation SF equals 3.4E-01 kg-day/mg. An oral RfD has been issued for DDT as 5E-04 kg-day/mg (IRIS, 1996).

Dieldrin is a polycyclic chlorinated pesticide to which short-term exposure to high doses causes tremors and convulsions, and chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the dieldrin source is removed. Dieldrin is classified as a B2 carcinogen by USEPA; the oral SF, inhalation SF, and oral RfD have been set by USEPA at 16 kg-day/mg, 16.1 kg-day/mg, and 0.00005 mg/kg-day, respectively (Dreisbach et al., 1987).

Heptachlor is a man-made chemical that was used in the past for killing insects in homes, buildings, and on food crops while pure heptachlor is a white powder, technical-grade heptachlor is tan and less pure. Heptachlor, which smells somewhat like camphor, does not burn easily or explode (ATSDR, 1991).

No studies were located regarding lethal effects in humans after oral exposure to heptachlor. However, since heptachlor is a major component of the insecticide chlordane, chlordane poisoning can be considered when evaluating heptachlor toxicity data. While there are no data on chronic oral exposures in humans in occupational studies of workers manufacturing heptachlor, the exposures are presumed to be predominantly inhalation, with contributions from the dermal route. No adverse health effects have been identified that could be positively associated with heptachlor exposure.

Heptachlor has been issued the USEPA weight-of-evidence classification of B2, a probable human carcinogen (IRIS, 1993). Heptachlor has an oral RfD, oral SF, and inhalation SF of 5E-04 mg/kg-day, 4.5 kg-day/mg, and 4.55 kg-day/mg, respectively (IRIS, 1996).

Heptachlor epoxide is the more toxic form of the insecticide heptachlor which was used to control flies, mosquitoes, and field insects. Benign and malignant liver tumors were induced in three strains of mice of both sexes. Heptachlor epoxide has been linked to liver carcinoma (Dreisbach, et al., 1987). USEPA determined this compound to be a class B2 carcinogen, and determined the oral SF and the inhalation SF to be 9.1 kg-day/mg. The primary target organs for this pesticide are the liver and kidneys. The USEPA has determined the oral RfD to be 1.3E-05 mg/kg-day (IRIS, 1996).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays have provided reproducible results in several laboratories and in multiple rat strains, with some evidence of multiple tumor sites. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV to be 400 mg/kg (USEPA, 1994c). USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L (USEPA, 1994c). Although short-term studies show that lead affects gene expression in rats, human evidence is inadequate. Lead can accumulate in bone marrow and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects other than carcinogenicity. Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate, with lead sometimes attached to binding sites, and other times free flowing. This

fluctuation and lack of previous lead exposure data make effects difficult to predict (Klaassen et al., 1986).

Polyaromatic hydrocarbons (PAHs- Including BEQs) are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well-established and there are no RfDs for them due to a lack of data. All the PAHs listed below are classified by USEPA as B2 carcinogens. Their carcinogenicity is addressed relative to that of Benzo(a)pyrene (BAP), having an oral SF of 7.3 kg-day/mg. The Toxicity Equivalent Factors (TEFs), also set by USEPA, are multipliers applied to the detected concentrations subsequently used to calculate excess cancer risk. PAHs which have TEFs are listed below.

PAHs	Toxicity Equivalent Factors
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Most PAHs classified as carcinogenic are due to the result of animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings and the SFs listed in USEPA's RBC Table are provisional. However, PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS (search date 6/28/95), BAP has been issued a weight-of-evidence classification of B2 based on insufficient human data specifically linking it to a carcinogenic effect. However, multiple animal studies in many species demonstrate BAP to be carcinogenic following administration by numerous routes.

As listed in IRIS, the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is based on data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells and transformed mammalian cells in culture. Similar results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen et al., 1986).

PCB Aroclors are a group of chlorinated hydrocarbons (such as *Aroclors-1248, 1254, and 1260*) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al., 1986; Dreisbach, et al., 1987). USEPA classified PCB Aroclors as group B2 carcinogens, primarily based on animal data. As listed in IRIS (search date 6/29/95), the basis for the classification is hepatocellular carcinomas in three strains of rats and two strains of mice and inadequate yet suggestive evidence of excess risk of liver cancer in humans by ingestion and inhalation or dermal contact. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. USEPA set PCB Aroclors' oral SF at 2.0 (kg-day/mg) and the RfDs at 0.00007 mg/kg-day for Aroclor-1260 and 0.00002 mg/kg-day for Aroclor-1254.

MCPA is a chlorophenoxy herbicide compound class developed in World War II in the United States and the United Kingdom to increase food production and as a possible chemical warfare agent. Chlorophenoxy compounds have been used since 1947 in agriculture for broad-leafed weeds; in the control of woody plants along roadside, railway, and utility right-of-ways; and in reforestation programs (Klaassen, 1996). The three most common chlorophenoxy

compounds are 2,4-D, 2,4,5-T, and MCPA. Most people exposed to chlorophenoxy herbicides complain of headache, dizziness, nausea, vomiting, abdominal pains, diarrhea, respiratory complications, aching, tender muscles, myotonia, weakness, and fatigue. There is some clinical evidence of renal dysfunction and transient albuminuria. The oral LD_{50} (Lethal Dose 50% of population) ranged from 300 to >1000 mg/kg in different species and only the dog appeared to be particularly sensitive (Klaassen, 1996). Toxicity of chlorophenoxy compounds increase with a decrease in the phenoxy side chain length (Patnaik, Pradyot, 1992). One study showed some neurotoxicity in the workers involved in the manufacture of 2,4-D and 2,4,5-T; however, most studies on humans were inconclusive (Klaassen, 1996).

Vanadium is not readily absorbed through the skin or by oral ingestion and is a ubiquitous by-product of petroleum refining. Vanadium is soluble in fats and oils (Klaassen et al., 1986). Municipal water supplies contain 0.001 to 0.006 mg/L of vanadium. The target organ is unclear and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg of vanadium in a daily dose. USEPA set the oral SF at 0.007 mg/kg-day.

8.5.4.5 Risk Characterization

Exposures for hypothetical residents and future site workers include incidental surface soil ingestion, surface soil dermal contact, and groundwater ingestion. Tables 8.5.15 and 8.5.16 present the estimated carcinogenic risks and HQs associated with the incidental ingestion pathways, while Tables 8.5.17 and 8.5.18 present the estimated carcinogenic risks and HQs associated with the dermal contact surface soil exposure pathway. LWA ILCR and HIs are summarized at the bottoms of these tables. Numbers in bold indicate that risk or hazard acceptable limits have been exceeded. These tables also include the FI/FC fraction used to conservatively estimate the actual area of contaminated land. The FI/FC fraction is detailed in Section 8.5.4.6.

Table 8.5.15
Hazard Quotients and Incremental Lifetime Cancer Risks for Surface Soil Ingestion
SWMU 59 NSA Memphis

					Residential Scenario			Site Worker Scenario	
Chemical	**EPC mg/kg**	**Oral RfD Used mg/kg-day**	**Oral SF Used mg/kg-day**	**FI/FC**	**Future Adult HQ**	**Future Child HQ**	**Future LWA ILCR**	**Future Worker HQ**	**Future Worker ILCR**
4,4'-DDE	2.3	NA	0.34	0.5	NA	NA	6.7E-07	NA	7.4E-08
4,4'-DDT	4	NA	0.34	0.5	NA	NA	2.1E-07	NA	1.2E-07
Aldrin	0.176	0.00003	17.0	1.0	0.0080	0.075	4.7E-06	0.0029	5.2E-07
Alpha-Chlordane	6.5	0.00006	0.35	0.3	0.045	0.42	1.1E-06	0.016	1.2E-07
Arsenic	27	0.0003	1.5	1	0.12	1.2	6.3E-05	0.044	7.1E-06
Aroclor-1260	0.49	NA	2.0	1.0	NA	NA	1.5E-06	NA	1.7E-07
BEQ	1.23	NA	7.3	0.6	NA	NA	8.4E-06	NA	9.4E-07
Dieldrin	1.8	0.00005	0.16	0.30	0.015	0.14	1.4E-07	0.0053	1.5E-08
gamma-Chlordane	8.8	0.00006	0.35	0.3	0.06	0.56	1.5E-06	0.022	1.6E-07
Heptachlor	3.9	0.0005	4.5	0.15	0.0016	0.015	4.1E-06	0.00057	4.6E-07
Heptachlor epoxide	2.2	0.000013	9.1	0.15	0.035	0.32	4.7E-06	0.012	5.2E-07
MCPA	6.5	0.0005	NA	0.1	0.0018	0.017	NA	0.00064	NA
Summary					0.3	3	1E-04	0.1	1E-05

Table 8.5.16
Hazard Quotients and Incremental Lifetime Cancer Risks for Surface Soil Ingestion (without FI/FC)
SWMU 59 NSA Memphis

		Oral RfD	Oral SF		Residential Scenario			Site Worker Scenario	
	EPC	Used	Used		Future Adult	Future	Future LWA		
Chemical	mg/kg	mg/kg-day	kg-day/mg	FI/FC	HQ	Child HQ	ILCR	HQ	ILCR
4,4'-DDE	2.5	NA	0.34	1	NA	NA	1.3E-06	NA	1.5E-07
4,4'-DDT	4	NA	0.34	1	NA	NA	4.2E-07	NA	2.4E-07
Aldrin	0.176	3E-05	17	1	0.008	0.075	4.7E-06	0.0029	5.2E-07
Alpha-Chlordane	6.5	6E-05	0.35	1	0.15	1.4	3.7E-06	0.053	4.0E-07
Arsenic	27	0.0003	1.5	1	0.12	1.2	6.3E-05	0.044	7.1E-06
Aroclor-1260	0.49	NA	2	1	NA	NA	1.5E-06	NA	1.7E-07
BEQ	1.23	NA	7.3	1	NA	NA	1.4E-05	NA	1.6E-06
Dieldrin	1.8	5E-05	0.16	1	0.05	0.467	4.7E-07	0.018	5.0E-08
gamma-Chlordane	8.8	6E-05	0.35	1	0.2	1.87	5.0E-06	0.073	5.3E-07
Heptachlor	3.9	0.0005	4.5	1	0.011	0.1	2.7E-05	0.0038	3.1E-06
Heptachlor epoxide	2.2	1.3E-05	9.1	1	0.233	2.13	3.1E-05	0.08	3.5E-06
MCPA	6.5	0.0005	NA	1	0.018	0.17	NA	0.0064	NA
Summary					0.8	7	1.5E-04	0.3	1.7E-05

Notes:

HQ	—	Hazard Quotient
ILCR	—	Incremental Lifetime Cancer Risk
kg-day/mg	—	kilogram per milligram per day
LWA	—	Lifetime Weighted Average
MCPA	—	2-methyl-4-chlorophenoxyacetic acid
mg/kg-day	—	milligrams per kilogram per day
NA	—	Not Applicable

Table 8.5.17
Hazard Quotients and Incremental Lifetime Cancer Risks for Dermal Exposure to Surface Soil
SWMU 59 NSA Memphis

						Residential Scenario			Site Worker Scenario	
Chemical	EPC mg/kg	Dermal RfD mg/kg-day	Dermal SF kg-day/mg	DAF	FI/FC	Future Adult HQ	Future Child HQ	Future LWA ILCR	Future Worker HQ	Future Worker ILCR
4,4'-DDE	2.5	NA	0.68	0.5	0.5	NA	NA	3.0E-07	NA	1.2E-07
4,4'-DDT	4	NA	0.68	0.5	0.5	NA	NA	4.8E-07	NA	1.9E-07
Aldrin	0.1759	0.000015	34	0.5	1.0	0.0066	0.022	2.1E-06	0.0047	8.6E-07
Alpha-Chlordane	6.5	0.00003	0.7	0.5	0.3	0.037	0.12	4.8E-07	0.026	1.96E-07
Arsenic	27	0.00006	7.5	0.2	1	0.025	0.083	7.1E-06	0.018	2.9E-06
Aroclor-1260	0.4889	NA	4.0	0.5	1.0	NA	NA	6.9E-07	NA	2.8E-07
BEQ	1.23	NA	14.6	0.5	0.6	NA	NA	3.8E-06	NA	1.5E-06
Dieldrin	1.8	0.000025	0.32	0.5	0.30	0.012	0.040	6.1E-08	0.009	2.5E-08
gamma-Chlordane	8.8	0.00003	0.7	0.5	0.3	0.049	0.16	6.5E-06	0.035	2.7E-07
Heptachlor	3.9	0.00025	9.0	0.5	0.15	0.0013	0.0043	1.9E-06	0.0009	7.5E-07
Heptachlor epoxide	2.2	0.000065	18.2	0.5	0.15	0.029	0.094	2.1E-06	0.02	8.6E-07
MCPA	6.5	0.00025	NA	0.5	0.1	0.0015	0.005	NA	0.001	NA
Summary						0.2	0.5	2E-05	0.1	9E-06

Table 8.5.18
Hazard Quotients and Incremental Lifetime Cancer Risks for Surface Soil Ingestion (without FI/FC)
SWMU 59 NSA Memphis

		Dermal RfD	Dermal SF			Residential Scenario			Site Worker Scenario	
	EPC	Used	Used			Future Adult	Future	Future LWA		
Chemical	mg/kg	mg/kg-day	kg-day/mg	DAF	FI/FC	HQ	Child HQ	ILCR	HQ	ILCR
4,4'-DDE	2.5	NA	0.68	0.5	1	NA	NA	6.0E-07	NA	2.4E-07
4,4'-DDT	4	NA	0.68	0.5	1	NA	NA	9.6E-07	NA	3.8E-07
Aldrin	0.1759	1.5E-05	34	0.5	1	0.0066	0.022	2.1E-06	0.0047	8.6E-07
Alpha-Chlordane	6.5	3E-05	0.7	0.5	1	0.12	0.4	1.6E-06	0.087	6.5E-07
Arsenic	27	6E-05	7.5	0.2	1	0.025	0.083	7.1E-06	0.018	2.9E-06
Aroclor-1260	0.4889	NA	4	0.5	1	NA	NA	6.9E-07	NA	2.8E-07
BEQ	1.23	NA	14.6	0.5	1	NA	NA	6.3E-06	NA	2.5E-06
Dieldrin	1.8	2.5E-05	0.32	0.5	1	0.04	0.133	2.0E-07	0.03	8.3E-08
gamma-Chlordane	8.8	3E-05	0.7	0.5	1	0.16	0.533	2.2E-05	0.12	9.0E-07
Heptachlor	3.9	0.00025	9	0.5	1	0.0087	0.029	1.3E-05	0.006	5.0E-06
Heptachlor epoxide	2.2	6.5E-06	18.2	0.5	1	0.19	0.63	1.4E-05	0.13	5.7E-06
MCPA	6.5	0.00025	NA	0.5	1	0.015	0.05	NA	0.01	NA
Summary						0.6	2	6.8E-05	0.4	2.0E-05

Notes:

HQ	—	Hazard Quotient
kg-day/mg	—	kilogram day per milligram
LWA	—	Lifetime Weighted Average
ILCR	—	Incremental Lifetime Cancer Risk
MCPA	—	2-methyl-4-chlorophenoxyacetic acid
mg/kg-day	—	milligrams per kilogram per day
NA	—	Not Applicable

TDEC assumes all groundwater is potential drinking water. Consequently, hypothetical future site residential and non-residential receptors are assumed to use loess groundwater for drinking water. Carcinogenic risk and HQ estimates for groundwater exposure scenarios are presented in Table 8.5.19. Surface soil and loess groundwater exposure pathways are discussed separately for hypothetical site residents and future site workers.

Hypothetical Site Residents

In accordance with RAGS, risk to site residents was evaluated for carcinogens using the LWA estimates of daily intake. Noncarcinogenic risk or carcinogenic hazard was estimated separately to address child and adult exposure. As shown in Figure 8.5.6, the sum of soil and loess groundwater risk estimates was 1.86E-4, with the soil exposure pathway contributing the largest portion of projected risk. This figure is qualitative in nature, and several chemicals are not easily distinguished due to smaller risk contribution. However, the relative risk contributions from each pathway and the largest individual chemical contributors can be easily discerned. Figure 8.5.7 provides a better view of the relative risk contributions from each individual chemical to the total risk. Arsenic is the largest risk contributor (37.8%). Figure 8.5.7 shows the soil and loess groundwater child hazard estimates. Figures 8.5.8 and 8.5.9 show the relative proportional child hazard contribution from the individual chemicals. Heptachlor epoxide is the largest hazard contributor (25.6%).

Surface Soil

The ingestion and dermal pathway ILCRs estimated for SWMU 59 surface soil were 1E-4 and 2E-5, respectively (See Tables 8.5.15 and 8.5.17). The estimated HI for the adult and child residential was 0.3 and 3 for the soil ingestion pathway, respectively. The dermal contact pathway HI estimates were 0.2 and 0.5 for both the adult resident and the child resident, respectively.

Table 8.5.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Water Ingestion of Loess Groundwter at SWMU 59 NSA Memphis

					Residential Scenario		Site Worker Scenario	
Chemical	**EPC mg/L**	**Oral RfD Used mg/kg-day**	**Oral SF Used kg-day/mg**	**Future Adult HQ**	**Future Child HQ**	**Future LWA ILCR**	**Future Site Worker HQ**	**Future Site Worker ILCR**
Dieldrin	0.000052	0.00005	46.0	0.03	0.07	3.6E-05	0.01	8.4E-06
Heptachlor	0.000069	0.0005	4.5	0.004	0.01	4.6E-06	0.001	1.1E-06
Heptachlor expoxide	0.00019	0.000013	9.1	0.4	0.93	2.6E-05	0.14	6.0E-06
Barioum	0.46	0.07	NA	0.18	0.42	NA	0.06	NA
Vanadium	0.047	0.007	NA	0.18	0.43	NA	0.07	NA
Summary				0.8	2	7E-05	0.2	2E-05

Figure 8.5.6 SWMU 59 Residential Risk Estimates

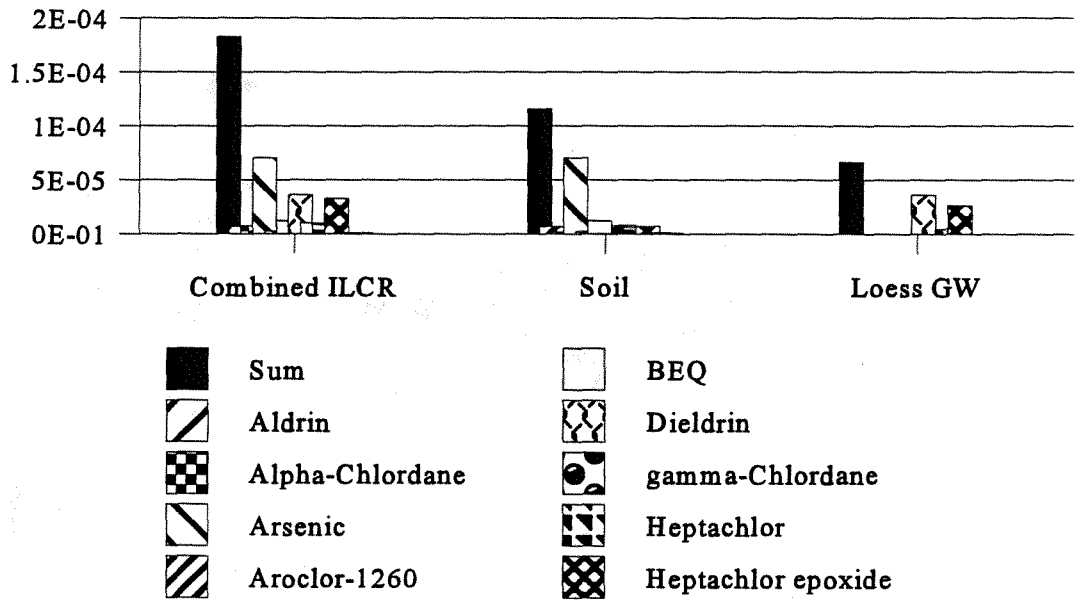


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Figure 8.5.7 SWMU 59 Residential Risk Contributors All Pathways

Risk Estimates are 1E-5 Times Value Shown

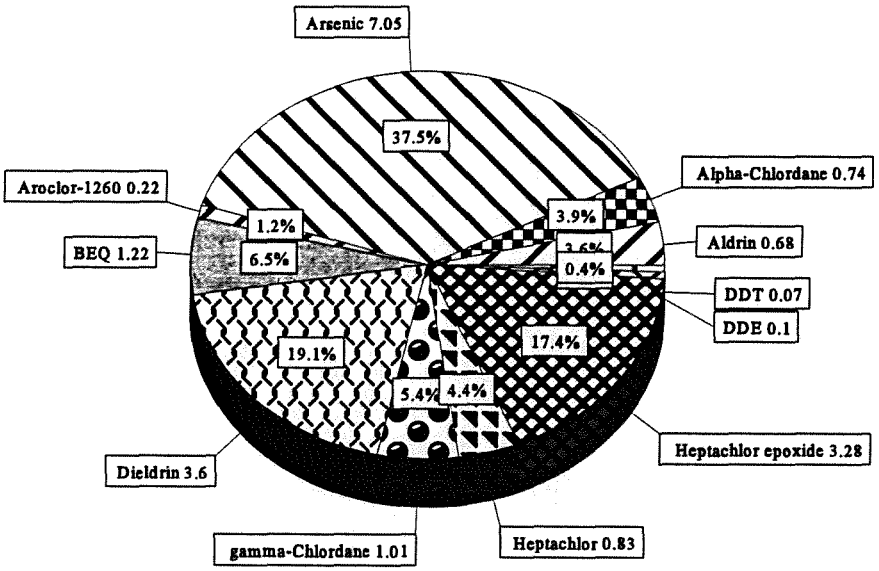

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Figure 8.5.8 SWMU 59 Residential Child Hazard Index Estimates

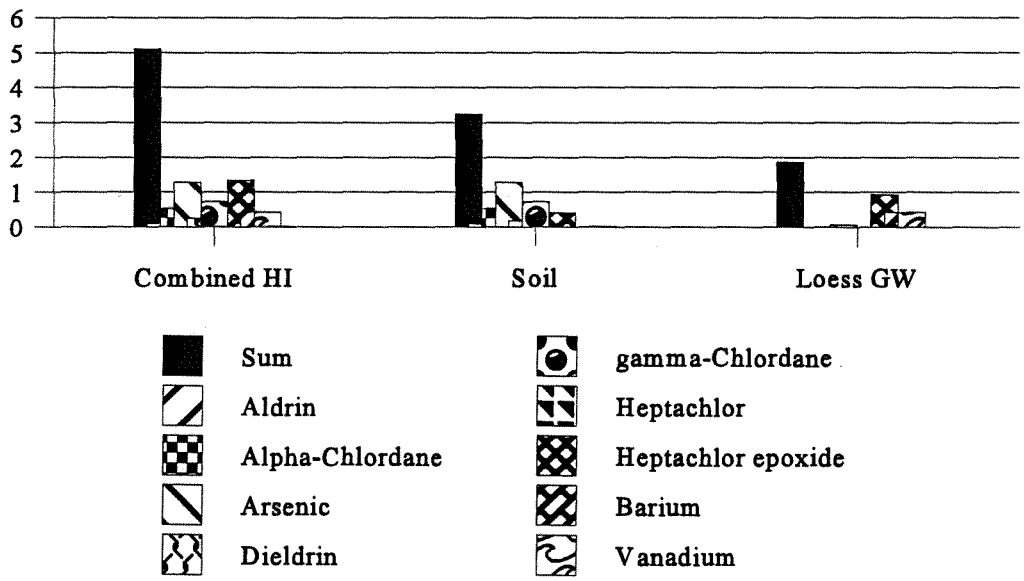

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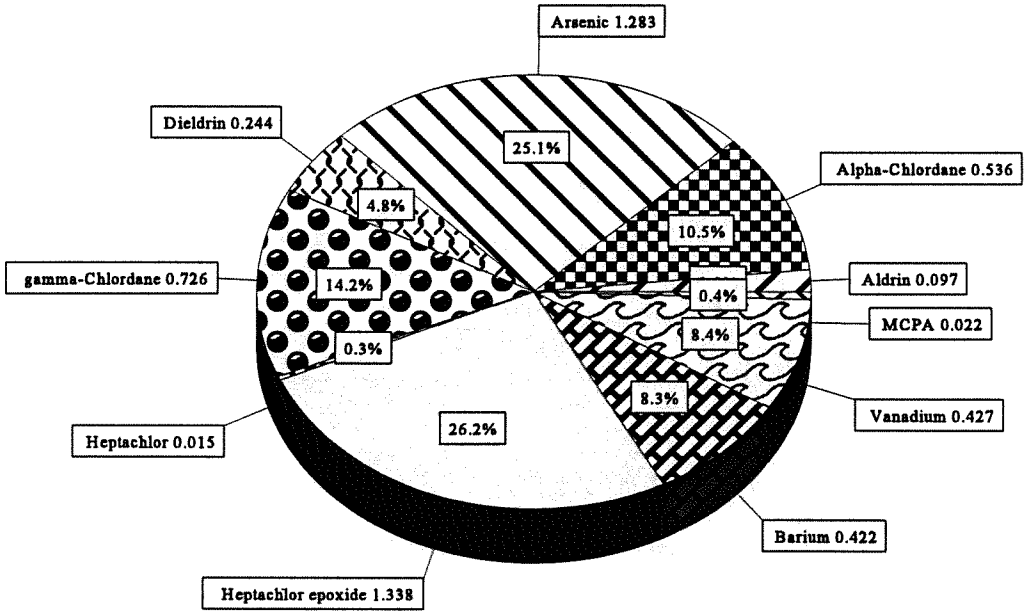
Figure 8.5.9 SWMU 59 Residential Child Hazard Index Contributors



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The LWA ILCR and child HI for exposure to surface soil exceeded 1E-4 and 1, respectively. The cancer risk contributors (>E-6) include aldrin, alpha-chlordane, arsenic, Aroclor-1260, BEQ, gamma-chlordane, heptachlor, and heptachlor epoxide. Chemicals which contribute to the hazard (>0.1) include alpha-chlordane, arsenic, dieldrin, gamma-chlordane, and heptachlor epoxide.

Loess Groundwater

The projected ingestion-related LWA ILCR equaled 7E-5. The HIs for adult and child residential receptors were estimated to be 0.8 and 2, respectively. The major contributors to the LWA ILCR (>E-6) were dieldrin, heptachlor, and heptachlor epoxide. The primary contributors to the child HI were heptachlor epoxide, barium, and vanadium.

Lead

Lead was evaluated with USEPA's Isokinetic Lead Uptake Model (IEUBK-Version 0.99d-T*he Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA 540-R-93-081). Given site-specific data, this model calculates the lead concentration in children's blood. USEPA recommends that there should be a 5% or less probability that the blood level in a child (age 0 to 84 months) should exceed 10 mg of lead per deciliter of blood (mg/dL). This model was used to evaluate a child's blood concentration at lead's average concentration in soil and loess groundwater at SWMU 59. Lead averaged 283 mg/kg in five surface soil samples and 21.7 mg/L in three loess groundwater samples. These average values were entered into the IEUBK model, along with the program's default values for diet and house dust. Figure 8.5.10 shows the percent probability of a child's (ages 0 to 84 months) blood level exceeding 10 mg/dL. The probability equaled 8.25% which exceeds the 5% acceptable limit.

When the uptake of the average soil concentration (283 mg/kg) was considered separate from the groundwater exposure pathway, the probability (2.7%) of a child's blood lead level exceeding 10 mg/dl lead does not exceed the recommended 5%. However, when the average groundwater

concentration (21.7 mg/L) was considered separate from the soil exposure pathway, the probability (6.42%) exceeds 5%. Based on these results, lead is retained as a COC for groundwater, but not for soil.

Hypothetical Site Workers

Figure 8.5.11 shows the risk estimates from the soil and loess groundwater exposure pathways. The cumulative risk estimate for both is 3.5E-5. Figure 8.5.12 shows the portion of risk each chemical contributes to the total risk for both exposure pathways. Neither exceeds 1E-4 risk nor a HI of 1.

Surface Soil

Sums of the site worker ILCRs estimates are 1E-5 and 9E-6 for the incidental ingestion and dermal contact pathways, respectively. Arsenic and BEQ were the risk contributors that exceeded or equaled 1E-6.

Loess Groundwater

The projected ingestion-related ILCR from groundwater was 2E-5, while the site worker HI was estimated to be 0.2. Dieldrin, heptachlor, and heptachlor epoxide were the only chemicals to contribute more than 1E-6 risk to the total ILCR. Heptachlor epoxide was the only chemical to contribute more than 0.1 to the HI.

COCs Identified

Identification of COCs was based on cumulative (all pathway) risk and hazard projected for SWMU 59. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In Assembly E HHRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-4 or greater and/or a cumulative HI above 1.0, if its

Figure 8.5.10 Probability of Lead Exceeding 10 μg/dL in the Blood of a Child Ages 0 to 84 Months from Incidental Soil Ingestion (Average Soil Concentration, 283 mg/kg) **and Groundwater Ingestion** (Average Concentration 21.7 μg/L) **at SWMU 59, Calculated by the IEUBK Model**

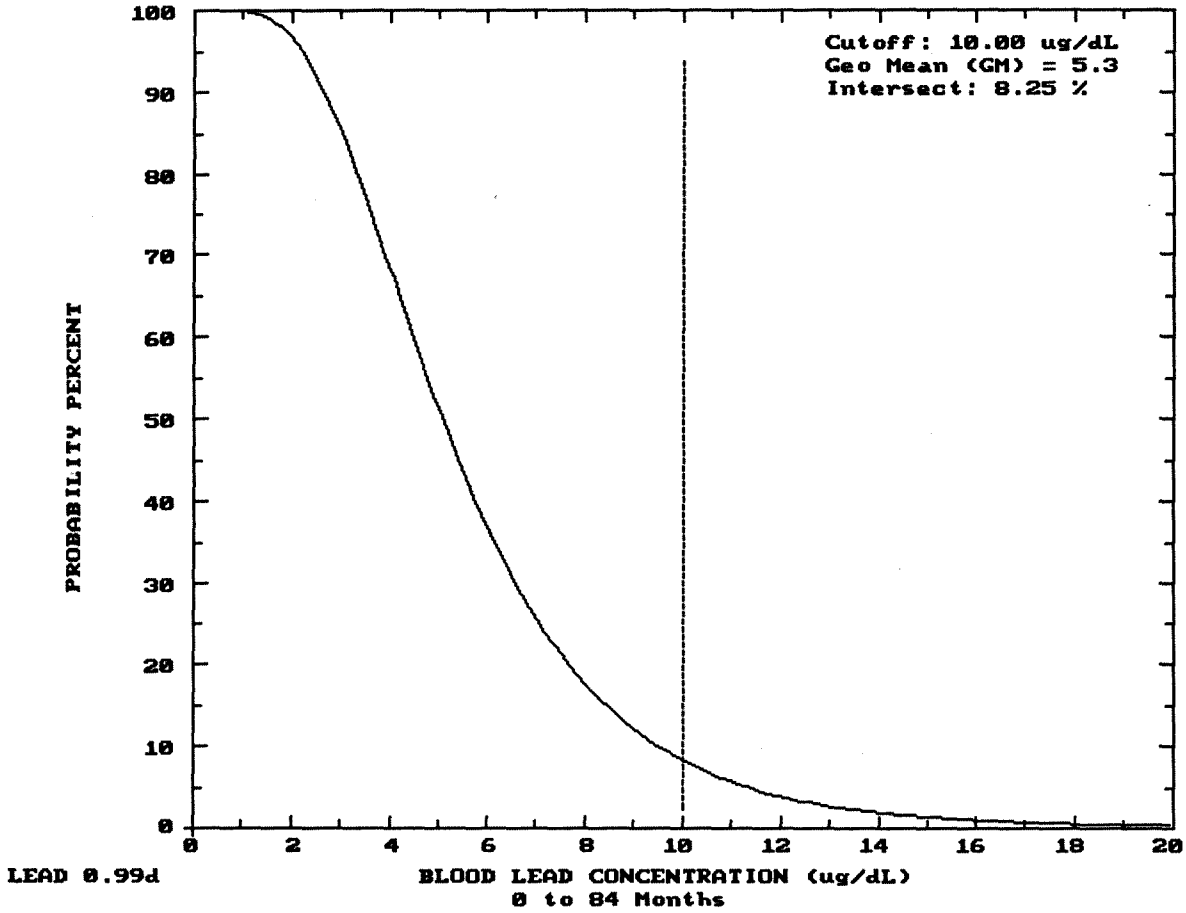

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Figure 8.5.11 SWMU 59 Industrial Risk Estimates

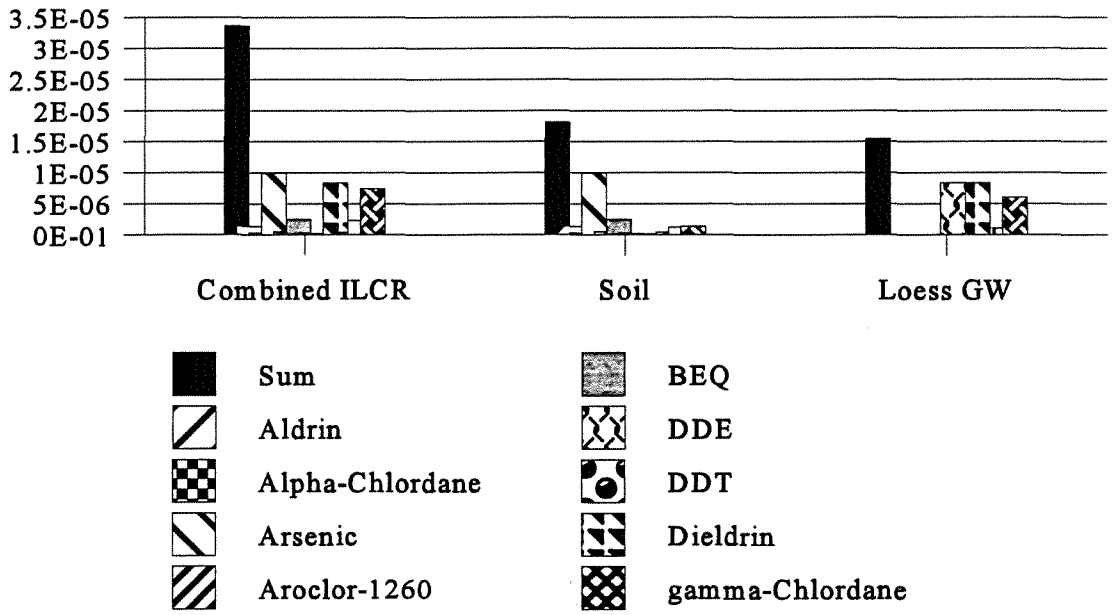

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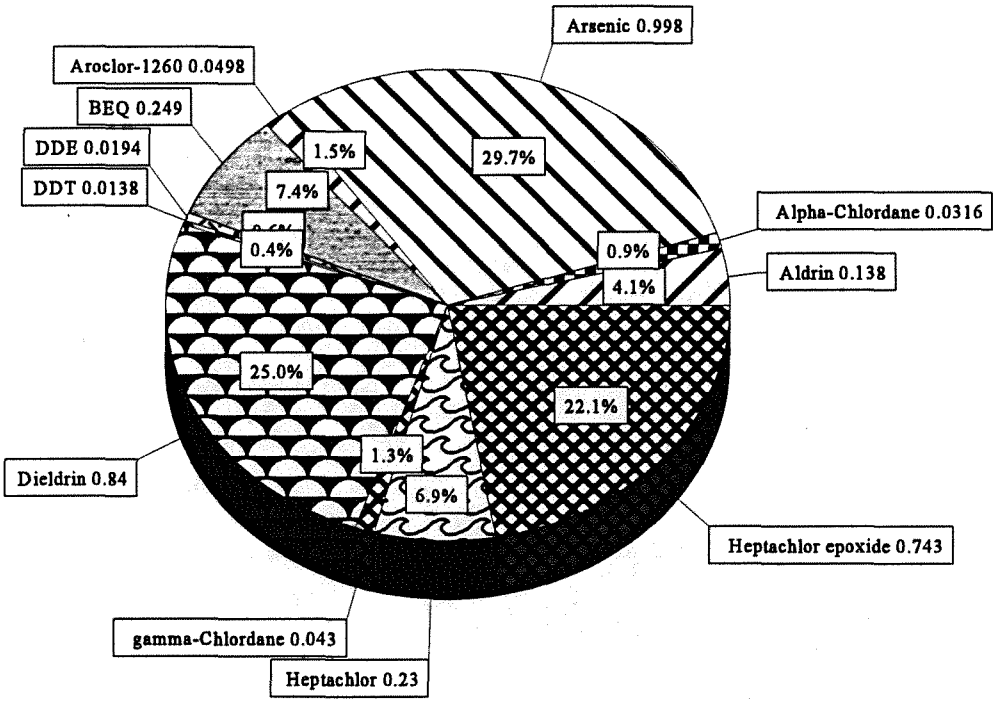
Figure 8.5.12 SWMU 59 Industrial Risk Contributors All Pathways

Risk Estimates are 1E-5 Times Value Shown



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individual ILCR exceeds 1E-6 or its HQ exceeds 0.1. The exception to this rule is lead which was already discussed in this section.

Hypothetical Site Residents

Surface Soil

COCs identified in surface soil at SWMU 59 included aldrin, alpha-chlordane, arsenic, Aroclor-1260, BEQ, dieldrin, gamma-chlordane, heptachlor, and heptachlor epoxide.

Loess Groundwater

Barium, vanadium, and heptachlor epoxide were identified as COCs in loess groundwater at SWMU 59 for this scenario based on their contribution to hazard for children. Lead was also identified as a COC based on childrens' groundwater ingestion at the age of 0 to 84 months.

Future Site Workers

Surface Soil

No COCs were identified in surface soil at SWMU 59 for the hypothetical site worker scenario.

Loess Groundwater

No COCs were identified in loess groundwater for the hypothetical site worker scenario based on contribution to risk/hazard.

8.5.4.6 Risk Uncertainty

Several parameters contribute to risk assessment uncertainty and variability including:

- Unknown future exposure settings and exposure pathways
- Toxicological uncertainty in the determination of SFs and RfDs
- EPC estimation

- Human exposure quantification
- Elimination of some CPSS could result in some inaccurate estimations

Exposure Setting and Exposure Pathways

Surface Soil

Currently there are no future reuse plans for SWMU 59, but a residential reuse is highly unlikely. Therefore, the residential scenario developed here is likely to overestimate exposure, which could result in overestimates in the projected risk/hazard values.

Loess Groundwater

Shallow groundwater is not currently used at SWMU 59 for potable or industrial purposes. The existing drinking and process water supply system at NSA Memphis is to remain in operation under the current reuse plan. As a result, groundwater use would not be expected under future site use scenarios. Therefore, the scenario established to project exposure to shallow groundwater is highly conservative and associated pathways are not expected to be completed in the future.

Subsurface Soil

One uncertainty for this site is the possibility of heavy construction. This HHRA addresses this possibility here. Construction work generally requires less than one year to complete a project, and chronic exposure is typically seven years or more. The current site worker scenario used in this assessment assumes 25-year exposure. Therefore, future worker assessment is considered to be protective of both current site use and future construction/maintenance exposure scenarios for surface soil. The future site resident scenario assumed existing buildings would be removed and replaced with dwellings. In addition, the future site residents and workers were assumed to use the onsite underlying aquifers as a source of drinking water.

Subsurface soil was assessed for the construction worker land use scenario in accordance with recommendations made by USEPA Region IV and TDEC. Most assumptions used to estimate construction worker's exposure are default site worker assumptions. The three exposure assumptions modified in accordance with USEPA and TDEC's suggestions are shown below:

Exposure Duration = 0.5 year (1 year used to estimate exposure for carcinogens)
Exposure Frequency = 120 days/year
Ingestion Rate = 340 mg/day (modified as discussed below)

The modified ingestion rate is based on the time-weighted average, assuming a worker would be exposed to a hole in the ground, incidentally ingesting 480 mg/day (RBCA/ASTM) for 0.5 year, and 200 mg/day for 0.5 year (USEPA, 1995b). The weighted average is 340 mg/day. Intake multipliers were calculated in accordance with RAGS, as discussed in the Technical Memorandum on HHRA.

Assuming a soil concentration of 1 mg/kg and applying the modified exposure assumptions presented above, this results in the following intake multipliers:

- Ingestion Hazard Multiplier = 1.6E-06
- Ingestion ILCR Multiplier = 1.28E-08

As presented in the Technical Memorandum on HHRA, the residential intake multipliers are:

- Ingestion Hazard Multiplier = 1.28E-07
- Ingestion ILCR Multiplier = 1.57E-09

RBCs were calculated by USEPA Region III using similar multipliers. The following equation can be used to calculate the RBC for a site resident exposed to soil:

$$RBC = \frac{\text{Target Risk Goal}}{\text{Ingestion Hazard Multiplier x Slope Factor}}$$

For example, the slope factor for arsenic is 1.5 kg-day/mg. Using arsenic as an example with a target risk goal of 1E-6 and the residential multiplier for carcinogens shown above, the RBC would equal approximately 0.43 mg/kg, the same value shown in USEPA Region III's RBC tables. Applying the multiplier for the construction worker scenario results in an RBC for a construction worker scenario approximately equal to 29.5 mg/kg, which is shown in Table 8.5.20.

Because a linear relationship exists between the two land use scenarios, residential RBCs for noncarcinogens and carcinogens can be related to construction worker RBCs using the following multipliers:

- Noncarcinogens = 8 * RBC_N (residential) = RBC_N (construction worker)
- Carcinogens = 68.63 * RBC_C (residential) = RBC_C (construction worker)

Toxicological Uncertainty

Surface Soil

COCs include aldrin, chlordane isomers, arsenic, Aroclor-1260, BEQ, heptachlor, and heptachlor epoxide. Arsenic is the only contaminant demonstrated to be carcinogenic in humans, but primarily through inhalation of arsenic, not incidental soil ingestion and dermal exposure. Arsenic causes squamous cell carcinoma (blackfoot disease) through ingestion, but because it is curable, USEPA has a policy of tolerance to 1E-3 cancer risk. Aldrin, chlordane isomers, Aroclor-1260,

Table 8.5.20
Construction Worker Scenario
SWMU 59
NSA Memphis

Chemical	MAX µg/kg	RBC res µg/kg	RBC const µg/kg	NOTE	RC µg/kg
2,4,5-T	1	780,000	6,240,000	N	NA
2-Butanone (MEK)	1,100	47,000,000	376,000,000	N	NA
4,4'-DDD	16	2,700	185,301	C	NA
4,4'-DDE	58	1,900	130,397	C	NA
4,4'-DDT	47	1,900	130,397	C	NA
4-Methyl-2-Pentanone (MIBK)	1	6,300,000	50,400,000	N	NA
Acetone	8,600	7,800,000	62,400,000	N	NA
Aldrin	5.7	380	26,079	C	NA
alpha-Chlordane	410	490	33,629	C	NA
Arsenic	10,400	430	29,511	C	20,320
Barium	166,000	5,500,000	44,000,000	N	265,120
Beryllium	560	150	10,295	C	1,000
bis(2-Ethylhexyl)phthalate (BEHP)	380	46,000	3,156,980	C	NA
Cadmium	1,600	39,000	312,000	N	3,240
Chromium	12,800	390,000	3,120,000	N	28,280
Cobalt	8,800	4,700,000	37,600,000	N	14,360
Copper	20,200	3,100,000	24,800,000	N	32,520
Dieldrin	150	40	2,745	C	NA
Dinoseb	7	78,000	624,000	N	NA
Ethylbenzene	1	7,800,000	62,400,000	N	NA
gamma-Chlordane	480	490	33,629	C	NA
Heptachlor	74	140	9,608	C	NA
Heptachlor epoxide	160	70	4,804	C	NA
Lead	14,800	1,300,000	1,300,000	a	19,800
Methylene chloride	4	85,000	5,833,550	C	NA
Nickel	14,600	1,600,000	12,800,000	N	NA
Selenium	380	390,000	3,120,000	N	NA
Technical Chlordane	3,200	490	33,629	C	NA
Tin	31,400	47,000,000	376,000,000	N	NA
Vanadium	27,000	550,000	4,400,000	N	43,680
Zinc	58,800	23,000,000	184,000,000	N	109,000

Notes:

MAX - Maximum reported concentration in subsurface soil
RBC res - Screening based on USEPA's 1998 Risk-Based Screening tables (USEPA, 1998)
RBC const - Screening based on construction worker soil ingestion as per RBCA/ASTM guidance
RC - NASP reference concentration
NA - Not applicable/not available
N - Noncarcinogen
C - Carcinogen
a - industrial cleanup goals used at other federal facilities

BEQ, heptachlor, and heptachlor epoxide have "B2" cancer ratings, which indicates that they cause cancer in animals but have not been demonstrated to cause cancer in humans. This rating may result in overestimation of the cancer risk from exposure to these compounds. Most are synthetic, fat-soluble pesticides which most likely have a cumulative effect. Due to their properties, dermal exposure would be a major exposure pathway, and a long-term chronic exposure would result in detrimental effects on the liver, kidney, and the central nervous system.

Loess Groundwater

COCs in loess groundwater at SWMU 59 include lead, heptachlor epoxide, barium, and vanadium based on their toxicant properties. Lead exposure effects have been difficult to determine; therefore its long-term effect cannot be completely determined. The primary target organs of heptachlor epoxide are the liver and kidneys. Barium's toxic effects include muscle stimulation, central nervous system effects, and increased blood pressure. Vanadium, whose primary entrance pathway of concern is inhalation, is not readily absorbed through the dermal or gastrointestinal routes, and appears to pose little danger through water ingestion.

Determination of Exposure Point Concentrations

Based on the guidance provided by USEPA and as discussed in the Technical Memorandum on HHRA (E/A&H, 1997e), EPCs are used to estimate CDI (Chronic Daily Intake). The uncertainty associated with EPCs primarily stems from their statistical determination (UCLs) or imposition of maximum concentrations.

Surface Soil

The 95% UCLs calculated for surface soil at SWMU 59 were used for aldrin's and Aroclor-1260's EPC. For all other COPCs in surface soil, the maximum concentrations were set to the EPCs. The FI/FC fraction was used with the maximum concentrations to adjust for the spatial distribution

of the individual COPCs except for lead. See Figures 8.5.13 and 8.5.14 in the Uncertainty Section to see how the FI/FC was determined. The EPC was set to the average lead concentration.

Loess Groundwater

All COPC EPCs in loess groundwater at SWMU 59 were based on the maximum reported concentration, and therefore, exposure is likely overestimated.

Frequency of Detection and Spatial Distribution

Surface Soil

In addition to the standard tabular presentation of risk estimates in Section 8.5.4.5, point estimate maps were plotted for surface soil to clarify the spatial distribution for risk managers. As an extension of conventional data presentation, excess cancer risk and hazard estimates were calculated for each sample location. Point estimates of risk and hazard were developed for both residential and industrial land use scenarios for relative comparison.

Table 8.5.21 was generated to present risk estimates for each COC at each sample location using the ratio of the reported concentration to the corresponding RGO and risk estimate used to develop the RGO.

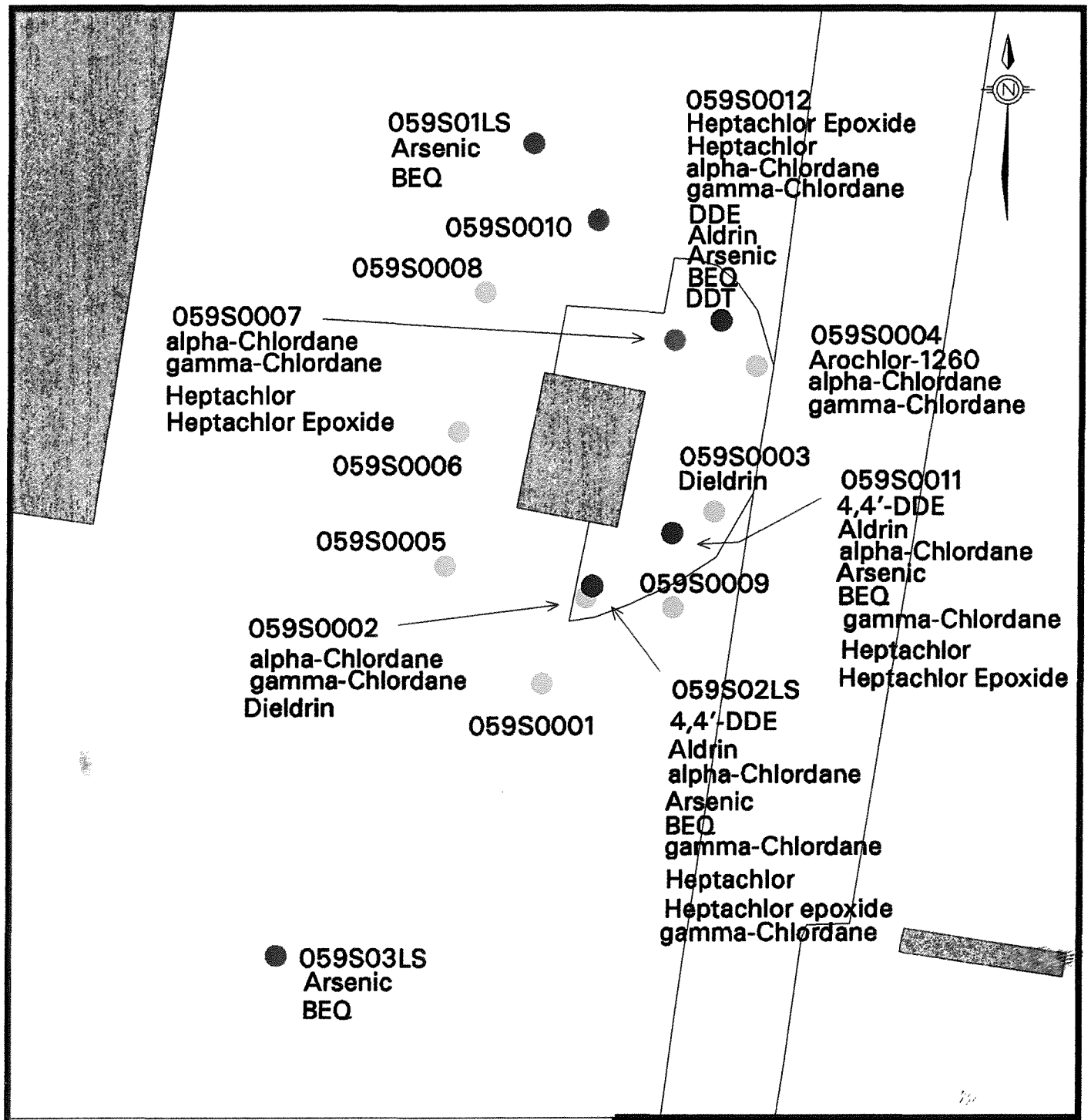
COCs were not detected at all sample locations, as discussed in Section 8.3.2. However, concentrations were assumed to be present in site samples slightly below sample quantitation limits, when COCs were reported as nondetects. As discussed in the Technical Memorandum on HHRA (E/A&H, 1997e), the assumed concentration for a specific organic COC equals either one-half of the lowest reported hit or one-half the reported sample quantitation limit. Using one-half the lowest reported hit accounts for any elevated sample quantitation limits that could bias risk estimates and overestimate risk by using some other assumed concentration. Assumed concentrations for inorganics equal one-half of the reported sample quantitation limit. After

estimating risk for each COC and each sample location, risk estimates were summed to provide cumulative risk estimates for each sample location and land use scenario. Individual hazard estimates were established as well as cumulative hazard estimates for each COC and each sample location. Figures 8.5.13 and 8.5.14 show risk and hazard estimates, respectively. These figures also show the sample locations that COCs were detected.

ArcView, a graphical data presentation and geographic information system software package, was used to plot risk and hazard estimates on NSA Memphis maps. The risk or hazard for individual locations was plotted using corresponding northing and easting data. All graphical presentations of risk and corresponding tables are based on RME exposure assumptions and RGOs presented in Section 8.3.4.8. Figures were developed for a residential land use scenario only.

Risk and hazard point mapping is useful for determining whether hot spots (or isolated areas of gross contamination) exist within an otherwise unimpacted area and in identifying areas where remedial activities would be more effective. This information is important because heterogeneous contaminant concentrations can affect the manner in which receptors are exposed to the affected media. As discussed earlier, it is sometimes appropriate to estimate the FI/FC from the contaminated source in computing CDI. Point maps allow for visual analysis of risk and hazard distributions and facilitate estimation of the extent of hot spots relative to the overall site area. These maps also support preliminary scoping of remedial requirements as well as assessment of potential cleanup alternatives in a Corrective Measures Study.

Cumulative risk maps could be misleading when different chemicals contribute to elevated risk estimates in a cluster of sample locations. Such an area could appear to be a hot spot, when chemicals with different toxicology were reported at each location. For this reason, it is important to support the figures with tables showing individual chemical concentrations along with risk and



LEGEND - RISK VALUES

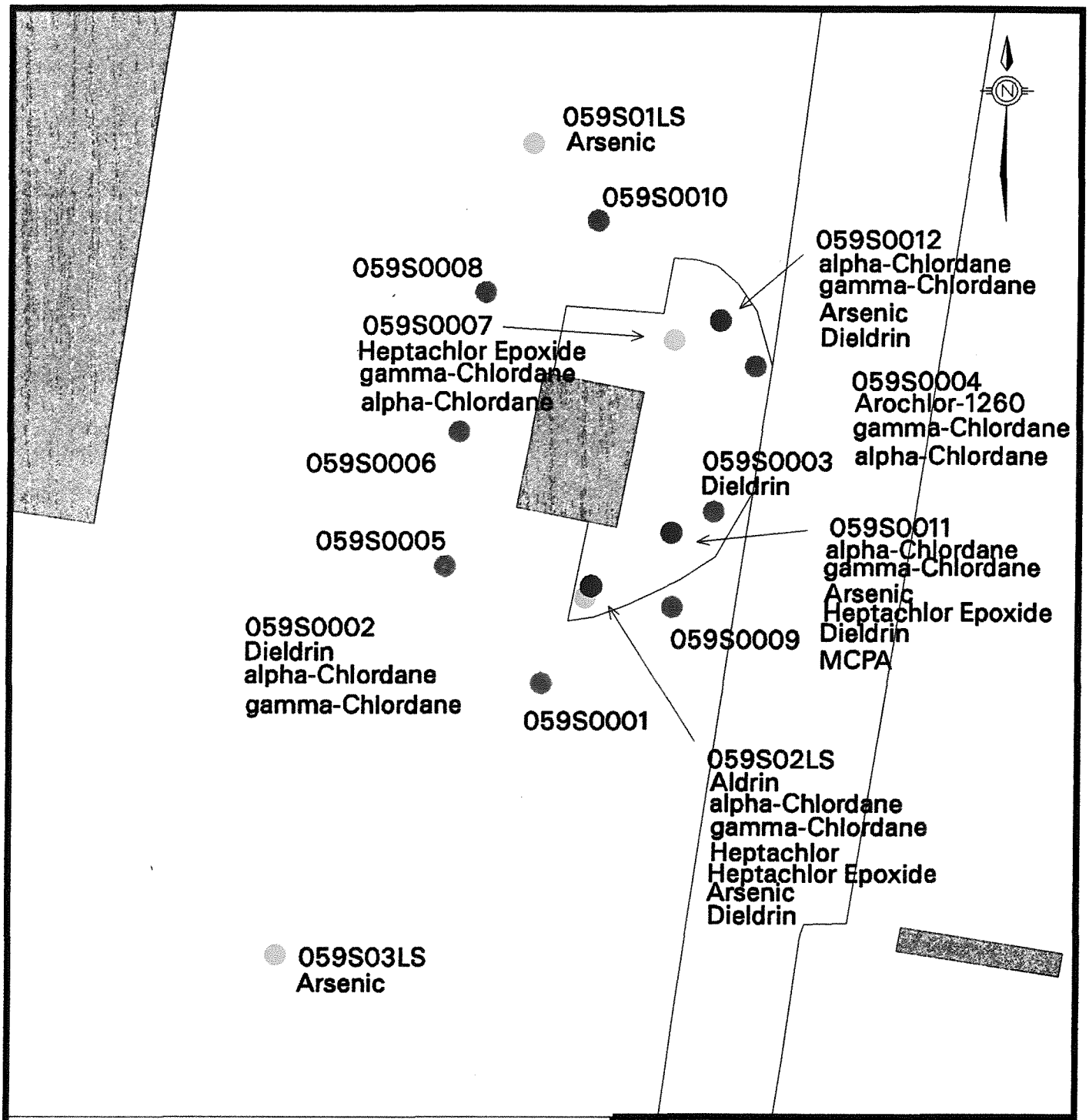
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 50

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.5.13
CUMULATIVE RESIDENTIAL
RISK IN SOIL
SWMU 59

AMIL: /homelee2/memphis_dsdlb_dirbeem_s/tsk_eesses/fig8and9



LEGEND - HAZARD VALUES

- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 50

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.5.14
CUMULATIVE RESIDENTIAL
HAZARD IN SOIL
SWMU 59

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
059S000102	µg/kg	19	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.3E-10
	µg/kg	19	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	µg/kg	190	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	9.7	U	2	Aldrin	2	0.0011	7.7E-08	0.0001	1.6E-08
	µg/kg	19	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.00004	3.2E-10
	µg/kg	19	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.00002	1.6E-10
	µg/kg	19	U	1.95	Dieldrin	1.95	0.0006	7.1E-10	0.0001	1.4E-10
	µg/kg	9.7	U	1	Heptachlor	1	0.00003	1.0E-08	0.00000	2.1E-09
	µg/kg	9.7	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.0001	4.2E-09
						sum	0.004	2.1E-07	0.0003	4.3E-08
059S000202	µg/kg	260	JD	260	4,4'-DDE	260	NA	2.0E-07	NA	4.1E-08
	µg/kg	180	JD	180	4,4'-DDT	180	NA	5.3E-08	NA	2.8E-08
	µg/kg	420	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	21	U	2	Aldrin	2	0.0011	7.7E-08	0.0001	1.6E-08
	µg/kg	430	DE	430	alpha-Chlordane	430	0.12	3.5E-07	0.0093	7.0E-08
	µg/kg	420	D	420	gamma-Chlordane	420	0.12	3.2E-07	0.0090	6.7E-08
	µg/kg	650	D	650	Dieldrin	650	0.0006	7.1E-10	0.0001	1.4E-10
	µg/kg	21	U	1	Heptachlor	1	0.00003	1.0E-08	0.00000	2.1E-09
	µg/kg	21	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.0001	4.2E-09
						sum	0.2367	3.0E-06	0.0185	6.2E-07
059S000302	µg/kg	39	JD	39	4,4'-DDE	39	NA	3.0E-08	NA	6.1E-09
	µg/kg	77	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	µg/kg	770	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	Units	Result	VQUAL	Assumed Conc.	Param	EPC	Child HQ	ILCR	Worker HQ	Worker ILCR
	µg/kg	38	U	2	Aldrin	2	0.0011	7.7E-08	0.0001	1.6E-08
	µg/kg	38	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.00004	3.2E-10
	µg/kg	38	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.00002	1.6E-10
	µg/kg	190	J	190	Dieldrin	190	0.063	6.9E-08	0.0049	1.4E-08
	µg/kg	38	U	1	Heptachlor	1	0.00003	1.0E-08	0.000003	2.1E-09
	µg/kg	38	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.0001	4.2E-09
						sum	0.066	3.0E-07	0.0052	6.2E-08
059S000402	µg/kg	130	D	130	4,4'-DDE	130	NA	1.0E-07	NA	2.0E-08
	µg/kg	110	D	110	4,4'-DDT	110	NA	3.2E-08	NA	1.7E-08
	µg/kg	210	JD	210	Aroclor-1260	210	NA	9.5E-07	NA	1.9E-07
	µg/kg	20	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	µg/kg	19	JD	19	alpha-Chlordane	19	0.0052	1.5E-08	0.00041	3.0E-09
	µg/kg	22	D	22	gamma-Chlordane	22	0.0060	1.7E-08	0.00047	3.5E-09
	µg/kg	40	U	1.95	Dieldrin	1.95	0.00064	7.1E-10	0.000050	1.4E-10
	µg/kg	20	U	1	Heptachlor	1	0.000033	1.0E-08	0.000003	2.1E-09
	µg/kg	20	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.000099	4.2E-09
						sum	0.0143	1.3E-06	0.0011	2.8E-07
059S000502	µg/kg	4.2	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.3E-10
	µg/kg	4.2	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	µg/kg	42	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	2.1	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	µg/kg	2.1	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.2E-10
	µg/kg	2.1	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
	µg/kg	4.2	U	1.95	Dieldrin	1.95	0.00064	7.1E-10	0.000050	1.4E-10
	µg/kg	2.1	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.1E-09
	µg/kg	2.1	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.2E-09
						sum	0.0039	2.1E-07	0.00030	4.3E-08
059S000602	µg/kg	340	D	340	4,4'-DDE	340	NA	2.622E-07	NA	5.33E-08
	µg/kg	120	D	120	4,4'-DDT	120	NA	3.507E-08	NA	1.88E-08
	µg/kg	420	U	19.5	Aroclor-1260	19.5	NA	8.847E-08	NA	1.80E-08
	µg/kg	21	U	2	Aldrin	2	0.0011	7.713E-08	0.000086	1.57E-08
	µg/kg	21	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.2E-10
	µg/kg	21	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10
	µg/kg	42	U	1.95	Dieldrin	1.95	0.00064	7.078E-10	0.000050	1.44E-10
	µg/kg	21	U	1	Heptachlor	1	0.000033	1.021E-08	0.0000026	2.08E-09
	µg/kg	21	U	1	Heptachlor epoxide	1	0.0013	2.064E-08	0.00010	4.20E-09
						sum	0.004	5E-07	0.0003	1E-07
059S000702	µg/kg	44	JD	44	4,4'-DDE	44	NA	3.4E-08	NA	6.9E-09
	µg/kg	25	JD	25	4,4'-DDT	25	NA	7.3E-09	NA	3.9E-09
	µg/kg	220	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	11	U	2	Aldrin	2	0.0011	7.7E-08	0.00009	1.6E-08
	µg/kg	370	JD	370	alpha-Chlordane	370	0.10	3.0E-07	0.0080	5.9E-08
	µg/kg	490	JD	490	gamma-Chlordane	490	0.13	3.8E-07	0.011	7.8E-08
	µg/kg	18	JD	18	Dieldrin	18	0.0059	6.5E-09	0.00046	1.3E-09
	µg/kg	99	D	99	Heptachlor	99	0.0033	1.0E-06	0.00026	2.1E-07
	µg/kg	140	JD	140	Heptachlor epoxide	140	0.18	2.9E-06	0.014	5.9E-07
						sum	0.42	6.7E-06	0.033	1.4E-06

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
059S000802	μg/kg	19	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.3E-10
	μg/kg	19	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	μg/kg	190	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	μg/kg	9.4	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	μg/kg	9.4	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.2E-10
	μg/kg	9.4	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10
	μg/kg	19	U	1.95	Dieldrin	1.95	0.00064	7.1E-10	0.000050	1.4E-10
	μg/kg	9.4	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.1E-09
	μg/kg	9.4	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.2E-09
						sum	0.0039	2.1E-07	0.0003	4.3E-08
059S000902	μg/kg	200	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.29E-10
	μg/kg	200	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.29E-10
	μg/kg	2000	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.80E-08
	μg/kg	100	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.57E-08
	μg/kg	100	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.20E-10
	μg/kg	100	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10
	μg/kg	200	U	1.95	Dieldrin	1.95	0.00064	7.1E-10	0.000050	1.44E-10
	μg/kg	100	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.08E-09
	μg/kg	100	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.20E-09
						sum	0.0039	2.08E-07	0.0003	4.25E-08
059S001002	μg/kg	190	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.3E-10
	μg/kg	190	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	μg/kg	1900	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	μg/kg	95	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	μg/kg	95	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.2E-10
	μg/kg	95	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
	µg/kg	190	U	1.95	Dieldrin	1.95	0.00064	7.1E-10	0.000050	1.4E-10
	µg/kg	95	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.1E-09
	µg/kg	95	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.2E-09
						sum	0.0039	2.1E-07	0.00030	4.3E-08
059S001101	µg/kg	1300	JD	1300	4,4'-DDE	1300	NA	1.003E-06	NA	2.039E-07
	µg/kg	1300	JD	1300	4,4'-DDT	1300	NA	3.799E-07	NA	2.039E-07
	µg/kg	2200	U	19.5	Aroclor-1260	19.5	NA	8.847E-08	NA	1.799E-08
	µg/kg	140	JD	140	Aldrin	140	0.077	5.399E-06	0.006	1.098E-06
	µg/kg	6500	JD	6500	alpha-Chlordane	6500	1.79	5.2E-06	0.14	1.0E-06
	µg/kg	6900	JD	6900	gamma-Chlordane	6900	1.9	5.5E-06	0.15	1.1E-06
	µg/kg	1800	JD	1800	Dieldrin	1800	0.59	6.533E-07	0.046	1.328E-07
	µg/kg	310	JD	310	Heptachlor	310	0.010	3.165E-06	0.0008	6.435E-07
	µg/kg	800	JD	800	Heptachlor epoxide	800	1.0	1.672E-05	0.080	3.4E-06
	µg/kg	6500		6500	MCPA	6500	0.015	NA	0.0012	NA
	mg/kg	15.3	J	15.3	Arsenic (As)	15.3	0.70	3.996E-05	0.035	5.654E-06
	µg/kg	967.5		967.5	BEQ	967.5	NA	1.602E-05	NA	3.258E-06
						sum	6.11	1.2E-04	0.46	2E-05
059S001201	µg/kg	2300	D	2300	4,4'-DDE	2300	NA	1.8E-06	NA	3.6E-07
	µg/kg	4000	D	4000	4,4'-DDT	4000	NA	1.2E-06	NA	6.3E-07
	µg/kg	5400	JD	5400	Aroclor-1260	5400	NA	2.4E-05	NA	5.0E-06
	µg/kg	200	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	µg/kg	860	D	860	alpha-Chlordane	860	0.24	6.7E-07	0.019	1.4E-07
	µg/kg	790	D	790	gamma-Chlordane	790	0.22	6.2E-07	0.0170	1.3E-07
	µg/kg	750	D	750	Dieldrin	750	0.25	2.7E-07	0.019	5.5E-08
	µg/kg	200	U	1	Heptachlor	1	0.00003	1.0E-08	0.0000026	2.1E-09
	µg/kg	200	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.2E-09

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
	µg/kg	1000	UJ	460	MCPA	460	0.015	NA	0.0012	NA
	mg/kg	27		27	Arsenic (As)	27	1.2	7.1E-05	0.062	1.0E-05
	µg/kg	1181.5		1181.5	BEQ	1181.5	NA	2.0E-05	NA	4.0E-06
						sum	1.95	1.2E-04	0.12	2.1E-05
059S01LS02	µg/kg	12	J	12	4,4'-DDE	12	NA	9.3E-09	NA	1.9E-09
	µg/kg	7.2	J	7.2	4,4'-DDT	7.2	NA	2.1E-09	NA	1.1E-09
	µg/kg	39	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	2	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	µg/kg	2	U	2	alpha-Chlordane	2	0.0005	1.6E-09	0.000043	3.2E-10
	µg/kg	2	U	1	gamma-Chlordane	1	0.0003	7.8E-10	0.000022	1.6E-10
	µg/kg	3.9	U	1.95	Dieldrin	1.95	0.0006	7.1E-10	0.000050	1.4E-10
	µg/kg	2	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.1E-09
	µg/kg	2	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.000099	4.2E-09
	µg/kg	940	U	460	MCPA	460	0.0152	NA	0.001	NA
	mg/kg	3.3	J	3.3	Arsenic (As)	3.3	0.1508	8.6E-06	0.008	1.2E-06
	µg/kg	192.15		192.15	BEQ	192.15	NA	3.2E-06	NA	6.5E-07
						sum	0.17	1.2E-05	0.0091	1.9E-06
059S02LS02	µg/kg	2500	DJ	2500	4,4'-DDE	2500	NA	1.9E-06	NA	3.9E-07
	µg/kg	1700	DJ	1700	4,4'-DDT	1700	NA	5.0E-07	NA	2.7E-07
	µg/kg	890	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	840	DJ	840	Aldrin	840	0.46	3.2E-05	0.036	6.6E-06
	µg/kg	4800	DJ	4800	alpha-Chlordane	4800	1.3	3.8E-06	0.10	7.8E-07
	µg/kg	8800	DJ	8800	gamma-Chlordane	8800	2.4	7.0E-06	0.19	1.4E-06
	µg/kg	1200	D	1200	Dieldrin	1200	0.40	4.4E-07	0.031	8.9E-08
	µg/kg	3900	D	3900	Heptachlor	3900	0.13	4.0E-05	0.010	8.1E-06
	µg/kg	2200	D	2200	Heptachlor epoxide	2200	2.8	4.5E-05	0.22	9.2E-06

Table 8.5.21

Risk and Hazard Estimates for each COPC at Each Sample Location

SWMU 59 NSA Memphis

							Residential		Industrial	
								LWA		
Sample ID	**Units**	**Result**	**VQUAL**	**Assumed Conc.**	**Param**	**EPC**	**Child HQ**	**ILCR**	**Worker HQ**	**Worker ILCR**
	µg/kg	920	U	460	MCPA	460	0.015	NA	0.0012	NA
	mg/kg	9.7	J	9.7	Arsenic (As)	9.7	0.44	2.5E-05	0.022	3.6E-06
	µg/kg	384.3		384.3	BEQ	384.3	NA	3.2E-06	NA	6.5E-07
						sum	7.97	1.9E-04	0.6	3.7E-05
059S03LS02	µg/kg	4.2	U	2.1	4,4'-DDE	2.1	NA	1.6E-09	NA	3.3E-10
	µg/kg	4.2	U	2.1	4,4'-DDT	2.1	NA	6.1E-10	NA	3.3E-10
	µg/kg	42	U	19.5	Aroclor-1260	19.5	NA	8.8E-08	NA	1.8E-08
	µg/kg	2.1	U	2	Aldrin	2	0.0011	7.7E-08	0.000086	1.6E-08
	µg/kg	2.1	U	2	alpha-Chlordane	2	0.00055	1.6E-09	0.000043	3.2E-10
	µg/kg	2.1	U	1	gamma-Chlordane	1	0.00027	7.8E-10	0.000022	1.6E-10
	µg/kg	4.2	U	1.95	Dieldrin	1.95	0.00064	7.1E-08	0.00005	1.4E-08
	µg/kg	2.1	U	1	Heptachlor	1	0.000033	1.0E-08	0.0000026	2.1E-09
	µg/kg	2.1	U	1	Heptachlor epoxide	1	0.0013	2.1E-08	0.00010	4.2E-09
	µg/kg	930	U	460	MCPA	460	0.015	NA	0.00119	NA
	mg/kg	7.2	J	7.2	Arsenic (As)	7.2	0.33	1.9E-05	0.017	2.7E-06
	µg/kg	192.15		192.15	BEQ	192.15	NA	3.2E-06	NA	6.5E-07
						sum	0.35	2.2E-05	0.018	3.4E-06

hazard estimates. These tables are sorted by sample location and also show cumulative values for each location.

Figures presented in this report are approximations which include many uncertainties. The numerous uncertainties in risk and hazard estimates presented in tables and figures should be considered by risk management when making decisions regarding the potential for exposure to site media.

Table 8.5.22 lists the FI/FC term for each COPC, frequency of detection, and abbreviated sample numbers. This table also lists comments for each COPC's spatial distribution. Table 8.5.22 and either Figure 8.5.13 or 8.5.14 can be used to visually determine the FI/FC term based on its spatial distribution at the site.

Table 8.5.22
Spatial Distribution of COPCs at SWMU 59 NSA Memphis

Chemical	FI/FC	Frequency of Detection	Sample Numbers	Comments on Spatial Distribution
4,4'-DDE	0.5	9/15	059S0002, 059S0003, 059S0004, 059S0006, 059S0007, 059S0011, 059S012, 059S01LS, 059S02LS	All detects were to the west, except for one at sample location 059S0006.
4,4'-DDT	0.5	8/15	059S0002, 059S0003, 059S0004, 059S0006, 059S0011, 059S012, 059S01LS, 059S02LS	All detects were to the west, except for one at sample 059S0006.
Aldrin	NA	2/15	059S0011, 059S02LS	The 95% UCL was used for the EPC.
alpha-Chlordane	0.3	6/15	059S0002, 059S0004, 059S0007, 059S0011, 059S0012, 059S02LS	Detects were confined to the west of the building, and they were close to each other.
Arsenic	1	5/5	059S0011, 059S0012, 059S01LS, 059S02LS, 059S03LS	All five samples analyzed for metals contained arsenic.
Aroclor-1260	NA	2/15	059S0004, 059S0012	The 95% UCL was used for the EPC.
BEQ	0.6	3/5	059S0011, 059S0012, 059S02LS	Detects were on west side, none on north, east, and south
Dieldrin	0.30	6/15	059S0002, 059S0003, 059S0007, 059S0011, 059S012, 059S02LS	All detects were on the western side of the building.
gamma-Chlordane	0.3	6/15	059S0002, 059S0004, 059S0007, 059S0011, 059S012, 059S02LS	Detects were confined to the west of the building, and they were close to each other.

Table 8.5.22
Spatial Distribution of COPCs at SWMU 59 NSA Memphis

Chemical	FI/FC	Frequency of Detection	Sample Numbers	Comments on Spatial Distribution
Heptachlor	0.15	3/15	059S0007, 059S0011, 059S02LS	Three samples were very close together on the southeastern side of the building. A fourth was on the western side.
Heptachlor epoxide	0.15	3/15	059S0007, 059S0011, 059S02LS	Three samples were very close together on the southeastern side of the building. A fourth was on the western side.
MCPA	0.1	1/5	059S0011	One detect

Quantification of Risk/Hazard

Uncertainty in the quantification of risk/hazard is due to possible cumulative effects of CPSS previously eliminated in the risk screening and the assumptions of the parameters used to estimate human exposures.

Surface Soil

CPSS eliminated from the formal assessment that did not exceed RBCs or RCs did not approach within 10% of their respective RBCs. Risk and/or hazard might be underestimated if several CPSS were near their respective RBCs, but this was not the case, reducing the likelihood of potentially significant cumulative risk/hazard with respect to the eliminated CPSS.

The Reasonable Maximum Exposure (RME) assumptions used to calculate the risk/hazard estimations to soil exposure is based on the 95th percentile, which tends to overestimate the risk/hazard. As a measure of variability, Central Tendency (CT) analysis was performed on surface soil exposure. In accordance with *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure-Draft* (USEPA, 1993a), the exposure duration of site residents was reduced from 30 to 9 years, with two of the years for child exposure, and seven years of the years for adult exposure. Exposure frequency was reduced from 350 to 234 days for site residents.

Using CT exposure assumptions, residential soil exposure ILCR estimate drops from 1.2E-4 to 2.4E-5, and the children's HI estimate drops from 3 to 0.7. Using the CT assumptions reduces the risk and hazard of surface soils to acceptable limits for residential use.

Loess Groundwater

Arsenic, beryllium, and chromium all exceeded their respective tap water RBCs, but not their RCs. No other CPSS came within 10% of their tap water RBCs.

When CT analysis was also performed for groundwater, site residents exposure duration was reduced from thirty to nine years and with two years for child exposure, and with seven years for adult exposure. Exposure assumptions were modified to reflect the 50th percentile rather than the 95th, and EPCs were not modified. Exposure frequency was reduced from 350 to 234 days for site residents and from 250 to 219 days for site workers. The drinking water ingestion rate for an adult was reduced from 2 to 1.4 liters per day, and exposure to groundwater was reduced by 25% to account for other water sources. Using these exposure assumptions, the adult and child HI was lowered from 0.8 and 2 to 0.05 and 0.2, respectively. As a result, the CT exposure scenario reduces the hazard exposure for groundwater to acceptable levels.

8.5.4.7 Risk Summary

Table 8.5.23 summarizes soil exposure pathway and groundwater exposure scenarios.

Table 8.5.23
Summation of Exposure Pathways
SWMU 59 — NSA Memphis

	Future Site Residents			Current and Future Site Workers	
Medium and Exposure Pathway	**Adult HI**	**Child HI**	**LWA ILCR**	**Worker HI**	**Worker ILCR**
Soil — Incidental Ingestion	0.3	2.7	9.7E-05	0.1	1E-05
Soil — Dermal Exposure	0.2	0.5	2.3E-05	0.1	9E-06
Sum of Soil	*0.5*	*3.2*	*1.2E-4*	*0.2*	*1.9E-05*
Loess Groundwater — Ingestion	0.8	2.1	7E-05	0.2	2E-05
Sum of Soil and Loess Groundwater	*1.4*	*5.3*	*2.1E-04*	*0.4*	*3.9E-05*

Notes:

HI — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average

Surface Soil

Acceptable levels of risk are exceeded for the cumulative incidental ingestion and dermal exposure for the soil exposure pathway. The cumulative soil ingestion and dermal contact exceeds 1E-4. The acceptable limits for child hazard are exceeded as well. The soil ingestion and dermal exposure HI equal 2.7 and 0.5, respectively. Industrial risk and/or hazard acceptable limits are not exceeded.

Loess Groundwater

Acceptable levels of the HI are exceeded for loess groundwater ingestion for children. The HI exceeds the threshold of 1. Industrial risk and/or hazard acceptable limits are not exceeded.

8.5.4.8 Remedial Goal Options

Soil

Table 8.5.24 lists RGOs for LWA ILCR and child HI for residential reuse.

Loess Groundwater

Table 8.5.25 list RGOs for LWA ILCR and child hazard residential reuse scenario. It should be noted that the EPCs for heptachlor epoxide and barium are below their respective MCLs. Vanadium's EPC is 46.8 mg/L compared to its RC of 40.9 mg/L.

Table 8.5.24
Residential Remedial Goal Options for COCs in Surface Soil
SWMU 59 NSA Memphis
(mg/kg)

Chemical	EPC	RC	RBC	Child Hazard at 0.1	Child Hazard at 1	Child Hazard at 3	LWA ILCR E10-6	LWA ILCR E10-5	LWA ILCR E10-4
Aldrin	0.84	NA	0.038	1.82	18.2	54.6	0.026	0.26	2.6
alpha-Chlordane	6.5	NA	1.83	0.36	3.6	10.3	1.3	13	130
Arsenic	27	14.58	0.43	2.2	21.9	65.6	0.4	3.8	38
Aroclor-1260	5.4	NA	0.32	NA	NA	NA	0.22	2.20	22.0
BEQ	1.2	NA	0.088	NA	NA	NA	0.06	0.6	.6
gamma-Chlordane	8.8	NA	1.83	0.36	3.6	10.3	1.3	13	130
Heptachlor	3.9	NA	0.14	3	30	90	0.098	0.98	9.8
Heptachlor epoxide	2.2	NA	0.07	0.079	0.79	2.37	0.05	0.5	5

Notes:
COC — Chemical of Concern
EPC — Exposure Point Concentration
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average
NA — Not Applicable
mg/kg — milligram per kilogram
RBC — Risk Based Concentration
RC — Reference Concentration, Background

Table 8.5.25
Residential Remedial Goal Options for COCs in Loess Groundwater
SWMU 59 NSA Memphis (all units are μg/L)

Chemical	EPC	MCLS	Tap Water RBC	RC	Child Hazard at 0.1	Child Hazard at 1	Child Hazard at 3	LWA ILCR at 10-6	LWA ILCR at 10-5	LWA ILCR at 10-4
Heptachlor epoxide	0.19	0.2	0.001	NA	0.02	0.20	0.61	0.007	0.07	0.7
Barium	463	2000	260	442	109.5	1095	3285	NA	NA	NA
Vanadium	46.8	NA	26	40.9	10.95	109.50	328.50	NA	NA	NA

Notes:
COC — Chemical of Concern
μg/L — micrograms per liter
NA — None Available or Not Applicable
Res. — Residential Re-use

8.5.5 Ecological Risk Assessment

8.5.5.1 Introduction

The focus of the SWMU 59 ERA is the terrestrial ecosystem associated with the site since other habitat types are not present. This assessment considers surface soil contaminant concentrations and distributions and exposure pathways that could result in unacceptable levels of exposure to terrestrial ecological receptors now or in the future. Potential aquatic risks associated with storm water runoff from this site is discussed in the ERA for SWMU 38 (Industrial Drainage Ditches Southside), in Section 8.4.

8.5.5.2 Problem Formulation

Site Description

The ecological features at SWMU 59 are minimal. The site is a small wooden structure surrounded by a semicircular perimeter of mowed grass which extends no more than 10 feet from the foundation. Beyond the grass border is a large asphalt-covered parking lot and roadway (First Avenue) which service several adjacent buildings.

Ecosystem at Risk

Based on visual observation, no quality habitat is available at SWMU 59. The grassy area surrounding the site could potentially be used by terrestrial receptors such as passerine birds and/or small mammals as foraging areas, but given the size of the area and surrounding human activity, this is not likely. Any such occurrence would most likely be transient or opportunistic. No viable terrestrial community exists within SWMU 59. With limited habitat and lack of terrestrial receptors, the SWMU 59 area does not warrant a preliminary ecological risk assessment.

8.5.6 Fate and Transport Assessment

Potential migration pathways associated with SWMU 59 include the surface soil erosion of sorbed constituents forming sediments and constituents leaching from soil-to-groundwater. Neither of these migration pathways should be significant at SWMU 59 due to the presence of paved and vegetated areas and because the large paved area would limit rainwater infiltration. However, these migration pathways are addressed in a screening level assessment. Also, the soil-to-air migration pathway is evaluated due to the exceedance of soil-to-air SSLs for some constituents.

SWMU 59 COCs include:

- ***Acetone, heptachlor epoxide, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, dieldrin, heptachlor, technical chlordane, gamma-chlordane, alpha-chlordane, benzo(a)anthracene, chrysene***, and ***pentachlorophenol*** which all exceeded their respective soil-to-groundwater SSLs.

- ***Arsenic*** and ***nickel*** which exceeded their respective soil-to-groundwater SSLs as well as their RCs.

- ***Aldrin, Aroclor-1260, arsenic, BEQ, chlordane, dieldrin, heptachlor,*** and ***heptachlor epoxide*** which are considered COCs in surface soil in the SWMU 59 HHRA.

- ***Barium, lead, vanadium,*** and ***heptachlor epoxide***, which are considered COCs in loess groundwater in the SWMU 59 HHRA.

- ***Heptachlor epoxide, aldrin, heptachlor,*** and ***technical chlordane*** which all exceeded their respective soil-to-air SSLs.

8.5.6.1 Soil-to-Groundwater Cross-Media Transport

Nineteen constituents (acetone, alpha-chlordane, gamma-chlordane, technical chlordane, dieldrin, heptachlor, heptachlor epoxide, TPH-DRO, arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel, tin, vanadium, and zinc) were detected in both soil and groundwater at SWMU 59. Sixteen constituents are highlighted as posing a potential soil-to-groundwater migration concern as determined by soil concentrations in excess of groundwater protection SSLs. These include one VOC (acetone), three SVOCs [benzo(a)anthracene, chrysene, and pentachlorophenol], ten pesticides (heptachlor, heptachlor epoxide, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, dieldrin, alpha-chlordane, gamma-chlordane, and technical chlordane), and two inorganics (arsenic and nickel). Generally, SVOCs, pesticides, and inorganics, have a relatively high affinity for soil particles and low water solubilities, which limits their movement to groundwater through advective and dispersive transport mechanisms. The maximum concentrations in soil of the above constituents were detected from samples collected from the grassy area of SWMU 59. This indicates the potential for an isolated area of soil-to-groundwater leaching, and since the majority of constituents are pesticides, widespread impact to the aquifer is not expected.

Alpha-chlordane, gamma-chlordane, technical chlordane, dieldrin, heptachlor, heptachlor epoxide, TPH-DRO, and lead were detected in groundwater at concentrations above the tap water RBC, MCL, or other applicable groundwater screening level. All of these contaminants were detected in soil at concentrations exceeding their SSL for soil-to-groundwater transfer, with the exception of lead and TPH-DRO. No SSLs are available for lead and TPH-DRO.

8.5.6.2 Soil-to-Sediment Cross-Media Transport

No sediment samples were taken at SWMU 59; however, surface soil samples were taken in various locations. These locations included grass or asphalt-covered areas. The asphalt areas are irrelevant in terms of discussing soil-to-sediment transport of contaminants. The contaminants

detected in surface soil samples from the grass-covered area include nine pesticides (heptachlor epoxide, technical chlordane, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, heptachlor, dieldrin, and aldrin), two SVOCs [benzo(b)fluoranthene and benzo(a)pyrene], one PCB (Aroclor-1260), and two inorganics (lead and arsenic).

Contaminants found in both the surface soil samples collected from SWMU 59 and the nearby sediment sample 38SM0016 include three pesticides (4,4'-DDE, alpha chlordane, and gamma chlordane), one PCB (Aroclor 1260), and two inorganics (arsenic and lead). All of these contaminants were detected at lower concentrations in the sediment sample than in surface soil, and all contaminants but arsenic and lead were at least one order of magnitude lower. Although evidence exists that contaminants in SWMU 59 surface soil have the potential to form contaminated sediments, contaminants in sediment sample 38SM0016 cannot be directly related to SWMU 59 surface soil due to surface water and sediment from many other areas being transported by the ditches.

8.5.6.3 Soil-to-Air Cross-Media Transport

Contaminants detected in surface soil were screened as potential hazards to air by the soil-to-air cross-media transport mechanism. Of the contaminants detected in surface soil, only pesticides were at levels above their respective soil-to-air volatilization screening levels. These include; aldrin, heptachlor, heptachlor epoxide, and technical chlordane. It should be noted that this screening level was derived to represent the acceptable mean concentration on a 30-acre site. This approach assumes that a homogeneous source exists which can consistently emit aldrin, heptachlor, heptachlor epoxide, and technical chlordane at a rate which will result in unacceptable ambient air concentrations. The limited extent of soil impacts at SWMU 59 indicate that the source strength is far less than that assumed in the screening level development model. As a result, it was concluded that the contaminants described above in surface soil do not represent a viable threat to ambient air quality via volatilization.

It should also be noted that there were no VOCs in surface soil which exceeded their respective soil-to-air SSL. VOCs would represent a greater risk to ambient air quality by volatilization based on their chemical properties (e.g., higher vapor pressure and higher Henry's Law Constant).

8.5.7 Conclusions and Recommendations

The following conclusions are presented based on the findings of the RFI:

- In 1990 an RFI was conducted at SWMU 59 consisting of shallow soil samples from eight boring locations surrounding Building S-335 and wipe samples from the building's interior surfaces. Several of the surface soil samples indicated chlordane and/or dieldrin at concentrations exceeding their RBC and/or SSL values, and one surface soil sample indicated arsenic exceeding its RC, RBC, and SSL. The wipe samples identified various pesticides were present on surfaces inside the building.

- Soil samples collected during the Assembly E RFI indicated the presence of VOCs, SVOCs, TPH, pesticides/PCBs, herbicides, and inorganics. Significant concentrations of pesticides (particularly chlordane) and arsenic were detected in shallow soil in the non-paved area of the site. Exceedances of screening values in soil samples are provided below.

  - Several SVOCs in soil samples exceeded screening values; benzo(a)pyrene and benzo(b)fluoranthene were indicated in hand auger samples above RBC values; benzo(a)anthracene, chrysene, and pentachlorophenol were indicated in hand auger samples above SSL values; and benzo(a)pyrene was indicated in one soil boring surface sample above its RBC value.

- Several pesticides in soil samples exceeded screening values; dieldrin, heptachlor, heptachlor epoxide, and technical chlordane were indicated in DPT soil samples at concentrations exceeding their respective RBCs and/or SSLs; various hand auger and/or soil boring samples indicated the following pesticides at concentrations exceeding their respective RBCs and/or SSLs: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, alpha-chlordane, Aroclor-1260, dieldrin, endrin, endrin aldehyde, gamma-chlordane, heptachlor, heptachlor epoxide, and technical chlordane.

- The only inorganics detected in soil at concentrations exceeding both their RCs and RBCs or SSLs were arsenic, lead, and nickel.

- Groundwater samples collected during the Assembly E RFI indicated VOCs, SVOCs, TPH-DRO, pesticides, and inorganics. No VOCs or SVOCs detected in groundwater exceeded their tap water RBC or MCL (where available). TPH-DRO, detected in one loess monitoring well sample, exceeded TDEC's total TPH groundwater cleanup standard for drinking water. The pesticides dieldrin, heptachlor, heptachlor epoxide, and technical chlordane were detected in one loess monitoring well at concentrations exceeding their tap water RBCs, but not their MCLs, except for dieldrin which has no MCL. The only inorganic detected in groundwater samples at a concentration in excess of a screening level was lead in two loess monitoring well samples which exceeded both lead's TTAL and the loess groundwater RC.

- During the SWMU 38 RFI, one surface and one subsurface sediment sample were collected southeast of SWMU 59 near an outfall of an underground storm sewer line. SSVs were exceeded by the following analytes in the surface sediment sample: Aroclor-1260, 4,4'-DDD, 4,4'-DDE, arsenic, cadmium, copper, lead, and nickel. No contaminant in the surface sediment sample exceeded the residential soil RBC or soil-to-

groundwater SSL and the RC for surface soil, where applicable. No contaminant in subsurface sediment exceeded both the soil-to-groundwater SSL and the RC for subsurface soil, where applicable.

- During the April/May 1997 groundwater sampling event the three loess and one upper fluvial deposits groundwater monitoring wells installed at SWMU 59 were sampled and analyzed for chlorinated pesticides/PCBs and VOCs. The only VOC identified was methylene chloride in one loess well and the concentration was below both its tap water RBC and MCL. No PCBs were identified in any of the groundwater samples. Dieldrin was identified in one loess well above its tap water RBC. Heptachlor epoxide was identified in the same loess well as the dieldrin detection and it was above its tap water RBC, but below its MCL. No MCL is available for dieldrin.

- The HHRA estimated the risk and hazard posed by soil and groundwater contaminants at SWMU 59. Two land use scenarios were evaluated for soil contaminants: the hypothetical site resident and the future site worker. The HHRA assumes that loess groundwater will be used as a drinking water source; however, the loess will likely never be used as a potable water source at NSA Memphis due to its low yield and poor aesthetic water quality. The HHRA evaluated the ingestion routes of exposure for loess groundwater contaminants for three scenarios: the adult site resident, the child site resident, and the site worker. The findings are as follows:

  — **Residential Land Use:** Aldrin, alpha-chlordane, arsenic, Aroclor-1260, BEQ, dieldrin, gamma-chlordane, heptachlor, and heptachlor epoxide were identified as COCs in soil for the residential land use scenario because the sum soil risk estimate is 1E-04, which meets the upper-bound of USEPA's acceptable risk range.

Barium, vanadium, and heptachlor epoxide were identified as COCs in loess groundwater at SWMU 59 for this scenario based on their contribution to hazard for children. Lead was also identified as a COC based on children's groundwater ingestion at the age of 0 to 84 months.

The cumulative HI estimates for the adult site resident and child site resident and site worker are 0.8 and 2. The HI estimated for the child site resident exceeds USEPA's threshold HI of 1, but the HI estimated for the adult site resident does not exceed USEPA's threshold.

— **Industrial Land Use:** No COCs were identified in SWMU 59 surface soil, loess groundwater, or fluvial deposits groundwater for the industrial land use scenario.

- The ERA concluded there is no quality habitat available and no viable terrestrial community exists at SWMU 59. The site is surrounded by asphalt and the grassy area covers only an estimated 1,600 square feet.

- The fate and transport assessment concluded the migration pathways of surface soil erosion, leaching from soil-to-groundwater, soil-to-sediment transport, and soil-to-air transfer should not be significant at SWMU 59 due to the predominance of asphalt cover and the grass that covers the small, unpaved area.

The following recommendations are presented based on the findings of the RFI:

- Pesticide contamination on the interior surface of Building S-335 and in the grass covered area surrounding the building should be addressed through the demolition of the building and a limited soil excavation. Proper removal and disposal of the building debris and

shallow soil would limit future risk to human health or the environment. Also, since loess monitoring well 059G02LS is in the grass area surrounding Building S-335, it will need to be abandoned prior to any soil removal in accordance with Memphis and Shelby County well abandonment regulations. A Voluntary Corrective Action Work Plan for the demolition of Building S-335 and the removal of contaminated soil both under the building and in the grass covered area adjacent to the building has been prepared and is being reviewed by the Navy. The work plan will be submitted to the BCT after Navy comments have been reviewed and addressed.

- Reassess the human health risk associated with SWMU 59 following the building demolition and soil excavation, in order to decide future actions concerning the SWMU.

- Conduct annual sampling and analysis of down gradient monitoring well pair 059G03LS and 059G03UF, and upgradient monitoring well 059G01LS for pesticides.

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8.6 SWMU 65

The Building S-362 Training Mock-Up Site, SWMU 65, has been used since the early 1950s to train personnel in aircraft startup. SWMU 65 includes Building S-362, a concrete pad mock-up area with spaces for approximately 15 planes; Building S-1503, a wood storage shelter; Building S-346, the former engine test cell building; and the surrounding grass-covered area.

SWMU 65 is bounded by Big Creek Drainage Canal on the south and Seventh Avenue on the east. A broad grassy area and levee separate the concrete pad area from Big Creek Drainage Canal. SWMU 65 topography slopes gently south. Storm water runoff from the concrete pads flows across the grassy area into a linear drainage depression along the south side of the site. An additional drainage depression bisects the site, conveying water from its west and east sides to the southern drainage depression. Drainage from both linear depressions enters a north-south drainage depression at the site's southeast corner, where it exits the SWMU and eventually enters Big Creek Drainage Canal at an outlet near Seventh Avenue. Figure 1.6 (Section 1) provides a site map of SWMU 65.

Two 30,000-gallon USTs, formerly used to fuel the test cell, were north of Building S-346. The USTs were removed in 1984, and no free product was observed in the excavated area; however, a hydrocarbon odor and discolored soil were noted in the excavation. Underground piping likely transported the jet fuel to the test cell; however, this piping has not been located.

Anticipated site constituents include VOCs and SVOCs that comprise jet fuel, engine oil, and hydraulic fluids. Chlorinated solvents, such as trichloroethene, trichloroethane, and tetrachloroethene, may also have been used as cleaning compounds at SWMU 65.

8.6.1 Previous Investigation Results

Three previous investigations have been conducted at SWMU 65. The first two investigations were in response to a 25-gallon jet propulsion fuel #5 (JP-5) release on April 28, 1992. The third investigation consisted of a geophysical survey to locate the former UST area and its associated piping. The following paragraphs describe the previous investigation results.

8.6.1.1 JP-5 Release Investigations

On May 4, 1992, Navy personnel excavated the soil in the JP-5 spill area near the easternmost concrete pad, collected four surface and subsurface soil samples, then backfilled with the excavated material. The samples were submitted to a laboratory for TPH analysis. Analytical results indicated TPH concentrations ranged from 38,900 mg/kg at the surface to 5,090 mg/kg at a depth of approximately 6 feet bls near the spill area.

In October and November 1992, Memphis Environmental Center Inc. performed a limited site investigation at SWMU 65 in response to the JP-5 spill (MEC, 1992). The investigation consisted of using a hollow-stem auger drill rig to advance and sample four soil borings and installing an upper alluvium groundwater monitoring well within each open borehole. Five additional soil borings were completed; three using a stainless-steel hand auger and two using a hollow-stem auger drill rig. Soil and groundwater samples were analyzed for TPH-GRO and TPH-DRO; and benzene, toluene, and xylene (BTX). Table 8.6.1 summarizes the analytical results.

As shown in the table, total TPH in soil, obtained by adding the GRO and DRO fractions, ranged from nondetect to 7,930 mg/kg. The majority of total TPH in the soil samples consisted of the TPH-DRO fraction, with concentrations increasing with depth in seven of nine soil borings. The sum of BTX constituents in soil samples ranged from nondetect to 28.0 mg/kg. Most total BTX in the soil samples consisted of xylene. Total TPH in upper alluvium groundwater ranged from

295 to 2,980 micrograms per liter (μg/L) and consisted primarily of TPH-DRO. No BTX was detected in the groundwater samples.

Table 8.6.1
Analytical Summary of Soil and Groundwater Samples — 1992 Site Investigation

Sample Location	Depth (feet bls)	TPH-GRO[a]	TPH-DRO[a]	Total TPH[b]	Benzene	Toluene	Xylenes	Total BTX[c]
Soil Samples (data in mg/kg)								
065G01UA[d]	1 - 3	49.3	2,820	2,869.3	ND	2.44	23.5	25.94
	3 - 5	34.1	801	835.1	ND	ND	3.45	3.45
065G02UA[d]	0 - 2	ND[e]	ND	ND	ND	ND	ND	ND
	4 - 6	ND	263	263	ND	ND	ND	ND
065G03UA[d]	0 - 2	ND	ND	ND	ND	ND	ND	ND
	4 - 6	102	595	697	ND	ND	11.2	11.2
065G04UA[d]	0 - 2	ND	ND	ND	ND	ND	ND	ND
	4 - 6	15.2	479	494.2	ND	ND	5.06	5.06
B-1	1 - 2	ND	7,930	7,930	ND	ND	2.06	2.06
	3 - 4	10.3	2,060	2,070.3	ND	ND	1.29	1.29
	4 - 5	18.4	5,160	5,178.4	ND	ND	5.19	5.19
B-2	0 - 1	ND	1,940	1,940	ND	ND	ND	ND
	1 - 2	ND	4,200	4,200	ND	ND	0.61	0.61
	4 - 5	23.1	2,450	2,473.1	ND	ND	2.69	2.69
B-3	2 - 4	ND	259	259	ND	ND	0.38	0.38
	4 - 6	37.8	670	707.8	ND	ND	6.91	6.91
B-4	0 - 2	ND	187	187	ND	ND	ND	ND
	4 - 6	19.2	939	958.2	ND	ND	4.54	4.54
B-5	1 - 2	10.8	189	199.8	ND	0.42	2.30	2.72
	4 - 5	118	3,810	3,928	ND	0.80	27.2	28.0
Groundwater Samples (data in μg/L)								
065G01UA[d]	5.0 - 15.0[f]	176	2,980	3,156	ND	ND	ND	ND
065G02UA[d]	4.0 - 14.0	147	2,110	2,257	ND	ND	ND	ND
065G03UA[d]	4.0 - 14.0	231	973	1,204	ND	ND	ND	ND
065G04UA[d]	4.0 - 14.0	ND	295	295	ND	ND	ND	ND

Notes:

a — TPH-GRO and TPH-DRO refer to total petroleum hydrocarbons – gasoline range organics and diesel range organics, respectively. TPH was analyzed using the TN Modified 8015 Method. Detection limits are provided in the *Site Investigation Report* (MEC, 1992).

b — Total TPH refers to the sum of TPH-GRO and TPH-DRO concentrations.

c — Total BTX refers to the sum of benzene, toluene, and xylene concentrations. BTX was analyzed using SW-846 Method 8020. Detection limits are provided in the *Site Investigation Report* (MEC, 1992).

d — The soil boring/monitoring well sample designations have been revised to reflect the current monitoring well identification system at Naval Support Activity (NSA) Memphis. 065G01UA, 065G02UA, 065G03UA, and 065G04UA are the revised designations for MW-1, MW-2, MW-3, and MW-4, respectively.

e — ND = parameter not detected.

f — Depth reported is the well screen interval.

8.6.1.2 Geophysical Survey

On July 18, 1995, E/A&H conducted a geophysical survey at SWMU 65 to verify the former location of the two USTs used to fuel Building S-346's engine test cell (E/A&H, 1995c). The EM-31 survey included a conductivity survey and an in-phase (metal detection) survey. Geophysical anomalies due to disturbed soil or metal objects were plotted on a map and compared to as-built engineering drawings obtained from the NSA Memphis Public Works Department. The conductivity survey identified a significant anomaly corresponding to the USTs' former locations. This anomaly was not identified by the in-phase survey indicating the USTs had been removed. A strong, localized anomaly was identified along the southeastern boundary of the surveyed area, but its source was not determined. Two additional linear anomalies may represent buried utility lines. One anomaly bisected the survey area and the second was along the surveyed area's eastern side.

8.6.2 RFI Characterization

RFI characterization focused on the nature and extent of contamination in the following media:

- Surface and subsurface soil near the existing monitoring wells and the former UST area
- Groundwater in the upper and deep alluvium
- Sediment in the two linear drainage depressions

8.6.2.1 DPT Soil and Groundwater Samples

Prior to installing soil borings and monitoring wells, a preliminary soil and groundwater screening investigation was conducted using DPT equipment (Geoprobe) operated by InSitu Technologies Inc. of Traveler's Rest, South Carolina. DPT screening results were used to determine the optimum placement and depth of the soil borings and monitoring wells. Based on the anticipated site constituents and sample volume limitations, TPH-GRO and TPH-DRO were selected as

indicator parameters for DPT soil samples, and VOCs as the indicator parameter for groundwater samples. The DPT investigation focused on the following areas:

- The JP-5 spill area and existing monitoring wells (065G01UA through 065G04UA) where hydrocarbon contamination was detected in the 1992 site investigation

- The former UST area, where a hydrocarbon odor was noted during the USTs' removal in 1984

- South of each concrete pad, where hydrocarbons would accumulate if spilled during airplane refueling and maintenance

Thirty DPT soil boring locations (065S0001 through 065S0030) were selected, and two soil samples were collected from each boring (Figure 8.6.1). The 0 to 2-foot interval (surface) and the 5- to 7-foot interval (subsurface) were sampled at each location, except for location 065S0023, where the subsurface sample was collected from the 7- to 9-foot interval, due to poor sample recovery in the 5- to 7-foot interval.

Eleven upper alluvium groundwater samples were collected from the following locations: 065G0001, 065G0004, 065G0007, 065G0010, 065G0013, 065G0015, 065G0018, and 065G0021 through 065G0024 (Figure 8.6.2). Upper alluvium groundwater sample depths ranged from 13 to 18 feet bls. Six deep alluvium groundwater samples were collected from locations 065G0001 through 065G0006 (Figure 8.6.2). Deep alluvium groundwater sample depths ranged from 37 to 40 feet bls.

Ten percent of the soil and groundwater samples were split as duplicates in accordance with the *Comprehensive RFI Work Plan* (E/A&H, 1994a). NET analyzed all primary and duplicate DPT

soil samples for TPH-GRO and TPH-DRO using the TN Modified 8015 Method, and all DPT groundwater samples for VOCs using SW-846 Method 8240. The following samples were split as duplicates during the DPT investigation:

- Three surface-soil samples (0 to 2-foot bls)
  - 065S0005
  - 065S0016
  - 065S0028

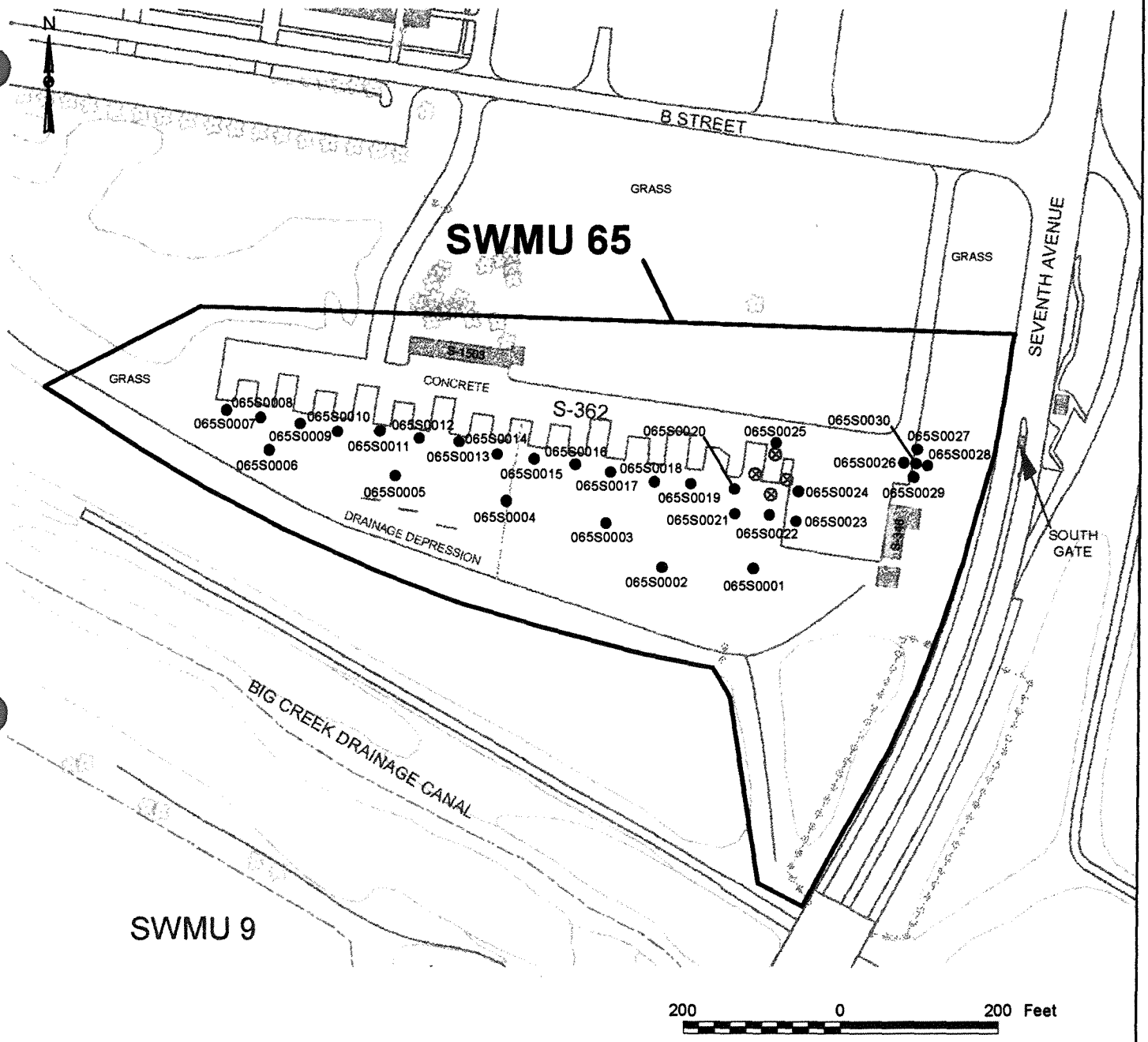
- Three subsurface-soil samples (5- to 7-foot bls)
  - 065S0015
  - 065S0016
  - 065S0028

- One upper alluvium groundwater sample (065G0013)

- One deep alluvium groundwater sample (065G0004)

All DPT samples were collected as outlined in the *Assembly E Site Investigation Plans* (E/A&H, 1995a), with the following exceptions:

- One DPT subsurface soil sample (location 065S0023) was collected from 7 to 9 feet bls instead of from 5 to 7 feet bls, due to poor sample recovery in the 5- to 7-foot interval.



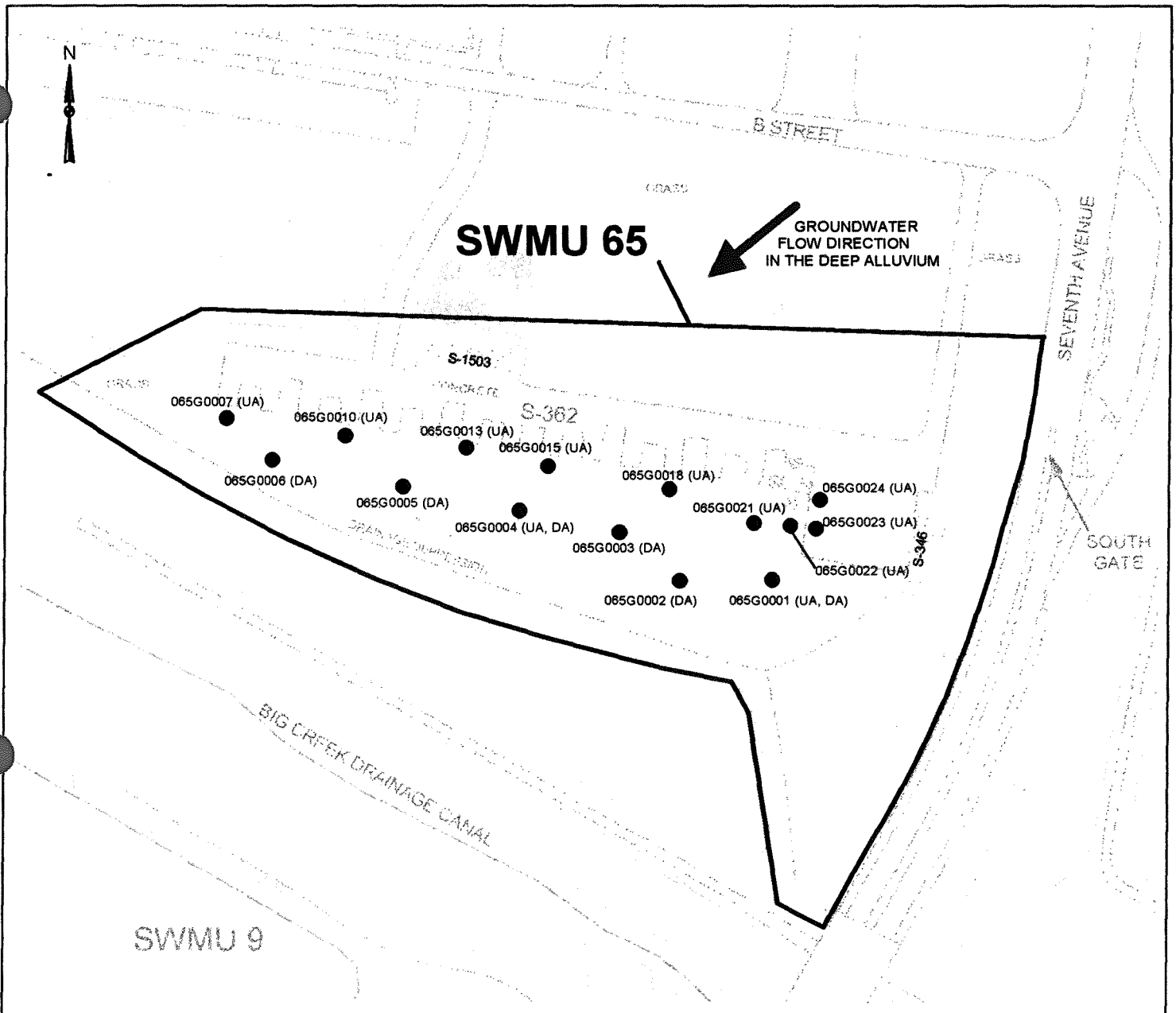
LEGEND

065S0023 ● DPT (GEOPROBE) SOIL SAMPLE LOCATION/DESIGNATION

⊗ EXISTING MONITORING WELL LOCATION FROM 1992 SITE INVESTIGATION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.1
DPT SOIL SAMPLE LOCATIONS
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE



LEGEND

065G0001 (UA,DA) ● DPT (GEOPROBE) GROUNDWATER SAMPLE LOCATION, DESIGNATION, AND INTERVAL SAMPLED

UA UPPER ALLUVIUM

DA DEEP ALLUVIUM

⊗ EXISTING MONITORING WELL LOCATION FROM 1992 SITE INVESTIGATION

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.2
DPT GROUNDWATER SAMPLE LOCATIONS
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE

- Eleven DPT upper alluvium groundwater samples were collected instead of the 30 samples proposed, due to time and equipment limitations. At least two hours were required for the Geoprobe screen point sampler to collect an adequate volume of groundwater for a VOC sample, and the Geoprobe equipment could not pull a vacuum to enhance groundwater recovery. DPT soil samples were screened with a Photovac Microtip HL 2000 photoionization detector (PID). Based on elevated PID readings (up to 221 ppm) in soil near the former JP-5 spill area, six of the 11 upper alluvium sampling locations were positioned surrounding and/or downslope from the former JP-5 spill area. No upper alluvium groundwater samples were collected from the former UST area because PID readings in soil were less than 10 ppm. Two of the upper alluvium DPT groundwater samples were collocated with the deep alluvium samples along the south side of the site. The remaining four upper alluvium DPT sampling locations were equally spaced south of the concrete pads.

8.6.2.2 Soil Boring and Monitoring Well Samples

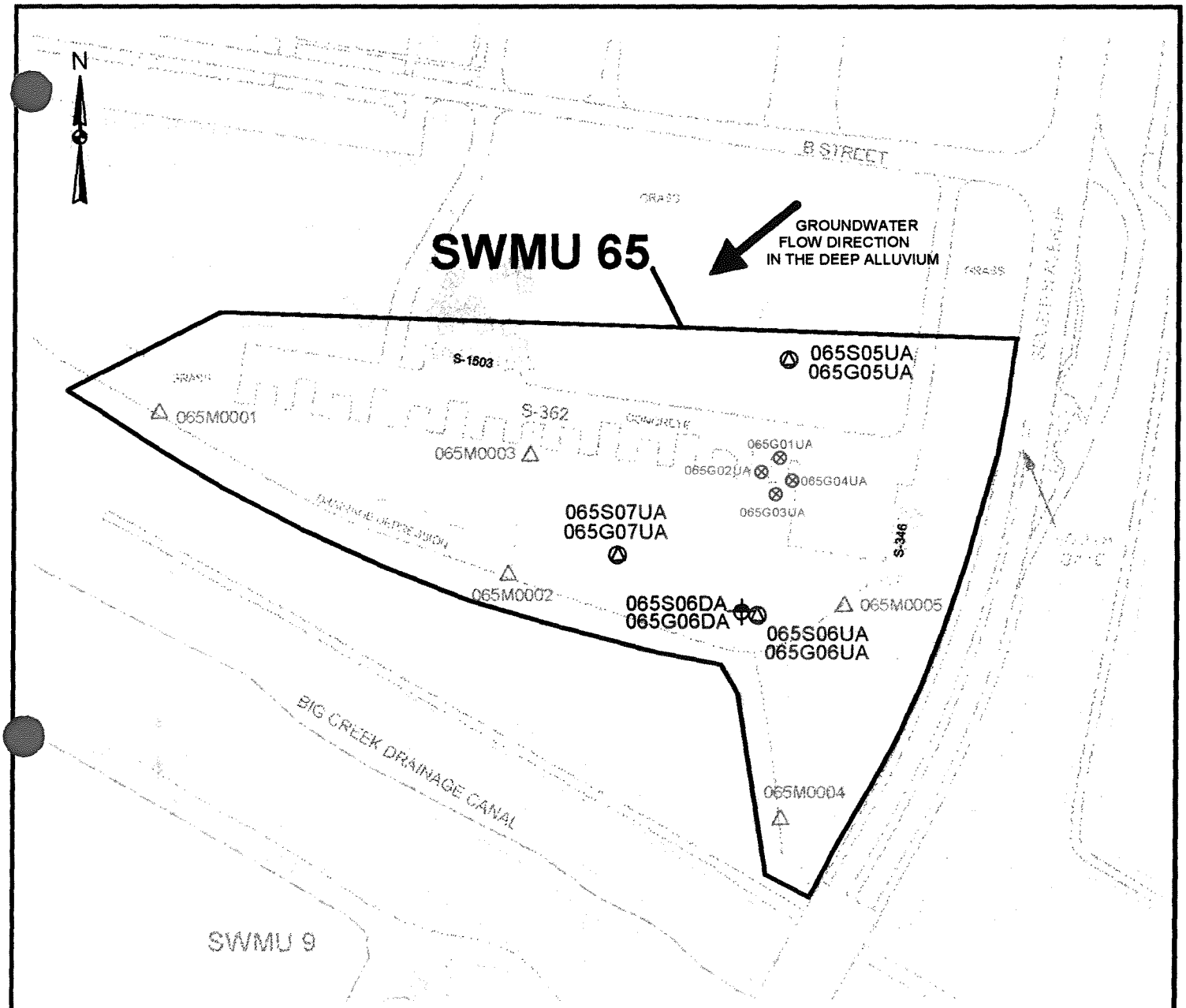
The optimal number, placement, and depth of the RFI soil borings and groundwater monitoring wells were based on the DPT screening investigation and the results of the 1992 site investigation. The soil borings and monitoring wells were placed to adequately characterize the nature and extent of hydrocarbon contamination in soil and groundwater in the SWMU's eastern section, to provide a geologic cross section of the alluvium, and to provide data for establishing the groundwater flow direction in the upper alluvium. Figure 8.6.3 shows the soil boring and monitoring well locations.

Three upper alluvium soil borings (065S05UA, 065S06UA, and 065S07UA) were placed around the primary area of shallow soil and groundwater hydrocarbon contamination (near the JP-5 spill) identified during DPT screening and the 1992 site investigation. Soil boring 065S05UA was positioned upgradient, and borings 065S06UA and 065S07UA were positioned downgradient of the spill area.

The upper alluvium soil borings were advanced and continuously sampled to 20 feet bls. Corresponding upper alluvium monitoring wells (065G05UA, 065G06UA, and 065G07UA) installed through the open boreholes, were screened between 10 and 20 feet bls. One deep alluvium soil boring (065S06DA), placed downgradient of the spill area, was advanced and sampled through the upper and deep alluvium into the Cockfield Formation. The Cockfield Formation was encountered at 42 feet bls, and the boring was terminated at 46 feet bls. The corresponding monitoring well (065G06DA), installed through the open borehole, was screened between 32 and 42 feet bls in the basal 10 feet of the deep alluvium just above the Cockfield Formation. Each soil boring was advanced, soil samples collected continuously, and monitoring wells installed with a rotasonic drill rig operated by Alliance Environmental of Marietta, Ohio.

The following intervals were sampled in each upper alluvium soil boring: 0.5 to 2 feet, 6 to 8 feet, and 12 to 14 feet bls. Soil sample intervals were approximately 2 feet thick to collect adequate sample volume for analysis. The uppermost portion of each surface soil sample — which contained organic material, roots, grass, and gravel — was discarded, yielding an approximate surface soil sampling interval of 0.5 to 2 feet bls. No soil samples were collected from the deep alluvium soil boring 065S06DA because it was collocated with upper alluvium soil boring 065S06UA.

In accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a), 10% of the soil samples were split as duplicates, which consisted of one soil sample from the 12- to 14-foot interval from soil boring 065S06UA. The primary and duplicate soil samples were submitted to NET for FSA, consisting of VOCs, SVOCs, TPH-GRO and TPH-DRO, chlorinated PCBs, organophosphorus pesticides, herbicides, Appendix IX metals, and cyanide. Section 3 lists the analytical test methods used for each soil sample, while the Attachment of the *Data Validation Report — Assembly E* (E/A&H, 1997a) lists analytes reported for each test method.



LEGEND

065G01UA — EXISTING UPPER ALLUVIUM SOIL BORING/ MONITORING WELL LOCATION AND DESIGNATION (1992 SITE INVESTIGATION)

065S05UA 065G05UA — UPPER ALLUVIUM SOIL BORING/ MONITORING WELL LOCATION AND DESIGNATION

065S06DA 065G06DA — DEEP ALLUVIUM SOIL BORING/MONITORING WELL LOCATION AND DESIGNATION

065M0002 — SEDIMENT SAMPLE LOCATION AND DESIGNATION

200 0 200 Feet

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FIGURE 8.6.3
SOIL BORING, MONITORING WELL, AND SEDIMENT SAMPLE LOCATIONS
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE

The three upper alluvium and one deep alluvium monitoring wells were purged and sampled in April 1996, several weeks after monitoring well installation and development. All groundwater samples were submitted to NET for FSA excluding TPH-GRO, since TICs from the VOC analyses would identify many of the lighter fraction hydrocarbons, if present. According to the Assembly E work plan, 10% of the groundwater samples collected during the Assembly E investigation would be split for duplicate analysis. Groundwater was sampled at SWMU 65 at the same time as groundwater sampling at other Assembly E SWMUs, with duplicate and other QA/QC groundwater samples collected assembly-wide rather than from individual SWMUs (i.e., 10% of the samples collected from all Assembly E SWMUs were split as duplicates). As a result, no duplicate groundwater samples were collected from SWMU 65.

8.6.2.3 Sediment Samples

Sediment samples were collected from the linear drainage depressions at SWMU 65 to determine if residual hydrocarbon contamination associated with past SWMU operations was present. Three sediment sample locations (065M0001, 065M0002, and 065M0005) were positioned along the drainage depression along the SWMU's south side, one sediment sample location (065M0003) was placed in the north-south drainage depression bisecting the site, and one sediment sample location (065M0004) was positioned in the north-south drainage depression at the site's southeast corner, which eventually conveys storm water runoff to Big Creek Drainage Canal. The sediment samples were collected with a stainless-steel hand auger from 0 to 6 inches bls and 18 to 24 inches bls at each sampling location. The 0 to 6-inch interval sediment sample from location 065M0004 was split as a duplicate in accordance with the *Assembly E Site Investigation Plans* (E/A&H, 1995a). Figure 8.6.3 shows the sediment sample locations.

According to the *Assembly E Site Investigation Plans* (E/A&H, 1995a), sediment samples would be analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX), TPH-GRO, and TPH-DRO. However, TPH-DRO was inadvertently omitted from the chain-of-custody; therefore there are no TPH-DRO data for sediment samples.

8.6.3 Nature and Extent of Contamination

The following sections describe the nature and extent of contamination in soil, groundwater, and sediment samples collected during the Assembly E SWMU 65 RFI.

8.6.3.1 Nature and Extent of Soil Contamination

This section summarizes the nature and extent of contamination in surface and subsurface soil samples collected at SWMU 65. It includes the results of the surface and subsurface soil samples collected during the DPT investigation and the soil boring (rotasonic drill rig) investigation. Sections 8.6.2.1 and 8.6.2.2 provide details and rationale for sample locations and intervals sampled.

VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides, herbicides, and Appendix IX metals were detected in surface and/or subsurface soil samples collected during the RFI. Constituents in surface soil are compared to their respective USEPA residential and industrial RBCs and SSLs. Constituents in subsurface soil samples are compared to their respective SSLs. Inorganics have also been compared to their established RCs, to determine if the element occurs naturally or may be the result of SWMU 65 operations. The calculations for the RCs are provided in the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a).

8.6.3.1.1 Organic Compounds in Soil Samples

VOCs, SVOCs, chlorinated pesticides, and herbicides were detected in soil samples. The following sections discuss the detected organic compound concentrations by parameter.

VOCs in Soil

The following VOCs were identified in soil boring samples: acetone, ethylbenzene, and total xylene. As shown in Table 8.6.2, none of the detected VOCs exceeded its respective residential RBC or SSL values.

SVOCs in Soil

The following SVOCs were detected in surface soil boring samples:

Benzo(a)anthracene	Chrysene
Benzo(a)pyrene	Dibenz(a,h)anthracene
Benzo(b)fluoranthene	Fluoranthene
Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene	Pyrene

Benzo(a)pyrene in a surface soil sample from soil boring location 065S07UA (210 μg/kg) was the only SVOC to exceed its residential RBC (88 μg/kg). No SVOCs were detected in subsurface soil boring samples. Figure 8.6.4 and Table 8.6.2 show the RBC exceedance in surface soil.

TPH in Soil

TPH-GRO and TPH-DRO were detected in many surface and subsurface soil samples collected during the DPT investigation, but only TPH-GRO was detected in soil samples from soil borings. The USEPA has not established an RBC or SSL for TPH. For evaluation, the TDEC cleanup level of 500,000 μg/kg for total TPH in nondrinking water aquifers (i.e., the upper alluvium) with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997) has been compared to total TPH concentrations in surface and subsurface soil from both DPT screening and soil borings. As shown on Figure 8.6.5, Table 8.6.2, and Table 8.6.3, the cleanup level for total TPH was exceeded only in the 5- to 7-foot interval sample from DPT soil boring 065S0022 (910,000 μg/kg).

Pesticides in Soil

Pesticides, detected only in soil boring samples collected from the surface interval, consisted of the following compounds:

4,4'-DDT	Dieldrin
gamma-Chlordane	alpha-Chlordane

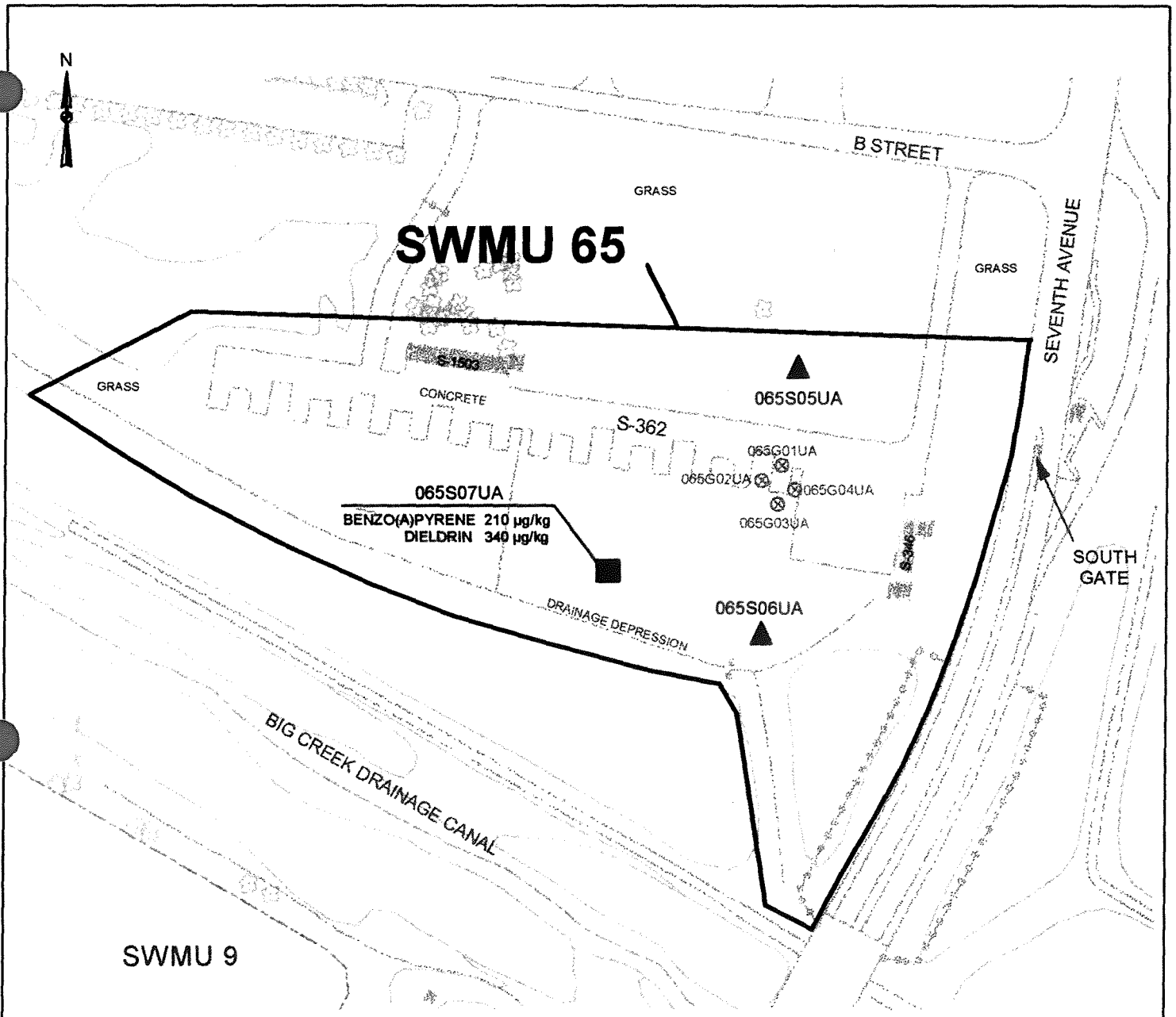
As shown on Table 8.6.2, dieldrin's residential RBC (40 μg/kg) and SSL (1 μg/kg) were exceeded at soil boring 065S07UA (340 μg/kg), the only soil sample where dieldrin was detected. This concentration also exceeded the RC (262 μg/kg) established for dieldrin at NSA Memphis in the *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d). However, the detected concentration did not exceed the industrial RBC (360 μg/kg). Figure 8.6.4 plots RBC exceedances in surface soil. Figure 8.6.6 plots SSL exceedances in surface and subsurface soil.

Herbicides in Soil

No herbicides were detected in surface soil samples from soil borings. However, the following were detected in subsurface soil boring samples:

2,4,5-TP (Silvex)	Dinoseb
MCPA	2,4-DB

As shown on Table 8.6.2, SSLs were not available for any of the detected herbicides.



LEGEND

200 0 200 Feet

▲ NO CONSTITUENT IN SURFACE SOIL EXCEEDED THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

■ ONE OR MORE CONSTITUENTS IN SURFACE SOIL EXCEEDED THE RESIDENTIAL RBC (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE), BUT DID NOT EXCEED THE INDUSTRIAL RBC.

065S07UA
BENZO(A)PYRENE 210 µg/kg
DIELDRIN 340 µg/kg

THE SURFACE SOIL SAMPLE FROM SOIL BORING 065S07UA CONTAINED THE FOLLOWING CONTAMINANTS THAT EXCEEDED THE RESIDENTIAL, BUT NOT THE INDUSTRIAL RBC: 210 µg/kg BENZO(A)PYRENE AND 340 µg/kg DIELDRIN.

µg/kg MICROGRAMS PER KILOGRAM

UA UPPER ALLUVIUM

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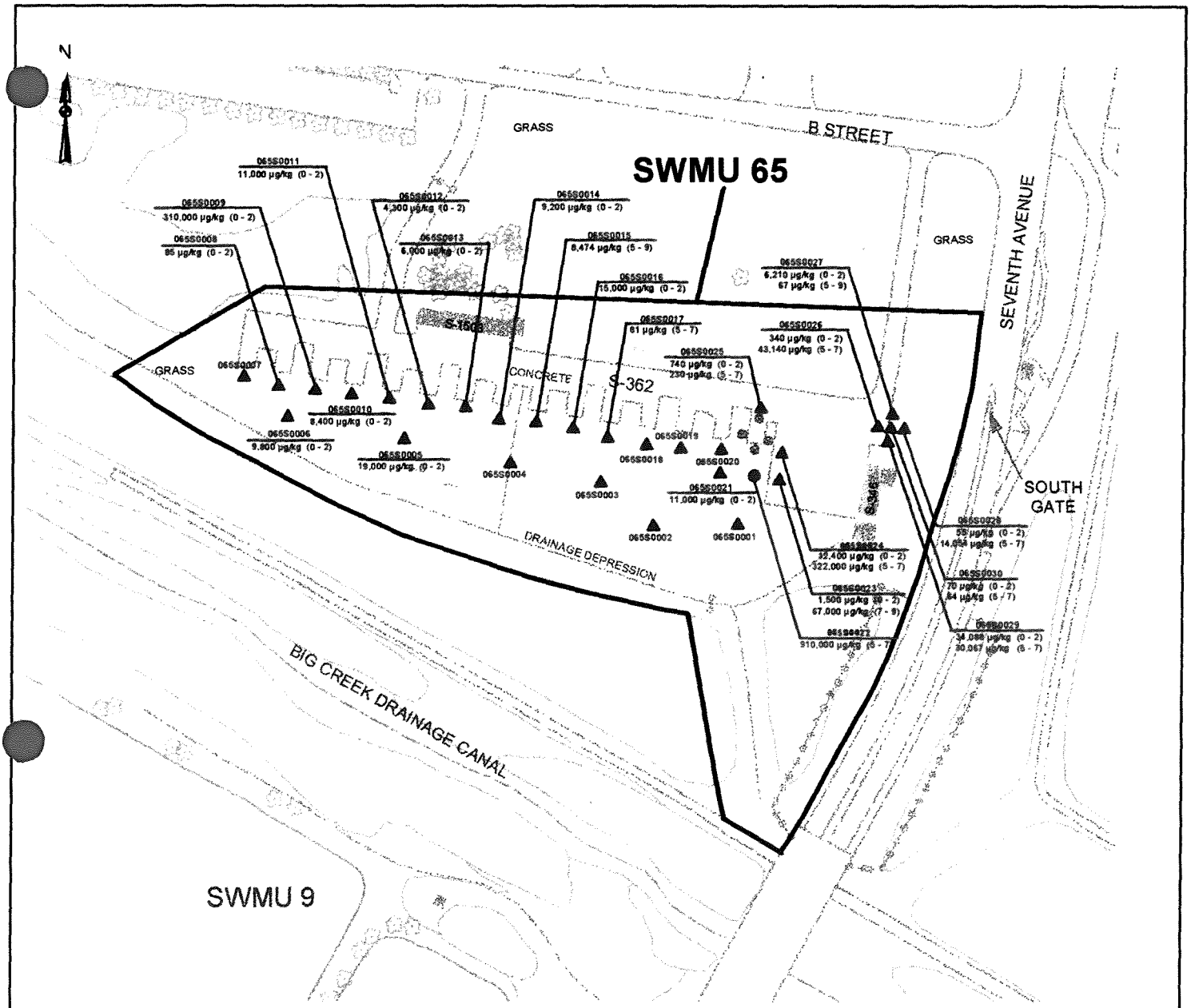
FIGURE 8.6.4
RBC EXCEEDANCES IN SOIL SAMPLES FROM SOIL BORINGS
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE



LEGEND

▲ THE TOTAL TPH CONCENTRATION (THE SUM OF TPH-GASOLINE RANGE ORGANICS AND TPH-DIESEL RANGE ORGANICS) DID NOT EXCEED THE 500,000 µg/kg TDEC CLEANUP STANDARD FOR TOTAL TPH.

● THE TOTAL TPH CONCENTRATION (THE SUM OF TPH-GASOLINE RANGE ORGANICS AND TPH-DIESEL RANGE ORGANICS) EXCEEDED THE 500,000 µg/kg TDEC CLEANUP STANDARD FOR TOTAL TPH.

065S0022
910,000 µg/kg (5 - 7)

910,000 µg/kg TOTAL TPH WERE DETECTED IN THE 5- TO 7-FOOT INTERVAL SOIL SAMPLE FROM LOCATION 065S0022; THIS CONCENTRATION EXCEEDED THE TDEC CLEANUP STANDARD OF 500,000 µg/kg FOR TOTAL TPH.

µg/kg MICROGRAMS PER KILOGRAM

200 0 200 Feet

NOTES:

1. SOIL SAMPLES WERE ANALYZED BY THE OFFSITE LABORATORY FOR TPH-GASOLINE RANGE ORGANICS AND TPH-DIESEL RANGE ORGANICS BY THE TENNESSEE MODIFIED 8015 METHOD.

TDEC CLEANUP STANDARD OF 500,000 µg/kg TOTAL TPH FOR NONDRINKING WATER AQUIFERS WITH A SOIL PERMEABILITY OF 10E-4 TO 10E-6 IS USED FOR COMPARISON. STANDARD OBTAINED FROM THE POLICY STATMENT FOR PETROLEUM CONTAMINATED SITES (TDEC MEMORANDUM, FEB. 14, 1997).

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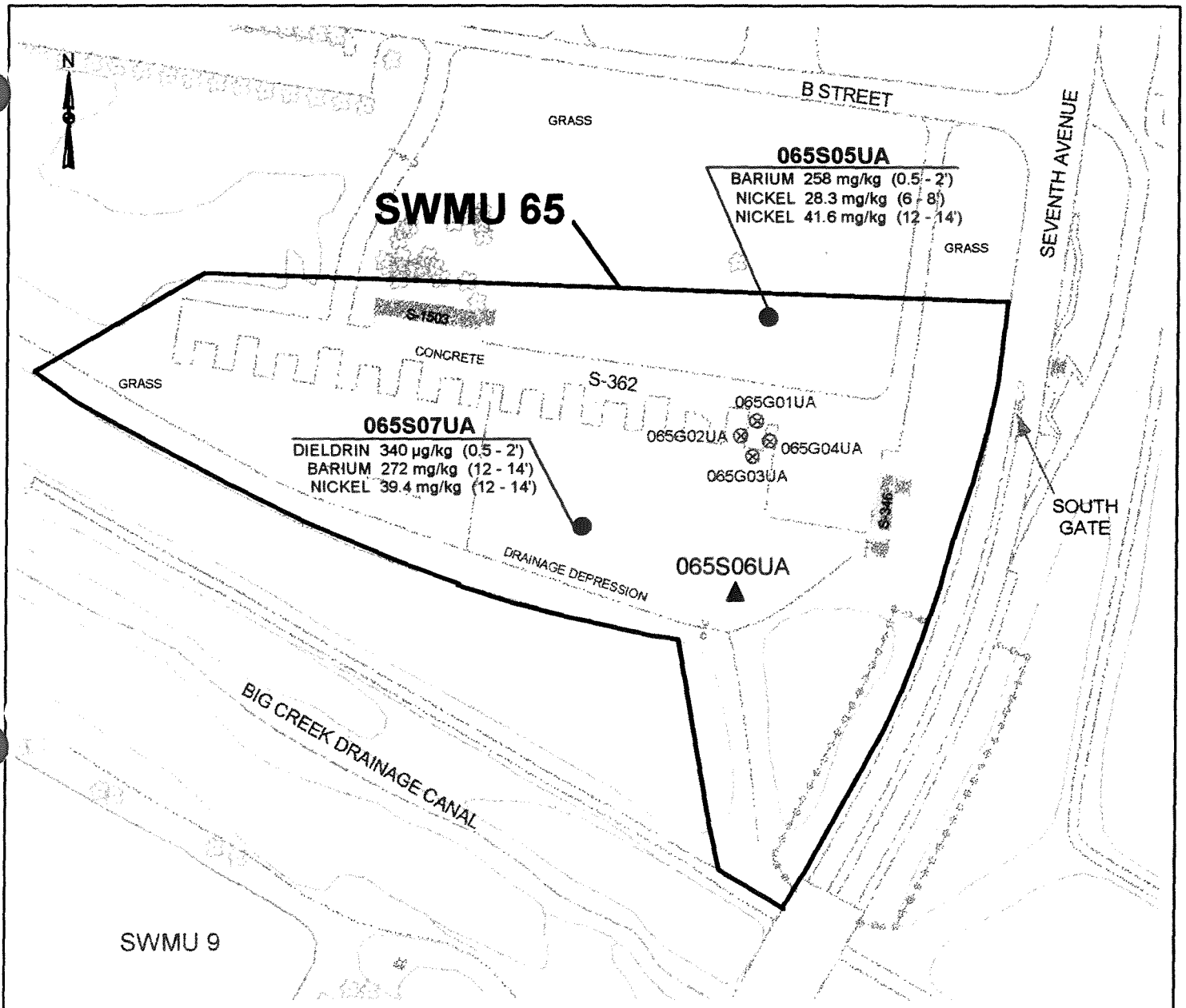
FIGURE 8.6.5
TOTAL TPH IN DPT SOIL SAMPLES
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE



LEGEND

▲ NO CONSTITUENT IN ANY SOIL SAMPLE FROM THIS SOIL BORING EXCEEDED ITS SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE)

● ONE OR MORE CONSTITUENTS IN A SOIL SAMPLE FROM THIS SOIL BORING EXCEEDED ITS SOIL TO GROUNDWATER SSL (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

065S07UA

DIELDRIN 340 µg/kg (0.5 - 2')
BARIUM 272 mg/kg (12 - 14')
NICKEL 39.4 mg/kg (12 - 14')

THE FOLLOWING CONSTITUENTS IN SOIL SAMPLES FROM SOIL BORING 065S07UA EXCEEDED THEIR RESPECTIVE SSLs (AND BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE): 340 µg/kg DIELDRIN IN THE SAMPLE FROM 0.5 TO 2 FEET BELOW LAND SURFACE; 272 mg/kg BARIUM AND 39.4 mg/kg NICKEL IN THE SOIL SAMPLE FROM 12 TO 14 FEET BELOW LAND SURFACE.

µg/kg MICROGRAMS PER KILOGRAM

mg/kg MILLIGRAMS PER KILOGRAM

200 0 200 Feet

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MILLINGTON, TENNESSEE

FIGURE 8.6.6
SOIL TO GROUNDWATER SSL EXCEEDANCES
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE

Table 8.6.2
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 65 — Building S-362 Training Mock-Up Site
(data in μg/kg)

Analyte[a]	Interval (feet bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[f]	SSL Exceedances
VOCs										
Acetone	0.5 - 2'	2/3	10 - 13	12	7,800,000	0	200,000,000	0	8,000	0
	6 - 8'	3/3	4 - 9	7	NA[g]	NA	NA	NA	8,000	0
Ethylbenzene	0.5 - 2'	1/3	1	1	7,800,000	0	200,000,000	0	5,000	0
Xylene (Total)	0.5 - 2'	3/3	1 - 7	4	160,000,000	0	1,000,000,000	0	74,000	0
	6 - 8'	1/3	3	3	NA	NA	NA	NA	74,000	0
SVOCs										
Benzo(a)anthracene	0.5 - 2'	1/3	120	120	880	0	7,800	0	700	0
Benzo(a)pyrene	0.5 - 2'	1/3	210	210	88	1 (065S07UA)	780	0	4,000	0
Benzo(b)fluoranthene	0.5 - 2'	1/3	230	230	880	0	7,800	0	4,000	0
Benzo(g,h,i)perylene	0.5 - 2'	1/3	180	180	3,100,000[h]	0	82,000,000[h]	0	–[i]	–
Benzo(k)fluoranthene	0.5 - 2'	1/3	160	160	8,800	0	78,000	0	4,000	0
Chrysene	0.5 - 2'	1/3	160	160	88,000	0	780,000	0	1,000	0
Dibenz(a,h)anthracene	0.5 - 2'	1/3	57	57	88	0	780	0	11,000	0
Fluoranthene	0.5 - 2'	1/3	94	94	3,100,000	0	82,000,000	0	980,000	0
Indeno(1,2,3-cd)pyrene	0.5 - 2'	1/3	140	140	880	0	7,800	0	35,000	0
Pyrene	0.5 - 2'	1/3	120	120	2,300,000	0	61,000,000	0	1,400,000	0
Total Petroleum Hydrocarbons										
TPH - Gasoline Range Organics	0.5 - 2'	1/3	87	87	–	–	–	–	500,000[j]	0
	12 - 14'	2/3	75 - 80	78	NA	NA	NA	NA	500,000	0

Table 8.6.2
Detected Concentrations of Organic Compounds in Soil Samples from Soil Borings
SWMU 65 — Building S-362 Training Mock-Up Site
(data in μg/kg)

Analyte[a]	Interval (feet bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC - Res. Exceedances	Industrial Soil RBC[e]	RBC - Ind. Exceedances	SSL[f]	SSL Exceedances
Pesticides/PCBs										
4,4'-DDT	0.5 - 2'	1/3	6.2	6.2	1,900	0	17,000	0	1,000	0
alpha-Chlordane	0.5 - 2'	1/3	5.4	5.4	1,825	0	16,352	0	2,000	0
Dieldrin	0.5 - 2'	1/3	340	340	40	1 (065S07UA)	360	0	1	1 (065S07UA)
gamma-Chlordane	0.5 - 2'	1/3	1.1	1.1	1,825	0	16,352	0	2,000	0
Herbicides										
2,4,5-TP (Silvex)	6 - 8'	1/3	4.8	4.8	NA	NA	NA	NA	–	–
2,4-DB	6 - 8'	1/3	12	12	NA	NA	NA	NA	–	–
	12 - 14'	1/3	6.2	6.2	NA	NA	NA	NA	–	–
Dinoseb	6 - 8'	2/3	5.1 - 7	6	NA	NA	NA	NA	–	–
	12 - 14'	1/3	3.4	3.4	NA	NA	NA	NA	–	–
MCPA	12 - 14'	1/3	17,000	17,000	NA	NA	NA	NA	–	–

Notes:

a — Nine soil samples were collected from three sampling locations from the following intervals: 0.5 to 2 feet bls, 6 to 8 feet bls, and 12 to 14 feet bls. The samples were submitted to the offsite laboratory for the following analyses: VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — Interval shown is feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs apply only for comparison to data from samples collected across the surface interval.

f — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

g — NA denotes RBC comparison is not applicable to this subsurface sample.

h — The RBCs for fluoranthene were used for benzo(g,h,i)perylene, which does not have RBCs.

i — – denotes RBC or SSL is not available for this analyte; therefore, no comparison can be made.

j — No RBC or SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^{-4} to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

Table 8.6.3
Detected Concentrations of TPH-GRO and TPH-DRO in DPT Soil Samples
SWMU 65 — Building S-362 Training Mock-Up Site
(data in μg/kg)

Analyte[a]	Interval (ft bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	TDEC Cleanup Standard[e]	TDEC Cleanup Standard Exceedances
TPH - GRO	0 - 2'	9/30	55 - 1,500	488	500,000	0
	5 - 9'	11/30	54 - 260,000	28,707	500,000	0
TPH - DRO	0 - 2'	13/30	4,300 - 310,000	34,985	500,000	0
	5 - 9'	7/30	8,400 - 650,000	154,200	500,000	0
Total TPH[f]	0 - 2'	17/30	55 - 310,000	27,011	500,000	0
	5 - 9'	11/30	64 - 910,000	126,834	500,000	1 (065S0022)

Notes:

a — Sixty soil samples were collected from thirty locations. Thirty samples were collected from 0 to 2 feet bls, and 29 samples were collected from 5 to 7 feet bls. One sample was collected from 7 to 9 feet bls (location 065S0023) due to poor sample recovery in the 5 to 7-foot interval. The samples were submitted to the offsite laboratory for TPH-GRO and TPH-DRO analysis by the Tennessee Modified 8015 Method.

b — Interval shown is in feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — No USEPA RBC or SSL has been established for TPH; therefore, the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^4 to 10^{-6} is used for comparison. The cleanup standard was obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

f — Total TPH refers to the sum of TPH-GRO and TPH-DRO.

8.6.3.1.2 Inorganics in Soil Samples

The following inorganics were detected in soil samples from soil borings:

Arsenic	Lead
Barium	Nickel
Beryllium	Selenium
Cadmium	Silver
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc

As shown on Table 8.6.4, no detected inorganic in surface soil exceeded both its RC and residential RBC; however, the inorganics barium and nickel were detected at concentrations exceeding both their RCs and SSLs. Figure 8.6.6 plots the RC and SSL exceedances. The following paragraphs discuss the exceedances for barium and nickel.

Table 8.6.4
Detected Concentrations of Inorganics in Soil Samples From Soil Borings
SWMU 65 — Building S-362 Training Mock-Up Site
(data in mg/kg)

Analyte[a]	Interval (ft bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	RC[g]	RC Exceedances
Arsenic	0.5 - 2'	3/3	4.7 - 5.7	5.2	0.43	3 (065S05UA, 065S06UA, 065S07UA)	3.8	3 (065S05UA, 065S06UA, 065S07UA)	15	0	14.58	0
	6 - 8'	3/3	1.9 - 8.1	4.1	NA[h]	NA	NA	NA	15	0	20.32	0
	12 - 14'	3/3	3.2 - 6.8	5.4	NA	NA	NA	NA	15	0	20.32	0
Barium	0.5 - 2'	3/3	167 - 258	215	5,500	0	140,000	0	32	3 (065S05UA, 065S06UA, 065S07UA)	233.46	1 (065S05UA)
	6 - 8'	3/3	130 - 193	163	NA	NA	NA	NA	32	3 (065S05UA, 065S06UA, 065S07UA)	265.12	0
	12 - 14'	3/3	120 - 272	205	NA	NA	NA	NA	32	3 (065S05UA, 065S06UA, 065S07UA)	265.12	1 (065S07UA)
Beryllium	0.5 - 2'	3/3	0.72 - 0.93	0.85	0.15	3 (065S05UA, 065S06UA, 065S07UA)	1.3	0	180	0	1	0
	6 - 8'	3/3	0.51 - 0.75	0.60	NA	NA	NA	NA	180	0	1	0
	12 - 14'	3/3	0.38 - 0.48	0.42	NA	NA	NA	NA	180	0	1	0
Cadmium	0.5 - 2'	3/3	1.5 - 1.8	1.6	39	0	1,000	0	6	0	1.54	2 (065S05UA, 065S06UA)
	6 - 8'	2/3	1.4 - 2.8	2.1	NA	NA	NA	NA	6	0	3.24	0
	12 - 14'	3/3	1.5 - 2.7	2.3	NA	NA	NA	NA	6	0	3.24	0
Chromium	0.5 - 2'	3/3	14.8 - 17.3	16.0	390	0	10,000	0	–[i]	–	23.89	0
	6 - 8'	3/3	12.9 - 19.6	15.6	NA	NA	NA	NA	–	–	28.28	0
	12 - 14'	3/3	10.8 - 11.4	11.1	NA	NA	NA	NA	–	–	28.28	0

Table 8.6.4
Detected Concentrations of Inorganics in Soil Samples From Soil Borings
SWMU 65 — Building S-362 Training Mock-Up Site
(data in mg/kg)

Analyte[a]	Interval (ft bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	RC[g]	RC Exceedances
Cobalt	0.5 - 2'	3/3	6.2 - 6.9	6.6	4,700	0	120,000	0	–	–	15.98	0
	6 - 8'	3/3	3.7 - 8.2	5.9	NA	NA	NA	NA	–	–	14.36	0
	12 - 14'	3/3	7.8 - 19.2	13.4	NA	NA	NA	NA	–	–	14.36	1 (065S07UA)
Copper	0.5 - 2'	1/3	18.6	18.6	3,100	0	82,000	0	–	–	24.19	0
	6 - 8'	2/3	16.8 - 23.6	20.2	NA	NA	NA	NA	–	–	32.52	0
	12 - 14'	3/3	16.5 - 21.6	19.1	NA	NA	NA	NA	–	–	32.52	0
Lead	0.5 - 2'	3/3	11.4 - 24.8	16.7	400[i]	0	1,300[i]	0	–	–	26.03	0
	6 - 8'	3/3	9.3 - 15.8	12	NA	NA	NA	NA	–	–	19.8	0
	12 - 14'	3/3	7.2 - 15.9	10.2	NA	NA	NA	NA	–	–	19.8	0
Nickel	0.5 - 2'	3/3	12.6 - 15.6	14	1,600	0	41,000	0	21	0	20.62	0
	6 - 8'	3/3	12.7 - 28.3	20	NA	NA	NA	NA	21	1 (065S05UA)	ND[h]	3 (065S05UA, 065S06UA, 065S07UA)
	12 - 14'	3/3	18.1 - 41.6	33	NA	NA	NA	NA	21	2 (065S05UA, 065S07UA)	ND	3 (065S05UA, 065S06UA, 065S07UA)
Selenium	0.5 - 2'	3/3	0.45 - 0.55	0.49	390	0	10,000	0	3	0	ND	3 (065S05UA, 065S06UA, 065S07UA)
	12 - 14'	2/3	0.3 - 0.51	0.4	NA	NA	NA	NA	3	0	ND	2 (065S05UA, 065S06UA)
Silver	12 - 14'	3/3	2.4 - 5.4	4.1	NA	NA	NA	NA	–	–	ND	3 (065S05UA, 065S06UA, 065S07UA)

Table 8.6.4
Detected Concentrations of Inorganics in Soil Samples From Soil Borings
SWMU 65 — Building S-362 Training Mock-Up Site
(data in mg/kg)

Analyte[a]	Interval (ft bls)[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances	RC[g]	RC Exceedances
Tin	0.5 - 2'	3/3	26.6 - 33.4	29.9	47,000	0	1,000,000	0	–	–	33.56	0
	6 - 8'	3/3	22.3 - 36.6	27.7	NA	NA	NA	NA	–	–	ND	3 (065S05UA, 065S06UA, 065S07UA)
	12 - 14'	3/3	25.6 - 29.5	27.1	NA	NA	NA	NA	–	–	ND	3 (065S05UA, 065S06UA, 065S07UA)
Vanadium	0.5 - 2'	3/3	26.6 - 30.7	28.5	550	0	14,000	0	–	–	45.11	0
	6 - 8'	3/3	13.6 - 36	21.8	NA	NA	NA	NA	–	–	43.7	0
	12 - 14'	3/3	19.7 - 29.4	23.4	NA	NA	NA	NA	–	–	43.7	0
Zinc	0.5 - 2'	3/3	53.3 - 59.7	57.3	23,000	0	610,000	0	42,000	0	98	0
	6 - 8'	3/3	56.9 - 85.9	68.5	NA	NA	NA	NA	42,000	0	109	0
	12 - 14'	3/3	44 - 63	55	NA	NA	NA	NA	42,000	0	109	0

Notes:

a — Nine soil samples were collected from three sampling locations from the following intervals: 0.5 to 2 feet bls, 6 to 8 feet bls, and 12 to 14 feet bls. The samples were submitted to the offsite laboratory for the following analyses: VOCs, SVOCs, TPH-GRO, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — feet below land surface

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply for comparison to data from samples collected across the surface interval.

f — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

g — Reference concentration (RC) is two times the mean background concentration established for 13 background surface soil samples and 5 background subsurface soil samples collected throughout NSA Memphis. Refer to the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

h — NA denotes RBC comparison is not applicable for this subsurface sample.

i — – denotes risk-based data are not available for this analyte; therefore, no comparison can be made.

j — No RBC exists for lead; the soil screening value for residential and industrial soil (400 μg/kg and 1,300 μg/kg) from Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-12 are used for comparison.

k — ND denotes analyte was not detected in background soil samples.

Barium's surface soil RC (233.46 mg/kg) and SSL (32 mg/kg) were exceeded in the 0.5 to 2-foot interval sample from location 065S05UA (258 mg/kg). Barium's subsurface soil RC (265.12 mg/kg) and SSL were exceeded in the 12- to 14-foot interval sample from location 065S07UA (272 mg/kg).

Nickel's subsurface soil RC (nondetect) and SSL (21 mg/kg) were exceeded in the 6- to 8-foot interval sample from location 065S05UA (28.3 mg/kg), and the 12- to 14-foot interval samples from locations 065S05UA (41.6 mg/kg) and 065S07UA (39.4 mg/kg).

8.6.3.1.3 SWMU 65 Follow Up Soil Sampling Summary

In June 1997, EnSafe personnel collected an additional soil sample from the spill area at SWMU 65 at the direction of the BCT to reconfirm spill contaminants. One soil sample was collected from 3 to 4 feet bls (065S003004) to determine if TPH concentrations in soil exceeded the TDEC clean up level of 500,000 μg/kg for total TPH in nondrinking water aquifers with soil permeabilities ranging from 10^{-4} to 10^{-6} cm/sec (TDEC, 1997). The concentrations identified in sample 065S003004 were as follows:

- TPH at 320,000 μg/kg
- TPH DRO at 700,000 μg/kg
- TPH-GRO at 7,300 μg/kg

The TPH-DRO concentration in sample 065S003004 exceeded the TDEC cleanup level for total TPH in soil. Note that the soil encountered during this sampling event was greenish-gray in color and exhibited a strong petroleum odor.

8.6.3.2 Nature and Extent of Groundwater Contamination

As discussed in Section 4, constituents in groundwater are compared to their respective tap water RBCs and MCLs for drinking water. None of the parameters identified in SWMU 65 groundwater samples exceeded their respective MCL. Inorganics in groundwater are also compared to their established RCs to determine if they occur naturally. This discussion includes the results of the DPT screening and monitoring well groundwater samples. Sections 8.6.2.1 and 8.6.2.2 provide details and rationale for sample locations and intervals sampled.

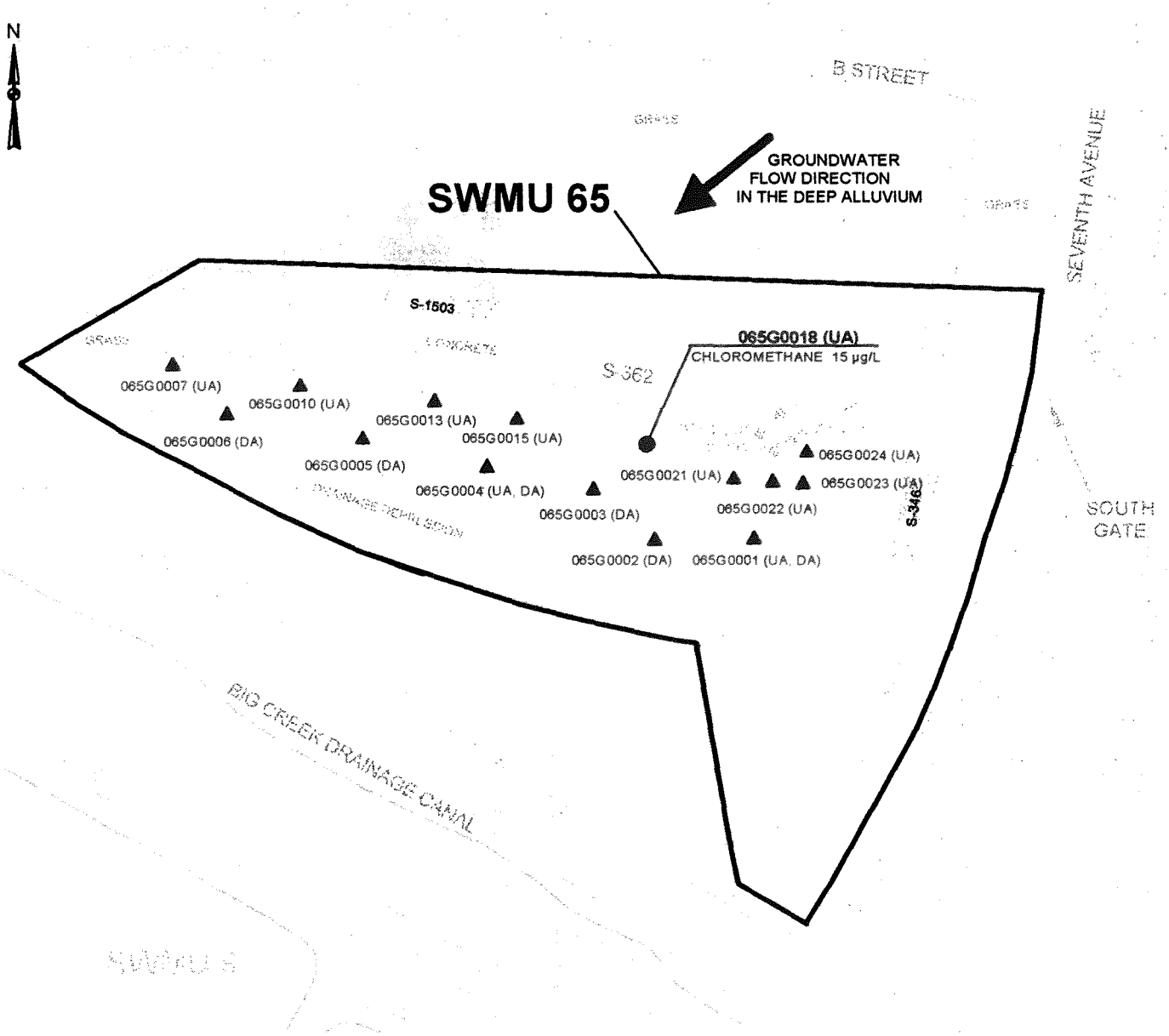
8.6.3.2.1 Organic Compounds in Groundwater Samples

No SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, or herbicides were detected in groundwater samples. VOCs were the only organic compounds detected in groundwater samples, as described below.

VOCs in Groundwater

Two VOCs — 2-butanone (MEK) and chloromethane — were detected in the upper alluvium groundwater samples collected during the DPT investigation. No VOCs were detected in the deep alluvium groundwater samples. As shown on Table 8.6.5, chloromethane was the only VOC that exceeded its tap water RBC (1.4 μg/L), with a detected concentration of 15 μg/L at location 065G0018. Figure 8.6.7 shows the single RBC exceedance in DPT groundwater samples.

The only VOC identified in the monitoring well groundwater samples was methylene chloride in the upper alluvium at location 065G07UA (2 μg/L). The detected concentration did not exceed its tap water RBC (4.1 μg/L) or MCL (5 μg/L). Table 8.6.6 summarizes the detected organic compounds in monitoring well groundwater samples.



LEGEND

▲ NO VOC IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER

● ONE OR MORE VOCs IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER

065G0018 (UA)
CHLOROMETHANE 15 µg/L

THE UPPER ALLUVIUM DPT (GEOPROBE) GROUNDWATER SAMPLE FROM LOCATION 065G0018 CONTAINED THE FOLLOWING CONSTITUENT THAT EXCEEDED THE RBC FOR TAP WATER: 15 µg/L CHLOROMETHANE.

µg/L MICROGRAMS PER LITER

UA UPPER ALLUVIUM

DA DEEP ALLUVIUM

200 0 200 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.7
RBC EXCEEDANCES IN DPT GROUNDWATER SAMPLES
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE

Table 8.6.5
Detected Concentrations of VOCs in DPT Groundwater Samples
SWMU 65 — Building S-364 Training Mockup Site
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances
2-Butanone (MEK)	UA	1/11	7	7	1,900	0	–[g]	–
Chloromethane	UA	1/11	15	15	1.4	1 (065G0018)	–	–

Notes:

a — Eleven upper alluvium groundwater samples and six deep alluvium groundwater samples were analyzed for VOCs by USEPA Method 8240 by the offsite laboratory.
b — UA = upper alluvium groundwater
c — Range lower limit is the lowest detected analyte concentration.
d — Mean based on detected analyte concentrations only.
e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).
f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
g — denotes MCL is not available for this analyte; therefore, no comparison can be made.

Table 8.6.6
Detected Constituents in Groundwater Samples from Monitoring Wells
SWMU 65 — Building S-362 Training Mockup Site
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances	RC[g]	RC Exceedances
Organic Compounds										
Methylene Chloride	UA	1/3	2	2	4.1	0	5	0	–[h]	–
Inorganics										
Arsenic	UA	1/3	4.5	4.5	0.045	1 (065G05UA)	50	0	4.2	1 (065G05UA)
	DA	1/1	5.6	5.6	0.045	1 (065G06DA)	50	0	4.2	1 (065G06DA)
Barium	UA	3/3	129 - 278	182	2,600	0	2,000	0	844	0
	DA	1/1	178	178	2,600	0	2,000	0	844	0
Chromium	UA	3/3	33.8 - 52.7	42	180	0	100	0	69.2	0
	DA	1/1	41.8	41.8	180	0	100	0	69.2	0
Cobalt	UA	3/3	7.8 - 15.5	10.7	2,200	0	–	–	27	0
Nickel	UA	3/3	30.2 - 47.6	40	730	0	100	0	57.6	0
Selenium	UA	1/3	2	2	180	0	50	0	ND	1 (065G06UA)
Vanadium	UA	3/3	9.8 - 24	16	260	0	–	–	11	2 (065G05UA, 065G06UA)
	DA	1/1	9.8	9.8	260	0	–	–	11	0
Zinc	UA	2/3	39.2 - 68.2	53.7	11,000	0	5,000	0	ND	2 (065G05UA, 065G06UA)

Notes:

a — Groundwater samples were collected from three upper alluvium monitoring wells and one deep alluvium monitoring well and analyzed by the offsite laboratory for VOCs, SVOCs, TPH-DRO, chlorinated pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, Appendix IX metals, and cyanide.

b — UA = upper alluvium groundwater; DA = deep alluvium groundwater

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — Reference concentration is two times the mean background concentration. Analytical data from one sampling event of one middle alluvium monitoring well was used to establish background concentrations. Refer to the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a) for background reference concentration calculations.

h — denotes risk-based data or background reference concentrations are not available for this analyte; therefore, no comparison can be made.

8.6.3.2.2 Inorganics in Groundwater Samples

The following inorganics were detected in the groundwater samples from monitoring wells:

Arsenic	Nickel
Barium	Selenium
Chromium	Vanadium
Cobalt	Zinc

Arsenic concentrations in the groundwater samples from upper alluvium location 065G05UA (4.5 μg/L) and deep alluvium location 065G06DA (5.6 μg/L) both exceeded arsenic's tap water RBC (0.045 μg/L) and RC (4.2 μg/L), while both detected concentrations were below the MCL (50 μg/L). No other inorganic exceeded both its RC and tap water RBC or drinking water MCL. Table 8.6.6 compares the detected inorganic constituents in groundwater to their respective RBCs for tap water, MCLs for drinking water, and RCs for alluvium groundwater. Figure 8.6.8 shows the tap water RBC exceedances for the upper and deep alluvium groundwater samples from monitoring wells.

8.6.3.2.3 Groundwater Samples From the April/May 1997 Sampling Event

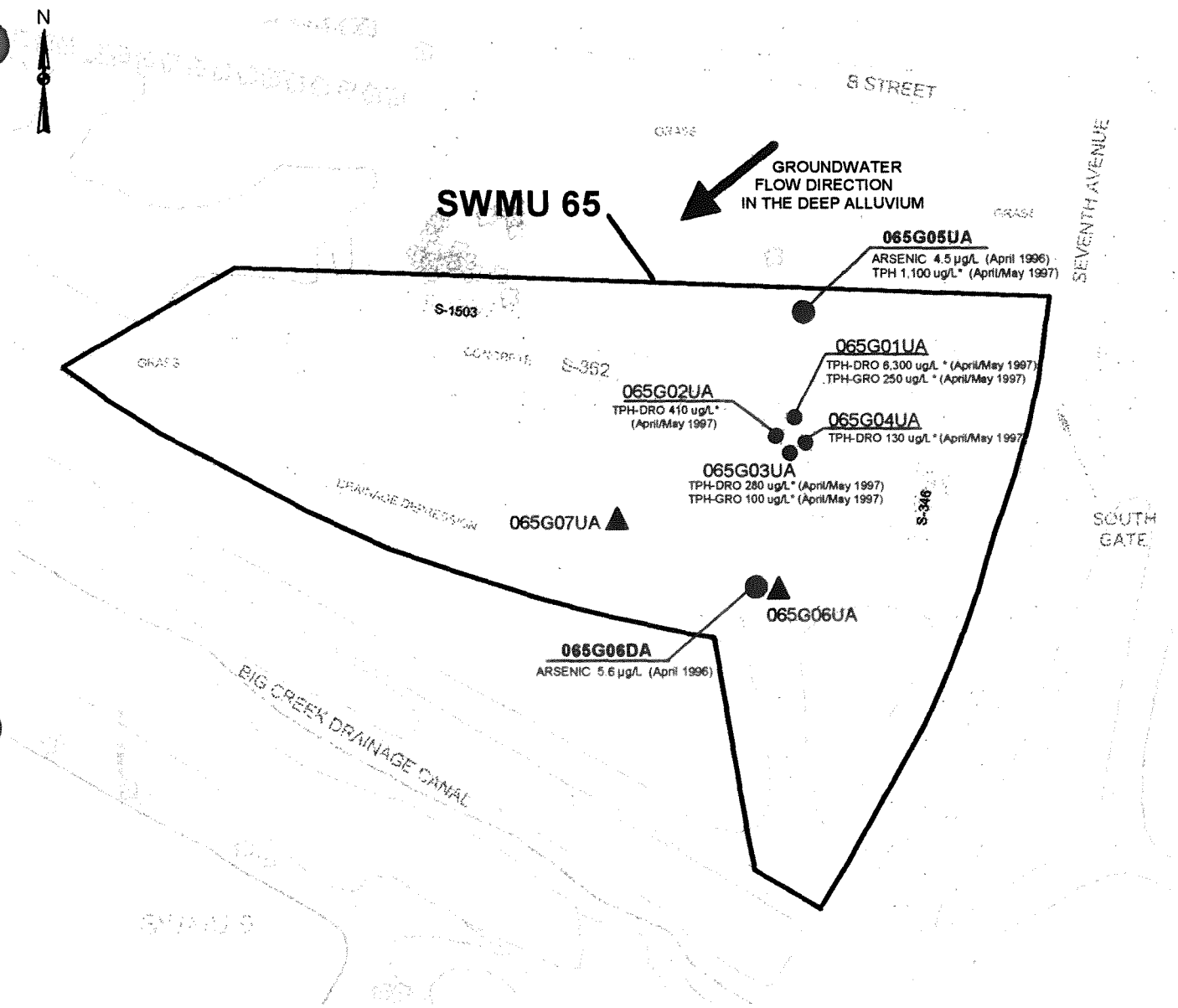
The four upper alluvium groundwater wells installed in 1992 and the three upper alluvium and one deep alluvium groundwater wells installed in 1996 at SWMU 65 were sampled during the April/May 1997 groundwater sampling event and submitted to an offsite laboratory for analysis of VOCs, TPH, TPH-GRO, and TPH-DRO.

Acetone was the only VOC identified in the groundwater samples collected during the April/May 1997 sampling event. Upper alluvium location 065G06UA had an acetone concentration of 130 μg/L, which was below its tap water RBC (3,700 μg/L). Acetone does not have an established MCL.

The detected concentrations of TPH, TPH-DRO, and TPH-GRO were compared to the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers. Exceedances of this standard were indicated in upper alluvium monitoring wells 065G01UA, 065G02UA, 065G03UA, 065G04UA, and 065G05UA. Table 8.6.7 summarizes the TPH concentrations and compares them to the TDEC standard. Figure 8.6.8 plots concentrations that exceeded the TDEC standard.

8.6.3.3 Nature and Extent of Sediment Contamination

Section 8.6.2.3 summarizes the number of samples taken, intervals sampled, and sediment sampling locations. As previously discussed, sediment samples were analyzed only for BTEX and TPH-GRO. No SSVs exist for toluene or TPH so a comparison of SSVs to surface sediment samples is not possible. However, since the linear drainage depressions at SWMU 65 contain water only intermittently, the screening parameters used for comparison to detected contaminants are the residential and industrial RBCs and SSLs. As shown on Table 8.6.8, toluene and TPH-GRO were the only organic constituents detected in sediment samples collected from the linear drainage depressions. Toluene was detected in both intervals of all five sediment sample locations; however, no detected concentration exceeded toluene's residential RBC (16,000,000 μg/kg) or SSL (5,000 μg/kg). As previously discussed, TPH has no established RBC or SSL; therefore, total TPH concentrations are compared to the TDEC soil cleanup standard of 500,000 μg/kg (TDEC, 1997). TPH-GRO was detected in both the surface and subsurface samples from locations 065M0004 and 065M0005; however, no detected concentration exceeds the TDEC soil cleanup standard.



LEGEND

▲ NO CONSTITUENT IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

● ONE OR MORE CONSTITUENTS IN GROUNDWATER EXCEEDED THE RBC FOR TAP WATER (AND THE BACKGROUND REFERENCE CONCENTRATION, WHERE APPLICABLE).

065G05UA
ARSENIC 4.5 µg/L

THE GROUNDWATER SAMPLE FROM MONITORING WELL 065G05UA CONTAINED THE FOLLOWING CONSTITUENT THAT EXCEEDED ONE OR MORE APPLICABLE STANDARDS: 4.5 µg/L ARSENIC.

µg/L MICROGRAMS PER LITER

* TPH, TPH-GRO, OR TPH-DRO CONCENTRATIONS EXCEEDED THE TDEC CLEANUP STANDARD OF 100 ug/L FOR TOTAL TPH IN DRINKING WATER AQUIFERS (TDEC, 1997).

200 0 200 Feet

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.8
RBC AND TOTAL TPH EXCEEDANCES IN GROUNDWATER SAMPLES FROM MONITORING WELLS
SWMU 65
BUILDING S-362 TRAINING MOCK-UP SITE

Table 8.6.7
Compounds Identified During the April/May 1997 Groundwater Monitoring Well Sampling Event
SWMU 65 — Building S-362 Training Mock-Up Site
(data in μg/L)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean Concentration[d]	RBC - Tap Water[e]	RBC Exceedances	MCL - Drinking Water[f]	MCL Exceedances
Total Petroleum Hydrocarbons								
TPH	UA	1/7	1,100	1,100	100[g]	1 (065G05UA)	–[h]	–
TPH-GRO	UA	2/7	100 - 250	175	100[g]	1 (065G01UA)	–	–
TPH-DRO	UA	4/7	130 – 6,300	1,780	100[g]	4 (065G01UA, 065G02UA, 065G03UA, 065G04UA)	–	–

Notes:

a — Only primary samples are included on this table. Groundwater samples were collected from seven upper alluvium and one deep alluvium monitoring wells and analyzed at an offsite laboratory for VOCs, TPH, TPH-DRO, and TPH-GRO.

b — Interval shown is the lithologic unit in the screened interval of the monitoring well. UA = upper alluvium groundwater.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Risk-based concentrations for tap water obtained from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Maximum contaminant levels in drinking water obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).

g — No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers has been substituted for the RBC for tap water. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

h — denotes MCL is not available for this analyte; therefore, no comparison can be made.

Table 8.6.8
Detected Concentrations of BTEX & TPH-GRO in Sediment Samples
SWMU 65 — Building S-362 Training Mock-Up Site
(data in μg/kg)

Analyte[a]	Interval[b]	Number of Detections[a]	Range[c]	Mean[d]	Residential Soil RBC[e]	RBC-Res. Exceedances	Industrial Soil RBC[e]	RBC-Ind. Exceedances	SSL[f]	SSL Exceedances
Toluene	0 - 6"	5/5	4 - 14	7	16,000,000	0	410,000,000	0	5,000	0
	18 - 24"	5/5	4 - 8	6	NA[g]	NA	NA	NA	5,000	0
TPH - GRO	0 - 6"	2/5	65 - 150	108	–[h]	–	–	–	500,000[i]	0
	18 - 24"	2/5	93 - 130	112	NA	NA	NA	NA	500,000	0

Notes:

a — Only primary samples are included in this table. Ten sediment samples were collected from five sampling locations from the following intervals: 0 to 6 inches below land surface and 18 to 24 inches below land surface. One of the 0 to 6-inch interval samples was split as a duplicate. The sediment samples were submitted to NET for analysis of BTEX and TPH-GRO (TN Modified 8015).

b — Depth is in inches below land (sediment) surface.

c — Range lower limit is the lowest detected analyte concentration.

d — Mean based on detected analyte concentrations only.

e — Soil Screening Levels, considered protective of contaminant transfer from soil to groundwater, are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a).

f — Residential and industrial screening values (RBC-Res., RBC-Ind.) are from the *Risk-Based Concentration Table, January to June 1996* (USEPA, 1996a). RBCs only apply to data from samples collected from the 0 to 6-inch interval.

g — NA denotes RBC comparison is not applicable to this subsurface sample.

h — denotes RBC is not available for this analyte; therefore, no comparison can be made.

i — No RBC or SSL exists for TPH; the TDEC soil cleanup level of 500,000 μg/kg total TPH for nondrinking water aquifers with a soil permeability of 10^4 to 10^{-6} has been substituted for the SSL. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).

8.6.4 Human Health Risk Assessment for SWMU 65

8.6.4.1 Site Background and Investigative Approach

SWMU 65 includes Building S-362; a concrete pad mock-up area with spaces for approximately 15 airplanes; Building S-346 the former engine test cell building; and Building S-1503 a wooden storage shelter. A detailed site description is discussed in Section 1.1.6. Two 30,000 gallon USTs formerly used to fuel the test cell were removed from this site in 1984, as described in Section 8.6. In addition, a spill of JP-5 fuel occurred in 1992. As a result, hydrocarbon contamination is present at the site. Building S-346 was used as classroom space, for training, and as a storm shelter. In addition, various aircraft were parked on 15 concrete pads west of Building S-362 for aircraft start-up training. Figure 1.6 in Section 1 is a SWMU 65 site map. This HHRA uses data from three surface soil samples and four alluvial groundwater samples. Table 3.1, previously presented, lists samples and analytical methods for each medium. Samples used in the HHRA are listed below and include DPT samples for groundwater:

- Surface soil — 065S05UA02, 065S06UA02, and 065S07UA02
- Alluvial monitoring wells — 065G05UA01, 065G06DA01, 065G06UA01, and 065G07UA01,
- Upper alluvial DPT samples — 065G0001, 065G0004, 065G0007, 065G0010, 065G0013, 065G0015, 065G0018, and 065G0021 through 065G0024
- Deep alluvium DPT samples — 065G0001, 065G0002, 065G0003, 065G0004, 065G0005, and 065G006.

The surface soil samples and four alluvial groundwater monitoring samples were analyzed for FSA, while the DPT groundwater samples were analyzed for VOCs only.

8.6.4.2 Identification of Chemicals of Potential Concern

COPCs were identified in accordance with Supplemental Guidance to RAGS, Bulletin 1 *Data Collection and Evaluation* (USEPA, 1995b) and with methods outlined in the Technical Memorandum on HHRA (E/A&H, 1997e). Reference concentrations were used in accordance with the *Technical Memorandum — Reference Concentrations* (E/A&H, 1996a).

Surface Soil

As shown in Table 8.6.9, only dieldrin was identified as a COPC in SWMU 65 surface soil.

Table 8.6.9
Chemicals Present in Surface Soil Samples at SWMU 65 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentration	Average Detected Concen-tration	Resi-dential RBC	Notes (a)	Number Over RBC	RC	Number Over RC
4,4'-DDT	µg/kg	1 / 3	4.2 — 4.2	6.2 — 6.2	6.2	1,900	c	0	NA	NA
Acetone	µg/kg	2 / 3	13 — 13	10 — 13	12	780,000	n	0	NA	NA
alpha-Chlordane	µg/kg	1 / 3	2.1 — 2.1	5.4 — 5.4	5.4	1,825	c	0	NA	NA
Arsenic	mg/kg	3 / 3	NA — NA	4.7 — 5.7	5.2	0.43	c	3	14.58	0
Barium	mg/kg	3 / 3	NA — NA	167 — 258	215	550	n	0	223.4	0
BEQ	µg/kg	1 / 3	420 — 420	318 — 318	318	88	c	1	565	0
Benzo(g,h,i)perylene (Pyrene)	µg/kg	1 / 3	420 — 420	180 — 180	180	230,000	c	0	NA	NA
Beryllium	mg/kg	3 / 3	NA — NA	0.72 — 0.93	0.85	0.15	c	3	1	0
Cadmium	mg/kg	3 / 3	NA — NA	1.5 — 1.8	1.6	3.9	n	0	1.54	2
Chromium	mg/kg	3 / 3	NA — NA	14.8 — 17.3	16	7800	n	0	23.89	0
Cobalt	mg/kg	3 / 3	NA — NA	6.2 — 6.9	6.6	470	n	0	15.98	NA
Copper	mg/kg	1 / 3	12 — 14	18.6 — 18.6	19	310	n	0	24.19	NA
* Dieldrin	µg/kg	1 / 3	4.2 — 4.2	340 — 340	340	40	c	1	262	1
Ethylbenzene	µg/kg	1 / 3	12 — 12	1 — 1	1	780,000	n	0	NA	NA
Fluoranthene	µg/kg	1 / 3	420 — 420	94 — 94	94	310,000	n	0	NA	NA
gamma-Chlordane	µg/kg	1 / 3	2.1 — 2.1	1.1 — 1.1	1	1,825	c	0	NA	NA
Lead	mg/kg	3 / 3	NA — NA	11.4 — 24.8	16.7	400	b	0	26.03	0
Nickel	mg/kg	3 / 3	NA — NA	12.6 — 15.6	14	160	n	0	20.62	0
Pyrene	µg/kg	1 / 3	420 — 420	120 — 120	120	230,000	n	0	NA	NA
Selenium	mg/kg	3 / 3	NA — NA	0.45 — 0.55	0.49	39	n	0	ND	NA
Tin	mg/kg	3 / 3	NA — NA	26.6 — 33.4	29.9	4,700	n	0	33.56	0
Vanadium	mg/kg	3 / 3	NA — NA	26.6 — 30.7	28.5	55	n	0	45.11	0

Table 8.6.9
Chemicals Present in Surface Soil Samples at SWMU 65 NSA Memphis

Chemical	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentration	Average Detected Concentration	Residential RBC	Notes (a)	Number Over RBC	RC	Number Over RC
Xylene-Total	µg/kg	3 / 3	NA — NA	1 — 7	4	16,000,000	n	0	NA	NA
Zinc	mg/kg	3 / 3	NA — NA	53.3 — 59.7	57.3	2,300	n	0	98	0

Notes:
( ) — Surrogate used based on toxicological similarity
* — Identified as a chemical of potential concern
** — quotient of 1.0 to 0.1
a — Screening based on Residential Soil Ingestion (USEPA, 1996a)
b — Screening based on 400 mg/kg of lead in soil
c — Carcinogen
n — Noncarcinogen, RBC screening value adjusted from hazard
BEQ — Benzo(a)pyrene equivalent
RC — Reference concentration; two-times the mean background (E/A&H, 1996a)
RBC — Risk Based Concentration (USEPA, 1996a)
mg/kg — micrograms per kilogram
mg/kg — milligrams per kilogram
NA — Not applicable/Not available
ND — nondetect

Alluvial Groundwater

As shown in Table 8.6.10, arsenic and chloromethane were identified as COPCs. Chloromethane was reported only in DPT samples collected from alluvial groundwater, as described in Section 8.6.2.

8.6.4.3 Exposure Assessment

Exposure Setting

The exposure setting of SWMU 65 is a building used for classroom space, training, or as a storm shelter; the adjacent concrete pads are used for aircraft start-up training. Future land use is not expected to change at SWMU 65.

Potential Exposed Populations

Potentially exposed populations are current and future site workers. The hypothetical future site resident scenario was included for a relative comparison to a future site worker scenario because

Table 8.6.10
Chemicals Present in Alluvial Groundwater Samples at SWMU 65 NSA Memphis

Contaminant	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentration	Average Detected Concentration	Residential RBC	Notes (a)	Number Over RBC	RC Alluvial GW	Number Over RC
* Arsenic	µg/L	2 / 4	2 — 2	4.5 — 5.6	5.1	0.045	c, b	2	4.2	2
Barium	µg/L	4 / 4	NA — NA	129 — 278	181	260	n	1	844	0
2-Butanone	µg/L	1 / 21	10 — 10	7 — 7	7	190	n	0	NA	NA
* Chloromethane	µg/L	1 / 21	10 — 10	15 — 15	15	1.4	c	1	NA	NA
Chromium	µg/L	4 / 4	NA — NA	33.8 — 52.7	42.3	3700	n	4	69.2	0
Cobalt	µg/L	3 / 4	4 — 4	7.8 — 15.5	10.7	220	n	0	27	0
Methylene chloride	µg/L	1 / 21	10 — 10	2 — 2	2	4.1	c	0	NA	NA
Nickel	µg/L	3 / 4	25 — 25	30.2 — 47.6	40.3	73	n	0	57.6	0
Selenium	µg/L	1 / 4	1 — 1	2 — 2	2	18	n	0	ND	NA
Vanadium	µg/L	4 / 4	NA — NA	9.8 — 24	15	26	n	0	11	2
Zinc	µg/L	2 / 4	26 — 29.6	39.2 — 68.2	53.7	1,100	n	0	ND	NA

Notes:

*	—	Identified as a chemical of potential concern
a	—	Screening based on Residential Soil Ingestion (USEPA, 1996a)
b	—	MCL is 50 µg/L
c	—	Carcinogen
n	—	Noncarcinogen, RBC screening value adjusted from a hazard quotient of 1.0 to 0.1
NA	—	Not applicable
RC	—	Reference concentration; two-times the mean background concentration (E/A&H, 1996a).
RBC	—	Risk Based Concentration (USEPA, 1996a)
µg/l	—	Micrograms per liter

future land use has not been specified. However, it is unlikely that there will be future residents because the U.S. Army is proposing to reuse the site as a vehicle parking area, as it is paved.

Exposure Pathways

Exposure pathways evaluated include: incidental soil ingestion, dermal contact with soil, and groundwater ingestion, and inhalation/dermal contact of VOCs during showering all of which were assessed for both residential and site worker scenarios. Uniform exposure was assumed for all sample locations. Table 8.6.11 lists exposure pathways considered in this HHRA.

Exposure Point Concentrations

Three samples were collected to assess soil, and four were collected to assess groundwater. Using less than 10 samples to calculate a UCL is not generally recommended (Gilbert, 1987). A plume was not defined for chloromethane, because it was reported in only one of 21 samples. Consequently, the maximum reported concentrations were used as the EPCs for both media. The EPC was adjusted by the FI/FC fraction to account for areas which are contaminated and areas which are not. Unadjusted EPCs and risk estimates are also presented.

Dieldrin was reported in only one of three soil samples, 065S07UA02. Spatial distribution of dieldrin is shown in Figure 8.6.4.

Soil risk estimates were assumed to represent exposure across the entire SWMU. Risk estimates presented in Section 8.6.4.5 can be divided by 0.5 to provide soil risk estimates for sample 065S07UA02. If future exposure was focused at this location, it would not be considered a hot spot based on risk and hazard estimates below 1E-4 and 1.0.

Table 8.6.11
Exposure Pathways Summary — SWMU 65
NSA Memphis Millington, Tennessee

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Hypothetical Residents			
	Air, Inhalation of gaseous contaminants emanating from soil	No	No VOCs were identified as COPCs in SWMU 65 soil.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Alluvial groundwater, Ingestion of contaminants during potable or general use	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Alluvial groundwater, Inhalation of VOCs from the groundwater	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Soil, Incidental ingestion	Yes	It is assumed that hypothetical residents will incidentally ingest soil
	Soil, Dermal contact	Yes	It is assumed that hypothetical residents would be dermally exposed to soil
	Sediment, Incidental ingestion	No	Toluene and TPH-DRO were the only chemicals reported in sediment. As discussed in Section 8.6.5, TPH-DRO has no RBC value and toluene concentrations did not approach their RBC values.
	Sediment, Dermal contact	No	Toluene and TPH-DRO were the only chemicals reported in sediment. As discussed in Section 8.6.5, TPH-DRO has no RBC value and toluene concentrations did not approach their RBC values.
Hypothetical Workers			
	Air, Inhalation of gaseous contaminants emanating from soil	No	No VOCs were identified as COPCs in SWMU 65 soil.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Alluvial groundwater, Ingestion of contaminants during potable or general use	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Alluvial groundwater, Inhalation of VOCs from the groundwater	Yes	Based on Tennessee law it is assumed that all groundwater is a potential source of drinking water. At present a base wide system supplies drinking water
	Soil, Incidental ingestion	Yes	It is assumed that workers will incidentally ingest soil
	Soil, Dermal contact	Yes	It is assumed that workers will be exposed to soil via dermal contact
	Sediment, Incidental ingestion	No	Toluene and TPH-DRO were the only chemicals reported in sediment. As discussed in Section 8.6.5, TPH-DRO has no RBC value and toluene concentrations did not approach their RBC values.
	Sediment, Dermal contact	No	Toluene and TPH-DRO were the only chemicals reported in sediment. As discussed in Section 8.6.5, TPH-DRO has no RBC value and toluene concentrations did not approach their RBC values.

Table 8.6.11
Exposure Pathways Summary — SWMU 65
NSA Memphis Millington, Tennessee

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Construction Worker			
	Air, inhalation of gaseous contaminants emanating from soil	No	No significant amount of VOCs were identified in this HHRA.
	Air, inhalation of chemicals entrained in fugitive dust	No	The particulate emission factor would result in orders of magnitude less exposure than that which would be estimated for direct exposure pathways, such as incidental soil ingestion.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Construction workers would be expected to use a drinking water source other than the upper water bearing zones at NSA Memphis.
	Shallow groundwater, inhalation of VOCs from the groundwater	No	Construction workers would be expected to use a drinking water source other than the upper water bearing zones at NSA Memphis.
	Soil, incidental ingestion	Yes (Qualified)	It is assumed that a construction worker will ingest incidental amount of subsurface soil. This is discussed in the uncertainty Section 8.6.4.6.
	Soil, dermal contact	Yes (Qualified)	It is assumed that a construction worker will ingest incidental amount of subsurface soil. This is discussed in the uncertainty Section 8.6.4.6.

Surface Soil

The EPC for dieldrin is 0.34 mg/kg.

Alluvial Groundwater

A uniform arsenic EPC of 5.6 μg/L was used, despite the fact that nondetects were reported for arsenic in two of the four wells sampled. The reported concentrations ranged from 4.5 to 5.6 μg/L. Incidentally, neither reported concentration exceeded arsenic's MCL of 50 μg/L. The maximum reported chloromethane concentration, 15 μg/L, was used as the EPC because no plume was defined.

Quantification of Exposure

Exposure was quantified as discussed in the Technical Memorandum on HHRA. In accordance with the memorandum, intake calculations were incorporated into risk estimates, and chronic daily intake is not presented separately.

8.6.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in the Technical Memorandum on HHRA. Table 8.6.12 presents toxicological references for COPCs identified at SWMU 65. Toxicological profiles for SWMU 65 COPCs are also presented.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 mg/kg/day as the oral RfD for arsenic based on a NOAEL of 0.8 mg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher concentrations. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, who determined the 1.5 kg-day/mg oral SF for arsenic. As listed Table 8.6.12 Toxicological References in IRIS (search date 9/1/95), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 mg/L arsenic (Klaassen, et al., 1986). The RBC for arsenic in tap water is 0.038 mg/L. As listed in IRIS (search date 9/1/95), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Table 8.6.12
Toxicological Reference Information
for Chemicals of Potential Concern
SWMU 65
NSA Memphis RFI

	Non-Carcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Oral Slope Factor (kg-day/mg)		Inhalation Slope Factor (kg-day/mg)		Weight of Evidence	Tumor Type
Arsenic	0.0003	a	M	hyperpigmentation	3	ND	ND	ND	ND	1.5	a	15.1	a	A	various
Chloromethane	ND	c	NA		ND	ND	ND	ND	ND	0.013	a	0.0063	e	NA	NA
Dieldrin	5E-05	a	M	liver lesions	100	ND			ND	16	a	ND		B2	hepatocarcinoma

Notes:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d EPA NCEA - Cincinnati (provisional)
e Withdrawn from IRIS/HEAST
NA Not applicable or not available
ND Not determined due to lack of information
L Low confidence
M Medium confidence

Chloromethane is a clear, colorless gas that has a faintly sweet, nonirritating odor at high levels in the air. A naturally occurring chemical, it is made in large amounts in the oceans and is produced by some plants and rotting wood and when such materials as grass, wood, charcoal, and coal burn. Chloromethane is also produced industrially, but most of it is destroyed during use. It is used mainly in the production of other chemicals such as silicones (72%), agricultural chemicals (8%), quaternary mines, and butyl rubber.

Case reports of humans exposed acutely to high concentrations of chloromethane have described severe neurological effects, sometimes followed by death. Effects on the cardiovascular system, liver, and kidney have also been described in the case reports of humans exposed for brief periods or for more prolonged periods occupationally (Gummart, 1961; McNally, 1946; Spevak et al., 1976). Numerous acute inhalation studies have identified the liver and kidney as target organs in rats and mice, the spleen in mice and dogs, and the testes and epididymides as target organs in rats. These studies have shown that species differences in susceptibility exist and that generally animals are more susceptible to relatively low exposures given continuously than to relatively high exposures given intermittently (ATSDR, 1990). USEPA has ranked chloromethane as a group C carcinogen (USEPA, 1993a). Chloromethane has an oral SF as well as an inhalation SF that are 1.3E-02 and 6.3E-03, respectively (HEAST, 1996).

Dieldrin is a member of the cyclodiene organochlorine pesticide family. These pesticides are neurotoxins. Aldrin, dieldrin, and endrin are structurally similar. Dieldrin and endrin are stereoisomers. The IRIS oral RfD and oral SF are 0.00005 mg/kg-day and 16 kg-day/mg, respectively (IRIS, 1995). Dieldrin is highly toxic and affects the central nervous system, liver, kidneys, and skin. Dieldrin causes headache, dizziness, nausea, vomiting, tremor, ataxia, clonic and tonic convulsions, and respiratory failure. The LD_{50} for mice is 38 mg/kg. It causes cancer in animals, but inadequate evidence exists for humans. Dieldrin is no longer used or manufactured in the United States (Klaassen et al., 1986).

8.6.4.5 Risk Characterization

Exposure to SWMU 65 media was assessed using two scenarios, future residential and industrial (site worker) scenarios. For each scenario, these exposure pathways were evaluated:

- incidental surface soil ingestion
- dermal contact with surface soil
- ingestion of groundwater
- dermal contact and inhalation of VOCs in groundwater while showering

TDEC assumes all groundwater is potential drinking water. Consequently, alluvial groundwater was assumed to be used as a drinking water source. Tables 8.6.13 and 8.6.14 present surface soil risk estimates for the incidental ingestion pathway, while Tables 8.6.15 and 8.6.16 present surface soil risk estimates for the dermal contact exposure pathways. Tables 8.6.14 and 8.6.16 also include the FI/FC fraction which is used to conservatively estimate the actual area of land which is contaminated. This FI/FC equaled 0.5 which was based on the spatial distribution of these contaminants as shown in Figure 8.6.4. Tables 8.6.17 and 8.6.18 present risk estimates for alluvial groundwater ingestion and dermal contact, respectively.

Hypothetical Site Residents

In accordance with RAGS, risk to site residents was evaluated for carcinogens using the LWA estimates of daily intake. Noncarcinogenic risk, or hazard was estimated separately to address child and adult exposure. As shown in Figure 8.6.9, the sum of soil and groundwater residential risk estimates exceeded 1E-4, with groundwater contributing more than 90% of the risk. The ingestion and dermal ILCRs for SWMU 65 surface soil were each 4E-6. Assuming alluvial groundwater would be used as a drinking water source, risk was estimated to be 4E-6. As shown in Figure 8.6.10, arsenic and chloromethane contributed to groundwater risk, and arsenic was the primary contributor to combined risk.

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Figure 8.6.9 SWMU 65 Residential Risk Estimates

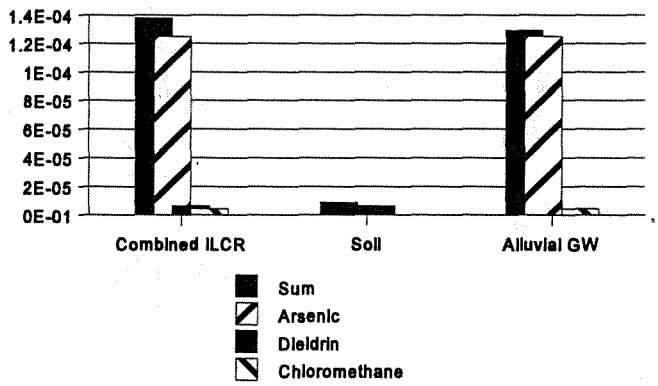

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Figure 8.6.10 SWMU 65 Residential Risk Contributors

Risk Estimates are 1E-5 Times Value Shown

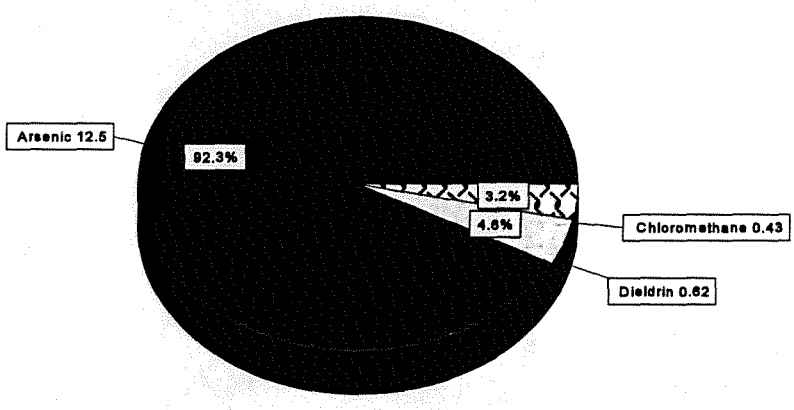

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Table 8.6.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Surface Soil Ingestion at SWMU 65 NSA Memphis

					Residential Scenario		Site Worker Scenario		
Chemical	EPC mg/kg	Oral RfD Used mg/kg-day	Oral SF Used kg-day/mg	FI/FC	Future Adult HQ	Future Child HQ	Future LWA ILCR	Future Worker HQ	Future Worker ILCR
Dieldrin	0.34	0.00005	16	0.5	0.005	0.043	4.3E-06	0.0017	4.8E-07

Table 8.6.14
Hazard Quotients and Incremental Lifetime Cancer Risks Using an FI/FC of 1.0
Surface Soil Ingestion at SWMU 65 NSA Memphis

					Residential Scenario		Site Worker Scenario		
Chemical	EPC mg/kg	Oral RfD Used mg/kg-day	Oral SF Used kg-day/mg	FI/FC	Future Adult HQ	Future Child HQ	Future LWA ILCR	Future Worker HQ	Future Worker ILCR
Dieldrin	0.34	0.00005	16	1.0	0.01	0.09	8.6E-06	0.0034	9.2E-07

Notes:

FI/FC — Fraction Ingested/Fraction Contaminated
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
kg-day/mg — kilogram day per milligram
LWA — Lifetime Weighted Average
mg/kg-day — milligrams per kilogram per day
NA — Not applicable
RfD — Reference Dose
SF — Slope Factor

Table 8.6.15
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Exposure to Surface Soil at SWMU 65 NSA Memphis

						Residential Scenario			Site Worker Scenario	
Chemical	EPC mg/kg	Adjusted Oral RfD Used mg/kg-day	Adjusted Oral SF Used kg-day/mg	DAF	FI/FC	Future Adult HQ	Future Child HQ	Future LWA ILCR	Future Site Worker HQ	Future Site Worker ILCR
Dieldrin	0.34	0.000025	32	0.5	0.5	0.0076	0.025	3.8E-06	0.005	1.6E-06

Table 8.6.16
Hazard Quotients and Incremental Lifetime Cancer Risks Using an FI/FC of 1.0
Dermal Exposure to Surface Soil at SWMU 65 NSA Memphis

						Residential Scenario			Site Worker Scenario	
Chemical	EPC mg/kg	Adjusted Oral RfD Used mg/kg-day	Adjusted Oral SF Used kg-day/mg	DAF	FI/FC	Future Adult HQ	Future Child HQ	Future LWA ILCR	Future Site Worker HQ	Future Site Worker ILCR
Dieldrin	0.34	0.000025	32	0.5	1.0	0.015	0.05	7.2E-06	0.01	3.2E-06

Notes:

LWA — Lifetime Weighted Average
DAF — Dermal Adjustment Factor
FI/FC — Fraction Ingested/Fraction Contaminated
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
SF — Slope Factor
kg-day/mg — kilogram day per milligram
mg/kg — milligrams per kilogram
mg/kg-day — milligrams per kilogram per day
NA — Not applicable
RfD — Reference Dose

Table 8.6.17
Hazard Quotients and Incremental Lifetime Cancer Risks
Alluvial Groundwater Ingestion at SWMU 65 NSA Memphis

				Residential Scenario			Site Worker Scenario	
		Oral RfD	Oral SF	Future	Future	Future	Future	Future
	EPC	Used	Used	Adult	Child	LWA	Adult	Adult
Contaminant	mg/L	mg/kg-day	kg-day/mg	HQ	HQ	ILCR	HQ	ILCR
Arsenic	0.0056	0.0003	1.5	0.5	1.19	1.2E-04	0.5	2.9E-05
Chloromethane	0.015	NA	0.013	NA	NA	2.9E-06	NA	6.8E-07
Summary				0.5	1.2	1E-04	0.5	3E-05

Table 8.6.18
Hazard Quotients and Incremental Lifetime Cancer Risks
Alluvial Groundwater Inhalation and Dermal Contact While Showering at SWMU 65 NSA Memphis

				Residential Scenario			Site Worker Scenario	
		Inhalation RfD	Inhalation SF	Future	Future	Future	Future	Future
	EPC	Used	Used	Adult	Child	LWA	Adult	Adult
Contaminant	mg/L	mg/kg-day	kg-day/mg	HQ	HQ	ILCR	HQ	ILCR
Chloromethane	0.015	NA	0.0063	NA	NA	1.4E-06	NA	3.3E-07

Notes:
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average
mg/kg-day — milligrams per kilogram per day
RfD — Reference Dose
SF — Slope Factor

As shown in Figure 8.6.11, HI estimates for child residents were 1.2 for groundwater ingestion and 0.03 for soil exposure. HI estimated for the adult resident was 0.005 for the soil ingestion pathway, while HI for the child ingestion pathway was estimated to be 0.04. The dermal contact HIs were estimated to be 0.008 and 0.03 for the adult and child, respectively. The groundwater HI was estimated to be 1.2. The only contributor to surface soil HI was dieldrin, and the only contributor to HI for alluvial groundwater was arsenic.

Future Site Workers

As shown in Figure 8.6.12, the sum of soil and groundwater exposure estimates was 3E-5. Over 90% of the risk exposure was due to alluvial groundwater contribution. The ingestion and dermal ILCRs for SWMU 65 surface soil were 5E-7, and 2E-6, respectively. Alluvial groundwater risk was estimated to be 3E-5. Dieldrin was the primary contributor to the ILCR for each soil pathway, while arsenic and chloromethane were the primary contributors to groundwater ILCR. Arsenic was the only HI contributor in alluvial groundwater. HIs estimated for the incidental ingestion and dermal contact soil pathways were 0.002 and 0.005, respectively. The HI for arsenic in alluvial groundwater was estimated to be 0.5 as shown on Figure 8.6.13.

Current Site Workers

Alluvial groundwater is not currently a potable water source for SWMU 65, nor is it expected to be in the future. In the absence of a completed exposure pathway, no threat to human health would be posed to current site workers. Consequently, the future site worker scenario would be protective of current site workers because the exposure frequency and exposure duration would be much less for current site workers.

COCs Identified

As described in the Technical Memorandum on HHRA, COCs were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In Assembly E HHRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative HI above 1.0, if its individual ILCR exceeds 1E-6 or its HQ exceeds 0.1.

Hypothetical Site Residents (Future Land Use)

Arsenic was identified as a COC for the hypothetical site resident scenario, based on the risk and hazard estimates for ingesting alluvial groundwater as a drinking water source. However, the

Figure 8.6.11 SWMU 65 Residential Child Hazard Index Estimates

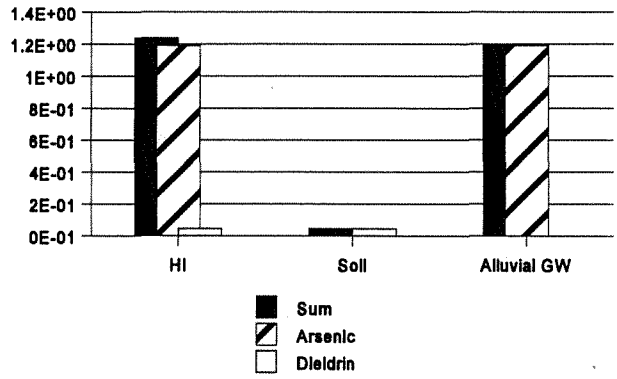

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Figure 8.6.12 SWMU 65 Industrial Risk Estimates

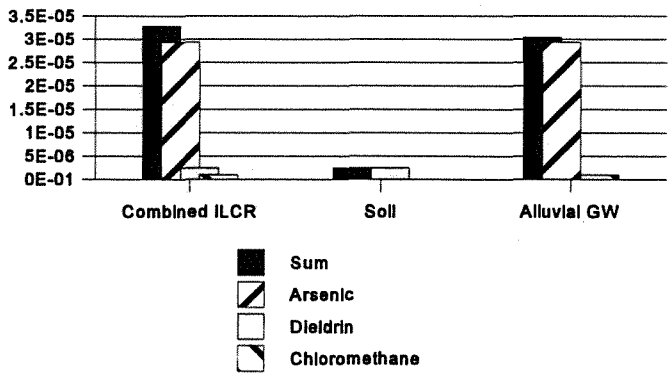

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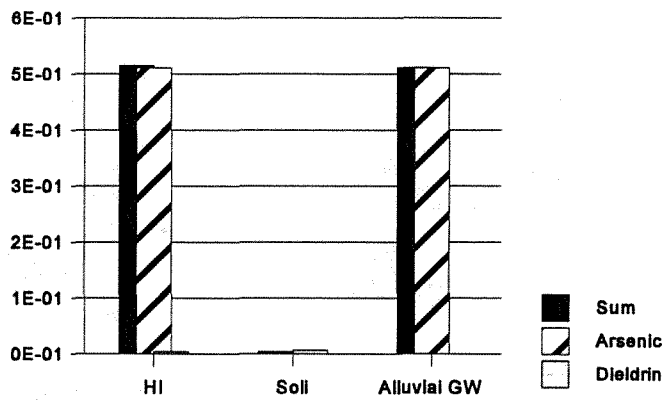
Figure 8.6.13 SWMU 65 Worker Hazard Index Estimates



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concentrations reported for arsenic in alluvial groundwater are approximately one order of magnitude less than the corresponding MCL.

Hypothetical Site Workers (Future Land Use)

No risk- or hazard-based COCs were identified for the hypothetical site worker scenario.

Hypothetical Site Workers (Current Land Use)

No risk- or hazard-based COCs were identified for the current site worker scenario.

8.6.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

Residential use of the site would not be expected, based on current site uses and the nature of the surrounding buildings. If this area were to be used as a residential site, the buildings would be demolished, and the surface soil conditions would likely change. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the exposure posed to current site workers and future site residents.

Alluvial groundwater is not currently used at SWMU 65 for potable or industrial purposes. At present, NSA Memphis has a system that supplies drinking and process water, including Assembly E. As a result, alluvial groundwater use would not be expected under future site use scenarios. Therefore, the scenario established to estimate exposure to chemicals reported in alluvial groundwater is highly conservative.

Determination of Exposure Point Concentrations

Based on the guidance provided by USEPA and discussed in the Technical Memorandum on HHRA, EPCs are used to estimate exposure. The uncertainty associated with EPCs primarily

stems from their statistical determination (UCLs) or imposition of maximum concentrations. In the case of SWMU 65, maximum reported concentrations were used as EPCs, which would tend to overestimate exposure.

Surface Soil

The dieldrin EPC is the maximum reported concentration. However, the FI/FC fraction was used to conservatively adjust exposure to the areas contaminated.

Dieldrin

The *Technical Memorandum — Surface Soil (0 to 1 foot) Background Dieldrin Concentrations at NSA Memphis* (E/A&H, 1997d) stated that dieldrin was detected at NSA Memphis at relatively insignificant concentrations. Dieldrin was used extensively in the 1950s and 1960s, and was applied as a pesticide at NSA Memphis during that time period. Dieldrin was also used in the pest control trade with chlordane for general subterranean termite control. As stated in the memorandum, "this finding indicates that dieldrin levels found at each SWMU do not necessitate remedial action in the absence of other significant carcinogenic risk contributors." The average background dieldrin concentration reported in the memorandum is 0.131 mg/kg; two-times the mean is 0.262 mg/kg. Therefore, the background risk posed by dieldrin should be considered when making risk-management decisions.

Subsurface Soil

Construction work generally requires less than one year to complete a project, and chronic exposure is typically seven years or more. The current site worker scenario used in this assessment assumes 25-year exposure. Therefore, future worker assessment is considered to be protective of both current site use and future construction/maintenance exposure scenarios for surface soil. The future site resident scenario assumed existing buildings would be removed and

replaced with dwellings. In addition, the future site residents and workers were assumed to use the onsite underlying aquifers as a source of drinking water.

Subsurface soil was assessed for the construction worker land use scenario in accordance with recommendations made by USEPA Region IV and TDEC. Most assumptions used to estimate construction worker's exposure are default site worker assumptions. The three exposure assumptions modified in accordance with USEPA and TDEC's suggestions are shown below:

Exposure Duration = 0.5 year (1 year used to estimate exposure for carcinogens)
Exposure Frequency = 120 days/year
Ingestion Rate = 340 mg/day (modified as discussed below)

The modified ingestion rate is based on the time-weighted average, assuming a worker would be exposed to a hole in the ground, incidentally ingesting 480 mg/day (RBCA/ASTM) for 0.5 year, and 200 mg/day for 0.5 year (USEPA, 1995b). The weighted average is 340 mg/day. Intake multipliers were calculated in accordance with RAGS, as discussed in the Technical Memorandum on HHRA.

Assuming a soil concentration of 1 mg/kg and applying the modified exposure assumptions presented above, this results in the following intake multipliers:

- Ingestion Hazard Multiplier = 1.6E-06
- Ingestion ILCR Multiplier = 1.28E-08

As presented in Quantification of Exposure within the Technical Memorandum on HHRA, the residential intake multipliers are:

- Ingestion Hazard Multiplier = 1.28E-07
- Ingestion ILCR Multiplier = 1.57E-09

RBCs were calculated by USEPA Region III using similar multipliers. The following equation can be used to calculate the RBC for a site resident exposed to soil:

$$RBC = \frac{\text{Target Risk Goal}}{\text{Ingestion Hazard Multiplier x Slope Factor}}$$

For example, the slope factor for arsenic is 1.5 kg-day/mg. Using arsenic as an example with a target risk goal of 1E-6 and the residential multiplier for carcinogens shown above, the RBC would equal approximately 0.43 mg/kg, the same value shown in USEPA Region III's RBC tables. Applying the multiplier for the construction worker scenario results in an RBC for a construction worker scenario approximately equal to 29.5 mg/kg, as shown in Table 8.6.19.

Because a linear relationship exists between the two land use scenarios, residential RBCs for noncarcinogens and carcinogens can be related to construction worker RBCs using the following multipliers:

- Noncarcinogens = 8 * RBC_N (residential) = RBC_N (construction worker)
- Carcinogens = 68.63 * RBC_C (residential) = RBC_C (construction worker)

Alluvial Groundwater

The arsenic EPC was based on the maximum detected concentration. As a result, site-wide exposure was overestimated. In addition, it should be noted that arsenic is not likely to be the result of the JP-5 fuel spill. Arsenic is likely to be part of the natural geochemistry or past agricultural practices based on similarity to RCs.

Table 8.6.19
Construction Worker Scenario
SWMU 65
NSA Memphis

Chemical	MAX µg/kg	RBC res µg/kg	RBC const µg/kg	NOTE	RC µg/kg
2,4,5-TP (Silvex)	4.8	7,800,000	62,400,000	N	NA
2,4-DB	12	630,000	5,040,000	N	NA
Acetone	9	7,800,000	62,400,000	N	NA
Arsenic	8,100	430	29,511	C	20,320
Barium	193,000	5,500,000	44,000,000	N	233,460
Beryllium	750	150	10,295	C	1,000
Cadmium	2,800	39,000	312,000	N	3,240
Chromium	19,600	390,000	3,120,000	N	28,280
Cobalt	8,200	4,700,000	37,600,000	N	14,360
Copper	23,600	3,100,000	24,800,000	N	32,520
Dinoseb	7	78,000	624,000	N	NA
Lead	15,800	1,300,000	1,300,000	a	19,800
Nickel	28,300	1,600,000	12,800,000	N	NA
Tin	36,600	47,000,000	376,000,000	N	NA
Vanadium	36,000	550,000	4,400,000	N	43,700
Xylene (Total)	3	160,000,000	1,280,000,000	N	NA
Zinc	85,900	23,000,000	184,000,000	N	109,000

Notes:

MAX - Maximum reported concentration in subsurface soil

RBC res - Screening based on the 1998 Risk-Based Concentration table (USEPA 1998).

RBC const - Screening based on construction worker soil ingestion as per RBCA/ASTM guidance

RC - NASP reference concentration

NA - Not applicable/not available

N - Noncarcinogen

C - Carcinogen

a - industrial cleanup goals used at other federal facilities

Arsenic

Arsenic was assessed as a carcinogen, and arsenic ILCR was a primary contributor to risk estimates for groundwater exposure pathways. USEPA evaluated the cancer potency of arsenic based on certain studies from the literature. Limitations in these studies and the methods used by USEPA would result in overestimates of arsenic risk. For example, arsenic's MCL is 50 mg/L (USEPA, 1996a), yet exposure to drinking water with 50 mg/L arsenic would equate with risk estimates greater than 1E-4. The technology-based method used to calculate the MCL for arsenic is not the same as risk-based methods used to assess risk.

USEPA derived the oral SF from a Taiwanese study of human exposures to groundwater containing arsenic (Tseng et al., 1968). The assumptions used by USEPA to derive the SF may have underestimated dietary exposure to arsenic (Yost et al., 1994). More recent water intake values were available for the Taiwanese population. These values are higher than the historical data used by USEPA. Using higher water intake values would reduce the expected cancer potency. In addition, toxic effects of arsenic could have been exacerbated because the study population was reportedly undernourished and many had chronic liver disease (Hsueh et al., 1995).

The calculation method USEPA used to determine the SF may also have overestimated the cancer-causing potential of arsenic. A linear dose response curve was assumed by USEPA, and the dose-response curve for arsenic may be sublinear (Loehr et al., 1989). In 1989, the USEPA Science Advisory Board concluded that, "...at dose levels below 200-250 micrograms arsenic per day there is a possible detoxification mechanism that may substantially reduce cancer risk from the levels USEPA has calculated using a linear-quadratic model fit to the Tseng data."

The Tseng study was based on water ingestion, and many studies indicate arsenic is more bioavailable from water than soil. Ingesting arsenic in soil may not elicit toxic responses, while

the same amount of arsenic ingested from groundwater may be toxic (ATSDR, 1992). Relative bioavailabilities of arsenic in soil to arsenic in groundwater range from 20% to 78% (Freeman et al., 1993, 1994).

USEPA determined that risk-based concentrations for arsenic should be multiplied by 10 to account for the uncertainty in arsenic's carcinogenicity (USEPA, 1988). For example, a risk-based concentration of 0.001 mg/L would be changed to 0.01 mg/L. In addition, the mean relative bioavailability of 78% is recommended by USEPA to address arsenic in soil. In summary, a risk-based concentration of 1 mg/kg would be modified (e.g., 1/0.78 = 1.282 mg/kg) to approximately 1.28 mg/kg. The 1.28 mg/kg concentration in soil would also be adjusted to account for the uncertainty in arsenic's SF, resulting in an adjusted value of 12.8 mg/kg. The relative bioavailability factor would not be applicable to groundwater concentrations, so a risk-based groundwater concentration of 0.001 mg/L would be modified to 0.01 mg/L. Therefore, risk and hazard estimates are potentially overestimates.

Frequency of Detection and Spatial Distribution

The FI/FC fraction accounted for some of the spatial variation in exposure calculations. Arsenic in groundwater was detected in only two of the four samples, and chloromethane was reported in only one of 21 samples. Exposure would not be expected to be focused at only the locations where these chemicals were reported. As a result, exposure was likely overestimated.

Quantification of Risk/Hazard

As indicated by the discussions above, uncertainty is inherent during the risk assessment process. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of variability and uncertainty are discussed below.

Surface Soil

Arsenic and beryllium's maximum reported concentrations exceeded their corresponding RBCs, but they were eliminated from the formal assessment based on comparisons to the RCs.

Alluvial Groundwater

Barium and chromium's maximum reported concentrations exceeded their corresponding RBCs, but they were eliminated from the formal assessment based on comparisons to the RCs. As a measure of variability, Central Tendency (CT) analysis was performed for groundwater. Exposure assumptions were modified to reflect the 50th percentile rather than the 95th. EPCs were not modified. In accordance with *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure-Draft* (USEPA, 1993a), the exposure durations were reduced from 30 to nine years for site residents, two years for child exposure, and seven years for adult exposure. Exposure frequency was reduced from 350 to 234 days per year for site residents and from 250 to 219 for site workers. The drinking water ingestion rate for an adult was reduced from 2 to 1.4 liters per day, and exposure to groundwater was reduced by 25% to account for other water sources.

Future Site Residents

The ILCR based on RME assumptions for alluvial groundwater was estimated to exceed 1E-4, while using CT assumptions would reduce the risk estimate to within USEPA's acceptable risk range of 1E-6 to 1E-4. Based on RME assumptions, the HI for the child residential receptor was estimated to exceed 1.0. However, the HI estimate based on CT assumptions is below the USEPA threshold of 1.0.

Future Site Workers

No COCs were identified for this scenario, so risk was not estimated assuming CT exposure.

Current Site Workers

No COCs were identified for this scenario, so risk was not estimated assuming CT exposure.

8.6.4.7 Risk Summary

Table 8.6.20 summarizes risk and hazard estimates for SWMU 65. Although risk estimates exceeding USEPA's upper bound acceptable risk range were calculated assuming alluvial groundwater would be used as a drinking water source, arsenic accounted for 100% of the groundwater estimated risk. The maximum concentration reported for arsenic in alluvial groundwater is approximately one order of magnitude less than the corresponding MCL.

Table 8.6.20
Risk Summary
SWMU 65 — NSA Memphis

	Future Site Residents			Current and Future Site Workers	
Media and Exposure Pathway	**Adult HQ**	**Child HQ**	**LWA ILCR**	**Worker HQ**	**Worker ILCR**
Soil — Incidental Ingestion	0.005	0.04	4e-06	0.002	5e-07
Soil — Dermal Exposure	0.008	0.03	4e-06	0.005	2e-06
Sum of Soil	0.001	0.07	8e-06	0.01	2e-06
Alluvial Groundwater — Ingestion	0.5	1	1e-04	0.5	3e-05
Alluvial Groundwater — Inhalation	NA	NA	1e-06	NA	3e-07
Sum of Groundwater	0.5	1	1e-04	0.5	3e-05
Sum of Soil and Alluvial Groundwater	0.5	1	1e-04	0.5	3e-05

Notes:
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average

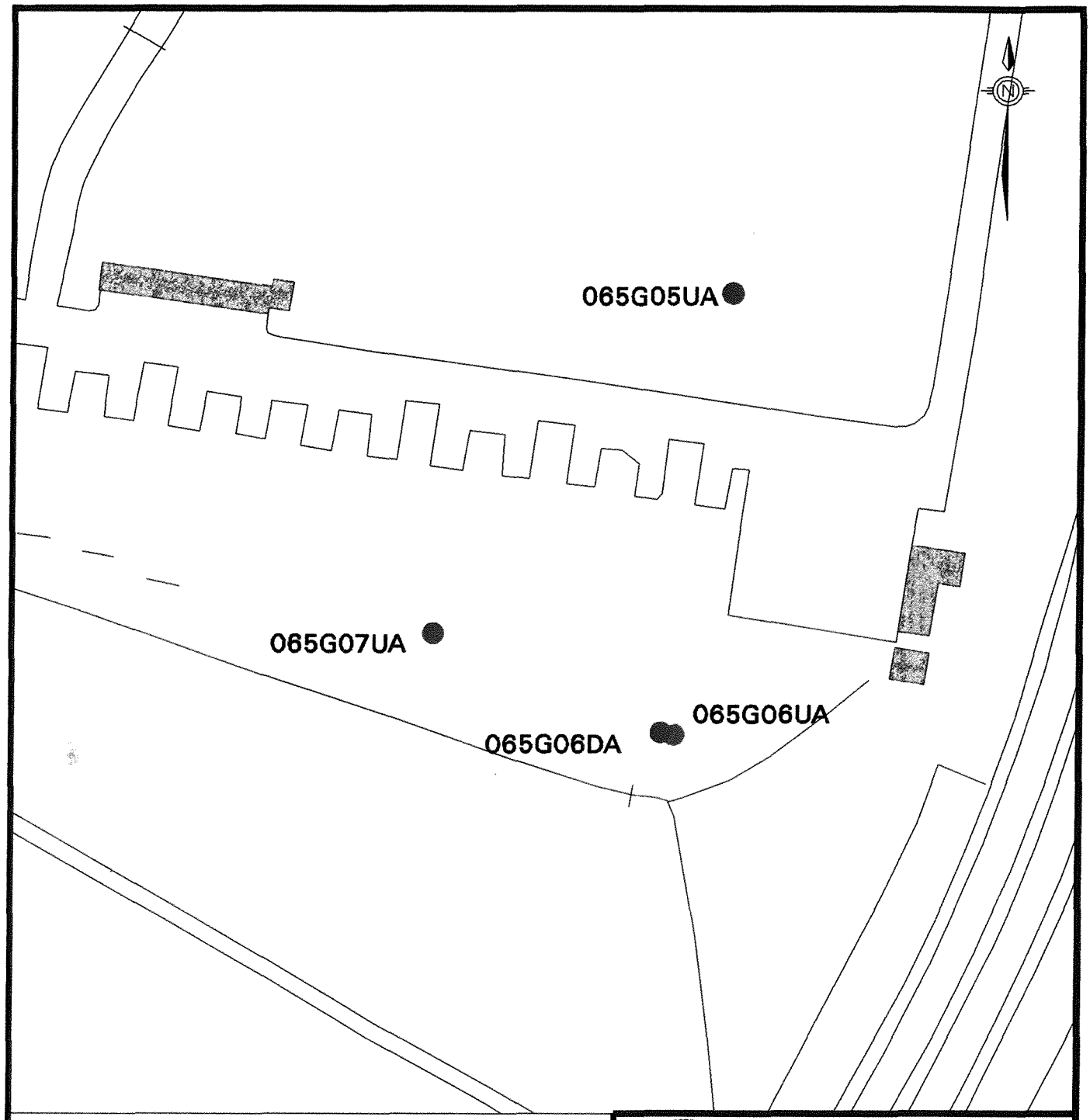
Remedial Goal Options

Although arsenic concentrations reported in alluvial groundwater are less than the corresponding MCL, based on USEPA guidance they are considered to be COCs. Table 8.6.21 lists the RGOs for arsenic in alluvial groundwater, as well as the MCL.

8.6.4.8 Summary Risk Figures

Risk figures were developed for arsenic risk and hazard in alluvial groundwater. As previously discussed, figures were developed only for a residential land use scenario, based on a child receptor for the presented risk and hazard estimates. However, estimates assuming industrial land use are provided in corresponding tables. Chloromethane contributed approximately two orders of magnitude less to cumulative risk than arsenic, so chloromethane was not included in point risk maps below. Chloromethane was reported in one DPT sample and would not change the risk estimates. DPT locations are not shown on the maps.

Table 8.6.22 presents individual risk and hazard estimates for arsenic in alluvial groundwater, sorted by sample location, which are presented graphically in Figures 8.6.14 and 8.6.15, respectively. Arsenic was the only contributor to alluvial groundwater risk and hazard. Arsenic was detected in groundwater samples 065G05UA01 and 065G06DA01. However, an assumed concentration was used for samples in which arsenic was not detected, as described in the Technical Memorandum on HHRA and shown in Table 8.6.22.



LEGEND - RISK VALUES

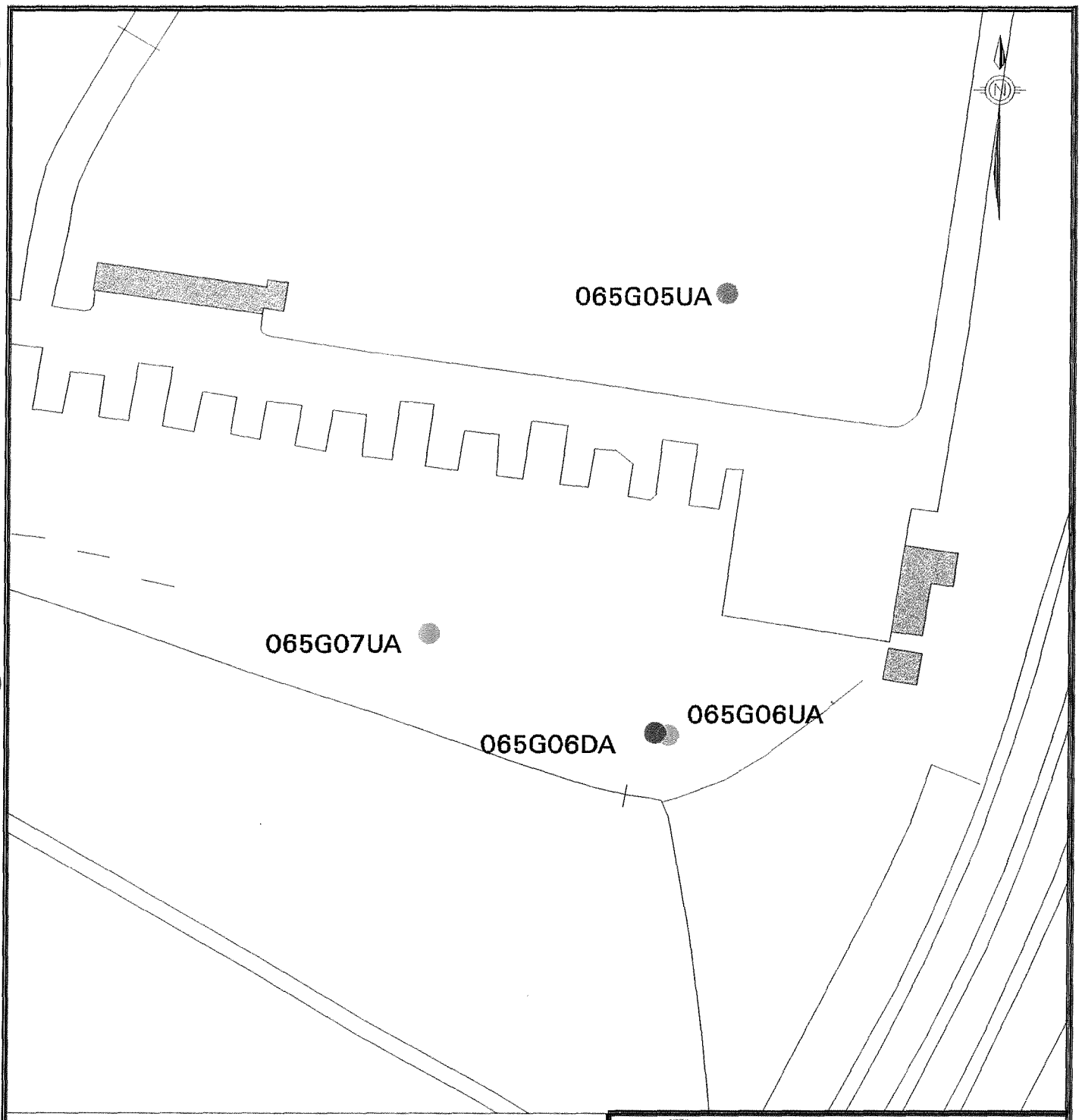
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 200

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.14
ARSENIC RISK
IN ALLUVIAL GROUNDWATER
SWMU 65

AML: /home/ce2/memphis_dir/site_dir/assem_e/risk_assess



LEGEND - HAZARD VALUES

- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 200

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.15
ARSENIC HAZARD
IN ALLUVIAL GROUNDWATER
SWMU 65

AML: /home/ce2/memphis_dir/site_dir/assem_e/risk_assess

Table 8.6.21
Remedial Goal Options for COCs
Alluvial Groundwater at SWMU 65 NSA Memphis

	Site Resident							*Site Worker*					
Chemical	**Risk LWA at 10-6 µg/L**	**Risk LWA at 10-5 µg/L**	**Risk LWA at 10-4 µg/L**	**Child Hazard at 0.1 µg/L**	**Child Hazard at 1 µg/L**	**Child Hazard at 3 µg/L**	**MCL µg/L**	**Risk LWA at 10-6 µg/L**	**Risk LWA at 10-5 µg/L**	**Risk LWA at 10-4 µg/L**	**Child Hazard at 0.1 µg/L**	**Child Hazard at 1 µg/L**	**Child Hazard at 3 µg/L**
Arsenic	0.045	0.448	4.482	0.4693	4.69	14.08	50	0.19	1.9	19	1.12	11.2	33.6
Chlormethane	3.5	35	350	NA	NA	NA	NA	14.8	148	1480	NA	NA	NA

Notes:
NA - Not Applicable/Not Available
COC - Chemical of Concern
ILCR - Incremental Lifetime Cancer Risk
LWA - Lifetime Weighted Average
µg/L - micrograms per liter

Table 8.6.22 Risk and Hazard Estimates for COCs per Sampling Location
Alluvial Groundwater
SWMU 65
NSA Memphis

Sample ID	Result µg/L	VQUAL	Chemical	Assumed Concentration µg/L	EPC µg/L	Residential Child HQ	Residential LWA ILCR	Industrial Site Worker HQ	Industrial Site Worker ILCR
065G05UA01	4.5	J	Arsenic	1	4.5	0.96	1.0E-04	0.40	2.4E-05
065G06DA01	5.6	J	Arsenic	1	5.6	1.19	1.2E-04	0.50	2.9E-05
065G06UA01	2	UJ	Arsenic	1	1	0.21	2.2E-05	0.09	5.3E-06
065G07UA01	2	UJ	Arsenic	1	1	0.21	2.2E-05	0.09	5.3E-06

Notes:
VQUAL - Validation qualifier
EPC - Exposure Point Concentration
LWA - Lifetime Weighted Average
HQ - Hazard Quotient
ILCR - Incremental Lifetime Excess Cancer Risk
U - The material was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
µg/L - micrograms per liter

8.6.5 Ecological Risk Assessment

8.6.5.1 Introduction

The focus of the ERA for SWMU 65 is on the terrestrial ecosystem associated with the site, since no other habitat types are present. The ERA considers surface soil contaminant concentrations and distributions and exposure pathways that could result in unacceptable levels of exposure to terrestrial ecological receptors now or in the future. Potential aquatic risks associated with storm water runoff are discussed in the ERA of the SWMU 38 RFI (Industrial Drainage Ditches — Southside), in Section 8.4.5.

8.6.5.2 Problem Formulation

Site Description

The ecological features at SWMU 65 are minimal. The site is a long paved area with several buildings surrounded by a grassy field and several small stands of trees. During the initial site assessment, a series of small, isolated depressions were observed along the southern site boundary which seemed to be retaining water. When the site was active, the paved area staged numerous jet airplanes which were repeatedly started for pilot training. Over time, the thrust from these ground-starts has created shallow oblong pits in the bare ground behind each plane. Lacking top soil, these isolated low areas retained storm water longer than the surrounding area. This condition occasionally makes these wet areas difficult to maintain, allowing grass around the few deeper pits to grow longer. Subsequent site visits have shown that since the removal of the jets, the pits are beginning to refill through wind-blown and water-born soil and these areas are being mowed.

To the south the site is bound by a high grassy berm beyond which is the Big Creek Drainage Canal. Drainage of the site itself is via two drainage ditches. Storm water from the northern portion of the site is carried northward beneath B Street to the southern branch of SWMU 38 by a small ditch and culvert. The remainder of the site is drained by a small drainage swale (not

associated with SMWU 38), which runs east near the base of the berm, beneath a small access road, and into a larger ditch at the southeastern corner of the site. This ditch then runs south, parallel to the tree line of the nearby woods and ultimately into Big Creek Drainage Canal. This offsite water body is included in a separate investigation.

Ecosystem at Risk

Based on visual observation, no quality habitat is available at SWMU 65. The grassy area surrounding the site could potentially be used by terrestrial receptors such as passerine birds and/or small mammals as foraging areas, but their occurrence would most likely be transient or opportunistic. Both the ditches on site and along the edge of the offsite woods remain dry except in direct response to precipitation, therefore do not support aquatic biota. The small wooded area southeast of the site does offer some suitable cover and foraging habitat for a variety of terrestrial species, but since no significant exposure pathway is present (from nearby drainage ditch), neither these woods nor its inhabitants are expected to be impacted by the low level of contaminants associated with SWMU 65. No viable terrestrial community exists within SWMU 65. With limited habitat and lack of terrestrial receptors, the SWMU 65 area does not warrant a preliminary ecological risk assessment.

8.6.6 Fate and Transport Assessment

Potential migration pathways associated with SWMU 65 include constituents leaching from soil to groundwater, and surface soil erosion of sorbed constituents forming sediments. The soil-to-air volatilization process is eliminated from further discussion based on the lack of VOCs detected in surface soil and the fact that no contaminant detected in surface soil exceeded the soil-to-air SSL. Based on local topography and associated surface water drainage patterns, the most likely receptors for constituents originating in the SWMU 65 area are the drainage depressions and Big Creek Drainage Canal. Also, groundwater is a potential receptor for constituents present in subsurface soil.

SWMU 65 contaminants of concern (COCs) include:

- ***Arsenic*** — identified in the HHRA as a COC in alluvial groundwater
- ***Barium*** — exceeded its SSL and RC in subsurface soil
- ***Nickel*** — exceeded its SSL and RC in subsurface soil
- ***Dieldrin*** — exceeded its SSL in subsurface soil

8.6.6.1 Soil-to-Groundwater Cross-Media Transport

Three constituents are highlighted as posing a potential soil-to-groundwater migration concern, as determined by soil concentrations exceeding groundwater protection SSLs. These include two inorganics (barium and nickel) and one pesticide (dieldrin). Of these constituents, only barium was present in SWMU 65 soil and groundwater. Arsenic was the only other constituent detected in soil and groundwater. Arsenic exceeded its RBC and background RC in both upper and deep alluvium groundwater, but not its soil-to-groundwater SSL, its background RC in soil, or its MCL in groundwater. Inorganics and pesticides are considered to be immobile and persistent in the environment, not readily diffusing into groundwater. The solubility of these constituents in groundwater is low, resulting in limited mobility in this environment. Therefore, widespread impacts to the aquifer are not expected.

Chloromethane, methylene chloride, and 2-butanone were detected in groundwater at SWMU 65 but not detected in soil; however, none of these constituents exceeded its respective RBCs. Continued impact to groundwater is not expected from these constituents due to their absence in soil.

Potential receptors relating to groundwater contamination are two production wells (PW-4 and PW-5). PW-4 is approximately 5,600 feet northwest of SWMU 65, while PW-5 is approximately 4,500 feet northwest of SWMU 65. It is highly unlikely that groundwater contamination would

migrate horizontally to the production well locations based on the groundwater flow direction and the travel distance. Dilutional effects would also greatly reduce concentrations should they travel this distance. Both production wells are screened greater than 1,400 feet bls and confining units that separate the screened interval from loess, alluvial, and fluvial deposits groundwater would greatly limit vertical contaminant migration.

Based on the limited impacts to groundwater and the tendency for inorganics and pesticides to sorb to the soil matrix, soil contaminants identified at SWMU 65 are not expected to adversely impact the aquifer.

8.6.6.2 Soil-to-Sediment Cross-Media Transport

The presence of concrete areas within SWMU 65 somewhat mitigates the potential for soil to form sediments from surface water runoff. However, grass-covered areas and drainage swales at SWMU 65 could transport surface soil contaminants.

Acetone was the only VOC detected in surface soil at SWMU 65. The remaining constituents identified in soil include SVOCs, pesticides, and inorganics, which all typically sorb to soil particles and do not readily diffuse into water. Therefore, their only transport process in surface soil would be soil-to-sediment transport as a result of erosion.

The SWMU 65 topography generally slopes to the south and storm water falling on the concrete pads typically flows south to the grassy area and into a drainage swale along the south side of the site. The vegetative cover at SWMU 65 should aid in preventing erosion of surface soil; therefore, any surface soil contamination is not expected to migrate significant distances, if at all.

8.6.7 Conclusions and Recommendations

The following conclusions are presented based on the findings of the RFI:

- A limited site investigation of SWMU 65 was conducted in 1992 in the area of a JP-5 spill. TPH-GRO, TPH-DRO, and BTEX were identified in soil samples from the surface to 6 feet bls. TPH-GRO and TPH-DRO were also detected in the four upper alluvium monitoring wells installed during the 1992 investigation.

- Soil samples collected during this RFI indicated the presence of VOCs, SVOCs, chlorinated pesticides, herbicides, and inorganics. No VOC exceeded any screening value. The only SVOC exceedance was for benzo(a)pyrene in one soil boring's surface-soil sample; the detected concentration exceeded its residential RBC only. One DPT subsurface soil sample exhibited a total TPH concentration exceeding the TDEC soil cleanup level for total TPH. The only pesticide that exceeded screening values was dieldrin in one soil boring surface-soil sample; the detected concentration exceeded its residential RBC, SSL, and RC. No detected inorganic in surface soil exceeded both its RC and residential RBC; however, barium concentrations in one surface and one subsurface soil boring sample, and nickel in one surface and two subsurface soil boring samples, exceeded both their RC and SSL.

- No SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, or herbicides were detected in the monitoring well groundwater samples collected during this RFI. Chloromethane, detected in only one DPT groundwater sample, was the only VOC in groundwater to exceed its tap water RBC. The arsenic concentration in one upper alluvium monitoring well and one deep alluvium monitoring well exceeded both its RC and tap water RBC; however, both detected concentrations were below arsenic's MCL.

- In April/May 1997 the four upper alluvium groundwater wells installed in 1992 and the three upper alluvium and one deep alluvium groundwater wells installed in 1996 were sampled and analyzed for VOCs, TPH, TPH-GRO, and TPH-DRO. The TPH, TPH-GRO, or TPH-DRO concentrations identified in five of the seven upper alluvium monitoring wells exceeded the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers.

- Ten sediment samples were collected from five locations during this RFI and analyzed for TPH-GRO and BTEX. Toluene, detected in all 10 samples, did not exceed its residential RBC or SSL. TPH-GRO was present in several sediment samples, but no detected concentration exceeded the TDEC soil cleanup standard.

- The HHRA identified arsenic as a COC for the hypothetical site resident scenario, based on the risk and hazard estimates for ingesting alluvial groundwater as a drinking water source. However, the concentrations reported for arsenic in alluvial groundwater are approximately one order of magnitude less than the corresponding MCL. Arsenic was not an anticipated site constituent and no records are available that indicate its use at SWMU 65, so it may be naturally occurring or a residual from past agricultural practices.

- The ERA determined no quality habitat is available at SWMU 65, which has no viable terrestrial community.

- Based on the limited impact to alluvial groundwater and the tendency for inorganics and pesticides to sorb to the soil matrix, soil contaminants identified at SWMU 65 are not expected to adversely impact the aquifer.

The following recommendations are presented based on the findings of the RFI:

- Assess the need for a Voluntary Corrective Action to remove soil around the JP-5 spill area, after the BCT evaluates the data from the soil sample collected to characterize the former JP-5 fuel spill area.

- Final determination on SWMU 65 groundwater should be deferred until the analytical results from the most recent groundwater sampling event have been evaluated by the BCT.

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9.0 CONCLUSIONS SUMMARY

Table 9.1.1 on the following page summarizes the conclusions and recommendations of the Assembly E RFI.

Table 9.1
Assembly E RFI Conclusions Summary

SWMU	Description	Suspected Contaminants	COCs Identified	ILCR > 1E-4?	HI > 1?	Ecological Risk?	Recommendations
2 — Southside Landfill	42-acre landfill operated from 1942 until 1970. The landfill received residential waste, office solid waste, aircraft parts, wastewater treatment plant sludge, incinerator ash, waste oil, oily sludge, and solvents generated from industrial operations, and possibly PCBs.	VOCs, SVOCs, metals, PCBs	Not applicable	Not applicable	Not applicable	Not applicable	Investigation Ongoing
9 — Sewage Lagoons	Two lagoons (400,000 and 141,000 sf) used as part of the wastewater treatment system from 1969 to 1978. Although primarily domestic wastewater was treated, limited amounts of industrial wastewater from aircraft maintenance were treated.	VOCs, SVOCs, and metals	**Groundwater:** Alluvial — arsenic, Chloroform, TCE **Fish ingestion:** 4,4'-DDE, Aroclor-1254, Aroclor-1260, arsenic	Site Resident	Adult Site Resident, Child Site Resident Adult Site Resident, Child Site Resident, Adolescent Trespasser, Child Trespasser	Yes	Continue annual groundwater monitoring for VOCs, TPH-GRO, and TPH-DRO. Continue the ban on fishing at the lagoons. Assess The TCE in SWMU 9 groundwater during the SWMU 2 investigation.
14 — Bldg. S-140 Site and 7th Ave. Ditch	Paint spray booth/paint water wash pits	Paint waste including hydrocarbons, metals, and solvents	**Groundwater:** Loess — PCE, TCE, 1,2-DCE Fluvial Deposits — arsenic, barium, benzene, vanadium	Site Resident	Adult Site Resident, Child Site Resident Child Site Resident	No	A Corrective Measure Study is recommended for the loess groundwater. Continue the annual groundwater monitoring for VOCs and sample for remedial design parameters.
38 — Misc. Southside Drainage Ditches	Drainage Ditches	Sediment contaminants from former industrial discharges including pesticides, metals, and SVOCs	No COCs were identified.	Not applicable	Not applicable	No	No further action is recommended for SWMU 38.

Table 9.1
Assembly E RFI Conclusions Summary

SWMU	Description	Suspected Contaminants	COCs Identified	ILCR >1E-4?	HI > 1?	Ecological Risk?	Recommendations
59 — Building S-335, Pesticide Storage Facility	Pesticide storage	Chlordane, dieldrin, DDT, arsenic	Surface Soil: aldrin, alpha-chlordane, arsenic, Aroclor-1260, BEQ, dieldrin, gamma-chlordane, heptachlor, heptachlor epoxide Groundwater: Loess — barium, vanadium, heptachlor epoxide, lead	Site Resident	Child Site Resident Child Site Resident	No	A Voluntary Corrective Action is recommended at SWMU 59 to demolish Building S-335 and to remove pesticide contaminated soil. Then reassess the human health risk following the removal actions. Continue annual groundwater monitoring for pesticides.
65 — Building S-362 Training Mock-up Site	Aircraft parking; jet engine testing; aircraft engine startup training; two 30,000-gallon JP-5 USTs used to fuel the test cell	Petroleum-related contamination including VOCs and SVOCs	Groundwater: Alluvial — arsenic	Site Resident	Child Site Resident	No	After the BCT evaluates the data from the soil sample collected to characterize the former JP-5 fuel spill area, assess the need for a Voluntary Corrective Action to remove soil. Final determination on SWMU 65 groundwater will be deferred until the analytical results from the most recent groundwater sampling event have been evaluated by the BCT.

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the same amount of arsenic ingested from groundwater may be toxic (ATSDR, 1992). Relative bioavailabilities of arsenic in soil to arsenic in groundwater range from 20% to 78% (Freeman et al., 1993, 1994).

USEPA determined that risk-based concentrations for arsenic should be multiplied by 10 to account for the uncertainty in arsenic's carcinogenicity (USEPA, 1988). For example, a risk-based concentration of 0.001 mg/L would be changed to 0.01 mg/L. In addition, the mean relative bioavailability of 78% is recommended by USEPA to address arsenic in soil. In summary, a risk-based concentration of 1 mg/kg would be modified (e.g., 1/0.78 = 1.282 mg/kg) to approximately 1.28 mg/kg. The 1.28 mg/kg concentration in soil would also be adjusted to account for the uncertainty in arsenic's SF, resulting in an adjusted value of 12.8 mg/kg. The relative bioavailability factor would not be applicable to groundwater concentrations, so a risk-based groundwater concentration of 0.001 mg/L would be modified to 0.01 mg/L. Therefore, risk and hazard estimates are potentially overestimates.

Frequency of Detection and Spatial Distribution

The FI/FC fraction accounted for some of the spatial variation in exposure calculations. Arsenic in groundwater was detected in only two of the four samples, and chloromethane was reported in only one of 21 samples. Exposure would not be expected to be focused at only the locations where these chemicals were reported. As a result, exposure was likely overestimated.

Quantification of Risk/Hazard

As indicated by the discussions above, uncertainty is inherent during the risk assessment process. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of variability and uncertainty are discussed below.

Surface Soil

Arsenic and beryllium's maximum reported concentrations exceeded their corresponding RBCs, but they were eliminated from the formal assessment based on comparisons to the RCs.

Alluvial Groundwater

Barium and chromium's maximum reported concentrations exceeded their corresponding RBCs, but they were eliminated from the formal assessment based on comparisons to the RCs. As a measure of variability, Central Tendency (CT) analysis was performed for groundwater. Exposure assumptions were modified to reflect the 50th percentile rather than the 95th. EPCs were not modified. In accordance with *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure-Draft* (USEPA, 1993a), the exposure durations were reduced from 30 to nine years for site residents, two years for child exposure, and seven years for adult exposure. Exposure frequency was reduced from 350 to 234 days per year for site residents and from 250 to 219 for site workers. The drinking water ingestion rate for an adult was reduced from 2 to 1.4 liters per day, and exposure to groundwater was reduced by 25% to account for other water sources.

Future Site Residents

The ILCR based on RME assumptions for alluvial groundwater was estimated to exceed 1E-4, while using CT assumptions would reduce the risk estimate to within USEPA's acceptable risk range of 1E-6 to 1E-4. Based on RME assumptions, the HI for the child residential receptor was estimated to exceed 1.0. However, the HI estimate based on CT assumptions is below the USEPA threshold of 1.0.

Future Site Workers

No COCs were identified for this scenario, so risk was not estimated assuming CT exposure.

Current Site Workers

No COCs were identified for this scenario, so risk was not estimated assuming CT exposure.

8.6.4.7 Risk Summary

Table 8.6.20 summarizes risk and hazard estimates for SWMU 65. Although risk estimates exceeding USEPA's upper bound acceptable risk range were calculated assuming alluvial groundwater would be used as a drinking water source, arsenic accounted for 100% of the groundwater estimated risk. The maximum concentration reported for arsenic in alluvial groundwater is approximately one order of magnitude less than the corresponding MCL.

Table 8.6.20
Risk Summary
SWMU 65 — NSA Memphis

	Future Site Residents			Current and Future Site Workers	
Media and Exposure Pathway	**Adult HQ**	**Child HQ**	**LWA ILCR**	**Worker HQ**	**Worker ILCR**
Soil — Incidental Ingestion	0.005	0.04	4e-06	0.002	5e-07
Soil — Dermal Exposure	0.008	0.03	4e-06	0.005	2e-06
Sum of Soil	0.001	0.07	8e-06	0.01	2e-06
Alluvial Groundwater — Ingestion	0.5	1	1e-04	0.5	3e-05
Alluvial Groundwater — Inhalation	NA	NA	1e-06	NA	3e-07
Sum of Groundwater	0.5	1	1e-04	0.5	3e-05
Sum of Soil and Alluvial Groundwater	0.5	1	1e-04	0.5	3e-05

Notes:
HQ — Hazard Quotient
ILCR — Incremental Lifetime Cancer Risk
LWA — Lifetime Weighted Average

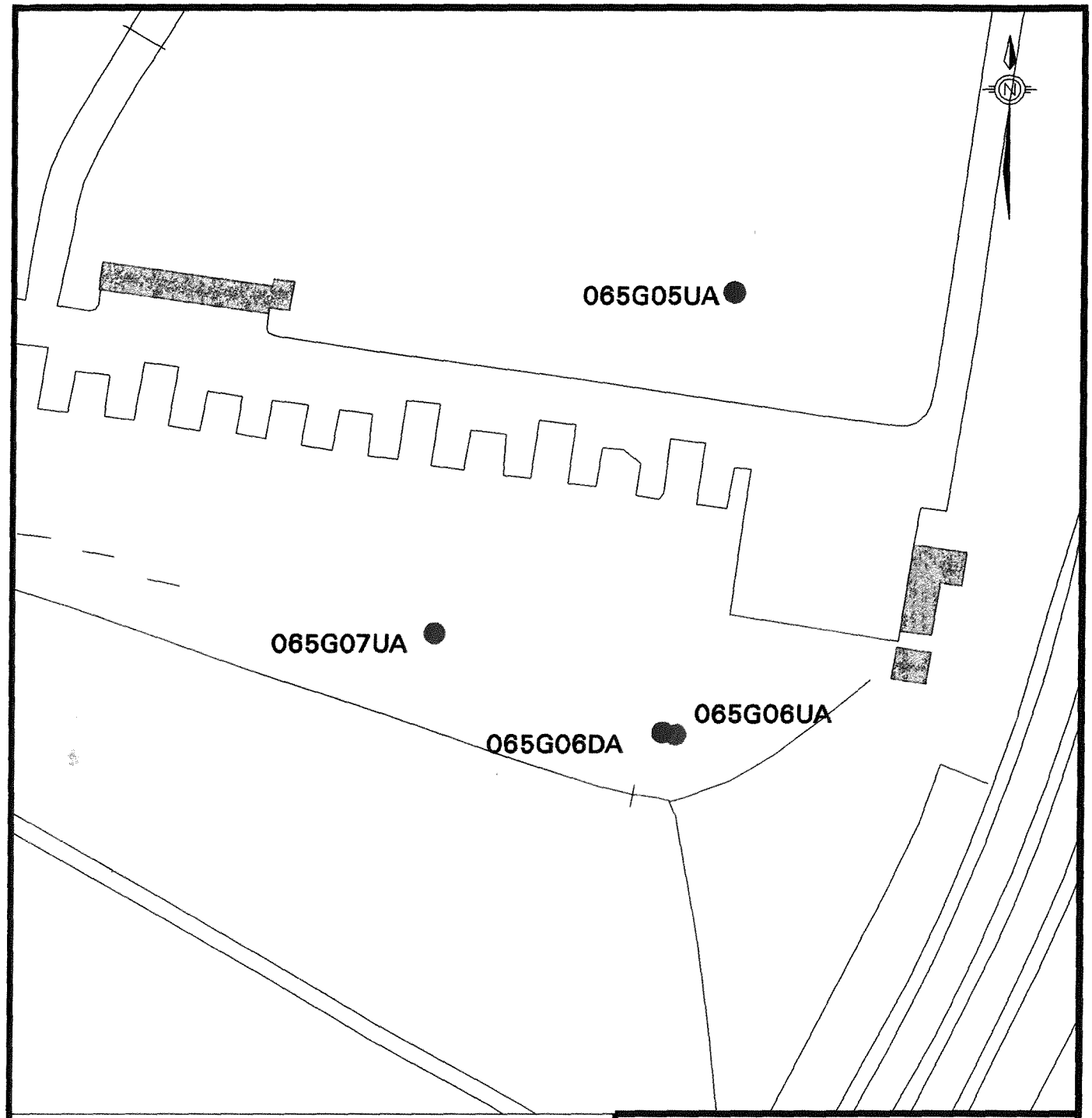
Remedial Goal Options

Although arsenic concentrations reported in alluvial groundwater are less than the corresponding MCL, based on USEPA guidance they are considered to be COCs. Table 8.6.21 lists the RGOs for arsenic in alluvial groundwater, as well as the MCL.

8.6.4.8 Summary Risk Figures

Risk figures were developed for arsenic risk and hazard in alluvial groundwater. As previously discussed, figures were developed only for a residential land use scenario, based on a child receptor for the presented risk and hazard estimates. However, estimates assuming industrial land use are provided in corresponding tables. Chloromethane contributed approximately two orders of magnitude less to cumulative risk than arsenic, so chloromethane was not included in point risk maps below. Chloromethane was reported in one DPT sample and would not change the risk estimates. DPT locations are not shown on the maps.

Table 8.6.22 presents individual risk and hazard estimates for arsenic in alluvial groundwater, sorted by sample location, which are presented graphically in Figures 8.6.14 and 8.6.15, respectively. Arsenic was the only contributor to alluvial groundwater risk and hazard. Arsenic was detected in groundwater samples 065G05UA01 and 065G06DA01. However, an assumed concentration was used for samples in which arsenic was not detected, as described in the Technical Memorandum on HHRA and shown in Table 8.6.22.



LEGEND - RISK VALUES

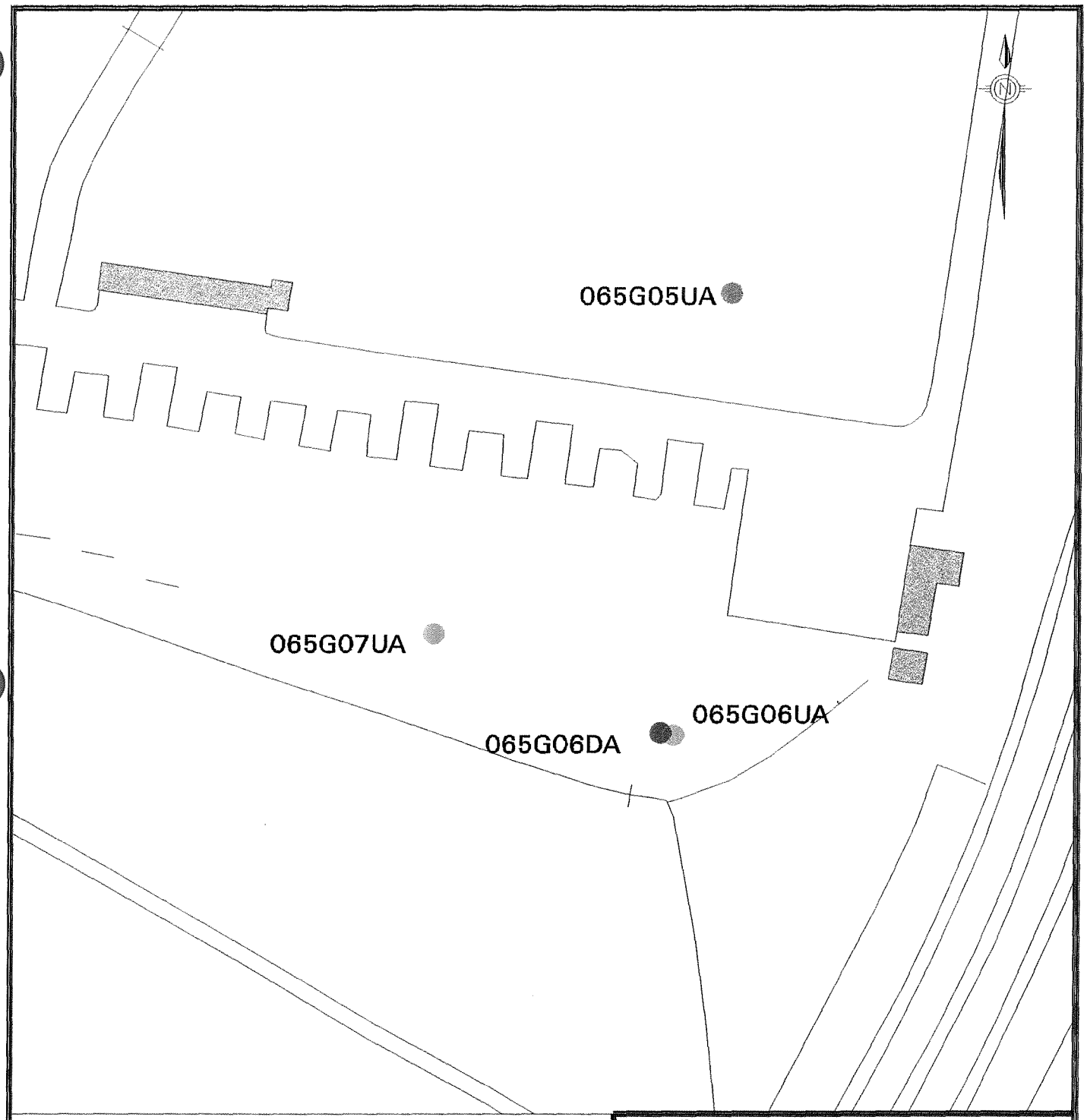
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

0 feet 200

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.14
ARSENIC RISK
IN ALLUVIAL GROUNDWATER
SWMU 65

AML: /home/ace2/memphis_dirjobs_dir/assem_e/risk_ecsecs



LEGEND - HAZARD VALUES

- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

0 feet 200

ASSEMBLY E
FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 8.6.15
ARSENIC HAZARD
IN ALLUVIAL GROUNDWATER
SWMU 65

AML: /home/ce2/memphis_dir/site_dir/assem_e/risk_assess

Table 8.6.21
Remedial Goal Options for COCs
Alluvial Groundwater at SWMU 65 NSA Memphis

	Site Resident							*Site Worker*					
Chemical	**Risk LWA at 10-6 µg/L**	**Risk LWA at 10-5 µg/L**	**Risk LWA at 10-4 µg/L**	**Child Hazard at 0.1 µg/L**	**Child Hazard at 1 µg/L**	**Child Hazard at 3 µg/L**	**MCL µg/L**	**Risk LWA at 10-6 µg/L**	**Risk LWA at 10-5 µg/L**	**Risk LWA at 10-4 µg/L**	**Child Hazard at 0.1 µg/L**	**Child Hazard at 1 µg/L**	**Child Hazard at 3 µg/L**
Arsenic	0.045	0.448	4.482	0.4693	4.69	14.08	50	0.19	1.9	19	1.12	11.2	33.6
Chlormethane	3.5	35	350	NA	NA	NA	NA	14.8	148	1480	NA	NA	NA

Notes:
NA - Not Applicable/Not Available
COC - Chemical of Concern
ILCR - Incremental Lifetime Cancer Risk
LWA - Lifetime Weighted Average
µg/L - micrograms per liter

Table 8.6.22 Risk and Hazard Estimates for COCs per Sampling Location
Alluvial Groundwater
SWMU 65
NSA Memphis

Sample ID	Result µg/L	VQUAL	Chemical	Assumed Concentration µg/L	EPC µg/L	Residential Child HQ	Residential LWA ILCR	Industrial Site Worker HQ	Industrial Site Worker ILCR
065G05UA01	4.5	J	Arsenic	1	4.5	0.96	1.0E-04	0.40	2.4E-05
065G06DA01	5.6	J	Arsenic	1	5.6	1.19	1.2E-04	0.50	2.9E-05
065G06UA01	2	UJ	Arsenic	1	1	0.21	2.2E-05	0.09	5.3E-06
065G07UA01	2	UJ	Arsenic	1	1	0.21	2.2E-05	0.09	5.3E-06

Notes:
VQUAL - Validation qualifier
EPC - Exposure Point Concentration
LWA - Lifetime Weighted Average
HQ - Hazard Quotient
ILCR - Incremental Lifetime Excess Cancer Risk
U - The material was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
µg/L - micrograms per liter

8.6.5 Ecological Risk Assessment

8.6.5.1 Introduction

The focus of the ERA for SWMU 65 is on the terrestrial ecosystem associated with the site, since no other habitat types are present. The ERA considers surface soil contaminant concentrations and distributions and exposure pathways that could result in unacceptable levels of exposure to terrestrial ecological receptors now or in the future. Potential aquatic risks associated with storm water runoff are discussed in the ERA of the SWMU 38 RFI (Industrial Drainage Ditches — Southside), in Section 8.4.5.

8.6.5.2 Problem Formulation

Site Description

The ecological features at SWMU 65 are minimal. The site is a long paved area with several buildings surrounded by a grassy field and several small stands of trees. During the initial site assessment, a series of small, isolated depressions were observed along the southern site boundary which seemed to be retaining water. When the site was active, the paved area staged numerous jet airplanes which were repeatedly started for pilot training. Over time, the thrust from these ground-starts has created shallow oblong pits in the bare ground behind each plane. Lacking top soil, these isolated low areas retained storm water longer than the surrounding area. This condition occasionally makes these wet areas difficult to maintain, allowing grass around the few deeper pits to grow longer. Subsequent site visits have shown that since the removal of the jets, the pits are beginning to refill through wind-blown and water-born soil and these areas are being mowed.

To the south the site is bound by a high grassy berm beyond which is the Big Creek Drainage Canal. Drainage of the site itself is via two drainage ditches. Storm water from the northern portion of the site is carried northward beneath B Street to the southern branch of SWMU 38 by a small ditch and culvert. The remainder of the site is drained by a small drainage swale (not

associated with SMWU 38), which runs east near the base of the berm, beneath a small access road, and into a larger ditch at the southeastern corner of the site. This ditch then runs south, parallel to the tree line of the nearby woods and ultimately into Big Creek Drainage Canal. This offsite water body is included in a separate investigation.

Ecosystem at Risk

Based on visual observation, no quality habitat is available at SWMU 65. The grassy area surrounding the site could potentially be used by terrestrial receptors such as passerine birds and/or small mammals as foraging areas, but their occurrence would most likely be transient or opportunistic. Both the ditches on site and along the edge of the offsite woods remain dry except in direct response to precipitation, therefore do not support aquatic biota. The small wooded area southeast of the site does offer some suitable cover and foraging habitat for a variety of terrestrial species, but since no significant exposure pathway is present (from nearby drainage ditch), neither these woods nor its inhabitants are expected to be impacted by the low level of contaminants associated with SWMU 65. No viable terrestrial community exists within SWMU 65. With limited habitat and lack of terrestrial receptors, the SWMU 65 area does not warrant a preliminary ecological risk assessment.

8.6.6 Fate and Transport Assessment

Potential migration pathways associated with SWMU 65 include constituents leaching from soil to groundwater, and surface soil erosion of sorbed constituents forming sediments. The soil-to-air volatilization process is eliminated from further discussion based on the lack of VOCs detected in surface soil and the fact that no contaminant detected in surface soil exceeded the soil-to-air SSL. Based on local topography and associated surface water drainage patterns, the most likely receptors for constituents originating in the SWMU 65 area are the drainage depressions and Big Creek Drainage Canal. Also, groundwater is a potential receptor for constituents present in subsurface soil.

SWMU 65 contaminants of concern (COCs) include:

- ***Arsenic*** — identified in the HHRA as a COC in alluvial groundwater
- ***Barium*** — exceeded its SSL and RC in subsurface soil
- ***Nickel*** — exceeded its SSL and RC in subsurface soil
- ***Dieldrin*** — exceeded its SSL in subsurface soil

8.6.6.1 Soil-to-Groundwater Cross-Media Transport

Three constituents are highlighted as posing a potential soil-to-groundwater migration concern, as determined by soil concentrations exceeding groundwater protection SSLs. These include two inorganics (barium and nickel) and one pesticide (dieldrin). Of these constituents, only barium was present in SWMU 65 soil and groundwater. Arsenic was the only other constituent detected in soil and groundwater. Arsenic exceeded its RBC and background RC in both upper and deep alluvium groundwater, but not its soil-to-groundwater SSL, its background RC in soil, or its MCL in groundwater. Inorganics and pesticides are considered to be immobile and persistent in the environment, not readily diffusing into groundwater. The solubility of these constituents in groundwater is low, resulting in limited mobility in this environment. Therefore, widespread impacts to the aquifer are not expected.

Chloromethane, methylene chloride, and 2-butanone were detected in groundwater at SWMU 65 but not detected in soil; however, none of these constituents exceeded its respective RBCs. Continued impact to groundwater is not expected from these constituents due to their absence in soil.

Potential receptors relating to groundwater contamination are two production wells (PW-4 and PW-5). PW-4 is approximately 5,600 feet northwest of SWMU 65, while PW-5 is approximately 4,500 feet northwest of SWMU 65. It is highly unlikely that groundwater contamination would

migrate horizontally to the production well locations based on the groundwater flow direction and the travel distance. Dilutional effects would also greatly reduce concentrations should they travel this distance. Both production wells are screened greater than 1,400 feet bls and confining units that separate the screened interval from loess, alluvial, and fluvial deposits groundwater would greatly limit vertical contaminant migration.

Based on the limited impacts to groundwater and the tendency for inorganics and pesticides to sorb to the soil matrix, soil contaminants identified at SWMU 65 are not expected to adversely impact the aquifer.

8.6.6.2 Soil-to-Sediment Cross-Media Transport

The presence of concrete areas within SWMU 65 somewhat mitigates the potential for soil to form sediments from surface water runoff. However, grass-covered areas and drainage swales at SWMU 65 could transport surface soil contaminants.

Acetone was the only VOC detected in surface soil at SWMU 65. The remaining constituents identified in soil include SVOCs, pesticides, and inorganics, which all typically sorb to soil particles and do not readily diffuse into water. Therefore, their only transport process in surface soil would be soil-to-sediment transport as a result of erosion.

The SWMU 65 topography generally slopes to the south and storm water falling on the concrete pads typically flows south to the grassy area and into a drainage swale along the south side of the site. The vegetative cover at SWMU 65 should aid in preventing erosion of surface soil; therefore, any surface soil contamination is not expected to migrate significant distances, if at all.

8.6.7 Conclusions and Recommendations

The following conclusions are presented based on the findings of the RFI:

- A limited site investigation of SWMU 65 was conducted in 1992 in the area of a JP-5 spill. TPH-GRO, TPH-DRO, and BTEX were identified in soil samples from the surface to 6 feet bls. TPH-GRO and TPH-DRO were also detected in the four upper alluvium monitoring wells installed during the 1992 investigation.

- Soil samples collected during this RFI indicated the presence of VOCs, SVOCs, chlorinated pesticides, herbicides, and inorganics. No VOC exceeded any screening value. The only SVOC exceedance was for benzo(a)pyrene in one soil boring's surface-soil sample; the detected concentration exceeded its residential RBC only. One DPT subsurface soil sample exhibited a total TPH concentration exceeding the TDEC soil cleanup level for total TPH. The only pesticide that exceeded screening values was dieldrin in one soil boring surface-soil sample; the detected concentration exceeded its residential RBC, SSL, and RC. No detected inorganic in surface soil exceeded both its RC and residential RBC; however, barium concentrations in one surface and one subsurface soil boring sample, and nickel in one surface and two subsurface soil boring samples, exceeded both their RC and SSL.

- No SVOCs, TPH, chlorinated pesticides/PCBs, organophosphorus pesticides, or herbicides were detected in the monitoring well groundwater samples collected during this RFI. Chloromethane, detected in only one DPT groundwater sample, was the only VOC in groundwater to exceed its tap water RBC. The arsenic concentration in one upper alluvium monitoring well and one deep alluvium monitoring well exceeded both its RC and tap water RBC; however, both detected concentrations were below arsenic's MCL.

- In April/May 1997 the four upper alluvium groundwater wells installed in 1992 and the three upper alluvium and one deep alluvium groundwater wells installed in 1996 were sampled and analyzed for VOCs, TPH, TPH-GRO, and TPH-DRO. The TPH, TPH-GRO, or TPH-DRO concentrations identified in five of the seven upper alluvium monitoring wells exceeded the TDEC groundwater cleanup level of 100 μg/L total TPH for drinking water aquifers.

- Ten sediment samples were collected from five locations during this RFI and analyzed for TPH-GRO and BTEX. Toluene, detected in all 10 samples, did not exceed its residential RBC or SSL. TPH-GRO was present in several sediment samples, but no detected concentration exceeded the TDEC soil cleanup standard.

- The HHRA identified arsenic as a COC for the hypothetical site resident scenario, based on the risk and hazard estimates for ingesting alluvial groundwater as a drinking water source. However, the concentrations reported for arsenic in alluvial groundwater are approximately one order of magnitude less than the corresponding MCL. Arsenic was not an anticipated site constituent and no records are available that indicate its use at SWMU 65, so it may be naturally occurring or a residual from past agricultural practices.

- The ERA determined no quality habitat is available at SWMU 65, which has no viable terrestrial community.

- Based on the limited impact to alluvial groundwater and the tendency for inorganics and pesticides to sorb to the soil matrix, soil contaminants identified at SWMU 65 are not expected to adversely impact the aquifer.

The following recommendations are presented based on the findings of the RFI:

- Assess the need for a Voluntary Corrective Action to remove soil around the JP-5 spill area, after the BCT evaluates the data from the soil sample collected to characterize the former JP-5 fuel spill area.

- Final determination on SWMU 65 groundwater should be deferred until the analytical results from the most recent groundwater sampling event have been evaluated by the BCT.

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9.0 CONCLUSIONS SUMMARY

Table 9.1.1 on the following page summarizes the conclusions and recommendations of the Assembly E RFI.

Table 9.1
Assembly E RFI Conclusions Summary

SWMU	Description	Suspected Contaminants	COCs Identified	ILCR >1E-4?	HI > 1?	Ecological Risk?	Recommendations
2 — Southside Landfill	42-acre landfill operated from 1942 until 1970. The landfill received residential waste, office solid waste, aircraft parts, wastewater treatment plant sludge, incinerator ash, waste oil, oily sludge, and solvents generated from industrial operations, and possibly PCBs.	VOCs, SVOCs, metals, PCBs	Not applicable	Not applicable	Not applicable	Not applicable	Investigation Ongoing
9 — Sewage Lagoons	Two lagoons (400,000 and 141,000 sf) used as part of the wastewater treatment system from 1969 to 1978. Although primarily domestic wastewater was treated, limited amounts of industrial wastewater from aircraft maintenance were treated.	VOCs, SVOCs, and metals	**Groundwater:** Alluvial — arsenic, Chloroform, TCE **Fish ingestion:** 4,4'-DDE, Aroclor-1254, Aroclor-1260, arsenic	Site Resident	Adult Site Resident, Child Site Resident Adult Site Resident, Child Site Resident, Adolescent Trespasser, Child Trespasser	Yes	Continue annual groundwater monitoring for VOCs, TPH-GRO, and TPH-DRO. Continue the ban on fishing at the lagoons. Assess The TCE in SWMU 9 groundwater during the SWMU 2 investigation.
14 — Bldg. S-140 Site and 7th Ave. Ditch	Paint spray booth/paint water wash pits	Paint waste including hydrocarbons, metals, and solvents	**Groundwater:** Loess — PCE, TCE, 1,2-DCE Fluvial Deposits — arsenic, barium, benzene, vanadium	Site Resident	Adult Site Resident, Child Site Resident Child Site Resident	No	A Corrective Measure Study is recommended for the loess groundwater. Continue the annual groundwater monitoring for VOCs and sample for remedial design parameters.
38 — Misc. Southside Drainage Ditches	Drainage Ditches	Sediment contaminants from former industrial discharges including pesticides, metals, and SVOCs	No COCs were identified.	Not applicable	Not applicable	No	No further action is recommended for SWMU 38.

Table 9.1
Assembly E RFI Conclusions Summary

SWMU	Description	Suspected Contaminants	COCs Identified	ILCR >1E-4?	HI > 1?	Ecological Risk?	Recommendations
59 — Building S-335, Pesticide Storage Facility	Pesticide storage	Chlordane, dieldrin, DDT, arsenic	**Surface Soil:** aldrin, alpha-chlordane, arsenic, Aroclor-1260, BEQ, dieldrin, gamma-chlordane, heptachlor, heptachlor epoxide **Groundwater:** Loess — barium, vanadium, heptachlor epoxide, lead	Site Resident	Child Site Resident Child Site Resident	No	A Voluntary Corrective Action is recommended at SWMU 59 to demolish Building S-335 and to remove pesticide contaminated soil. Then reassess the human health risk following the removal actions. Continue annual groundwater monitoring for pesticides.
65 — Building S-362 Training Mock-up Site	Aircraft parking; jet engine testing; aircraft engine startup training; two 30,000-gallon JP-5 USTs used to fuel the test cell	Petroleum-related contamination including VOCs and SVOCs	**Groundwater:** Alluvial — arsenic	Site Resident	Child Site Resident	No	After the BCT evaluates the data from the soil sample collected to characterize the former JP-5 fuel spill area, assess the need for a Voluntary Corrective Action to remove soil. Final determination on SWMU 65 groundwater will be deferred until the analytical results from the most recent groundwater sampling event have been evaluated by the BCT.

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LEGEND

SOLID WASTE MANAGEMENT UNIT (SWMU) BOUNDARY

65-P06 — DPT PIEZOCONE LOCATION AND DESIGNATION

SWMU 2 DPT SAMPLING LOCATION

SWMU 9 DPT SAMPLING LOCATION

SWMU 14 DPT SAMPLING LOCATION

SWMU 59 DPT SAMPLING LOCATION

SWMU 65 DPT SAMPLING LOCATION

PW-5 (Sh:U-59) — PRODUCTION WELL LOCATION AND DESIGNATION

1000 0 1000 2000 Feet

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.1
DPT PIEZOCONE AND SAMPLING LOCATIONS

LEGEND

SOLID WASTE MANAGEMENT UNIT (SWMU) BOUNDARY

TH-8 (Sh:V-80)	STRATIGRAPHIC TEST HOLE OR SOIL BORING
PW-5 (Sh:U-59)	PRODUCTION WELL AND ASSOCIATED STRATIGRAPHIC TEST HOLE
002G13MA	SWMU 2 MONITORING WELL
009G02DA	SWMU 9 MONITORING WELL
014G01LS	SWMU 14 MONITORING WELL
059G03UF	SWMU 59 MONITORING WELL
065G06UA	SWMU 65 MONITORING WELL
0BGG04LF	BACKGROUND MONITORING WELL

MONITORING WELL NAME SUFFIXES

LS	WELL SCREENED IN LOESS
UF	WELL SCREENED IN UPPER PART OF FLUVIAL DEPOSITS
LF	WELL SCREENED IN LOWER PART OF FLUVIAL DEPOSITS
UA	WELL SCREENED IN UPPER PART OF ALLUVIUM
MA	WELL SCREENED IN MIDDLE PART OF ALLUVIUM
DA	WELL SCREENED IN DEEP PART OF ALLUVIUM

1000 0 1000 2000 Feet

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RCRA FACILITY INVESTIGATION
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TENNESSEE

FIGURE 2.2
SOIL BORING AND MONITORING WELL LOCATIONS