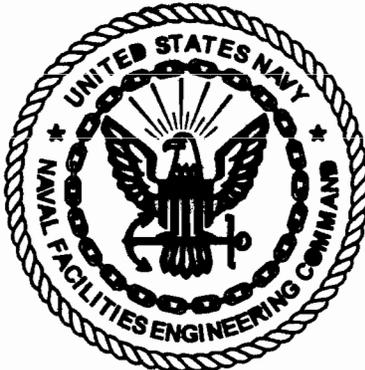


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DRAFT COMBINED SOLID WASTE MANAGEMENT UNIT 9 CORRECTIVE MEASURES  
STUDY REPORT VOLUME 1 OF 2 SECTIONS 1 THROUGH 9 CNC CHARLESTON SC  
12/22/1999  
ENSAFE

**COMPREHENSIVE LONG-TERM  
ENVIRONMENTAL ACTION NAVY  
CHARLESTON NAVAL COMPLEX  
CHARLESTON, SOUTH CAROLINA**



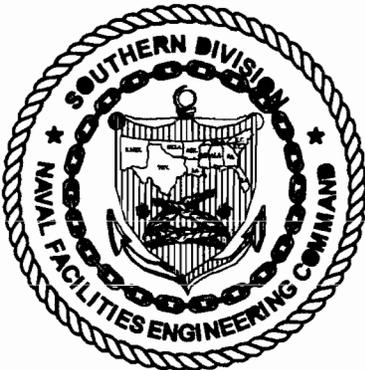
**CTO-029**

**Contract Number: N62467-89-D-0318**

**DRAFT COMBINED SWMU 9  
CORRECTIVE MEASURES STUDY REPORT  
Volume I of II (Sections 1 through 9)**

**Prepared for:**

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



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**December 22, 1999  
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Appendix B	Groundwater Contaminants of Concern Isocons
Appendix C	Monitored Natural Attenuation Interim Report

## ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AOC	Area of Concern
BEQ	Benzo(a)pyrene Equivalent
BEHP	Bis(2-ethylhexyl)phthalate
bgs	Below ground surface
BR	Baseline Risk Assessment
BRAC	Base Realignment and Closure Act of 1988 and Defense Base Closure and Realignment Act of 1990, collectively
BTEX	Benzene, toluene, ethylbenzene, & xylene
BTU	British Thermal Unit
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMS	Corrective Measures Study
CNC	Charleston Naval Complex
CNSY	Charleston Naval Shipyard
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CRP	Community Relations Plan
CSAP	Comprehensive Sampling and Analysis Plan
DET	U.S. Navy Environmental Detachment
E/A&H	EnSafe/Allen & Hoshall
ft <sup>2</sup>	Square feet
GW	Ground Water
hr	Hour
HSWA	Hazardous and Solid Waste Amendments
HTTD	High-Temperature Thermal Desorption
IM	Interim Measures
ISM	Interim Stabilization Measures
LS	Lump Sum
LTTD	Low-Temperature Thermal Desorption
MCL	Maximum Contaminant Level
mg/kg	Milligram per kilogram

## ABBREVIATIONS, ACRONYMS, AND SYMBOLS (continued)

mg/L	Miligram per liter
NA	Not Available/Not Applicable
NAVBASE	Naval Base Charleston
ND	Not Detected
NFI	No Further Investigation
NM	Not Measured
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OSWER	Office of Solid Waste and Emergency Response
pg/L	icogram per liter
PCB	Polychlorinated Biphenyl
PIP	Public Involvement Plan
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
RAB	Restoration Advisory Board
RBC	Risk-Based Concentration
RBSL	Risk-based Screening Level
RCRA	Resource Conservation and Recovery Act of 1976
RDA	Charleston Naval Complex Redevelopment Authority
RFI	RCRA Facility Investigation
RGO	Remedial Goal Option
ROC	Run of Crush
SAA	Satellite Accumulation Area
SCDE	Supercritical Carbon Dioxide Extraction
SCDHEC	South Carolina Department of Health and Environmental Control
SOB	Statement of Basis
SOUTHDIV	Southern Division Naval Facilities Engineering Command
SSL	Soil Screening Levels
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCDD	Tetrachlorodibenzo-p-dioxin
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbons

## ABBREVIATIONS, ACRONYMS, AND SYMBOLS (continued)

$\mu\text{g}/\text{kg}$	microgram per kilogram
$\mu\text{g}/\text{L}$	microgram per liter
UCL	Upper Confidence Limit
USBPTA	United States Border Patrol Training Academy
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
UV	Ultraviolet
VOC	Volatile Organic Compound
WF	Weighting Factor
$\text{yd}^3$	cubic yards

**1.0 INTRODUCTION**

**Purpose and Organization of Report**

The purpose of this Corrective Measures Study (CMS) is to identify, screen, develop, evaluate, and compare remedial action alternatives to mitigate hazards and threats to human health and the environment from soil and groundwater contamination at Combined SWMU 9 at the Charleston Naval Complex (CNC), Charleston, South Carolina.

The CMS is being performed under the Resource Conservation and Recovery Act of 1976 (RCRA), based upon the findings reported in the *Zone H RCRA Facility Investigation Report, NAVBASE Charleston, North Charleston, South Carolina* (EnSafe, 1998), and the *Zone G RCRA Facility Investigation Report, NAVBASE Charleston, North Charleston, South Carolina* (EnSafe, 1999). As required by RCRA, the CNC Restoration Advisory Board (RAB) provides a focus for community input to the remedial decision-making process. The RAB meets regularly at open public meetings. The RAB consists of community members, regulators, Southern Division Naval Facilities Engineering Command (SOUTHDIV) representatives, and other CNC project team representatives.

Upon completion of the CMS, a Statement of Basis (SOB) that documents the CMS process and presents the preferred site alternative will be made available for public comment to ensure that decision makers are aware of public concerns. The selection of the final remedy for the site could be affected by public input. The primary decision makers for CNC are SOUTHDIV, the South Carolina Department of Health and Environmental Control (SCDHEC), and the United States Environmental Protection Agency (USEPA).

This CMS report has been organized according to the format in the Office of Solid Waste and Emergency Response (OSWER) Directive 9902.3-2A, *RCRA Corrective Action Plan* (Final, May 1994):

- **Section 1, Introduction:** This section presents the reports purpose and summarizes the project.
- **Section 2, Site Description:** This section presents Combined SWMU 9's history and background and the results of previous investigations, including the RCRA Facility Investigation (RFI), baseline risk assessment (BRA), interim stabilization measures (ISM) performed by the U.S. Navy Environmental Detachment (DET), and supplemental CMS sampling.
- **Section 3, Remedial Objectives:** To improve the CMS's focus, this section summarizes the chemicals of concern (COCs) to be directly addressed by this CMS and their remedial objectives. In some cases, this section justifies the inclusion or removal of COCs identified in the RFI based on the compound's contribution or lack there of to significant risks, hazards, or other regulatory standards applicable to this site. In other cases, remedial objectives have been modified in response to calculated Zone H and G background risk and hazard.
- **Section 4, Identification and Screening of Technologies:** This section presents response actions and identifies and screens remedial technologies that may be used to achieve remedial action objectives.
- **Section 5, Development and Evaluation of Alternatives:** This section presents potential remedial alternatives and evaluates each in detail with respect to the nine evaluation criteria

identified in OSWER Directive 9902.3-2A, *RCRA Corrective Action Plan* (Final, 1  
May 1994). It presents strengths and weaknesses to prioritize or rank them relative to the 2  
nine evaluation criteria. 3

- **Section 6, Recommendations:** This section assesses the relative performance of the 4  
alternatives and presents recommendations. 5
  
- **Section 7, Public Involvement Plan:** This section summarizes the public involvement 6  
plan as it relates to the CMS. 7
  
- **Section 8, References:** This section lists applicable references used during preparation of 8  
the CMS. 9
  
- **Section 9, Signatory Requirement:** This section provides the applicable CMS signatory 10  
requirement. 11

## 2.0 SITE DESCRIPTION 1

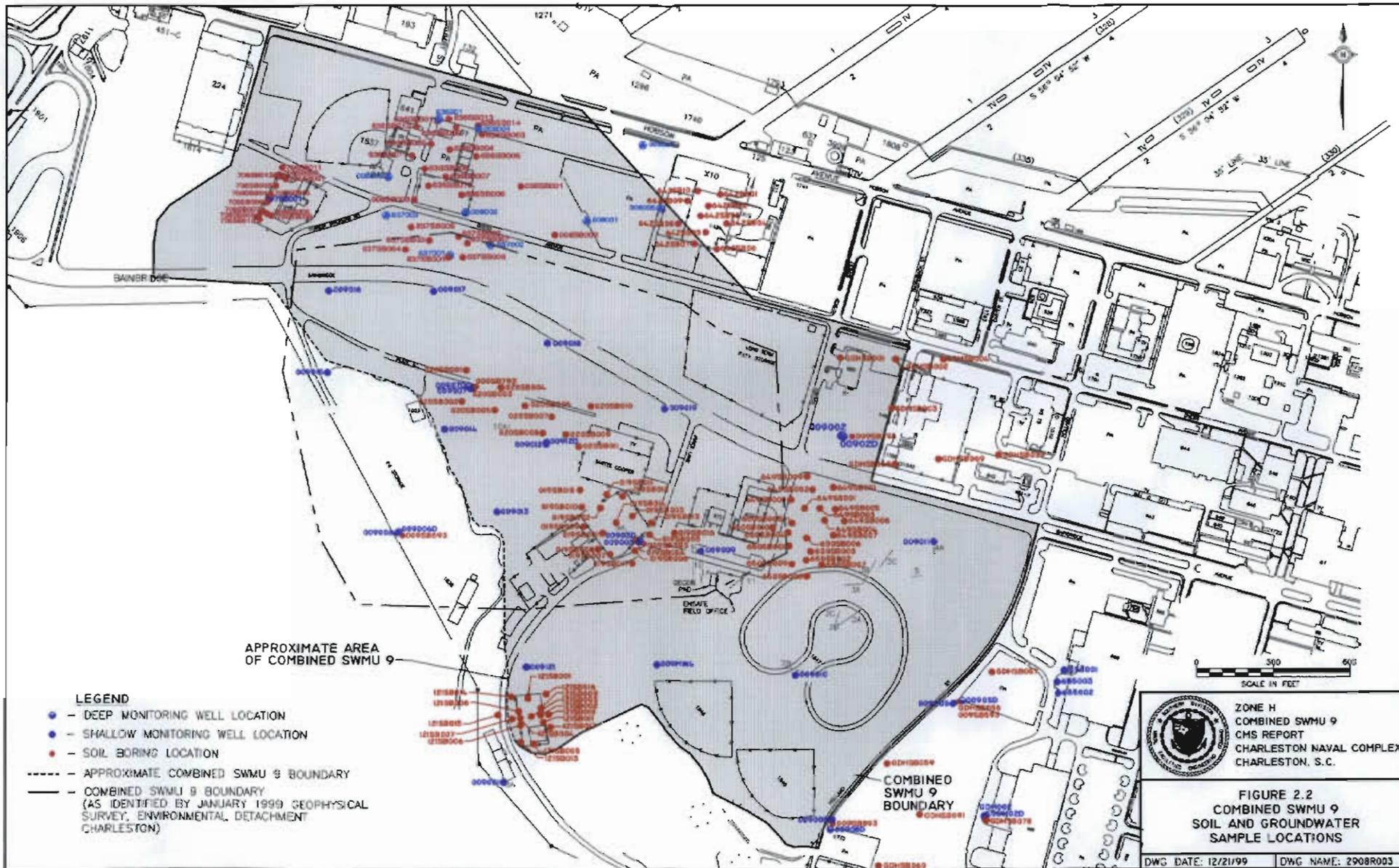
### 2.1 General 2

Combined SWMU 9 (SWMUs 8, 19, 20, and 121; AOCs 636, 637, 642, 649, 650, 651 and 706) 3  
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Combined SWMU 9 (Figure 2.1), an approximately 120-acre closed landfill at the base's southern end, is generally bounded by Shipyard Creek to the southwest, Hobson Avenue to the northeast, and Holland Street to the southeast. The landfill was used for industrial and domestic solid waste disposal from the 1930s until the early 1970s. Though Combined SWMU 9 was a military-use landfill, it can be considered a municipal-type landfill because it contains municipal-type and low-hazard military-specific wastes. In accordance with the United States Environmental Protection Agency (USEPA) guidance regarding presumptive remedies for landfills, this particular landfill is considered a low-level risk because it contains primarily municipal-type wastes (e.g., medical waste, empty oil containers, empty Freon tanks, cargo netting, gas masks, concrete, wood, and domestic refuse). 5  
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Seven additional sites were investigated concurrently with SWMU 9 (thus the term *Combined SWMU 9*) during the RFI because they were within the landfill's estimated perimeter. In January 1999 the Environmental Detachment Charleston (DET) conducted an intrusive geophysical investigation to verify the northern boundary of the landfill (see Section 2.3 for more information on this investigation). This investigation found that landfill extended farther north than previously thought and included four additional sites that were investigated for the Zone G RFI. It was decided that all eleven sites would be included in the CMS for combined SWMU 9. The eleven sites that make up Combined SWMU 9 are SWMU 8, a former oil sludge disposal pit; SWMU 19, a former solid waste transfer station; SWMU 20, a former waste disposal area that appears to have been used for disposal of primarily construction and demolition debris; SWMU 121, a former satellite accumulation area associated with a recycling operation; Area of Concern (AOC) 636, an area where subsurface disposal of unused torpedoes and munitions allegedly occurred; AOC 637, a former burning dump; AOC 642, a former pistol range used during the 1940's; AOCs 649, 650, and 651, areas formerly used to store ship repair supplies; 15  
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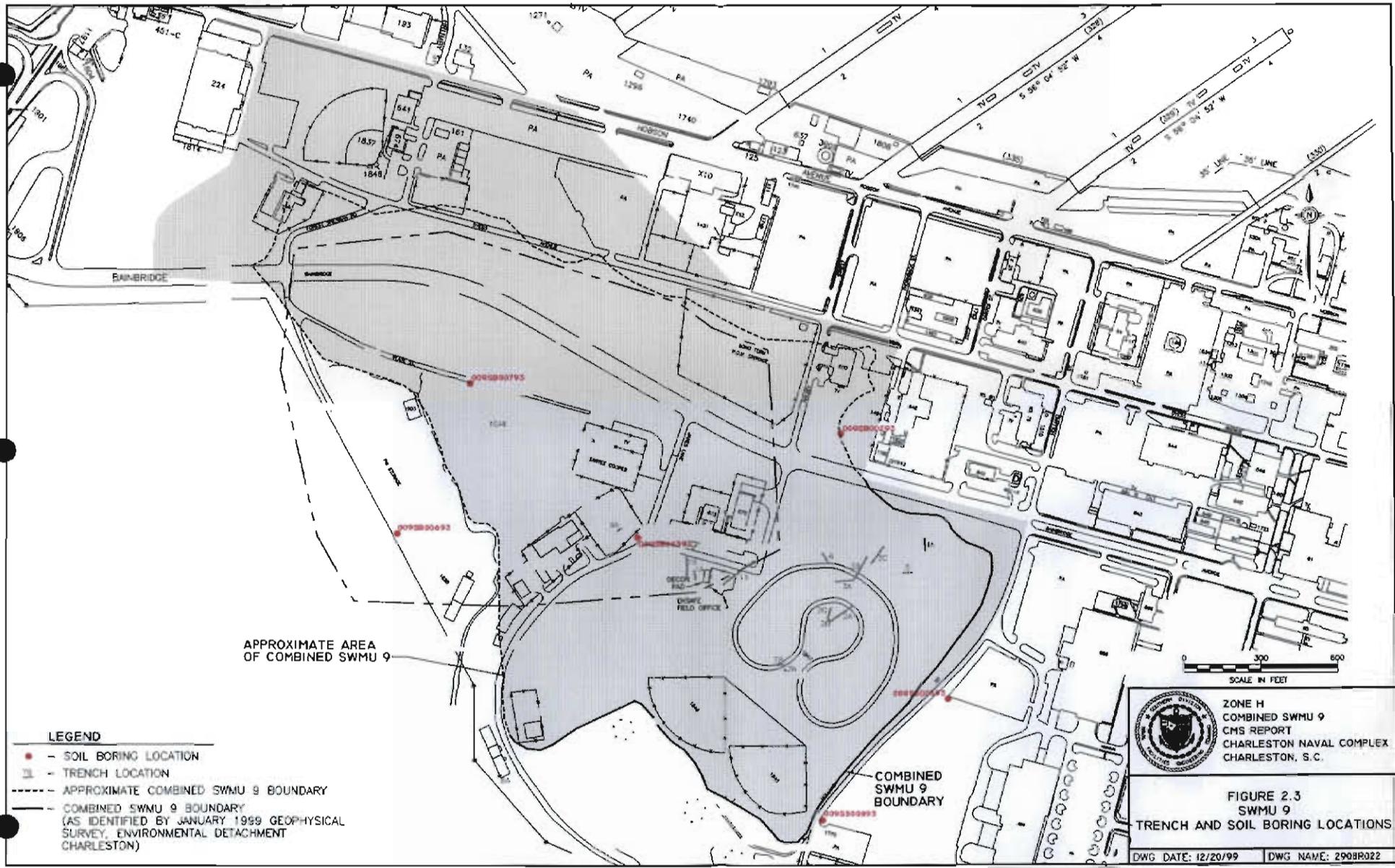
AOC 654, the location of a former septic tank disposal system; and AOC 706, the former hazardous waste storage and transit facility. The CNC project team has eliminated AOC 654 from further CMS considerations.

The United States Border Patrol Training Academy (USBPTA), a current tenant at the former naval base, frequently uses the running track onsite for physical conditioning. The balance of Combined SWMU 9 consists of grassed fields, wetlands, medium-sized brush and wooded areas, a transformer substation, and Buildings 161, 246, 641, 650, 672, 673, and 674.

The Charleston Naval Complex Redevelopment Authority has proposed to use the area within Combined SWMU 9 and north of Bainbridge Avenue for break-bulk storage. Break-bulk consists of miscellaneous non-containerized items that are temporarily stored or stacked on the ground. The surface of the storage site is typically covered with gravel or asphalt, or sometimes concrete. The items are eventually shipped offsite via an adjacent maritime port. The balance of Combined SWMU 9 is scheduled for industrial and deed restricted reuse.

## 2.2 RFI/CMS Sampling Summary

RFI soil samples were collected from Combined SWMU 9 in 1993, 1994, and 1995. Soil data from individual sites are discussed separately because contaminant distribution in soil appears to be definable and geographically unique. The data from the analysis of the remaining media sampled, groundwater in particular, indicate that it is more appropriate to discuss the sites collectively since it would be inherently difficult to identify specific point sources for contaminants that may have commingled. Sediment and surface water data will be presented in this report. Figure 2.2 identifies locations for all RFI sampling points. Appendix A provides the chain of custodies, validation reports, and Anadata reports for sampling done as part of this draft CMS Report. Due to their size, appendices for this draft report are provided in a separate binder entitled *Draft Combined SWMU 9 CMS Report, Volume II of II, Appendices A-C*. Similar information pertaining to RFI activities can be found in the *Zone H RFI Report* or *Zone G RFI Report*.



**2.2.1 Soil**

**SWMU 9 Soil Sampling and Analysis**

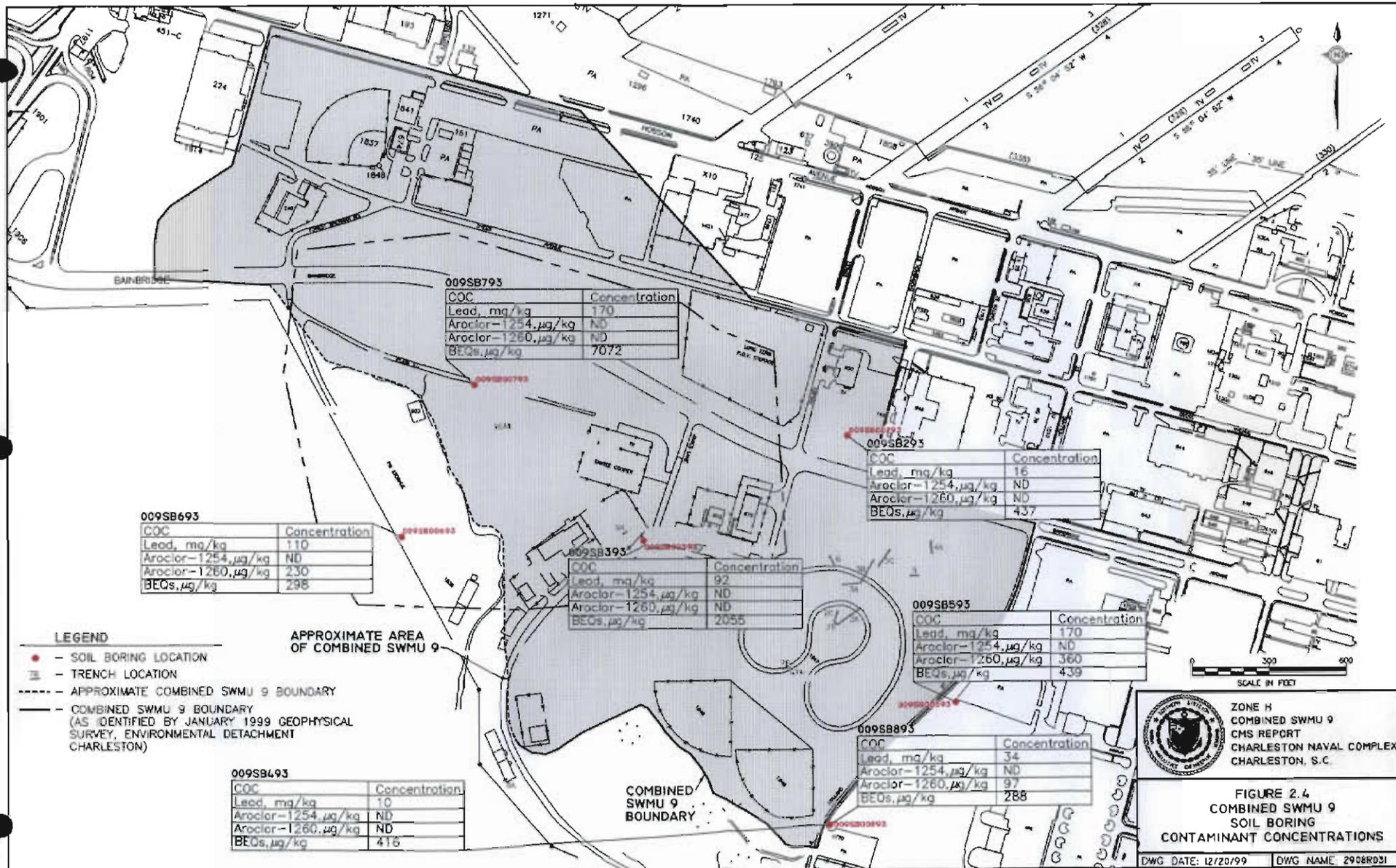
During the RFI, eleven trenches were constructed and sampled in the SWMU 9 area. This does not include the test pits excavated by the DET in 1999 — which were not sampled — to identify the boundaries of the landfill (discussed in Section 2.3). One subsurface soil sample was collected from each trench to characterize the types and concentrations of compounds or elements in SWMU 9 soil. Samples were typically collected from 2 to 5 feet below ground surface (bgs), depending on the type of waste and the presence of material that could be sampled. These samples are considered to be subsurface soil samples. Seven surface and three subsurface soil samples were also collected at the location of seven monitoring wells subsequently installed in the SWMU 9 area. Trench and soil sample locations are shown on Figure 2.3.

There was no analytical soil sampling conducted during the CMS. However, an attempt to characterize existing landfill cap thickness was made and it is briefly described later in this section and is entitled Combined SWMU 9 Surface Cover Thickness Determination.

The parameters which exceeded their Risk-based Screening Level (RBSLs) — and are thus Chemicals of Potential Concern (COPCs) — are lead, Aroclor-1254, Aroclor-1260, and benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene, collectively termed benzo(a)pyrene equivalents (BEQs). Table 2.1 summarizes the soil analytical data obtained from trench samples and seven monitoring well locations in SWMU 9. Figure 2.4 shows the contaminant concentration at each trench and monitoring well location.

**Combined SWMU 9 Surface Cover Thickness Determination**

As part of the CMS, hand-auger locations were also advanced to determine the thickness of soil overlying the landfill area. Figure 2.5 is a contour map showing the soil thicknesses across the landfill area to determine the thickness of existing cap material for its suitability as a continuing cap.



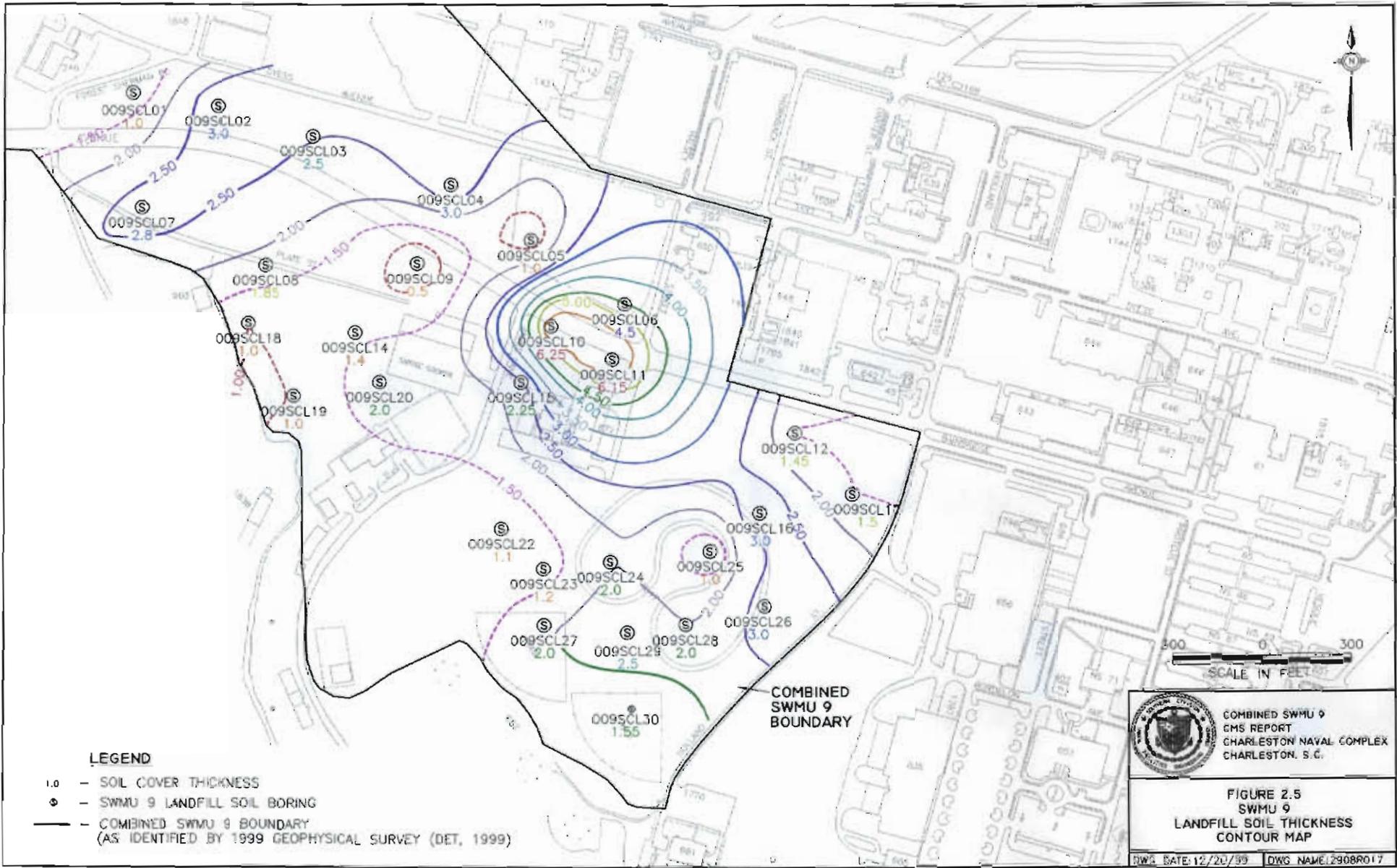


Table 2.1  
 Zone H Soil Data for COCs at SWMU 9  
 Trench and Well Locations

Sample Number	Pb (mg/kg)	Aroclor-1254 (µg/kg)	Aroclor-1260 (µg/kg)	B(a)A (µg/kg)	B(b)F (µg/kg)	B(a)P (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs <sup>4</sup> (µg/kg)
<b>Risk Based Concentration <sup>1</sup></b>	<b>400</b>	<b>320</b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>1,300</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>
<b>Background (mg/kg)<sup>3</sup></b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
009STO1C93	51.7 J	220	39 U	3,900 U	540 DJ	440 DJ	3,900 U	3,900 U	540.4
009STO2A93	147 UJ	740	180 U	360 U	360 U	30 J	360 U	360 U	80.5
009STO3A93	417 J	220 U	1,300	360 U	430 U	430 U	430 U	430 U	91.5 U
009STO3C93	38.4 J	37 U	37 U	370 U	35 J	370 U	370 U	370 U	90.5
009STO4A93	24.5 J	380	47 U	470 U	470 U	470 U	470 U	470 U	91.5 U
009STO5A93	18.6 J	2,500	190 U	380 U	74 J	53 J	380 U	380 U	106.4
009STO6A93	206 J	140	41 U	410 U	67 J	39 J	410 U	410 U	91.7
009STO7B93	2.6 J	38 U	38 U	770 U	770 U	770 U	770 U	770 U	91.5 U
009STO8A93	349 J	46 U	46	46 J	52 J	460 U	460 U	460 U	93.0
009STO9A93	106 J	37 U	920	130 J	160 J	83 J	370 U	370 U	154.3
009ST10A93	131 J	78 U	580	460 J	820 J	430 J	1,900 U	1,900 U	602.8
009ST10D93	127 J	190 U	620	330 J	440 J	240 U	1,900 U	1,900 U	160.6
009SB02193	16 J	39 UJ	39 UJ	390 U	56 J	390 U	390 U	390 U	92.6
009SB02293	23 J	44 U	44 U	440 U	440 U	440 U	440 U	440 U	91.5 U
009SB03193	92 J	38 UJ	38 UJ	1,500 J	2,100 J	1,400 J	380 U	890 J	1,894.8

Table 2.1  
 Zone H Soil Data for COCs at SWMU 9  
 Trench and Well Locations

Sample Number	Pb (mg/kg)	Aroclor-1254 (µg/kg)	Aroclor-1260 (µg/kg)	B(a)A (µg/kg)	B(b)F (µg/kg)	B(a)P (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs <sup>a</sup> (µg/kg)
Risk Based Concentration <sup>1</sup>	400	320	320	870	870	87	87	870	87
Industrial Risk-Based RGO (1E-06) <sup>2</sup>	1,300	ND	ND	ND	ND	ND	ND	ND	ND
Background (mg/kg) <sup>3</sup>	ND	ND	ND	ND	ND	ND	ND	ND	423
009SB04193	10 J	37 U	37 U	370 U	66 J	370 U	370 U	370 U	93.6
009SB05193	170 J	38 U	<b>360</b>	380 U	380 U	380 U	380 U	380 U	88.5
009SB05293	7.1 J	48 U	48 U	480 U	480 U	480 U	480 U	480 U	91.5 U
009SB06193	110 J	38 U	230 J	380 U	100 J	58 J	380 U	380 U	114.1
009SB07193	170 J	74 UJ	74 UJ	<b>5,500</b>	<b>8,300</b>	<b>5,100</b>	<b>470 J</b>	1,800 U	<b>6,986.5</b>
009SB08193	34 J	41 U	97 J	410 U	59 J	34 J	410 U	410 U	85.9
009SB08D93	39.7	40 U	78 U	400 U	400 U	400 U	400 U	400 U	91.5

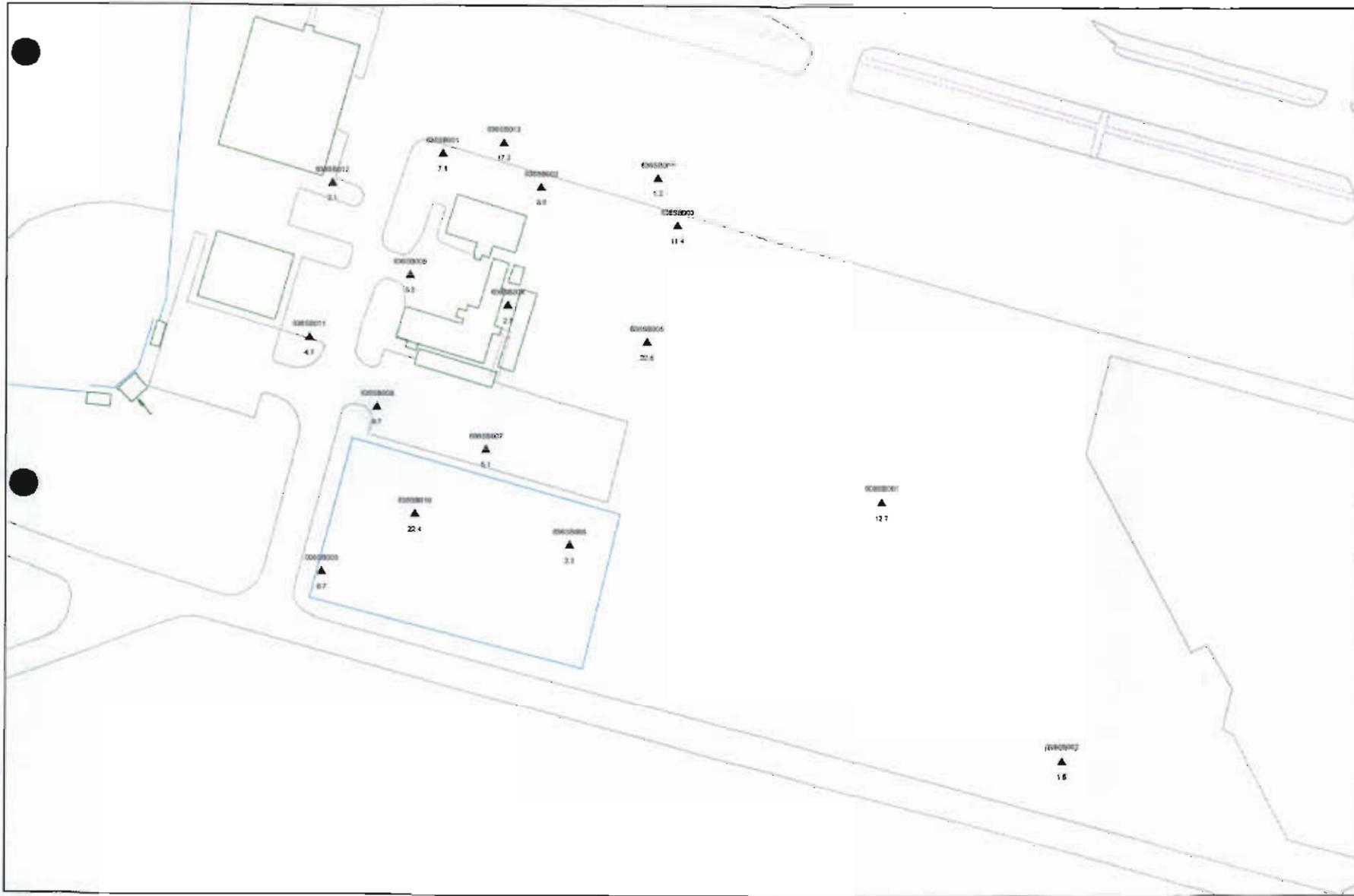
- Notes:**
- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
  - 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI – Risk Assessment for Industrial Reuse Scenario.
  - 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
  - J — The associated numerical value is an estimated quantity.
  - DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
  - U — The material was analyzed but not detected at the listed numerical quantization limit.
  - UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
  - ND — The value was not determined
  - (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO, or background whichever is higher.

Thirty hand-auger borings were advanced in the SWMU 9 area so that the existing soil cap thickness could be evaluated. Borings were advanced until either evidence of buried debris or groundwater were encountered. Soil cap thicknesses ranged from 0.5 feet to 6.25 feet with an average thickness of 2.25 feet. In many borings along the south and western where the soil cap thickness is less than 2 feet thick, refusal was marked by landfill debris or a black tarp-like material. In the areas of greatest cap thickness, refusal was marked by encountering the water table.

### **SWMU 8 and AOC 636 Soil Sampling and Analysis**

SWMU 8 and AOC 636 were investigated concurrently due to their close proximity and their potential for similar COPCs. SWMU 8 is an area that contained three unlined pits that were used to dispose of oil sludge from 1944 to 1977. AOC 636 is the former torpedo magazine where subsurface disposal of unused torpedoes and munitions allegedly occurred prior to 1944. In 1993, 31 pre-RFI soil borings were advanced. During the RFI investigation, 12 first round soil borings were advanced in September, 1996, and five second round borings were advanced in January 1997. Of the 48 soil borings advanced, 48 surface and 21 subsurface soil samples were taken. All 48 surface soil samples were used for the human health risk assessment. Aroclor-1260, BEQs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene], antimony, arsenic, chromium, lead, thallium, aldrin, dieldrin, and hydrazine were identified as COPCs in surface soil. Only BEQs and arsenic were identified as surface soil COCs for the future site worker per the Zone G RFI. Much of the SWMU 8/AOC 636 area was excavated during the SWMU 8 Interim Measure (IM) conducted by the former DET, as discussed in Section 2.3. Table 2.2 summarizes the analytical data obtained from the soil boring locations for each of the COCs. Figure 2.6 and Figure 2.7 show the contaminant concentration at each location for arsenic and BEQs, respectively.



0 75 Feet

- ▲ ARSENIC
- BOUNDARY
- ▭ BLDG
- FENCE
- ROAD
- SIDE-WALKS
- WATER
- PIER



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Figure 2.6  
 SWMU 8 & AOC 636 - Arsenic in Upper  
 Interval Surface Soil (mg/kg)



0 75 Feet

- ▲ BEQs
- BOUNDARY
- ▭ BLDG
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS
- ▭ WATER
- ▭ PIER



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Figure 2.7  
 SWMU 8 & AOC 636 - BEQs in Upper  
 Interval Surface Soil (µg/kg)

Table 2.2  
 Zone G Soil Data for COCs at SWMU 8 and AOC 636

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	B(k)F (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>8,700</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>300</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
S08SB01193	10	3,800 U	450 J	3,800 U	3,800 U	3,800 U	3,800 U	481.3
S08SB02193	20	400 U	400 U	27 J	400 U	400 U	400 U	57.0
S08SB02293	8	430 U	430 U	57.3 U				
S08SB03193	2.95	380 U	380 U	54.5 J	380 U	380 U	380 U	59.9
S08SB03293	21	590	790	1,300	370 J	150 J	540	1,187.4
S08SB04193	5.6 J	390 U	46 J	44 J	390 U	390 U	390 U	79.0
S08SB05193	1.6 J	460 U	36 J	86 J	460 U	460 U	460 U	73.3
S08SB06193	5 J	360 U	360 U	57.3 U				
S08SB07193	1.9 J	410 U	410 U	57.3 U				
S08SB08193	6.9 J	430 U	430 U	57.3 U				
S08SB09193	5.9 J	140 J	100 J	190 J	420 U	420 U	420 U	159.3
S08SB10193	3.1 J	400 U	400 U	57.3 U				
S08SB11193	9.3	430,200	31,600	41,750	20,750	4,555	18,400	85,442.5
S08SB11293	9.6 J	180 J	140 J	210 J	100 J	500 U	500 U	205.9
S08SB12193	2.2 J	660	480	2,700	760	400 U	400 U	852.1
S08SB12293	2.2 J	19,000 U	3,800 J	19,000 U	5,100 J	19,000 U	19,000 U	3,891.4
S08SB13193	8.6 J	440 U	440 U	57.3 U				

Table 2.2  
 Zone G Soil Data for COCs at SWMU 8 and AOC 636

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	B(k)F (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>8,700</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>300</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
S08SB14193	6.2 J	390 U	110 J	390 U	70 J	390 U	99 J	149.8
S08SB15193	2.2 J	200 J	120 J	400 J	180 J	420 U	420 U	208.3
S08SB16193	3.5 J	420 U	65 J	130 J	420 U	420 U	420 U	107.0
S08SB17193	7.05	1,950	1,560	2,000	775	260 J	850	2,309.9
S08SB18193	3.8 J	7,700	6,700	9,200	2,800	830 J	2,600	9,515.6
S08SB19193	5.9	340 U	59 J	98 J	340 U	340 U	340 U	97.5
S08SB19293	5.7	400 U	400 U	84 J	400 U	400 U	400 U	62.7
S08SB20193	8.4	350 U	350 U	57.3 U				
S08SB20293	12	410 U	410 U	57.3 U				
S08SB21193	3.6	360 U	360 U	57.3 U				
S08SB21293	5.9 U	200 J	490	390 U	390 U	390 U	390 U	538.8
S08SB22193	2.6	380 U	380 U	57.3 U				
S08SB22293	6.6	380 U	850	760	380 U	380 U	380 U	954.6
S08SB23193	1.1 U	380 U	380 U	380 U	380 U	380 U	380 U	57.3 U
S08SB23293	12	490 U	35 J	67 J	490 U	490 U	490 U	70.4
S08SB24193	150	370 U	370 U	57.3 U				
S08SB24293	7.9	460	360 U	630	360 U	360 U	250 J	184.3

Table 2.2  
 Zone G Soil Data for COCs at SWMU 8 and AOC 636

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	B(k)F (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>8,700</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>300</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
S08SB25193	7.9	370 U	370 U	57.1				
S08SB25293	1.1 UJ	370 U	370 U	57.3 U				
S08SB26193	7.6 J	420 U	420 U	57.3 U				
S08SB26293	2.8 J	410 U	160 J	120 J	410 U	410 U	410 U	200.9
S08SB27193	4 J	370 U	370 U	370 U	120 J	370 U	370 U	58.1
S08SB27293	3 J	440 U	440 U	57.3 U				
S08SB28193	3.8 J	360 U	360 U	57.3 U				
S08SB28293	6.5 J	2,400	1,600	2,400	730 J	780 U	760 J	2,189.3
S08SB29193	2.1 J	370 U	370 U	57.3 U				
S08SB30193	3 J	360 U	360 U	57.3 U				
S08SB30293	1.45	420 U	57.5 J	420 U	420 U	420 U	420 U	88.9
008SB31193	8.85	16,000	14,000	18,000	7,400	2,400 J	6,950	20,588
008SB31293	7.6 J	380 U	380 U	57.3 U				
008SB00101	12.7	400 U	400 U	57.3 U				
008SB00201	1.5	400 U	400 U	57.3 U				
008SB00301	6.7	940	730	800	830	380 U	290 J	966.1
636SB00101	7.1 J	130 J	200 J	270 J	160 J	42 J	130 J	296.8

Table 2.2  
 Zone G Soil Data for COCs at SWMU 8 and AOC 636

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	B(k)F (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>8,700</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>300</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
636SB00201	7.05	182.5 J	187 J	215 J	180 J	80 J	190 J	299.6
636SB00202	5.1 J	420 U	420 U	57.3 U				
636SB00301	11.4 J	270 J	360 J	490	270 J	53 J	170 J	509.1
636SB00302	13.5 J	62 J	78 J	86 J	70 J	450 U	450 U	57.3 U
636SB00401	2.7 J	400 U	400 U	57.3 U				
636SB00402	9.2 J	67 J	72 J	130 J	110 J	460 U	58 J	122.4
636SB00501	22.8 J	39 J	380 U	42 J	380 U	380 U	380 U	59.9
636SB00502	12.3 J	56 J	69 J	120 J	71 J	430 U	45 J	115.6
636SB00601	2.3	47 J	56 J	54 J	48 J	380 UJ	52 J	95.5
636SB00701	5.1	83 J	98 J	120 J	100 J	410 UJ	82 J	151.3
636SB00801	6.7	240 J	190 J	420 J	300 J	380 UJ	140 J	297.5
636SB00901	5.5	370 U	38 J	46 J	40 J	370 U	38 J	73.1
636SB00902	18.4	800 U	800 U	57.3 U				
636SB01001	22.4	370 U	370 U	57.0				
636SB01101	4.7	170 J	140 J	140 J	100 J	400 U	85 J	204.4
636SB01201	2.1	380 U	380 U	57.3 U				
636SB01301	17.2	390 U	390 U	57.3 U				

Table 2.2  
 Zone G Soil Data for COCs at SWMU 8 and AOC 636

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	B(k)F (µg/kg)	D(a,h)A (µg/kg)	I(1,2,3-cd)P (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>8,700</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>300</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
636SB01302	13.2	480 U	480 U	57.3 U				
636SB01401	1.2 J	390 U	390 U	57.3 U				
636SB01402	8.4	49 J	50 J	420 U	56 J	420 U	420 U	84.0

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI – Risk Assessment for Industrial Reuse Scenario.
- 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- J — The associated numerical value is an estimated quantity.
- U — The material was analyzed but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
- ND — The value was not determined.
- (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

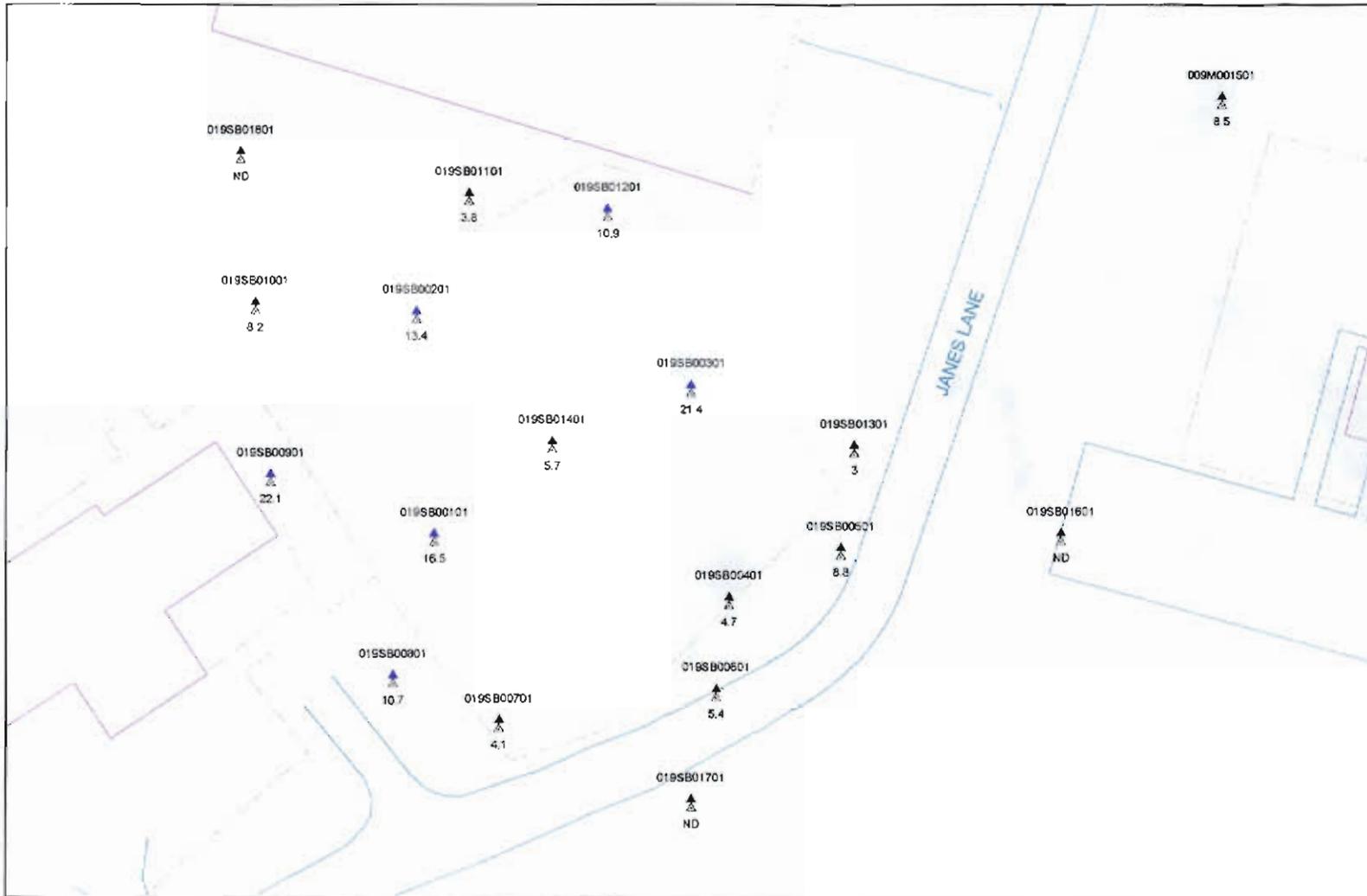
Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

**SWMU 19 Soil Sampling and Analysis**

SWMU 19 is the solid waste transfer station that temporarily stored solid waste before transport offsite. Wastes stored on the bare ground were dry trash, tires, and empty 55-gallon drums. Eighteen surface soil samples and two subsurface soil samples were collected in two rounds at SWMU 19. The parameters that exceeded their RBSLs included BEQs [benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene], Aroclor-1254, Aroclor-1260, antimony, arsenic, beryllium, copper, lead, nickel, and zinc. Of these, only arsenic, lead, Aroclor-1260, and BEQs were identified as COCs based on their contribution to risk/hazard, per the Zone H RFI Risk Assessment. Table 2.3 summarizes the analytical data obtained from the soil boring locations for each of the COCs. Figures 2.8 through 2.11 show the contaminant concentration at each sample location for arsenic, lead, Aroclor-1260, and BEQs, respectively.

**SWMU 20 Soil Sampling and Analysis**

SWMU 20 is an area previously used for waste disposal/storage. Beginning in 1985, various waste materials — batteries, concrete, wood, and sand blasting residue — were stored on the ground at SWMU 20 without any containment. Eleven surface soil samples and one subsurface soil sample were collected from 11 locations at SWMU 20. The parameters that exceeded their RBSLs were BEQs [benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene], arsenic, and manganese. Of these, only BEQs were identified as a COCs based on their contribution to risk, per the Zone H RFI Risk Assessment. Table 2.4 summarizes the analytical data obtained from the soil boring locations for each of the COCs. Figure 2.12 shows the BEQ contaminant concentration at each sample location.



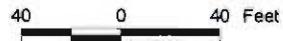
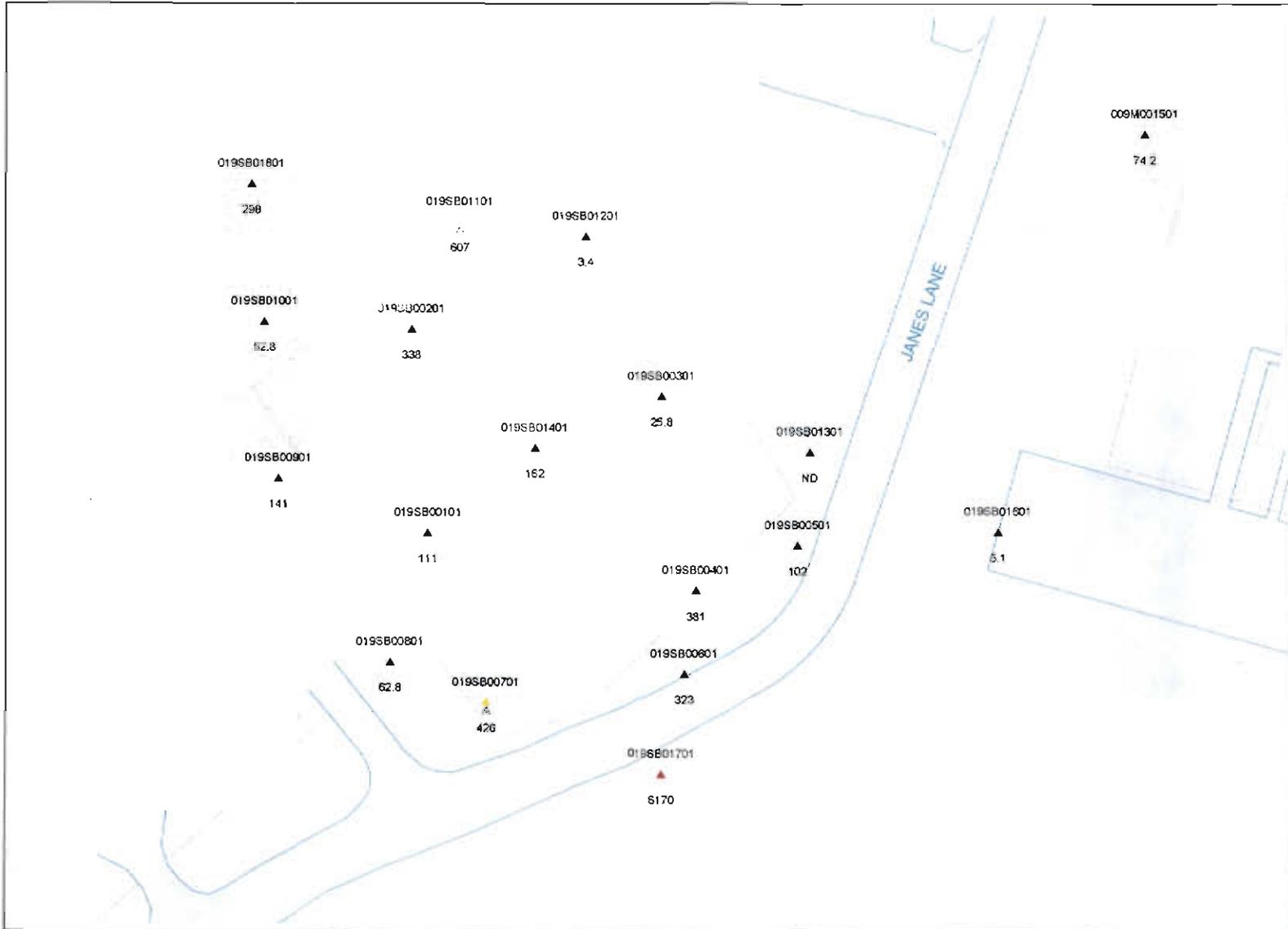
**LEGEND**

- ARSENIC (mg/kg)**
- ▲ 0 - 9.4 (Below Background)
  - ▲ 9.41 - 27 (< 1E-05 Industrial Risk)
  - ▲ 27.01 - 38 (< 1E-04 Residential Risk)
  - ▲ 38.01 - 270 (< 1E-04 Industrial Risk, > 1E-04 Residential Risk)
  - ▲ 270.01 - 100000
- BUILDING  
 BOUNDARY  
 FENCE  
 ROAD  
 SIDE-WALKS



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Figure 2.8  
 SWMU 19  
 Arsenic in Upper Interval Surface Soil



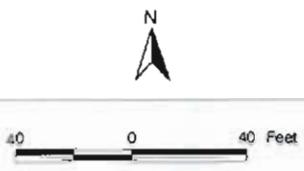
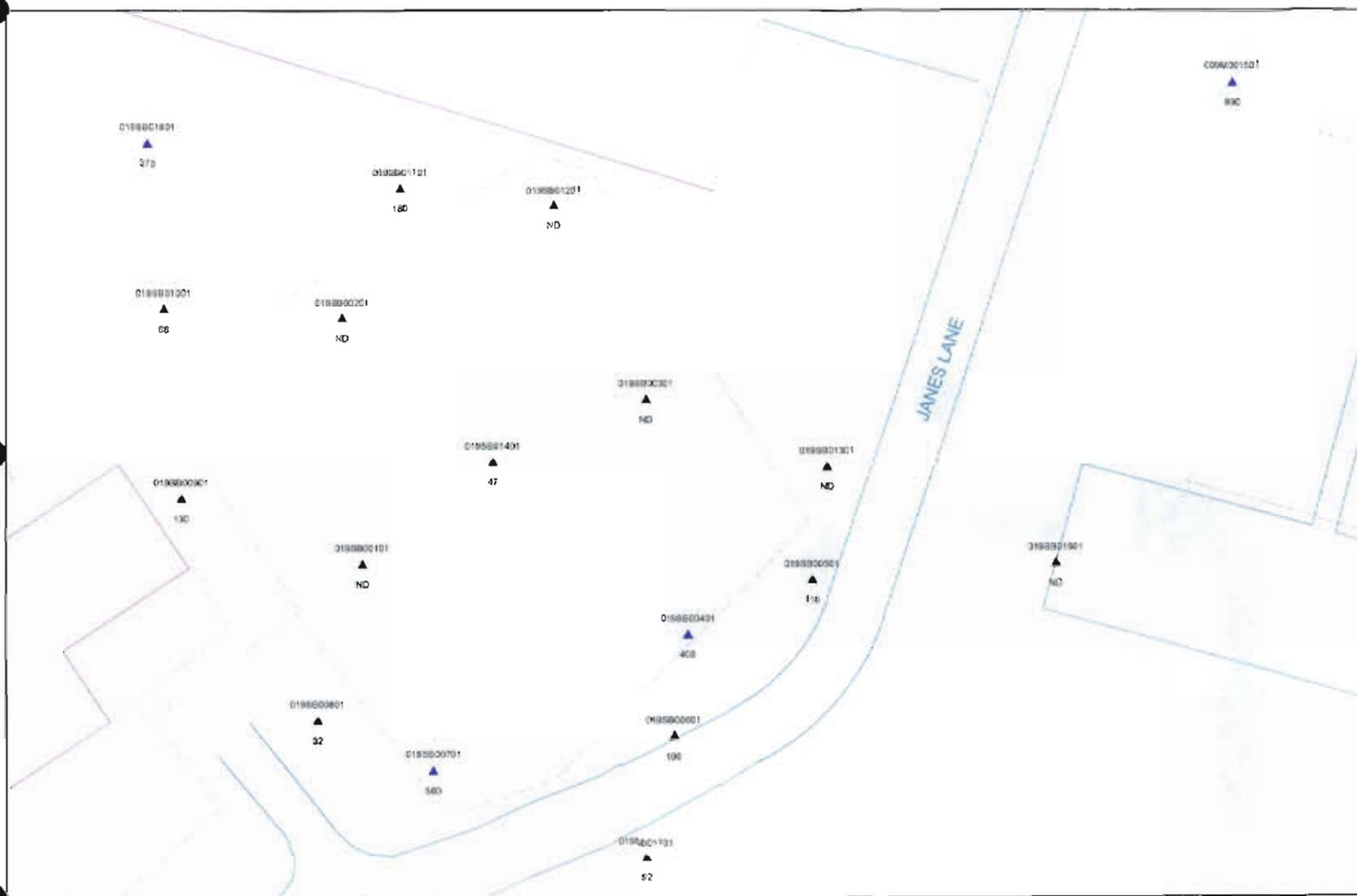
**LEGEND**

- LEAD (mg/kg)**
- ▲ 0 - 399.999 (Below USEPA Residential Clean Up Standard)
  - ▲ 400 - 1299.999 (Above USEPA Residential Clean Up Standard)
  - ▲ 1300 - 100000 (Above USEPA Industrial Clean Up Standard)
- BUILDING**  
**BOUNDARY**  
**FENCE**  
**ROAD**  
**SIDE-WALKS**



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**Figure 2.9  
 SWMU 19  
 Lead in Upper Interval Surface Soil**



**LEGEND**

- AROCLOR 1260 (µg/kg)**
- ▲ 0 - 229 (< 1E-06 Residential Risk)
  - ▲ 229.01 - 1100 (< 1E-05 Industrial Risk)
  - ▲ 1100.01 - 2206 (< 1E-05 Residential Risk)
  - ▲ 2206.01 - 11046 (< 1E-05 Industrial Risk)
- BUILDING BOUNDARY**  
**FENCE**  
**ROAD**  
**SIDE WALKS**



**COMBINED SWMU 9  
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Figure 2.10  
 SWMU 19  
 Aroclor 1260 in Upper Interval Surface Soil

Figure 2.11  
SWMU 19  
BEGs in Upper Interval Surface Soil

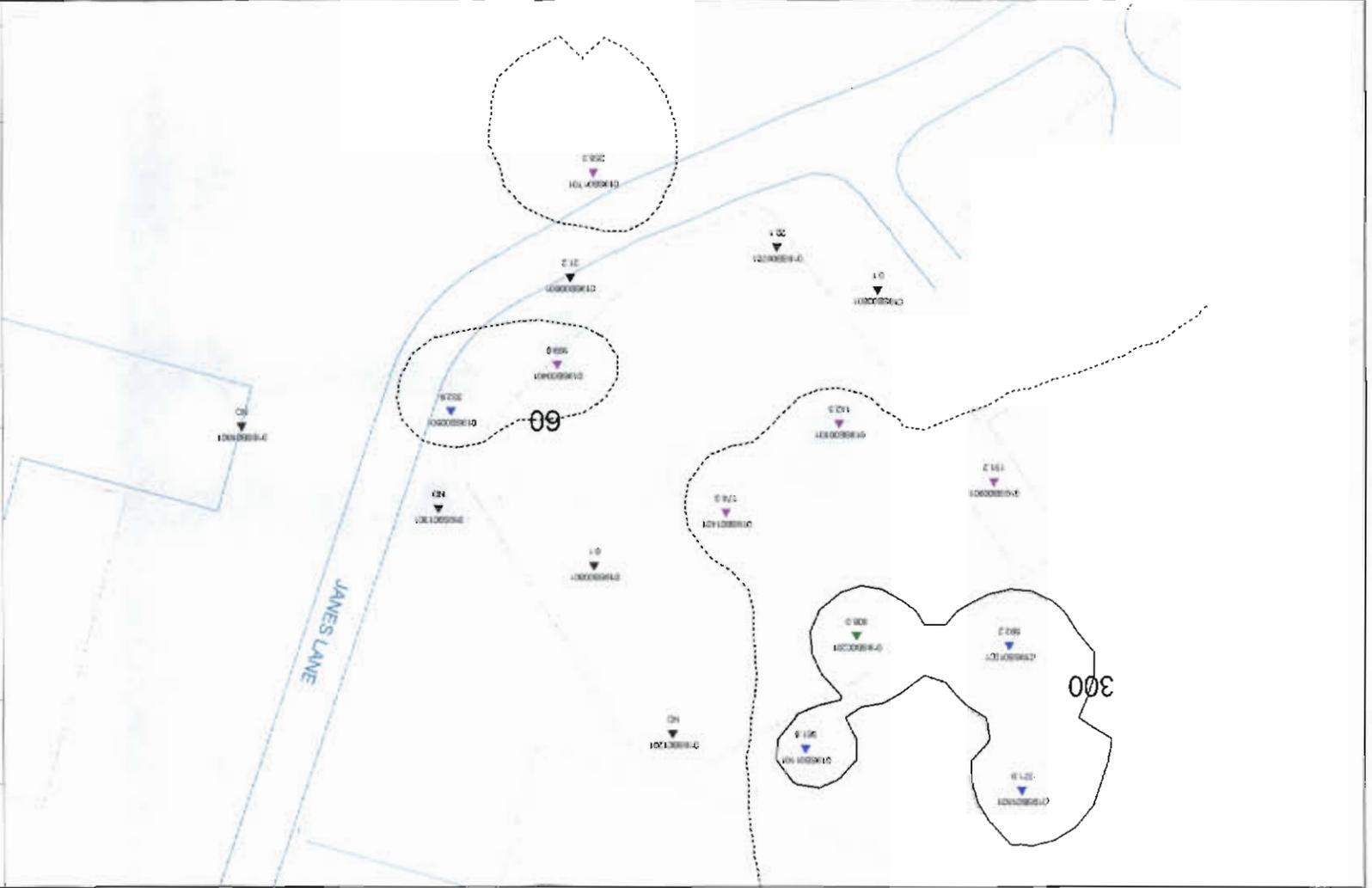
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CHARLESTON NAVAL COMPLEX  
Chleston, SC

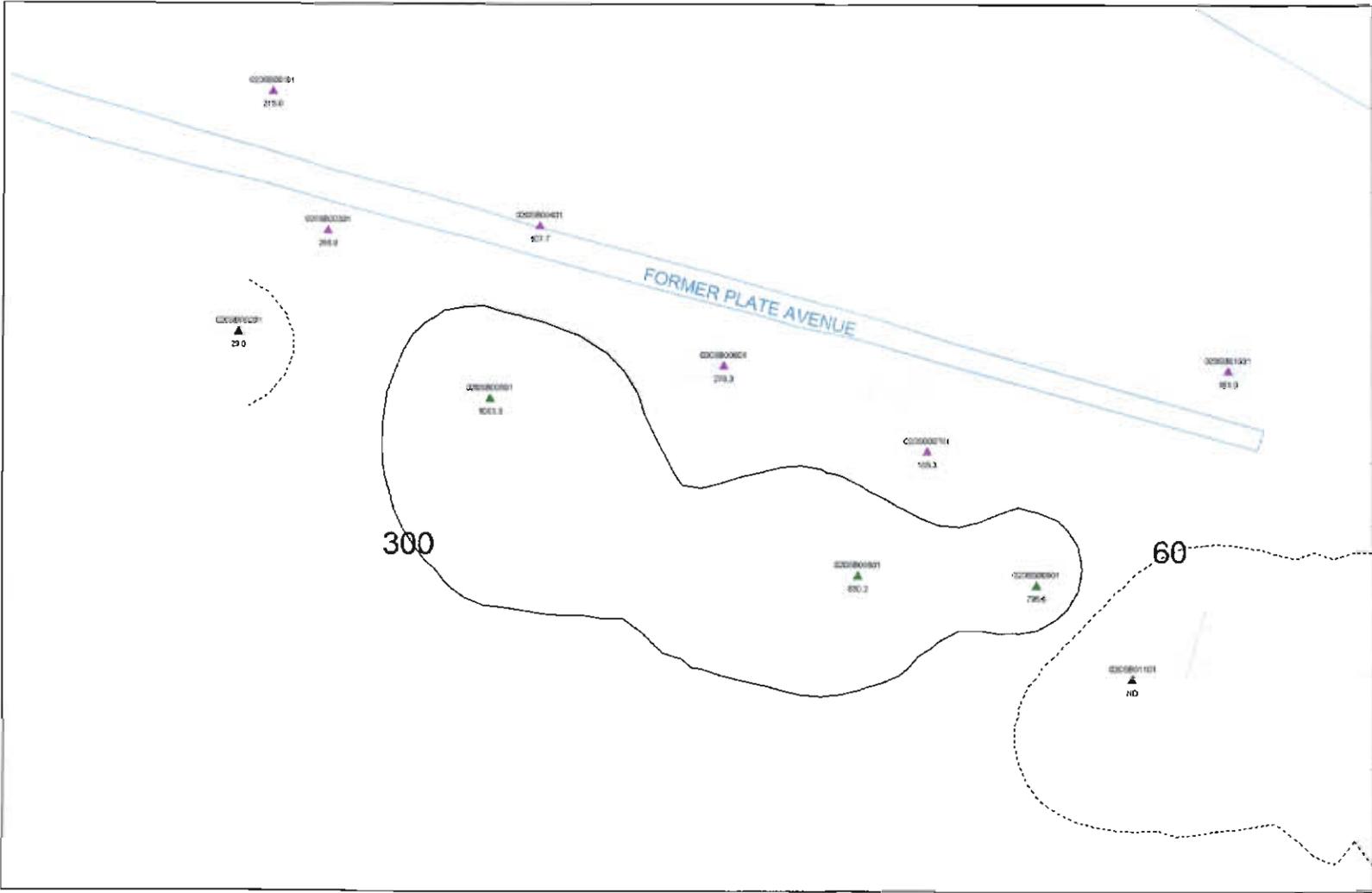


ENSAFÉ

- BEGs (mg/kg)
- 0 - 53,000 (-) 12.08 Bushwater Road
  - 52 - 208,000 (-) 12.08 Bushwater Road
  - 302 - 508,000 (-) 12.05 Bushwater Road
  - 402 - 208,000 (-) 12.05 Bushwater Road
  - 302 - 508,000 (-) 12.04 Bushwater Road
  - 402 - 208,000 (-) 12.04 Bushwater Road
  - 502 - 308,000 (-) 12.04 Bushwater Road
- Change Line
- ROAD
  - SEAL WALVS
  - SEAL
  - SEAL DMS
  - SEAL DMS

LEGEND





30 0 30 60 Feet

**LEGEND**

- BEQs (µg/kg)
- ▲ 0 - 59.999 (< 1E-06 Residential Risk)
  - ▲ 60 - 299.999 (< 1E-05 Industrial Risk)
  - ▲ 300 - 599.999 (< 1E-05 Residential Risk)
  - ▲ 600 - 2999.999 (< 1E-05 Industrial Risk)
  - ▲ 3000 - 5999.999 (< 1E-04 Residential Risk)
  - ▲ 6000 - 30000 (< 1E-04 Industrial Risk; > 1E-04 Residential Risk)
- Contour Lines
  - ▭ BUILDING BOUNDARY
  - ▭ FENCE
  - ▭ ROAD
  - ▭ SIDE-WALKS



**COMBINED SWMU 9  
CMS REPORT  
CHARLESTON NAVAL COMPLEX  
Charleston, SC**

Figure 2.12  
SWMU 20  
BEQs in Upper Interval Surface Soil

Table 2.3  
 Zone H Soil Data for COCs at SWMU 19

Sample Number	Arsenic (mg/kg)	Lead (mg/kg)	Aroclor-1260 (µg/kg)	B(a)A (µg/kg)	B(b)F (µg/kg)	B(a)P (µg/kg)	D(a,h)A (µg/kg)	BEQs (µg/kg)
<b>Risk Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>400</b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.706</b>	<b>1,300</b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>297</b>
<b>Background<sup>3</sup></b>	<b>15.6</b>	<b>118</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
019SB00101	16.5	111 J	40 U	160 J	150 J	110 J	390 U	184.0
019SB00102	8.3	509	50 U	490 U	490 U	490 U	490 U	91.5 U
019SB00201	13.4	168	40 U	851	1,100	668	390 U	845.8
019SB00301	21.4	25.8 J	40 U	450 U	450 U	450 U	450 U	91.5
019SB00401	4.7	381	400	190 J	180 J	160 J	400 UJ	240.8
019SB00402	7.7	238	40 U	1,700	1,700	1,400	250	2,062.6
019SB00501	8.8	102	110 J	370 J	240 J	260 J	420 U	370.3
019SB00601	5.4 J	323	190 J	750 U	210 J	750 U	750 U	108.1
019SB00701	4.1 J	426	560	100 J	100 J	390 U	390 U	103.3
019SB00801	10.7	62.8	32 J	420 U	420 U	420 U	420 U	91.5
019SB00901	22.1	141	130 J	140 J	270 J	110 J	480 U	193.4
019SB01001	8.2	52.8	68	390 J	470 J	500 J	850 U	634.0
019SB01101	3.8	607	180	390	440 J	460 J	390 J	599.0
019SB01201	10.9	3.4	50 U	480 U	480 U	480 U	480 U	91.5 U
019SB01301	3 J	7.6 UJ	40 UJ	390 U	390 U	390 U	390 U	91.5 U
019SB01401	5.7 J	162	37 J	220 J	254 J	192 J	370 U	215.8

Table 2.3  
 Zone H Soil Data for COCs at SWMU 19

Sample Number	Arsenic (mg/kg)	Lead (mg/kg)	Aroclor-1260 ( $\mu\text{g}/\text{kg}$ )	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>400</b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.706</b>	<b>1,300</b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>297</b>
<b>Background<sup>3</sup></b>	<b>15.6</b>	<b>118</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
019SB01601	2 U	5.1 J	40 U	390 UJ	390 U	390 U	390 U	91.5 U
019SB01701	8.2 U	670	92	190 J	270 J	210 J	410 U	300.1
019SB01801	2.6 U	298	370	250 J	330 J	310 J	770 U	413.6

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI - Risk Assessment for Industrial Reuse Scenario.
- 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- J — The associated numerical value is an estimated quantity.
- DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
- U — The material was analyzed but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
- ND — The value was not determined
- (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

Table 2.4  
 Zone H Soil Data for COCs at SWMU 20

Sample Number	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk-Based Concentration<sup>1</sup></b>	870	870	87	87	87
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	ND	ND	ND	ND	297
<b>Background<sup>3</sup></b>	ND	ND	ND	ND	423
020SB00101	230 J	220 J	<b>210 J</b>	430 U	256.9
020SB00201	79 J	200 J	380 UJ	380 UJ	111.8
020SB00301	200 J	250 J	<b>210 J</b>	360 U	304.4
020SB00401	86 J	110 J	87 U	380 U	149.5
020SB00501	<b>950 J</b>	<b>1,400 J</b>	<b>820 J</b>	370 UJ	<b>1,120.7</b>
020SB00601	190 J	290 J	<b>220 J</b>	360 U	315.7
020SB00701	150 J	190 J	<b>150 J</b>	390 U	227.0
020SB00801	470 U	700	<b>580</b>	<b>100</b>	<b>830.2</b>
020SB00901	660	600	<b>570</b>	75 J	<b>795.6</b>
020SB01001	150 J	140 J	<b>130 J</b>	420 U	202.8
020SB01101	1,300 U	1,300 U	1,300 U	1,300 U	91.5 U
020SB01102	580 J	680 J	<b>400 J</b>	750 U	<b>652.4</b>

**Notes:**

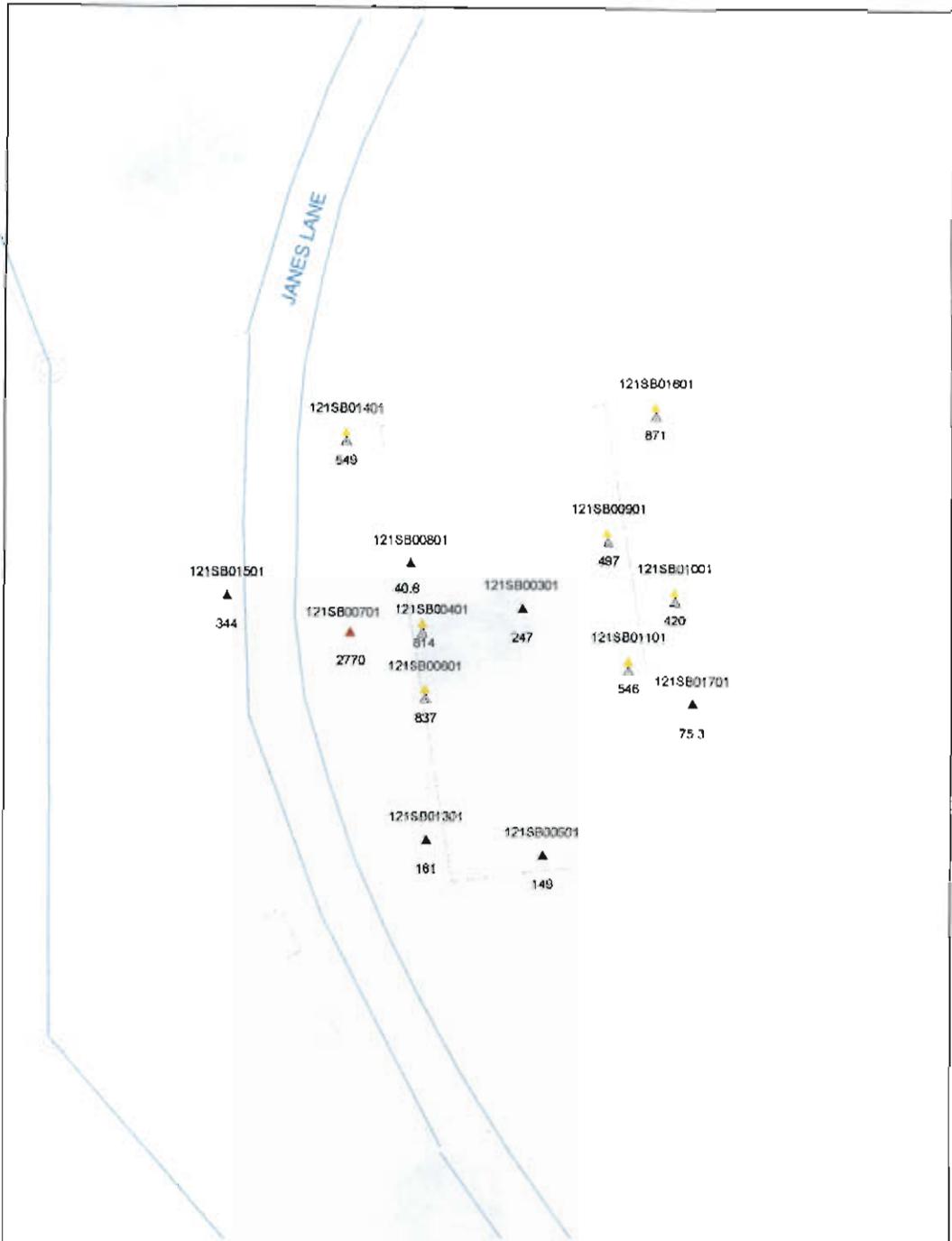
- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
  - 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI – Risk Assessment for Industrial Reuse Scenario.
  - 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
  - J — The associated numerical value is an estimated quantity.
  - DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
  - U — The material was analyzed but not detected at the listed numerical quantization limit.
  - UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
  - ND — The value was not determined
  - (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

**SWMU 121 Soil Sampling and Analysis**

SWMU 121 is the site of former Building 801 and its associated satellite accumulation area (SAA). For six years prior to Base closure in 1996, site operations at Building 801 consisted of the collection, sorting, and storage of recyclable material. The associated SAA was an 8-foot by 8-foot sheet metal building with a concrete floor where hazardous waste was accumulated. The SAS had no secondary containment structures. Sixteen surface soil samples and two subsurface soil samples were collected in three sampling rounds at SWMU 121. The parameters that exceeded their RBSLs include BEQs [benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene], Aroclor-1248, Aroclor-1254, Aroclor-1260, arsenic, beryllium, chromium, copper, lead, manganese, mercury, nickel, thallium, vanadium, and zinc. Of these, only arsenic, lead, Aroclor-1254, Aroclor-1260, and BEQs were identified as COCs per the Zone H RFI Risk Assessment. Table 2.5 summarizes the analytical data obtained from the soil boring locations for each of the COCs. Figures 2.13 through 2.17 show the contaminant concentration at each sample location for arsenic, lead, Aroclor-1254, Aroclor-1260, and BEQs, respectively.

**AOC 637 Soil Sampling and Analysis**

AOC 637 is the site of a former burning dump that was used from the late 1940s to the early 1950s. It is located between Dyess Avenue and Bainbridge Avenue. AOC 637 was initially approved to be investigated as a group with SWMU 8 and AOC 636, but because subsurface conditions were found to be different from the other two sites, it was eventually investigated independently. Five first round soil borings were advanced in September 1996 and two second round soil borings were advanced in January 1997. Of the five first round soil borings, only one subsurface sample was taken due to the high water table at the other four locations and of the two second round soil borings, only one subsurface sample was taken for the same reason. BEQs, arsenic, thallium, and hydrazine were identified as COPCs in surface soil. Only arsenic and BEQs were identified as surface soil COCs for the future site worker per the Zone G RFI. Table 2.6 summarizes the analytical data obtained from the soil boring locations at AOC 637 for each of the COCs. Figure 2.18 and Figure 2.19 show the contaminant concentration at each sample location for arsenic and BEQs, respectively.



**LEGEND**

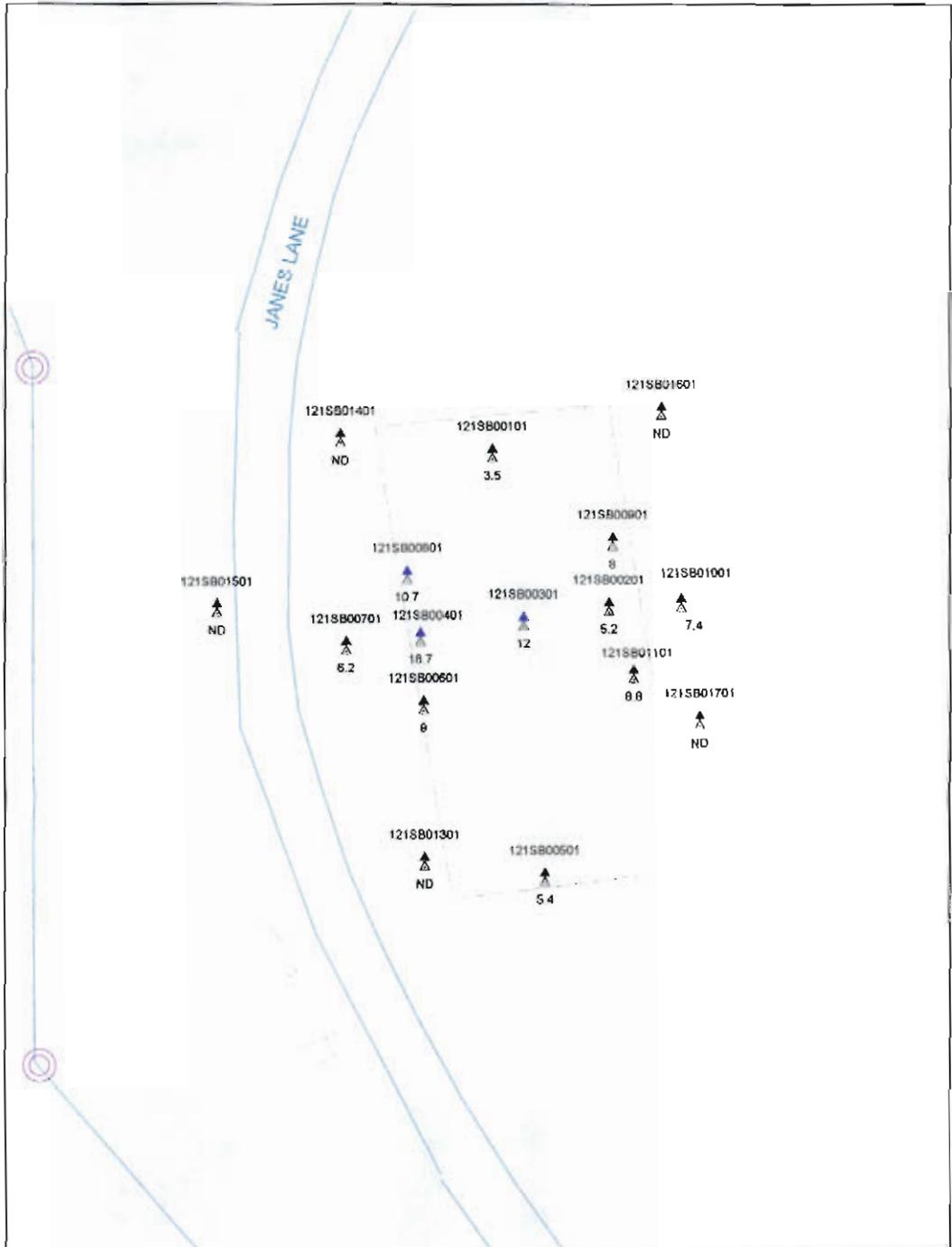
- LEAD (mg/kg)**
- ▲ 0 - 300,000 (Below USCFR Residential Clean Up Standard)
  - 400 - 1,000,000 (Above USCFR Residential Clean Up Standard)
  - 1,500 - 10,000,000 (Above USCFR Industrial Clean Up Standard)
- BUILDING  
 --- BOUNDARY  
 --- FENCE  
 --- ROAD  
 --- SIDE-WALKS



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Figure 2.14  
 SWMU 121  
 Lead in Upper Interval Surface Soil



**LEGEND**

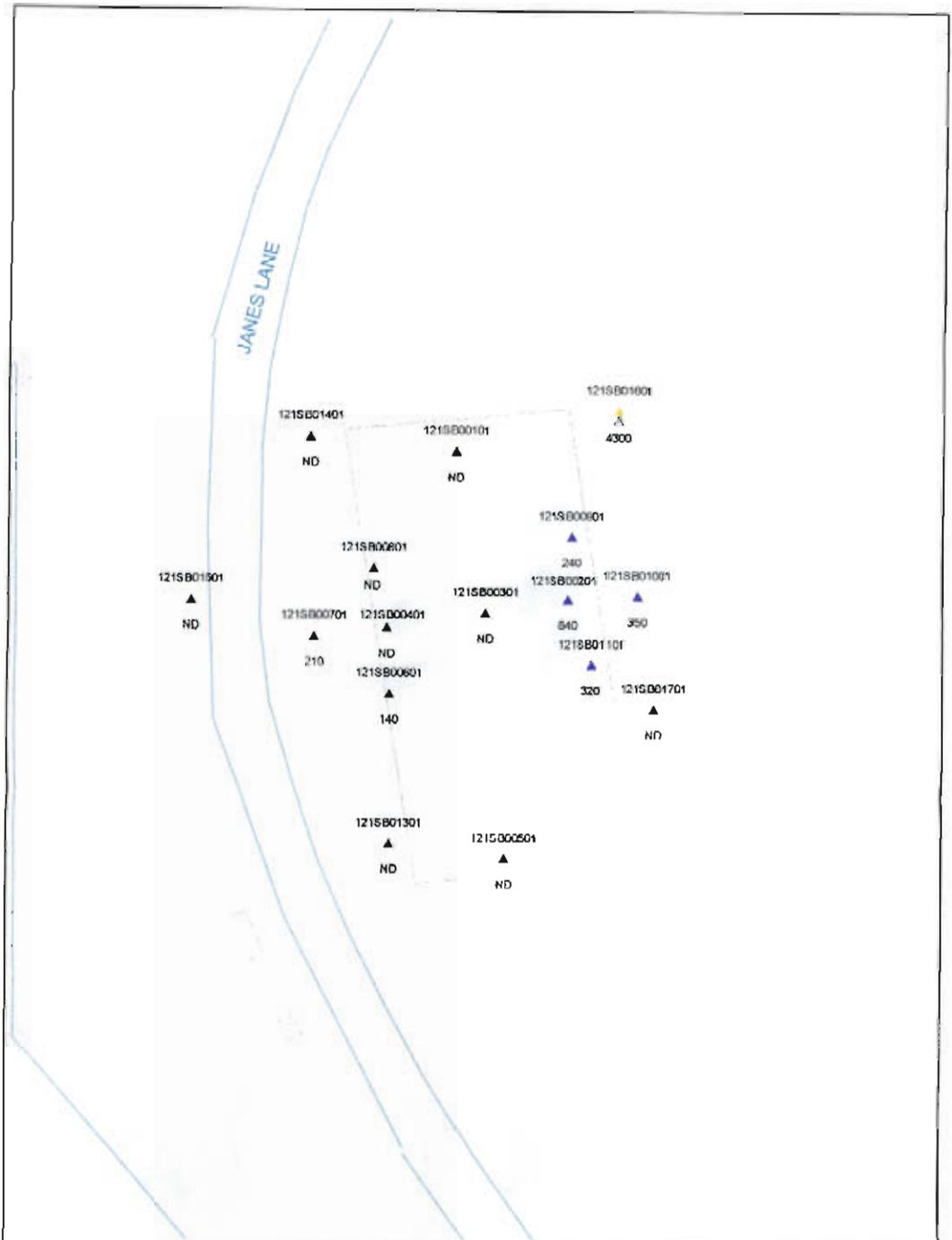
- ARSENIC (mg/kg)
- ▲ 0 - 8.4 (Steele Background)
  - ▲ 11.41 - 27 (> 1E-05 Industrial Risk)
  - ▲ 27.01 - 28 (> 1E-04 Residential Risk)
  - ▲ 38.01 - 270 (> 1E-04 Industrial Risk, > 1E-04 Residential Risk)
  - ▲ 270.01 - 100000
- ▭ BUILDING
  - ▭ BOUNDARY
  - ▭ FENCE
  - ▭ ROAD
  - ▭ SIDEWALK



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Figure 2.13  
SWMU 121  
Arsenic in Upper Interval Surface Soil



**LEGEND**

Aroclor 1254 (µg/kg)

- ▲ 0 - 220 (< 1E-08 Residential Risk)
- ▲ 220.01 - 1100 (< 1E-06 Industrial Risk)
- ▲ 1100.01 - 2200 (< 1E-05 Residential Risk)
- ▲ 2200.01 - 11000 (> 1E-05 Industrial Risk)

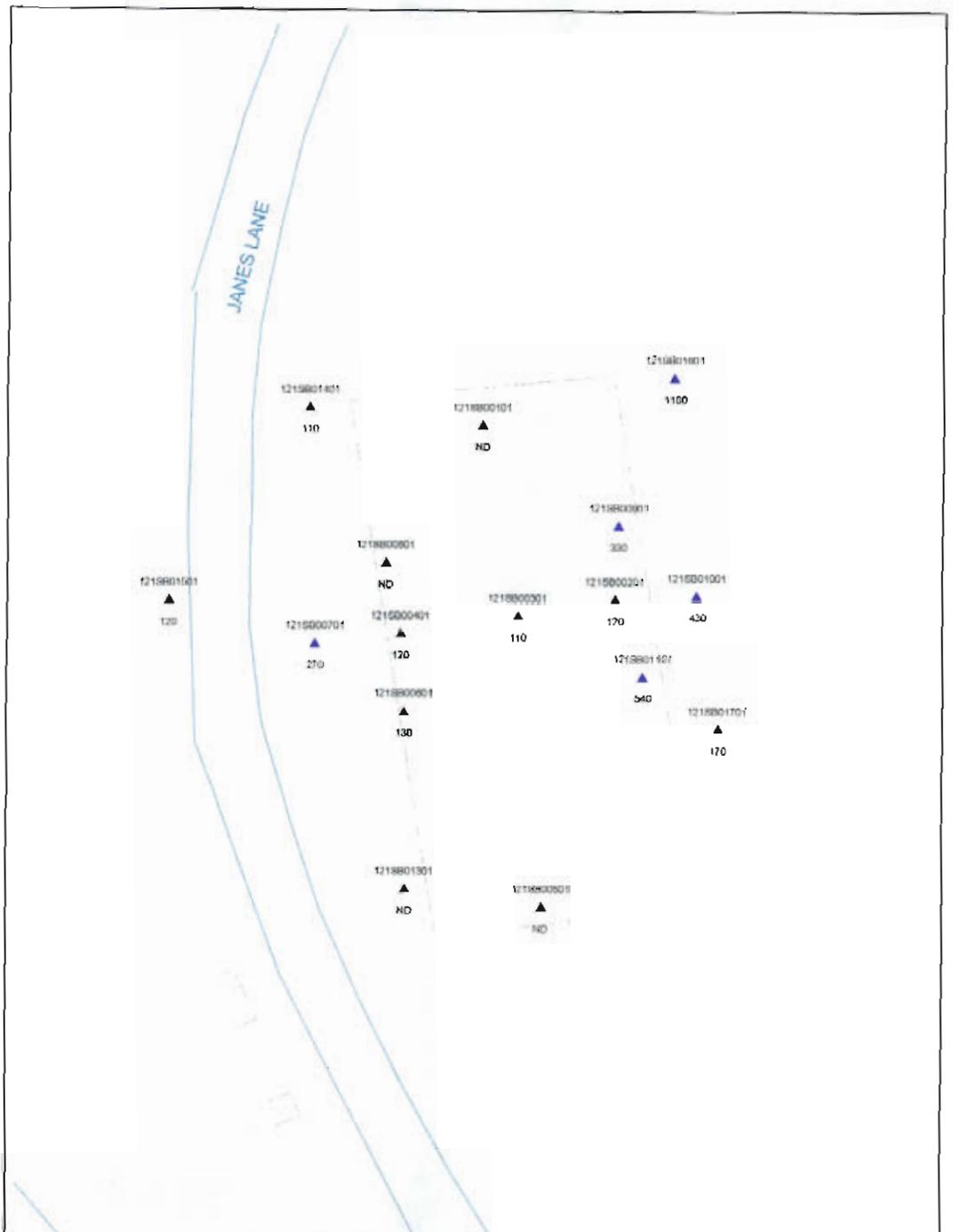
- BUILDING
- BOUNDARY
- FENCE
- ROAD
- SIDE-WALKS



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Figure 2.15  
 SWMU 121  
 Aroclor 1254 in Upper Interval Surface Soil



**LEGEND**

**AROCLOR 1260 (µg/kg):**  
 ▲ 0 - 220 (< 1E-08 Residential Risk)  
 ▲ 220.01 - 1100 (< 1E-06 Industrial Risk)  
 ▲ 1100.01 - 2200 (< 1E-05 Residential Risk)  
 ▲ 2200.01 - 11000 (< 1E-05 Industrial Risk)

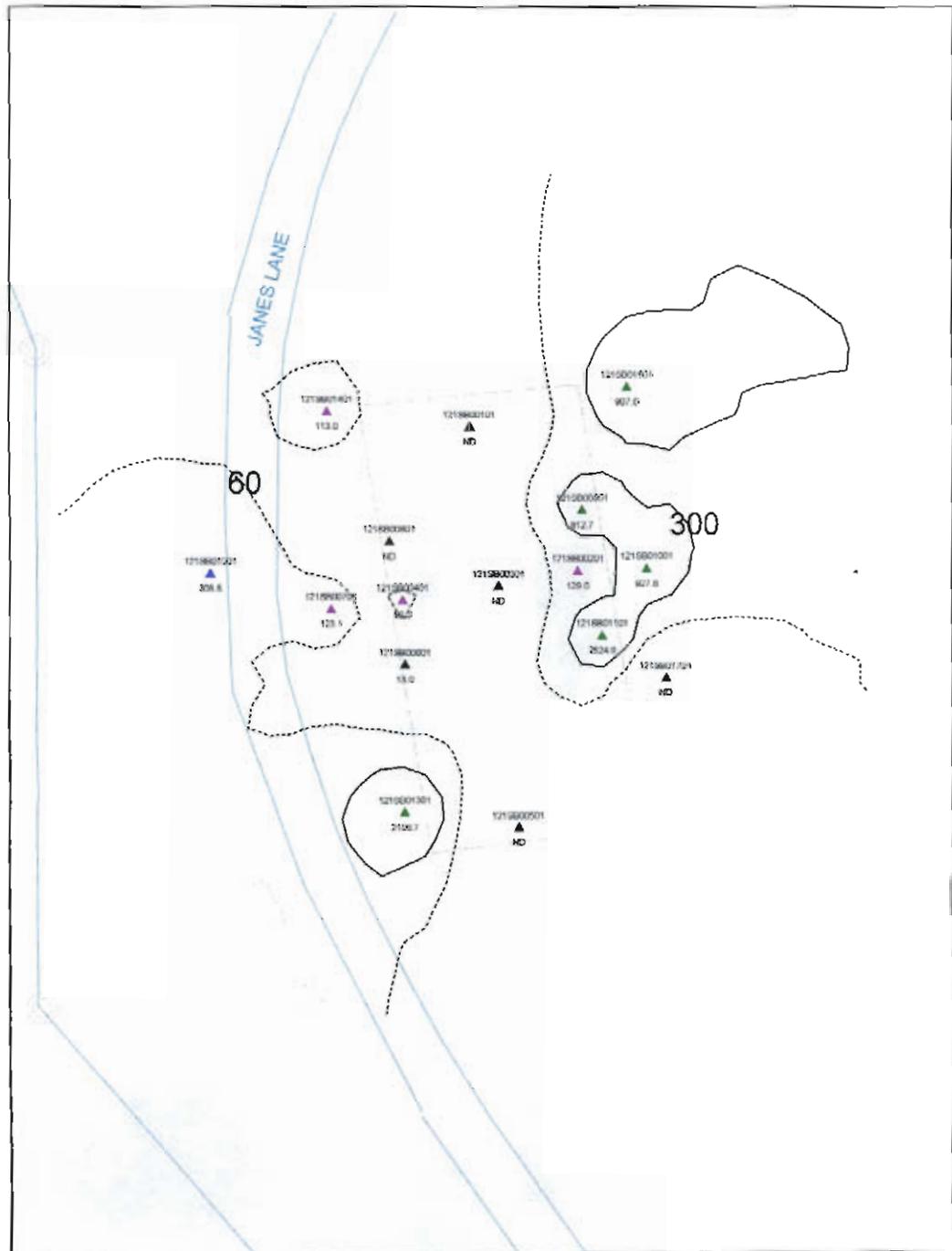
— BUILDING  
 — BOUNDARY  
 — FENCE  
 — ROAD  
 — SIDE-WALKS



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**Figure 2.16  
 SWMU 121  
 Aroclor 1260 in Upper Interval Surface Soil**



<p><b>LEGEND</b></p> <p>BEQs (µg/kg)</p> <ul style="list-style-type: none"> <li>▲ 0 - 50,000 (&lt; 1E-03 Residential Risk)</li> <li>▲ 50 - 250,000 (&lt; 1E-03 Industrial Risk)</li> <li>▲ 250 - 500,000 (&lt; 1E-03 Residential Risk)</li> <li>▲ 500 - 2,500,000 (&lt; 1E-03 Industrial Risk)</li> <li>▲ 2,500 - 10,000,000 (&lt; 1E-04 Residential Risk)</li> <li>▲ 10,000 - 30,000 (&lt; 1E-04 Industrial Risk)</li> <li>▲ 30,000 - 100,000,000 (&gt; 1E-04 Residential Risk)</li> </ul> <p>CONTOUR LINES</p> <ul style="list-style-type: none"> <li>BUILDING BOUNDARY</li> <li>FENCE</li> <li>ROAD</li> <li>SIDE-WALKS</li> </ul>	<p>N</p>	<p><b>COMBINED SWMU 9 CMS REPORT CHARLESTON NAVAL COMPLEX Charleston, SC</b></p>
<p>10 0 10 20 30 40 50 Feet</p>		<p><b>Figure 2.17 SWMU 121 BEQs in Upper Interval Surface Soil</b></p>
<p><b>ENSAFE</b></p>		<p>g:\projects\charleston\zone 121\fig_217</p>



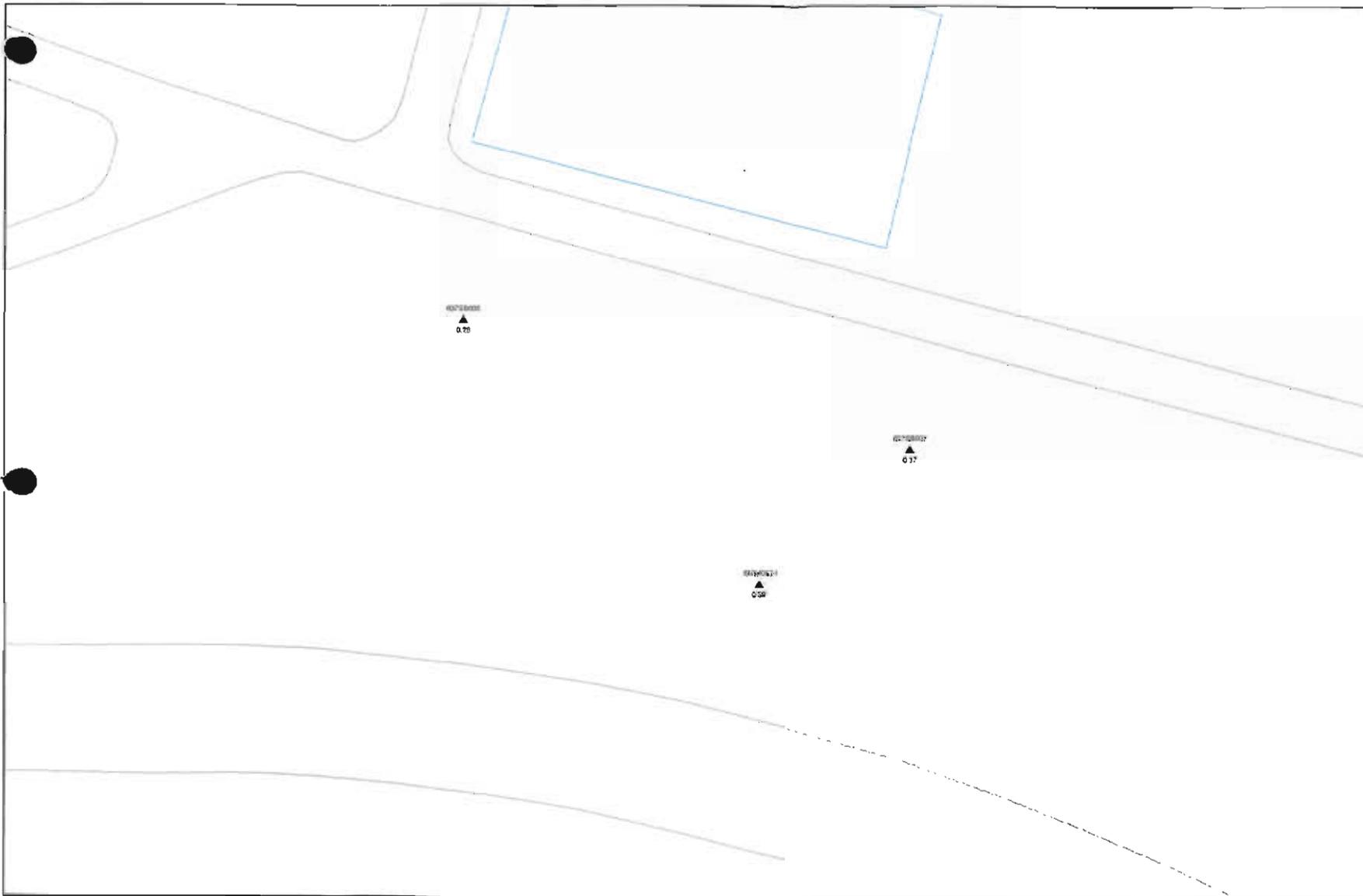
0 50 Feet

- ▲ ARSENIC
- BOUNDARY
- BLDG
- FENCE
- ROAD
- SIDE-WALKS
- WATER
- PIER



COMBINED SWMU 9  
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 Charleston, SC

Figure 2.18  
 AGC 637 - Arsenic in Upper Interval  
 Surface Soil (mg/kg)



0 50 Feet

- ▲ BEQs
- ▬ BLDG
- ▬ FENCE
- ▬ ROAD
- ▬ SIDE-WALKS
- ▬ WATER
- ▬ PIER



COMBINED SWMU 9  
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Figure 2.19  
 ACC 637 - BEQs in Upper Interval  
 Surface Soil (µg/kg)

Table 2.5  
 Zone H Soil Data for COCs at SWMU 121

Sample Number	As (mg/kg)	Lead (mg/kg)	Aroclor-1254 ( $\mu\text{g}/\text{kg}$ )	Aroclor-1260 ( $\mu\text{g}/\text{kg}$ )	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>400</b>	<b>320</b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>0.383</b>	<b>1,300</b>	<b>282</b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>60</b>
<b>Background<sup>3</sup></b>	<b>15.6</b>	<b>118</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
121SB00101	3.5 J	93.5	40 U	40 U	360 U	360 U	360 U	360 U	91.5 U
121SB00201	5.4 J	254	840	120 J	111 J	165 J	99.7	410 U	167.0
121SB00301	12	247	40 U	110	420 U	420 UJ	420 UJ	420 UJ	91.5 U
121SB00401	18.7	814	40 U	120	93 J	92 J	130 J	400 U	138.1
121SB00501	5.4	149	40 U	40 U	1,600 U	1,600 U	1,600 U	1,600 U	91.5 U
121SB00601	9	837	140	130	420 U	130 J	420 U	420 U	100
121SB00701	6.2	2,770	210	270	390 U	230 J	100 J	390 UJ	169.1
121SB00702	10.7	508	82	88	160 J	200 J	200 J	460 UJ	280.2
121SB00801	10.7	40.6	40 U	40 U	430 U	430 U	430 U	430 U	91.5 U
121SB00901	8	497	240	330	520	780	540	110 J	812.7
121SB01001	7.4	420 J	350	430	510	1,300	620	98 J	928.0
121SB01101	8.8	546	320	540	1,900	2,700	1,700	280 J	2,524.9
121SB01301	9.9 U	161	40 U	40 U	1,600	2,000	1,400	270 J	2,106.7
121SB01401	5.4 U	549	40 U	110	430 U	120 J	100 J	430 U	158.6

Table 2.5  
 Zone H Soil Data for COCs at SWMU 121

Sample Number	As (mg/kg)	Lead (mg/kg)	Aroclor-1254 ( $\mu\text{g}/\text{kg}$ )	Aroclor-1260 ( $\mu\text{g}/\text{kg}$ )	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>400</b>	<b>320</b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>0.383</b>	<b>1,300</b>	<b>282</b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>60</b>
<b>Background<sup>3</sup></b>	<b>15.6</b>	<b>118</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
121SB01501	1.6 U	344	40 U	120	240 J	390 J	240 J	410 U	347.3
121SB01601	13.5 U	871	4,300	1,100	570 J	1,000	620	100 J	907.6
121SB01701	2.4 U	75.3	40 U	170	420 UJ	420 U	420 U	420 U	91.5 U

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI – Risk Assessment for Industrial Reuse Scenario.
- 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- J — The associated numerical value is an estimated quantity.
- DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
- U — The material was analyzed but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
- ND — The value was not determined
- (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated

Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher. according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

Table 2.6  
 Zone G Soil Data for COCs at AOC 637

Sample ID	As (mg/kg)	B(a)A (µg/kg)	B(a)P (µg/kg)	B(b)F (µg/kg)	D(a,h)A (µg/kg)	BEQs (µg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>	<b>870</b>	<b>87</b>	<b>870</b>	<b>87</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>140</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>453</b>
637SB00101	7.3	1,000 J	890 J	1,400 J	320 J	1,507.4
637SB00201	6.9	390 U	390 UJ	140 J	390 UJ	69.7
637SB00301	6.8	760 J	680 J	680 J	360 UJ	898.3
637SB00302	5.9	410 UJ	410 UJ	410 UJ	410 UJ	57.3 U
637SB00401	4.2	370 UJ	370 UJ	370 UJ	370 UJ	57.3 U
637SB00501	8.25	56 J	56 J	54 J	390 U	93.3
637SB00601	6	560	600	370 U	170 J	869.6
637SB00602	7.5	110 J	140 J	140 J	47 J	224.4
637SB00701	19.0 J	390 J	360 J	110 J	160 J	518.5

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
  - 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI – Risk Assessment for Industrial Reuse Scenario.
  - 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
  - J — The associated numerical value is an estimated quantity.
  - DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
  - U — The material was analyzed but not detected at the listed numerical quantization limit.
  - UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
  - ND — The value was not determined
  - (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

### **AOC 642 Soil Sampling and Analysis**

AOC 642 is the former pistol range used during the 1940s that was originally thought to be located south of Building X-10 and west of Buildings X-12 and 1431. The RFI was conducted assuming that this was the location. However, after further review of historical aerial photographs, the site was found to be located farther to the west in SWMU 8. Ten soil borings were advanced during the RFI in September 1996. Of the ten soil borings, only one subsurface sample was taken due to the shallow water table at the other nine locations. Arsenic, beryllium, manganese, nickel, and thallium were identified as COPCs in surface soil. Only arsenic was identified as a surface soil COC for the future site worker per the Zone G RFI. Table 2.7 summarizes the analytical data obtained from the soil boring locations at AOC 642 for each of the COCs. Figure 2.20 shows the arsenic concentration at each sample location.

### **AOCs 649, 650, and 651 Soil Sampling and Analysis**

Because of their proximity, AOCs 649, 650, and 651 have been grouped together. AOC 649, the former Braswell Storage Area, stored sandblast media, welding supplies, and other unknown materials used in ship repair. AOC 650, the former metal trades storage area, also stored unknown materials for ship repair. AOC 651, the former sandblaster storage area, stored sandblast media resulting from ship repair. Nine surface soil samples and one subsurface soil sample were collected from AOC 649. Eight surface soil samples were collected at AOC 650. The parameters that exceeded their RBSLs were BEQs [benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, ideno(1,2,3-cd)pyrene], Aroclor-1254, copper, and mercury. Of these, only BEQs and Aroclor-1254 were identified as COCs based on their contribution to risk/hazard, per the Zone H RFI Risk Assessment at AOC 650 (which includes 651). No COCs were identified for AOCs 649; however, because of the proximity of AOCs 649 and 650, BEQs and Aroclor-1254 will be considered COCs for both sites. Table 2.8 summarizes the analytical data obtained from the soil boring locations for each of the COCs. Figure 2.21 and Figure 2.22 show the contaminant concentrations at each sample location for Aroclor-1254 and BEQs, respectively.



0 50 Feet

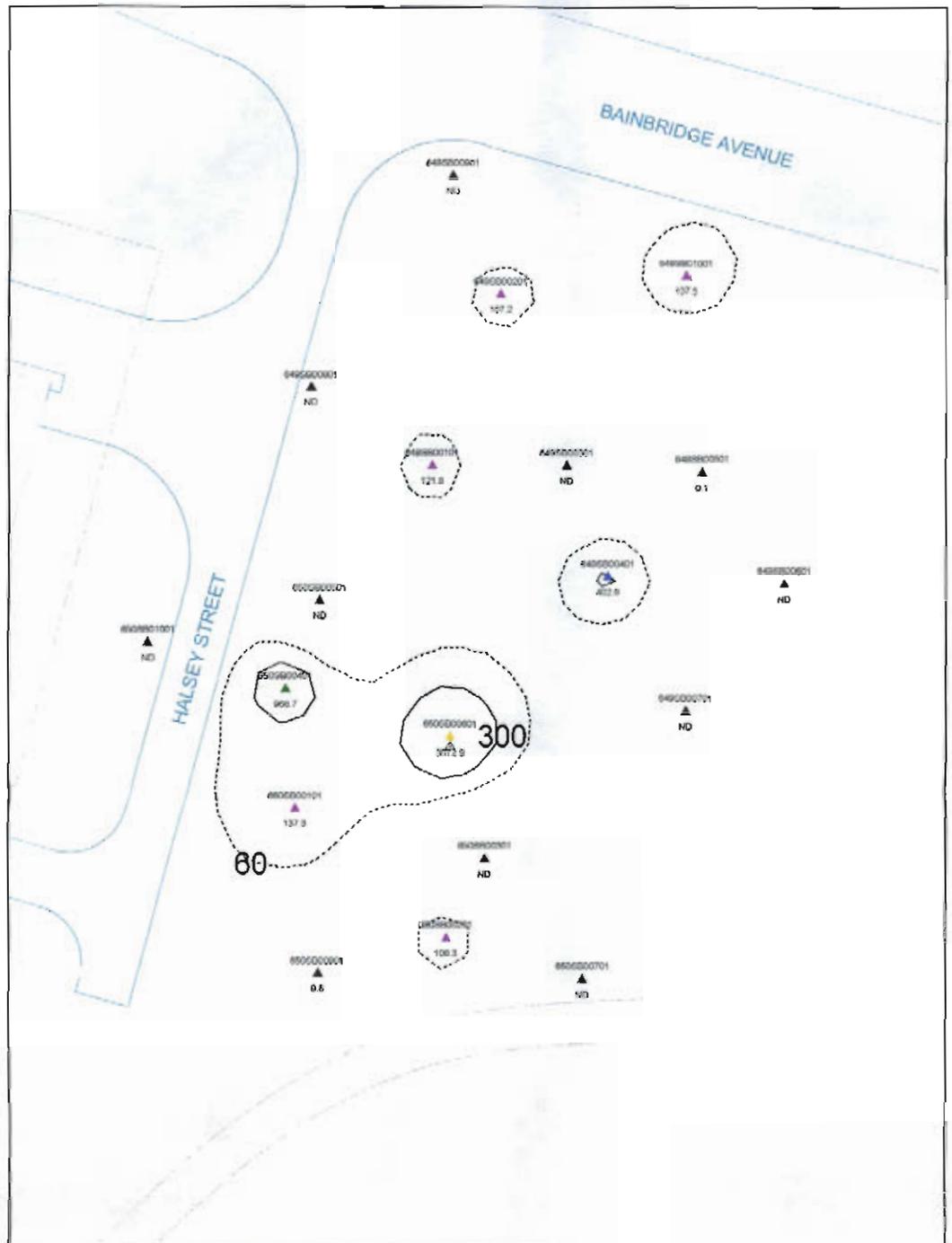
- ▲ ARSENIC
- BOUNDARY
- ▭ BLDG
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS
- ▭ WATER
- ▭ PIER



COMBINED SWMU 9  
 CMS REPORT  
 CHARLESTON NAVAL COMPLEX  
 Charleston, SC

Figure 2-20  
 AOC 642 - Arsenic in Upper Interval  
 Surface Soil (mg/kg)





**LEGEND**

**BEQs (µg/kg)**

- ▲ 0 - 50,000 (= 1C-05 Residential Risk)
- ▲ 50 - 200,000 (= 1C-05 Industrial Risk)
- ▲ 300 - 500,000 (= 1B-05 Residential Risk)
- ▲ 600 - 2,000,000 (= 1B-05 Industrial Risk)
- ▲ 3000 - 5,000,000 (= 1C-04 Residential Risk)
- ▲ 6000 - 30,000 (= 1B-04 Industrial Risk, = 1C-04 Residential Risk)

--- CONTOUR LINES

▭ BUILDING  
▭ FENCIBLE  
▭ ROAD  
▭ SIDEWALK



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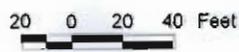


Figure 2.22  
AOC 649/650/651  
BEQs in Upper Interval Surface Soil

**Table 2.7**  
**Zone G Soil Data for COCs at AOC 642**

Sample ID	As (mg/kg)
<b>Risk-Based Concentration<sup>1</sup></b>	<b>0.43</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>2.7</b>
<b>Surface Background<sup>3</sup></b>	<b>17.2</b>
642SB00101	6.5
642SB00201	4.5 J
642SB00301	<b>19.4 J</b>
642SB00401	<b>31.7 J</b>
642SB00501	8.9 J
642SB00601	<b>82.0 J</b>
642SB00701	<b>30.7 J</b>
642SB00801	5.0 J
642SB00802	1.7 J
642SB00901	6.4 J
642SB01001	13.5 J
642SB01102	1.7

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI - Risk Assessment for Industrial Reuse Scenario.
- 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- J — The associated numerical value is an estimated quantity.
- DJ — The associated numerical value is from a diluted sample and is an estimated quantity.
- U — The material was analyzed but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
- ND — The value was not determined
- (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

**Table 2.8**  
 Zone H Soil Data for COCs at AOCs 649, 650, and 651

Sample Number	Aroclor-1254 ( $\mu\text{g}/\text{kg}$ )	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	I(1,2,3-cd)P ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk-Based Concentration<sup>1</sup></b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>297</b>
<b>Background<sup>3</sup></b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
649SB00101	330 U	136 J	232 J	95.4 J	380 U	62.5 J	161.4
649SB00201	78U	99.1 J	163 J	80.9 J	430 U	430 U	149.4
649SB00301	76 U	420 UJ	420 UJ	420 UJ	420 UJ	420 U	91.5 U
649SB00401	74 U	253 J	464 J	239 J	72.1 J	198 J	403.3
649SB00501	83 U	460 U	460 U	460 U	460 U	460 U	91.5
649SB00601	40 U	440 U	440 U	440 U	440 U	440 U	91.5 U
649SB00701	40 U	430 U	430 U	430 U	430 U	430 U	91.5 U
649SB00801	40 U	450 U	450 U	450 U	450 U	450 U	91.5 U
649SB00901	30 J	440 U	440 U	440 U	440 U	440 U	91.5 U
649SB01001	62	130 J	130 J	110 J	470 U	470 U	179.3
650SB00101	73 U	85.9 J	216 J	107 J	400 UJ	400 UJ	179.5
650SB00201	407	86.1 J	173 J	80.3 J	420 U	420 U	148.5
650SB00301	330 U	1,660 U	420 U	1,660 U	1,660U	1,660 U	91.5 U
650SB00401	73 U	798	1,660 U	679	410 U	438	1,006.5
650SB00501	40 U	450 U	450 U	450 U	45 U	450 U	91.5 U
650SB00601	40 U	1,900	4,000	2,000	390 J	910	3,073.3
650SB00701	40 U	430 U	430 U	430 U	430 U	430 U	91.5 U

Table 2.8  
 Zone H Soil Data for COCs at AOCs 649, 650, and 651

Sample Number	Aroclor-1254 ( $\mu\text{g}/\text{kg}$ )	B(a)A ( $\mu\text{g}/\text{kg}$ )	B(b)F ( $\mu\text{g}/\text{kg}$ )	B(a)P ( $\mu\text{g}/\text{kg}$ )	D(a,h)A ( $\mu\text{g}/\text{kg}$ )	I(1,2,3-cd)P ( $\mu\text{g}/\text{kg}$ )	BEQs ( $\mu\text{g}/\text{kg}$ )
<b>Risk-Based Concentration<sup>1</sup></b>	<b>320</b>	<b>870</b>	<b>870</b>	<b>87</b>	<b>87</b>	<b>870</b>	<b>87</b>
<b>Industrial Risk-Based RGO (1E-06)<sup>2</sup></b>	<b>282</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>297</b>
<b>Background<sup>3</sup></b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>	<b>423</b>
650SB00901	40 U	97 J	440 U	440 U	440 U	440 U	97.5
650SB01001	51	400 U	400 U	400 U	400 U	400 U	91.5 U
650SB01002	30 J	410 U	410 U	410 U	410 U	410 U	91.5 U

**Notes:**

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — Remedial Goal Options (RGOs) obtained from Zone H RFI - Risk Assessment for Industrial Reuse Scenario.
- 3 — Background reference values per June 1997 project team technical subcommittee meeting. BEQ background reference values per the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.
- J — The associated numerical value is an estimated quantity.
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- U — The material was analyzed but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed but not detected, and had a quality control (QC) outlier causing the data to be estimated.
- ND — The value was not determined
- (a) — BEQs are calculated by multiplying the carcinogenic polycyclic aromatic hydrocarbons (cPAH) by their respective toxicity equivalence factors (TEF) and assuming that nondetect values are estimated according to the memo from Barry Doll, EnSafe, Inc. to Johnny Tapia, SCDHEC, *CNC Background Calculations for Carcinogenic PAHs in Terms of BEQs*, July 29, 1999.

Bold values indicate parameter concentrations that exceed their Risk-Based Concentration, Industrial Risk-Based RGO or background, whichever is higher.

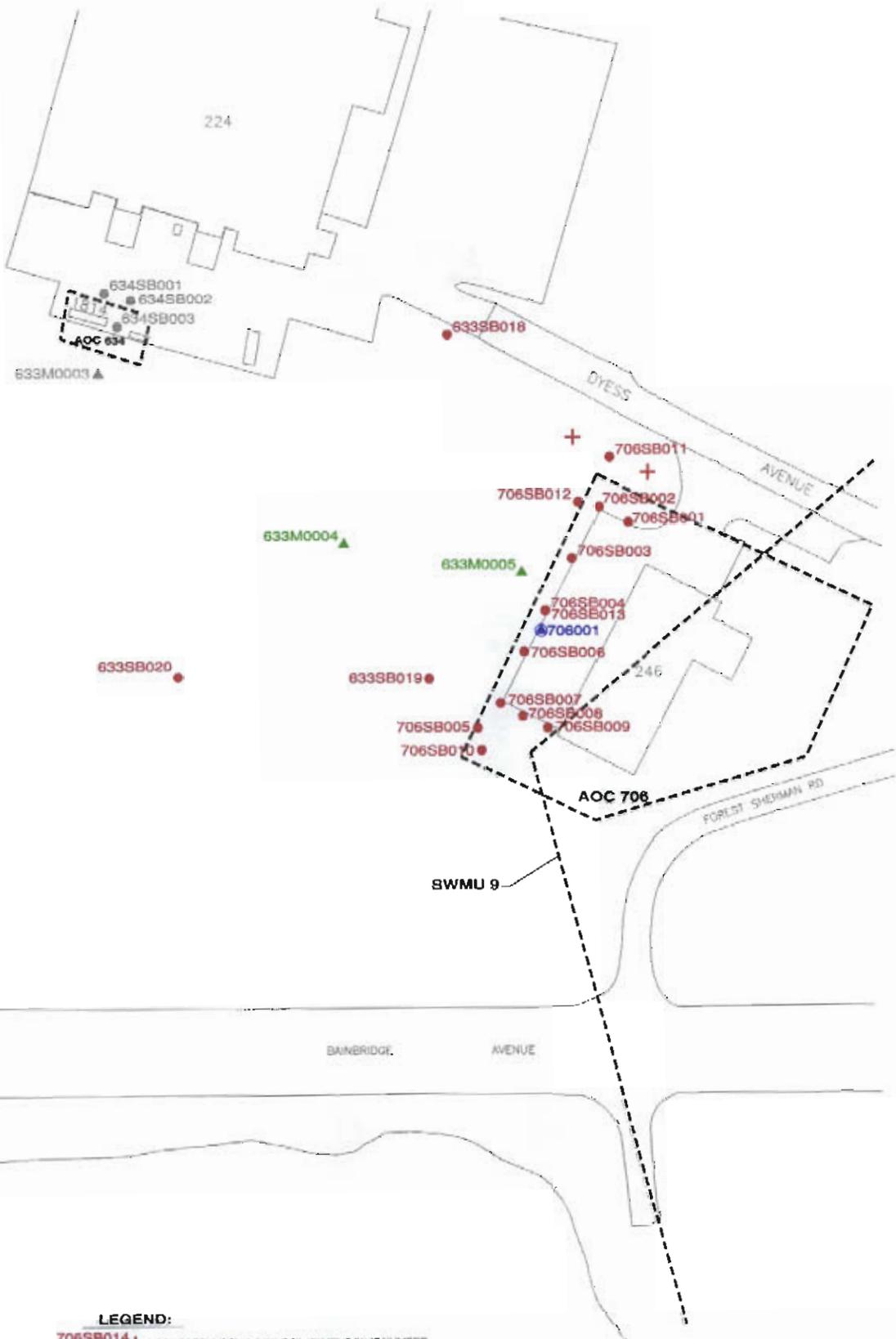
### **AOC 706 Soil Sampling and Analysis**

AOC 706 is located behind Building 246, the former hazardous waste storage and transit facility. Building 246 and the surrounding paved area were constructed in 1986 and prior to this, the land parcel appears to have been an open lot surrounded by trees. Ten soil borings were advanced during the RFI in August and September 1996. At seven of the ten locations, surface and subsurface sample were obtained. Subsurface samples were not taken at the other three locations due to the shallow water table. Antimony and cadmium were identified as COPCs in surface soil. However, neither chemical was identified as a surface soil COC for the future site worker per the Zone G RFI. Three additional soil borings were advanced in July 1999 to determine the extent of soil contamination.

A risk assessment that included these three most recent soil samples has not been performed; however, the *Final Zone G RFI Report* will present a risk assessment that includes these data. Because no COCs have been identified in surface soil at this time, a table is not presented for AOC 706 soil data. Further, remedial alternatives for this site will not be considered as part of this draft CMS, but may be evaluated in the final CMS report if the risk assessment shows that COCs are an issue at this site. Figure 2.23 shows the sample locations at this AOC.

### **Combined SWMU 9 Subsurface Soil**

Because Combined SWMU 9 is a landfill, lower interval soil (3 to 5 ft. depth) will not be addressed in this CMS. The primary purpose of the CMS is to evaluate and propose potential remedies for surface soil risks/hazards. A secondary purpose of the CMS is to propose a groundwater monitoring plan for the landfill perimeter. Both of these remedial alternatives, as well as others, are discussed in Sections 3, 4 and 5 of this CMS.



**LEGEND:**

- 706SB014+ PROPOSED AOC706 SITE SOIL SAMPLE W/ ID NUMBER
- 706001Ⓢ EXISTING AOC706 SITE MONITORING WELL W/ ID NUMBER
- 706SB008● EXISTING AOC706 SITE SOIL SAMPLE W/ ID NUMBER
- 633M005▲ EXISTING SITE SEDIMENT SAMPLE W/ ID NUMBER
- ⊕ ⊖ ⊙ ADJACENT SITE SAMPLES
- S— SANITARY SEWER LINE
- S— STORM SEWER LINE
- DIRECTION OF FLOW - STORMWATER RUNOFF
- FENCE
- ⊠ AOC/SWMU FEATURES



ZONE H  
 COMBINED SWMU 9  
 CMS REPORT  
 CHARLESTON NAVAL COMPLEX  
 CHARLESTON, S.C.

FIGURE 2.23  
 AOC 706  
 SOIL SAMPLE LOCATIONS

## **2.2.2 Groundwater**

### **Combined SWMU 9 Groundwater Sampling and Analysis**

Seventeen shallow groundwater samples were collected in the primary groundwater sampling event near SWMU 9 to determine shallow groundwater quality. Eight deep groundwater samples were collected in the primary groundwater sampling event near SWMU 9 to determine deep groundwater quality. Refer to Figure 2.2 for well locations. In the first sampling round, both deep and shallow groundwater samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), cyanide, and metals. Three shallow groundwater samples were duplicated and submitted for herbicide, hexavalent chromium, dioxin, and organophosphorus pesticide analyses, in addition to the standard suite of analyses. Two of the shallow duplicate sample and one other shallow sample were also analyzed for total petroleum hydrocarbons (TPH). Based on the results of the shallow groundwater sample analyses, four additional shallow monitoring wells were constructed along the south side of Bainbridge Avenue (near the northwest boundary of Zone H) and sampled for the standard suite of analytical parameters. One of the four samples was duplicated and submitted for analysis of additional compounds, as above. Although the four additional wells were installed shortly after second-round groundwater sampling had begun, data from analyses of the initial samples collected from the wells have been included with the first-round sample results. Consequently, no second-round samples were collected from these wells.

In the second sampling round at SWMU 9, groundwater samples collected from the 17 original shallow wells and eight deep wells were submitted for analysis of VOCs, SVOCs, pesticides, and metals. Three shallow samples were duplicated and analyzed for the same parameters as the primary samples.

Based on data from the first round of sampling, eight COCs were identified as part of the Zone H RFI Risk Assessment. These COCs include azobenzene, benzene, benzidine, 1,2-dichloroethane,

bis(2-chloroethyl)ether, pentachlorophenol, vinyl chloride, and 2,3,7,8-Tetrachlorodibenzo- 1  
p-dioxin (TCDD). Second round sampling and subsequent risk assessment indicated 15 COCs in 2  
shallow groundwater. These include benzene, chlorobenzene, 1,4-dichlorobenzene, 3  
1,2-dichloroethane, 1,2-dichloroethene, methylene chloride, 2,4-dimethylphenol, 4  
hexachlorobenzene, hexachlorbutadiene, 4-methylphenol, vinyl chloride, arsenic, barium, 5  
beryllium, and cadmium. Tables 2.9 and 2.10 summarize the COC groundwater data for the 6  
shallow and deep wells, respectively. Because Combined SWMU 9 groundwater data is so 7  
extensive and to make the table summary easier to read, only the results which indicated the 8  
presence of a COC in the water sample are presented in the table. All the analytical results are 9  
presented in Anadata which is included in Appendix A. 10

### **Zone G Groundwater Sampling and Analysis** 11

Six shallow monitoring wells were installed at SWMU 8/AOC 636 in September 1993 and were 12  
sampled in November 1993. During the RFI, the six wells were redeveloped and an additional 13  
shallow well was installed at AOC 636 in September 1996. These six wells were sampled 14  
four times between November 1996 and December 1997. Based on data from the first round of 15  
RFI sampling, antimony, barium, thallium, vanadium, and bis(2-ethylhexyl)phthalate (BEHP) were 16  
identified as COPCs. Standpipes that were installed as part of the DET IM were sampled in 17  
August 1999 for VOCs, SVOCs, and hydrazine. No free-product was detected in any of the 18  
standpipes. To address concerns developed from earlier soil and groundwater sampling phases, 19  
three additional shallow wells were installed – two wells at AOC 637 and one well at AOC 706. 20  
Results of sampling events are summarized in Table 2.9 below. Appendix B contains Figures 21  
showing the COC concentration isocons for all sites that are part of Combined SWMU 9. 22

Two deep grid-based monitoring wells were installed at Zone G to facilitate groundwater sampling 23  
at the base of the shallow aquifer. No deep monitoring wells were installed at Zone G sites. 24

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu\text{L}$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu\text{g/L}$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
008-GSP-01-01																			76.6										
008-GSP-01-02																													
008-GSP-01-03																			14.6										
008-GSP-01-04																													
008-GSP-01-05																			5.6										
008-GSP-01-06																													
008-GSP-01-07																			6.7										
008-GSP-01-08																													
008-GSP-01-09																													
008-GSP-01-10																													
008-GSP-01-11																			5										
008-GSP-01-12																			10.1										
008-GSP-01-13																			6.7										
008-GSP-01-14																			5.6										
008-GSP-01-15																			7										

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Ti	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
008-GSP-01-16																		6											
008-GSP-01-17																		5.6											
008-GSP-01-18																		7.4											
008-GW-001-01																				6.4 J	40.6			4.6 J					6.8 J
008-GW-001-02																				5 J	66.8 J	0.71 J		1.7 J					18.3 J
008-GW-001-03																		16.7		5.6 J	38.3 J	1.19 J		2.77 J					24
008-GW-001-04																		8			33.9 J	0.33 J		1.7 J					5.2 J
008-GW-002-01												1 J			2 J					1,520				9.1 J			3.9 J		1.3 J
008-GW-002-02						8						1 J			1 J			7.3			739 J			1.3 J	5.2 J				1.9 J
008-GW-002-03																				645 J	0.23 J								3.1 J
008-GW-002-04						2 J												5.1			404 J			1.1 J	1.3 J				1.4 J
008-GW-003-01																				8 J	67.5				3 J	22.6 J			49
008-GW-003-02											5				3 J			23.6		13	69.6 J	3.7 J		9.4 J	7.4 J	12.6 J	7.4 J		12.4 J
008-GW-003-03																				10.2	93.9 J	1.3 J		6.7 J					19.5 J
008-GW-003-04																		22.1			57.1 J	0.32 J		3 J	1.1 J				29.5

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
008-GW-004-01											46									4.3 J	74.5							4.6 J	
008-GW-004-02																				9.4 J	70 J	0.67 J		2.6 J			6.4 J	1.6 J	
008-GW-004-03																		9.09		2.3 J	78.8 J	1.1 J						1.7 J	
008-GW-004-04																		7.6			67.6 J	0.28 J	0.44 J						
008-GW-005-01																				6.8 J	23.5							2.5 J	
008-GW-005-02																				2.8 J	18.9 J			1.5 J			5.8 J	3.6 J	
008-GW-005-03																		10.2		4.5 J	23.8 J	0.28 J		1.1 J				5.2 J	
008-GW-005-04																		8.4			15.6 J	0.35 J	1.4 J					3.2 J	
008-GW-006-01																				17.7	11.9				10.2 J			2.9 J	
008-GW-006-02																				17.2	12.5 J	0.27 J						2.2 J	
008-GW-006-03												6 J				5 J		5.1		31.7								3.5 J	
008-GW-006-04																				24.7	7.9 J							2.4 J	
636-GW-001-01																						56.7							2.9 J
636-GW-001-02																				10.2	35.5 J	0.41 J	0.71 J	1.7 J				5 J	
636-GW-001-03																		16		3.6 J	106		1.4 J	3.2 J				5.7 J	

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	De	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (g/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
636-GW-01-04																		5.8			77.8 J		2.1 J						3 J
637-GW-01-01																				6.6 J	6,000			33.6	44.1	8.7 J	3 J		5.7 J
637-GW-01-02																				4.3 J	2,840 J	0.39 J		13.2	13				2.7 J
637-GW-01-03																				5.1 J	3,660 J	0.23 J		14.6					24.7 J
637-GW-01-04																					3,450 J		0.98 J	17.2	18.9				3.3 J
637-GW-02-A1																			5.8	38		211	0.35 J	1.4 J	1.2 J				
637-GW-02-A2																				5.1		220 J	0.55 J	1.7 J					
637-GW-02-A3																					247 J		0.89 J	1.2 J					
637-GW-02-A4																						122		1.3 J	1.9 J				1.1 J
637-GW-03-A1																			8	7.9 J	6,740 J	0.5 J	0.36 J	8.2 J	13.3 J	10.3 J	5.5 J		1.5 J
637-GW-03-A2																					3.4 J	4,640 J		1.6 J					2.2 J
637-GW-03-A3																						2,750 J		1.5 J	12.8				1.2 J
637-GW-03-A4																						46.3		1.2 J	5.7				1.6 J
638-GW-04-C1																													
653-GW-04-01																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V		
Tap Water RBC ( $\mu$ /L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26		
MCL ( $\mu$ g/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA		
653-GW-001-02																														
653-GW-001-03																														
653-GW-001-04																														
653-GW-002-01																														
653-GW-002-02																														
653-GW-002-03																														
653-GW-002-04																														
653-GW-003-01																														
653-GW-003-02																					9.2 J									
653-GW-003-03																														
653-GW-003-04																														
653-GW-003-05																														
653-GW-003-06																					41.9									
653-GW-003-C1																														
706-GW-001-A1																					7.3 J	539		0.4 J	5.2 J			3.8 J	9 J	2.6 J

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethoxy)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentaachlorophenol	hydrazine	tetryl	As	Ba	Bc	Cd	Cr	Pb	Sb	Tl	V
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA
706-GW-001-A2																				6.8 J	422 J	0.6 J	2 J	2.3 J				1.8 J
706-GW-001-A3																					299 J	0.28 J	1.3 J					2 J
706-GW-001-A4																					16.6	1,440	0.48 J	2.1 J	1.3 J	9.4 J		1.2 J
706-GW-001-A5																					39.9	2,290				45.6 J		2 J
009-GW-001-01	1.8 J																			1.8 J	206					17.4		
009-GW-001-02																					194 J							
009-GW-001-03												36			3 J						191 J					3.8 J		
009-GW-001-04	2 J												38		1 J													
009-GW-001-C1																												
009-GW-002-01																												
009-GW-002-02																												
009-GW-002-03																												
009-GW-002-04								NR	NR																		7.4 J	
009-GW-003-01	1.9 J											18									10.5	884		5.3 J	13.6		1 J	9.1 J
009-GW-003-02												16									8.4 J	1,410						

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
009-GW-003-03												14								10.2	1,200								
009-GW-003-04	1 J							NR	NR			2 J									841								1.1 J
009-GW-004-01																				2.9 J	107				9 J				
009-GW-004-02																					123								
009-GW-004-03																					156 J		0.72 J						3.6 J
009-GW-004-04								NR	NR													1.6 J							0.98 J
009-GW-004-C1																		13.9											
009-GW-005-01																					43.6 J								
009-GW-005-02																				4.1 J									
009-GW-005-03																						1.9 J							
009-GW-005-04								NR	NR																			3.6 J	
009-GW-006-01																					60.9 J								101
009-GW-006-02	2.1 J								58				74	2.8						3.8 J									67.9
009-GW-006-03																					85.5 J			11.6					354
009-GW-006-04								NR	NR															4.1 J					126

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V		
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26		
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA		
009-GW-007-01	11 J	63 J	59	86			720			140 J		17,000 J			4,400 J				2.4 J	419					2.4 J				7.2 J	
009-GW-007-02	10 J	37	56	160	13 J		360			78 J		650			1,400						478 J	1.4 J								
009-GW-007-03	18	39	49	130	68		620			90 J		1,200			2,700					1.6 J	435				6.5 J			16.8 J	7.6 J	
009-GW-007-04	13	41	52	430 D	330 D			NR	NR	53		580 DJ									386				5.9 J			2.7 J		
009-GW-008-01																														
009-GW-008-02																					75	48								
009-GW-008-03																						159 J								
009-GW-008-04								NR	NR																				6.2 J	
009-GW-008-C1																														
009-GW-009-01	2.9 J																				11.5	84 J				52.6		1.4 J	3.7 J	
009-GW-009-02	7																				5.7 J					33.5				
009-GW-009-03	12																				4.6 J					11.9 J				
009-GW-009-04	6							NR	NR																0.49 J		10.7		3.1 J	
009-GW-010-01	180	1,300																											8.4 J	
009-GW-010-02	77	480																							383 J		1.9 J			

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethoxy)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	De	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µL)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	** **	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
009-GW-010-03	220	1,200																			485		1.6 J	6.4 J					9.5 J
009-GW-010-04	100	440	D					NR	NR												553		0.5 J	1.3 J					
009-GW-011-01																													3.3 J
009-GW-011-02																				35.9									
009-GW-011-03																				25.3 J									5.1 J
009-GW-011-04								NR	NR											32.7								4 J	
009-GW-012-01	2.6 J	14																			92.3 J			1,460					
009-GW-012-02																				22.6			1.6 J		5.4				
009-GW-012-03		8																		56	87.4 J								7 J
009-GW-012-04		16 J			4 JB			NR	NR											38.2	83.6			1.1 J					4.8 J
009-GW-013-01	4.4 J	31 J			4.2															1.3 J	155			4.3	2.8 J	1	1 J		6.3 J
009-GW-013-02	2.6 J	18																			216		1.7 J		1.9 J				
009-GW-013-03		30																			181 J						16 J		6.4 J
009-GW-013-04	4 J	25						NR	NR											2.5	182			3.7 J			5.4 J		5.1 J

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu\text{L}$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu\text{g/L}$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
009-GW-013-C1																		14											
009-GW-014-01	9	61																			283								
009-GW-014-02	4.3 J																			25.4	281		1.8 J		1.9 J				
009-GW-014-03	4.3 J	26																		36	262		2.1 J						3.6 J
009-GW-014-04	5.39							NR	NR											4.8 J	256			0.95 J				4.7 J	
009-GW-015-01																						409							
009-GW-015-02					9 J															7.3 J	534		1.3 J		4.2 J				
009-GW-015-03										56										9.4 J	459								
009-GW-015-04								NR	NR											8.1 J	437			0.98 J	1.8 J		4.4 J	4.3 J	
009-GW-016-01	28 J	10										5.5 J			27					827	827		1.2 J		20.8	18.8 J			
009-GW-016-02								2.6 J																					
009-GW-016-03	3.7 J															6.7 J					951		2 J		27.9				5.8 J
009-GW-016-04								NR	NR			1 J			5 J						951			3.2 J	22.6				2.1 J
009-GW-017-01																						499							
009-GW-017-03																										1.3 J			

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V		
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26		
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA		
009-GW-017-04	29 J							NR	NR																					
009-GW-018-01																11 J					1,200				8.2					
009-GW-018-03																					1,110				19.8 J					
009-GW-018-04								NR	NR												762			0.8 J	11.2				7.3 J	
009-GW-019-01	28																				401				2.6 J					
009-GW-019-03	26																			2.2 J	222					2.2 J				
009-GW-019-04	29 J																												6.6 J	
009-GW-024-01	1 J																													
009-GW-024-C1																														20.8
009-GW-121-01	3.2 J	9																										6.4 J	6.5 J	
009-GW-121-02																									314	4.1 J				
009-GW-121-03																					448	448			1.6 J					
009-GW-121-04																														
FDS-GW-01A-01	5					280									39															
FDS-GW-01A-02	4 J					230																								

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu$ /L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu$ g/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-01B-01																													
FDS-GW-01B-02																													
FDS-GW-01C-01																													
FDS-GW-01C-02																													
FDS-GW-01D-01																													
FDS-GW-01D-02																													
FDS-GW-01E-01																													
FDS-GW-01E-02																													
FDS-GW-01E-C1																													
FDS-GW-02A-01																													
FDS-GW-02A-02																													
FDS-GW-02B-01																													
FDS-GW-02B-02																													
FDS-GW-02C-01																													
FDS-GW-02C-02																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-03A-01																													
FDS-GW-03A-02																													
FDS-GW-03B-01																													
FDS-GW-03B-02																													
FDS-GW-03C-01																													
FDS-GW-03C-02																													
FDS-GW-04A-01																													
FDS-GW-04A-02																													
FDS-GW-04B-01																													
FDS-GW-04B-02																													
FDS-GW-04C-01																													
FDS-GW-04C-02																													
FDS-GW-05A-01																													
FDS-GW-05A-02																													
FDS-GW-05B-01																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu$ L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu$ g/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-05B-02																													
FDS-GW-05C-01																													
FDS-GW-05C-02																													
FDS-GW-06A-01																													
FDS-GW-06A-02																													
FDS-GW-06B-01																													
FDS-GW-06B-02			6																										
FDS-GW-06C-01																													
FDS-GW-06C-02																													
FDS-GW-07A-01																													
FDS-GW-07A-02																1J													
FDS-GW-07B-01																													
FDS-GW-07B-02																	3J												
FDS-GW-07C-01																													
FDS-GW-07C-02																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Bc	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-07D-01																													
FDS-GW-07D-02																24													
FDS-GW-08A-01																													
FDS-GW-08A-02																													
FDS-GW-08B-01																													
FDS-GW-08B-02																													
FDS-GW-08C-01																													
FDS-GW-08C-02																													
FDS-GW-09A-01																													
FDS-GW-09A-02																													
FDS-GW-09B-01																													
FDS-GW-09B-02																													
FDS-GW-09C-01																													
FDS-GW-09C-02																													
FDS-GW-10A-01																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu/L$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu g/L$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-10A-02																													
FDS-GW-10B-01																													
FDS-GW-10B-02																													
FDS-GW-10C-01																													
FDS-GW-10C-02																													
FDS-GW-11A-01																													
FDS-GW-11A-02																													
FDS-GW-11B-01																													
FDS-GW-11B-02																													
FDS-GW-11C-01																													
FDS-GW-11C-02																													
FDS-GW-12A-01																													
FDS-GW-12A-02																													
FDS-GW-12B-01																													
FDS-GW-12B-02																													

21

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	trityl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu/L$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu g/L$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-12C-01																													
FDS-GW-12C-02																													
FDS-GW-13A-01																													
FDS-GW-13A-02																													
FDS-GW-13B-01																													
FDS-GW-13B-02																													
FDS-GW-13C-01																													
FDS-GW-13C-02																													
FDS-GW-13D-01																													
FDS-GW-13D-02																													
FDS-GW-13E-01																													
FDS-GW-13E-02																													
FDS-GW-14A-01																													
FDS-GW-14A-02																													
FDS-GW-14B-01																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethoxy)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC (µ/L)	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL (µg/L)	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-14B-02																													
FDS-GW-14C-01																													
FDS-GW-14C-02																													
FDS-GW-15A-01		6														23													
FDS-GW-15A-02																21													
FDS-GW-15B-01																													
FDS-GW-15B-02																													
FDS-GW-15C-01																													
FDS-GW-15C-02																													
FDS-GW-16A-01																													
FDS-GW-16A-02																													
FDS-GW-16B-01																													
FDS-GW-16B-02																													

Table 2.9  
 Combined SWMU 9 Shallow Groundwater Data - Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	terryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V	
Tap Water RBC ( $\mu\text{L}$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**.**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26	
MCL ( $\mu\text{g/L}$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA	
FDS-GW-16C-01																													
FDS-GW-16C-02																													
FDS-GW-17A-01																													
FDS-GW-17A-02																													
FDS-GW-17B-01																													
FDS-GW-17B-02																													
FDS-GW-17B-03																													
FDS-GW-17B04											10 J																		
FDS-GW-18A-01																													
FDS-GW-18A-02																													10 J

Table 2.9

Combined SWMU 9 Shallow Groundwater Data – Four Quarters

Sample No.	benzene	chlorobenzene	1,2-dichloroethane	1,2-dichloroethene	methylene chloride	xylene	VC	azobenzene	benzidine	bis(2-chloroethyl)ether	bis(2-ethyl)phthalate	2,4-dimethylphenol	hexachlorobenzene	hexachlorobutadiene	4-methylphenol	naphthalene	pentachlorophenol	hydrazine	tetryl	As	Ba	Be	Cd	Cr	Pb	Sb	Tl	V
Tap Water RBC ( $\mu\text{L}$ )	0.36	11	0.12	5.5	4.1	1,200	0.019	0.61	0.00029	0.0096	4.8	73	0.042	0.86	18	0.65	0.56	0.022	**,**	0.045	260	7.3	1.8	5,500	NA	1.5	0.26	26
MCL ( $\mu\text{g/L}$ )	5	100	5	NA	5	10,000	2	NA	NA	NA	6	NA	1	1	NA	NA	1			50	2,000	4	5	100	15	6	2	NA
GDH-GW-003-05	43																											
GDH-GW-003-C1	43																											

Notes:

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — RGOs obtained from Zone H RFI – Risk Assessment.
- 3 — Background obtained values per June 1997 project team technical subcommittee meeting.
- GW — Groundwater
- ND — Not Detected
- RBC — Risk-based concentration
- J — The associated numerical value is an estimated quantity.
- U — The material was analyzed, but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed, but not detected, and had a QC outlier causing the 3.0 data to be estimated.
- NDA — No data available in Amadata.
- $\mu\text{G/L}$  — micrograms per liter

Bold values indicate parameter concentrations that exceed their tap water RBC or MCL, whichever is higher.

Blank entry indicates either non detect or no analysis performed

NA Not Available/Not Applicable

**Table 2.10  
Combined SWMU 9 Deep Groundwater Data – Four Quarters**

<b>Sample No.</b>	<b>Date</b>	<b>Cadmium (<math>\mu\text{g/L}</math>)</b>	<b>Manganese (<math>\mu\text{g/L}</math>)</b>	<b>Thallium (<math>\mu\text{g/L}</math>)</b>
<b>Tap Water RBC</b>		<b>1.8</b>	<b>73</b>	<b>0.26</b>
<b>MCL</b>		<b>5</b>	<b>NL</b>	<b>2</b>
009-GW-02D-01	11/02/94	2.1 U	73.3	5.8 UJ
009-GW-02D-02	04/17/95	1.2 UJ	184	3.3 U
009-GW-02D-03	09/14/95	3.5 J	171	17.3 J
009-GW-02D-04	03/19/96	0.5 U	96.7	2.7 UJ
009-GW-03D-01	11/19/94	2.1 U	805	4 U
009-GW-03D-02	04/19/95	2.6 J	1,220	3.3 U
009-GW-03D-03	09/26/95	3.8 J	910 J	6.4 UJ
009-GW-03D-04	04/04/96	0.5 U	766	5.7 UJ
009-GW-04D-01	11/21/94	2.1 U	26.6	160 J
009-GW-04D-02	04/19/95	2.7 J	16.6 U	3.3 U
009-GW-04D-03	09/27/95	4.3 J	29.4 U	12.5 U
009-GW-04D-04	04/05/96	0.5 U	7.7 UJ	2.7 UJ
009-GW-05D-01	11/02/94	2.1 U	94	4 UJ
009-GW-05D-02	04/19/95	1.2 UJ	252	3.3 U
009-GW-05D-03	09/28/95	4.8 J	181	50 U
009-GW-05D-04	04/09/96	0.5 U	159	2.7 U
009-GW-06D-01	11/22/94	2.1 U	139 J	5.8 UJ
009-GW-06D-02	04/20/95	3.2 J	278	3.3 U
009-GW-06D-03	10/02/95	4.8 J	172	55.6 J
009-GW-06D-04	04/15/96	0.5 U	144	7.1 U
009-GW-07D-01	11/10/94	2.1 U	755	10 U
009-GW-07D-02	04/24/95	1.2 UJ	1,270	3.3 U
009-GW-07D-03	09/15/95	4.6 J	822	17.2 J

**Table 2.10**  
**Combined SWMU 9 Deep Groundwater Data – Four Quarters**

Sample No.	Date	Cadmium ( $\mu\text{g/L}$ )	Manganese ( $\mu\text{g/L}$ )	Thallium ( $\mu\text{g/L}$ )
<b>Tap Water RBC</b>		<b>1.8</b>	<b>73</b>	<b>0.26</b>
<b>MCL</b>		<b>5</b>	<b>NL</b>	<b>2</b>
009-GW-07D-04	03/21/96	0.5 UJ	<b>809 J</b>	2.9 UJ
009-GW-008D-01	11/28/94	2.1 U	<b>211 J</b>	5.1 UJ
009-GW-08D-02	04/25/95	1.2 UJ	<b>321</b>	3.3 U
009-GW-08D-03	09/28/95	3.9 J	<b>261</b>	50 U
009-GW-08D-04	04/09/96	0.5 U	<b>283</b>	2.7 U
009-GW-12D-01	11/18/94	2.2 J	<b>719</b>	2 U
009-GW-12D-02	04/24/95	1.2 UJ	<b>990</b>	3.3 U
009-GW-12D-03	09/29/95	1.8 J	<b>675</b>	1.6 UJ
009-GW-12D-04	04/11/96	0.5 U	<b>631</b>	2.7 UJ

*Notes:*

- 1 — RBCs obtained from USEPA Region III Risk-Based Concentration Table, April 1998.
- 2 — RGOs obtained from Zone H RFI – Risk Assessment.
- 3 — Background obtained values per June 1997 project team technical subcommittee meeting.
- J — The associated numerical value is an estimated quantity.
- U — The material was analyzed, but not detected at the listed numerical quantization limit.
- UJ — The material was analyzed, but not detected, and had a QC outlier causing the 3.0 data to be estimated.
- NDA — No data available in Anadata.
- NA — Not applicable.

Bold values indicate parameter concentrations that exceed their Tap Water RBC or MCL, whichever is higher.

### 2.2.3 Sediment 1

#### SWMU 9 Sediment Sampling and Analysis 2

Fifteen sediment samples were collected from nearby water bodies to measure the potential impact 3  
 from Combined SWMU 9. The locations of the samples were based on areas that would most 4  
 likely be impacted by a potential release from Combined SWMU 9 and were collected from 5  
 multiple ecological and wetland settings. Contaminants found in sediments were not the same 6

contaminants found in the adjacent Combined SWMU 9 SWMUs/AOCs and therefore do not appear to be related. Further evaluation of the sediments will undertaken in the Zone J RFI.

### **AOC 637 Sediment Sampling and Analysis**

One sediment sample was taken at AOC 637 to determine the impact of contaminant transport via the surface water drainage pathway from the site. It was considered a dry sediment sample in the Ecological Risk Assessment (ERA) for the Zone G RFI Report and is located in Subzone G-2. Subzone G-2 consists of grassy, low-lying fields with some mature trees. Surface soil and sediment samples in this subzone were found to have no risk potential for lethal effects to terrestrial wildlife. The sediment sample was not considered in the HHRA.

## **2.2.4 Surface Water**

### **Combined SWMU 9 Surface Water Sampling and Analysis**

Four surface water samples were collected from nearby water bodies to measure the potential impact from Combined SWMU 9. Surface water samples were collected from the water column in the Shipyard Creek and wetlands adjacent to SWMU 9. No VOCs, SVOCs or pesticides/PCBs were detected in any surface water samples. Dioxin was detected in one duplicate surface water sample at 2.246 pg/L; however no water quality criteria are currently listed for dioxin. Metals that exceeded marine surface water quality criteria includ chromium, lead, nickel, zinc, and copper. Further evaluation of the surface water will undertaken in the Zone J RFI.

### **AOC 637 Surface Water Sampling and Analysis**

One surface water sample was taken at AOC 637 to determine the impact of contaminant transport via the surface water drainage pathway from the site. Bis(2-ethylhexyl)phthalate was detected above the fresh water surface water chronic screening value. Metals that exceeded the screening value include aluminum, beryllium, cadmium, chromium, copper, iron, lead, mercury, and zinc. This sample was not included in the ERA or the HHRA.

**2.3 ISM Status**

**SWMU 9 Geophysical Investigation and Aerial Topographic Survey**

The U.S. Navy Environmental Detachment (DET) Charleston performed an additional intrusive geophysical investigation in January 1999. In addition, an aerial topographic survey of the landfill area was completed in April 1999 to verify the landfill’s northern boundary.

The initial test pits were staked out approximately every 50 feet (Figure 2.24) along the existing estimated northern boundary of the landfill. The northern boundary at the time of the DET investigation extended from the north side of Bainbridge Avenue near Building 1785 to the north side of Bainbridge Avenue near Building 246. Following excavation, each test pit was visually inspected for the presence of landfill debris which, if observed, necessitated excavation of another test pit approximately 25 to 100 feet outward from the initial test pit. Likewise, if no landfill debris was observed at an initial test pit, a subsequent test pit was excavated inward from the initial location. This process continued until the actual extent of the landfill boundary in the area north of Bainbridge Avenue was determined. Following visual inspection and logging of the unearthed material, each test pit was backfilled with the same material that was removed during excavation, then graded to appear as undisturbed as practical.

The aerial topographic survey was conducted after the geophysical survey so that the flyover would include all areas identified by the new landfill boundary. This topographic map is included as Figure 2.25.

**SWMU 8 Excavation**

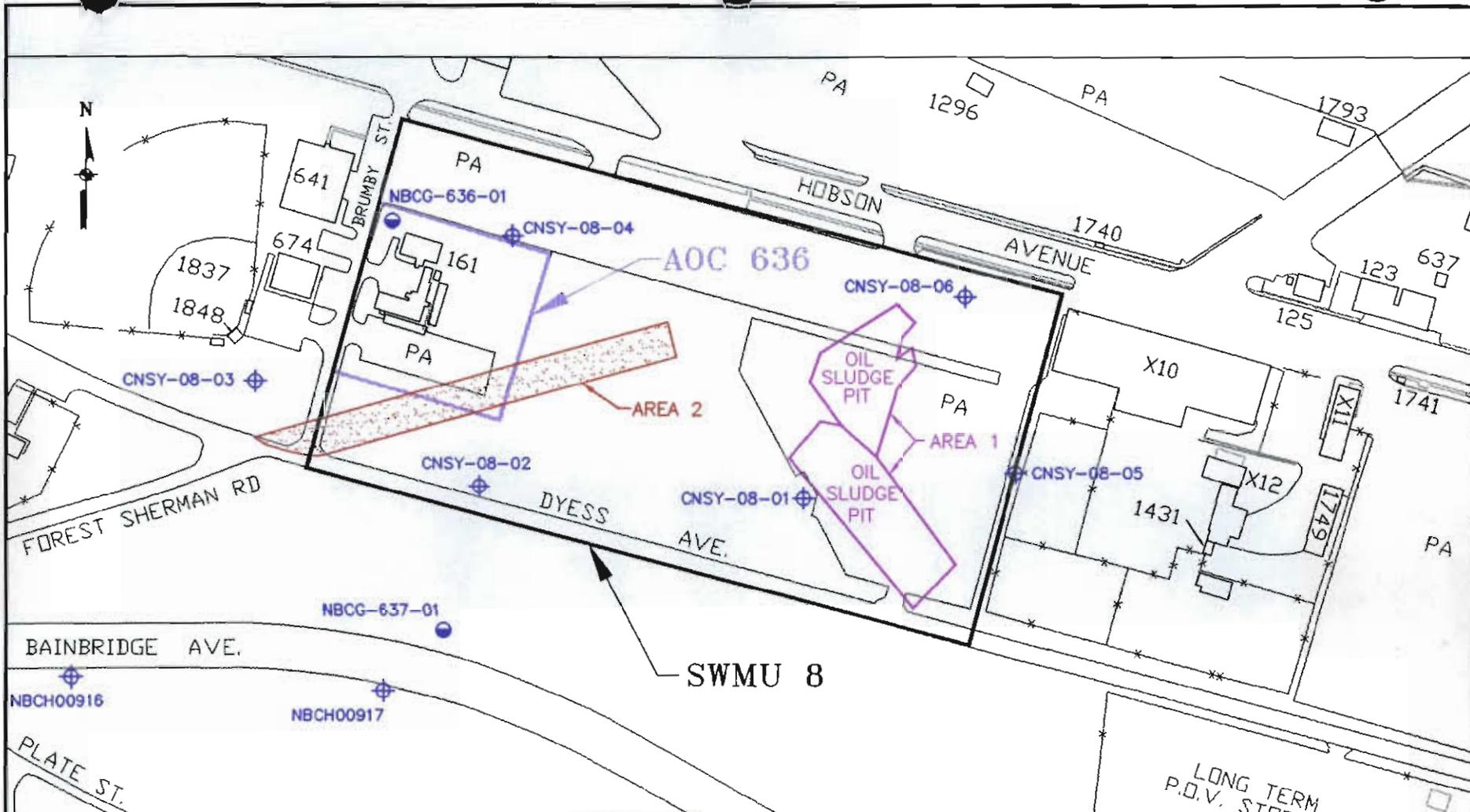
The objective of the ISM performed by the DET was to perform soil borings to locate and delineate the oil contaminated soil boundaries, and to excavate and remove the source of contamination (visible sludge), heavily contaminated soil, and free product. Additionally, AOC 636 (former torpedo magazine) was to be investigated for buried explosives or propellants.

The execution of the ISM consisted of separating SWMU 8 into two work areas by performing soil screenings. The first area (Area 1) contained two smaller pits and the second area (Area 2) contained free product waste oil (Figure 2.26). Excavation and proper disposal/recycling of materials and site restoration was performed in each area. A free product recovery system was installed in Area 2. Additionally Area 2 was investigated for unexploded ordnance.

The contaminated area of Area 1 was determined to be approximately 51,000 square feet.

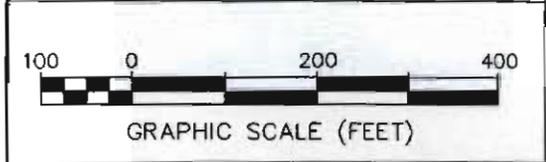
Following the removal of run of crush (ROC) and gravel; 12" sludge piping was discovered at approximately two feet below ground surface. The piping was found to run in an east to west direction and intersected with four additional feed lines, which possibly were the transfer lines of the abandoned oil pits. The pipe's surface wrapping was sampled and found to contain asbestos. Asbestos was removed from some sections of the pipe, with other sections of pipe removed with the asbestos attached. Approximately 437 linear feet of pipe was disposed as asbestos containing waste material. Excavation of the area was to a depth of 4 to 5 feet below ground surface where an approximate 6 inch oil sludge layer was encountered. All visible oil/sludge impacted soil was removed resulting in approximately 500 tons of soil being disposed of to a permitted Subtitle D landfill. Additionally, scrap metal, timbers, glass and other miscellaneous debris was removed. Groundwater was encountered at approximately 4 to 5 feet. The site was backfilled, compacted and graded.

The impacted soils of Area 2 were determined by using soil borings and digging test trenches. The total size of excavation increased the dimensions of the area to approximately 845 feet long by 65 feet wide to a depth of 10 to 12 feet deep. Groundwater was encountered at approximately 4 to 5 feet. Approximately 26,000 tons of petroleum contaminated soil was removed and disposed of in a Subtitle D landfill. Scrap metal, timbers, glass, brick and other miscellaneous debris was removed. Approximately 50,000 gallons of waste oil was recovered and recycled. Approximately 242 linear feet of 12" asbestos lagged oil sludge piping was removed and disposed of as asbestos containing waste material. Piping was removed outside of excavation and plugged.



**LEGEND**

-  - LOCATION OF OIL BODY
-  - SOIL BORING/SHALLOW MONITORING WELL
-  - EXISTING WELL



ZONE H  
COMBINED SWMU 9  
CMS REPORT  
CHARLESTON NAVAL COMPLEX  
CHARLESTON, S.C.

FIGURE 2.26  
LOCATION OF AREA 1 AND AREA 2  
AT SWMU 8

The Area 2 excavation was filled with #57 granite from the bottom up to 5 foot bgs. A layer of geofabric was then installed. The remaining 5 feet was filled with clean soil and a 4 inch layer of ROC. A total of eighteen 18 12-inch diameter polyvinyl chloride (PVC) vertical recovery pipes were installed approximately 50 foot apart to a depth of 10 to 12 feet to facilitate recovery of any residual free product or alternative remedial remedies.

This ISM effectively removed all visible sludge/contaminated soil from Areas 1 and 2. AOC 636 was investigated and determined that no further action was required.

### **3.0 REMEDIAL OBJECTIVES**

To improve the focus of this CMS, this section summarizes the COCs to be directly addressed and their remedial objectives. In some cases, this section justifies the inclusion or removal of COCs identified in the RFI based on the compound’s contribution or lack thereof to significant risks, hazards, or other regulatory standard applicable to this site. In other cases, remedial objectives in addition to those presented in the RFI have been included due to concerns over setting goals below calculated Zone H or Zone G background risk and hazard.

#### **3.1 Soil**

The following sections present the remedial objectives for surface soil at Combined SWMU 9. Any unacceptable risk or hazard posed by surface soil will be actively addressed. Buried landfill waste at Combined SWMU 9 will not be directly addressed (e.g., excavation, in situ treatment) per USEPA guidance for the Comprehensive Environmental Recovery, Compensation, and Liability Act (CERCLA) presumptive remedies at municipal landfills. Therefore, there will be no attempt by this CMS to identify, screen or evaluate potential remedial alternatives for buried waste at the former landfill.

##### **3.1.1 Soil Remedial Objectives**

The USEPA presumptive remedy suggests that a streamlined risk assessment may be possible at candidate sites. For this reason and by CNC project team consensus, in the case of Combined SWMU 9, a streamlined approach considers only industrial background risk and hazard when evaluating and determining soil remedial options (Section 4.2). Residential reuse scenarios that are presented in this CMS are for information and comparison only. The remedy identification, evaluation, and ranking is strictly based on an industrial reuse scenario.

As stated in Section 2; arsenic, lead, Aroclor-1254, Aroclor-1260, and BEQs are the soil COCs at Combined SWMU 9. They were classified as COCs under the industrial scenario risk

assessment, because they contributed to a surface soil risk of greater than  $1E-06$ . None of the COCs contributed to hazard greater than 1.0 or an individual hazard greater than 0.1.

**Arsenic** in surface soil will be addressed at SWMUs 19 and 121 as part of this CMS. However, subsurface soil arsenic will not be further addressed in this CMS for the following reasons:

- Arsenic concentrations in groundwater samples are below maximum contaminant levels (MCLs) and suggest that it's not migrating from the subsurface soil to groundwater at a rate threatening to groundwater.
- The lower-interval detections at SWMU 19 and 121 do not correlate to surface detections and are not representative of vertical migration through the soil. Therefore, the results do not indicate the presence of a spill or other arsenic point release.
- Arsenic did not exceed its subsurface soil background reference concentrations (22.5 milligrams per kilogram [mg/kg]) in samples from SWMUs 19 or 121, and the maximum subsurface soil concentration (10.7 mg/kg at SWMU 121) was approximately 30% less than Zone H's calculated background concentration (15.6 mg/kg).

**Lead** will be addressed at SWMUs 19 and 121 as part of this CMS. The CNC project team approved lead clean-up goals of 400 mg/kg for residential re-use and 1,300 mg/kg for industrial re-use based on USEPA blood-level modeling. However, an assembly of potential remedial alternatives will be based only upon the 1,300 mg/kg threshold.

At SWMU 19, three of 17 surface soil samples exceeded 400 mg/kg lead. Of these three, only one sample (019-SB-017-01, 6,170 mg/kg lead) exceeded the industrial clean-up goal. At

SWMU 19, none of the subsurface soil samples exceeded the industrial clean-up goal, therefore 1  
subsurface soil lead at SWMU 19 will not be further addressed in this CMS. 2

At SWMU 121, eight of 16 surface soil samples exceeded 400 mg/kg. Of these eight, only one 3  
sample (121-S-B-007-01, 2,770 mg/kg lead) exceeded the industrial cleanup goal. No subsurface 4  
soil samples exceeded the lead industrial clean-up goals at SWMU 121, therefore subsurface soil 5  
lead at SWMU 121 will not be further addressed in this CMS. 6

**Aroclor-1254** will be addressed at SWMU 121 and AOCs 649, 650, and 651. The minimum 7  
remedial goal option (RGO) for Aroclor-1254 is 282 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ) based on 8  
an industrial re-use scenario risk of 1E-06. Four of 16 surface soil samples at SWMU 121 9  
exceeded 282  $\mu\text{g}/\text{kg}$ , the highest of which was 4,300  $\mu\text{g}/\text{kg}$ . At AOC 649, 650, and 651, only 10  
one sample 650-S-B-002-01 exceeded 282  $\mu\text{g}/\text{kg}$  with a concentration of 407  $\mu\text{g}/\text{kg}$ . Subsurface 11  
Aroclor-1254 will not be further addressed at either SWMU 121 or AOCs 649, 650, and 651 in 12  
this CMS because no subsurface soil sample exceeded its soil screening level (SSL) of 13  
1,000  $\mu\text{g}/\text{kg}$ . 14

**Aroclor-1260** will be addressed at SWMU 19 and SWMU 121. The minimum RGO for 15  
Aroclor-1260 is 282  $\mu\text{g}/\text{kg}$  based on an industrial risk of 1E-06. Only three of 17 surface soil 16  
samples at SWMU 19 and four of 16 surface soil samples at SWMU 121 had Aroclor-1260 17  
concentrations above 282  $\mu\text{g}/\text{kg}$ . Subsurface Aroclor-1260 will not be further addressed at either 18  
SWMU 121 or 19 in this CMS because no subsurface soil sample exceeded its SSL (1,000  $\mu\text{g}/\text{kg}$ ). 19

**BEQs** in surface soil will be addressed at SWMUs 19, 20, 121, and AOCs 649 and 650, as part 20  
of this CMS. However, BEQs will not be addressed in subsurface soils for the following reasons: 21

- BEQs did not exceed the SSL (1,600  $\mu\text{g}/\text{kg}$ ) in surface soil. The maximum lower-interval concentration was 2,062  $\mu\text{g}/\text{kg}$  at SWMU 19; however, BEQs were not identified as a groundwater COC at Combined SWMU 9. Therefore, BEQs will not be addressed in subsurface soils.

### 3.1.2 Soil Remedial Goal Options

RFI remedial goal options (RGOs) are based on a 95% upper tolerance limit (UTL) site concentration driving a certain level of risk or hazard in surface soil. It is important to note that RFI RGOs are not maximum allowable residual concentrations. Rather, these RGOs represent the 95% UTL of the mean residual concentration. Which means 5% error is allowed or 5% residual contamination would remain.

In addition to these RFI RGOs, alternate RGOs can be calculated by evaluating the incremental reduction in site risk as areas of greatest contamination are removed or otherwise remediated. Such calculations can be used to estimate the area and volume of soil requiring remediation to achieve some risk- or hazard-specific goal such as background risk and hazard. RGOs under risk reduction-based clean-up scenarios are generally equal to Zone H background concentrations. However, risk-reduction based RGOs can be set above background in cases where residual site-risk above background is acceptable and desirable based on site-specific characteristics.

Zone H background risk was calculated by applying the zone-specific background concentration of arsenic to the risk and hazard formulas. Background arsenic concentrations (15.4 mg/kg) generate a Zone H background industrial risk of 5.8E-06. Background BEQ concentrations (0.42 mg/kg) generate a Zone H background industrial risk of 1.4E-06. Therefore, cleanup to an industrial risk level greater than 7.2E-06 (less in a numerical sense) is not warranted at the Zone H SWMUs and AOCs. None of the COCs contributed to hazard greater than 1.0 or an individual hazard greater than 0.1.

Similarly, Zone G background risk was calculated by applying the zone-specific background concentration of arsenic to the risk and hazard formulas. Background arsenic concentrations (17.2 mg/kg) generate a Zone G background industrial risk of 5.8E-06. Background BEQ concentrations (0.453 mg/kg) generate a Zone G background industrial risk of 1.8E-06. Therefore, cleanup to an industrial risk level greater than 7.6E-06 (less in a numerical sense) is not warranted at the Zone G SWMUs and AOCs. Because the total site risk at Zone G is less than that for Zone H (7.6E-06 versus 7.2E-06) removal and/or treatment of Zone G soils is not warranted. None of the COCs contributed to hazard greater than 1.0 or an individual hazard greater than 0.1.

This CMS will use the Zone H background risk for arsenic RGO for evaluating remedial technologies and costs at SWMUs 8, 9, 19, 20, and 121, and AOCs 636, 637, 642, 649, 650, and 651. The background risk for BEQs at Zones G and H are not used for evaluating remedial technologies because its more conservative to base remedial goals on arsenic seeming it is a key risk driver.

At Combined SWMU 9, industrial point risks were ranked in terms of their relative contribution to overall site risk. Tables 3.1 through 3.5 each display the greatest point contributors to industrial risk at each of the Zone H sites within Combined SWMU 9. Figures 3.1 through 3.5 show the reduction in site industrial risk as each point is removed or otherwise remediated. The graphs show which points and the corresponding areas of the site which must be remediated in order to achieve a residual site industrial risk equal to or less than Zone H background industrial risk.

Similarly, Table 3.6 displays the greatest point contributors to industrial risk at each of the Zone G sites within Combined SWMU 9. None of the COCs contributed to hazard greater than 1.0 or an individual hazard greater than 0.1.

Table 3.1  
 Combined SWMU 9 Industrial Scenario Point Risk Reduction Summary

Point to be Removed	Point Risk	Estimated Area (ft <sup>2</sup> )	Cumulative Area (ft <sup>2</sup> )	Site Risk Remaining After Point Removal
None	NA	0	0	9.4E-06
121SB016	1.1E-05	3,000	3,000	8.1E-06
019SB007	5.6E-06	6,520	9,520	6.7E-06
121SB002	4.0E-06	1,016	10,536	6.2E-06
121SB011	1.3E-05	2,360	12,896	5.9E-06
121SB010	6.7E-06	3,000	15,896	5.6E-06
009-SB-071-93	2.5E-05	8,427	24,323	5.3E-06
650SB006	1.0E-05	5,799	30,122	5.1E-06
019SB009	9.7E-06	6,250	36,372	4.9E-06
019SB003	9.7E-06	7,895	44,267	4.7E-06
121SB004	8.1E-06	1,081	45,348	4.5E-06
019SB001	7.3E-06	5,896	51,244	4.4E-06
121SB013	9.0E-06	5,000	56,244	4.2E-06
009-SB-031-93	9.7E-06	5,125	61,369	4.1E-06
650SB003	6.5E-06	4,216	65,585	4E-06
121SB009	6.3E-06	2,390	67,975	3.8E-06

**Note:** Dashed line indicates point at which soils no longer contribute to overall Zone H background industrial risk greater than 7.2E-06. Estimated areas are based on computer generated Thiessen polygons.

**Fig 3.1 Combined SWMU 9 Point Removal  
 Industrial Risk Reduction Graph**

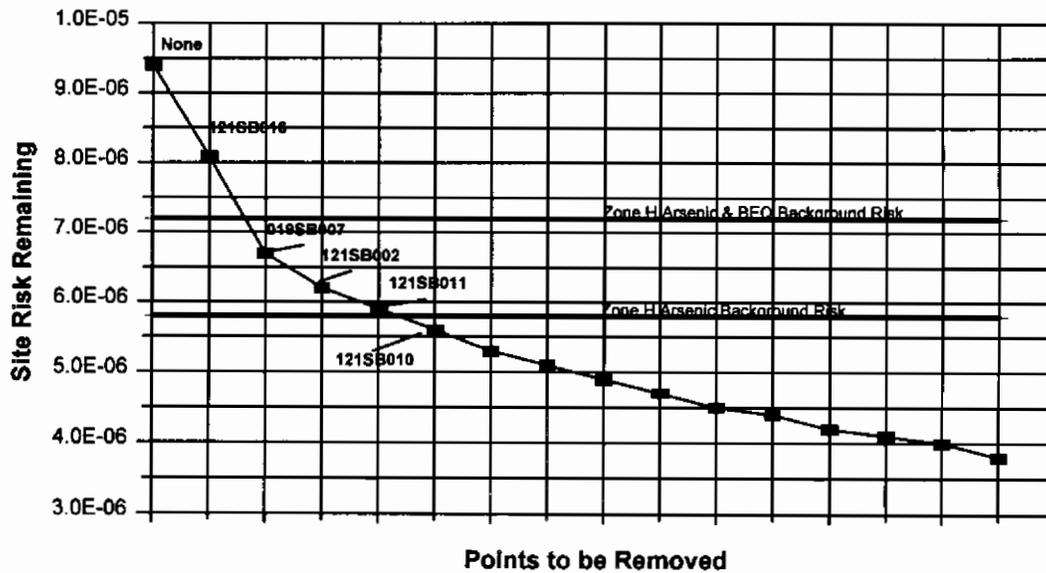
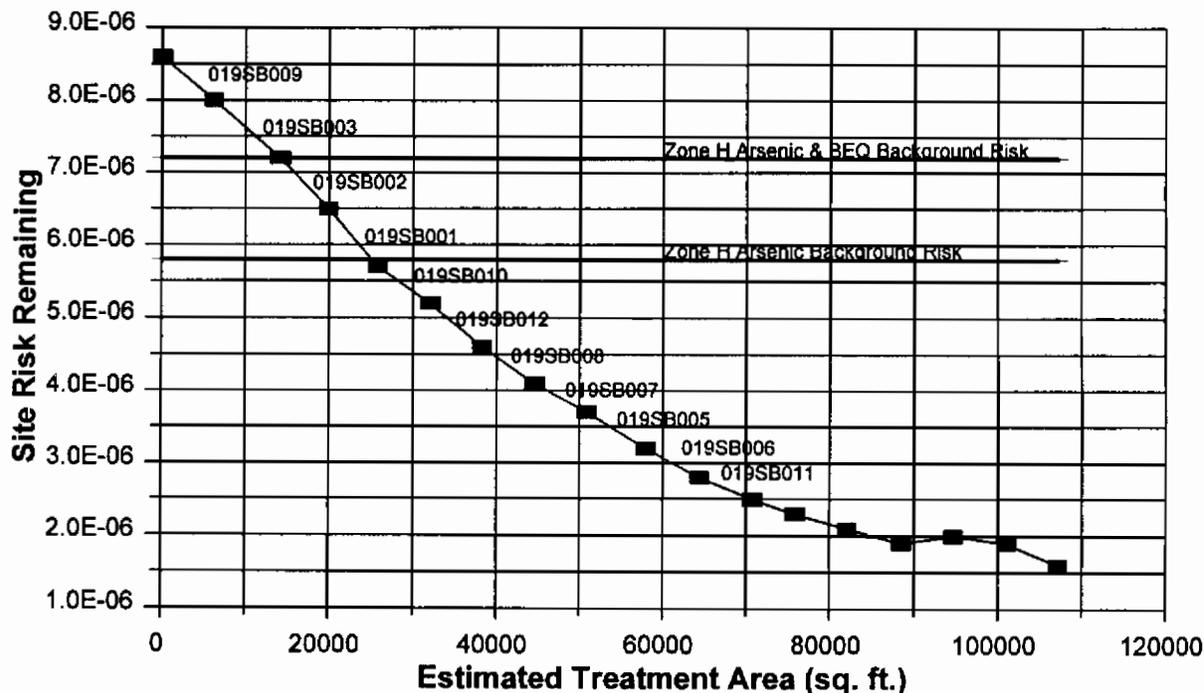


Table 3.2  
 SWMU 19 Industrial Scenario Point Risk Reduction Summary

Point to be Removed	Estimated Area (ft <sup>2</sup> )	Cumulative Area (ft <sup>2</sup> )	Point Risk	Site Risk Remaining After Point Removal
None	0	0	NA	8.6E-06
019SB009	6,250	6,250	9.7E-06	8E-06
019SB003	7,895	14,145	9.7E-06	7.2E-06
019SB002	5,838	19,983	7.9E-06	6.5E-06
019SB001	5,896	25,878	7.3E-06	5.7E-06
019SB010	6,250	32,128	6.7E-06	5.2E-06
019SB012	6,250	44,628	5.6E-06	4.6E-06
019SB008	6,250	44,628	5.6E-06	4.1E-06
019SB007	6,250	50,878	5.6E-06	3.7E-06
019SB005	7,116	57,995	5.2E-06	3.2E-06
019SB006	6,509	64,503	5.1E-06	2.8E-06
019SB011	6,250	70,753	4.1E-06	2.5E-06
019SB004	5,125	75,878	3.5E-06	2.3E-06
019SB018	6,250	82,128	3.5E-06	2.1E-06
019SB014	6,399	88,527	3.4E-06	1.9E-06
019SB017	6,250	94,777	3.3E-06	2E-06
019SB013	6,250	101,027	2.7E-06	1.9E-06
019SB016	6,250	107,277	1.9E-06	1.6E-06

**Note:** Dashed line indicates point at which soils no longer contribute to overall Zone H background arsenic industrial risk greater than 5.8E-06. Estimated areas are based on computer generated Thiessen polygons.

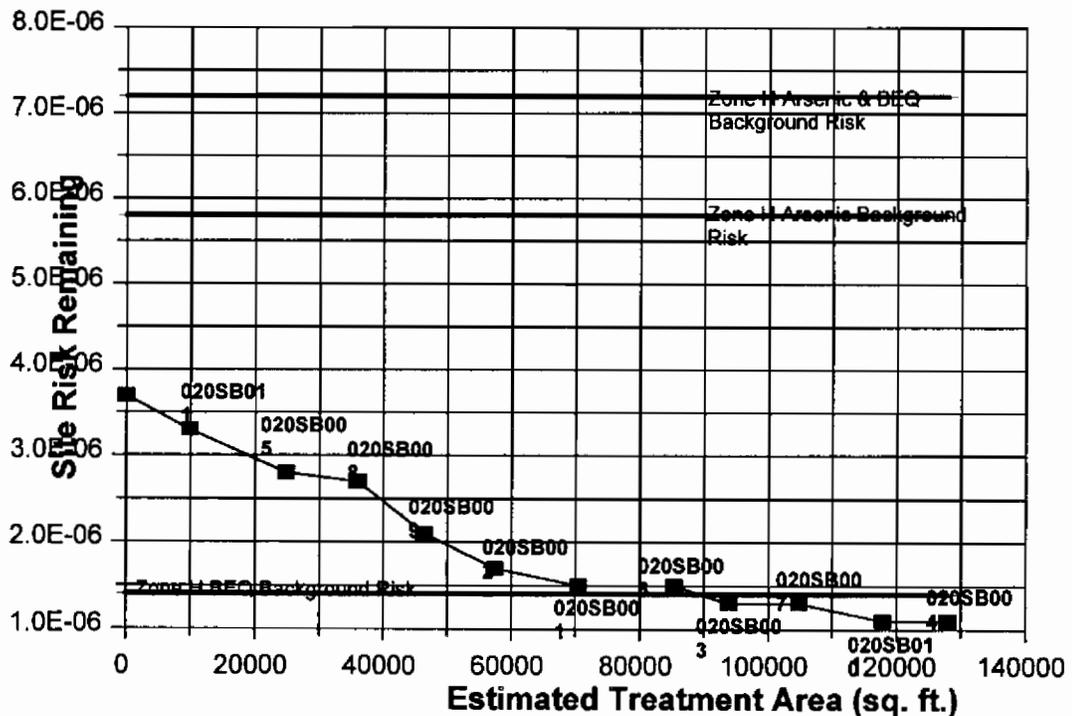
**Figure 3.2 SWMU 19 Point Removal  
 Industrial Risk Reduction Graph**



**Table 3.3**  
**SWMU 20 Industrial Scenario Point Risk Reduction Summary**

Point to be Removed	Estimated Area (ft <sup>2</sup> )	Cumulative Area (ft <sup>2</sup> )	Point Risk	Site Risk Remaining After Point Removal
None	0	0	NA	3.7E-06
020SB011	10,000	10,000	5.1E-06	3.3E-06
020SB005	15,000	25,000	4.3E-06	2.8E-06
020SB008	11,000	36,000	2.8E-06	2.7E-06
020SB009	10,477	46,477	2.7E-06	2.1E-06
020SB002	11,000	57,477	2.1E-06	1.7E-06
020SB001	13,000	70,477	1.7E-06	1.5E-06
020SB006	15,000	85,477	1.5E-06	1.5E-06
020SB003	8,427	93,904	1.5E-06	1.3E-06
020SB007	11,000	104,904	1.3E-06	1.3E-06
020SB010	13,000	117,904	1.3E-06	1.1E-06
020SB004	10,000	127,904	1.1E-06	1.1E-06

**Figure 3.3 SWMU 20 Point Removal Industrial Risk Reduction Graph**

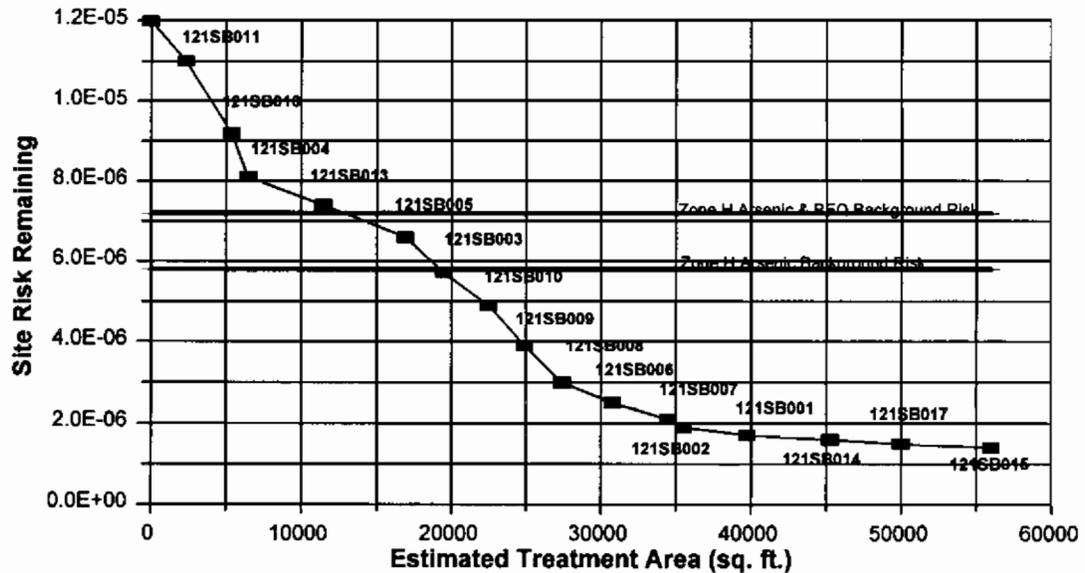


**Table 3.4**  
**SWMU 121 Industrial Scenario Point Risk Reduction Summary**

Point to be Removed	Estimated Area (ft <sup>2</sup> )	Cumulative Area (ft <sup>2</sup> )	Point Risk	Site Risk Remaining After Point Removal
None	0	0	NA	1.2E-05
121SB011	2,360	2,360	2.7E-06	1.1E-05
121SB016	3,000	5,360	4.0E-06	9.2E-06
121SB004	1,081	6,441	6.2E-06	8.1E-06
121SB013	5,000	11,441	8.1E-06	7.4E-06
121SB005	5,500	16,941	8.3E-06	6.6E-06
121SB003	2,578	19,519	5.2E-06	5.7E-06
121SB010	3,000	22,519	4.0E-06	4.9E-06
121SB009	2,390	24,909	5.7E-06	3.9E-06
121SB008	2,487	27,396	6.3E-06	3E-06
121SB006	3,396	30,792	6.7E-06	2.5E-06
121SB007	3,698	34,490	1.3E-05	2.1E-06
121SB002	1,016	35,506	9.0E-06	1.9E-06
121SB001	4,250	39,756	2.4E-06	1.7E-06
21SB014	5,500	45,256	2.2E-06	1.6E-06
121SB017	4,750	50,006	1.1E-05	1.5E-06
121SB015	6,000	56,006	2.3E-06	1.4E-06

**Note:** Dashed line indicates point at which soils no longer contribute to overall Zone H background arsenic industrial risk greater than 5.8E-06. Estimated areas are based on computer generated Thiessen polygons.

**Figure 3.4 SWMU 121 Point Removal  
 Industrial Risk Reduction Graph**

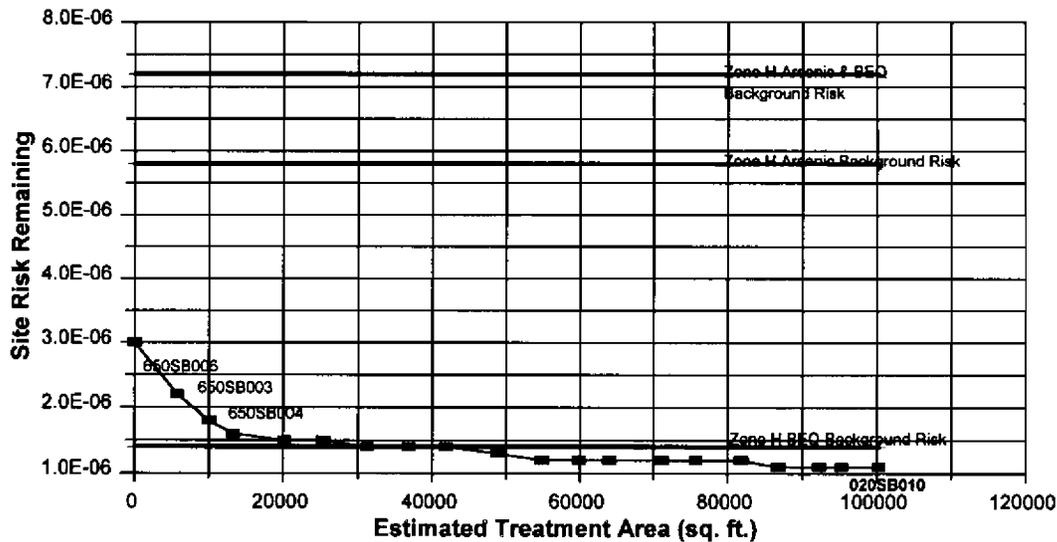


*Draft Combined SWMU 9 Corrective Measures Study Report  
Charleston Naval Complex  
Section 3 – Remedial Objectives  
Revision: 0*

**Table 3.5  
AOCS 649, 650, and 651 Industrial Scenario Point Risk Reduction Summary**

<b>Point to be Removed</b>	<b>Estimated Area (ft<sup>2</sup>)</b>	<b>Cumulative Area (ft<sup>2</sup>)</b>	<b>Point Risk</b>	<b>Site Risk Remaining After Point Removal</b>
None	0	0	NA	3E-06
650SB006	5,799	5,799	1.0E-05	2.2E-06
650SB003	4,216	10,016	6.5E-06	1.8E-06
650SB004	3,253	13,268	4.0E-06	1.6E-06
649SB005	6,915	20,184	1.8E-06	1.5E-06
650SB005	5,244	25,428	1.8E-06	1.5E-06
649SB008	6,000	31,428	1.8E-06	1.4E-06
649SB009	5,500	36,928	1.7E-06	1.4E-06
649SB006	5,000	41,928	1.7E-06	1.4E-06
649SB007	7,000	48,928	1.7E-06	1.3E-06
650SB007	6,000	54,928	1.7E-06	1.2E-06
650SB009	5,000	59,928	1.7E-06	1.2E-06
649SB003	4,080	64,009	1.6E-06	1.2E-06
650SB010	7,000	71,009	1.6E-06	1.2E-06
649SB004	4,798	75,807	1.4E-06	1.2E-06
649SB010	6,000	81,807	1.3E-06	1.2E-06
650SB001	5,000	86,807	1.2E-06	1.1E-06
649SB002	5,495	92,302	1.2E-06	1.1E-06
650SB002	3,098	95,400	1.1E-06	1.1E-06
649SB001	5,006	100,405	1.1E-06	1.1E-06

**Fig 3.5 AOC 649/650/651 Point Removal  
Industrial Risk Reduction Graph**



**Table 3.6  
 Combined SWMU 8 Industrial Scenario Point Risk Reduction Summary**

<b>Point to be Removed</b>	<b>Industrial Point Risk</b>	<b>Estimated Area</b>	<b>Cumulative Area</b>	<b>Site Risk Remaining After Point Removal</b>
None	NA	0	0	1.1E-05
670SB31	9.9E-05	2338	2338	9.9E-06
684SB35	1.0E-04	3268	5606	8.8E-06
684SB21	8.7E-05	2142	7748	7.9E-06
670SB23	2.6E-05	2580	10328	7.5E-06
015SB04	2.6E-05	488	10816	7.0E-06
684SB03	3.2E-05	2496	13312	6.6E-06
684SB44	3.1E-05	4694	18006	6.1E-06
670SB29	2.5E-05	3732	21738	5.8E-06
684SB04	2.0E-05	2616	24354	5.5E-06
684SB24	1.7E-05	2062	26416	5.3E-06
670SB03	1.6E-05	2715	29131	5.1E-06
684SB26	1.3E-05	3066	32197	4.9E-06
670SB12	1.1E-05	2486	34683	4.7E-06
684SB43	1.4E-05	3024	37707	4.5E-06
670SB05	1.1E-05	2499	40206	4.4E-06
670SB32	1.1E-05	5000	45206	4.2E-06
684SB15	1.0E-05	3413	48619	4.1E-06
014SB106	1.0E-05	10000	58619	3.9E-06
684SB01	1.0E-05	5000	63619	3.9E-06
684SB20	9.3E-06	1882	65501	3.8E-06
684SB36	8.2E-06	3468	68969	3.7E-06
015SB03	7.0E-06	762	69731	3.6E-06
670SB04	7.6E-06	2454	72185	3.5E-06
670SB26	7.1E-06	2613	74798	3.4E-06
684SB23	7.2E-06	1612	76410	3.3E-06
670SB01	5.9E-06	3724	80134	3.3E-06
670SB08	6.8E-06	2438	82572	3.2E-06
670SB07	6.5E-06	2172	84744	3.1E-06
670SB06	5.3E-06	4145	88889	3.1E-06
670SB16	5.3E-06	2435	91324	3.0E-06

**Table 3.6  
Combined SWMU 8 Industrial Scenario Point Risk Reduction Summary**

<b>Point to be Removed</b>	<b>Industrial Point Risk</b>	<b>Estimated Area</b>	<b>Cumulative Area</b>	<b>Site Risk Remaining After Point Removal</b>
670SB34	7.2E-06	2942	94266	3.0E-06
684SB27	5.5E-06	2592	96858	2.9E-06
670SB24	5.0E-06	4000	100858	2.8E-06
684SB09	4.9E-06	2664	103522	2.8E-06
014SB04	4.6E-06	7149	110671	2.7E-06
684SB14	4.5E-06	2604	113275	
670SB02	4.8E-06	3837	117112	
670SB18	4.1E-06	6288	123400	
670SB10	4.0E-06	4636	128036	
670SB15	4.1E-06	3373	131409	
014SB05	3.9E-06	2569	133978	
670SB14	3.8E-06	5640	139618	
670SB22	3.8E-06	4000	143618	
014SB10	3.6E-06	4000	147618	
684SB31	3.6E-06	3000	150618	
670SB09	3.5E-06	2493	153111	
684SB07	3.5E-06	2446	155557	
670SB11	3.4E-06	2724	158281	
670SB17	3.4E-06	2597	160878	
014SB02	3.3E-06	3854	164732	
014SB06	3.3E-06	2532	167264	
670SB20	3.3E-06	2571	169835	
670SB27	3.2E-06	4000	173835	
670SB21	3.2E-06	2662	176497	
014SB08	3.1E-06	4938	181435	
684SB22	3.5E-06	2996	184431	
684SB05	3.1E-06	2568	186999	
670SB19	3.0E-06	2502	189501	
684SB18	2.9E-06	2274	191775	
015SB01	2.9E-06	3108	194883	
014SB01	2.8E-06	4942	199825	

**Table 3.6  
 Combined SWMU 8 Industrial Scenario Point Risk Reduction Summary**

<b>Point to be Removed</b>	<b>Industrial Point Risk</b>	<b>Estimated Area</b>	<b>Cumulative Area</b>	<b>Site Risk Remaining After Point Removal</b>
684SB25	3.1E-06	3263	203088	
014SB07	2.9E-06	5280	208368	
684SB28	3.0E-06	2714	211082	
684SB02	2.7E-06	2407	213489	
014SB09	2.6E-06	3000	216489	
670SB25	2.5E-06	3606	220095	
014SB03	2.2E-06	4393	224488	
684SB10	2.1E-06	2470	226958	
014SB11	2.0E-06	10000	236958	
670SB13	2.1E-06	2509	239467	
684SB16	1.9E-06	2636	242103	
684SB29	1.8E-06	3560	245663	
684SB17	1.9E-06	5861	251524	
684SB40	2.3E-06	5000	256524	
684SB19	1.8E-06	2292	258816	
684SB30	1.5E-06	3000	261816	
015SB02	1.5E-06	3773	265589	
684SB13	1.2E-06	2577	268166	
015SB06	1.5E-06	1481	269647	
684SB08	8.6E-07	9505	279152	
684SB33	1.0E-06	5141	284293	
015SB05	9.9E-07	1997	286290	
684SB11	6.7E-07	2133	288423	
684SB34	8.0E-07	5097	293520	
684SB32	7.3E-07	3475	296995	
670SB30	7.1E-07	7056	304051	
684SB12	4.8E-07	2966	307017	
015SB07	5.3E-07	1453	308470	
684SB41	3.2E-07	7000	315470	
684SB42	3.2E-07	7000	322470	
684SB06	2.6E-07	2423	324893	

**Table 3.6**  
**Combined SWMU 8 Industrial Scenario Point Risk Reduction Summary**

Point to be Removed	Industrial Point Risk	Estimated Area	Cumulative Area	Site Risk Remaining After Point Removal
015SB08	1.5E-07	2722	327615	
670SB28	1.5E-07	7140	334755	
670SB33	1.5E-07	5141	339896	
670SB35	1.5E-07	5000	344896	
684SB37	1.5E-07	7205	352101	
684SB38	1.5E-07	4000	356101	
684SB39	1.5E-07	3000	359101	

*Note:* Dashed line indicates point at which soils no longer contribute to overall Zone G background arsenic industrial risk greater than 5.8E-06. Estimated areas are based on computer generated Thiessen polygons.

Compound-specific surface soil RGOs developed during the RFI and the alternate site risk-based RGOs are summarized in Tables 3.7 and 3.8. These values present the range from which the final remedial objectives will be selected by the CNC project team based on the alternative evaluations discussed in Section 5.0. Based on future use plans, the remedial objectives selected from the RGO tables will be used as cleanup goals during the CMS. As previously stated, the residential re-use scenario is being included only for comparison purposes.

**Table 3.7**  
**Zone H Surface Soil Remedial Goal Options (mg/kg)**

**Residential Reuse Scenarios — Zone H**

Parameter	Hazard-Based RGOs				Risk-Based RGOs				Background Concentration
	0.1	1	3	Alternate	1E-06	1E-05	1E-04	Alternate	
Arsenic	2.19	21.9	66	NA	0.383	3.83	38.3	15.6	15.6
Lead	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	400 <sup>2</sup>	NA <sup>3</sup>	NA <sup>3</sup>	NA <sup>3</sup>	400 <sup>2</sup>	118
Aroclor-1254	0.12	1.2	4	NA	0.060	0.60	6.0	ND	ND
Aroclor-1260	NA	NA	NA	NA	0.060	0.60	6.0	ND	ND
BEQs	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	0.06	0.6	6.0	0.42	0.42

**Table 3.7**  
**Zone H Surface Soil Remedial Goal Options (mg/kg)**

**Industrial Reuse Scenarios — Zone H**

Parameter	Hazard-Based RGOs				Risk-Based RGOs				Background Concentration
	0.1	1	3	Alternate	1E-06	1E-05	1E-04	Alternate	
Arsenic	4.3	43.5	1305	NA	2.7	27.1	270.6	15.4 <sup>4</sup> = 5.8E-06	15.6
Lead	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	1,300 <sup>2</sup>	NA <sup>3</sup>	NA <sup>3</sup>	NA <sup>3</sup>	1,300 <sup>2</sup>	118
Aroclor-1254	1.5	15	46	NA	0.28	2.82	28.15	ND	ND
Aroclor-1260	ND	ND	ND	NA	0.28	2.82	28.15	ND	ND
BEQs	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	NA <sup>1</sup>	0.30	3.0	29.7	0.42 <sup>5</sup> = 1.4E-06	0.42

**Notes:**

- 1 — Chemical (lead, BEQs) does not contribute to hazard.
- 2 — USEPA soil guidance concentration for lead based on childhood exposure as predicted by IEUBK model.
- 3 — Chemical (lead) is not a recognized carcinogen and therefore does not contribute to risk.
- 4 — RGO corresponds to the Zone H background industrial risk for arsenic.
- 5 — RGO corresponds to the Zone H background industrial risk for BEQs.
- NA — Not Applicable
- ND — Not Determined

**Table 3.8**  
**Zone G Surface Soil Remedial Goal Options (mg/kg)**

**Residential Reuse Scenarios — Zone G**

Parameter	Hazard-Based RGOs				Risk-Based RGOs				Background Concentration
	0.1	1	3	Alternate	1E-06	1E-05	1E-04	Alternate	
Arsenic	2.2	22	66		0.38	3.8	38	4.1E-05	17.2
BEQs	ND	ND	ND		0.060	0.60	6.0	8.7E-06	0.45

**Industrial Reuse Scenarios — Zone G**

Parameter	Hazard-Based RGOs				Risk-Based RGOs				Background Concentration
	0.1	1	3	Alternate	1E-06	1E-05	1E-04	Alternate	
Arsenic	43	435	1305		2.7	27	270	5.8E-06	17.2
BEQs	ND	ND	ND		0.3	3	30	1.8E-06	0.45

**Notes:**

- 1 — Chemical (BEQs) does not contribute to hazard.
- 2 — RGO corresponds to the Zone G background industrial risk for arsenic.
- 3 — RGO corresponds to the Zone G background industrial risk for BEQs.
- NA — Not Applicable
- ND — Not Determined

Because residual site risk goals can be established within a range of 1E-06 to 1E-04, selecting an appropriate RGO can be based on a residual site risk within this range. For example, at SWMU 19 (Figure 3.2), in order to achieve the soil remedial objective to reduce overall industrial site risk to 2.0E-06, an area over 80,000 square feet (ft<sup>2</sup>) will require removal and/or treatment. Alternatively, to achieve risk equal to that posed by Zone H background arsenic concentrations (5.8E-06), only about 25,000 ft<sup>2</sup> of soil would require removal and/or treatment. Moreover, to achieve risk equal to that posed by Zone H background arsenic and BEQ concentrations (7.2E-06), less than 25,000 ft<sup>2</sup> of soil would require removal and/or disposal. While such exercises in comparative risk versus volume should not be the sole decision tool in selecting a residual risk goal, they do directly influence the cost effectiveness and implementability of any alternative selected.

### **3.1.3 Soil Site Risk Reduction**

Rather than assigning a risk or hazard to each parameter for each surface sampling location, total site risk exceeding background can be determined by accounting for the risk contributed by each sample point. The risk contributed by each surface sample point can be determined by summing each COCs risk at that location. Overall site risk exceeding background can then be reduced by focusing removal actions on sample points that correspond to the most risk. Site hazard was not evaluated because none of the COCs contributed to hazard greater than 1.0 or an individual hazard greater than 0.1.

The UCL Method can be used to evaluate the risk contributed by each point. Site risk reduction by this method is demonstrated in Table 3.1. Notice that in order to achieve the soil remedial objective to reduce overall industrial site risk to 1.0E-06, an area of 392,000 ft<sup>2</sup> (or 15,000 cubic yards [yd<sup>3</sup>]) of soil assuming 1 foot depth) would require removal and/or treatment. Alternatively to achieve a site-wide residual Zone H arsenic background risk of

5.8E-06, approximately 15,896 yd<sup>3</sup> of soil would require removal, disposal, and/or some other response action such as treatment or capping. 1  
2

### 3.2 Groundwater 3

The following sections present the remedial objectives for groundwater at Combined SWMU 9. 4  
Groundwater within the confines of the landfill boundary will not be directly addressed 5  
(e.g., ex or in situ treatment) per USEPA guidance for CERCLA presumptive remedies at 6  
municipal landfills. However, groundwater at the perimeter of the landfill will be monitored over 7  
an extended period to ensure offsite migration of contaminated groundwater does not adversely 8  
impact sensitive nearby receptors such as Shipyard Creek. 9

#### 3.2.1 Groundwater Remedial Objectives 10

In accordance with the USEPA guidance regarding presumptive remedies for landfills, this 11  
particular landfill is considered a low-level risk because it contains primarily municipal-type 12  
wastes (e.g., medical waste, empty oil containers, empty Freon tanks, cargo netting, gas masks, 13  
concrete, wood, and domestic garbage). There is no known active methane gas generation at this 14  
landfill. 15

Combined SWMU 9 represents an ideal candidate landfill for which to apply the presumptive 16  
remedy because it exhibits the following characteristics: 17

- low level risks (excluding hot-spots) 18
- waste treatment is impractical due to waste volume and heterogeneity 19
- non hazardous waste portion of waste is relatively greater than hazardous waste portion 20
- surface impoundments, injection wells, waste piles, working cells are not present 21

While the presence of hot-spots contributing to groundwater contamination within the Combined 22  
SMWU 9 boundary is possible, their potential locations are unknown will likely never be 23

identified. Further, it is not likely that a potential hot-spot is a principal threat waste; it is unlikely that it is in a discrete and accessible part of the landfill; and it is likely not large enough so that its removal will substantially reduce the overall site risk yet small enough so that its removal is practical. Therefore, active remediation of potential hot-spots at Combined SWMU 9 is not warranted per the presumptive remedy.

Furthermore, all the wells which show contamination are within the Combined SWMU 9 landfill boundary as shown on Figure 2.2. The wells along the downgradient perimeter of the Combined SWMU 9 boundary (009GW002, 009GW02D, 009GW005, 009GW05D, 009GW008, 009GW08D, and 009GW011) do not show any contamination above MCLs, with the exception of 009GW008, which has an arsenic concentration of 75  $\mu\text{g/L}$  (MCL = 50  $\mu\text{g/L}$ ). However, in four rounds of sampling, this well had only one arsenic detection above the MCL, and the two subsequent rounds of sampling showed arsenic concentrations well below its MCL at 36  $\mu\text{g/L}$  and 12.1  $\mu\text{g/L}$ . Therefore, there is no evidence to indicate that contaminated groundwater is moving offsite into the impounded wetlands area adjacent the southern portion of Combined SWMU 9 and towards Shipyard Creek. No offsite migration of impacted groundwater is occurring, therefore the presumptive remedy applies.

Per the presumptive remedy, remediation of groundwater within the confines and edges of the landfill is not warranted. However, long-term monitoring (e.g., 30 years) of perimeter wells is recommended to ensure there is no offsite migration to nearby sensitive receptors. In addition, the restriction of groundwater usage through institutional controls is recommended.

#### **GEL 15**

Building 1838 is a single story structure constructed in 1979. Combined SWMU 9 lies north of Shipyard Creek but Building 1838 is located adjacent and south of the creek's headwaters. The area associated with this building is commonly referred to as GEL 15.

The GEL 15 area was initially investigated as part of Combined SWMU 9. During subsequent investigations in 1998 and 1999 it was determined that groundwater in this area was impacted with VOCs and SVOCs. Because the GEL 15 area and Combined SWMU 9 are hydrogeologically separated by Shipyard Creek, these two sites are being addressed under separate CMSs.

### **3.3 Sediment**

#### **3.3.1 Sediment Remedial Objectives**

No COCs were identified in sediments in Combined SWMU 9; therefore, the development of sediment RGOs is not warranted.

### **3.4 Surface Water**

#### **3.4.1 Surface Water Remedial Objectives**

No COCs were identified in surface water in Combined SWMU 9; therefore, the development of surface water RGOs is not warranted.

## **4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES**

This section describes the initial steps toward remedy selection: identification and screening of applicable technologies. Once technologies are identified, they are reviewed based on site-specific conditions and waste constraints. Screening occurs when technologies are either eliminated from or retained for further consideration. From the technologies retained, alternatives for remedial action at Combined SWMU 9 will be developed and further evaluated in Section 5.

### **4.1 Potential Response Actions**

Remedial action technologies can be broadly categorized into general response actions for consideration in the CMS. From these generalized categories, potentially applicable technologies will be selected. The general categories of response actions are summarized below.

- **Institutional Controls:** Institutional controls often supplement engineering controls, as appropriate, for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants. Institutional controls should not supplant active response measures as the sole remedy unless active measures are determined to be impractical. Institutional controls typically include:
  - Site access controls
  - Public awareness, education
  - Groundwater use restrictions
  - Long-term monitoring
  - Deed restrictions
  - Warning against excavation, soil use, etc.

- **Monitored Natural Attenuation (MNA):** This term refers to dilution, dispersion, advection, and biotic degradation of contaminants in the environment. Monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with remediation objectives and to ensure that receptors are not threatened.
- **Treatment:** This treatment can be used to reduce the toxicity, mobility, or volume of the principal threats posed by a site, where practical.
- **Containment:** This engineering control would protect human health and the environment by preventing or controlling exposure to site contaminants for waste that poses a relatively low long-term threat, or where treatment is impractical.
- **Combination:** Appropriate methods can be combined to protect human health and the environment.

## 4.2 Technology Screening

Applicable soil technologies and site and waste constraints are summarized in Table 4.1. Site and waste constraints were used to screen or retain the applicable soil technologies. Screening of potential groundwater technologies was not warranted as will be discussed in Section 4.2.2.

### 4.2.1 Technology Screening Results for Soil Remediation

Combined SWMU 9 soil contamination is primarily confined to the upper-most 0 to 3 feet below ground surface. This soil layer is part of the existing landfill cap which is approximately one to six feet in thickness. This material is generally comprised of hard, tight, silty, clayey fill down to the water table. As such, this material is characterized by relatively low permeability and porosity and a variable organic content. The water table ranges from approximately 4 to 6 feet in this area as affected by location, tidal influence, and time of year (e.g., seasonal precipitation influences).

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
<b><i>Institutional Controls</i></b>				
Institutional Controls	Leaves contaminated soil in place. Site access would be controlled by site access controls, public awareness, education, deed restrictions, etc.	Does not remove the source — plans for future site use may be impacted.	None.	Yes
<b><i>Containment</i></b>				
Surface Cap	Capping is a containment technology that will limit human contact with soil and reduce infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	Plans for future site use may be impacted by capping technology. Subsidence at Combined SWMU 9 could limit capping effectiveness.	None.	Yes
<b><i>Soil in Situ Biological Treatment Technologies</i></b>				
Bioremediation	Naturally occurring microbes are stimulated by circulating water-based solutions through contaminated soils to enhance biodegradation. Nutrients, oxygen, hydrogen peroxide, and other amendments may enhance biodegradation and contaminant desorption from subsurface materials. Bioremediation may occur in aerobic and anaerobic conditions.	Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones.	In situ bioremediation most readily treats non-halogenated volatile, semivolatile, and fuel hydrocarbons. High concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms.	No
Bioventing	Air is either extracted from or injected into the unsaturated soils to increase oxygen concentrations and stimulate biological activity. Flow rates are much lower than for soil-vapor extraction, minimizing volatilization and release of contaminants to the atmosphere.	Bioventing is applicable to contaminants in the vadose zone.	Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Electrokinetically Enhanced Bioremediation	An electric field is applied to electrokinetically transport nutrients and biodegrade bacteria to areas of contamination.	The effectiveness of an electric field can be reduced by the presence of buried metallic conductors, and pH and reduction-oxidation changes induced by the process electrode reactions. Permeability, degree of water saturation, and/or high water table can also impact the process effectiveness.	This technology is appropriate for treating soils contaminated with petroleum hydrocarbons and other compounds easily biodegraded under anaerobic conditions.	No
Landfarming	Contaminated soil is cultivated to enhance contaminant biodegradation.	In situ landfarming should only be performed in low-risk areas where contaminant leaching is not a concern.	In situ landfarming cannot support anaerobic conditions, which are required to cultivate the proper microorganisms for biodegradation of some contaminants.	No
Monitored Natural Attenuation (MNA)	MNA is a long-term management philosophy. Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminants to acceptable concentrations.	MNA may not be a good remediation choice for locations where site conditions make it difficult to predict direction of contaminant movement.	Some inorganics can be immobilized through MNA, but they will not be degraded.	No
Phytoremediation	Phytoremediation is the use of plants to remove, contain, and/or degrade contaminants. Examples include: enhanced rhizosphere biodegradation, phytoaccumulation, phytodegradation, and phytostabilization.	Climatic or hydrologic conditions may restrict the remediation plant's rate of growth and treatment is generally limited to within 3 feet of the soil surface. Due to time required for remediation, plans for future site use may be impacted by phytoremediation.	High concentrations of hazardous materials can be toxic to plants.	Yes

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
<i>Soil in Situ Physical/chemical Treatment Technologies</i>				
Chemical Oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide.	Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with low concentrations of halogenated and non halogenated volatiles and semivolatiles, polychlorinated biphenyls (PCBs), pesticides, cyanides, and volatile and nonvolatile metals.	No
Electrokinetic Separation	Low intensity direct electrical current is applied across electrode pairs that have been implanted in the ground on either side of the contaminated zone. Contaminants desorbed from the soil surface are transported toward cathodes or anodes, depending on their charge.	The effectiveness of electrokinetic remediation can be reduced by the presence of buried metallic conductors, immobilization of metal ions by undesirable chemical reactions with naturally occurring and co-disposed chemicals, and pH and reduction-oxidation changes induced by the process electrode reactions. Permeability and degree of water saturation can also impact the process effectiveness.	This technology can be used to treat soil contaminated with heavy metals, radionuclides, and organic contaminants.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Fracturing	Cracks are developed by fracturing beneath the surface in low permeability and over-consolidated sediments to open new passageways that increase the effectiveness of many in situ processes and enhance extraction efficiencies. Fracturing must be used with a treatment technology such as soil-vapor extraction, bioremediation, vitrification, electrokinetics or pump-and-treat systems. Technologies used in fracturing include blast-enhanced fracturing, pneumatic fracturing, hydraulic fracturing, and Lasagna process.	Cemented sediments limit fracturing effectiveness and fractures will close in non clayey soils. The technology should not be used in areas of high seismic activity. Fracturing can potentially interfere with utilities and site activities.	The potential exists for opening new pathways, which could spread contaminants such as dense nonaqueous phase liquids (DNAPLs).	No
Pressure Dewatering	Air is injected into the soil at a rate that increases groundwater pressure, resulting in groundwater flow away from the air injection site. This technique increases the amount of soil that can be biodegraded through bioventing.	Pressure dewatering applies to remediating contaminants in the vadose zone.	Pressure dewatering applies to contaminant that is more readily degraded aerobically than anaerobically.	No
Soil Flushing	Soil flushing uses water or a solvent to leach contaminants from the soil. Groundwater extraction must be included to prevent spreading contamination in groundwater.	Low-permeability soils are difficult to treat with soil flushing. Soil flushing should only be used where flushed contaminants and flushing fluid can be contained and recaptured.	Mobilization of NAPLs in response to cosolvent flooding can worsen the extent of site contamination.	No
Soil-Vapor Extraction (SVE)	SVE uses extraction wells and vacuum pumps to create a pressure gradient to volatilize contaminants from the soil. The off gases from the extraction wells may require treatment prior to release into the atmosphere.	This technology can be used at sites where areas of contamination are large and deep and/or underneath a structure. Soils should be fairly homogeneous and have high permeability, porosity, and uniform particle size distributions.	SVE applies to soils contaminated with VOCs and some SVOCs. The presence of NAPL in subsurface soil may affect the efficiency of SVE on organic compounds.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Solidification/ Stabilization (S/S)	In situ S/S immobilizes contaminants by mixing site soil with portland cement, lime, or a chemical reagent to reduce the mobility of the contaminant. Large augering equipment is used to mix soils in place with the reagent.	This technology will likely leave a solid mass, similar to concrete, which may impact future use of the site. For stabilization, a tillable mass may remain, as stabilized sites are merely a chemical and not physical process.	This technology works well for inorganics, including radionuclides. Although organic contaminated soils may be treated with S/S, some organics can delay or inhibit reactions necessary for solidification.	No
<b><i>Soil in Situ Thermal Treatment Technologies</i></b>				
Aquathermolysis	Water is heated to 200° to 450°C under pressure and injected into a contaminated area. At these temperatures water acts as a catalyst, reactant and solvent.	Shallow groundwater will limit the effectiveness this technology. Aquathermolysis can impact utilities and water/sewer transport systems.	Aquathermolysis may be effective in aiding the remediation of waste oils, chromium and volatile organic compounds.	No
Thermally Enhanced Soil Vapor Extraction	Site soils are electrically heated to 700°F or higher to degrade and volatilize contaminants. A vacuum system covering the entire treatment area collects all offgases and vaporizes them with heating elements. Residual gases are passed through activated carbon. Different heating systems that are used for this technology include: electrical heating blankets, radio frequency/electromagnetic heating, and hot air injection.	This technology typically requires at least 5 feet between groundwater and the bottom of the treatment zone. Heating the soil to high temperatures can impact utilities and water/sewer transport systems.	This technology has been proven to remove some VOCs, SVOCs, pesticides, herbicides, and PCBs from soil. It can remove some volatile forms of metals from soil, although elemental forms will not be removed.	No
Vitrification	Electrical heating is used to melt contaminated soils, producing a glass-like matrix with very low leaching characteristics.	Shallow groundwater tends to interfere with this process. The technology will create a vitreous mass that may impact future use of the site.	Some organic and inorganic contaminants may volatilize in the process.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
<i>Soil ex Situ Biological Treatment Technologies</i>				
Biopiles	Excavated soils are mixed with amendments, nutrients, and fillers and placed in aboveground enclosures. In an aerated static pile, excavated soils are formed into piles and aerated with blowers or vacuum pumps. Compost piles and static piles are examples of biopiles.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. A large amount of space is required for biopiles.	Biopile treatment has been used to treat nonhalogenated VOCs and fuel hydrocarbons. Halogenated VOCs, SVOCs, and pesticides also can be treated, but the process effectiveness will vary and may apply only to some compounds within these contaminant groups. Heavy metals cannot be degraded by biopiles and can be toxic to the microorganisms.	No
Biosorption	Biosorption is the sorptive removal of toxic metals from solution by a specially prepared biomass.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. This technology may not be effective for clayey soil.	Biosorption removes toxic metals from solution. Not proven effective at concentrations above 30 ppm.	No
Fungal Biodegradation	Fungal biodegradation refers to the degradation of a wide variety of organopollutants by using the lignin-degrading or wood-rotting enzyme system of white rot fungus.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	White rot fungus can degrade and mineralize a number of organopollutants, including the predominant conventional explosives TNT, RDX, and HMX. In addition, white rot fungus has the potential to degrade and mineralize other recalcitrant materials such as DDT, PAHs, and PCBs.	No
Landfarming	Contaminated soil is excavated, applied into lined beds, and periodically turned over or tilled to aerate and enhance biodegradation of contaminants.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. A large amount of space is required for landfarming.	Inorganic contaminants will not be biodegraded and volatile contaminants must be pretreated to prevent polluting the air.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Slurry Phase Biological Treatment	An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed continuously to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Nonhomogeneous soils and clayey soils can create material handling problems.	Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs.	No
<b><i>Soil ex Situ Physical/chemical Treatment Technologies</i></b>				
Chemical Extraction	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. The fractions of soil to be treated are processed in a slurry with specific leachant mixtures to ionize target metals. The treated mixture is further treated to develop an enriched leaching solution, which is then treated to remove the target metals.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Soils with higher clay content may reduce extraction efficiency and require longer contact times.	Acid extraction is suitable for treating soils contaminated by heavy metals.  Solvent extraction has been shown to be effective in treating soils containing primarily organic contaminants, but is generally least effective on very high molecular weight organic and very hydrophilic substances.	No
Chemical Oxidation	Chemical oxidation is a process in which the oxidation state of a contaminant is increased while the oxidation state of the reactant is decreased. The reactant can be another element, including the oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide or chlorine dioxide.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Iron and manganese in the soil will compete with contaminants for oxygen.	This technology is effective in treating media contaminated with low concentrations of halogenated and non-halogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Dehalogenation	Reagents are added to soils contaminated with halogenated organics. The dehalogenation process is achieved by either replacing the halogen molecules or decomposing and partially volatilizing the contaminants. Examples of dehalogenation include base-catalyzed decomposition and glycolate/alkaline polyethylene glycol (A/PEG).	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. High clay and moisture content will increase treatment costs. Capture and treatment of residuals from the process will be especially difficult for soils containing high levels of fines and moisture.	The target contaminant groups for dehalogenation treatment are halogenated SVOCs and pesticides. The technology can be used but may be less effective against selected halogenated VOCs.	No
Physical Separation	Separation techniques concentrate contaminated solids through physical means. These processes seek to detach contaminants from their medium (e.g., soil, sand, or other binding material). Gravity separation, magnetic separation, and sieving/physical separation are examples of this technology.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Specific gravity of particles will affect settling rates and process efficiency.	The target contaminant groups are SVOCs, fuels, and inorganics (including radionuclides). The technologies can be used on selected VOCs and pesticides. Magnetic separation is specifically used on heavy metals, radionuclides, and magnetic radioactive particles, such as uranium and plutonium compounds.	No
Soil Washing	Excavated soil is washed with aqueous-based solutions to separate contaminants sorbed onto fine particles from the rest of the soil matrix. This technology only separates the contaminants and does not destroy them. Further treatment or disposal of the process water is required.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. High humic content in soil may require pretreatment. It may be difficult to remove organics adsorbed to clay-size particles.	This technology is effective at removing SVOCs and inorganics. It is less effective at treating VOCs.	Yes

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Soil Vapor Extraction	A vacuum is applied to a network of aboveground piping to encourage volatilization of organics from the excavated soil. The process includes a system for handling offgases.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. A large amount of space is required for this technology. High moisture content, high humic content, or compact soils will inhibit volatilization.	SVE is applicable to soils contaminated with VOCs and some SVOCs.	No
Solar Detoxification	Solar detoxification is a process that destroys contaminants by photochemical and thermal reactions using the ultraviolet energy in sunlight.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Site must have adequate sunlight.	The target contaminant groups for solar detoxification are VOCs, SVOCs, solvents, pesticides, and dyes. The process may also remove some heavy metals from water.	No
Solidification/Stabilization (S/S)	Contaminants are physically bound or encased within a stabilized mass, or chemical reactions are induced with stabilizing agents. The contaminants are not removed or destroyed, but their mobility is reduced. Examples of S/S technologies include: bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, pozzolan/portland cement, radioactive waste solidification, sludge stabilization, and soluble phosphates.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	This technology works well for inorganics including radionuclides. Although organic-contaminated soils may be treated with S/S, some organics can delay or inhibit reactions necessary for solidification.	No

Table 4.1  
 Soil Technology Screening for Combined SWMU 9

Technology	Description	Site Constraints	Waste Constraints	Retained
Supercritical Carbon Dioxide Extraction (SCDE)	This process employs supercritical carbon dioxide as a solvent to remove normally insoluble organic compounds. It does not destroy target contaminants.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Elevated water content can have a negative impact on SCDE performance.	This technology can remove normally insoluble organics from soil.	No
<b>Soil ex Situ Thermal Treatment Technologies</b>				
Aquathermolysis	Water is heated to 200° to 450°C under pressure and is injected into a contaminated area. At these temperatures water acts as a catalyst, reactant and solvent.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	Aquathermolysis may be effective in aiding the remediation of waste oils, chromium and volatile organic compounds.	No
Distillation	Hydrocarbons and water are volatilized from contaminated media using either heat or vacuum.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	This technology is limited to the removal of organic contaminant from wastes.	No
High-Pressure Oxidation	Wet air oxidation and supercritical water oxidation belong to this technology category. Both processes use high pressure and temperature to treat organic contaminants.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	Wet air oxidation can treat hydrocarbons and other organic compounds.  Supercritical water oxidation is applicable for PCBs and other stable compounds.	No
Hot Gas Decontamination	This process involves raising the temperature of the contaminated material for a specified period of time. The gas effluent from the material is treated in an afterburner system to destroy all volatilized contaminants.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	This process is applicable for demilitarizing explosive items, such as mines and shells (after removal of explosives), or scrap material contaminated with explosives.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Incineration/ Pyrolysis	Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A combustion gas treatment system must be included with the incinerator. The circulating bed combustor, fluidized bed reactor, infrared combustor, and rotary kiln are examples of incinerators. Pyrolysis is a thermal process that chemically changes contaminated sediment by heating it in the absence of air. Pyrolysis can be achieved by limiting oxygen to rotary kilns and fluidized bed reactors. Molten salt destruction is another example of pyrolysis.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration may be effective in treating organic- contaminated soil, but not for soil with metals as the primary contaminants. The target contaminant groups for pyrolysis are SVOCs and pesticides. Pyrolysis is not effective in either destroying or physically separating inorganics from the contaminated medium. Volatile metals may be removed by the higher temperatures, but are not destroyed.	No
Open Burn/Open Detonation	In open burn operations, explosives or munitions are destroyed by self-sustained combustion, which is ignited by an external source, such as flame, heat, or a detonatable wave. Open detonation destroys detonatable explosives and munitions by detonating with an energetic charge.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. For safety purposes, substantial space is required for open processes. Open burn/open detonation requires a RCRA Subpart X permit.	Open burn/open detonation can be used to destroy excess, obsolete, or unserviceable munitions, components, and energetic materials, as well as media contaminated with energetics.	No
Thermal Desorption	Soil is generally heated between 200° and 1,000°F to separate VOCs, water, and some SVOCs from the solids into a gas stream. The organics in the gas stream must be treated or captured. Thermal desorption may be used at high or low temperatures depending on the volatility of the contaminants.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Highly abrasive feed can damage the processor unit. Clay and silty soils and soil with high humic content increase reaction time due to binding of contaminants.	Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption.	No

**Table 4.1**  
**Soil Technology Screening for Combined SWMU 9**

Technology	Description	Site Constraints	Waste Constraints	Retained
Vitrification	Electrical heating is used to melt contaminated soils, producing a glass-like matrix with very low leaching characteristics.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap.	This technology is primarily used for radioactive contaminants.	No
<b><i>Other Soil Treatment Technologies</i></b>				
Excavation and Offsite Disposal	Contaminated soil is excavated and disposed of offsite at a licensed waste disposal facility.	Existing structures and utilities may impede or restrict excavation. Any extensive excavation operations at this closed landfill could compromise existing structures and the existing soil cap. Transportation of the soil through populated areas may affect community acceptance.	TCLP results may impact disposal options.	Yes

Evaluation of potential remedial technologies was evaluated based on these general site characteristics and the contaminants discussed in Section 2. The following technologies were all screened from further consideration because they did not treat all of the primary contaminants in Combined SWMU 9 soil.

Only surface soil and not landfill waste will be addressed as part of this CMS. As discussed in Sections 2 and 3, the USEPA landfill presumptive remedy does not address treatment of the buried waste, but merely its containment.

#### 4.2.1.1 Technologies Eliminated

The following potential remedial technologies have been screened from further consideration and evaluation in the CMS.

#### In situ Bioremediation

- **Bioremediation** was screened from further consideration because it works well primarily in the saturated zone of the soil/groundwater interface. Very large volumes of water would be required to saturate (and keep saturated) contaminated areas to maintain adequate microbial growth at Combined SWMU 9. Nor does it effectively remediate inorganics or BEQs.
- **Bioventing** was screened from further consideration because it does not effectively treat inorganics and BEQs, two primary contaminants at Combined SWMU 9. In addition, the shallow water table limits its effectiveness of the technology because it is difficult to move gases and vapor through the subsurface. The vadose zone should extend at least 10 feet below the ground surface to provide enough soil for bioventing to be an effective way to treat soil contaminants. Furthermore, soil-vapor transport can be severely limited in a soil with a high bulk density, low porosity, and low permeability.

- **Electrokinetically Enhanced Bioremediation** was screened from further consideration 1  
also because it does not effectively treat inorganics and BEQs. Metal ions can be 2  
immobilized by undesirable chemical reactions with naturally occurring and codispersed. 3  
In addition, the vadose zone should extend at least 10 feet below the ground surface to 4  
provide enough soil for this technology to effectively treat contaminants in it. 5  
Furthermore, a heterogenous subsurface (nearly all fill) can reduce removal efficiencies. 6
- **Landfarming** was screened from further consideration because the existing landfill cover 7  
is uneven. Because the depths of contaminated soil vary and landfill debris is present 8  
within this variation, landfarming would be difficult and inefficient. 9
- **Monitored Natural Attenuation** was screened from further consideration because it does 10  
not effectively treat inorganics since these compounds are often immobilized during the 11  
process, but not destroyed. Immobilization may involve adsorption, coprecipitation, 12  
precipitation, and diffusion into the soil matrix, and may either be reversible or slowly 13  
reversible. MNA may treat BEQs effectively, but institutional controls may be required 14  
and limit access to the site during "remediation." 15

#### **Thermal Technologies**

 16

- **Aquathermolysis (in situ and ex situ)** was screened from further consideration because 17  
it does not effectively treat inorganics and BEQs. The shallow water table limits this 18  
technology's effectiveness because it is difficult to move the heated water through the 19  
subsurface without impacting the aquifer. The vadose zone should extend at least 10 feet 20  
below the ground surface to provide enough volume of soil for aquathermolysis to be an 21  
effective approach to treat contaminants in soil. 22

- **Vitrification (in situ and ex situ)** was screened from further consideration because it may impact future use of the site. Ex situ was screened from further consideration because it is primarily used to treat radioactive contaminants and removal of surface soil for subsequent treatment may compromise the existing landfill cover.

#### **Ex situ Bioremediation**

- **Biopiles (or composting)** was screened from further consideration because it treats VOCs and fuel hydrocarbons more effectively than it treats inorganics and BEQs. Composting is generally limited to wastes containing smaller hydrocarbon molecules. The presence of salts or metals may inhibit microbial activity. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Biosorption** was screened from further consideration because it treats dissolved species more effectively than it treats soil-sorbed constituents. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Fungal Biodegradation** was screened from further consideration because it does not effectively treat inorganics and BEQs. Fungal biodegradation is generally limited to organopollutants. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Ex situ Landfarming** was screened from further consideration because a significant amount of land area is required for treatment. In addition, ex situ landfarming requires a more sophisticated (i.e., costly) engineering system than in situ landfarming or bioremediation and removal of surface soil for subsequent treatment may compromise the existing landfill cover. Any extensive excavation may compromise the integrity of the existing soil cover.

- **Slurry-Phase Biological Treatment** was screened from further consideration because it is primarily used to treat nonhalogenated VOCs and SVOCs — it does not effectively treat inorganics and BEQs. Any extensive excavation may compromise the integrity of the existing soil cover.

#### **Chemical and Physical Treatment**

- **Chemical Extraction** was screened from further consideration because it does not effectively treat BEQs. Chemical extraction effectively treats soils containing inorganic and organic contaminants, but is generally least effective on very high-molecular-weight organics' and very hydrophilic substances. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Chemical Oxidation (in situ and ex situ)** were screened from further consideration because they treat VOCs and SVOCs more effectively than they treat inorganics. Moreover, chemical oxidation is typically used to treat soils containing contaminants too concentrated or too toxic for bioremediation to be effective. For in situ oxidation, soils must be sufficiently permeable for the oxidant solution to reach the contamination and for reaction products to move away from the area. Furthermore, background metal concentrations would likely interfere with the process by competing for the chemical oxidants. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Dehalogenation** was screened from further consideration because it does not effectively treat inorganics and BEQs. Dehalogenation is limited to halogenated contaminants. Any extensive excavation may compromise the integrity of the existing soil cover.

- **Distillation** was screened from further consideration because it is limited to the removal of organic contamination. Any extensive excavation may compromise the integrity of the existing soil cover. 1  
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- **Electrokinetic Separation** was screened from further consideration because it is more effective for treating consolidated soil contamination than its does compounds dispersed over a large site, as they are at Combined SWMU 9. 4  
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- **Fracturing** was screened from further consideration because it does not apply to current site conditions. 7  
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- **High-Pressure Oxidation** was screened from further consideration because it does not effectively treat inorganics and BEQs. Any extensive excavation may compromise the integrity of the existing soil cover. 9  
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- **Hot Gas Decontamination** was screened from further consideration because it is primarily used to demilitarize explosives which are not known to be located in Combined SWMU 9. Any extensive excavation may compromise the integrity of the existing soil cover. 12  
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- **Incineration and Pyrolysis** were screened from further consideration because they do not effectively treat inorganics and BEQs. Any extensive excavation may compromise the integrity of the existing soil cover. 15  
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- **Open Burn/Open Detonation** was screened from further consideration because it is primarily used for demilitarizing explosives which are not known to be located in Combined SWMU 9. 18  
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- **Pressure Dewatering** was screened from further consideration because vadose-zone technologies are not being considered for this site. Soil-vapor transport can be severely limited in a soil with a high bulk density, low porosity, and low permeability. In addition, the disposal and potential pretreatment of a significantly large volume of water generated from a dewatering process at the landfill would deem the entire process technically and financially infeasible. 1  
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- **Physical Separation** was screened from further consideration because of the dispersed and relatively low concentrations of inorganic contamination at Combined SWMU 9. Physical separation is typically deployed for sites that contain significant mass of separable matter. It may not yield cost-effective quantities of recoverable metals, and it does not effectively treat BEQs. Any extensive excavation may compromise the integrity of the existing soil cover. 7  
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- **Soil Flushing** was screened from further consideration because groundwater contamination is independent of soil contamination. 13  
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- **Soil Vapor Extraction (in situ, ex situ, and thermally enhanced)** were screened from further consideration because vadose-zone technologies are not being considered for this site. The shallow water table limits the effectiveness of the technology because of the difficulty of moving gases and vapor through the subsurface. The vadose zone should extend at least 10 feet below the ground surface to provide a sufficient volume of soil for soil vapor extraction (SVE) to be an effective approach for treatment of contaminants in soil. Furthermore, soil vapor transport can be severely limited in a soil with a high bulk density, low porosity, and low permeability. Ex situ SVE was screened from further consideration because it effectively treats VOCs and SVOCs, but not BEQs, PCBs or inorganics. 15  
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- **In situ Solidification/Stabilization** was screened from further consideration because it may interfere with future site use and it would be very disruptive of the current cap.
- **Solar Detoxification** was screened from further consideration because it primarily targets VOCs, SVOCs, and solvents rather than inorganics and BEQs. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Solidification/Stabilization** was screened from further consideration because it works well for inorganics primarily. While arsenic and lead are COCs at some SWMUs and AOCs at Combined SWMU 9, BEQs appear to be the primary contaminants, and they may therefore inhibit reactions necessary for solidification. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Supercritical Carbon Dioxide Extraction (SCDE)** was screened from further consideration because it does not effectively treat inorganics and BEQs. Any extensive excavation may compromise the integrity of the existing soil cover.
- **Thermal Desorption** was screened from further consideration because it does not effectively treat inorganic compounds. BEQs may be treated with thermal desorption; however, Combined SWMU 9 BEQs concentrations are too low to supply sufficient British Thermal Units (BTUs) to warrant this thermal technology — it would likely be cost prohibitive. Any extensive excavation may compromise the integrity of the existing soil cover.

#### 4.2.1.2 Technologies Retained

The following potential remedial technologies have been retained for further consideration and evaluation in the CMS.

<b>Institutional Controls</b>	1
• Institutional Controls	2
<b>Containment</b>	3
• Surface Cap (or hot-spot capping)	4
<b>In situ Biological Treatment Technologies</b>	5
• Phytoremediation	6
<b>In situ Physical/Chemical Treatment Technologies</b>	7
• none	8
<b>In situ Thermal Treatment Technologies</b>	9
• none	10
<b>Ex situ Biological Treatment Technologies</b>	11
• none	12
<b>Ex situ Physical/Chemical Treatment Technologies</b>	13
• Soil Washing	14
<b>Ex situ Thermal Treatment Technologies</b>	15
• none	16
<b>Other Treatment Technologies</b>	17
• Excavation and Offsite Disposal (or hot-spot excavation)	18

#### **4.2.2 Technology Screening Results for Groundwater Remediation**

As previously discussed, the USEPA presumptive remedy for municipal landfills applies to Combined SWMU 9. Subsequently, the identification and screening of potential remedial alternatives for contaminated groundwater within the confines and at the perimeter of the landfill is not warranted. However, a remedial alternative comprised of long-term monitoring (e.g., 30 years) of perimeter wells and institutional controls is proposed for Combined SWMU 9. The Code of Federal Regulations (40 CFR 258.61) require that groundwater be monitored in the uppermost aquifer at the landfill boundary or at a set point of compliance downgradient of the landfill for 30 years as part of post-closure requirements. Groundwater samples must be monitored for metals and VOCs.

This proposal is further discussed in Section 6.2, Groundwater Recommendations.

## **5.0 DEVELOPMENT AND EVALUATION OF ALTERNATIVES**

The purpose of the detailed analysis of alternatives is to provide decision makers with adequate information to select an appropriate site remedy. During the detailed analysis, each alternative is assessed against the evaluation criteria described in the OSWER Directive Number 9902.3-2A. Assessment results are then arrayed to compare the alternatives and identify key tradeoffs among them.

### **5.1 Evaluation Process**

The evaluation process is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for a site, and satisfy RCRA requirements for selecting the remedial action.

#### **Primary Criteria**

Four evaluation criteria have been developed to address the RCRA requirements and considerations and their additional technical and policy considerations. The evaluation criteria with the associated statutory considerations that must be met are:

- Primary Criteria 1 — Protection of human health and the environment
- Primary Criteria 2 — Attainment of cleanup standards
- Primary Criteria 3 — Source control
- Primary Criteria 4 — Compliance with applicable waste management standards

#### **Secondary Criteria**

The alternatives are scored on their abilities to meet the four primary criteria, as well as five secondary criteria. These secondary criteria can help rank remedial alternatives that have met all four of the primary criteria described above.

- Secondary Criteria 1 — Long-term reliability and effectiveness 1
- Secondary Criteria 2 — Reduction of toxicity, mobility, or volume 2
- Secondary Criteria 3 — Short-term effectiveness 3
- Secondary Criteria 4 — Implementability 4
- Secondary Criteria 5 — Cost 5

Each remedial alternative is evaluated with respect to the above criteria, as described in the following sections. 6  
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### **5.1.1 Protection of Human Health and the Environment** 8

Corrective action remedies must protective human health and the environment. Each alternative must satisfy this criteria to be eligible for selection. Evaluation of this criteria should provide a final measure to assess whether each alternative adequately protects human health and the environment. Its overall assessment draws on the assessments conducted under other evaluation criteria, especially long-term reliability and effectiveness, short-term effectiveness, and compliance with applicable waste management standards. 9  
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Evaluation of the overall protectiveness of an alternative should focus on whether an alternative achieves adequately eliminates, reduces, or controls the risks posed through each pathway by treatment, engineering, or institutional controls. In making this determination, this evaluation considers whether an alternative poses any unacceptable short-term or cross-media impacts. 15  
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### **5.1.2 Attainment of Cleanup Standards** 19

Remedies must attain media cleanup standards set by the implementing agency, which may be derived from existing state or federal regulations or other standards. The media cleanup standards for a remedy will often play a large role in determining the extent of the remedy and technical approaches to it. In some cases, certain technical aspects of the remedy, such as the practical 20  
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capabilities of remedial technologies, may influence the media cleanup standards that are 1  
established to some degree. 2

In addition, this CMS will evaluate whether the potential remedial alternatives will achieve the 3  
preliminary remediation objective as identified by the implementing agency as well as other, 4  
alternative remediation objectives proposed in the CMS. The amount time required for each 5  
alternative to meet these standards will be estimated and included in this discussion. 6

### **5.1.3 Source Control** 7

A critical objective of any remedy must be to stop further environmental degradation by 8  
controlling or eliminating further releases that may threaten human health and the environment. 9  
Unless source control measures are taken, efforts to clean up releases may be ineffective or, at 10  
best, continue indefinitely. Therefore, an effective source control program is essential to ensure 11  
the long-term reliability and effectiveness of the corrective action program. 12

The source control standard is not intended to mandate a specific remedy or class of remedies. 13  
Instead, the CMS will examine a wide range of options. This standard should not be interpreted 14  
to preclude the equal consideration of other protective remedies to control the source, such as 15  
partial waste removal, capping, slurry walls, in situ treatment or stabilization, and consolidation. 16

This CMS report will also address whether source control measures are necessary, and if so, the 17  
type of actions that would be appropriate. For any source control measure proposed, its estimated 18  
effectiveness based on site conditions and the history of the specific technology will be discussed. 19

### **5.1.4 Compliance with Applicable Waste Management Standards** 20

Corrective action remedies must comply with applicable waste management standards. To be 21  
eligible for selection, each alternative must satisfy this criteria, which is used to evaluate whether 22

each alternative will meet all the federal and state waste management standards identified in the remedial process. The detailed analysis should identify which requirements are applicable or relevant and appropriate to an alternative. The lead agency (the U.S. Navy) determines which requirements are applicable or relevant and appropriate, in consultation with the support agencies (SCDHEC and USEPA). Each alternative’s compliance with the following waste management standards should be addressed during the detailed analysis:

- Chemical-specific regulations
- Location-specific regulations
- Action-specific regulations

#### **5.1.5 Long-term Reliability and Effectiveness**

This secondary criterion evaluates a remedial actions results by the amount of risk remaining at the site after response objectives have been met. This evaluation primarily focuses on the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following should be addressed for each alternative:

- **Magnitude of Residual Risk:** This factor assesses the residual risk from untreated waste or treatment residuals when remedial activities are complete. This risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of constituents in waste, media, or treatment residuals remaining onsite.
- **Adequacy and Reliability of Controls:** This factor assesses the adequacy and suitability of any controls used to manage treatment residuals or untreated wastes remaining onsite. It may include an assessment of containment systems and institutional controls to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

**5.1.6 Reduction of Toxicity, Mobility, or Volume** 1

This criterion gives preference to remedial actions using treatment technologies that permanently and significantly reduce hazardous substances' toxicity, mobility, or volume. The evaluation should consider the following specific factors: 2  
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- The treatment processes, the remedies they will use, and the materials they will treat. 5
  
- The amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed. 6  
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- The degree of expected reduction in toxicity, mobility, or volume, measured as a percentage of reduction (or order of magnitude) when possible. 8  
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- The degree to which the treatment will be irreversible. 10
  
- The type and quantity of treatment residuals that will remain following treatment. 11

**5.1.7 Short-term Effectiveness** 12

Evaluation of a remedial alternative's short-term effectiveness is based on its effect on human health and the environment during implementation. Short-term effectiveness is based on four key factors: 13  
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- Risks to the community during implementation. 16
- Risks to workers during implementation. 17
- Potential for adverse environmental impact as a result of implementation. 18
- Time until remedial response objectives are achieved. 19

**5.1.8 Implementability** 1

This criterion addresses the technical and administrative feasibility of implementing an alternative 2  
and the availability of various services and materials required during its implementation. It 3  
involves analysis of the following factors: 4

**Technical Feasibility** 5

- Technical difficulties and unknowns associated with construction and operation. 6
- Potential technical problems during implementation that may lead to schedule delays. 7
- Ease of remedial action and potential future activities based on technology performance. 8
- Ability and ease of remedy effectiveness monitoring, including an evaluation of the risks 9  
of exposure should monitoring be insufficient to detect a system failure. 10

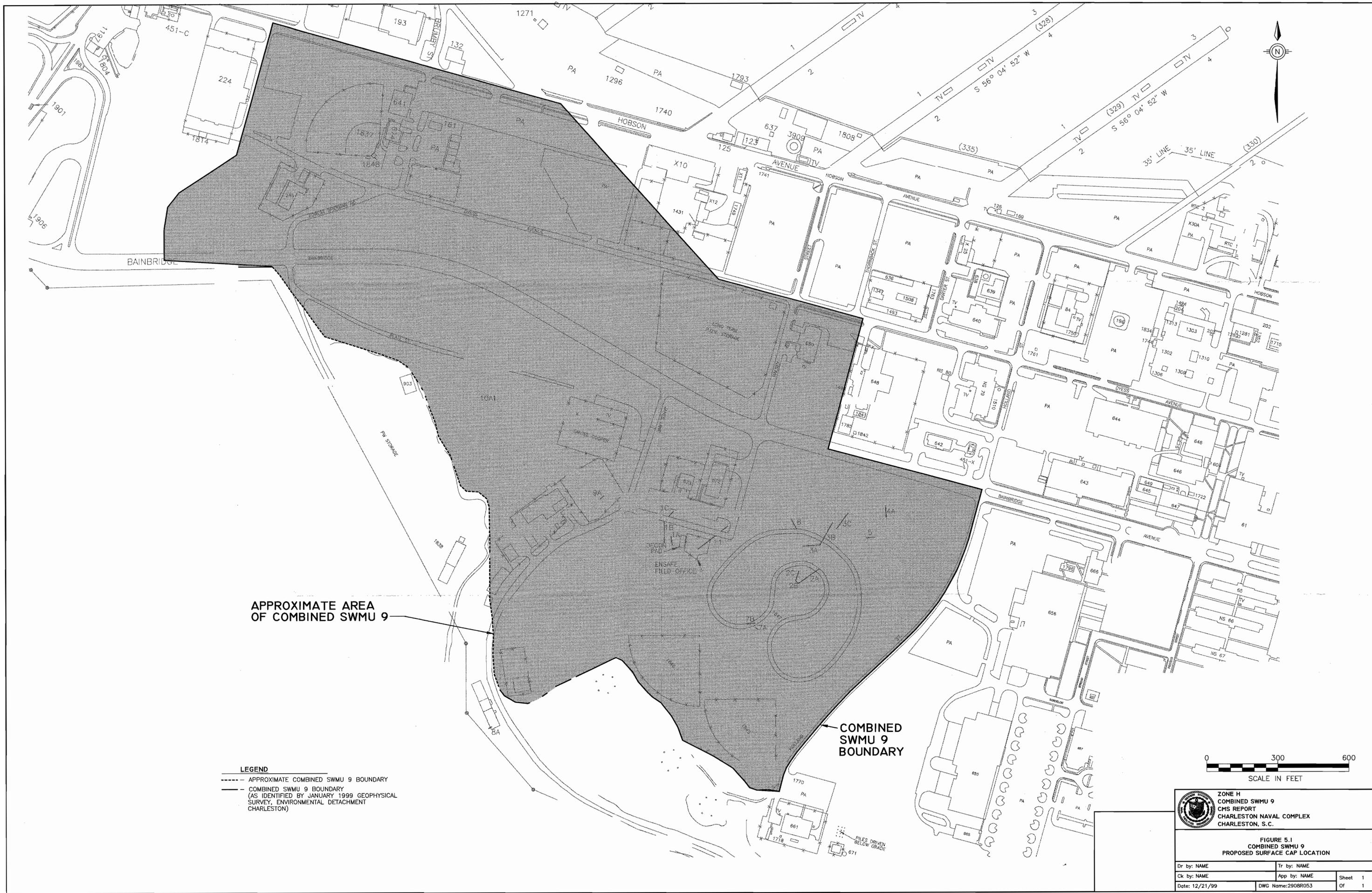
**Administrative Feasibility** 11

- Activities needed to coordinate with other offices and agencies. 12

13

**Availability of Services and Materials** 14

- Availability of adequate offsite treatment, storage capacity, and disposal services. 15
- Availability of necessary equipment and specialists, and provisions to ensure any necessary 16  
additional resources. 17
- Availability of services and materials, plus the potential to obtain competitive bids, which 18  
may be particularly important for innovative technologies. 19
- Availability of prospective technologies. 20



APPROXIMATE AREA  
OF COMBINED SWMU 9

COMBINED  
SWMU 9  
BOUNDARY

**LEGEND**  
 - - - - - APPROXIMATE COMBINED SWMU 9 BOUNDARY  
 \_\_\_\_\_ COMBINED SWMU 9 BOUNDARY  
 (AS IDENTIFIED BY JANUARY 1999 GEOPHYSICAL  
 SURVEY, ENVIRONMENTAL DETACHMENT  
 CHARLESTON)

**ZONE H  
 COMBINED SWMU 9  
 CMS REPORT  
 CHARLESTON NAVAL COMPLEX  
 CHARLESTON, S.C.**

**FIGURE 5.1  
 COMBINED SWMU 9  
 PROPOSED SURFACE CAP LOCATION**

Dr by: NAME	Tr by: NAME	
Ck by: NAME	App by: NAME	Sheet 1
Date: 12/21/99	DWG Name: 2908R053	Of 1

### 5.1.9 Cost

Cost estimates for each remedial alternative are based on engineering analyses, published estimates of necessary technology, and costs for similar actions (such as excavation) at other remediation sites. The cost estimate for a remedial alternative typically consists of three principal elements: capital cost, operations and maintenance (O&M) costs, and present-worth analysis. Costs are expressed in 1999 dollars.

#### Capital Costs

- *Direct costs* for equipment, labor, and materials used to develop, construct, and implement a remedial action.
- *Indirect costs* for engineering, financial, and other services that are not actually part of construction, but are required to implement a remedial alternative. The percentage applied to the direct cost varies with the degree of difficulty associated with construction and/or implementation of the alternative. In this CMS, the indirect costs include health and safety items, permitting and legal fees, bid and scope contingencies, engineering design and services, and miscellaneous supplies or costs.

**Annual O&M Costs:** O&M costs refer to post-construction costs necessary to ensure the continued effectiveness of a remedial action. They typically refer to long-term power and material costs (such as the operational cost of a water treatment facility), equipment replacement costs, and long-term monitoring costs.

**Present-Worth Analysis:** This analysis makes it possible to compare remedial alternatives on the basis of a single cost. This cost represents an amount that would be sufficient to cover all costs associated with the remedial action during its planned life, if invested in the base year and disbursed as needed. A performance period appropriate to each alternative is assumed for

present-worth analyses. Discount rates of 6% are assumed for base calculations. An increase in the discount rate decreases the alternative’s present worth.

The cost elements for each remedial alternative are summarized in the cost analysis section. The study estimate costs provided for the alternatives are intended to reflect actual costs with an accuracy of minus 30% to plus 50%, in accordance with USEPA guidelines.

## **5.2 Evaluation of Soil Remedial Alternatives**

The soil alternatives include institutional controls, capping, in situ and ex situ treatment, and excavation and disposal. Depending on remedial objectives and property reuse considerations for the former landfill, each alternative may include institutional controls and monitoring. The following alternatives have been developed from the technologies retained from the screening described in Section 4.0. Because Combined SWMU 9 includes nine, easily delineated SWMUs (8 [AOC 636 included], 9, 19, 20, 121) and AOCs ( 637, 642, 649/650/ 651 — considered to be one site, and 706), and because each of these sites has site-specific contaminants, the alternatives presented below may include combinations of remedial options for Combined SWMU 9:

- Alternative 1: Institutional Controls
- Alternative 2: Low-Permeability Surface Cap
- Alternative 3: Excavation and Offsite Disposal
- Alternative 4: Hot-Spot Low-Permeability Surface Cap
- Alternative 5: Hot-Spot Excavation and Offsite Disposal
- Alternative 6: Phytoremediation
- Alternative 7: Excavation and Treatment by Soil Washing

## 5.2.1 Alternative 1: Institutional Controls

With this alternative, no remedial actions would be taken to contain, remove, or treat soil in which contaminants exceed remedial objectives. Soil would remain in place. Land-use restrictions and other necessary controls (e.g., fences, natural barriers) would be implemented to ensure restricted access to contaminated soil is restricted. This alternative would not alter existing site wide industrial risk.

### 5.2.1.1 Institutional Controls: Primary Criteria

#### Protection of Human Health and the Environment

Installation of institutional controls would additionally protect human health and the environment by reducing the potential for ingestion or dermal contact. Under the institutional controls scenario, this soil would remain, but risks due to unintended exposure would be reduced by elimination of the dermal contact and ingestion pathways that are present with uncontrolled access.

This alternative allows the existing residual industrial risk of  $9.5E-06$  at Combined SWMU 9 to remain as-is, which is less than the  $1E-04$  threshold typically requiring further action. It is higher than the Zone H background industrial risk for arsenic and BEQs ( $7.2E-06$ ). For these reasons, this alternative would require CNC project team and public approval.

#### Attainment of Cleanup Standards

Under this alternative, the remedial goal would be to decrease the potential for exposure to receptors through land use restrictions. Cleanup standards in the form of contaminant concentrations would not be applicable for soil. However, groundwater within the Combined SWMU 9 boundary would remain onsite in excess of drinking water MCLs.

## **Source Control**

This alternative does not address soil source control. However, appropriate institutional controls would reduce the likelihood of additional risks to future site workers by minimizing exposure pathways. Soil in which contaminants exceed remedial objectives would remain in place.

## **Compliance with Applicable Waste Management Standards**

No waste will be managed under this alternative. Therefore, waste management standards do not apply.

### **5.2.1.2 Institutional Controls: Secondary Criteria**

#### **Long-term Reliability and Effectiveness**

Long-term reliability and effectiveness of institutional controls is limited to the ability to control access to the contaminated soil. The volume and concentrations of soil would remain unchanged. This alternative lacks treatment actions that would require reliability and effectiveness.

#### **Reduction of Toxicity, Mobility, or Volume**

This alternative would not reduce the toxicity, mobility or volume of soil contaminants. Contaminants would remain untreated and in place onsite.

#### **Short-term Effectiveness**

There are no short-term effects resulting from the institutional controls alternative.

#### **Implementability**

The institutional controls alternative is technically feasible and easily implemented. Land-use restrictions and administrative coordination are required to implement institutional controls. Offsite services, materials, specialists, or innovative technologies would not be required. No implementation risks are associated with this alternative.

**Cost**

Costs associated with institutional controls are presented in Table 5.1. They include cost for establishing the controls, soil and groundwater monitoring, and report preparation every five years for 30 years. Soil monitoring will involve obtaining 12 samples every five years, and groundwater sampling will involve sampling 40 wells every five years. All soil and groundwater samples will be analyzed for VOCs, SVOCs, metals, and PCBs. The total cost for this alternative is \$476,343.

**Table 5.1**  
**Alternative 1: Institutional Controls**

Action	Quantity	Cost per Unit	Total Cost
<i>Capital Costs</i>			
Institutional Controls	LS	\$110,000	\$110,000
<i>Operations and Maintenance Costs</i>			
Soil Sampling, Site Monitoring, and Report Preparation every Five Years for 30 Years. (Note: Total cost represents present worth at 6% over 30 years)	6 events	\$85,000/event	\$207,562
Engineering/Oversight	LS	20% cost	\$63,512
Contingency/Miscellaneous	LS	25% cost	\$95,269
<b>Subtotal</b>			<b>\$366,343</b>
<b>Total</b>			<b>\$476,343</b>

*Note:*

LS — lump sum

**5.2.2 Alternative 2: Low-Permeability Surface Cap**

This alternative uses a physical barrier to cover contaminated soil to eliminate dermal and gastrointestinal contact over the entire Combined SWMU 9 area. Cover construction will consist of a 120-acre, 24-inch thick low permeability soil layer with a vegetative cover. Land use would be restricted to industrial purposes using institutional controls to minimize uncontrolled exposure. Implementing this alternative would achieve an industrial site risk of less than 1.0E-6. Low-permeability surface cap placement location is shown on Figure 5.1.

**5.2.2.1 Low-Permeability Surface Cap: Primary Criteria**

**Protection of Human Health and the Environment**

The low-permeability cover would eliminate the threat of dermal and gastrointestinal contact for current and future site workers. Contaminated soil would be left onsite indefinitely; however, the cover would be maintained to ensure adequate protection. This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through institutional controls. Cover construction and maintenance would be easily implemented and current site controls (site security and access control) and the institutional controls would be adequate to ensure minimal disturbance of the cover. Short-term risks from inhalation and dermal contact during implementation would be minimal, and could be controlled using common engineering techniques and personal protective equipment (PPE).

**Attainment of Cleanup Standards**

Surface capping would attain media cleanup standards as established by the CNC project team by eliminating exposure pathways that could lead to dermal and gastrointestinal contact. As a result, industrial risk-based cleanup standards would be achieved. This alternative would thus minimize the threat to human health and the environment by eliminating potential exposure and migratory pathways.

**Source Control**

This alternative would effectively control the source by eliminating further releases (e.g., reducing rainfall infiltration, minimizing dermal contact) from surface soil that may threaten human health and the environment. However, buried landfill waste will continue to act as a source of groundwater contamination. Furthermore, institutional controls would drastically reduce the likelihood of additional risks to future site workers.

**Compliance with Applicable Waste Management Standards**

The cover would isolate or eliminate contaminants exceeding remedial objectives in environmental media, but not manage solid or hazardous waste. Potential contact with soil in which contaminants exceed remedial objectives is eliminated by removing the primary pathways. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. This alternative would not trigger any location-specific regulations.

**5.2.2.2 Low-Permeability Surface Cap: Secondary Criteria**

**Long-term Reliability and Effectiveness**

A cover would effectively reduce site worker contact with the contaminated soil. However, institutional controls and routine O&M would be required to ensure that any exposure to human and environmental receptors is within protective levels. Managing Combined SWMU 9 as an industrial site and restricting land use would eliminate residual site risk.

Soil covers are generally reliable containment controls. If the cover failed, site workers could be exposed; however, repairs could be made to re-establish the cover's integrity. However, future liability may be incurred because the waste would not be destroyed.

**Reduction of Toxicity, Mobility, or Volume**

Capping does not remove, treat, or remediate the contaminated soil; it only contains the soil. The soil cover is considered reversible — since the contaminants exceeding remedial objectives remain onsite, they may be exposed if the cover fails due to poor maintenance. This alternative would not reduce waste toxicity, mobility, or volume.

**Short-term Effectiveness**

Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff. After design plans are approved, cover construction would be expected to take several months.

It is anticipated that the time frame until remedial objectives are satisfied will be relatively brief. Consequently, worker exposure to the contaminants would be minimal.

**Implementability**

A soil cover with institutional controls is technically and administratively feasible. This alternative could be readily applied at the site because the proposed areas to be covered are easily accessible to site workers. Thus, implementation of this alternative would involve emplacement of the cover, implementation of the institutional controls, and establishment of maintenance requirements. Future monitoring and maintenance would involve visually inspecting the cover periodically and repairing any damage or degradation (if required). However, repairs would be easily implemented. Soil covering would not require any extraordinary services or materials.

**Cost**

Costs associated with surface capping are presented in Table 5.2. The capital cost for a 24-inch thick low-permeability soil layer with a vegetative cover, including application of institutional controls, would be \$12,538,050. The present worth O&M costs for this cover are \$140,676 over a 30 year period. Therefore, the total cost for implementing this alternative and maintaining it for a 30-year period is \$12,678,726.

**Table 5.2**  
**Alternative 2**  
**Low-Permeability Surface Cap Costs**

Action	Quantity	Cost per Unit	Total Cost
<b><i>Building Demolition/Asphalt Removal</i></b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	285,000 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$1,140,000
Transportation to Landfill (building/asphalt)	265 days	\$80/hr	\$169,600
Disposal (buildings/asphalt)	9,000 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$180,000
Engineering/Oversight	LS	20% cost	\$298,920
Contingency/Miscellaneous	LS	25% cost	\$448,380
<b>Subtotal</b>			<b>\$2,241,900</b>
<b><i>Capital Costs</i></b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Grading/Site Preparation (Rough grading)	590,000 yd <sup>2</sup>	\$0.99/yd <sup>2</sup>	\$584,100
24-inch Soil Cover	395,000 yd <sup>3</sup>	\$15/yd <sup>3</sup>	\$5,925,000
Vegetative Cover	120 acre	\$2,000/acre	\$240,000
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20%	\$1,372,820
Contingency/Miscellaneous	LS	25%	\$2,059,230
<b>Subtotal</b>			<b>\$10,296,150</b>
<b><i>Operation and Maintenance Cost (Note: Total cost represents present worth at 6% over 30 years)</i></b>			
Maintain Cover (30 years)	30 years	\$2,000/yr	\$28,000
Inspection	30 years	\$1,000/yr	\$15,000
Soil and GW Sampling and Reporting	6 events/30 yrs	\$40,000/event	\$97,676.00
<b>Subtotal</b>			<b>\$140,676</b>
<b>Total</b>			<b>\$12,678,726</b>

**Notes:**

- LS — lump sum
- GW — groundwater
- yr — year
- hr — hour
- ft<sup>2</sup> — square feet
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

### 5.2.3 Alternative 3: Excavation and Offsite Disposal

This alternative would excavate and dispose of all surface soil with organic and inorganic contaminants driving risk above 1E-06 under an industrial re-use scenario. Minor institutional controls will be required to minimize uncontrolled exposure to subsurface soils.

To achieve an industrial risk-based goal of 1E-06, more than 392,000 ft<sup>2</sup> or 15,000 yd<sup>3</sup> of soil will require removal/disposal (assuming an excavation depth of one foot) from areas surrounding the SWMU 9 landfill. The approximate volume of soil requiring removal from each site is presented in Tables 3.2 through 3.5. If the SWMU 9 landfill surface soil is also excavated, a total of 195,000 yd<sup>3</sup> (120 acres = extent of SWMU 9 landfill) would need to be removed. This scenario addressed contaminated soil on a *point-risk basis*, and therefore more soil would require excavation and disposal than the *site risk remedial scenario* presented in Section 5.2.5 (Alternative 5, Hot-Spot Excavation and Offsite Disposal at Combined SWMU 9). Excavated soil would be placed in discrete stockpiles for toxicity characteristic leaching procedure (TCLP) sampling and analysis. Based on the sampling results, the stockpiles will be designated as either hazardous or nonhazardous and disposed of accordingly. After the contaminated soil is removed, clean backfill would be placed in the excavated areas and the area regraded.

#### 5.2.3.1 Excavation and Offsite Disposal: Primary Criteria

##### Protection of Human Health and the Environment

Excavation and offsite disposal protects human health and the environment by removing contaminated soil posing a risk above calculated background levels. This alternative, coupled with appropriate institutional controls, would eliminate risk to human health and the environment due to dermal and gastrointestinal contact.

Short-term risks from inhalation and dermal contact during implementation would be minimal and could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

### **Attainment of Cleanup Standards**

Excavation would attain media cleanup standards as established by the CNC project team (in the interim, cleanup levels are assumed to be background concentrations for each of the COCs where applicable). Contaminated soil would be excavated at select locations until confirmation samples satisfy remedial objectives. Excavation is one of the most aggressive remedial technologies and would likely require the least time to attain cleanup standards.

### **Source Control**

This alternative would effectively control the source by eliminating the most contaminated media. Furthermore, institutional controls will further reduce the likelihood of additional risks by eliminating potential exposure pathways to residual contamination (below calculated background concentrations for each COC). However, buried landfill waste will continue to act as a source of groundwater contamination.

### **Compliance with Applicable Waste Management Standards**

Excavation and offsite disposal meets chemical-specific regulations for the associated sitewide remedial objectives protective of future industrial site workers. Excavation activities onsite may require compliance with federal, state, and local air emissions and storm water control regulations. Transportation offsite would trigger U.S. Department of Transportation regulations. Land disposal restrictions would be triggered if the contaminated soil were determined to be a hazardous waste. TCLP analysis will be performed on several samples to determine if the excavated soil exhibits the toxicity characteristics. No location-specific regulations would be triggered by this alternative.

### 5.2.3.2 Excavation and Offsite Disposal: Secondary Criteria

#### Long-term Reliability and Effectiveness

This alternative would reduce the quantity of soil in which contaminant concentrations exceed industrial risk-based RGOs. However, residual risk would remain after its completion. As such, minor institutional controls would be required to ensure that any exposure to human and environmental receptors is within protective levels.

Removal to a landfill is a reliable and well established option because onsite risks are eliminated. However, since the excavated soil would be transferred to a landfill, future liability might be incurred because the waste is not destroyed.

#### Reduction of Toxicity, Mobility, or Volume

Excavation would eliminate the soil source area and therefore, eliminate contaminants that exceed remedial objectives. This alternative includes the removal of the most contaminated soil from the site and disposal in a secure Subtitle C or D landfill (based on TCLP waste analysis). Since the source would no longer remain onsite, excavation is considered irreversible. However, the waste's overall toxicity, mobility, and volume would not be reduced.

#### Short-term Effectiveness

The excavation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks could be reduced by implementing dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. It is anticipated that the time frame until remedial objectives would be satisfied is several months. Consequently, worker exposure to the contaminants would be minimal.

**Implementability**

Excavation with offsite disposal is technically and administratively feasible at Combined SWMU 9. Removal and offsite disposal is a common remedial alternative that has been applied at previous sites. The only potential technical problems that might slow removal activities are materials handling and disposal (standby time between confirmatory sampling and disposal), and potential foundation support measures (if required). Also, the northern portion of Combined SWMU 9 includes paved areas and buildings, which would require demolition and disposal. The soil volumes are relatively large (approximately 195,000 yd<sup>3</sup>) yet removal activities are anticipated to be easily implemented. Areas to be excavated are readily accessible. No future remedial actions would be required after this alternative is completed.

Excavation with offsite disposal would not require any extraordinary services or materials. The Bee's Ferry Road Landfill in Charleston, South Carolina is a Class D facility and has accepted nonhazardous soil from interim removal actions on the base. The Safety-Kleen (Pinewood) Inc. Landfill is a Class C facility that will accept hazardous waste.

**Costs**

Costs associated with excavation and offsite disposal are presented in Table 5.3. The remediation costs for industrial reuse, including institutional controls, would be \$28,191,900 for excavation and disposal to a nonhazardous Subtitle D landfill and \$75,441,900 for excavation and disposal to a hazardous, Subtitle C landfill. If the excavated soil were distributed between the nonhazardous and hazardous landfills based on TCLP characterization, the actual total cost would fall between these two extremes. There are no O&M costs associated with this alternative.

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**Table 5.3**  
**Alternative 3 – Excavation and Offsite Disposal Costs**

Action	Quantity	Cost per Unit	Total Cost
<b>Building Demolition/Asphalt Removal</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	285,000 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$1,140,000
Transportation to Landfill (building/asphalt)	265 days	\$80/hr	\$169,600
Disposal (buildings/asphalt)	9,000 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$180,000
Engineering/Oversight	LS	20% cost	\$298,920
Contingency/Miscellaneous	LS	25% cost	\$448,380
<b>Subtotal</b>			<b>\$2,241,900</b>
<b>Subtitle D Disposal Facility</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Soil Excavation	195,000 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$3,900,000
Transportation	225,000 yd <sup>3</sup>	\$8/yd <sup>3</sup>	\$1,800,000
Soil Disposal	225,000 yd <sup>3</sup>	\$36/yd <sup>3</sup>	\$8,100,000
Confirmation/TCLP Samples	100 samples	\$100/sample	\$10,000
Backfill	225,000 yd <sup>3</sup>	\$7/yd <sup>3</sup>	\$1,575,000
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20% cost	\$3,100,000
Contingency/Miscellaneous	LS	25% cost	\$4,650,000
<b>Subtotal</b>			<b>\$23,250,000</b>
<b>Total (Subtitle D)</b>			<b>\$25,491,900</b>
<b>Subtitle C Disposal Facility</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Soil Excavation	195,000 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$3,900,000
Transportation	225,000 yd <sup>3</sup>	\$8/yd <sup>3</sup>	\$1,800,000
Soil Disposal	330,000 tons	\$120/ton	\$39,600,000
Confirmation/TCLP Samples	100 samples	\$100/sample	\$10,000
Backfill	225,000 yd <sup>3</sup>	\$15/yd <sup>3</sup>	\$3,375,000
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20% cost	\$9,760,000
Contingency/Miscellaneous	LS	25% cost	\$14,640,000
<b>Subtotal</b>			<b>\$73,200,000</b>
<b>Total (Subtitle C)</b>			<b>\$75,441,900</b>

**Notes:**

- LS — lump sum
- GW — groundwater;
- yr — year;
- hr — hour;
- ft<sup>2</sup> — square feet;
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

**5.2.4 Alternative 4: Hot-Spot Low-Permeability Surface Cap**

This alternative uses a physical barrier to cover specific areas containing contaminated soil at Combined SWMU 9. The barrier will eliminate the potential for dermal and gastrointestinal contact. Land use would be restricted to industrial purposes using institutional controls to minimize uncontrolled exposure. The barrier cap would consist of a 24-inch thick low-permeability soil layer with a vegetative cover over those areas which contribute the greatest arsenic risk, estimated at one-half acre. Implementing this alternative would achieve Zone H arsenic background risk of 5.8E-06. Hot-spot low-permeability surface cap placement location is shown in Figure 5.2.

This alternative differs from alternative 2, low-permeability surface cap, in that alternative 2 proposes a surface cap for the "entire" landfill.

**5.2.4.1 Hot-Spot Low-Permeability Surface Cap: Primary Criteria**

**Protection of Human Health and the Environment**

The hot-spot low-permeability cover would eliminate the threat of dermal and gastrointestinal contact for current and future site workers. Contaminated soil would be left onsite indefinitely; however, the cover would be maintained to ensure adequate protection. This alternative would protect human health and the environment by physically eliminating receptor pathways and controlling access through institutional controls. Hot-spot cover construction and maintenance would be easily implemented and current site controls (site security and access control) and the institutional controls would be adequate to ensure minimal disturbance of the cover. Short-term risks from inhalation and dermal contact during implementation would be minimal, and could be controlled using common engineering techniques and PPE.

**Attainment of Cleanup Standards**

Hot-spot surface capping would attain media cleanup standards as established by the CNC project team by eliminating dermal and gastrointestinal contact. As a result, industrial risk-based cleanup standards for Zone H arsenic background risk would be achieved. This alternative would thus minimize the threat to human health and the environment by eliminating potential exposure and migratory pathways.

**Source Control**

This alternative would effectively control the source by eliminating further releases (e.g., reducing rainfall infiltration, minimizing dermal contact) from the surface soil that may threaten human health and the environment. However, buried landfill waste will continue to act as a source of groundwater contamination. Furthermore, institutional controls would drastically reduce the likelihood of additional risks to future site workers.

**Compliance with Applicable Waste Management Standards**

The cover would isolate or eliminate contaminants exceeding remedial objectives in environmental media, but not manage solid or hazardous waste. The potential for contact with soil in which contaminants exceed remedial objectives is eliminated by removing the primary pathways. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations. This alternative would not trigger any location-specific regulations.

**5.2.4.2 Hot-Spot Low-Permeability Surface Cap: Secondary Criteria**

**Long-term Reliability and Effectiveness**

A cover would effectively reduce site worker contact with the contaminated soil. However, institutional controls and routine O&M would be required to ensure that any exposure to human and environmental receptors is within protective levels. By managing Combined SWMU 9 as an industrial site and restricting land use, residual site risk would be eliminated.

Soil covers are generally reliable containment controls. If the cover failed, site workers could be exposed; however, repairs could be made to re-establish the cover’s integrity. Future liability might be incurred because the waste is not destroyed.

**Reduction of Toxicity, Mobility, or Volume**

Capping does not remove, treat, or remediate the contaminated soil; it provides containment only. The soil and combination cover is considered reversible — since the contaminants exceeding remedial objectives remain onsite, they may be exposed if the cover fails due to poor maintenance. This alternative would not reduce toxicity, mobility, or volume through treatment.

**Short-term Effectiveness**

Adverse impacts to the surrounding environment are not anticipated during cover construction; engineering controls would be applied to manage storm water runoff. Once design plans are approved, cover construction would be expected to take several months, depending on the time of year construction begins. During construction, there would be a risk of dermal or gastrointestinal contact to construction workers and exposure to particulate emissions; however, this risk would be reduced by proper material handling practices and appropriate use of PPE.

It is anticipated that the time frame until remedial objectives are satisfied will be relatively brief. Consequently, worker exposure to the contaminants will be minimal.

**Implementability**

Hot-spot soil cover with institutional controls is technically and administratively feasible. This alternative could be readily applied at the site because the areas proposed to be covered are easily accessible to site workers. Thus, implementation of this alternative would involve emplacement of the cover, implementation of the institutional controls, and establishment of maintenance requirements. Future monitoring and maintenance would involve visually inspecting the cover periodically and repairing any damage or degradation (if required). However, repairs would be easily implemented. Soil covering would not require any extraordinary services or materials.

**Cost**

Costs associated with hot-spot surface capping are presented in Table 5.4. This alternative assumes that any areas covered by asphalt or buildings would remain in lieu of the low-permeability soil cover. The capital cost for a hot-spot 24-inch thick low permeability soil layer with a vegetative cover, including application of institutional controls, is estimated to be \$210,720. Present worth O&M costs for this alternative are \$140,676 over a 30-year period. The total cost for implementing this alternative and maintaining it over a 30-year period is \$351,396.

**Table 5.4  
 Alternative 4  
 Hot-Spot Low-Permeability Surface Cap Costs**

Action	Quantity	Cost per Unit	Total Cost
<b>Capital Costs</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Grading/Site Preparation (rough grading)	2,000 yd <sup>2</sup>	\$0.99/yd <sup>2</sup>	\$1,980
24-inch Soil Cover	1,500 yd <sup>2</sup>	\$15/yd <sup>2</sup>	\$22,500
Vegetative Cover	0.5 acre	\$2,000/acre	\$1,000
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20%	\$28,096
Contingency/Miscellaneous	LS	25%	\$42,144
<b>Subtotal</b>			<b>\$210,720</b>
<b>Operation and Maintenance Cost (Note: Total cost represents present worth at 6% over 30 years)</b>			
Maintain cover (30 years)	30 years	\$2,000/yr	\$28,000
Inspection	30 years	\$1,000/yr	\$15,000
Soil and GW Sampling and Reporting	6 events/30 yrs	\$40,000/event	\$97,676
<b>Subtotal</b>			<b>\$140,676</b>
<b>Total</b>			<b>\$351,396</b>

**Notes:**

- LS — lump sum
- GW — groundwater
- yr — year
- hr — hour
- ft<sup>2</sup> — square feet
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

**5.2.5 Alternative 5: Hot-Spot Excavation and Offsite Disposal**

Total site risk can be determined by accounting for the risk contributed by each sample point. As such, site risk can be drastically reduced by removing the most contaminated points which minimize the volume of soil requiring disposal. Under this alternative, contaminated soil would be excavated according to the site risk reduction analysis developed and discussed in Section 3.3 (Zone H background arsenic risk for sites containing both inorganic and organic risk drivers) and disposed offsite at an approved landfill. Land use will be restricted to industrial purposes under this scenario to minimize uncontrolled exposure.

To achieve a site wide residual Zone H arsenic background risk of 5.8E-06, approximately 15,896 ft<sup>2</sup> (600 yd<sup>3</sup>) of soil would require removal/disposal. Table 3.1 (shown earlier in Section 3) presents sample points requiring removal for both goals. Excavated soil would be placed in discrete stockpiles for TCLP sampling and analysis. TCLP analysis will be performed on several samples to determine if the excavated soil exhibits the toxicity characteristics. Based on the sampling results, the stockpiles will be designated as either hazardous or nonhazardous and disposed of accordingly. After contaminated soil is removed, clean backfill would be placed in the excavated areas and graded.

**5.2.5.1 Hot-Spot Excavation and Offsite Disposal: Primary Criteria**

**Protection of Human Health and the Environment**

Hot-spot excavation and disposal protects human health and the environment by removing soil in which contaminants contribute to site risk exceeding background. This alternative, coupled with appropriate institutional controls, would eliminate risk to future site workers and the environment due to dermal and gastrointestinal contact.

Short-term risks from inhalation and dermal contact during implementation would be minimal and could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

### **Attainment of Cleanup Standards**

Excavation would attain media cleanup standards as established by the CNC project team (in the interim, cleanup standards are assumed to be based on site-risk reduction). Contaminated soil would be excavated at select locations until confirmation samples satisfy site-wide risk reduction remedial objectives. Like site-wide excavation, hot-spot excavation is a more aggressive remedial technology and would likely attain CNC project team cleanup standards in the least time.

### **Source Control**

This alternative would effectively control the source by eliminating the most contaminated media. However, buried landfill waste will continue to act as a source of groundwater contamination. Furthermore, institutional controls would drastically reduce the likelihood of additional risks to future site workers by eliminating potential exposure pathways to residual contamination (below selected site wide risk reduction remedial objectives).

### **Compliance with Applicable Waste Management Standards**

This alternative meets chemical-specific regulations for the associated site-wide remedial objectives protective of future industrial site workers. Excavation activities on-site may require compliance with federal, state, and local air emissions and storm water control regulations. Transportation offsite would trigger U.S. Department of Transportation regulations. Land disposal restrictions would be triggered if the contaminated soil were determined to be a hazardous waste. TCLP analysis will be performed on several samples to determine if the excavated soil exhibits the toxicity characteristics. Based on the sampling results, the excavated soil would be designated as either hazardous or nonhazardous and disposed accordingly.

**5.2.5.2 Hot-Spot Excavation and Offsite Disposal: Secondary Criteria**

**Long-term Reliability and Effectiveness**

This alternative would reduce the quantity of soil in which contaminant concentrations exceed site wide risk reduction remedial objectives. A residual site wide industrial risk below 5.8E-06 would remain after this remedial alternative was complete. Therefore, institutional controls would be required to ensure that any exposure to human and environmental receptors would be within protective levels.

Removal to a landfill is a reliable and well-accepted option because onsite risks are eliminated. However, since the excavated soil would be transferred to a landfill, future liability might be incurred because the waste would not be destroyed.

**Reduction of Toxicity, Mobility, or Volume**

Hot-spot excavation with offsite disposal does not satisfy this preference for treatment. Excavation would eliminate the source area and the contaminants affecting site wide remedial objectives. This alternative would remove the most contaminated soil from the site and dispose of it in a secure Subtitle C or D landfill (based on TCLP waste analysis). Because the source would no longer remain onsite after this technology is employed, excavation is considered irreversible. However, the waste’s overall toxicity, mobility and volume would not be reduced.

**Short-term Effectiveness**

The excavation operation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Excavation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc. It is anticipated

that the time frame until remedial objectives are satisfied will be relatively brief. Consequently, 1  
worker exposure to the contaminants will be minimal. 2

### **Implementability**

 3

Hot-spot excavation with offsite disposal is technically and administratively feasible at 4  
Combined SWMU 9. Removal and offsite disposal are common remedial alternatives that have 5  
been applied at previous sites. The only potential technical problems that might slow removal 6  
activities are materials handling and disposal (standby time between confirmatory sampling and 7  
disposal), and potential foundation support measures (if required). The soil volumes are relatively 8  
small (approximately 600 yd<sup>3</sup>) and removal activities are anticipated to be easily implemented. 9  
Areas to be excavated are readily accessible. No future remedial actions would be required after 10  
this alternative is completed. 11

Hot-spot excavation with offsite disposal would not require any extraordinary services or 12  
materials. The Bee's Ferry Road Landfill in Charleston, South Carolina, is a Class D facility and 13  
has accepted nonhazardous soil from interim removal actions on the base. The Safety-Kleen 14  
(Pinewood) Inc. Landfill is a Class C facility that will accept hazardous waste. 15

### **Costs**

 16

Costs associated with this alternative are presented in Table 5.5. The costs presented are for 17  
building and asphalt demolition and disposal — which would go either to a Subtitle D landfill or 18  
a construction and demolition landfill, disposal of contaminated soil as a nonhazardous waste to 19  
a Subtitle D landfill, and disposal of waste as hazardous waste to a Subtitle C landfill. The total 20  
cost for excavation and disposal to a nonhazardous, Subtitle D landfill, including application of 21  
institutional controls is estimated to be \$258,600. This includes the cost of the building and 22  
asphalt demolition and disposal. Alternatively, the total cost for excavation and disposal to a 23  
hazardous, Subtitle C landfill is estimated to be \$400,860 (also includes cost of the building and 24

asphalt demolition and disposal). If the excavated soil is distributed between the nonhazardous and hazardous landfills based on TCLP characterization, then the actual total cost would fall between these two extremes. There are no O&M costs associated with this alternative.

**Table 5.5**  
**Alternative 5**  
**Hot-Spot Excavation and Offsite Disposal Cost**

Action	Quantity	Cost per Unit	Total Cost
<b>Building Demolition/Asphalt Removal</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	2,500 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$1,000
Transportation to Landfill (building/asphalt)	2 days	\$80/hr	\$640
Disposal (buildings/asphalt)	105 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$2,100
Engineering/Oversight	LS	20% cost	\$1,748
Contingency/Miscellaneous	LS	25% cost	\$2,622
<b>Subtotal</b>			<b>\$13,110</b>
<b>Subtitle D Disposal Facility</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Soil Excavation	600 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$12,000
Transportation	700 yd <sup>3</sup>	\$8/yd <sup>3</sup>	\$5,600
Soil Disposal	700 yd <sup>3</sup>	\$36/yd <sup>3</sup>	\$25,200
Confirmation/TCLP Samples	10 samples	\$100/sample	\$1,000
Backfill	700 yd <sup>3</sup>	\$7/yd <sup>3</sup>	\$4,900
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20% cost	\$32,740
Contingency/Miscellaneous	LS	25% cost	\$49,110
<b>Subtotal</b>			<b>\$245,550</b>
<b>Total (Subtitle D)</b>			<b>\$258,660</b>
<b>Subtitle C Disposal Facility</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Soil Excavation	600 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$12,000
Transportation	700 yd <sup>3</sup>	\$8/yd <sup>3</sup>	\$5,600
Soil Disposal	1,000 tons	\$120/ton	\$120,000
Confirmation/TCLP Samples	10 samples	\$100/sample	\$1,000

**Table 5.5**  
**Alternative 5**  
**Hot-Spot Excavation and Offsite Disposal Cost**

Action	Quantity	Cost per Unit	Total Cost
Backfill	700 yd <sup>3</sup>	\$7/yd <sup>3</sup>	\$4,900
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20% cost	\$51,700
Contingency/Miscellaneous	LS	25% cost	\$77,550
<b>Subtotal</b>			<b>\$387,750</b>
<b>Total (Subtitle C)</b>			<b>\$400,860</b>

**Notes:**

- LS — lump sum
- GW — groundwater
- yr — year
- hr — hour
- ft<sup>2</sup> — square feet
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

### 5.2.6 Alternative 6: Phytoremediation

Phytoremediation is an emerging technology that uses specific plant species and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in soil, sediments, groundwater, surface water, and even the atmosphere. Several types of phytoremediation systems would apply to Combined SWMU 9:

- *Phytoextraction:* Metals, radionuclides, and certain organic compounds (i.e., petroleum hydrocarbons) are removed by direct uptake into the plant tissue. Implementation of a phytoextraction program involves planting at least one species that hyperaccumulates COCs.
- Hyperaccumulation, a specific technology for the remediation of low-level, widespread heavy-metal and radionuclide contamination, is defined as the ability of a plant to uptake and store more than 2.5% of its dry weight in heavy metals. To accomplish hyperaccumulation, plants are grown in contaminated soil or water and assimilate the

contaminants through a process known as *translocation*. In this process, contaminants are absorbed by the root system of a plant and moved to the aboveground parts — the stems and leaves — where they can easily be harvested and removed from the site.

- *Phytostabilization*: Certain plant species are used to absorb and precipitate contaminants, generally metals, reducing their bioavailability, and so reducing the potential for human exposure to these contaminants. Plants used in this process often produce a large root biomass that is able to immobilize the COCs through uptake, precipitation, or reduction.
- *Phytotransformation*: Certain plants are used to degrade contaminants through plant metabolism.
- *Phytostimulation*: Microbial biodegradation is stimulated in the root zone. The plants provide carbonaceous material and essential nutrients through liquids released from roots and root tissue decay. In addition, oxygen released from plants increases the oxygen content in the microbially rich rhizopheric zone.

Laboratory and field studies would be used to determine the appropriate plant species required to remediate the COCs. In addition, these studies would help in the planting scheme design including plant spacing, fertilization frequency, soil amendments, and water requirements.

Under this alternative, contaminated soil would be treated according to the site risk reduction analysis developed and discussed in Section 3.3 (Zone H arsenic background risk). Disposal of resulting contaminated plant material would be offsite at an approved landfill. Minimal institutional controls (e.g., fencing, signs, deed restrictions) would be required to minimize uncontrolled exposure for the industrial scenario.

**5.2.6.1 Phytoremediation: Primary Criteria** 1

**Protection of Human Health and the Environment** 2

Phytoremediation protects human health and the environment by slowly removing, transforming, 3  
or immobilizing contaminants in the soil. This alternative, coupled with appropriate institutional 4  
controls, would eliminate risk to future site workers and the environment and drastically reduce 5  
the potential for continued contaminant migration. 6

Short-term risks from inhalation and dermal contact during implementation would be minimal and 7  
could be controlled using common engineering techniques and appropriate PPE. This alternative 8  
would comply with applicable waste management standards and remedial objectives. 9

Phytoremediation is still considered an innovative technology. As such, long-term reliability and 10  
effectiveness are relatively unknown. However, substantial research has been conducted to: 11  
(1) identify and develop plants that are more effective on target compounds, (2) understand the 12  
biological processes behind phytoremediation, and (3) increase the number of field-scale 13  
applications. Phytoremediation, which may be two to three times less expensive than chemical 14  
and physical remedial technologies, is a passive approach that is effective months and years rather 15  
than weeks. 16

Finally, public acceptance of phytoremediation can be very high, in part because of the park-like 17  
aesthetic, which includes bird and wildlife habitats. 18

**Attainment of Cleanup Standards** 19

Phytoremediation would attain media cleanup standards as established by the CNC project team. 20  
Phytoremediation is the one of the least aggressive remedial technology and would likely require 21  
the most time to attain proposed cleanup standards. 22

**Source Control**

This alternative would provide effective source control by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk. Disposition of resulting affected plant material would eliminate the contaminants from the site. However, buried landfill waste will continue to act as a source of groundwater contamination. Furthermore, institutional controls would drastically reduce the likelihood of additional risks to future site workers by eliminating potential exposure pathways to residual contamination.

**Compliance with Applicable Waste Management Standards**

Phytoremediation meets remedial objectives that are protective of future industrial site workers. Transportation of harvested materials offsite may trigger U.S. Department of Transportation regulations. Land-disposal restrictions would be triggered if the contaminated media were determined to be a hazardous waste. Although it is anticipated that the harvested plant materials would be nonhazardous, TCLP analyses would likely be performed for verification. No location-specific regulations would be triggered by this alternative.

**5.2.6.2 Phytoremediation: Secondary Criteria**

**Long-term Reliability and Effectiveness**

Phytoremediation is currently limited to research activities and limited field testing. While several recent and ongoing applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology are scarce. Reported results show fair potential for practical applications of phytoremediation techniques to achieve remedial objectives and regulatory approval; however, at least two or three more years of field tests are necessary to validate the initial, small-scale field tests.

### **Reduction of Toxicity, Mobility, or Volume**

This alternative would effectively reduce toxicity, mobility, or volume by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk. Toxicity would be reduced by phytotransformation and phytostimulation, which use biological processes to degrade the contaminants to less toxic forms. However, this alternative may generate more toxic treatment residuals. Mobility would be reduced by phytoextraction and phytostabilization, which either immobilize the contaminants in the subsurface or in the plant leaves. Volume would be reduced by phytoextraction. Contaminants, particularly metals, are transferred from the soil to the plants, which can be harvested and disposed of in a landfill. Typically the volume of plant material requiring disposal is much less than the original quantity of contaminated soil. Moreover, with appropriate monitoring and maintenance, toxicity, mobility, and volume reduction would be irreversible.

### **Short-term Effectiveness**

The phytoremediation operation would be sufficiently removed from the public to reduce health and safety concerns associated with soil remediation. Workers would be exposed to increased particulate emissions during planting and grading activities and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan that specifies PPE, respiratory protection, etc.

### **Implementability**

Phytoremediation is technically and administratively feasible at Combined SWMU 9. Areas to be remediated are readily accessible. Contaminants are generally in the top 1 to 3 feet of soil, which contributes to phytoremediation success. Overall, this alternative is easy to install, maintain, and monitor. Only landscaping equipment would be required to implement this technology.

Confirmatory sampling would be required to monitor its performance. No future remedial actions would be required after this alternative is completed. Institutional controls would be required.

Specific methods for application to contaminated sites have not been standardized, but general principles have been established. The general steps followed in the design and implementation of a phytoremediation project for any of the techniques include:

- Site characterization, including determination of soil and water chemistry/conditions, climate, and contaminant distributions.
- Treatability studies to determine remediation rates and appropriate plant species, planting density location, etc. Agricultural analyses and principles are required to complete the treatability study.
- Preliminary field testing at the site to monitor results and refine design parameters.
- Full-scale remediation
- Disposal of resulting plant material.

Phytoremediation would probably take years to satisfy remedial objectives. Table 5.6 summarizes its advantages and limitations.

**Table 5.6  
 Phytoremediation Advantages and Limitations  
 (Miller, 1996 and Chappell, 1997)**

Advantages	Limitations
In situ technology	Limited to shallow soils, streams, and groundwater — generally restricted to groundwater within 10 feet of the ground surface
Passive treatment with minimal associated O&M	High concentration of hazardous materials can be toxic to plants
Solar powered	Regulator unfamiliarity
Organic pollutants may be degraded to carbon dioxide and water, removing, as opposed to transferring, environmental toxicity	Climatic and agricultural conditions may influence growth rate and indirectly influence, treatment system effectiveness
Cost-effective for large volumes of soil having low concentrations	Slower than mechanical treatment systems
Overall costs can be 10% to 20% of traditional ex situ systems	Only effective for moderately hydrophobic contaminants
Transfer is faster than monitored natural attenuation	Toxicity and bioavailability of degradation products are unknown
Significant public acceptance	Contaminants may be mobilized into the groundwater (for soil applications)
Air emissions are minimal	Contaminants may enter food chain through animal consumption
Secondary wastes are not generated	
Soil and groundwater remain in place and can be used post-treatment	

**Costs**

Costs associated with phytoremediation are presented in Tables 5.7 and 5.8; however, current costs estimates for phytoremediation vary widely. The area that would need to be remediated to achieve Zone H arsenic background risk is 0.4 acres. The cost estimate in Table 5.7 uses one acre for simplicity in calculating costs. For comparison, Table 5.8 presents the costs of phytoremediation over the entire 120 acre Combined SWMU 9 area. The cost for phytoremediation would range from \$466,260 to \$12,852,000, depending on the cleanup objective and the subsequent size of the area subject to treatment. These costs include present worth O&M costs over a 30-year period.

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**Table 5.7**  
**Alternative 6a**  
**Phytoremediation Cost**  
**(to arsenic background risk)**

Action	Quantity	Cost per Unit	Total Cost
<b>Building Demolition/Asphalt Removal</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	1,000 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$4,000
Transportation to C&D Landfill	1 day	\$80/hr	\$640
Disposal at C&D Landfill	35 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$700
Engineering/Oversight	LS	20% cost	\$2,068
Contingency/Miscellaneous	LS	25% cost	\$3,102
<b>Subtotal</b>			<b>\$15,510</b>
<b>Phytoremediation Activities</b>			
<i>Capital Costs</i>			
Laboratory/Pilot/Field Studies	LS	\$80,000	\$80,000
Mobilization/Demobilization	LS	\$5,000	\$5,000
Planting	1 acre	\$10,000/acre	\$10,000
Soil Cover and Amendments	1 acre	\$7,500	\$7,500
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20%	\$42,500
Contingency/Miscellaneous	LS	25%	\$63,750
<b>Subtotal</b>			<b>\$318,750</b>
<i>Operations and Maintenance (Note: Total cost represents present worth at 6% over 30 years)</i>			
Horticulture (plant health)	1 acre	\$1,000/acre/yr	\$15,000
Pruning	1 acre	\$1,000/acre/yr	\$15,000
Harvesting	1 acre	\$2,000/acre/yr	\$28,000
Inspection	LS	\$1,000/yr	\$15,000
Soil Sampling and Analysis	30 events	\$2,000/event	\$15,000
Engineering/Oversight	LS	20% cost	\$17,600
Contingency/Miscellaneous	LS	25% cost	\$26,400
<b>Subtotal</b>			<b>\$132,000</b>
<b>Total</b>			<b>\$466,260</b>

**Notes:**

- LS — lump sum
- GW — groundwater
- C&D — construction & demolition
- yr — year
- hr — hour
- ft<sup>2</sup> — square feet
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

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**Table 5.8**  
**Alternative 6b — Phytoremediation Cost**  
 (to 1E-06 industrial risk)

Action	Quantity	Cost per Unit	Total Cost
<b>Building Demolition/Asphalt Removal</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	550,000 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$2,200,000
Transportation to C&D Landfill	90 days	\$80/hr	\$58,000
Disposal at C&D Landfill	21,000 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$420,000
Engineering/Oversight	LS	20% cost	\$536,600
Contingency/Miscellaneous	LS	25% cost	\$804,900
<b>Subtotal</b>			<b>\$4,024,500</b>
<b>Phytoremediation Activities</b>			
<i>Capital Costs</i>			
Laboratory/Pilot/Field Studies	LS	\$80,000	\$80,000
Mobilization/Demobilization	LS	\$5,000	\$5,000
Planting	120 acres	\$10,000/acre	\$1,200,000
Soil Cover and Amendments	120 acres	\$7,500	\$900,000
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20%	\$459,000
Contingency	LS	25%	\$688,500
<b>Subtotal</b>			<b>\$3,442,500</b>
<i>Operations and Maintenance Costs (Note: Total cost represents present worth at 6% over 30 years)</i>			
Horticulture (plant health)	120 acres	\$500/acre/yr	\$825,000
Pruning	120 acres	\$500/acre/yr	\$825,000
Harvesting	120 acres	\$1,000/acre/yr	\$1,650,000
Inspection	LS	\$1,000/yr	\$15,000
Soil Sampling and Analysis	30 events	\$20,000/event	\$275,000
Engineering/Oversight	LS	20% cost	\$718,000
Contingency/Miscellaneous	LS	25% cost	\$1,077,000
<b>Subtotal</b>			<b>\$5,385,000</b>
<b>Total</b>			<b>\$12,852,000</b>

**Notes:**

- LS — lump sum
- GW — groundwater
- C&D — construction & demolition
- yr — year
- hr — hour
- ft<sup>2</sup> — square feet
- yd<sup>3</sup> — cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

**5.2.7 Alternative 7: Excavation and Treatment by Soil Washing**

Soil washing separates contaminants sorbed onto fine soil particles from bulk soil in an aqueous-based system based on particle size. In this process, all soil in which contaminants exceed Zone H background risk for arsenic would be excavated and treated onsite or disposed of. The excavated soil would be stockpiled onsite and sampled for waste characterization by TCLP. Soil characterized as nonhazardous would be disposed of in Subtitle D landfill. Soil characterized as hazardous waste would be washed with water augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove contaminants. The cleaned soil fraction can be returned to the site for continued use.

Soil washing removes contaminants from soils by either:

- Dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH).
- Concentrating them into a smaller volume of soil through particle-size separation, gravity separation, and attrition scrubbing.

Soil washing is a media-transfer technology. The contaminated water generated from soil washing must subsequently be treated for arsenic, lead, PCBs, and BEQs.

**5.2.7.1 Excavation and Treatment by Soil Washing: Primary Criteria**

**Protection of Human Health and the Environment**

Excavation and treatment by soil washing protects human health and the environment by removing soil in which contaminants exceed Zone H background risk for arsenic. This alternative would eliminate risk to human health and the environment due to dermal and gastrointestinal contact. Appropriate institutional controls are required for the industrial reuse remediation option.

Short-term risks from inhalation and dermal contact during implementation would be minimal and could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

### **Attainment of Cleanup Standards**

Excavation and treatment by soil washing would attain media cleanup standards as established by the CNC project team. Contaminated soil would be excavated at select locations until confirmation samples satisfy remedial objectives. The contaminated soil would be treated to remove contaminants, then backfilled to the site. Soil washing typically takes less than one month for this volume of soil.

### **Source Control**

This alternative would effectively control the source by removing contaminants from the most contaminated soil. However, buried landfill waste will continue to act as a source of groundwater contamination. Institutional controls for the industrial reuse scenario would further reduce the likelihood of additional risks by eliminating potential exposure pathways to residual contamination.

### **Compliance with Applicable Waste Management Standards**

Excavation and treatment by soil washing meets chemical-specific regulations for the site wide remedial objectives protective of future industrial site workers under the industrial reuse scenario. Excavation and treatment activities onsite may require compliance with federal, state, and local air emissions and storm water control regulations. Treated soil would be analyzed to determine residual contaminant concentrations. The resulting washwater would be disposed of by a local approved publically owned treatment works (POTW) or treated prior to discharge via an National Pollutant Discharge Elimination system (NPDES) — or similar — permit. State and federal discharge regulations would apply.

**5.2.7.2 Excavation and Treatment by Soil Washing: Secondary Criteria** 1

**Long-term Reliability and Effectiveness** 2

This alternative would reduce the quantity of soil in which contaminant concentrations contribute to the largest proportion of Zone H arsenic background risk. Minor institutional controls might be required for the industrial reuse scenario to ensure that any exposure to human and environmental receptors would be within protective levels. 3  
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Soil washing does not destroy contaminants — instead it separates the contaminants from the soil, thereby reducing the hazardous waste volume. Because the contaminants are transferred from the soil to the wash water, this wastewater requires further treatment. 7  
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9

**Reduction of Toxicity, Mobility, or Volume** 10

Soil washing reduces site contamination by removing contaminants from the soil. With this alternative, site toxicity, contaminant mobility, and hazardous waste volume would be reduced. Residual contamination would remain onsite, but at concentrations below remedial objectives. 11  
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**Short-term Effectiveness** 14

The excavation and treatment operation would be sufficiently removed from the public to reduce health and safety concerns associated with soil removal. Temporary fencing would be installed around the work zone to control site access to remediation workers only. Remediation workers would be exposed to increased particulate emissions and might also have more dermal contact with hazardous constituents. However, worker risks can be reduced by implementing dust control technologies and a site-specific health and safety plan specifying PPE, respiratory protection, etc. Remedial objectives can probably be met in approximately one month. Consequently, worker exposure to the contaminants would be minimal. 15  
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**Implementability**

Excavation and soil washing is technically and administratively feasible at Combined SWMU 9. Commercial-scale units are available for soil washing. The potential technical problems that might slow remediation activities are concrete and asphalt removal to access contaminated soil, materials handling, backfilling to the site (standby time between confirmatory sampling and backfill), and potential foundation support measures (if required). The soil volumes are moderately small (approximately 360 yd<sup>3</sup>), but approximately 10% of the contaminated soil is beneath reinforced concrete and/or asphalt. No future remedial actions would be required after soil washing.

**Cost**

Costs associated with excavation and treatment by soil washing are presented in Table 5.9. The cost for excavation and treatment by soil washing at Combined SWMU 9 for an industrial re-use scenario for Zone H arsenic background risk (5.2E-06), including application of institutional controls, is \$559,317. These costs were calculated based on the worst case, which is all excavated soil is characterized as hazardous waste. If the excavated soil were distributed between the nonhazardous and hazardous based on TCLP characterization, the actual total cost would be less. No O&M costs are associated with this alternative.

**Table 5.9**  
**Alternative 7**  
**Excavation and Treatment by Soil Washing Cost**  
**(to arsenic background risk)**

Action	Quantity	Cost per Unit	Total Cost
<b>Building Demolition/Asphalt Removal</b>			
Mobilization/Demobilization	LS	\$5,000	\$5,000
Existing Surface Cover Excavation (buildings/asphalt)	1,000 ft <sup>2</sup>	\$4/ft <sup>2</sup>	\$4,000
Transportation to C&D Landfill	1 day	\$80/hr	\$640
Disposal at C&D Landfill	35 yd <sup>3</sup>	\$20/yd <sup>3</sup>	\$700
Engineering/Oversight	LS	20% cost	\$2,068
Contingency/Miscellaneous	LS	25% cost	\$3,102
<b>Subtotal</b>			<b>\$15,510</b>

**Table 5.9**  
**Alternative 7**  
**Excavation and Treatment by Soil Washing Cost**  
 (to arsenic background risk)

Action	Quantity	Cost per Unit	Total Cost
<b>Soil Washing Activities</b>			
Site Preparation	LS	\$125,000	\$125,000
Mobilization/Demobilization	LS	\$16,000	\$16,000
Pretreatment Unit (rent)	LS	\$55,500	\$55,500
Startup/Shakedown	LS	\$17,500	\$17,500
Decontamination	LS	\$1,000	\$1,000
Process Equipment Rental	1 month	\$81,000/m	\$81,000
Process Labor	80 hours	\$255/hr	\$20,400
Maintenance/Spare Parts	950 tons	\$2.25/ton	\$2,138
Water Pre-treatment and Disposal	LS	\$10,000	\$10,000
Consumables (chemicals)	1,000 yd <sup>3</sup>	\$34/yd <sup>3</sup>	\$34,000
Engineering/Oversight	LS	20% cost	\$72,508
Contingency/Miscellaneous	LS	25% cost	\$108,761
<b>Subtotal</b>			<b>\$543,807</b>
<b>Total</b>			<b>\$559,317</b>

*Notes:*

- LS -- lump sum
- GW -- groundwater
- C&D -- construction & demolition
- yr -- year
- hr -- hour
- ft<sup>2</sup> -- square feet
- yd<sup>3</sup> -- cubic yards

transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

### 5.3 Evaluation of Groundwater Remedial Alternatives

As previously discussed in Section 3, only one groundwater remedial alternative is being proposed for Combined SWMU 9. The remedy proposed consists of long-term monitoring of perimeter wells and implementation of institutional controls to ensure groundwater is not used for potable purposes.

**5.3.1 Alternative 1: Long-term Monitoring and Institutional Controls**

With this alternative, no remedial actions would be taken to contain, remove, or treat groundwater within the confines of the landfill boundary in which contaminants exceed remedial objectives. However, monitoring wells at the perimeter of the landfill will be monitored over a 30 year period to ensure contaminated groundwater does not adversely impact nearby sensitive receptors within receiving surface waters such as Shipyard Creek to the south or the Cooper River to the north. The implementation of deed restrictions through institutional controls will ensure the contaminated groundwater is not withdrawn and used for potable purposes.

**5.3.1.1 Long-term Monitoring and Institutional Controls: Primary Criteria**

**Protection of Human Health and the Environment**

Installation of the long-term monitoring plan does not provide any additional protection of human health and the environment from groundwater inside the landfill boundary. However, long-term monitoring does provide data to protect areas outside of the landfill boundary from potential adverse affects to human health and the environment. Long-term monitoring ensures that groundwater leaving the landfill does not exceed regulatory limits which may impact Shipyard Creek to the south or the Cooper River to the north. Restrictions on groundwater withdrawals inside or near the landfill would also offer protection to potential groundwater users.

**Attainment of Cleanup Standards**

Use of the presumptive remedy for municipal-type landfills requires that groundwater within the landfill not be remediated to any regulatory standard. Although groundwater inside the landfill has exceeded various drinking water MCLs, groundwater downgradient of the landfill has not exceeded MCLs during sampling for the RFI. Long-term monitoring will ensure that groundwater leaving the landfill boundary remains below applicable MCLs.

**Source Control**

Use of the presumptive remedy for municipal-type landfills requires that no source control measures be taken for groundwater remediation. As part of the CMS for surface soil, excavation of impacted soil areas may be removed to decrease risk at a particular site, which may prove to be a form of source control for certain contaminants in groundwater. However, since no subsurface soil or buried landfill waste will be removed during excavation, any source control affects will be minimal.

**Compliance with Applicable Waste Management Standards**

Purge water will be produced during routine sampling of the perimeter wells. Although groundwater in these wells has been found to be below MCLs, all purge water will be disposed of in accordance with the RFI Comprehensive Sampling and Analysis Plan (CSAP).

**5.3.1.2 Long-term Monitoring and Institutional Controls: Secondary Criteria**

**Long-term Reliability and Effectiveness**

Long-term monitoring does not reduce risk to human health and the environment due to groundwater or the volume and concentration of contaminants in groundwater inside the landfill boundary. Long-term monitoring does provide reliable and effective means of assuring that risk to areas outside of the landfill does not increase to levels that would not be protective of human health and the environment. The monitoring wells chosen for long-term sampling were designed for effective monitoring for at least 30 years. Since groundwater in these wells have not had high concentrations of solvents or benzene, toluene, ethylbenzene, and xylene (BTEX), the PVC piping should not degrade over the monitoring period.

Institutional controls are effective only as long as there is some oversight and enforcement mechanism in place. To date, the CNC project team has yet to determine what agency or

organization would provide this oversight. Thus, the long-term reliability and effectiveness of institutional controls is presently unknown.

### **Reduction of Toxicity, Mobility, or Volume**

No reduction of toxicity, mobility, or volume of contaminated groundwater will be provided with long-term monitoring. Long-term monitoring does ensure that contaminated groundwater does not leave the site, thereby providing data to show that the mobility of groundwater remains low inside the landfill.

### **Short-term Effectiveness**

No risks to human health and the environment will be encountered during implementation of long-term monitoring and institutional controls other than those associated with routine sampling of monitoring wells. All sampling will occur in accordance with the RFI Health and Safety Plan and CSAP. Proper personal protective equipment will be utilized during sampling.

### **Implementability**

The long-term monitoring program and institutional controls can be easily implemented. Future land use of the areas where wells are located must ensure that these wells are easily accessible.

### **Cost**

Table 5.10 gives a cost estimate for the groundwater monitoring plan and institutional controls as described. Each sampling event would cost approximately \$22,000. Sampling events will occur semiannually for years 1 through 5, annually for years 6 through 10, and every five years thereafter, up to 30 years. This will result in a total of 19 sampling events over the monitoring period, at a total cost of \$458,745.

**Table 5.10**  
**Alternative 1 for Groundwater**  
**Long Term Monitoring and Institutional Controls Costs**

Action	Amount	Cost per Unit	Total Cost
<i>Capital Costs</i>			
Institutional Controls	LS	\$110,000	\$110,000
Engineering/Oversight	LS	20%	\$22,000
Contingency/Miscellaneous	LS	25%	\$33,000
<b>Subtotal</b>			<b>\$165,000</b>
<i>Operation and Maintenance Cost (Note: Total cost represents present worth at 6% over 30 years)</i>			
Field Sampling	19 events/30 years	\$7,000/event	\$101,670
Sample Analysis & Sampling Equipment	19 events/30 years	\$7,000/event	\$103,113
Report Preparation	19 events/30 years	\$8,000/report	\$88,962
<b>Subtotal</b>			<b>\$293,745</b>
<b>Total</b>			<b>\$458,745</b>

*Notes:*

- LS — lump sum
  - GW — groundwater
  - C&D — construction & demolition
  - yr — year
  - hr — hour
  - ft<sup>2</sup> — square feet
  - yd<sup>3</sup> — cubic yards
- transportation, disposal, and backfill volumes include fluff factor of approximately 15%.

## 5.4 Comparison of Alternatives

After the alternatives have been fully described and individually assessed against the nine criteria, each alternative's performance relative to each other is assessed. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another. This section highlights differences between alternatives as they meet each of the criteria, especially the secondary criteria. The focus should help determine which options are cost-effective and which remedy uses permanent solutions and treatment to the maximum extent practicable.

#### 5.4.1 Comparative Analysis of Soil Alternatives

This section comparatively analyzes soil remedial alternatives, examining potential advantages and disadvantages according to each of the nine criteria. All the alternatives evaluated in Section 5.2 are technically feasible, implementable, and have been developed and used at other sites. All alternatives generally protect human health. All alternatives, except implementation of institutional controls, are protective of the environment. State and community acceptance are determined in the same manner for each alternative. The key criteria that distinguish the soil alternatives focus are long-term reliability and effectiveness, reduction of toxicity, mobility and volume, short-term effectiveness, implementability, and cost.

##### 5.4.1.1 Primary Criteria

All alternatives considered for selection must comply with the primary criteria: protection of human health and the environment, attainment of cleanup standards, source control, and compliance with applicable waste management standards.

##### Protection of Human Health and the Environment

This criterion evaluates the overall degree of protectiveness afforded to human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially the other three primary criteria.

Alternative 1, *Institutional Controls*, protects receptors by restricting land use. The soil would remain onsite, but risks would be reduced by elimination of dermal contact and ingestion pathways that exist with uncontrolled access. Furthermore, institutional controls are an essential component of the landfill presumptive remedy.

Alternatives 2 and 4, *Low-permeability Surface Cap and Hot-Spot Low-permeability Surface Cap*, respectively, protect human health and the environment through containment and land-use

restrictions and prevents completion of dermal and gastrointestinal pathways. Hot-spot capping aims to efficiently reduce site risk and achieve remedial objectives by maximizing against contaminant contact while minimizing the area requiring capping. Alternatively, general capping aims to minimize exposure, overall.

Alternatives 3 and 5, *Excavation and Offsite Disposal and Hot-spot Excavation and Offsite Disposal*, respectively, protect human and health and the environment through removal of affected soil media. Hot-spot excavation and offsite disposal aims to efficiently reduce site risk and achieve remedial objectives by maximizing contaminant removal and minimizing soil removal. Alternatively, general excavation with offsite disposal aims to remove point risk to remedial objectives.

Alternative 6, *Phytoremediation*, protects human health and the environment by slowly removing, transforming, or immobilizing contaminants that contribute to site risk. Coupled with institutional controls, this alternative eliminates dermal contact and ingestion pathways over time.

Alternative 7, *Excavation and Treatment by Soil Washing*, protects human health and the environment by removing contaminants that contribute to site risk.

### **Attainment of Cleanup Standards**

Alternative 1 results in a residual industrial site risk of 9.5E-06.

Alternatives 2 and 4 comply with remedial objectives for protection of human health and the environment because the risk pathway is eliminated by capping the contaminated soil and residual site risk is less than 1E-06. However, the contaminated soil would remain onsite.

Alternatives 3 and 5 comply with remedial objectives by removing the affected soil. Alternative 3 1  
addresses point risk by eliminating all points (and their associated areas) that exceed remedial 2  
objectives. Alternative 5 reduces site risk by removing the most contaminated areas. 3

Alternative 6 complies with remedial objectives; however, this technology would likely require 4  
years to attain cleanup standards. 5

Alternative 7 complies with remedial objectives by removing the affected soil and treating the 6  
contaminants in the soil. This results in a much lesser volume of contaminated media requiring 7  
disposal. 8

**Source Control** 9

Alternative 1 does not address source control. Contaminated soil would remain above remedial 10  
objectives selected by the CNC project team. In accordance with the landfill presumptive remedy, 11  
this alternative does not address buried landfill waste. 12

Alternatives 2 and 4 do not remove the source. However, these alternatives would provide 13  
effective source control by limiting further releases that might threaten human health or the 14  
environment. However, the contaminated soil would remain onsite. In accordance with the 15  
landfill presumptive remedy, these alternatives do not address buried landfill waste 16

Alternative 3 and 5 would provide effective source control by eliminating the most contaminated 17  
soil. However, contaminated soil that contributes to acceptable residual site risk would remain 18  
onsite — institutional controls would be required to limit exposure pathways to residual 19  
contamination. Alternative 5 would effectively control the source by eliminating media in which 20  
contaminants exceed remedial objectives on a point-by-point basis. Soil below remedial objectives 21

would remain onsite. In accordance with the landfill presumptive remedy, these alternatives do not address buried landfill waste

Alternative 6 would provide effective source control by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk offsite. Disposal of resulting affected plant material would remove the contaminants from the site. In accordance with the landfill presumptive remedy, this alternative does not address buried landfill waste

Alternative 7 would provide effective source control by separating contaminants from the soil. Disposal of the resulting affected wash media would eliminate the contaminants from the site. In accordance with the landfill presumptive remedy, this alternative does not address buried landfill waste.

**Compliance with Applicable Waste Management Standards**

No waste would be managed under Alternative 1. Therefore, waste management standards do not apply.

Alternatives 2 and 4 would isolate or eliminate contaminants exceeding remedial objectives in environmental media, but not manage solid or hazardous waste. Site grading would need to comply with federal, state, and local air emissions and storm water control regulations.

Alternatives 3 and 5 meet remedial objectives. Excavation activities on-site might require compliance with federal, state, and local air emissions and storm water control regulations. Transportation and land disposal restrictions would be triggered by disposal of contaminated soil offsite. Although it is anticipated that excavated soil is non-hazardous, TCLP analysis would be performed for verification.

Alternative 6, phytoremediation, meets remedial objectives. Transportation and land disposal restrictions might be triggered if contaminated harvested materials require offsite disposal.

Alternative 7, soil washing, which will require excavation and treatment activities on-site, might require compliance with federal, state, and local air emissions and storm water control regulations. Transportation and land disposal restrictions would be triggered by disposal of contaminated water and/or other media.

#### **5.4.1.2 Secondary Criteria**

Five secondary criteria typically highlight the major differences between the alternatives: long-term reliability and effectiveness, reduction of toxicity, mobility, or volume, short-term effectiveness, implementability, and cost.

#### **Long-term Reliability and Effectiveness**

Alternative 1 lacks treatment actions that would require reliability and effectiveness. Institutional controls is limited to the ability to control access to contaminated soil. The volume and concentration of contaminants in the soil would remain unchanged.

Alternatives 2 and 4 would effectively reduce site worker contact with the contaminated soil during capping. However, institutional controls and routine O&M would be required to ensure that any exposure to human and environmental receptors is within protective levels.

Alternatives 3 and 5, site-wide excavation and hot-spot excavation and offsite disposal, would reduce the quantity of soil in which contaminant concentrations exceed site-wide risk reduction remedial objectives. With Alternative 5, background residual risk would remain following the completion of this remedial alternative — institutional controls would be required to ensure that exposure is within protective limits.

Alternative 6 is limited to research and limited field testing. However, only institutional controls would be required to prevent exposure to human and environmental receptors during the application of phytoremediation.

Alternative 7 would reduce the volume of soil exceeding background residual risk, and as such, institutional controls would be required to ensure that exposure is within protective limits.

### **Reduction of Toxicity, Mobility, or Volume**

Alternative 1 does not reduce contaminant toxicity, mobility, or volume.

Alternatives 2 and 4, both capping alternatives, do not remove, treat, or remediate the contaminated soil; it provides containment only. The soil and combination covers are considered reversible since the contaminants exceeding remedial objectives remain onsite. Regular maintenance is required to ensure that the integrity of the cover is sustained.

Alternatives 3 and 5, excavation and offsite disposal, eliminate the contaminants that affect site remedial objectives. However, the waste's overall toxicity, mobility, and volume would not be reduced with this alternative since the contaminated soil would merely be transferred to another location (Subtitle C or D landfill).

Alternative 6 effectively reduces toxicity, mobility, and volume reduction by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk. With appropriate monitoring and maintenance, these biologically and chemically enhanced processes would be irreversible.

Alternative 7, soil washing, effectively reduces the toxicity, mobility, and volume of contaminants in soil, but transfers the contaminants to another media, washwater. The contaminants in the water can be transported offsite for treatment.

**Short-term Effectiveness**

No short-term effects are associated with Alternative 1.

Alternatives 2, 3, 4, 5, 6, and 7 include exposure to workers, which can be effectively controlled using engineering controls and appropriate PPE during planting, harvesting, tilling, grading, capping, excavating or soil washing activities. The remedial time frame for Alternative 6 is relatively long since it relies on biological and assimilative processes. However, worker exposure during O&M activities would be minimal. Remedial time frames for Alternatives 2, 3, 4, 5, and 7 are relatively short (likely less than three to four months).

**Implementability**

All 7 alternatives can be implemented at Combined SWMU 9 and are technically and administratively feasible.

**Costs**

In Table 5.11, the alternatives are scored on their strengths in relation to the criteria listed above so that they can be compared to assist in the remedy selection process. Alternatives range in cost from \$253,720 for hot-spot capping to \$75,441,900 for site-wide excavation of surface soil and offsite disposal at a Subtitle C landfill.

**Table 5.11**  
**Soil Alternatives Cost Comparison**

Alternative	Capital Costs	O&M	Total Cost
1 Institutional Controls	\$110,000	\$366,343	\$476,343
2 Low-Permeability Surface Cap	\$10,296,150	\$140,676	\$12,678,726
3 Excavation and Offsite Disposal	NA	NA	\$28,191,900 (Subtitle D)
	NA	NA	\$75,441,900 (Subtitle C)
4 Hot-Spot Low-Permeability Surface Cap (to arsenic background risk)	\$210,720	\$140,676	\$351,396
5 Hot-Spot Excavation and Offsite Disposal (to arsenic background risk)	NA	NA	\$258,660 (Subtitle D)
	NA	NA	\$400,860 (Subtitle C)
6a Phytoremediation (to arsenic background risk)	\$334,260	\$132,000	\$466,260
6b Phytoremediation (to 1E-06 industrial risk)	\$6,048,170	\$5,385,000	\$12,852,000
7 Excavation and Treatment by Soil Washing (to arsenic background risk)	\$559,317	NA	\$559,317

## 5.4.2 Comparative Analysis of Groundwater Alternatives

No comparison of alternatives will be made since only one alternative is being presented. Long-term monitoring and institutional controls is required for municipal-type waste landfills and the presumptive remedy requires that no groundwater remediation take place in the landfill.

## 5.5 Summary and Ranking of Alternatives

### 5.5.1 Soil

Per the CNC project team’s request, each soil alternative was assigned a score for each of the primary and secondary criteria based on the comparative analysis of alternatives in Section 5.4. For primary criteria, the scoring methodology is presented as:

- 0 — criteria not met
- 1 — criteria may be met
- 2 — criteria met
- 3 — criteria exceeded

For secondary criteria, the scoring methodology is presented as:

- **0** — poor
- **1** — below average
- **2** — average
- **3** — above average

The scores can be multiplied by a weighting factor to emphasize their importance. At this time, the primary criteria have been weighted more heavily than the secondary criteria. A comment is included to justify each score and summarize the comparative analysis discussion in Section 5.4. Finally, the scores for each criteria are summed to develop an overall score for each alternative, which is used to rank the seven alternatives and provide a tool for selecting the final site remedy. The results are summarized in Tables 5.12a - g. Table 5.12h summarizes the scores for all seven alternatives.

The recommended final site remedy is discussed in Section 6.

### **5.5.2 Groundwater**

The groundwater alternative will not be ranked since there are no other alternatives to compare.

**Table 5.12a**  
**Summary of Evaluation of Soil Alternative 1**  
**Institutional Controls**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Protects receptors by restricting land use. Soil would remain onsite, but risks would be reduced by eliminating exposure pathways.	1	2
Attainment of Cleanup Standards	2	Does not comply with remedial objectives.	0	0
Source Control	2	Does not address source control in surface soil. Buried landfill waste remains at site.	0	0
Compliance with Applicable Waste Management Standards	2	No waste is managed under this alternative. Therefore, waste management standards do not apply.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Lacks treatment actions that would require reliability and effectiveness. The volume and concentration of contaminants would be left in place.	1	1
Reduction of Toxicity, Mobility, and Volume	1	Does not reduce toxicity, mobility, or volume of waste.	0	0
Short-term Effectiveness	1	There are no short-term effects associated with this alternative.	3	3
Implementability	1	Technically and administratively feasible. Most rapid alternative to implement.	3	3
Cost	1	\$476,343	2	2
<b>Ranking Score</b>				<b>15</b>

**Notes:**

- PW — Present worth
- 1 — Weighting factor (WF) assigned by CNC project team consensus
- 2 — Criteria-specific evaluation score:

**Primary:**  
 0 — criteria not met  
 1 — criteria may be met  
 2 — criteria met  
 3 — criteria exceeded

**Secondary:**  
 0 — poor  
 1 — below average  
 2 — average  
 3 — above average

**Table 5.12b**  
**Summary of Evaluation of Soil Alternative 2**  
**Low-Permeability Soil Cap**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Protects human health and the environment through containment and land-use restrictions; exposure pathways eliminated.	2	4
Attainment of Cleanup Standards	2	Complies with remedial objectives for protection of human health and the environment. However, contaminated soil remains onsite.	1	2
Source Control	2	Surface soil source not removed. However, the cap would provide effective source control by eliminating further releases. Buried landfill waste remains at site.	2	4
Compliance with Applicable Waste Management Standards	2	Solid or hazardous waste would not be managed under this alternative. However, site grading activities must comply with air emissions and storm water regulations.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Institutional controls and routine O&M would be required to ensure long-term reliability of cap.	2	2
Reduction of Toxicity, Mobility, and Volume	1	Does not reduce toxicity, mobility, or volume. Soil exceeding remedial objectives remains onsite.	0	0
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible. Soil cover is amenable to industrial reuse scenarios.	2	2
Cost	1	\$12,678,726	1	1
<b>Ranking Score</b>				<b>21</b>

**Notes:**

- PW — Present worth
- 1 — Weighting factor (WF) assigned by CNC project team consensus
- 2 — Criteria-specific evaluation score:

**Primary:**

- 0 — criteria not met
- 1 — criteria may be met
- 2 — criteria met
- 3 — criteria exceeded

**Secondary:**

- 0 — poor
- 1 — below average
- 2 — average
- 3 — above average

**Table 5.12c**  
**Summary of Evaluation of Soil Alternative 3**  
**Excavation and Offsite Disposal**

Evaluation Criteria	Weighing Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Removes soil to a restricted access area (landfill) where exposure pathways are minimal.	3	6
Attainment of Cleanup Standards	2	Complies with point-risk reduction remedial objectives.	3	6
Source Control	2	Effective surface soil source control by eliminating most contaminated media. All soil exceeding calculated background concentrations would be removed. Buried landfill waste remains at site.	3	6
Compliance with Applicable Waste Management Standards	2	Meets remedial objectives. Remedial activities must comply with air emissions and storm water regulations, and transportation and land disposal restrictions.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Background residual site risk would remain. Institutional controls would be required to eliminate exposure pathways.	2	2
Reduction of Toxicity, Mobility, and Volume	1	Removes soil that exceeds site risk remedial objectives. However, overall toxicity, mobility, or volume would not be reduced. It merely transfers the impacted soil elsewhere.	1	1
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible. Will require 225,000 yd <sup>3</sup> clean fill.	2	2
Cost	1	\$28,191,900 (Subtitle D landfill disposal) \$75,441,900 (Subtitle C landfill disposal)	1 0	1 0
<b>Ranking Score</b>				<b>29-30</b>

**Notes:**

- PW** — Present worth
- 1** — Weighting factor (WF) assigned by CNC project team consensus
- 2** — Criteria-specific evaluation score:

**Primary:**

- 0 — criteria not met
- 1 — criteria may be met
- 2 — criteria met
- 3 — criteria exceeded

**Secondary:**

- 0 — poor
- 1 — below average
- 2 — average
- 3 — above average

**Table 5.12d**  
**Summary of Evaluation of Soil Alternative 4**  
**Hot-Spot Low-Permeability Surface Cap**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Protects human health and the environment through containment and land-use restrictions; exposure pathways eliminated.	2	4
Attainment of Cleanup Standards	2	Complies with remedial objectives for protection of human health and the environment. However, contaminated soil remains onsite.	1	2
Source Control	2	Surface soil source not removed. However, the cap would provide effective soil source control by eliminating further releases. Buried landfill waste remains at site.	2	4
Compliance with Applicable Waste Management Standards	2	Solid or hazardous waste would not be managed under this alternative. However, site grading activities must comply with air emissions and storm water regulations.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Institutional controls and routine O&M would be required to ensure long-term reliability of cap.	2	2
Reduction of Toxicity, Mobility, and Volume	1	Does not reduce toxicity, mobility, or volume. Soil exceeding remedial objectives remains onsite.	0	0
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible. Soil and asphalt cover is amenable to industrial reuse scenarios.	2	2
Cost	1	\$351,396	3	3
<b>Ranking Score</b>				<b>23</b>

**Notes:**

- PW** — Present worth
- 1** — Weighting factor (WF) assigned by CNC project team consensus
- 2** — Criteria-specific evaluation score:

**Primary:**

- 0 — criteria not met
- 1 — criteria may be met
- 2 — criteria met
- 3 — criteria exceeded

**Secondary:**

- 0 — poor
- 1 — below average
- 2 — average
- 3 — above average

**Table 5.12e**  
**Summary of Evaluation of Soil Alternative 5**  
**Hot-Spot Excavation and Offsite Disposal**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Removes soil to a restricted access area (landfill) where exposure pathways are minimal.	3	6
Attainment of Cleanup Standards	2	Complies with site risk reduction remedial objectives.	3	6
Source Control	2	Effective surface soil source control by eliminating most contaminated media. Soil with acceptable residual risk would remain onsite. Buried landfill waste remains at site.	2	4
Compliance with Applicable Waste Management Standards	2	Meets remedial objectives. Remedial activities must comply with air emissions and storm water regulations, and transportation and land disposal restrictions.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Residual site risk would remain. Institutional controls would be required to eliminate exposure pathways.	2	2
Reduction of Toxicity, Mobility, and Volume	1	Eliminates soil that exceeds site risk remedial objectives. However, overall toxicity, mobility, or volume would not be reduced.	1	1
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible.	3	3
Cost	1	\$258,660 (Subtitle D landfill disposal)	3	3
		\$400,860 (Subtitle C landfill disposal)	2	2
<b>Ranking Score</b>				<b>30-31</b>

**Notes:**

- PW — Present worth
- 1 — Weighting factor (WF) assigned by CNC project team consensus
- 2 — Criteria-specific evaluation score:

<p><b>Primary:</b></p> <ul style="list-style-type: none"> <li>0 — criteria not met</li> <li>1 — criteria may be met</li> <li>2 — criteria met</li> <li>3 — criteria exceeded</li> </ul>	<p><b>Secondary:</b></p> <ul style="list-style-type: none"> <li>0 — poor</li> <li>1 — below average</li> <li>2 — average</li> <li>3 — above average</li> </ul>
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**Table 5.12f**  
**Summary of Evaluation of Soil Alternative 6**  
**Phytoremediation**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Protects human health and the environment by slowly removing, transforming, or immobilizing contaminants. Coupled with institutional controls.	2	4
Attainment of Cleanup Standards	2	Complies with remedial objectives. Requires relatively lengthy treatment period.	2	4
Source Control	2	Slowly removes or immobilizes surface soil source. Buried landfill waste remains at site.	2	4
Compliance with Applicable Waste Management Standards	2	Meets remedial objectives. Transportation and land disposal restrictions might be triggered if contaminated harvested materials require offsite disposal.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Limited to research and limited field testing.	1	1
Reduction of Toxicity, Mobility, and Volume	1	Effective reduction of toxicity, mobility, and volume. With appropriate monitoring and maintenance, process should be irreversible.	2	2
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible. Potentially one of the slowest alternatives to implement.	2	2
Cost	1	\$466,260 (to arsenic background risk)	2	2
		\$12,852,000 (to 1E-06 industrial risk)	1	1
<b>Ranking Score</b>				<b>24-25</b>

**Notes:**

- PW — Present worth
- 1 — Weighting factor (WF) assigned by CNC project team consensus
- 2 — Criteria-specific evaluation score:

**Primary:**

- 0 — criteria not met
- 1 — criteria may be met
- 2 — criteria met
- 3 — criteria exceeded

**Secondary:**

- 0 — poor
- 1 — below average
- 2 — average
- 3 — above average

**Table 5.12g**  
**Summary of Evaluation of Soil Alternative 7**  
**Excavation and Treatment by Soil Washing**

Evaluation Criteria	Weighting Factor <sup>1</sup>	Comments	Score <sup>2</sup>	Score x WF
<b>Primary Criteria</b>				
Protection of Human Health and the Environment	2	Protects human health and the environment by separating contaminants from site soil.	3	6
Attainment of Cleanup Standards	2	Complies with remedial objectives.	3	6
Source Control	2	Removes surface soil source. Buried landfill waste remains at site.	3	6
Compliance with Applicable Waste Management Standards	2	Meets remedial objectives. Transportation and land disposal restrictions might be triggered if contaminated materials require offsite disposal.	2	4
<b>Secondary Criteria</b>				
Long-term Reliability and Effectiveness	1	Effective at treating soil, but contaminants transferred to wash water.	1	1
Reduction of Toxicity, Mobility, and Volume	1	Effective reduction of toxicity, mobility, and volume.	3	3
Short-term Effectiveness	1	Minimal worker exposure, which can be effectively controlled with engineering controls and PPE.	2	2
Implementability	1	Technically and administratively feasible.	1	1
Cost	1	\$559,317	2	2
<b>Ranking Score</b>				<b>31</b>

**Notes:**

- PW** -- Present worth  
**1** -- Weighting factor (WF) assigned by CNC project team consensus  
**2** -- Criteria-specific evaluation score:

<b>Primary:</b>	<b>Secondary:</b>
0 — criteria not met	0 — poor
1 — criteria may be met	1 — below average
2 — criteria met	2 — average
3 — criteria exceeded	3 — above average

Table 5.12h  
 Soil Alternative Evaluation Summary

Evaluation Criteria	WF <sup>1</sup>	Alternative 1 Institutional Controls		Alternative 2 Low-Permeability Surface Cap		Alternative 3 Excavation and Offsite Disposal		Alternative 4 Hot-Spot Low-Permeability Surface Cap		Alternative 5 Hot-Spot Excavation and Offsite Disposal		Alternative 6 Phytoremediation		Alternative 7 Soil Washing	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
<b>Primary Criteria</b>															
Protection of human health and environment	2	1	2	2	4	3	6	2	4	3	6	2	4	3	6
Attainment of cleanup standards	2	0	0	1	2	3	6	1	2	3	6	2	4	3	6
Source control	2	0	0	2	4	3	6	2	4	2	4	2	4	3	6
Compliance with applicable waste management standards	2	2	4	2	4	2	4	2	4	2	4	2	4	2	4
<b>Secondary Criteria</b>															
Long-term reliability and effectiveness	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Reduction in toxicity, mobility, or volume	1	0	0	0	0	1	1	0	0	1	1	2	2	3	3
Short-term effectiveness	1	3	3	2	2	2	2	2	2	2	2	2	2	2	2
Implementability	1	3	3	2	2	2	2	2	2	3	3	2	2	1	1
Cost	1	2	2	1	1	1	1	3	3	3	3	3	2	2	2
						0	0			2	2	1	1		
<b>Ranking Score</b>	—	—	15	—	21	—	29-30	—	23	—	30-31	—	24-25	—	31

**Notes:**

- 1 — Weighting factor (WF) assigned by CNC project team consensus
- 2 — Interim Stabilization Measure Completion with No Further Remedial Action

**6.0 RECOMMENDATIONS**

**6.1 Soil Recommendations**

Of the seven alternatives, *Alternative 5 — Hot-Spot Excavation and Offsite Disposal*, appears to be most beneficial under the industrial reuse scenario because:

1. This alternative is easier to implement as well as immediately implementable in comparison to the other six alternatives.
2. This alternative meets the Zone H arsenic background risk objectives.
3. This alternative provides as much or more long-term effectiveness than some of the other alternatives, such as institutional controls.
4. This alternative allows for unrestricted industrial use of the property.
5. This alternative is generally more cost effective.
6. Surface soil exposure concerns are eliminated.
7. It is relatively cost effective in comparison to the other six alternatives.

Due to the U.S. Navy’s desire for future industrial use of the property, *Alternative 1—Institutional Controls (in solitude)*, is disqualified. Note, however that institutional controls used in conjunction with other remedial alternatives is considered more viable. *Alternative 2 — Low-Permeability Surface Cap*, is disqualified partly because of the cost associated with it, but also because future industrial use would be limited to only those uses that did not disturb cap integrity. Similarly, *Alternative 4 — Hot-Spot Low-Permeability Surface Cap* would limit future

industrial use, although it is a viable option based on cost. Realistically, any industrial use requiring medium to extensive use of buildings, roads, and utilities would likely compromise the integrity of a low-permeability cap alternative. Both of these alternatives would result in residual contamination remaining on the property at concentrations that exceed industrial cleanup goals.

*Alternative 3 – Excavation and Offsite Disposal* would achieve clean-up goals. However, at estimates ranging from \$28,191,900 to \$75,441,900, it is cost prohibitive.

*Alternative 6 – Phytoremediation* of Combined SWMU 9 is fairly O&M intensive. While this alternative is cost efficient and aesthetically acceptable to the public, the time required to achieve clean up goals would restrict use of the property for an indefinite period of time, and thus would prove to be counter to redevelopment goals.

*Alternative 7 – Excavation and Treatment by Soil Washing* is a viable alternative; however, the cost to mobilize and rent a soil washing unit compared to the volume of soil being treated does not warrant its use. Furthermore, soil washing involves a complex treatment train and the wash water generated can make this alternative messy and time intensive to use.

## **6.2 Groundwater Recommendations**

Because this is a military municipal-type landfill, and because of the groundwater characteristics this landfill exhibits (refer to Section 2.2.2), use of the presumptive remedy is recommended. In using the presumptive remedy, no further remedial action is required to address groundwater at Combined SWMU 9. However, Combined SWMU 9 does appear to be a strong candidate for monitored natural attenuation (MNA).

### 6.2.1 Natural Attenuation Sampling at Combined SWMU 9

Combined SWMU 9 (and the adjacent SWMU 196) was one of ten sites at which two rounds of natural attenuation data were collected in February — March 1998 and September — October 1998. The goal of these events was to confirm VOC trends evident during the quarterly RFI sampling and to obtain a baseline geochemical data set necessary for determining if monitored natural attenuation (MNA) might be a potential remedial alternative for each site. Combined SWMU 9 was included in the MNA evaluation due to the prevalence of petroleum hydrocarbons (BTEX) and chlorinated aliphatic hydrocarbons (CAHs) in shallow groundwater. Graphical presentation of the VOC detections during the RFI and MNA sampling events are presented in Appendix C.

A mobile laboratory was used in both rounds for analytes not requiring fixed laboratory analysis, as specified by the EPA guidance document *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (referred to herein as Technical Protocol, 1998). For data QA/QC, the same fixed lab was used in both rounds. Sampling methods and analyses are included in Appendix C.

Sampling results and a preliminary ranking for biodegradation potential at each well location were summarized in Table 1 of Appendix C. Although the ranking is based solely on CAH degradation, as specified in the Technical Protocol (1998), wells with other VOC contamination were included in the table as a means of data presentation. Therefore, the rankings for non-CAH contaminated wells are not pertinent. Isopleths of VOCs and selected geochemical parameters were constructed to evaluate their spatial distribution (Appendix C). A shallow groundwater piezometric map was constructed from synoptic water level measurements collected prior to Round 2 sampling (Appendix C).

**6.2.1.1 Summary of SWMU 9 MNA data**

The following summary was presented to the Navy and SCDHEC in an April 1999 meeting (see "Current Status of MNA Evaluation at Combined SWMU 9" in Appendix C).

MNA is not an ideal remedial alternative at Combined SWMU 9 for several reasons listed below:

- No source removal or control

As shown in the figures in Attachment Z, BTEX and chlorobenzene are the most pervasive groundwater contaminants at the site and occur predominantly in co-mingled plumes. CAHs are limited to two separate locations: well 009007 adjacent to the marsh feeding Shipyard Creek, and well 009021 at SWMU 196. Several methods (temporary wells, hydropunches, and trenching) were utilized during the RFI to ascertain the sources and extent of contamination at many highly contaminated wells, such as 009007, but none provided any additional insight. As a result, it is very difficult to estimate the size and extent of these masses in the subsurface, which greatly hinders the predictability of natural attenuation. Furthermore, monitored natural attenuation is predicated upon source control and/or removal; without these measures, the effectiveness of MNA cannot be adequately predicted.

- Contamination at points of compliance

Marshes, wetlands, and Shipyard Creek— the points of compliance at Combined SWMU 9 — lie along the entire southern and western boundaries of the site. The path of Shipyard Creek and the marshes associated with it also cross the site to the west, placing wetlands closer to the interior of the site. Two of the highest solvent locations lie immediately upgradient of marshes (009007 and 009021). Similarly, BTEX compounds detected at GDH026 and 009001 lie at the last monitoring point from an isolated wetland and Shipyard Creek, respectively. For monitored

natural attenuation to be viable as a site remedy, VOC-contaminated groundwater must not reach any ecological or human health receptor. If this cannot be demonstrated, MNA cannot be achieved.

- No viable groundwater flowpaths for monitoring

The monitoring well network at Combined SWMU 9 was designed ideally for a landfill-type evaluation, with wells in the interior to monitor changes directly within the landfill, and wells along its exterior to monitor potential offsite migration. This design is not well-suited for evaluating MNA because of the difficulty in identifying representative groundwater flowpaths within the VOC plumes. Flowpath evaluation is a critical component for a natural attenuation study since the degradation of VOCs and the associated geochemical changes must be demonstrated along representative groundwater flowpaths within a plume. The majority of the groundwater flowpaths that currently exist at the site are too long to monitor chemical changes with any certainty. This is especially true with the wells in the interior of the site. In an attempt to establish a smaller scale groundwater flowpath from 009007, where the highest concentrations of CAHs exist, four downgradient wells were installed, three of which lie directly in the marsh. No VOCs were detected in any of these downgradient wells, suggesting that the contaminants are not mobile despite being approximately 20 feet from the marsh.

As a result of these issues, MNA data collection and evaluation was terminated at Combined SWMU 9.

**7.0 PUBLIC INVOLVEMENT PLAN**

**7.1 General**

The following Public Involvement Plan (PIP) is included as part of this report in accordance with the EPA’s guidance on RCRA CMS. This PIP reflects and summarizes information prepared and presented in the U.S. Navy’s Community Relations Plan (CRP), prepared for the Charleston Naval Complex in 1995.

Under RCRA, no interaction is required with the community during the Corrective Measures Study process. Public input is required to be solicited only at the beginning of the permitting process, or during certain permit modifications. Therefore, the U.S. Navy has outlined a voluntary program of informing local communities throughout the entire RCRA corrective action process. Activities are detailed in the 1995 CRP for the former Naval facility.

However, because the CMS process results in a modification to the facility’s RCRA permit, certain provisions are made to solicit the public’s input on the preferred alternative (as the reason for the modification). The requirements are identical to those required for a draft permit.

Two primary objectives are stated in the CRP:

- To initiate and sustain community involvement.
- To provide a mechanism for communicating to the public.

**7.2 RFI Public Involvement Plan**

To achieve these objectives, the CRP identifies public involvement and outreach activities at each step of the corrective action process. For example, the following activities have been designated for the completion of the RFI. All have been accomplished.

- Updating and publicizing the information repository. 1
  - Continuing to publicize the point of contact. 2
  - Updating the mailing list. 3
  - Distributing fact sheets and/or writing articles to explain RFI findings. 4
  - Informing community leaders of the RFIs completion and results. 5
  - Updating and continuing to provide presentations for informal community groups, whenever possible. 6  
7
  - Updating the community on RFI results through public Restoration Advisory Board meetings. 8  
9  
10
- 7.3 CMS Public Involvement Plan** 11
- During the Corrective Measures Study, the following activities will be carried out as part of the U.S. Navy’s current and ongoing community involvement program. 12  
13
- Distributing a fact sheet and/or writing articles for publication that report CMS recommendations. 14  
15
  - Continuing to update the mailing list. 16
  - Continuing to respond to requests for speaking engagements. 17

- Updating the community on CMS status through public Restoration Advisory Board meetings. 1  
2

#### **7.4 Statement of Basis Public Involvement Plan** 3

Upon completion of the CMS, the following activities are required when the preferred alternative has been proposed: 4  
5

- A Statement of Basis will be prepared, explaining the proposed remedy and the method by which it was chosen. 6  
7
- A 45-day comment period will be provided to allow community members the opportunity to review and comment on the preferred alternative. 8  
9
- The availability of the comment period and Statement of Basis will be announced in a public notice. 10  
11
- The community will be provided an update on the preferred remedy through the informal and publicized Restoration Advisory Board meetings. 12  
13

In addition, the following activities will be carried out, as identified in the CRP: 14

- Updating and publicizing the information repository. 15
- Publicizing the environmental point of contact. 16
- Continuing to update the mailing list. 17

**7.5 Restoration Advisory Board**

The RAB is a key component of this community outreach program. It is through the RAB that the U.S. Navy has a regular, scheduled, and publicized forum for interfacing with community members on the progress of the environmental program, including the CMS. In addition, RAB members are key instruments in measuring community interest in specific issues and knowledge of them. A Community Relations Subcommittee to the RAB has been tasked with identifying issues and information to be addressed by the U.S. Navy.

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**8.0 REFERENCES**

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Black, H. (1995) *Absorbing Possibilities: Phytoremediation*, Innovations, Vol. 103, No 12, December, Environmental Health Perspectives, National Institute for Environmental Health Sciences.

Chappell, J. (1997) *Phytoremediation of TCE using Populus*, prepared for the USEPA Technology Innovation Office.

EnSafe, Inc. (July 5, 1996) *RCRA Facility Investigation for Zone H*, NAVBASE Charleston

Miller, R.R. (1996) *Technology Overview Report: Phytoremediation*, Groundwater Remediation Technologies Analysis Center, Pittsburgh, PA.

Naval Base Charleston (April 2, 1997) *SWMU 9 Presumptive Remedy Discussion*

U.S. Navy Environment Detachment Charleston (DET). (January 25, 1999) *Final Report, Geophysical/Intrusive Survey, Combined SWMU 9 Closed Landfill*, Charleston Naval Complex, Charleston, SC

U.S. Navy Environment Detachment Charleston (DET). (November 17, 1999) *Interim Measure for SWMU 8*, Charleston Naval Complex, Charleston, SC

South Carolina Department of Health and Environmental Control (November 1997) *Corrective Action Engineering and Operations Engineering Sections Decision flowchart for Landfills that are SWMUs*

- United States Environmental Protection Agency (USEPA). (May 1994) *RCRA Corrective Action Plan (Final)*, Office of Waste Programs Enforcement Office of Solid Waste 1  
2
- United States Environmental Protection Agency (USEPA). (December 1996) *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills*, Office of Solid Waste and Emergency Response 3  
4  
5
- United States Environmental Protection Agency (USEPA). (January 1997) *Landfill Presumptive Remedy Saves Time and Cost*, Office of Solid Waste and Emergency Response 6  
7
- EnSafe Inc., (1998). *Zone A Final RCRA Facility Investigation Report*, EnSafe Inc., Memphis, Tennessee. 8  
9
- EnSafe Inc., (1999). *SWMU 196 Work Plan Addendum*, EnSafe Inc., Memphis, Tennessee. 10
- Weidemeier, T.H., et al. (1995). *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater*: U.S. Air Force Center for Environmental Excellence, San Antonio, TX. 11  
12  
13
- Weidemeier, T.H., et al. (1998). *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*, EPA/600/R-98/128. 14  
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**9.0 SIGNATORY REQUIREMENT**

Condition I.E. of the Hazardous and Solid Waste Amendments (HSWA) portion of RCRA Part B Permit (EPA SCO 170 022 560) states: *All applications, reports, or information submitted to the Regional Administrator shall be signed and certified in accordance with 40 CFR §270.11.* The certification reads as follows:

*I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.*

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Henry N. Sheppard II, P.E.  
Caretaker Site Office, Charleston

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Date