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DRAFT ZONE H COMBINED SOLD WASTE MANAGEMENT UNIT 14 CORRECTIVE
MEASURES STUDY REPORT CNC CHARLESTON SC (DRAFT ACTING AS FINAL)
10/22/1999
ENSAFE INC.

**DRAFT ZONE H
COMBINED SWMU 14
CORRECTIVE MEASURES STUDY REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SOUTH CAROLINA**

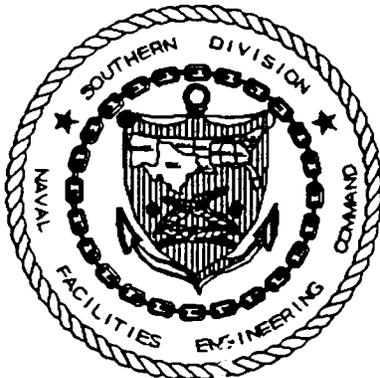


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Prepared for:

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



Prepared by:

**EnSafe Inc.
5720 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962**

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

Date: October 22, 1999
Signature: Michael Palmitt For
Name: Ted Blahnik
Title: CMS Zone Manager

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Appendix B	CMS Risk and Hazard Assessment

Acronym List

AOC	area of concern
A/PEG	alkaline polyethylene glycol
BEHP	bis(2-Ethylhexyl)phthalate
BEQ	benzo(a)Pyrene equivalent
bgs	below ground surface
BRA	baseline risk assessment
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
CNC	Charleston Naval Complex
COC	chemical of concern
cPAHs	carcinogenic polycyclic aromatic hydrocarbons
Cr(VI)	hexavalent chromium
Cr(III)	trivalent chromium
CRP	Community Relations Plan
DANC	decontaminating agent noncorrosive
DCE	dichloroethylene
DDT	dichlorodiphenyltrichloroethane
DET	Navy Environmental Detachment
DNAPL	dense nonaqueous phase liquid
EM	electromagnetic
ft ²	square feet
GIS	geographic information system
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazocine
IRP	Installation Restoration Program
ISM	interim stabilization measures
LS	lump sum
MCL	maximum contaminant level
MEK	2-butanone
mg/kg	milligrams per kilogram
MIBK	4-methyl-2-pentanone
MNA	monitored natural attenuation
MRCCG	maximum residual concentration cleanup goal

NAPL	nonaqueous phase liquid
NS	not sampled
O&M	operations and maintenance
OSWER	Office of Solid Waste and Management
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PIP	Public Involvement Plan
PPE	personal protective equipment
PW	present worth
RAB	Restoration Advisory Board
RBC	risk-based concentration
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	RCRA Facility Investigation
RGO	remedial goal option
SCDE	supercritical carbon dioxide extraction
SCDEHC	South Carolina Department of Health and Environmental Control
SOB	statement of basis
SOUTHDIV	Southern Division Naval Facilities Engineering Command
S/S	solidification/stabilization
SSL	soil screening level
SSV	sediment screening value
SVE	soil-vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TCA	1,1,2,2-trichloroethane
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxicity equivalency factors
TEQ	2,3,7,8-TCDD equivalents
TNT	2,4,6-trinitrotoluene
UCL	upper confidence level
US	United States
USEPA	United States Environmental Protection Agency
UV	ultraviolet

VC vinyl chloride
VOCs volatile organic compounds

WF weighting factor

$\mu\text{g/L}$ micrograms per liter
 $\mu\text{g/kg}$ micrograms per kilogram

yd^3 cubic yard

1.0 INTRODUCTION

Purpose and Organization of Report

This Corrective Measures Study (CMS) identifies, screens, develops, evaluates, and compares remedial action alternatives to mitigate hazards and threats to human health and the environment from soil and groundwater contamination at Combined Solid Waste Management Unit (SWMU) 14 (SWMU 14, SWMU 15, Area of Concern (AOC) 670, and AOC 684) at the Charleston Naval Complex (CNC), Charleston, South Carolina.

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

When the CMS is complete, 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 CNC decision makers include 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 report’s purpose and summarizes the project. 1
2

- **Section 2, Site Description:** This section presents Combined SWMU 14’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 Navy Environmental Detachment (DET), and supplemental CMS sampling. 3
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- **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 chemical’s contribution or lack thereof 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 background risk and hazard. 8
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- **Section 4, Identification and Screening of Technologies:** This section outlines response actions and identifies and screens remedial technologies that may be used to achieve remedial action objectives. 15
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- **Section 5, Development and Evaluation of Alternatives:** This section evaluates potential remedial alternatives according to the nine evaluation criteria identified in OSWER Directive 9902.3-2A, *RCRA Corrective Action Plan* (Final, May 1994), presenting strengths and weaknesses to prioritize or rank them relative to the nine evaluation criteria. 18
19
20
21

- **Section 6, Recommendations:** This section assesses the relative performance of the alternatives and presents recommendations. 1
2

- **Section 7, Public Involvement Plan:** This section summarizes the public involvement plan as it relates to the CMS. 3
4

- **Section 8, References:** This section lists applicable references used to prepare the CMS. 5

- **Section 9, Signatory Requirement:** This section provides the applicable signatory requirements for the CMS. 6
7

2.0 SITE DESCRIPTION

2.1 General

Combined SWMU 14 encompasses SWMUs 14 and 15, and AOCs 670 and 684 as shown on Figure 2-1. SWMU 14 is an abandoned chemical disposal area where miscellaneous chemicals, warfare decontaminating agents, and possibly industrial wastes are reported to have been buried. SWMU 15 is the site of a former propane-fired incinerator reported to have been used to destroy classified documents. Only the concrete slab and concrete propane tank saddles remain. AOC 670 is a former outdoor trap and skeet range in use from approximately 1960 until the late 1970s. Lead shot and clay targets were not recovered during its operation. AOC 684 is a former outdoor pistol range that operated from the early 1960s until 1981. Firearms were discharged into a soil berm; spent ammunition was not recovered. The discussion of nature and extent of contamination in the RFI included all samples collected in the Combined SWMU 14 area prior to the ISM and the CMS.

Current and Future Use

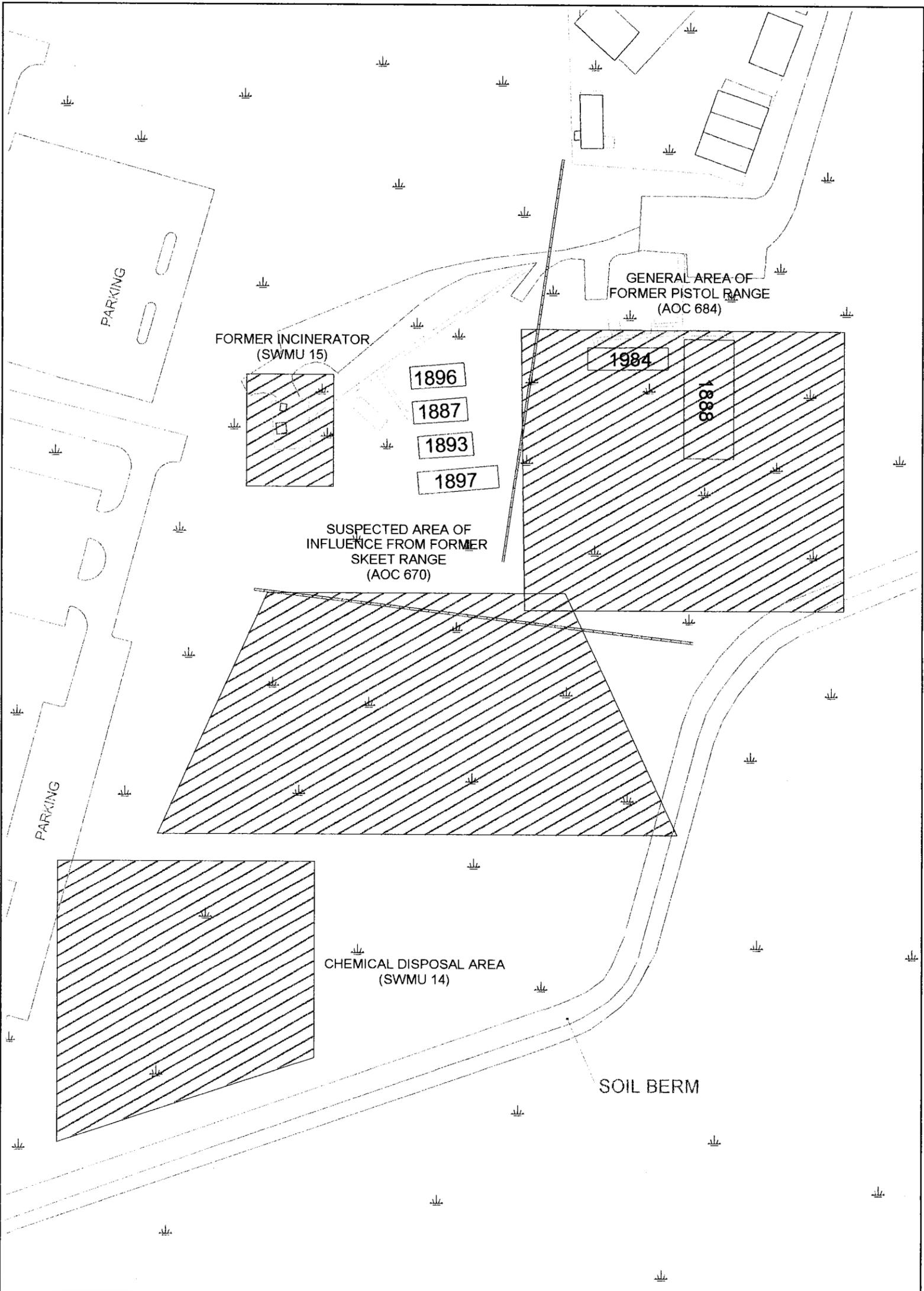
The Combined SWMU 14 site is not currently used by either federal or nonfederal tenants. According to the Charleston Naval Complex Redevelopment Authority, this area may be used for industrial or recreational purposes in the future.

2.2 Sampling Results

2.2.1 Soil

Geophysical and Soil-Gas Survey

A 1992 geophysical and soil-gas survey (EnSafe/A&H, 1995) investigated the presence of buried containers and/or contaminant plumes in the Combined SWMU 14 area. Geophysical and soil-gas samples were collected on a 100-by-100-foot grid, with some additional samples taken to detail plan-view anomalies. Geophysical anomalies identified during the geophysical survey were used

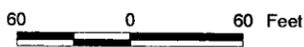


LEGEND

- BUILDING BOUNDARY
- FENCE
- ROAD
- SIDE-WALKS
- DRAINAGE DITCH
- GRASS
- AOCs and SWMUs



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**Figure 2.1
 Site Map**

as a basis for subsequent RFI and ISM sampling. Most of the soil-gas stations returned below-
detection concentrations for individual analytes and total volatiles. As such, the soil-gas data
suggest that the contaminants in the soil itself were not significant; several explanations were
provided:

- Spills may have never occurred.
- Substances not analyzed for were spilled.
- Contamination is deeper than the soil gas sampling.
- Contaminants had migrated or diffused.
- Contaminants are bound up in silty, clayey soils.

The geophysical and soil-gas investigation report was included in Appendix E of the
Final RFI Report for Zone H.

RCRA Facility Investigation

Soil was sampled during the RFI to identify whether contamination resulted from chemicals and
other waste disposal in the Combined SWMU 14 area and whether residual chemical
contamination resulted from small arms activities nearby. One hundred and thirty-five (72 upper-
interval and 63 lower-interval) soil samples were collected during the first round of soil sampling
at Combined SWMU 14. Most of the contamination detected in RFI soil samples at Combined
SWMU 14 was apparently related to the former incinerator (SWMU 15) and the former skeet
range (AOC 670).

Identification of Chemicals of Concern in Soil

COCs in the Combined SWMU 14 area were based on the soil sampling results, fate-and-transport
analysis, and risk-based calculations conducted during the RFI.

SWMU 14 Chemicals of Concern

Six COCs were identified in the samples collected from the SWMU 14 portion of the Combined SWMU 14 sampling area: 1,2,3-trichloropropane, benzo(a)pyrene equivalents (BEQs), aluminum, arsenic, beryllium, and vanadium. The primary contributors to surface soil risk were arsenic, beryllium, and BEQs. The primary hazard contributors were aluminum, arsenic, and vanadium. However, after the RFI was completed, the residential soil RBC for beryllium changed from 0.16 milligrams per kilogram (mg/kg) to 160 mg/kg (USEPA Region III Risk-Based Concentration (RBC) Table, 1998) since it is no longer considered a carcinogenic compound except for ambient air. As a result, beryllium was no longer considered a COC for SWMU 14.

Lead was originally not considered a COC because the mean surface soil concentration (385 mg/kg) fell below the residential cleanup goal (400 mg/kg). However, CMS lead shot sampling results indicated that lead was pervasive in the southern portion of the site. As a result, lead concentrations were considered on a point-by-point basis, and lead was classified as a COC. The cleanup goals were based on the USEPA Office of Solid Waste and Emergency Response Directive 9355.4-12 which states that lead in soil in excess of 400 mg/kg may pose a health risk in children through elevated blood levels. This number is based primarily on the surface soil ingestion pathway with minor contributions through dust inhalation and dermal contact.

SWMU 14 COC data are summarized in Table 2.1.

SWMU 15 Chemicals of Concern

Arsenic and BEQs were identified as COCs in the SWMU 15 portion of the Combined SWMU 14 sampling area. The primary contributors to surface soil risk were arsenic and BEQs. The sole hazard contributor was arsenic. Following the corrective measures investigation (see Section 2.3), lead was classified as an additional COC for SWMU 15. SWMU 15 COC data are summarized in Table 2.2.

Table 2.1
Zone H Soil Data for COCs at SWMU 14

Sample Number	Aluminum (mg/kg)	Arsenic (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	1,2,3-Trichloropropane ($\mu\text{g}/\text{kg}$) ^b	BEQs ^a ($\mu\text{g}/\text{kg}$)
RBC	7,800	0.43	400	55	91	87
Surface Soil Background	26,000	15.6	118	73	NA	424
Subsurface Soil Background	46,200	22.5	68.7	132	NA	208
SSL	560,000	15	400	3,000	0.0051	1,600
Upper-interval Soil Samples						
014-S-B-001-01	NS	14.2 UJ	44.5 UJ	50.1	5.0 U	92.1 U
014-S-B-002-01	NS	16.8 UJ	44.6 UJ	65.1	5.0 U	92.1 U
014-S-B-003-01	NS	11.0 UJ	24.8 UJ	68.6	5.0 U	92.1 U
014-S-B-004-01	NS	17.9 UJ	72.5	68.6	5.0 U	92.1 U
014-C-B-004-01	NS	11.9	95.2 J	55.8	5.0 U	92.1 U
014-S-B-005-01	NS	19.2 UJ	915.0	65.7	5.0 U	96.0
014-S-B-006-01	NS	16.8 UJ	808.0	68.8	5.0 U	92.1 U
014-S-B-007-01	NS	13.2 UJ	83.0	62.5	5.0 U	122.7
014-S-B-008-01	NS	16.2 UJ	295.0	40.4	91.2	92.1 U
014-S-B-009-01	NS	13.8 UJ	164.0	63.1	5.0 U	92.1 U
014-S-B-010-01	29,600	19.3 U	656.0	71.9	NS	NS
014-S-B-011-01	14,800	10.7 U	134.0	49.3	NS	NS
014-S-B-106-01	24,600	13.6	320 J	67.9	NS	1,475.2
014S-W-001-14	NS	20.3 UJ	16.7 UJ	41.2	5.0 U	92.1 U

Table 2.1
Zone H Soil Data for COCs at SWMU 14

Sample Number	Aluminum (mg/kg)	Arsenic (mg/kg)	Lead (mg/kg)	Vanadium (mg/kg)	1,2,3-Trichloropropane (μ g/kg) ^b	BEQs ^a (μ g/kg)
Lower-interval Soil Samples						
014-S-B-001-02	NS	10.4 UJ	18.1 UJ	29.8 UJ	5.0 U	92.1 U
014-S-B-002-02	NS	10.3 UJ	18.8 UJ	35.0	5.0 U	92.1 U
014-S-B-003-02	NS	8.2 UJ	26.3 UJ	41.1	5.0 U	92.1 U
014-S-B-004-02	NS	7.5 UJ	17.0 UJ	22.9 UJ	5.0 U	92.1 U
014-S-B-005-02	NS	12.8 UJ	27.0 UJ	46.9	5.0 U	92.1 U
014-S-B-006-02	NS	12.8 UJ	33.8 UJ	50.4	5.0 U	92.1 U
014-S-B-007-02	NS	13.6 UJ	44.7	74.0	5.0 U	93.7
014-S-B-008-02	NS	13.8 UJ	21.8 UJ	36.4	5.0 U	92.1 U
014-S-B-009-02	NS	17.3 UJ	31.9 UJ	69.2	5.0 U	92.1 U

Notes:

- (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*, February 5, 1999.
- (b) μ g/kg — micrograms per kilogram
- (c) NS: Not sampled.
- (d) Data Qualification:
 U — Undetected. The analyte was analyzed but not detected.
 J — Estimated value. One or more quality control (QC) parameters were outside control limits or the value was detected below the laboratory's quantification limit.
 UJ — Undetected and estimated. The analyte was analyzed but not detected and the quantitation limit is estimated because at least one QC parameters was outside control limits.
- (e) **Bold concentrations** — Indicates upper-interval soil samples with concentrations exceeding the greater of the following: RBC or surface soil background OR lower-interval soil samples with concentrations exceeding the greater of the following: subsurface background concentration or SSL.

Table 2.2
 Zone H Soil Data for COCs at SWMU 15

Sample ID	Arsenic (mg/kg)	Lead (mg/kg)	BEQs ^a (μ g/kg) ^b
RBC	0.43	400	87
Surface Soil Background	15.6	118	424
Subsurface Soil Background	22.5	68.7	208
SSL	15	400	1,600
Upper-interval Soil Samples			
015-S-B-001-01	6.4	21.0 J	157.5
015-S-B-002-01	3.6	7.3 U	92.1 U
015-S-B-003-01	15.0	21.3	444.8
015-S-B-004-01	51.4	83.7 J	1,919.4
015-C-B-004-01	54.8	71.8	2,137.4
015-S-B-005-01	NS ^c	NS	293.5
015-S-B-006-01	NS	NS	447.8
015-S-B-007-01	NS	NS	156.0
015-S-B-008-01	NS	NS	92.1 U
Lower-interval Soil Samples			
015-S-B-001-02	12.1	23.6	92.1 U
015-S-B-002-02	13.4	29.5	92.1 U
015-S-B-003-02	12.3	28.7	92.1 U
015-S-B-004-02	12.4	33.0 J	92.1 U
015-S-B-008-02	NS	NS	92.1 U

Notes:

- (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*, February 5, 1999.
- (b) μ g/kg — micrograms per kilogram
- (c) NS: Not sampled.
- (d) Data Qualification:
 - U — Undetected. The analyte was analyzed but not detected.
 - J — Estimated value. One or more quality control (QC) parameters were outside control limits or the value was detected below the laboratory's quantification limit.
- (e) **Bold concentrations** — Indicates upper-interval soil samples with concentrations exceeding the greater of the following: RBC or surface soil background OR lower-interval soil samples with concentrations exceeding the greater of the following: subsurface background concentration or SSL.

AOCs 670 and 684 Chemicals of Concern

Aluminum, antimony, arsenic, beryllium, thallium, Aroclor-1254, Aroclor-1260, and BEQs were identified as COCs in the AOC 670 and 684 portion of the Combined SWMU 14 sampling area. The primary contributors to surface soil risk were arsenic and BEQs. The hazard contributors were antimony, arsenic, and thallium. However, after the RFI was completed, the residential soil RBC for beryllium changed from 0.16 milligrams per kilogram (mg/kg) to 160 mg/kg (USEPA Region III Risk-Based Concentration (RBC) Table, 1998) since it is no longer considered a carcinogenic compound except for ambient air. As a result, beryllium was no longer considered a COC for AOCs 670 and 684.

Lead was originally not considered a COC because the mean surface soil concentration (1,213 mg/kg) fell below the USEPA adult cleanup/screening level (1,300 mg/kg) also referred to as the industrial reuse level. Furthermore, it was concluded that lead concentrations at AOC 670 would not require specific action under the hypothetical child exposure scenario, which is based on USEPA’s Lead Uptake/Biokinetic Model (Version 0.99d). Following the corrective measures investigation, lead was classified as an additional COC for AOC 670 because lead concentrations exceeded the residential cleanup goal (400 mg/kg) on a point-by-point basis. The cleanup goals were based on the USEPA Office of Solid Waste and Emergency Response Directive 9355.4-12 which states that lead in soil in excess of 400 mg/kg may pose a health risk in children through elevated blood levels. This number is based primarily on the surface soil ingestion pathway with minor contributions through dust inhalation and dermal contact.

COC data are summarized in Tables 2.3 and 2.4 for AOCs 670 and 684, respectively.

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Table 2.3
Zone H Soil Data For COCs at AOC 670

Sample ID	Antimony (mg/kg)	Arsenic (mg/kg)	Aluminum (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Aroclor- 1254 (µg/kg) ^b	Aroclor- 1260 (µg/kg)	BEQs ^a (µg/kg)
RBC	3.1	0.43	7,800	400	0.55	320	320	87
Surface Soil Background	NA	15.6	26,000	118	1.1	NA	NA	424
Subsurface Soil Background	NA	22.5	46,200	68.7	1.3	NA	NA	208
SSL	2.7	15	560,000	400	0.35	1,000	1,000	1,600
Upper-interval Soil Samples								
670-S-B-001-01	1.4 UR	15.6	14,200.0	21.0	2.3 U	50.0 U	50.0 U	92.1 U
670-S-B-002-01	1.6 UR	9.7	11,400.0	94.2	2.7 U	50.0 U	50.0 U	351.2
670-S-B-003-01	NS	NS	NS ^c	NS	NS	50.0 U	50.0 U	7,762.0
670-C-B-003-01	7.6 U	9.9 U	NS	9.8 UJ	1.8 U	33.0 U	33.0 U	741.4
670-S-B-004-01	7.4 UJ	11.3	13,700.0	9.5 UJ	0.5 U	40.0 U	40.0 U	1023.1
670-S-B-005-01	1.6 UJ	15.2	21,700.0	35.3 J	0.5 U	50.0 U	50.0 U	1,590.9
670-S-B-006-01	1.6 UJ	13.8	19,100.0	39.6 J	0.5 U	50.0 U	50.0 U	92.1 U
670-S-B-007-01	7.8 UJ	8.9	6,150.0	10.1 UJ	0.5	20.0 U	20.0 U	92.1 U
670-S-B-008-01	7.7 UJ	9.7	10,800.0	20.4 J	0.5 U	50.0 U	50.0 U	958.1
670-S-B-009-01	9.5 J	9.1	6,740.0	18.2 J	0.5 U	50.0 U	50.0 U	92.1 U
670-S-B-010-01	8.6 UJ	10.4	14,800.0	26.8 J	0.8 J	50.0 U	50.0 U	92.1 U
670-S-B-011-01	6.0 UR	8.9	3,220.0	7.7 UJ	2.0 U	50.0 U	50.0 U	92.1 U
670-S-B-012-01	11.4 J	23.7	9,190.0	871.0 J	1.3 U	50.0 U	50.0 U	704.8
670-S-B-013-01	7.2 UR	10.9	9,940.0	9.2 U	1.7 U	50.0 U	50.0 U	92.1 U
670-C-B-013-01	16.3 U	9.3 U	NS	20.6 UJ	1.9 U	33.0 U	33.0 U	107.8
670-S-B-014-01	17.2 UJ	9.5	11,200.0	44.0 J	0.5 U	20.0 U	20.0 U	92.2
670-S-B-015-01	6.6 UJ	8.5	NS	18.6 J	1.6 UJ	33.0 U	33.0 U	148.4
670-C-B-015-01	8.4 UJ	10.9	NS	14.4 J	2.0 UJ	NS	NS	NS
670-S-B-016-01	1.9 U	12.1 J	20,200.0	68.8	0.6 U	50.0 U	50.0 U	254.3
670-S-B-017-01	12.6 U	8.2 J	6,630.0	16.3 U	0.6 U	50.0 U	50.0 U	92.1 U
670-S-B-018-01	1.6 U	10.1 J	11,000.0	45.0	0.5 U	50.0 U	50.0 U	92.1 U
670-S-B-019-01	13.8 U	7.0 J	NS	56.8	2.3 UJ	33.0 U	33.0 U	127.1
670-S-B-020-01	9.5 UJ	8.4	NS	12.2 UJ	2.2 UJ	33.0 U	33.0 U	92.1 U
670-S-B-021-01	11.0 U	7.9 J	5,540.0	14.2 U	0.5 U	40.0 U	40.0 U	96.3
670-S-B-022-01	10.2 U	9.3 J	10,800.0	51.2	0.5 U	40.0 UJ	40.0 UJ	92.1 U

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Table 2.3
Zone H Soil Data For COCs at AOC 670

Sample ID	Antimony (mg/kg)	Arsenic (mg/kg)	Aluminum (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Aroclor- 1254 (µg/kg) ^b	Aroclor- 1260 (µg/kg)	BEQs ^a (µg/kg)
670-S-B-023-01	167.0 R	69.0	14,900.0	20,900	1.4	50.0 U	50.0 U	92.1 U
670-S-B-024-01	1.2 U	13.0 J	20,800.0	63.1	0.4 U	50.0 U	50.0 U	92.1 U
670-S-B-025-01	1.6 UJ	13.7 UJ	NS	133.0	0.6 UJ	NS	NS	NS
670-S-B-026-01	12.0 UJ	12.3 J	NS	1,690 J	0.2 UJ	33.0 UJ	33.0 UJ	92.1 U
670-S-B-027-01	10.9 U	8.3 J	NS	14.0 UJ	0.2 U	33.0 U	33.0 U	92.1 U
670-S-B-028-01	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-029-01	NS	NS	NS	NS	NS	NS	NS	7,525.1
670-S-B-030-01	NS	NS	NS	NS	NS	NS	NS	212.0
670-S-B-031-01	NS	NS	NS	NS	NS	NS	NS	3,766.2
670-C-B-031-01	1.6 U	15.4	NS	36.5	0.5 U	33.0 U	33.0 U	51,734.8
670-S-B-032-01	1.3 UJ	17.2	NS	44.4	1.5 U	33.0 U	33.0 U	916.9
670-S-B-033-01	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-034-01	NS	NS	NS	NS	NS	NS	NS	2,136.3
670-S-B-035-01	NS	NS	NS	NS	NS	NS	NS	92.1 U
Lower-interval Soil Samples								
670-S-B-001-02	1.9 UR	14.2	18,200.0	34.8	0.9 U	60.0 U	60.0 U	92.1 U
670-S-B-002-02	2.0 UR	14.0	11,100.0	20.4 J	0.5 U	60.0 U	60.0 U	92.1 U
670-S-B-003-02	NS	NS	NS	NS	NS	60.0 U	60.0 U	92.1 U
670-S-B-004-02	2.0 UJ	19.5	19,400.0	35.0 J	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-005-02	2.1 UJ	18.0	22,100.0	39.3 J	0.7 U	60.0 U	60.0 U	92.1 U
670-S-B-006-02	1.2 U	13.6 J	20,800.0	16.0	0.4 U	60.0 UJ	60.0 UJ	92.1 U
670-S-B-007-02	2.1 UJ	29.4	18,800.0	33.2 J	0.7 U	30.0 U	30.0 U	92.1 U
670-S-B-008-02	1.9 UJ	22.7	15,300.0	36.1 J	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-009-02	2.0 UJ	20.4	27,400.0	35.6 J	0.6 U	30.0 U	30.0 U	92.1 U
670-S-B-010-02	2.3 J	19.5	30,100.0	40.8 J	0.7 U	70.0 U	70.0 U	92.1 U
670-S-B-011-02	2.7 J	13.8	19,100.0	32.6 J	0.9 U	60.0 U	60.0 U	92.1 U
670-S-B-012-02	1.9 UR	18.2	20,000.0	37.2	0.9 U	50.0 U	50.0 U	92.1 U
670-S-B-013-02	1.9 UJ	23.0	19,100.0	35.4 J	0.6 U	30.0 U	30.0 U	92.1 U
670-S-B-014-02	1.9 UJ	9.0	13,700.0	11.6 J	0.6 U	30.0 U	30.0 U	92.1 U
670-S-B-015-02	2.5 UJ	19.2	NS	32.1	0.6 UJ	33.0 U	33.0 U	103.0

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Table 2.3
 Zone H Soil Data For COCs at AOC 670

Sample ID	Antimony (mg/kg)	Arsenic (mg/kg)	Aluminum (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Aroclor- 1254 ($\mu\text{g}/\text{kg}$) ^b	Aroclor- 1260 ($\mu\text{g}/\text{kg}$)	BEQs ^a ($\mu\text{g}/\text{kg}$)
670-S-B-016-02	1.8 U	16.2 J	31,200.0	39.3	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-017-02	2.1 U	23.3 J	30,200.0	46.5	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-018-02	1.9 U	21.6 J	24,400.0	38.3	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-019-02	1.8 UJ	16.4	NS	39.8	1.2 U	33.0 U	33.0 U	92.1 U
670-S-B-020-02	1.4 U	20.8	NS	42.0	2.9 U	33.0 U	33.0 U	137.1
670-S-B-021-02	2.2 U	25.4 J	28,100.0	41.2	0.7 U	60.0 UJ	60.0 UJ	92.1 U
670-S-B-022-02	1.9 U	18.4 J	19,500.0	31.0	0.6 U	60.0 UJ	60.0 UJ	92.1 U
670-S-B-023-02	1.6 U	18.1 J	26,500.0	47.4	0.5 U	60.0 U	60.0 U	92.1 U
670-S-B-024-02	2.3 U	23.1 J	18,700.0	46.3	0.6 U	60.0 U	60.0 U	92.1 U
670-S-B-025-02	1.7 UJ	20.0 UJ	NS	53.1 UJ	0.5 UJ	NS	NS	NS
670-S-B-026-02	1.8 U	19.7 J	NS	46.1	0.3 U	33.0 U	33.0 U	92.1 U
670-S-B-027-02	8.5 U	4.4 J	NS	14.3 J	0.7 U	33.0 U	33.0 U	92.1 U
670-S-B-028-02	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-030-02	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-032-02	1.5 UJ	24.9	NS	41.8	1.9 U	33.0 U	33.0 U	114.1
670-S-B-033-02	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-034-02	NS	NS	NS	NS	NS	NS	NS	92.1 U
670-S-B-035-02	NS	NS	NS	NS	NS	NS	NS	92.1 U

Notes:

- (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*, February 5, 1999.
- (b) $\mu\text{g}/\text{kg}$ — micrograms per kilogram
- (c) NS: Not sampled.
- (d) Data Qualification:
 U — Undetected. The analyte was analyzed but not detected.
 J — Estimated value. One or more quality control (QC) parameters were outside control limits or the value was detected below the laboratory's quantification limit.
 UJ — Undetected and estimated. The analyte was analyzed but not detected and the quantitation limit is estimated because at least one QC parameters was outside control limits.
 R/UR — Unusable data. One of more QC parameters grossly exceeded control limits.
- (e) **Bold concentrations** — Indicates upper-interval soil samples with concentrations exceeding the greater of the following: RBC or surface soil background OR lower-interval soil samples with concentrations exceeding the greater of the following: subsurface background concentration or SSL.

Table 2.4
 Zone H Soil Data For COCs at AOC 684

Sample ID	Antimony (mg/kg)		Arsenic (mg/kg)		Lead (mg/kg)		Thallium (mg/kg)		Aroclor-1254 (μ g/kg) ^b		Aroclor-1260 (μ g/kg)		BEQs ^a (μ g/kg)	
RBC	3.1		0.43		400		0.55		320		320		87	
Surface Soil Background	NA		15.6		118		1.1		NA		NA		424	
Subsurface Soil Background	NA		22.5		67.8		1.3		NA		NA		208	
SSL	2.7		15		400		0.35		1,000		1,000		1,600	
Upper-interval Soil Samples														
684-S-B-001-01	1.1	UJ	3.3	U	27.3		0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-002-01	1.4	UJ	1.9	U	10.3		0.3	UJ	33.0	U	33.0	U	92.1	U
684-C-B-002-01	1.4	UJ	7.0	J	22.9		0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-003-01	1.7	UJ	8.5		75.9		0.4	UJ	33.0	U	33.0	U	8,567.0	
684-S-B-004-01	1.8	UJ	12.7		67.9		0.4	UJ	33.0	U	33.0	U	4,407.7	
684-S-B-005-01	1.2	UJ	7.4		61.6		0.3	UJ	33.0	U	33.0	U	121.7	
684-S-B-006-01	1.5	UJ	0.6	U	3.9	J	0.4	UJ	33.0	U	33.0	U	92.1	U
684-S-B-007-01	1.6	UJ	9.0		24.8		0.4	UJ	33.0	U	376.0		92.1	U
684-S-B-008-01	6.0	U	1.9		11.2		0.1	J	33.0	U	33.0	U	92.1	U
684-S-B-009-01	5.6	J	12.9		38.9		2.9	J	33.0	U	33.0	U	92.1	U
684-S-B-010-01	6.0	U	5.2		117.0		0.1	J	330.0	U	330.0	U	92.1	U
684-S-B-011-01	6.0	U	1.4		46.4		1.0	U	330.0	U	330.0	U	92.1	U
684-S-B-012-01	6.2	J	0.9	J	4.1		1.0	U	330.0	U	330.0	U	92.1	U
684-S-B-013-01	4.6	J	2.8		8.5		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-014-01	12.4		11.7		35.1		1.2	J	33.0	U	33.0	U	92.1	U

Table 2.4
 Zone H Soil Data For COCs at AOC 684

Sample ID	Antimony (mg/kg)	Arsenic (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Aroclor-1254 (μ g/kg) ^b	Aroclor-1260 (μ g/kg)	BEQs ^a (μ g/kg)
684-S-B-015-01	11.9	13.5	47.2	1.3 J	330.0 U	330.0 U	1,515.5
684-S-B-016-01	5.3 J	4.8	4.0	1.5 J	33.0 U	33.0 U	92.1 U
684-S-B-017-01	7.7	3.6	10.2	1.0 U	330.0 U	330.0 U	167.0
684-S-B-018-01	10.1	6.4	22.3	1.0 U	33.0 U	33.0 U	169.4
684-S-B-019-01	11.3 UJ	5.1 UJ	24.7 U	0.8 U	165.0 U	165.0 U	241.5
684-S-B-020-01	1.9 UJ	11.3 UJ	57.2	0.9 U	165.0 U	165.0 U	2,153.5
684-S-B-021-01	1.8 UJ	3.8 UJ	14.1 UJ	0.8 U	165.0 U	165.0 U	25,501.3
684-S-B-022-01	11.3 UJ	5.1 UJ	16.1 UJ	0.6 U	165.0 U	165.0 U	395.1
684-S-B-023-01	1.6 UJ	11.6 UJ	62.5	0.7 U	33.0 U	33.0 U	1,236.7
684-S-B-024-01	1.9 UJ	16.2 UJ	39.0	1.0 U	33.0 U	33.0 U	4,270.4
684-S-B-025-01	1.5 UJ	10.6 UJ	50.7	1.0 U	33.0 U	33.0 U	329.2
684-S-B-026-01	1.7 U	16.3 J	50.8	0.3 U	33.0 U	33.0 U	1,962.9
684-S-B-027-01	1.4 U	9.9 J	32.4	0.3 U	33.0 U	33.0 U	544.5
684-S-B-028-01	1.8 UR	11.2 UJ	21.6 UJ	0.5 UJ	33.0 U	33.0 U	274.1
684-S-B-029-01	1.6 UJ	9.0 UJ	16.0 UJ	0.7 UJ	33.0 U	33.0 U	92.1 U
684-S-B-030-01	9.0 UJ	7.5 UJ	11.5 UJ	0.6 UJ	33.0 U	33.0 U	92.1 U
684-S-B-031-01	1.8 UJ	18.6 UJ	43.0 UJ	0.5 UJ	33.0 U	33.0 U	92.1 U
684-S-B-032-01	NS	NS	NS	NS	50.0	60.0	217.5
684-S-B-033-01	NS	NS	NS	NS	160.0	71.0	301.1
684-S-B-034-01	NS	NS	NS	NS	50.0 U	50.0 U	237.7

Table 2.4
Zone H Soil Data For COCs at AOC 684

Sample ID	Antimony (mg/kg)		Arsenic (mg/kg)		Lead (mg/kg)		Thallium (mg/kg)		Aroclor-1254 (μ g/kg) ^b		Aroclor-1260 (μ g/kg)		BEQs* (μ g/kg)	
684-S-B-035-01	NS		NS		NS		NS		50.0	U	50.0	U	29,871.0	
684-S-B-036-01	NS		NS		NS		NS		40.0	U	40.0	U	1,626.1	
684-C-B-036-01	6.9	U	11.7		27.6		0.4	U	33.0	U	33.0	U	698.4	
684-S-B-037-01	NS		NS		NS		NS		40.0	U	40.0	U	92.1	U
684-S-B-038-01	NS		NS		NS		NS		40.0	U	40.0	U	92.1	U
684-S-B-039-01	NS		NS		NS		NS		40.0	U	40.0	U	92.1	U
684-S-B-040-01	NS		NS		NS		NS		NS		NS		696.1	
684-S-B-041-01	NS		NS		NS		NS		NS		NS		96.0	
684-S-B-042-01	NS		NS		NS		NS		NS		NS		92.1	U
684-S-B-043-01	NS		NS		NS		NS		NS		NS		4,266.7	
684-S-B-044-01	NS		NS		NS		NS		NS		NS		10,311.0	
684-C-B-044-01	NS		NS		NS		NS		NS		NS		8,119.4	
Lower-interval Soil Samples														
684-S-B-001-02	1.3	UJ	5.0		7.2		0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-002-02	1.1	UJ	2.8	U	5.8		0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-003-02	1.3	UJ	1.3	U	4.3	J	0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-005-02	1.4	UJ	9.4		15.6		0.3	UJ	33.0	U	33.0	U	92.1	U
684-S-B-006-02	1.5	UJ	4.5		4.4	J	0.4	UJ	33.0	U	33.0	U	92.1	U

Table 2.4
Zone H Soil Data For COCs at AOC 684

Sample ID	Antimony (mg/kg)		Arsenic (mg/kg)		Lead (mg/kg)		Thallium (mg/kg)		Aroclor-1254 (μ g/kg) ^b		Aroclor-1260 (μ g/kg)		BEQs ^a (μ g/kg)	
684-S-B-007-02	4.8	J	2.0		4.8		0.1	J	330.0	U	330.0	U	92.1	U
684-S-B-008-02	6.0	U	5.1		6.5		0.1	J	33.0	U	33.0	U	92.1	U
684-S-B-009-02	6.0	U	2.2		8.9		0.1	J	330.0	U	330.0	U	92.1	U
684-S-B-011-02	7.2	J	3.1		3.0		0.9	J	33.0	U	33.0	U	92.1	U
684-S-B-013-02	6.4	J	2.2		3.6		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-014-02	8.7		2.8		4.4		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-015-02	8.6	J	11.2		30.8		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-016-02	5.1	J	7.7		28.9		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-018-02	3.5		2.4		5.3		1.0	U	33.0	U	33.0	U	92.1	U
684-S-B-019-02	1.5	UJ	7.3	UJ	1.9	UJ	0.5	U	33.0	U	33.0	U	92.1	U
684-S-B-022-02	2.9	UJ	21.1	UJ	34.3	UJ	0.9	U	33.0	U	33.0	U	92.1	U
684-S-B-023-02	1.9	UJ	13.3	UJ	31.5	UJ	1.2	U	33.0	U	33.0	U	92.1	U
684-S-B-024-02	1.6	UJ	15.4	UJ	35.0	UJ	0.8	U	33.0	U	33.0	U	92.1	U
684-S-B-025-02	2.4	UJ	23.7	UJ	41.9	UJ	0.8	U	33.0	U	33.0	U	92.1	U
684-S-B-027-02	1.9	U	17.8	J	41.6		0.3	U	33.0	U	33.0	U	185.5	
684-S-B-029-02	2.5	UJ	14.0	UJ	39.1	UJ	0.6	UJ	33.0	U	33.0	U	92.1	U
684-S-B-030-02	2.0	UJ	22.3	UJ	33.8	UJ	0.7	UJ	33.0	U	33.0	U	92.1	U
684-S-B-035-02	NS		NS		NS		NS		60.0	U	60.0	U	167.8	
684-S-B-036-02	NS		NS		NS		NS		50.0	U	50.0	U	92.1	U
684-S-B-039-02	NS		NS		NS		NS		40.0	U	40.0	U	92.1	U

Table 2.4
Zone H Soil Data For COCs at AOC 684

Sample ID	Antimony (mg/kg)	Arsenic (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Aroclor-1254 (μ g/kg) ^b	Aroclor-1260 (μ g/kg)	BEQs ^a (μ g/kg)
684-S-B-040-02	NS	NS	NS	NS	NS	NS	232.3
684-S-B-041-02	NS	NS	NS	NS	NS	NS	92.1 U
684-S-B-042-02	NS	NS	NS	NS	NS	NS	92.1 U
684-S-B-043-02	NS	NS	NS	NS	NS	NS	92.1 U
684-S-B-044-02	NS	NS	NS	NS	NS	NS	92.1 U

Notes:

- (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*, February 5, 1999.
- (b) μ g/kg — micrograms per kilogram
- (c) NS: Not sampled.
- (d) Data Qualification:
 U — Undetected. The analyte was analyzed but not detected.
 J — Estimated value. One or more quality control (QC) parameters were outside control limits or the value was detected below the laboratory's quantification limit.
 UJ — Undetected and estimated. The analyte was analyzed but not detected and the quantitation limit is estimated because at least one QC parameters was outside control limits.
 R/UR — Unusable data. One of more QC parameters grossly exceeded control limits.
- (e) **Bold concentrations** — Indicates upper-interval soil samples with concentrations exceeding the greater of the following: RBC or surface soil background OR lower-interval soil samples with concentrations exceeding the greater of the following: subsurface background concentration or SSL.

Compounds in Combined SWMU 14 Soil

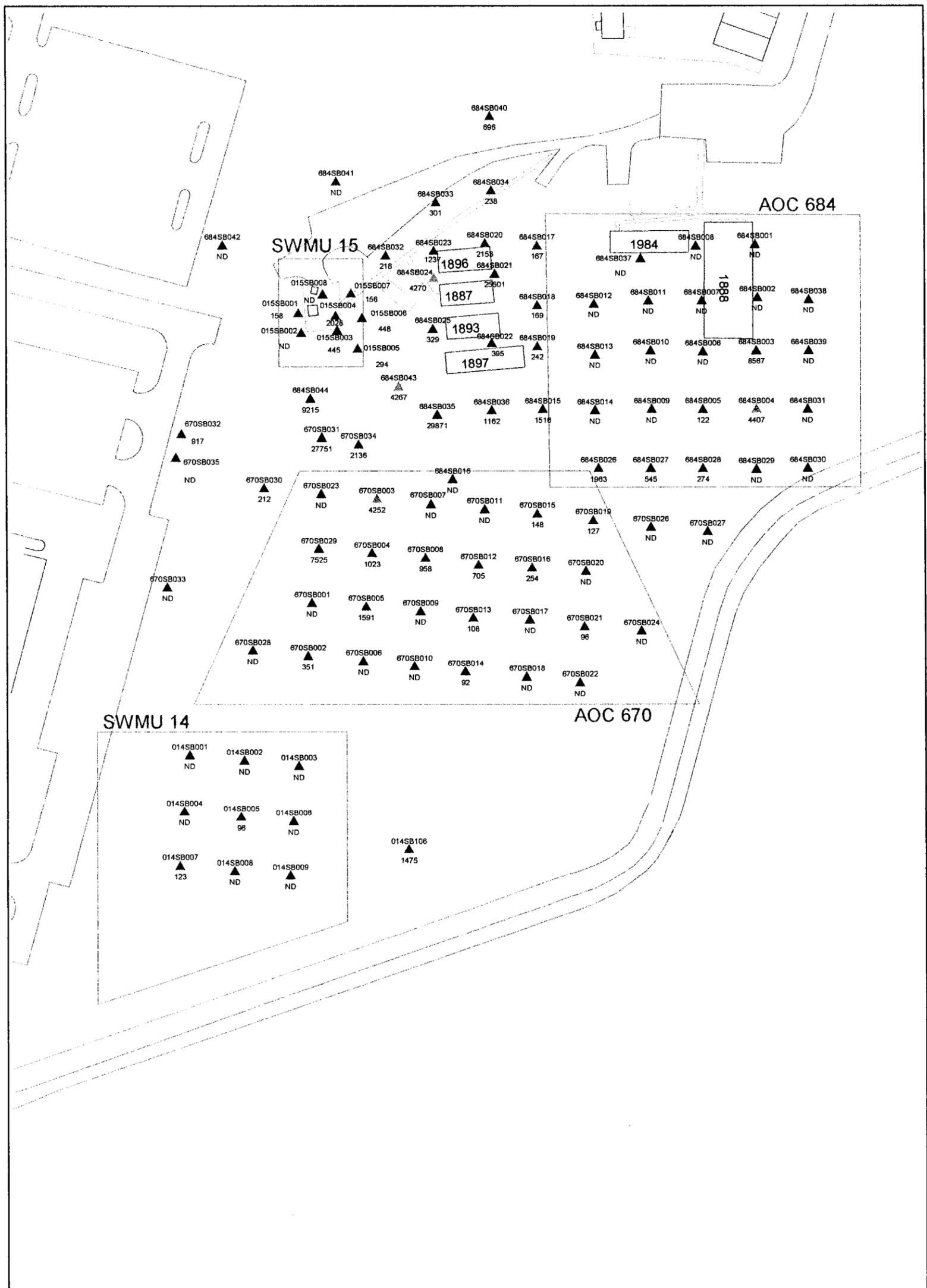
1,2,3-trichloropropane exceeded its RBC (91 $\mu\text{g}/\text{kg}$) in only one of 10 upper-interval locations (14SB008) at SWMU 14.

BEQs were the only semivolatile organic compound (SVOC) detected at concentrations that exceeded surface soil background concentrations in the upper-interval. The exceedances were in samples collected south, southeast, and east of the incinerator pad of SWMU 15, roughly located at sample locations 684SB035, 684SB044, and 670SB031. Elevated BEQs concentrations were also detected southeast of former Building 1888 (see Figure 2.2). BEQs exceeded their RBC (87 $\mu\text{g}/\text{kg}$) and surface soil background concentration (424 $\mu\text{g}/\text{kg}$) in upper-interval soil samples as shown in Table 2.5.

Table 2.5
BEQs Surface Soil Contamination Distribution

Location	Number of Exceedances	Total Number of Samples Collected	Range of Concentrations Exceeding BEQs Criteria ($\mu\text{g}/\text{kg}$)
SWMU 14	1	11	1,475.2
SWMU 15	3	8	444.8 - 2,137.4
AOC 670	9	33	704.8 - 51,734.8
AOC 684	14	44	544.5 - 29,871
Combined SWMU 14	27	96	444.8 - 51,734.8

The distribution of BEQs in the upper-interval is shown in Figure 2.2. Lower-interval BEQs contamination was confined to a small area south of former Building 1897 as shown in Figure 2.3. SWMU 15 was a paper incinerator, which may account for the presence of high concentrations of BEQs in the AOCs 670 and 684 sampling areas.



LEGEND

BEQs ($\mu\text{g}/\text{kg}$)

- ▲ X < 92.1 (NON DETECT)
- ▲ 92.1 < X < 300 (< 1E-06 Industrial Risk)
- ▲ 300 < X < 600 (< 1E-05 Residential Risk)
- ▲ 600 < X < 3000 (< 1E-05 Industrial Risk)
- ▲ 3000 < X < 6000 (< 1E-04 Residential Risk)
- ▲ 6000 < X < 30000 (< 1E-04 Industrial Risk)

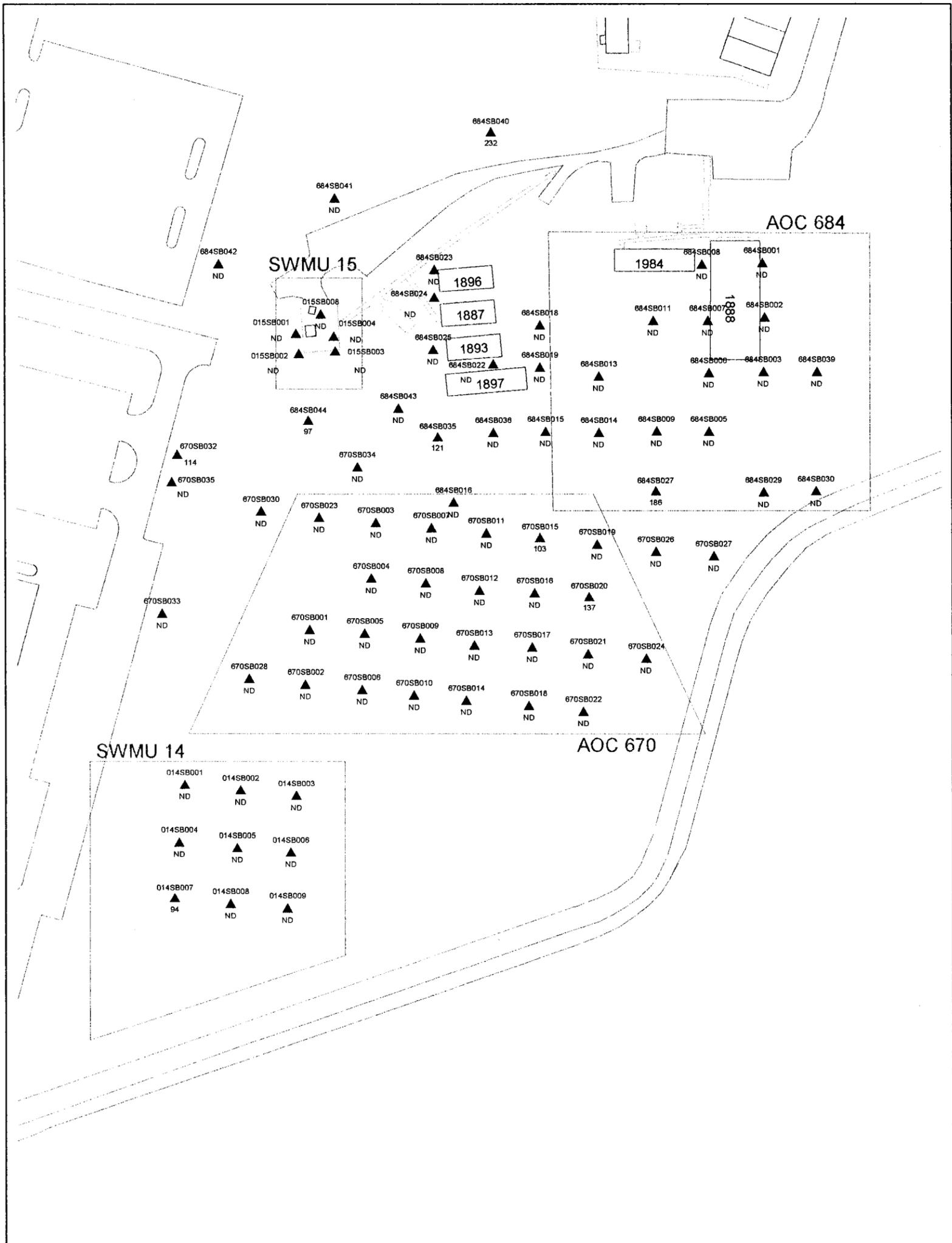
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS



**COMBINED SWMU 14
CMS REPORT
CHARLESTON NAVAL COMPLEX
Charleston, SC**

0 100 Feet

Figure 2.2
BEQs in Upper-Interval Surface Soil



LEGEND

- BEQs ($\mu\text{g}/\text{kg}$)
- ▲ $X < 92.1$ (NON DETECT)
 - ▲ $92.1 < X < 1600$ (< Groundwater Protection SSL at DAF = 10)
 - ▲ $X > 1600$ (> Groundwater Protection SSL at DAF = 10)

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



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Figure 2.3
BEQs in Lower-Interval Surface Soil

Aroclor-1254 did not exceed its RBC (320 $\mu\text{g}/\text{kg}$) at any of the 39 upper-interval sample locations. 1
2

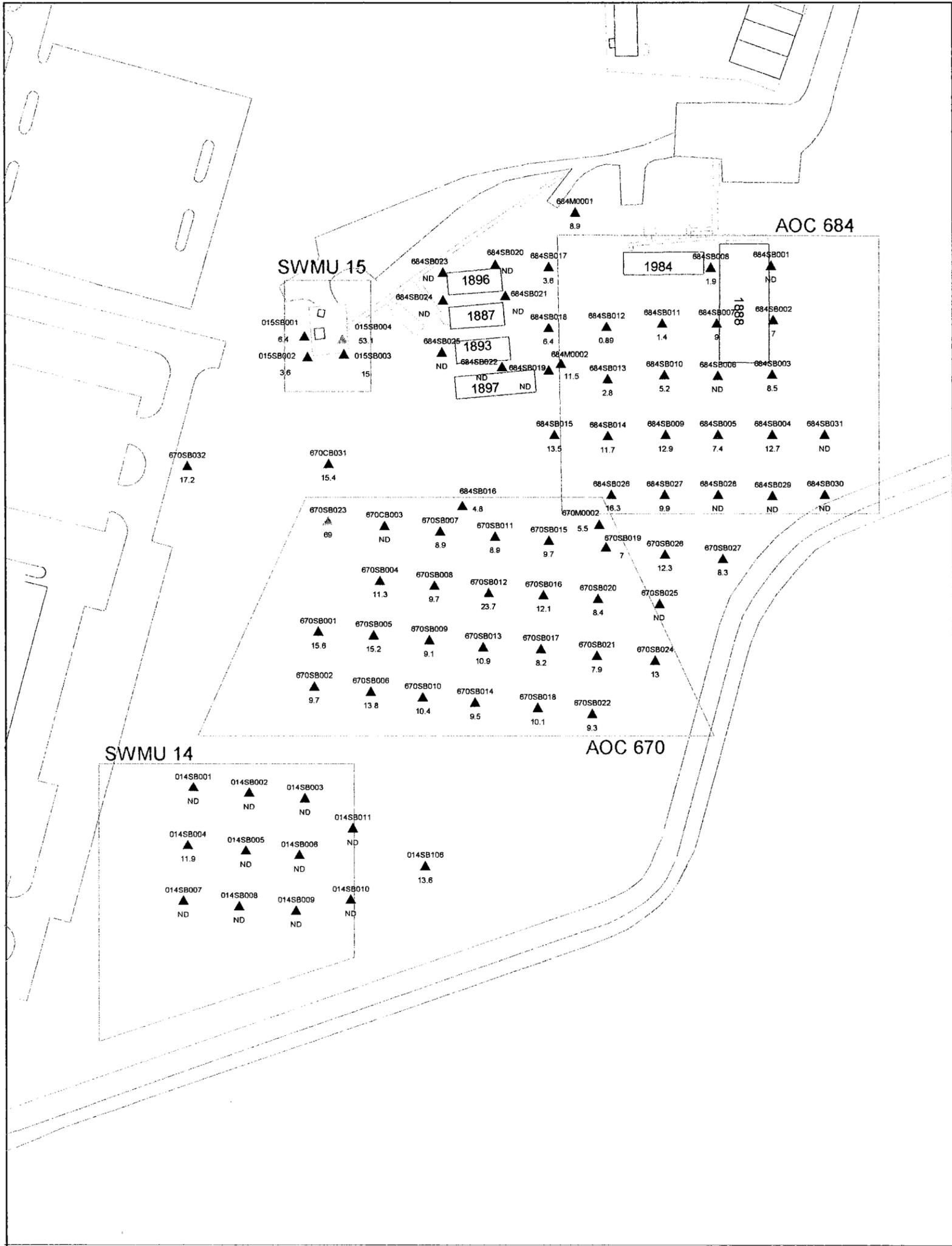
Aroclor-1260 exceeded its RBC (320 $\mu\text{g}/\text{kg}$) in one of the 39 upper-interval sample locations (684SB007). However, none of the sample locations exceeded the preliminary remediation goal of 1 mg/kg (40 CFR 761.120). 3
4
5

Aluminum exceeded its RBC (7,800 mg/kg) and surface soil background concentration (26,000 mg/kg) in one of three upper-interval sample locations (14SB010) at SWMU 14. No aluminum samples were collected from AOC 684. 6
7
8

Arsenic exceeded its RBC (0.43 mg/kg) and surface soil background concentration (15.6 mg/kg) at one of four upper-interval locations (15SB004) at SWMU 15, three of 29 upper-interval locations at AOC 670 (670SB012, -023, and -032), and one of 32 upper-interval locations (684SB026) at AOC 684. The distribution of arsenic in the upper-interval is shown on Figure 2.4. 9
10
11
12

Arsenic exceeded its SSL (15 mg/kg) and subsurface soil background concentration (22.5 mg/kg) in seven of 27 lower-interval AOC 670 soil samples (670SB007, -008, -013, -017, -021, -024, and -032). Arsenic's distribution in the lower-interval is shown on Figure 2.5. It exceeded upper- and lower-interval criteria at one location (670SB032) at AOC 670. 13
14
15
16

Antimony exceeded its RBC (3.1 mg/kg) in two of 29 upper-interval soil samples at AOC 670 (670SB009 and -012) and eight of 32 upper-interval soil samples at AOC 684 (684SB009, -012, -013, -014, -015, -017, -016, and -018). The distribution of antimony in the upper-interval is shown in Figure 2.6. It exceeded its SSL (2.7 mg/kg) at seven of 49 lower-interval sample locations in AOCs 670 and 684 (684SB007, -011, -013, -014, -015, -016, -018). Its distribution in the lower-interval is shown on Figure 2.7. 17
18
19
20
21
22



LEGEND

- ARSENIC (mg/kg)
- ▲ X < 15.6 (Below Background)
 - ▲ 15.61 < X < 27 (< 1E-05 Industrial Risk)
 - ▲ 27.01 < X < 38 (< 1E-04 Residential Risk)
 - ▲ 38.01 < X < 270 (< 1E-04 Industrial Risk; > 1E-04 Residential Risk)
 - ▲ X > 270.01 (> 1E-04 Industrial Risk)

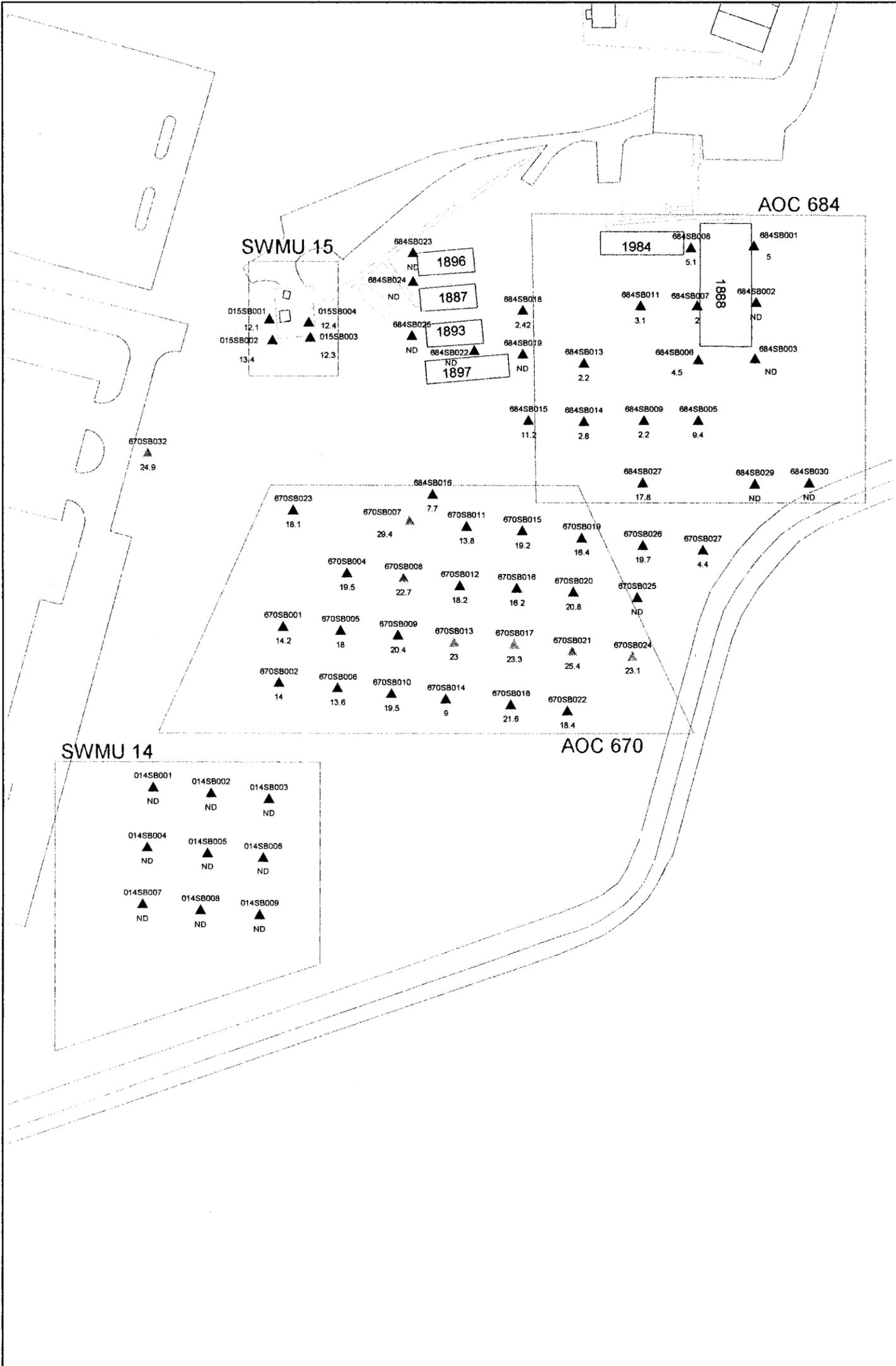
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS



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 Charleston, SC

0 100 Feet

Figure 2.4
 Arsenic in Upper-Interval Surface Soil



LEGEND

ARSENIC (mg/kg)

- ▲ X < 22.5 (Below Background)
- ▲ X > 22.5 (> Groundwater Protection SSL at DAF = 10 (15mg/kg))

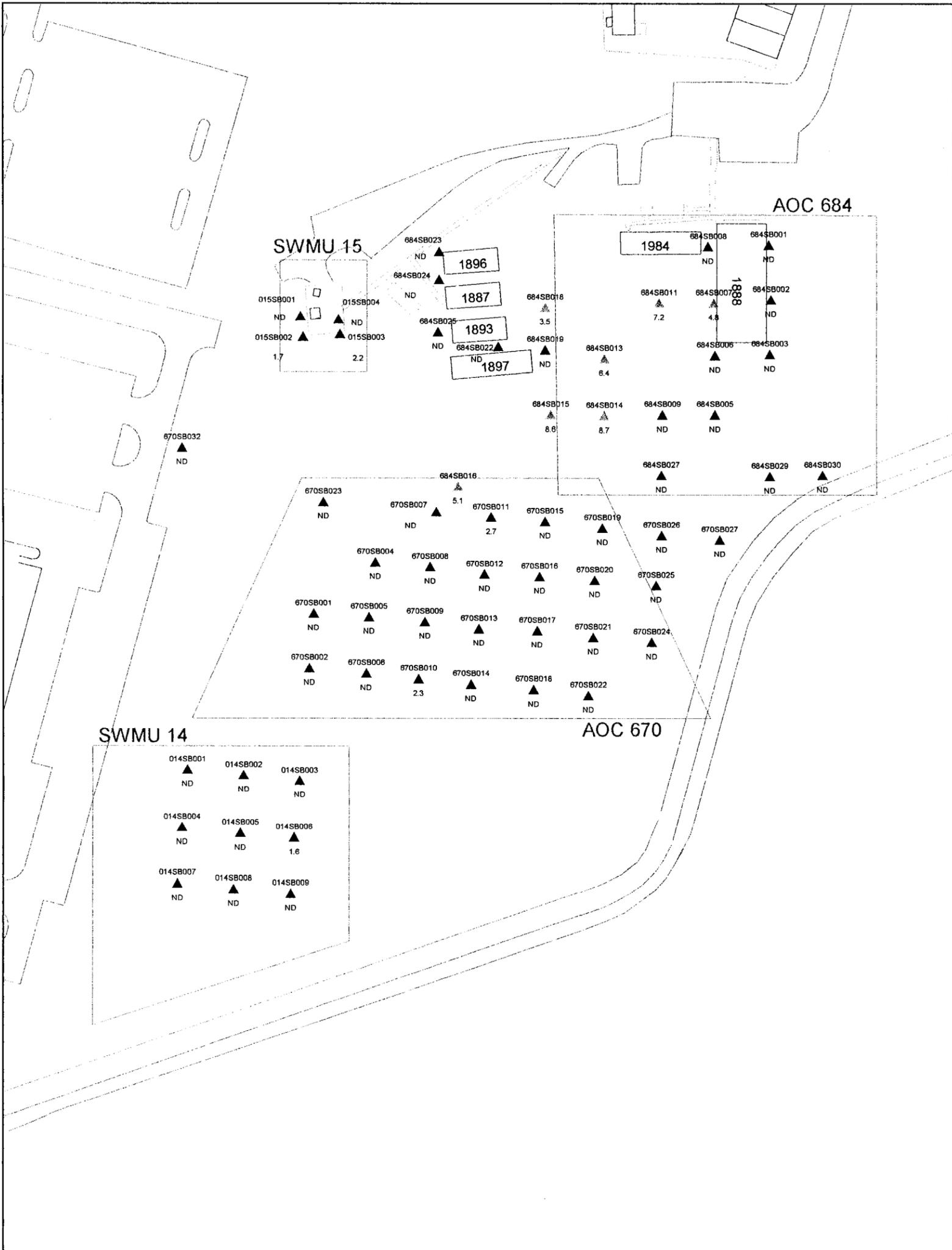
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS



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Charleston, SC**

0 100 Feet

**Figure 2.5
Arsenic in Lower-Interval Surface Soil**



LEGEND

- ANTIMONY (mg/kg)
- ▲ X < 2.7 (< Groundwater Protection SSL at DAF = 10)
 - ▲ X > 2.7 (> Groundwater Protection SSL at DAF = 10)
- ▭ BUILDING BOUNDARY
 - ▭ FENCE
 - ▭ ROAD
 - ▭ SIDE-WALKS



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0 100 Feet

Figure 2.7
 Antimony in Lower-Interval Surface Soil

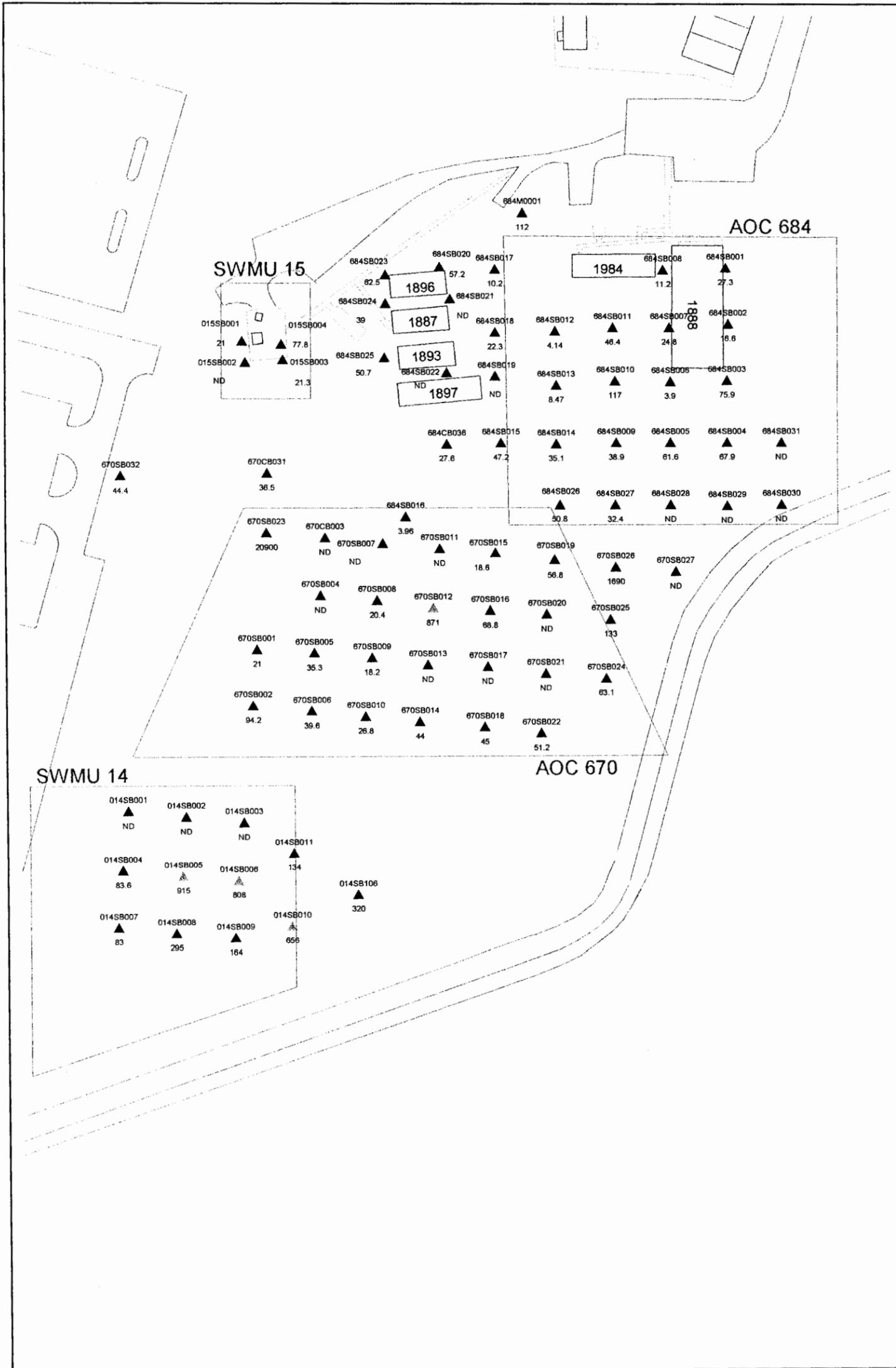
Lead exceeded its residential RBC (400 mg/kg) and surface soil background concentration (118 mg/kg) at three of 13 upper-interval soil samples at SWMU 14 (014SB005, -06, and -010) and three of 29 upper-interval soil samples at AOC 670 (670SB012, -023, and -026). Lead's distribution in the upper-interval is shown on Figure 2.8.

Thallium exceeded its RBC (0.55 mg/kg) and surface soil background concentration (1.1 mg/kg) at one of 29 upper-interval soil samples at AOC 670 (670SB023) and four of 32 soil samples at AOC 684 (684SB009, -014, -015, and -016). Thallium's distribution in the upper-interval is shown on Figure 2.9.

Vanadium exceeded its RBC (55 mg/kg) in nine of 12 upper-interval soil sample locations at SWMU 14. However, none of the concentrations exceeded vanadium's surface soil background concentration (73 mg/kg). None of the lower-interval soil samples exceeded vanadium's SSL (3,000 mg/kg) and subsurface soil background concentration (132 mg/kg).

Corrective Measures Investigation

Because the initial RFI investigation focused on residual chemicals, surface soil was not mechanically screened to determine approximate quantities and type of residual lead shot material remaining at the pistol and skeet ranges. Therefore, soil was sampled in this investigation to estimate the area/volume of particulate lead-impacted soil due to nearby firearm discharge. Relevant analytical reports are included in Appendix A.



LEGEND

LEAD (mg/kg)

- ▲ X < 400
- ⊕ 400 < X < 1300 (Above USEPA Residential Clean Up Standard)
- ▲ X > 1300 (Above USEPA Industrial Clean Up Standard)

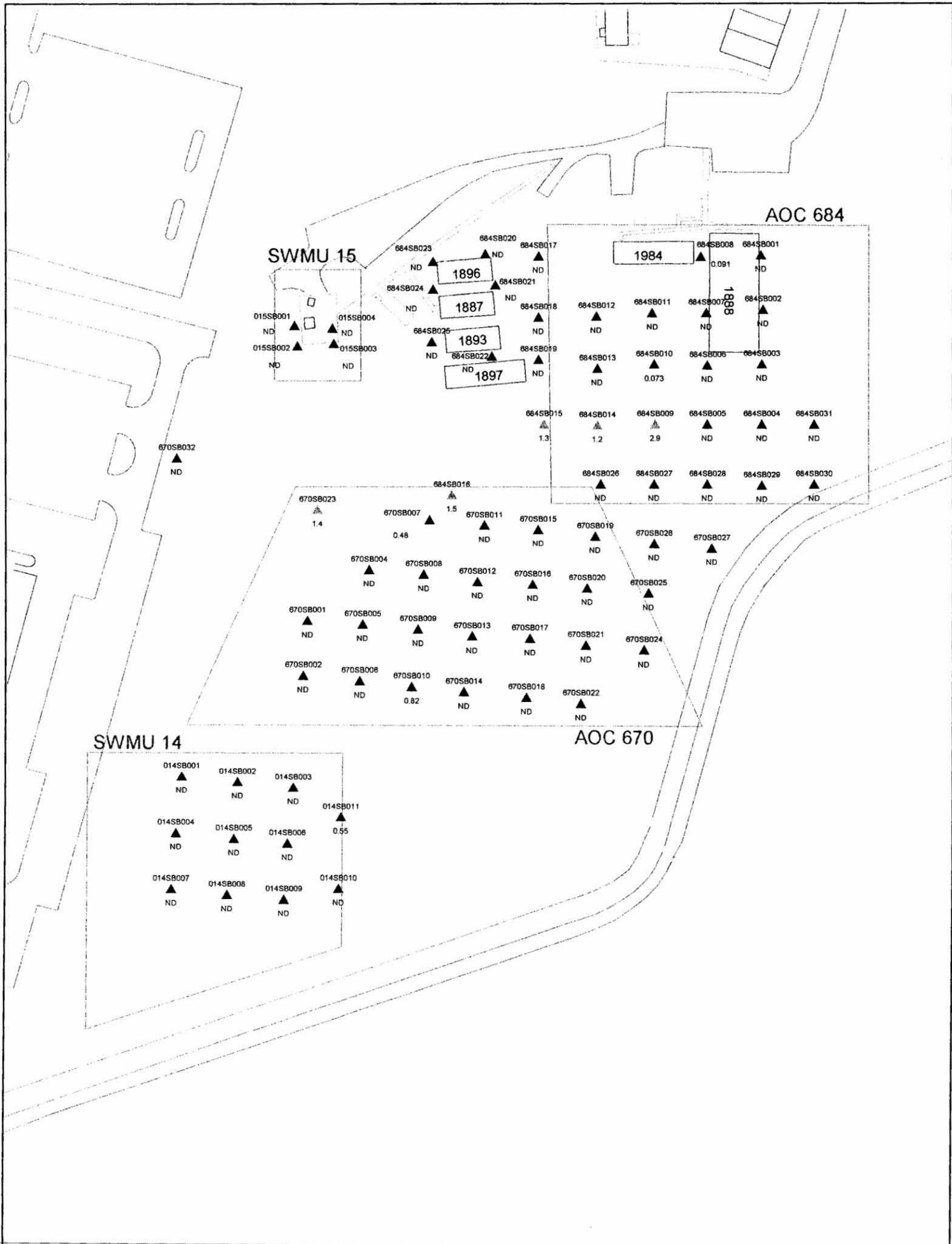
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS



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Charleston, SC**

0 100 Feet

**Figure 2.8
Lead in Upper-Interval Surface Soil**



LEGEND

- THALLIUM (mg/kg)
- ▲ X < 1.1 (Below Background)
 - △ 1.11 < X < 5.81 (< 1.0 Residential Hazard)
 - ▲ X > 5.81 (< 3.0 Residential Hazard)
 - BUILDING
 - BOUNDARY
 - FENCE
 - ROAD
 - SIDE-WALKS



COMBINED SWMU 14
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 Charleston, SC

0 100 Feet

Figure 2.9
 Thallium in Upper-Interval Surface Soil

Thirty-three surface soil samples were collected from the former outdoor trap and skeet range as indicated on Figure 2.10. Samples were collected in three rounds: (1) samples one to 16 (June 23, 1998), (2) samples 17 to 22 (July 28, 1998), and (3) samples 23 to 33 (October 21, 1998) in an attempt to delineate the extent of lead-shot-impacted soil. Initially, sample locations were based on the areas thought to be impacted by firearm discharge in the southern portion of Combined SWMU 14 and along the dike around the area. Additional sampling locations were based on analytical results.

One-foot by 1-foot by 4-inch surface soil samples were collected at each location and placed in plastic bags. All soil samples were sieve-analyzed for lead-shot concentration and particle-size distribution by Soil Consultants, Inc, Charleston, South Carolina. Table 2.6 summarizes the analytical data for the soil samples collected from Combined SWMU 14. The 0.0469-inch shot size is equivalent to the commonly known number 7½ or 8 shot, which were fired with shotguns at the skeet range. Lead shot distribution is also shown on Figure 2.10.

**Table 2.6
 Lead Shot Analysis Summary for Combined SWMU 14**

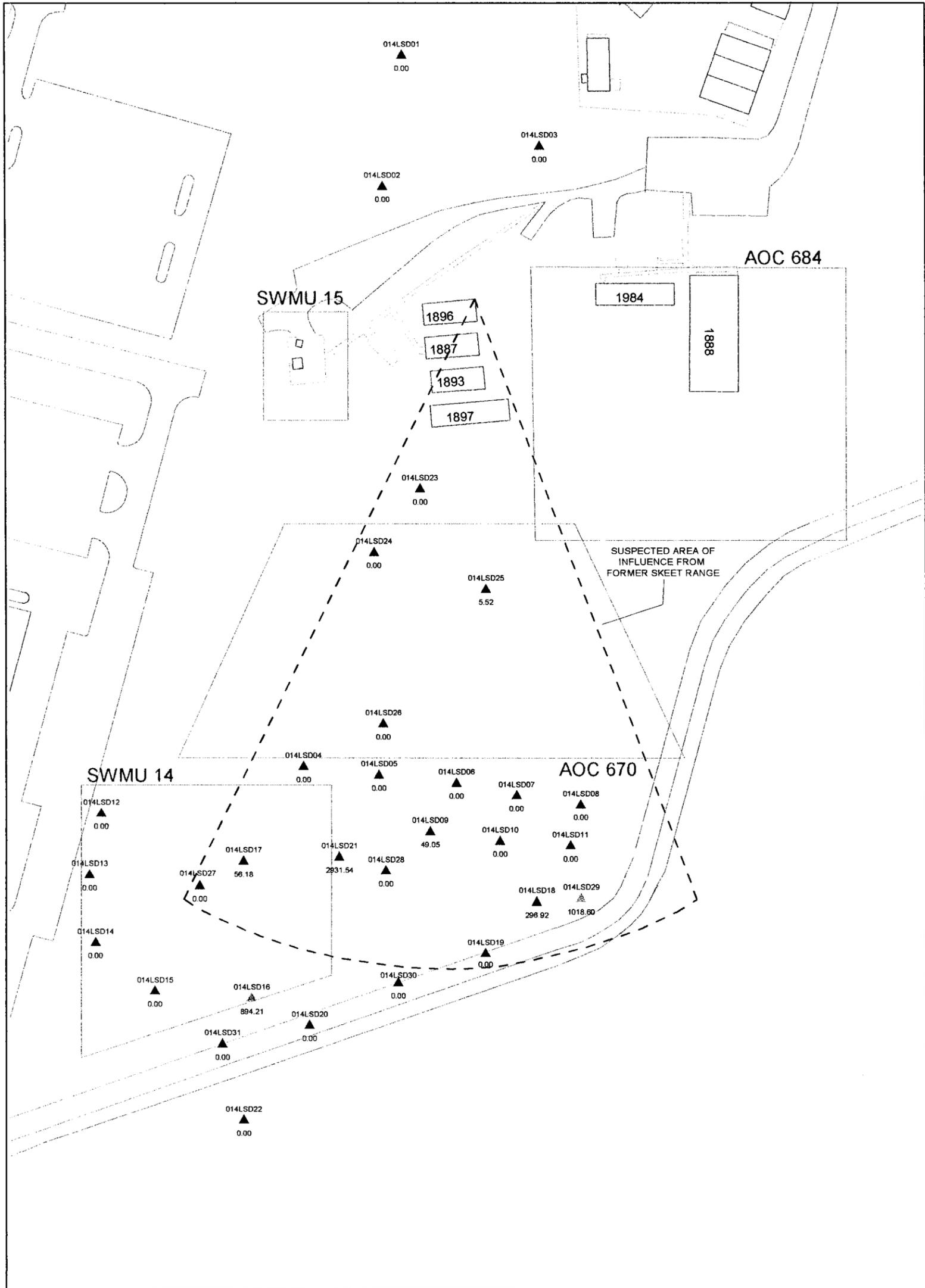
Sample ID	Initial Wet Mass (kg)	Initial Dry Mass (kg)	Shot Size: Sieve and Inches	Lead Shot Mass (mg)	Lead Shot Concentration (mg/kg)
014LSD0101	7.0974	4.9989	—	0	0
014LSD0201	8.3175	7.5204	—	0	0
014LSD0301	9.2996	7.2959	—	0	0
014LSD0401	8.4644	7.2947	—	0	0
014LSD0501	7.2644	6.2844	—	0	0
014LSD0601	9.7939	7.3786	—	0	0
014LSD0701	7.4900	5.3723	—	0	0
014LSD0801	8.7151	6.9537	—	0	0
014LSD0901	8.3601	6.1162	No. 16 sieve; 0.0469 inches	300	49.05
014LSD1001	9.5173	8.1275	—	0	0

**Table 2.6
 Lead Shot Analysis Summary for Combined SWMU 14**

Sample ID	Initial Wet Mass (kg)	Initial Dry Mass (kg)	Shot Size: Sieve and Inches	Lead Shot Mass (mg)	Lead Shot Concentration (mg/kg)
014LSD1101	11.5570	8.1426	—	0	0
014LSD1201	6.2177	5.3266	—	0	0
014LSD1301	8.4807	7.8432	—	0	0
014LSD1401	10.5655	8.2790	—	0	0
014LSD1501	11.7710	8.4280	—	0	0
014LSD1601	8.8273	7.0453	No. 16 sieve; 0.0469 inches	6,300	894.21
014LSD1701	6.6222	5.3399	No. 16 sieve; 0.0469 inches	300	56.18
014LSD1801	6.6898	5.3886	No. 16 sieve; 0.0469 inches	1,600	296.92
014LSD1901	7.2834	6.0579	—	0	0
014LSD2001	5.8627	4.8622	—	0	0
014LSD2101	6.9765	5.7990	No. 16 sieve; 0.0469 inches	17,000	2,931.54
014LSD2201	7.0476	5.3642	—	0	0
014LSD2301	4.1665	3.7163	—	0	0
014LSD2401	3.2431	2.3389	—	0	0
014LSD2501	2.7209	1.8122	No. 16 sieve; 0.0469 inches	10	5.52
014LSD2601	4.2111	2.9215	—	0	0
014LSD2701	3.3593	2.4085	—	0	0
014LSD2801	4.1724	2.8367	—	0	0
014LSD2901	4.1486	3.0434	No. 16 sieve; 0.0469 inches	3,100	1,018.6
014LSD3001	4.4923	3.5398	—	0	0
014LSD3101	3.8257	2.8192	—	0	0
014LSD3201	3.0422	2.1674	—	0	0
014LSD3301	5.0878	3.5958	—	0	0

Notes:

mg — milligram
 kg — kilogram

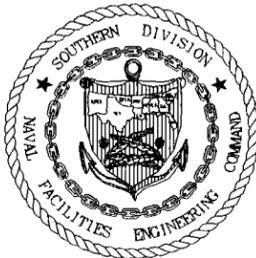


LEGEND

LEAD SHOT CONTAMINATION
(mg lead particulate per kg soil)

- ▲ X < 400
- ▲ 400 < X < 1300 (Above USEPA Residential Cleanup Standards)
- ▲ X > 1300 (Above USEPA Industrial Clean Up Standards)

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



**COMBINED SWMU 14
CMS REPORT
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Charleston, SC**

0 100 Feet

**Figure 2.10
Lead Shot Distribution**

2.2.2 Groundwater

RCRA Facility Investigation

Groundwater was sampled during the RFI to identify whether contamination resulted from chemicals and other waste disposal in the Combined SWMU 14 area, and whether residual chemical contamination resulted from small arms activities nearby.

Five monitoring well pairs (shallow/deep wells) were installed to sample groundwater at Combined SWMU 14. The deep monitoring wells were designed to allow groundwater directly above the Ashley Formation to be sampled (top of formation: 35 to 45 feet below ground surface). First-round groundwater samples were analyzed for all Appendix IX parameters. Second-round groundwater samples were analyzed for volatile organic compounds (VOCs), pesticides, herbicides, and metals.

The primary contributors to shallow groundwater risk were bis(2-Ethylhexyl)phthalate (BEHP) (common laboratory artifact) and 2,3,7,8-TCDD equivalents (TEQs - e.g., dioxins); both detected in first-quarter sampling only. The hazard contributors were aluminum and vanadium. However, due to dioxins' hydrophobic nature, they are not expected to migrate from soil to groundwater. Furthermore, TEQ concentrations reported in the shallow groundwater do not exceed the maximum contaminant level (MCL).

The primary contributors to deep groundwater risk were heptachlor epoxide, BEHP, and TEQs; each was detected in first-quarter sampling only. The hazard contributors were cadmium and thallium, which was also detected exclusively in first quarter samples. Due to hydrophobic nature of heptachlor epoxide and dioxins, neither would be expected to migrate from soil to groundwater. Furthermore, TEQ concentrations reported in the deep groundwater do not exceed its MCL.

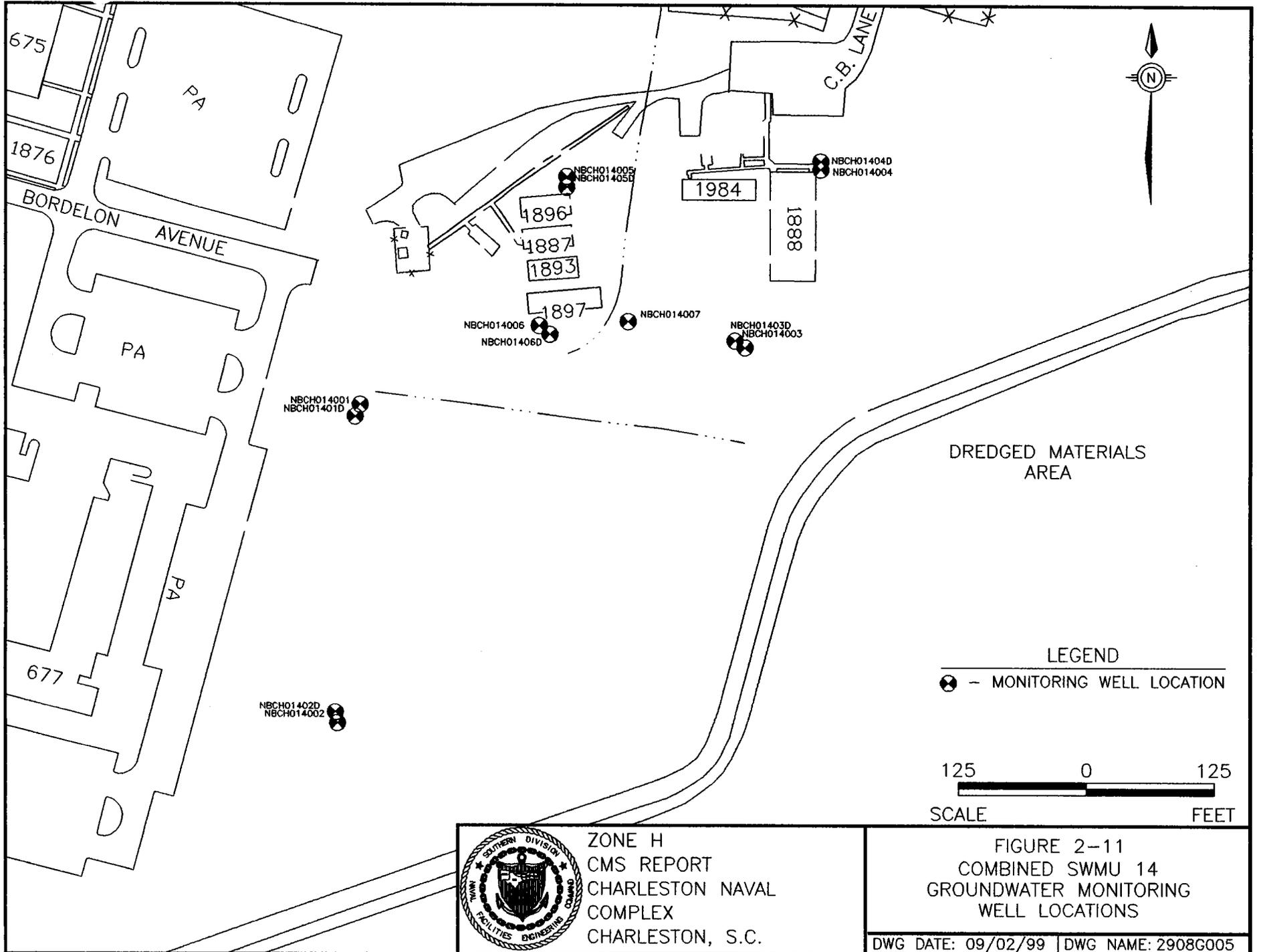
The fate-and-transport screening process for Combined SWMU 14 identified chromium and lead at concentrations exceeding their fate-and-transport screening criteria in both soil and groundwater. Shallow groundwater migration is a slow process for Zone H due to low hydraulic gradients (<0.006). As such, sorption is likely to be the dominant process affecting fate and transport for lead and chromium rather than groundwater migration. On a site-specific basis, only lead was identified in SWMU 14 for soil-to-groundwater migration concern based on soil concentrations and detections in down gradient monitoring wells. No constituents were identified as soil-to-groundwater migration concerns for SWMU 15, AOC 670, and AOC 684.

No groundwater COCs were identified for Combined SWMU 14.

Corrective Measures Investigation

An additional nested groundwater monitoring well pair (shallow/deep wells) and a single shallow well were installed near the decontaminating agent non-corrosive (DANC) container DET excavation area to evaluate the subsurface impact of the formerly buried waste (see Section 2.3 for ISM discussion).

Wells NBCH014006 and NBCH01406D were installed directly in the DET excavation area; well NBCH014007 was installed approximately 60 to 70 feet downgradient (see Figure 2.11). Table 2.7 summarizes the analytical data for the CMS groundwater samples collected from Combined SWMU 14 during July 1998, February 1999, and March 1999. Relevant analytical reports, chain of custodies, and validated data are included in Appendix A. Vinyl chloride was detected in well NBCH014006 above its MCL and tap water RBC in July 1998. However, no VOCs were detected in groundwater samples collected from well NBCH014007 in February 1999 and wells NBCH014006 and -06D in March 1999. Furthermore, no VOCs, except for acetone, were detected in groundwater samples collected from wells NBCH014006 and -007 during a July 1999 sampling event. Acetone, which is a common laboratory artifact, was detected in well NBCH014006 at 4.79 µg/L (two orders of magnitude below its RBC of 370 µg/L).



ZONE H
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FIGURE 2-11
 COMBINED SWMU 14
 GROUNDWATER MONITORING
 WELL LOCATIONS
 DWG DATE: 09/02/99 | DWG NAME: 2908G005

Table 2.7
 Combined SWMU 14 CMS Groundwater Samples ($\mu\text{g/L}$)

Date	Sample ID	Compound	Concentration	MCL	Tap Water RBC
7/98	014GW06D01	4-Methyl-2-Pentanone (MIBK)	3.0	NA	290
	014GW03D05	Carbon disulfide	2.0	NA	100
	014GW00601	Vinyl chloride	17.0	2.0	0.019
2/99	014GW00701	ND			
3/99	014GW06D02	ND			
	014GW00602	ND			
7/99	014GW00603	Acetone	4.79	NA	370
	014GW00702	ND			

Notes:

$\mu\text{g/L}$ — micrograms per liter
 NA — not applicable
 ND — nondetect

2.2.3 Sediment

Two sediment samples were collected during the RFI from an intermittent drainage ditch east of Buildings 1896, 1887, 1893, and former 1897 to measure the potential impact from previous site activities. In addition, two samples were collected from the intermittent drainage ditch that divides AOCs 670 and 684. All sediment samples were collected from 0 to 1 foot below the sediment surface and detections were compared to USEPA Region IV sediment screening values (SSV).

Contaminant concentrations in sediment were essentially equal to respective concentrations in soil, which suggests the potential for surface soil erosion to form a depositional zone within the drainage feature. With no apparent outlet from the drainage feature from which the Combined SWMU 14 sediment samples were collected during the RFI, further migration of sediments beyond Combined SWMU 14 would not be expected.

No sediment COCs were identified in the RFI for Combined SWMU 14.

2.2.4 Surface Water

One surface water sample was collected during the RFI from an intermittent drainage ditch that divides AOCs 670 and 684 to measure the potential impact from adjacent SWMUs. Detections were compared to USEPA chronic marine surface water quality criteria.

No surface water COCs were identified in the RFI for Combined SWMU 14.

2.3 Interim Stabilization Measures

ISMs were performed by the DET as part of the Navy Installation Restoration Program (IRP) to eliminate sources of environmental contamination or limit the spread of environmental contaminants prior to the completion of the CMS. Specifically, the ISM’s primary objective was to investigate and remove anomalies (containers of warfare decontaminating agents (DANC) particularly) and lead contamination identified in the RFI report dated July 5, 1996. Anomalies detected during geodetic and EM61 surveys were investigated using a trackhoe with personnel in Level B protection.

Approximately 90 five-gallon empty and partially or fully deteriorated DANC containers were removed from a location south of Building 1897 as described in the *Interim Measure Completion Report for Solid Waste Management Unit 14* (DET, 1998). Waste was buried in Combined SWMU 14 from the mid 1940s until 1977. Crystallized residual mass (1,1,2,2-trichloroethane) in the buried DANC containers was thought to have impacted soil and groundwater at the Combined SWMU 14.

After the building and its foundation were demolished and removed, an additional 50 five gallon DANC containers were excavated from the area within the building’s footprint. Affected soil was also excavated during the removal process. Thirty soil samples were collected to confirm the removal of all DANC-contaminated materials that exceeded USEPA Region III industrial RBCs

(DET, 1998). Two sample points required further excavation to remove residual contamination. 1
Afterwards, the excavated areas were backfilled with clean soil. All other anomalies resulted in 2
construction debris. An additional EM61 survey was performed to ensure that all anomalies were 3
cleared from the site. 4

Water intrusion in the bottom of the excavation was sampled and analyzed for Appendix IX VOCs. 5
The following were detected in the groundwater sample: PCE, (92.4 $\mu\text{g/L}$), TCE (85.1 $\mu\text{g/L}$), 6
cis-DCE (166 $\mu\text{g/L}$), trans-DCE (29.4 $\mu\text{g/L}$), and vinyl chloride (26.0 $\mu\text{g/L}$). However, water 7
intrusion samples may represent sediment-borne contamination released during soil excavation 8
rather than groundwater contamination. Furthermore, groundwater samples from wells within the 9
former burial location collected during the CMS (see Section 2.2.2) in February and March 1999 10
did not contain any VOC contamination. As stated above, confirmation sampling has 11
demonstrated that all residuals in soil have been removed from the site. 12

The uppermost 6 inches of soil above the anomalies, assumed to be influenced by lead shot in the 13
AOC 670 and 684 area, was required by the ISM work plan to be disposed of as hazardous waste. 14
Approximately 40 cubic yards (yd^3) of soil were accumulated during the anomaly excavations. 15
Four grab samples were collected, composited into one sample, and analyzed for total metals and 16
toxicity characteristic leaching procedure (TCLP). Two additional composite samples were 17
collected from the lead-shot-impacted areas. Based on the analytical results and an approval letter 18
from the SCDHEC (September 25, 1997), the soil was placed back into their original excavations 19
from which miscellaneous nonhazardous metal debris had been removed. These excavations were 20
not taken into account during the re-evaluation of site risk (see Section 3.3) because the excavated 21
soil volume was relatively small and large areas of soil were unaffected by the DET's point 22
removals. 23

This ISM implemented by the DET was not intended to be the final remedial action taken at Combined SWMU 14; however, it is consistent with the ultimate cleanup of the site. Moreover, it is assumed that soil and water samples collected during these ISM activities could be used to further define the environmental concerns at Combined SWMU 14. Soil and water samples collected during the ISM are summarized in Tables 2.8 and 2.9.

Table 2.8
Interim Stabilization Measures for Combined SWMU 14:
Soil Contamination

Compound	Detections/ Samples Collected	Concentration Range for Detections	RBC	SSL	Background Concentration
Screening Samples from DANC Excavation ($\mu\text{g}/\text{kg}$)					
1,1,2,2-tetrachloroethane	11/17	1.26 - 313,000	3,200	1.5	NA
1,1,2-trichloroethane	1/17	480	NA	NA	NA
PCE	4/17	2.84 - 2,000	12,000	30	NA
TCE	8/17	1.33 - 27,800	58,000	30	NA
1,2-trans-DCE	3/17	1.84 - 76.9	70,000	200	NA
Vinyl Chloride	1/17	1.66	340	6.7	NA
2-Butanone (MEK)	1/17	13.6	4,700,000	3,900	NA
1,2-dibromo- 3-chloropropane	1/17	2.84	NA	NA	NA
Chloroform	1/17	9.75	105,000	300	NA
Chlorobenzene	1/17	39.2	160,000	650	NA
Methylene Chloride	13/17	1.25 - 28.2	85,000	10	NA
Confirmation Samples from DANC Excavation ($\mu\text{g}/\text{kg}$)					
1,1,2,2-tetrachloroethane	6/13	2.75 - 45.9	3,200	1.5	NA
Vinyl Chloride	5/13	1.62 - 239	340	6.7	NA
PCE	2/13	15.6 - 250	12,000	30	NA
TCE	9/13	1.13 - 6,670	58,000	30	NA
1,2-cis-DCE	10/13	1.17 - 9,810	70,000	200	NA
1,2-trans-DCE	3/13	9.4 - 1,490	70,000	200	NA
Acetone	7/13	7.16 - 6,700	780,000	8,000	NA
2-Butanone (MEK)	7/13	40.8 - 174	4,700,000	3,900	NA

Table 2.8
Interim Stabilization Measures for Combined SWMU 14:
Soil Contamination

Compound	Detections/ Samples Collected	Concentration Range for Detections	RBC	SSL	Background Concentration
Confirmation Samples from DANC Excavation ($\mu\text{g}/\text{kg}$) (continued)					
Methylene Chloride	8/13	1.22 - 298	85,000	10	NA
Ethylbenzene	1/13	54	780,000	6,500	NA
Xylenes (total)	1/13	65.5	16,000,000	70,000	NA
Lead Shot Area Samples (mg/kg)					
Antimony	1/1	5.25	3.1	2.7	1.86
Arsenic	3/3	7.96 - 14.5	0.43	15	7.49
Lead	3/3	52.2 - 200	400	400	35.6
Thallium	1/1	8.26	0.55	0.35	0.24
Vanadium	1/1	20	55	3,000	27.1

Table 2.9
Interim Stabilization Measures for Combined SWMU 14:
Water Intrusion Samples ($\mu\text{g}/\text{L}$)

Compound	Detections/ Samples Collected	Concentration Range for Detections	MCL	Tap Water RBC
1,2-cis-DCE	1/1	166	70	NA
1,2-trans-DCE	1/1	29.4	100	NA
TCE	1/1	85.1	5.0	NA
Vinyl Chloride	1/1	26	2.0	NA
1,1,2,2-tetrachloroethane	1/1	92.4	NA	0.053

Notes:

$\mu\text{g}/\text{L}$ — micrograms per liter
 mg/kg — milligrams per kilogram
 NA — not applicable

Data summarized from *Interim Measure Completion Report for Solid Waste Management Unit 14* (DET, 1998)

ISM Status

The DET is planning to excavate lead-contaminated soil in Summer of 1999 at SWMU 14 (014SB005, -006, -010, and 014LSD16, -21, and -29), AOC 670 (670SB012, -023, and -026), and from the berm around the dike in the southern portion of the site. Soil will be excavated until confirmation samples indicate that the contamination has been removed — all soil with lead concentrations above 400 mg/kg will be excavated by the DET. Lead contamination includes residual chemical lead and lead particulate matter from Combined SWMU 14 firearms activities. These points were excluded from the risk assessment discussed in Section 3.

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3.0 REMEDIAL OBJECTIVES 1

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 have been modified in response to calculated Zone H background risk and hazard. 2
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3.1 Soil Chemicals of Concern 7

Arsenic, BEQs, and lead are the primary surface soil COCs at Combined SWMU 14. However, 1,2,3-trichloropropane, aluminum, antimony, Aroclor-1254, Aroclor-1260, thallium, and vanadium were also classified as COCs in the RFI because at least one soil sample exceeded regulatory, risk-based, or background criteria. 8
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1,2,3-trichloropropane exceeded its RBC (91 $\mu\text{g}/\text{kg}$) in only one of nine surface soil samples (014SB008); it was not detected in the other eight samples. This lone detection (91.2 $\mu\text{g}/\text{kg}$) was essentially equivalent to the residential RBC. Trichloropropane was originally retained as a COC because its concentration at soil sampling location 014SB008 exceeded its soil-to-air volatilization screening level (30 $\mu\text{g}/\text{kg}$). However, due to the limited extent of detections, impacts to ambient air related to trichloropropane volatilization are unlikely to exceed acceptable risk-based air concentrations. Consequently, this compound will not be addressed further in this CMS. 12
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Aluminum exceeded its RBC (7,800 mg/kg) and surface soil background reference concentration (26,000 mg/kg) in one of three upper-interval sample locations (14SB010) at SWMU 14. Aluminum concentrations are essentially equal to background concentrations which suggests that a spill or other point release did not impact the site. Furthermore, aluminum soil concentrations are typically elevated in the clayey soils like those found at Combined SWMU 14. Aluminum drives a hazard quotient of 0.26, which is above the corrective action threshold of 0.1 for a 19
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specific chemical; however, the overall site hazard of 0.91 is below the corrective action threshold of 1.0 for total site hazard. Furthermore, the highest aluminum-driven point hazard is less than 0.5. Consequently, aluminum will not be addressed further as part of this CMS.

Antimony exceeded its RBC (3.1 mg/kg) in two of 29 upper-interval soil samples at AOC 670 (670SB009 and -012) and eight of 32 upper-interval soil samples at AOC 684 (684SB009, -012, -013, -014, -015, -017, -016, and -018). However, antimony drives a hazard quotient of only 0.000071, which is significantly below the corrective action threshold of 0.1 for a specific chemical and the Zone H background hazard for antimony (0.071).

Antimony exceeded its SSL (2.7 mg/kg) at seven of 49 lower-interval sample locations in AOC 684 (684SB007, -011, -013, -014, -015, -016, -018). However, antimony was not detected in groundwater samples collected during the RFI, which suggests that subsurface soil-to-groundwater migration is not occurring at a rate that threatens groundwater. Therefore, antimony will not be addressed further as part of this CMS.

Aroclor-1254 and Aroclor-1260 were originally retained as COCs because two samples contained these compounds at concentrations exceeding their risk-based screening levels (RBSLs). However, Aroclor-1254 did not exceed its residential RBC (320 $\mu\text{g}/\text{kg}$) at any of the 39 upper-interval sample locations. Aroclor-1260 only exceeded its residential RBC (320 $\mu\text{g}/\text{kg}$) in one of 39 upper-interval locations (684SB007) at a concentration of 376 $\mu\text{g}/\text{kg}$; the industrial RBC for polychlorinated biphenyls (PCBs) is 2,900 $\mu\text{g}/\text{kg}$. Furthermore, none of the sample locations exceeded the preliminary remediation goal of 1 mg/kg (40 CFR 761.120). This sample concentration and frequency of detection is not reflective of a release. Therefore, Aroclor-1254 and -1260 will not be addressed further as part of this CMS.

Thallium exceeded its RBC (0.55 mg/kg) and surface soil background reference concentration (1.1 mg/kg) at only one of 28 upper-interval soil samples at AOC 670 (670SB023) and four out of 32 soil samples at AOC 684 (684SB009, -014, -015, and -016). It did not exceed its subsurface soil background concentration in any lower-interval soil samples. Thallium will not be addressed further as part of this CMS for the following reasons:

- Thallium exceeded its surface soil background reference concentrations in only 8% of upper-interval samples. Moreover, the 95% upper confidence interval of the site thallium sample mean is lower than the zone background reference concentration. Therefore, thallium’s frequency and concentrations are not indicative of an acute thallium release at the site.
- Thallium drives a hazard quotient of only 0.023, which is significantly below the corrective action threshold of 0.1 for a specific chemical.

Vanadium exceeded its RBC (55 mg/kg) at nine of 12 SWMU 14 upper-interval soil sample locations. However, none of the concentrations exceeded its surface soil background reference concentration (73 mg/kg). None of the lower-interval soil samples exceeded the subsurface soil background concentration for vanadium. Since vanadium detections do not exceed calculated background concentrations, it will not be addressed further as part of this CMS.

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

- Arsenic exceeded its SSL (15 mg/kg) in 24 of 72 subsurface soil samples. However, the calculated subsurface background reference concentration (22.5 mg/kg) also exceeds the SSL. Furthermore, arsenic concentrations in groundwater samples are below MCLs,

which suggests that subsurface soil-to-groundwater migration is not occurring at a rate that threatens groundwater.

- The lower-interval arsenic detections do not correlate to surface soil arsenic detections and are therefore not representative of vertical migration through the soil. Furthermore, the results do not indicate the presence of a spill or other arsenic point release.
- Only 9% of arsenic samples exceed subsurface soil calculated background reference concentration (22.5 mg/kg), and the maximum subsurface soil concentration (29.4 mg/kg) is only 30% higher than the site's calculated subsurface background concentration.

BEQs in surface soil will be addressed as part of this CMS. However, BEQs will not be addressed in subsurface soils. No samples exceeded the SSL for BEQs (1,600 $\mu\text{g}/\text{kg}$), and BEQs were not detected in any groundwater samples collected at Combined SWMU 14. The maximum lower-interval concentration is only 167.8 $\mu\text{g}/\text{kg}$.

Lead will be addressed based on USEPA blood-level model protection numbers of 400 mg/kg residential and 1,300 mg/kg industrial.

3.2 Groundwater Chemicals of Concern

No groundwater COCs were identified in the RFI. However, the first round (July, 1998) shallow groundwater sample from well NBCH014006, installed in the former DANC excavation area, contained a vinyl chloride concentration (17.0 $\mu\text{g}/\text{L}$) that exceeded its RBC and MCL. However, vinyl chloride was not detected in second (March 1999) and third round (July 1999) samples from this same well; no VOCs were detected in deep well NBCH014W06D. No chlorinated VOCs were detected in wells NBCH014001 through -005 in four rounds of sampling, and no VOCs were

detected in first (February 1999) and second round (July 1999) groundwater samples collected from well NBCH014007, which is downgradient of NBCH014006.

Vinyl chloride is an anaerobic degradation product of 1,1,2,2-trichloroethane (TCA) which is the main chemical component of the DANC contamination removed by the DET. The presence of vinyl chloride following the excavation suggests that the chlorinated hydrocarbon residue (i.e., TCA) had been degraded in the biologically active vadose and saturated zones.

Acetone, which is a common laboratory artifact, was detected in a sample from well NBCH014006 at 4.79 $\mu\text{g/L}$ during the July 1999 sampling event. The detected concentration is two orders of magnitude below its RBC of 370 $\mu\text{g/L}$. Acetone was not detected in any other groundwater samples collected during the investigation (RFI and CMS) of Combined SWMU 14

Acetone was detected in the soil removed from the former DANC burial area and disposed offsite (43,400 $\mu\text{g/kg}$). However, acetone was only detected in seven of 30 sidewall and bottom confirmation samples at concentrations ranging from 40.8 to 174 $\mu\text{g/kg}$, which are substantially below its surface soil RBC (780,000 $\mu\text{g/kg}$) and protection of groundwater screening level (8,000 $\mu\text{g/kg}$).

Based on the lack of groundwater contaminants in excess of MCLs or RBCs described above and the apparent natural degradation of chlorinated VOCs formerly present at the site, groundwater will not be further addressed in this CMS.

3.3 Remedial Goal Options

3.3.1 Human Health Risks and Hazards

In the RFI, remedial goal option (RGO) refers to the 95% upper confidence level (UCL) of the mean residual concentration of a chemical which produces a specific level of risk and/or hazard.

RFI RGOs were based on selected regulatory thresholds. The CMS work plan introduced alternate RGOs based on risk reduction analysis and comparison to Zone H background risk. The SCDHEC expressed interest in also setting maximum residual concentrations corresponding to the RGOs in order to facilitate confirmation sampling.

RFI RGOs did not consider cumulative effects of different chemicals. They simply gave the residual site risk and hazard for a given 95% UCL concentration of a given chemical. CMS RGOs (Table 3.1) are more conservative than RFI RGOs in that they consider the cumulative effects of the COCs. The minimum RGO presented corresponds to Zone H background risk, because cleaning up soils to concentrations below Zone H background is not practical. Other RGOs were based on risk reduction analysis (Appendix B) which showed a decreasing rate of reduction in risk and hazard relative to increases in the area of the site to be treated. All RGOs are below the regulatory hazard threshold of 1.0 and risk threshold of 1.0E-04.

Table 3.1
Combined SWMU 14 CMS Remedial Goal Options

	Address All Points > Background UCL		Decrease Residual Site Risk to Zone H Background Risk		Address All Point Risk > 1.0E-04 and Point Hazard > 1.0		No Further Remedial Action	
	MRCCG (mg/kg)	95% Site UCL	MRCCG (mg/kg)	95% Site UCL	MRCCG (mg/kg)	95% Site UCL	MRCCG (mg/kg)	95% Site UCL
Arsenic	7.5	4.4	10.0	6.4	20.0	9.5	62.0	12.3
BEQs	0.2	0.09	1.0	0.13	4.3	0.44	29.9	1.77
	Residual Hazard	Residual Risk	Residual Hazard	Residual Risk	Residual Hazard	Residual Risk	Residual Hazard	Residual Risk
Residential	0.2	1.3E-05	0.3	1.9E-05	0.5	3.2E-05	0.6	6.1E-05
Industrial	0.01	1.9E-06	0.01	2.8E-06	0.02	5.0E-06	0.02	1.1E-05
Estimated Treatment Area	200,000 ft ²		105,000 ft ²		25,000 ft ²		0 ft ²	

Notes:

- MRCCG — maximum residual concentration cleanup goal
- UCL — Upper confidence level
- BEQs — Benzo(a)pyrene equivalents; calculated by multiplying the cPAHs by their respective TEFs

3.3.2 Ecological Risks and Hazards

Four potential ecological receptors were evaluated during the RFI for Combined SWMU 14: infaunal invertebrates, terrestrial wildlife, vegetation, and aquatic wildlife.

Infaunal Invertebrates

Except for lead, soil inorganic concentrations should not present a risk to infaunal species (e.g., small crustaceans). Lead-contaminated soil will be addressed during the DET ISM in Summer of 1999 (see Section 2.3). Individual PAH concentrations may not be critical, but additive effects from detected PAHs, along with other SVOCs detected, may threaten soil infaunal species. However, high PAH concentrations in soil can also lead to increased populations of microorganisms capable of degrading the compounds.

Terrestrial Wildlife

A potential lethal risk to short-tailed shrew is present based on the maximum soil concentration observed for lead (20,900 mg/kg). However, lead-contaminated soil will be addressed during the DET ISM in summer of 1999 (see Section 2.3). A potential sublethal risk to Eastern cottontail rabbit was indicated by the Wildlife Contaminant Exposure Model for surface soil, due primarily to arsenic at two locations: 670SB023, which will be addressed during the DET ISM in Summer of 1999 because of lead shot contamination, and 015SB004, which will be addressed during the corrective measures process.

Vegetation

Although lead concentrations were high (20,900 mg/kg) in soil at Combined SWMU 14, the monotypic nature of the grass fields and the low capacity of grasses to store significant amounts of metals will reduce the risk of lead phytotoxic effects to an acceptable level. Furthermore, and as previously discussed, lead in surface soil will be addressed by the DET during an ISM in summer 1999.

Aquatic Wildlife

The sediment collected in Combined SWMU 14, particularly in the westernmost sample 670M000101, exhibited high concentrations of lead, PAHs, and other SVOC compounds. These sediments, however, were collected in low-lying surface depressions which, based on their frequent dryness, do not support significant communities of aquatic wildlife. These land-locked depressions also lack apparent connections to other wetlands and water bodies. With a lack of suitable habitat and the inability to convey surface water, no risk is predicted for aquatic wildlife.

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 14 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:** These 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:** 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 remedial objectives and to ensure that receptors are not threatened. 1
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- **Treatment:** Used to reduce the toxicity, mobility, or volume of the principal threats posed by a site, where practical. 5
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- **Containment:** Protects 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. 7
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- **Combination:** Appropriate methods can be combined to protect human health and the environment. 10
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4.2 Technology Screening 12

Applicable technology descriptions, site constraints, and waste constraints are summarized in Table 4.1 at the end of Section 4. Site and waste constraints were used to screen or retain the applicable technologies. 13
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4.2.1 Results for Soil Remediation 16

Combined SWMU 14 soil contamination is primarily confined to the uppermost 0 to 3 feet below ground surface, which is generally comprised of hard, tight, silty, clayey fill down to the water table. It has relatively low permeability and porosity and a variable organic content. The water table ranges from approximately 4 to 6 feet in this area based on location, tidal influence, and time of year (e.g., seasonal precipitation differences). 17
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Evaluation of potential remedial technologies was based on these general site characteristics and the contaminants discussed in Sections 2 and 3. 1
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4.2.1.1 Eliminated Technologies (Phase I) 3

The following soil technology categories were screened from further consideration based on general site and waste stream constraints: 4
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Institutional Controls 6

- None 7

Containment 8

- None 9

In Situ Biological Treatment Technologies 10

- **Bioventing** was screened from further consideration because it does not effectively treat inorganics and BEQs. In addition, the shallow water table limits its effectiveness because it is difficult to control gases and vapor in the subsurface. The vadose zone should extend at least 10 feet below the ground surface to provide a sufficient volume of 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. 11
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- **Electrokinetically enhanced bioremediation** was screened from further consideration because it does not effectively treat inorganics and BEQs. Metals can be immobilized by undesirable chemical reactions with naturally occurring and co-dispersed chemicals. In addition, the vadose zone should extend at least 10 feet below the ground surface to provide a enough soil for this technology to effectively treat soil contaminants in it. 18
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Furthermore, a heterogenous subsurface (nearly all fill at this site) can reduce removal efficiencies. 1
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In Situ Physical/Chemical Treatment Technologies 3

- **In situ and ex situ chemical oxidation** were screened from further consideration because they treat VOCs and SVOCs more effectively than inorganics and BEQs. Moreover, chemical oxidation is typically used to treat soil containing contaminants too concentrated or too toxic for enhanced bioremediation to be effective. For in situ oxidation, soil 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. 4
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- **Electrokinetic separation** was screened from further consideration because it treats consolidated soil contamination more effectively than compounds dispersed over a large site such as Combined SWMU 14 12
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- **Fracturing** was screened from further consideration because it does not apply to current site conditions. 15
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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. 17
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- **Soil flushing** was screened from further consideration because groundwater contamination is independent of soil contamination. Soil flushing might cross-contaminate the groundwater. 20
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- **In situ soil-vapor extraction (SVE)** was screened from further consideration because vadose zone technologies are not being considered for this site. The shallow water table limits the technology’s effectiveness because it is difficult to control gases and vapor in the subsurface. The vadose zone should extend at least 10 feet below the ground surface to provide a sufficient volume of soil for SVE to effectively treat soil contaminants. 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 inorganics and BEQs.
- **In situ solidification/stabilization** was screened from further consideration because it may interfere with future site use.

In Situ Thermal Treatment Technologies

- **In situ and ex situ electrical resistance heating** were screened from further consideration because they do not effectively treat inorganics and BEQs. The shallow water table limits the technology’s effectiveness because it is difficult to move the heated water through the subsurface without impacting the aquifer. The vadose zone should extend at least 10 feet below the ground surface to provide a sufficient volume of soil for electrical resistance heating to effectively treat soil contaminants. Furthermore, effective transport of the heated water can be severely limited in a soil with a high bulk density, low porosity, and low permeability. Finally, because the affected area is greater than 1 acre (~7 acres), this technology would likely be prohibitively expensive.
- **Steam or hot water injection** was screened from further consideration because this technology is most effective in sandy soil.

- **In situ vitrification** was screened from further consideration because it may impact future use of the site. **Ex situ vitrification** was screened from further consideration because it is primarily used to treat radioactive contaminants.

Ex Situ Biological Treatment Technologies

- **Biopiles (or composting)** was screened from further consideration because it treats VOCs and fuel hydrocarbons more effectively than it does inorganics and BEQs. Composting is generally limited to wastes containing smaller hydrocarbon molecules. The presence of salts or metals may inhibit microbial activity.
- **Biosorption** was screened from further consideration because it treats dissolved species more effectively than it does soil-sorbed constituents.
- **Fungal biodegradation** was screened from further consideration because it does not effectively treat inorganics and BEQs. Fungal biodegradation is generally limited to organic compounds.
- **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 enhanced bioremediation.
- **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.

Ex Situ Physical/Chemical Treatment Technologies	1
• Dehalogenation was screened from further consideration because it does not effectively treat inorganics and BEQs. Dehalogenation is limited to halogenated contaminants.	2 3
• Solar detoxification was screened from further consideration because it primarily targets VOCs, SVOCs, and solvents rather than inorganics and BEQs.	4 5
• Supercritical carbon dioxide extraction (SCDE) was screened from further consideration because it does not effectively treat inorganics and BEQs.	6 7
Ex Situ Thermal Treatment Technologies	8
• Distillation was screened from further consideration because it is limited to the removal of organic contamination, and not site inorganics.	9 10
• High-pressure oxidation was screened from further consideration because it does not effectively treat inorganics and BEQs.	11 12
• Hot gas decontamination was screened from further consideration because it is primarily used for managing explosives.	13 14
• Incineration and pyrolysis were screened from further consideration because they do not effectively treat inorganics and BEQs.	15 16
• 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 14 BEQs concentrations are too low to supply sufficient heat energy to warrant this thermal technology — it would likely be cost prohibitive.	17 18 19 20

- **Open burn and detonation** were screened from further consideration because they are used primarily to treat munitions rather than inorganics and BEQs.

Other Technologies

- None

4.2.1.2 Eliminated Technologies (Phase II)

The following technologies are effective for *only one* of the two principal waste streams (inorganics and BEQs) and were therefore screened from further consideration:

Institutional Controls

- None

Containment

- None

In Situ Biological Treatment Technologies

- **Enhanced bioremediation** was screened from further consideration because it does not effectively treat inorganic compounds. BEQs may be treated with this technology, although less effectively than lighter hydrocarbons.
- **Monitored natural attenuation (MNA)** was screened from further consideration because it does not effectively treat inorganics since these compounds are often immobilized during the process, but not destroyed. Immobilization may involve adsorption, coprecipitation, precipitation, and diffusion into the soil matrix, and may either be reversible or slowly reversible. MNA may treat BEQs and other PAHs effectively, but institutional controls may be required and limit access to the site during remediation.

In Situ Physical/Chemical Treatment Technologies	1
• None	2
In Situ Thermal Treatment Technologies	3
• None	4
Ex Situ Biological Treatment Technologies	5
• None	6
Ex Situ Physical/Chemical Treatment Technologies	7
• Chemical extraction was screened from further consideration because it does not effectively treat BEQs (molecular weight = 252). Chemical extraction has been shown to be effective in treating soil containing inorganic and organic contaminants, but is generally least effective on very high molecular weight organics and very hydrophilic substances.	8 9 10 11 12
• Physical separation was screened from further consideration for several reasons:	13
— Due to dispersed and relatively low concentrations of inorganic contamination at Combined SWMU 14, physical separation may not yield cost-effective quantities of recoverable metals.	14 15 16 17
— Lead-shot contamination can be effectively treated with physical separation, however, these areas are scheduled to be removed by the DET during additional ISM activities before the implementation of corrective measures.	18 19 20
— It does not effectively treat BEQs.	21

- **Soil washing** was screened from further consideration because of *potential* site constraints. 1
Soil washing does treat inorganics and BEQs; however, its effectiveness decreases when 2
a soil’s clay and silt content of the soil increases. Since the soil at Combined SWMU 14 3
is primarily clay, this technology may be impractical since the primary treatment 4
mechanism is separation of the fine and coarse soil materials with the assumption that the 5
contaminants adhere to the fine stream. If the fine stream is a substantial portion of the 6
soil matrix, then volume reduction is minimal. 7
- **Ex situ stabilization/solidification** effectively treats inorganics and BEQs; however, it was 8
screened from further consideration because it may not be practical for the soil 9
concentrations at Combined SWMU 14. There is no current threat to the groundwater via 10
migration from soil. As a result, binding the contaminants to the soil matrix would not 11
provide a substantial benefit. Furthermore, there would still be a dermal and 12
gastrointestinal contact risk if the material remained onsite. 13

Ex Situ Thermal Treatment Technologies 14

- None 15

Other Technologies 16

- None 17

4.2.1.3 Retained Technologies 18

Soil technologies retained for further consideration are listed below. 19

Institutional Controls 20

- Institutional controls 21

Containment	1
• Surface cap	2
In Situ Biological Treatment Technologies	3
• Phytoremediation	4
• In situ landfarming	5
In Situ Physical/Chemical Treatment Technologies	6
• None	7
In Situ Thermal Treatment Technologies	8
• None	9
Ex Situ Biological Treatment Technologies	10
• None	11
Ex Situ Physical/Chemical Treatment Technologies	12
• None	13
Ex Situ Thermal Treatment Technologies	14
• None	15
Other Technologies	16
• Excavation with offsite disposal	17

- The technologies retained are:** 1
- Institutional controls 2
 - Surface cap 3
 - Phytoremediation 4
 - In situ landfarming 5
 - Excavation with offsite disposal 6

4.2.2 Technology Screening Results for Groundwater Remediation 7

Groundwater remedial technology identification and screening was not required during the CMS. 8
Because the source was removed by the DET and based on the results of additional groundwater 9
sampling performed during the CMS, Combined SWMU 14 shallow groundwater complies with 10
all MCLs and does not require remedial action. 11

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
<i>INSTITUTIONAL CONTROLS</i>				
Institutional Controls	Leaves contaminated soil in place. Exposure would be limited by site access controls, public awareness, education, deed restrictions, etc. Required for industrial reuse scenarios.	Does not remove the source — plans for future site use may be impacted.	None.	Yes
<i>CONTAINMENT TECHNOLOGIES</i>				
Surface Cap	Capping is a containment technology specifically for large areas of contamination that limits human contact with soil and reduces infiltration of rainwater through contaminated soil. Capping materials include soil, asphalt, and concrete.	Plans for future site use may be impacted by capping technology.	Capping is not applicable for low concentrations or sporadic distributions of contaminants.	Yes
<i>IN SITU BIOLOGICAL TREATMENT TECHNOLOGIES</i>				
Enhanced Biodegradation	Enhanced biodegradation involves injecting materials into the vadose zone to promote microbial growth and accelerate natural processes. Some common additives are hydrogen peroxide, air, oxygen, nutrients, and carbon sources.	Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones.	This technology primarily applies to organic hydrocarbons. High concentrations of heavy metals, highly chlorinated organics, long-chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms.	No; waste constraint (metals).
Bioventing	Air is either extracted from or injected into the unsaturated soil to increase oxygen concentrations and stimulate aerobic 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. High-permeability soil is preferred and low moisture content is required.	Bioventing is applicable for any contaminant that more readily degrades aerobically than anaerobically.	No; site (shallow water table) and waste constraints (metals).

**Table 4.1
Soil Technology Screening for Combined SWMU 14**

Technology	Description	Site Constraints	Waste Constraints	Retained
Electrokinetically Enhanced Bioremediation	A form of enhanced biodegradation, electric fields are applied to the contaminated zone to encourage migration of nutrients into the zone and enhance microbial growth within the zone. Bench-scale tests have achieved greater than 75% TCE removal from low-permeability clayey soil.	The effectiveness of an electrical field can be reduced by buried metallic conductors, and pH and reduction-oxidation changes induced by the process electrode reactions. Low-permeability soil is preferred over sand, and some moisture is required.	This technology treats soil contaminated with organic compounds that biodegrade easily under anaerobic conditions.	No; site (shallow water table) and waste constraints (metals).
Landfarming	Soil is cultivated to enhance aerobic contaminant biodegradation.	In situ landfarming can only be performed in low-risk areas where contaminant leaching is not a concern. It is typically implemented in the upper 2 feet of soil.	In situ landfarming works best with nonchlorinated petroleum hydrocarbons.	Yes
Monitored Natural Attenuation (MNA)	Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface material 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 contaminant movement.	Some inorganics can be immobilized through MNA, but they will not be degraded.	No; waste constraint (metals).

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
IN SITU PHYSICAL/CHEMICAL TREATMENT TECHNOLOGIES				
Chemical Oxidation	Chemical oxidation increases the oxidation state of a contaminant while decreasing the oxidation state of the reactant. 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. Delivery of oxidants is limited in low-permeability soil. Uniform application can be difficult in heterogeneous soil.	This technology is effective in treating media contaminated with low concentrations of halogenated and nonhalogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals.	No; site (shallow water table) and waste constraints (metals and BEQs).
Electrokinetic Separation	Low-intensity direct electrical current is applied across electrode pairs 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.	Effectiveness is reduced by 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. Low-permeability and low moisture content also reduce effectiveness.	This technology can be used to treat soil contaminated with heavy metals, radionuclides, and organics.	No; site constraint.
Fracturing	Fractures are created in low-permeability and over-consolidated sediment which open new passageways to increase the effectiveness of many in situ processes and enhance extraction efficiency. Fracturing must be used with a treatment technology such as soil vapor extraction or in situ bioremediation. Fracture technologies include blast-enhanced, pneumatic, and hydraulic fracturing.	Cemented sediment limits fracturing effectiveness and fractures will close in non-clayey soil. The technology should not be used in areas of high seismic activity. Fracturing could 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; site constraint.

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Pressure Dewatering	Air is injected into the soil at a rate that increases groundwater pressure, directing groundwater flow away from the air injection site. This technique increases the amount of soil that can be biodegraded through bioventing.	Pressure dewatering is best suited to remediating contaminants in the vadose zone.	Pressure dewatering is best suited to any contaminants that are more readily degraded aerobically than anaerobically.	No; site constraint (shallow water table).
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 soil is difficult to treat with soil flushing. Soil flushing should only be used where the 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; site constraint (shallow water table).
Soil Vapor Extraction	SVE uses extraction wells and vacuum pumps to create a pressure gradient that removes water vapor and contaminants from the vadose zone. SVE is often used in conjunction with other technologies.	This technology can be used at sites with large areas of contamination that are deep and/or underneath a structure. Soil should be fairly homogeneous and have high permeability, porosity, and uniform particle size distribution.	SVE applies to soil contaminated with VOCs and some SVOCs. NAPL in subsurface soil may limit SVE's effectiveness in removing organic compounds.	No; site (shallow water table) and waste constraints (metals and BEQs).
Solidification/Stabilization	In situ solidification/stabilization immobilizes contaminants by using large augers to mix portland cement, lime, or a chemical reagent into the soil to reduce contaminant mobility.	This technology will likely leave a solid mass, similar to concrete, which may impact future site use.	This technology works well for inorganics, including radionuclides. Some VOCs can delay or inhibit reactions necessary for solidification.	No; site constraint (interference with future site use).

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
IN SITU THERMAL TREATMENT TECHNOLOGIES				
Electrical Resistance Heating	Electrical current applied to the water table heats groundwater up to the boiling point. The increased temperature improves volatilization, recovery, and long-term in situ degradation of organic compounds. In situ vapor extraction must be used with this technology.	This technology is very effective for small areas of high VOC concentration. However, compared to other technologies, electricity can be very expensive when used to heat areas greater than one acre. This technology is most effective in saturated or high-moisture silt and clayey soil.	This technology primarily addresses organic contamination, but some metals can be reduced to less toxic states [e.g., Cr(VI) to Cr(III)].	No; site (large affected area) and waste constraints (metals and BEQs).
Steam or Hot Water Injection	Steam generated above or below ground or hot water generated above ground is used to heat the subsurface to improve volatilization, mobility, recovery, and long-term in situ degradation of organic compounds. In situ vapor extraction must be used with steam injection; groundwater extraction must be used with hot water injection.	This technology is most effective in sandy soil. Hot water injection is more effective than steam injection below the water table. An injection permit is required.	This technology primarily addresses organic contamination. However, some metals can be reduced to less toxic states [e.g., Cr(VI) to Cr(III)].	No; site constraint (clayey soil).
Vitrification	Electrical heating is used to melt contaminated soil, 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 site use.	This technology is primarily used for radioactive contaminants. Some organic and inorganic contaminants may volatilize in the process.	No; site constraint.

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
<i>EX SITU BIOLOGICAL TREATMENT TECHNOLOGIES</i>				
Biopiles	Excavated soil is mixed with amendments, nutrients, and fillers to support microbial growth, which is the contaminant degrading mechanism. In an aerated static pile, excavated soil is formed into piles and aerated with blowers or vacuum pumps. Biopiles such as compost piles and static piles are maintained in aboveground enclosures.	Existing structures and utilities may impede or restrict excavation. Biopiles require a lot of space.	This technology treats nonhalogenated VOCs and fuel hydrocarbons. Halogenated VOCs, SVOCs, and pesticides also can be treated, but effectiveness varies; treatment 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; waste constraint (metals and BEQs)
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. This technology may not be effective for clayey soil.	Biosorption removes toxic metals from solution. Not proven effective at concentrations above 30 ppm.	No; waste constraint.
Fungal Biodegradation	Fungal biodegradation refers to the degradation of a wide variety of organopollutants with the lignin-degrading or wood-rotting enzyme system of white rot fungus.	Existing structures and utilities may impede or restrict excavation.	White rot fungus can degrade and mineralize organic compounds, including predominant conventional explosives (TNT, RDX, and HMX) and other recalcitrant materials (DDT, PAHs, and PCBs).	No; waste constraint (metals and BEQs).
Landfarming	Contaminated soil is excavated, applied into lined beds and periodically turned over or tilled to aerate and enhance contaminant biodegradation.	Existing structures and utilities may impede or restrict excavation. Landfarming requires a lot of space.	Inorganic contaminants will not be biodegraded. VOCs may require additional treatment to limit volatilization.	No; site constraint

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Slurry Phase Biological Treatment	An aqueous slurry is created by combining soil with water and other additives to degrade organic contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed.	Existing structures and utilities may impede or restrict excavation. Nonhomogeneous soil and clayey soil can create material handling problems.	Slurry-phase bioreactors primarily treat nonhalogenated SVOCs and VOCs in excavated soil or dredged sediment. Slurry-phase bioreactors containing co-metabolites and specially adapted microorganisms can be used to treat halogenated VOCs and SVOCs, pesticides, and PCBs.	No; waste constraint (metals and BEQs).
<i>EX SITU PHYSICAL/CHEMICAL TREATMENT TECHNOLOGIES</i>				
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 leachate mixtures to ionize target metals. This mixture is further treated to develop an enriched leaching solution from which target metals are then removed.	Existing structures and utilities may impede or restrict excavation. Soil with higher clay content may reduce extraction efficiency and require longer contact times.	Acid extraction is suitable for treating soil contaminated by heavy metals. Solvent extraction effectively treats soil containing primarily organic contaminants, but is generally least effective on high molecular weight organics and extremely hydrophilic substances.	No; waste constraint (BEQs).
Chemical Oxidation	Chemical oxidation increases the oxidation state of a contaminant while decreasing the oxidation state of the reactant. 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. 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 nonhalogenated volatiles and semivolatiles, PCBs, pesticides, cyanides, and volatile and nonvolatile metals.	No; waste constraint.

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Dehalogenation	Reagents are added to soil 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. High clay and moisture content will increase treatment costs. Capture and treatment of residuals from the process will be especially difficult for soil with high levels of fines and moisture.	The target contaminant groups for dehalogenation treatment are halogenated SVOCs and pesticides. This technology may be less effective for treating some halogenated VOCs.	No; waste constraint (metals and BEQs).
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. 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; site constraint.
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. Soil with a high humic content may require pretreatment. Organics adsorbed to clay-size particles may be difficult to remove.	This technology effectively removes SVOCs and inorganics, but is less effective at treating VOCs.	No; site constraint.

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Soil Vapor Extraction	A vacuum is applied to a network of aboveground piping to encourage organics to volatilize from the excavated soil. The process includes a system for handling offgases.	Existing structures and utilities may impede or restrict excavation. SVE requires a lot of space. High moisture and humic content or soil compaction will inhibit volatilization.	SVE applies to soil contaminated with VOCs and some SVOCs.	No; site constraint (shallow water table).
Solar Detoxification	Solar detoxification destroys contaminants with photochemical and thermal reactions using the ultraviolet energy in sunlight. Reagents such as TiO ₂ , hydrogen peroxide, or Fe(III) may be required to act as catalysts.	Existing structures and utilities may impede or restrict excavation. Site must have adequate sunlight.	The target contaminant groups for solar detoxification are VOCs, SVOCs, solvents, pesticides, and dyes.	No; waste constraint (metals and BEQs).
Solidification/Stabilization	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.	This technology works well for inorganics, including radionuclides. Although organic-contaminated soil may be treated with solidification/stabilization, some organics can delay or inhibit reactions necessary for solidification. Organics may leach from stabilized material after treatment.	No; site constraint (interference with future site use).
Supercritical Carbon Dioxide Extraction	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. Elevated water content can negatively impact SCDE performance.	This technology can remove normally insoluble organics from soil.	No; waste constraint (metals and BEQs).

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
<i>EX SITU THERMAL TREATMENT TECHNOLOGIES</i>				
Distillation	Hydrocarbons and water are volatilized from contaminated media using either heat or vacuum. This technology can be used to recover and collect organic compounds for reuse.	Existing structures and utilities may impede or restrict excavation.	This technology is limited to the removing organic contaminants from wastes.	No; waste constraint (metals).
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.	Wet air oxidation can treat hydrocarbons and other organic compounds. Supercritical water oxidation applies to PCBs and other stable compounds.	No; waste constraint (metals and BEQs).
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.	This process applies to demilitarizing explosive items such as mines and shells (after removal of explosives), or scrap material contaminated with explosives.	No; waste constraint (ordnance not present).

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Incineration/ Pyrolysis	<p>Incineration burns contaminated sediment at high temperatures (1,600° - 2,200°F) to volatilize and combust organic contaminants. A 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.</p> <p>Pyrolysis 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.</p>	Existing structures and utilities may impede or restrict excavation. Highly abrasive feed can damage the processor unit. The technology requires drying the soil to achieve less than 1% moisture content.	Incineration is not effective in treating soil contaminated with heavy metals. The target contaminant groups for pyrolysis are SVOCs and pesticides. Volatile metals may be removed by the higher temperatures but are not destroyed.	No; waste constraint (ordnance not present).
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. 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; waste constraint.
Thermal Desorption	Soil is heated between 200° and 1,000°F, depending on the volatility of the target compound, to separate VOCs, water, and some SVOCs from the solids into a gas stream. Organics in the gas stream must be treated or captured.	Existing structures and utilities may impede or restrict excavation. Highly abrasive feed can damage the processor unit. Clayey and silty soil and soil with high humic content increase reaction time due to contaminant binding.	Inorganic contaminants or metals that are not particularly volatile will not be effectively removed by thermal desorption.	No; waste constraint (low BEQ concentrations).

Table 4.1
Soil Technology Screening for Combined SWMU 14

Technology	Description	Site Constraints	Waste Constraints	Retained
Vitrification	Electrical heating is used to melt contaminated soil, producing a glass-like matrix with very low leaching characteristics.	Existing structures and utilities may impede or restrict excavation.	This technology is primarily used for radioactive contaminants.	No; site constraints (radioactive material not present, and COC mass is not sufficient).
OTHER TECHNOLOGIES				
Excavation with 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. Transportation of the soil through populated areas may affect community acceptance.	TCLP results may impact disposal options.	Yes

5.0 DEVELOPMENT AND EVALUATION OF ALTERNATIVES 1

The purpose of the detailed analysis of alternatives is to provide decision makers with adequate 2
information to select an appropriate site remedy. During the detailed analysis, each alternative 3
is assessed against the evaluation criteria described in the OSWER Directive Number 9902.3-2A. 4
Assessment results are then arrayed to compare the alternatives and identify key tradeoffs among 5
them. 6

5.1 Evaluation Process 7

The evaluation process is designed to provide decision makers with sufficient information to 8
adequately compare the alternatives, select an appropriate remedy for a site, and satisfy RCRA 9
requirements for selecting the remedial action. 10

Primary Criteria 11

Four evaluation criteria have been developed to address the RCRA requirements and 12
considerations and their additional technical and policy considerations. The evaluation criteria 13
with the associated statutory considerations that must be met are: 14

- Primary Criteria 1 — Protection of human health and the environment 15
- Primary Criteria 2 — Attainment of cleanup standards 16
- Primary Criteria 3 — Source control 17
- Primary Criteria 4 — Compliance with applicable waste management standards 18

Secondary Criteria 19

The alternatives are scored on their abilities to meet the four primary criteria as well as 20
five secondary criteria. These secondary criteria can help rank remedial alternatives that have met 21
all four of the primary criteria described above. 22

- Secondary Criteria 1 — Long-term reliability and effectiveness 1
- Secondary Criteria 2 — Reduction in 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
7

5.1.1 Protection of Human Health and the Environment 8

Corrective action remedies must be protective of 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. The overall assessment of protection draws on the assessments conducted under other evaluation criterion, 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 a remedial alternative should gauge whether an alternative achieves adequate protection by eliminating, reducing, or controlling the risks each pathway poses through treatment, engineering, or institutional controls. 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 will be required to attain media cleanup standards set by the implementing agency, which may be derived from existing state or federal regulations (e.g. groundwater standards) or other standards. The media cleanup standards for a remedy will often play a large role in determining the extent of and technical approaches to the remedy. In some cases, certain technical 20
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aspects of the remedy, such as the practical capabilities of remedial technologies, may influence 1
to some degree the media cleanup standards that are established. 2

In addition, this CMS will evaluate whether the potential remedial technologies will achieve the 3
preliminary remediation objective identified by the implementing agency, as well as other 4
alternative remediation objectives proposed in the CMS. The time frame for each alternative to 5
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, will essentially involve a perpetual cleanup. Therefore, an effective source control program 11
is essential to ensure the long-term effectiveness and protectiveness of the corrective action 12
program. 13

The source control standard is not intended to mandate a specific remedy or class of remedies. 14
Instead, the CMS will examine a wide range of options. This standard should not be interpreted 15
to preclude the equal consideration of using other protective remedies to control the source, such 16
as partial waste removal, capping, slurry walls, in situ treatment/stabilization and consolidation. 17

This CMS report will also evaluate whether source control measures are necessary, and if so, the 18
type of actions that would be appropriate. Any proposed source control measure will include a 19
discussion on estimated effectiveness based on site conditions and history of the specific 20
technology. 21

5.1.4 Compliance with Applicable Waste Management Standards

Corrective action remedies must comply with applicable waste management standards. Each alternative must satisfy this criteria to be eligible for selection. This criteria is used to evaluate whether each alternative will meet all the federal and state waste management standards identified in previous stages of the remedial process.

5.1.5 Long-Term Reliability and Effectiveness

The evaluation of alternatives under this secondary criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is 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 at the conclusion of remedial activities. 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 addresses the preference for remedial actions employing treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances. 2
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The evaluation should consider the following specific factors: 4

- The treatment processes, the remedies they will employ, 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

The short-term effectiveness of a remedial alternative is evaluated relative to 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 of the remedial action. 16
- Risks to workers during implementation of the remedial action. 17
- Potential for adverse environmental impact as a result of implementation. 18
- Time until remedial response objectives are achieved. 19

5.1.8 Implementability

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

Technical Feasibility

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

Administrative Feasibility

Activities needed to coordinate with other offices and agencies.

Availability of Services and Materials

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

5.1.9 Cost

Detailed cost estimates for each remedial alternative are based on engineering analyses, suppliers' estimates of necessary technology and costs for similar actions (such as excavation) at other RCRA and RCRA sites. The cost estimate for a remedial alternative typically consists of four principal elements: capital cost, annual operation and maintenance (O&M) costs, costs for evaluation reports, 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.

Evaluation Reports

Those costs are associated with reports prepared to evaluate the results of the selected alternative.

Present-Worth Analysis

This analysis makes it possible to compare remedial alternatives on the basis of a single cost representing 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 present worth of the alternative.

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 Development and Evaluation of Soil Remedial Alternatives

The alternatives include containment, in situ treatment, and excavation with offsite disposal. Depending on remedial objectives and property reuse considerations, each alternative may include institutional controls and monitoring. With the exception of Alternative 1, the following alternatives have been developed from the technologies retained from the screening described in Section 4:

- Alternative 1: ISM Completion with No Further Remedial Action
- Alternative 2: Phytoremediation
- Alternative 3: In Situ Landfarming
- Alternative 4: Low-Permeability Surface Cap
- Alternative 5: Excavation with Offsite Disposal

5.2.1 Alternative 1: ISM Completion with No Further Remedial Action 1

No further remedial actions beyond the DET ISM would be taken to contain, remove, or treat soil 2
contamination that exceeds remedial objectives. Soil would remain in place. This alternative 3
would achieve a site wide residential risk of 6.1E-05 above background. 4

Implementation of this remedial alternative is viable because residual residential site wide risk is 5
within the USEPA acceptable range (1.0E-06 to 1.0E-04) following the DET ISM described in 6
Section 2.3. The DET is scheduled to complete the final ISM in 1999: excavation and disposal 7
of lead shot-contaminated soil from SWMU 14 and from the berm at the southern end of 8
Combined SWMU 14. Residual residential is 0.63, which is also below the USEPA threshold 9
of 1.0. 10

5.2.1.1 ISM Completion with No Further Remedial Action: Primary Criteria 11

Protection of Human Health and the Environment 12

This alternative provides no additional protection of human health and the environment beyond 13
the DET ISM. This alternative assumes that future use would be residential. Under this scenario, 14
arsenic- and BEQ-contaminated soil would remain onsite. No institutional controls are included 15
in this alternative. 16

Attainment of Cleanup Standards 17

ISM completion with no further remedial action will result in a residual residential site risk of 18
6.1E-05 and site hazard of 0.63. These risk and hazard values are within USEPA's acceptable 19
range of 1.0E-06 to 1.0E-04 and below the hazard threshold of 1.0 (USEPA, 1995). 20

Source Control 21

This alternative does not address source control beyond ISM completion. Arsenic- and BEQ- 22
contaminated soil would remain above remedial objectives. However, VOC-contaminated soil was 23

removed by the DET in 1998 when the former DANC burial area was excavated; lead- 1
contaminated soil will be removed during the final DET ISM in Summer of 1999. 2

Compliance with Applicable Waste Management Standards 3

No waste will be managed under this alternative. Therefore, waste management standards do not 4
apply. 5

5.2.1.2 ISM Completion with No Further Remedial Action: Secondary Criteria 6

Long-Term Reliability and Effectiveness 7

Long-term reliability and effectiveness of Alternative 1 is minimal. Soil volumes and 8
concentrations would remain unchanged and this alternative does not reduce the magnitude of 9
current site risk following completion of ISM activities. 10

Reduction of Toxicity, Mobility, or Volume 11

This alternative would not reduce the toxicity, mobility, or volume of soil contaminants. Some 12
contaminants — those not addressed during the DET ISM — would remain untreated and in place 13
onsite. 14

Short-Term Effectiveness 15

There are no short-term effects resulting from this alternative. 16

Implementability 17

This alternative is technically feasible and easily implemented. Following completion of the ISM, 18
no additional construction, operation, or reliability issues would be associated with this alternative. 19
Administrative coordination, offsite services, materials, specialists, or innovative technologies 20
would not be required. No implementation risks are associated with this alternative. 21

Cost

No costs are associated with this alternative.

5.2.2 Alternative 2: 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 be applicable to Combined SWMU 14:

- *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 the 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. 1
2

- *Phyostimulation:* Microbial biodegradation is stimulated in the root zone. The plants 3
provide carbonaceous material and essential nutrients through liquids released from roots 4
and root tissue decay. In addition, oxygen released from plants increases the oxygen 5
content in the microbially rich rhizopheric zone. 6

Laboratory and field studies would be used to determine the appropriate plant species required to 7
remediate the COCs. In addition, these studies would help in the planting scheme design including 8
plant spacing, fertilization frequency, soil amendments, and water requirements. 9

During remedial activities, one or more of the following institutional controls would be 10
implemented as part of this alternative: 11

- Site access controls: fences, signs, gates, and additional site personnel 12
- Public awareness 13
- Long-term monitoring of general site conditions 14
- Land-use restrictions 15
- Excavation warnings and soil-use restrictions 16

5.2.2.1 Phytoremediation: Primary Criteria 17

Protection of Human Health and the Environment 18

Phytoremediation protects human health and the environment by slowly removing, transforming, 19
or immobilizing contaminants in the soil. This alternative, coupled with appropriate institutional 20
controls during implementation, would eliminate risk to potential future residents or site workers 21
and the environment and drastically reduce the potential for continued contaminant migration. 22

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 remedial objectives. 1
2
3

Phytoremediation is still considered an innovative technology. As such, long-term reliability and effectiveness are relatively unknown. However, substantial research has been conducted to (1) identify and develop plants that are more effective on target compounds, (2) understand the biological processes behind phytoremediation, and (3) increase the number of field-scale applications. Phytoremediation, which may be two to three times less expensive than chemical and physical remedial technologies, is a passive approach that is effective over a period of months and years rather than weeks. 4
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Finally, public acceptance of phytoremediation can be very high, in part because of the park-like aesthetic, which includes bird and wildlife habitats. 11
12

Attainment of Cleanup Standards 13

Phytoremediation is capable of meeting concentration cleanup standards similar to naturally occurring Zone H background concentrations or other less conservative cleanup standard established by the Project Team. Phytoremediation is the one of the least aggressive remedial technology and would likely require the most time to attain any proposed cleanup standards. Once design plans are approved, this alternative would be expected to take several years to satisfy remedial objectives. 14
15
16
17
18
19

Source Control 20

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. Furthermore, institutional controls 21
22
23

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 which are protective of future residential and industrial site users. 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 be performed for verification. No location-specific regulations would be triggered by this alternative.

5.2.2.2 Phytoremediation: Secondary Criteria

Long-Term Reliability and Effectiveness

Phytoremediation is currently limited to research activities and limited field testing. While several recent and on-going applications have reportedly been successful in lowering contaminant concentrations, complete full-scale applications of this innovative technology projects are scarce. Reported results show fair potential for practical applications of these 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 provide effective toxicity, mobility, or volume reduction 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, the toxicity, mobility, or volume reduction processes 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 14. 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 of the process. No future remedial actions would be required after this alternative is completed. Institutional controls would be required during implementation because soil would still represent an exposure threat until the contamination above remedial goals was phytoremediated.

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. 1
2

- Treatability studies to determine rates of remediation and appropriate plant species, density of planting, location, etc. Agricultural analyses and principles are required to complete the treatability study. 3
4
5

- Preliminary field testing at the site to monitor results and refine design parameters. 6

- Full-scale remediation 7

- Disposal of resulting plant material. 8

Phytoremediation would probably take more than 10 years to reduce COC concentrations to background levels. Table 5.1 summarizes its advantages and limitations. 9
10

Cost 11

Costs associated with phytoremediation are presented in Table 5.2; however, current estimates costs for phytoremediation vary widely. Phytoremediation capital costs would be \$373,400, annual O&M costs would be \$30,000, and long-term monitoring costs would be \$22,000 per year. As appropriate, the long-term monitoring program can be modified with regulatory approval. The total cost for phytoremediation over a 30 year period would be \$1,089,200. 12
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Table 5.1
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, 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	

Table 5.2
Phytoremediation with Institutional Controls Costs

Action	Quantity	Cost per Unit	Total Cost
<i>Capital Costs</i>			
Laboratory/pilot/field studies	LS	\$80,000	\$80,000
Mobilization/demobilization	LS	\$5,000	\$5,000
Planting	7 acres	\$10,000/acre	\$70,000
Soil cover and amendments	7 acres	\$7,500	\$52,500
Institutional controls	LS	\$50,000	\$50,000
Engineering/oversight	LS	20%	\$51,500

Table 5.2
Phytoremediation with Institutional Controls Costs

Action	Quantity	Cost per Unit	Total Cost
Contingency/miscellaneous	LS	25%	\$64,400
Subtotal			\$373,400
<i>Operations and Maintenance Costs</i>			
Horticulture (plant health)	7 acres	\$1,000/acre	\$7,000
Pruning	7 acres	\$1,000/acre	\$7,000
Harvesting	7 acres	\$2,000/acre	\$14,000
Inspection	LS	\$2,000	\$2,000
Subtotal			\$30,000
Present worth value at 6% discount rate over 30 years			\$413,000
<i>Phytoremediation Long-Term Monitoring Annual Program</i>			
Soil sampling (field work)	50 hrs	\$130/hr	\$6,500
Soil analysis	20 samples per year	\$200/sample	\$4,000
Evaluation	50 hrs	\$94/hr	\$4,700
Reporting/engineering	LS	20% cost	\$3,000
Misc. equipment, supplies, travel	LS	25% cost	\$3,800
Subtotal			\$22,000
Present worth value subtotal at 6% for 30 years			\$302,800
Total			\$1,089,200

Notes:

Cost estimates developed from Miller, 1996 and Chappell, 1997.

LS — lump sum

5.2.3 Alternative 3: In Situ Landfarming

In situ landfarming is a demonstrated, active treatment process which uses soil's assimilative capacity to degrade, immobilize and transform COCs. Periodic disking or tilling will maintain appropriate oxygen levels in the soil while nutrient (phosphorus and nitrogen) and enhanced/engineered bacteria addition can supplement the process and improve degradation rates. Under certain conditions, landfarming has proven itself to be an effective and economical remedial

technology. In situ landfarming can be used for organic and inorganic compounds; however, it treats organic compounds more effectively than inorganic compounds.

During remedial activities, one or more of the following institutional controls would be implemented as part of this alternative:

- Site access controls: fences, signs, gates, and additional site personnel
- Public awareness
- Long-term monitoring of general site conditions
- Land-use restrictions
- Excavation warnings and soil-use restrictions

5.2.3.1 In Situ Landfarming: Primary Criteria

Protection of Human Health and the Environment

In situ landfarming protects human health and the environment by slowly degrading, transforming, or immobilizing contaminants in the soil that contribute to site risk. This alternative, coupled with appropriate institutional controls during implementation, would eliminate risk to potential future residents or site workers and the environment due to dermal and gastrointestinal contact and drastically reduce the potential for contaminant migration. However, because immobilization of inorganic compounds does not destroy the compounds, they will remain onsite as a potential risk to future residents.

Short-term risks to site remediation workers from inhalation and dermal contact during implementation (due to tilling and disking) may be moderate, but could be controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and remedial objectives.

Finally, public acceptance of bioremediation can be very high, in part because of the "farm-like" aesthetic. 1
2

Attainment of Cleanup Standards 3

Landfarming is capable of meeting concentration cleanup standards similar to naturally occurring 4
Zone H background concentrations or other less conservative cleanup standard established by the 5
Project Team. Landfarming is only slightly more aggressive than phytoremediation and would 6
be expected to take several months or years to satisfy remedial objectives. 7

Source Control 8

This alternative would provide effective source control by slowly degrading, transforming, or 9
immobilizing contaminants in the soil that contribute to site risk. Institutional controls would 10
drastically reduce the likelihood of additional risks to future site workers by eliminating potential 11
exposure pathways to residual contamination. 12

Compliance with Applicable Waste Management Standards 13

In situ landfarming meets remedial objectives that protects future industrial site workers. Since 14
the waste will remain onsite and in place, no U.S. Department of Transportation regulations nor 15
land-disposal restrictions would be triggered during remedial activities. Furthermore, no 16
location-specific regulations would be triggered by this alternative. 17

5.2.3.2 In Situ Landfarming: Secondary Criteria 18

Long-Term Reliability and Effectiveness 19

In situ landfarming has proven itself to be an effective and economical remediation technology for 20
the treatment of a wide range of hydrocarbons, including BEQs (PAHs). Inorganics, although not 21
degraded, are immobilized during the biological transformation of organic compounds. 22

Contaminants would be degraded to nontoxic elemental compounds through biodegradation. 1
Future risk due to exposure to surface soil would be reduced by in situ landfarming. 2

Reduction of Toxicity, Mobility, or Volume 3

This alternative would provide effective toxicity, mobility, or volume reduction by slowly 4
degrading, transforming, or immobilizing contaminants in the soil that contribute to site risk. 5
Toxicity is reduced by biological processes that degrade the contaminants to less toxic forms. 6
These biological processes would also immobilize inorganic compounds in the treatment zone 7
(upper 1 to 2 feet). However, soil tilling and disking, while providing oxygen, may volatilize a 8
minor fraction of the organic contamination even though heavy BEQs would likely resist 9
volatilization. Volume reduction, though likely to be minimal, would occur due to contaminant 10
degradation or volatilization. With appropriate monitoring and maintenance, the toxicity, 11
mobility, or volume reduction processes would be irreversible. 12

Short-term Effectiveness 13

Implementation of in situ landfarming would have some short-term effects on site workers due 14
primarily to soil tilling and disking. Short-term risks from inhalation and dermal contact during 15
implementation may be moderate but could be controlled using common engineering techniques 16
and appropriate PPE. Adverse impacts to the surrounding environment are not anticipated during 17
treatment activities; engineering and institutional controls would be applied to manage storm water 18
runoff and erosion. Once design plans are approved, this alternative would be expected to take 19
several years to satisfy remedial objectives. 20

Implementability 21

In situ landfarming is technically and administratively feasible at Combined SWMU 14. Areas 22
to be remediated are readily accessible. Contaminants are generally in the top 1 to 3 feet of soil 23
which contributes to landfarming success. Overall, this alternative is easy to implement, maintain, 24

and monitor. Only farming equipment and tanks/accessories to distribute the nutrients would be required to implement this technology. Confirmatory sampling would be required to monitor the performance of the process. No future remedial actions would be required after this alternative is completed.

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 landfarming 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 rates of remediation and appropriate nutrient/fertilizer and (possible) bacteria addition. Agricultural analyses are required to complete the treatability study.
- Preliminary field testing at the site to monitor results and refine design parameters.
- Full-scale remediation

Cost

Costs associated with in situ landfarming are presented in Table 5.3; however, current cost estimate for landfarming may vary. In situ landfarming capital costs would be \$181,300, annual O&M costs would be \$43,500 including long-term monitoring. As appropriate, the long-term monitoring program can be modified with regulatory approval. The total cost for in situ landfarming over 30 years would be \$780,100. The monitoring period is negotiable — costs were evaluated over 30 years for consistency.

Table 5.3
In Situ Landfarming with Institutional Controls Costs

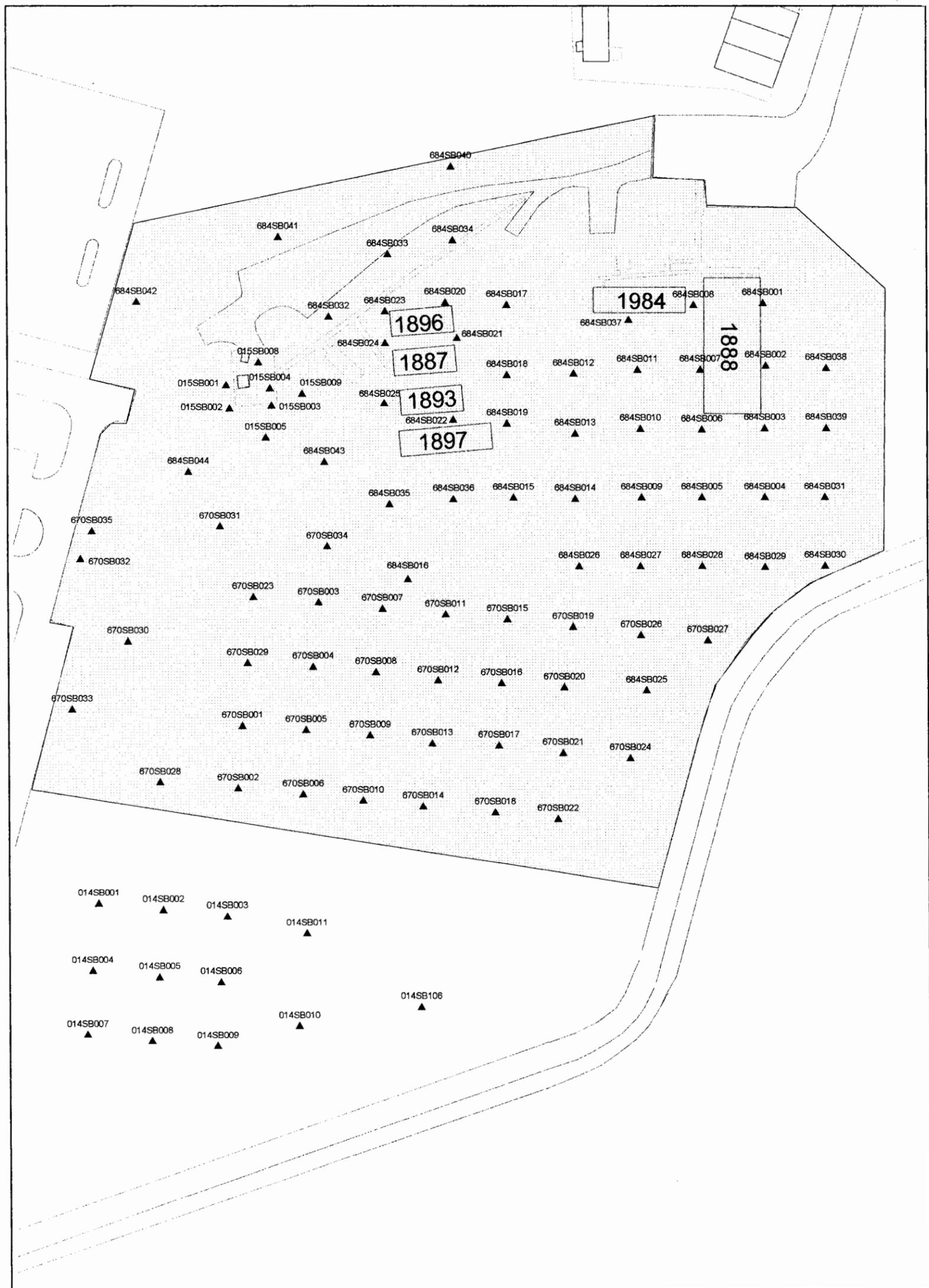
Action	Quantity	Cost	Total Cost
Capital Costs			
Laboratory/pilot/field studies	LS	\$50,000	\$50,000
Mobilization/demobilization	LS	\$5,000	\$5,000
Treatment area preparation — storm water controls — site grading	LS	\$10,000	\$10,000
Irrigation system and piping	LS	\$10,000	\$10,000
Institutional controls	LS	\$50,000	\$50,000
Engineering/oversight	LS	20%	\$25,000
Contingency/miscellaneous	LS	25%	\$31,300
Subtotal			\$181,300
Annual Operations and Maintenance Costs			
Tilling	2 days/week	\$100/day	\$10,000
Moisture control and site monitoring	2 day/week	\$100/day	\$10,000
Sampling	50 samples	\$200/sample	\$10,000
Engineering/oversight	LS	20%	\$6,000
Contingency	LS	25%	\$7,500
Subtotal			\$43,500
Present worth value at 6% discount rate over 30 years			\$598,800
Total			\$780,100

Note:

LS — lump sum

5.2.4 Alternative 4: Low-Permeability Surface Cap

This alternative uses a physical barrier to cover contaminated soil to eliminate the potential for dermal and gastrointestinal contact. It is not intended to prevent leaching (i.e., it is not a RCRA cap). Land use would be restricted to using institutional controls to minimize uncontrolled exposure and to protect the cap from invasive activities. The estimated placement of the low-permeability surface cap is shown on Figure 5.1.



LEGEND

- ▲ Sample Points w/ ID
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS
- ▭ Proposed Location of Soil or Combination Soil and Asphalt-Concrete Surface Cap



**COMBINED SWMU 14
CMS REPORT
CHARLESTON NAVAL COMPLEX
Charleston, SC**

60 0 60 Feet

**Figure 5.1
Proposed Surface Cap Location**

The area to be covered is approximately seven acres, approximately 70% of the site, and represents the area of the site in which contaminants exceed their remedial objectives. The actual location and size of the cover would be selected after the confirmation samples were collected and future land-use requirements better defined.

Cover construction would consist of two alternatives, depending on future site use: (1) a 24-inch thick, low-permeability soil layer with a vegetative cover and (2) a combination cover: 60% soil cover and 40% 8-inch asphalt concrete pavement (includes sub-base), coupled with a drainage system to divert runoff from the asphalt concrete cover surface. The soil cover would be sloped to manage storm water runoff and prevent erosion. The combination cover would be designed to comply with future site needs.

For either cap system, confirmation sampling would complement current soil data to help delineate the extent of soil in which contaminant concentrations exceed the remedial objectives. This would ensure that all contaminated soil exceeding remedial objectives is covered.

One or more of the following institutional controls would be implemented as part of this alternative:

- Site access controls: fences, signs, gates, and additional site personnel
- Public awareness
- Long-term monitoring of general site conditions
- Land-use restrictions
- Excavation warnings and soil-use restrictions

5.2.4.1 Low-Permeability Surface Cap: Primary Criteria 1

Protection of Human Health and the Environment 2

The cover(s) would eliminate the threat of dermal and gastrointestinal contact for current and 3
future site workers. Contaminated soil would be left onsite indefinitely; however, the cover would 4
be maintained to ensure adequate protection. This alternative would protect human health and the 5
environment by physically eliminating receptor pathways and controlling access through 6
institutional controls. Cover construction and maintenance would be easily implemented and 7
current site controls (site security, access control, and fencing) and additional institutional controls 8
would be adequate to ensure minimal disturbance of the cover. Short-term risks from inhalation 9
and dermal contact during implementation would be minimal, and could be controlled using 10
common engineering techniques and PPE. 11

Attainment of Cleanup Standards 12

Assuming clean cap material is used, surface capping would attain media cleanup standards below 13
1.0E-06 residential risk or less conservative value such as background risk by eliminating dermal 14
and gastrointestinal contact. As a result, risk-based cleanup standards would be achieved. This 15
alternative would minimize the threat to human health and the environment by eliminating 16
potential migration and exposure pathways. 17

Source Control 18

This alternative would provide effective source control by eliminating further releases that might 19
threaten human health and the environment by limiting rainwater infiltration and preventing direct 20
contact to the contaminants. Furthermore, institutional controls would drastically reduce the 21
likelihood of additional risks to future site workers or residents. 22

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.

5.2.4.2 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.

Soil and combination 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 may 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 covers are 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.

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, actual cover construction would be expected to take a relatively short period of time

(less than 6 months). During construction of either cover, there would be a potential risk of dermal or gastrointestinal contact and inhalation of particulate emissions; however, this risk would be reduced by using proper material handling practices and appropriate PPE.

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

Implementability

A soil or combination cover with institutional controls is technically and administratively feasible. This alternative could be readily applied at the site since the proposed areas to be covered are easily accessible to site workers. Thus, implementation of this alternative would merely involve emplacement of the cover, implementation of institutional controls, and establishment of maintenance requirements. Future monitoring and maintenance would involve periodic cover inspections and damage or degradation repair (if required); however, repairs would be easily implemented. The cover(s) would not require any extraordinary services or materials.

The cover location and material selection is not intended to interfere with future site use. The cover could be designed to serve as a beneficial part of future industrial site operations.

Cost

Costs associated with surface capping are presented in Tables 5.4 (soil cover) and 5.5 (asphalt concrete and soil combination cover). The total cost for a 24-inch thick low-permeability soil layer with a vegetative cover, including institutional controls and long-term monitoring, would be \$688,200. Alternatively, the total cost for a combination soil/asphalt concrete cover, including application of institutional controls and long-term monitoring, would be \$1,143,600. O&M costs for these covers are \$6,000/year and \$7,000/year, respectively. Long-term monitoring would be

required to maintain the effectiveness and integrity of the surface cover. The monitoring period 1
 is negotiable — costs were evaluated over 30 years for consistency. 2

Table 5.4
Soil Cover with Institutional Controls Cost

Action	Quantity	Cost per Unit	Total Cost
<i>Capital Costs</i>			
Mobilization/demobilization	LS	\$5,000	\$5,000
Confirmation Samples	25	\$200/sample	\$5,000
Grading/site preparation	5,000 yd ³	\$1.50/yd ³	\$7,500
24-inch soil cover	22,500 yd ³	\$15.00/yd ³	\$337,500
Vegetative cover	7 acres	\$1,800/acre	\$12,600
Institutional controls	LS	\$50,000	\$50,000
Engineering/oversight	LS	20%	\$83,500
Contingency/miscellaneous	LS	25%	\$104,500
Subtotal			\$605,600
<i>Operation and Maintenance Cost</i>			
Maintain cover (30 years)	LS	\$5,000	\$5,000
Inspection and reporting	LS	\$1,000	\$1,000
Subtotal			\$6,000
Present worth value at 6% discount rate over 30 years			\$82,600
Total			\$688,200

Table 5.5
Soil and Asphalt Concrete Combination Cover with Institutional Controls Costs

Action	Quantity	Cost per Unit	Total Cost
<i>Capital Costs</i>			
Mobilization/demobilization	LS	\$5,000	\$5,000
Confirmation Samples	25	\$200/sample	\$5,000
Grading/site preparation	5,000 yd ³	\$1.50/yd ³	\$7,500
Drainage system	LS	\$25,000	\$25,000
Asphalt concrete surface (8 inches)	120,000 ft ²	\$3.50/ft ²	\$420,000

Table 5.5
Soil and Asphalt Concrete Combination Cover with Institutional Controls Costs

Action	Quantity	Cost per Unit	Total Cost
24-inch soil cover	13,500 yd ³	\$15.00/yd ³	\$202,500
Vegetative cover	4 acres	\$1,800 / acre	\$7,200
Institutional controls	LS	\$50,000	\$50,000
Engineering/oversight	LS	20%	\$144,400
Contingency/miscellaneous	LS	25%	\$180,700
Subtotal			\$1,047,200
<i>Operation and Maintenance Cost</i>			
Maintain drainage and cover (30 years)	LS	\$6,000	\$6,000
Inspection and reporting	LS	\$1,000	\$1,000
Subtotal			\$7,000
Present worth value at 6% discount rate over 30 years			\$96,400
Total			\$1,143,600

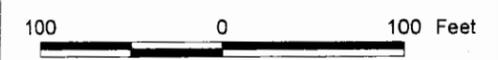
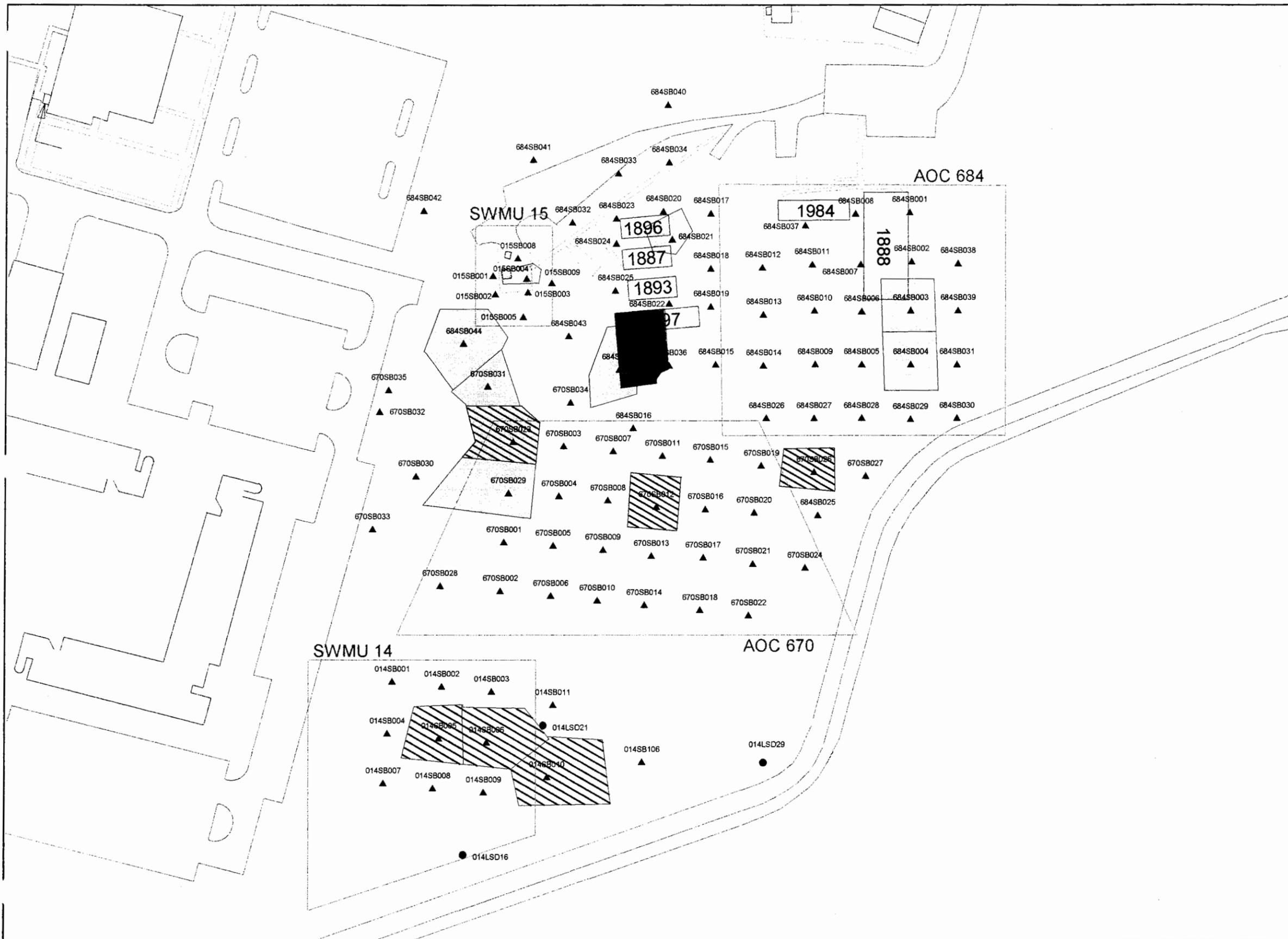
5.2.5 Alternative 5: Excavation with Offsite Disposal

Three versions of an excavation alternative were developed to address the RGOs established in Section 3. Each alternative achieves increasingly more stringent remedial goals:

Alternative 5a: Address all point risk greater than 1.0E-04 and point hazard greater than 1.0

All soil in which point risk exceeds 1.0E-04 and point hazard exceeds 1.0 would be excavated down to one foot below ground surface and disposed of in an offsite landfill. These risk and hazard thresholds translate to site cleanup goals of 20.0 mg/kg for arsenic and 4.3 mg/kg for BEQs. Lead concentrations exceeding 400 mg/kg (residential reuse threshold) would be excavated during the DET ISM in Summer of 1999.

Approximately 1,000 yd³ of soil would require removal/disposal under this scenario. Sample points requiring removal are shown on Figure 5.2. Alternative 5a would result in a residual residential site risk of 3.2E-05, which is only slightly more than ½ current site risk.



LEGEND

- ▲ Sample Points w/ ID
- Lead Shot - Contaminated Sampling Point (Addressed During DET ISM - Quantity of Soil Removed Based on Confirmation Sampling.)
- ▭ BUILDING
- ▭ BOUNDARY
- ▭ FENCE
- ▭ ROAD
- ▭ SIDE-WALKS
- ▭ Already Excavated by the DET and Replaced with Clean Fill
- ▨ Areas Requiring Excavation (Removed During DET ISM Addressing Lead - Contaminated Soil)
- ▭ Areas Requiring Excavation

* All excavation areas are based on Risk-Thiessen Polygons



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Figure 5.2
Alternative 5a: Excavation with Offsite Disposal of all Sample Points Exceeding 1.0E-04 Point Risk and 1.0 Point Hazard

Excavation Locations

Alternative 5b: Decrease residual site risk to Zone H inorganic background risk 1

Rather than removing individual sample points above risk and hazard thresholds, total site risk at 2
Combined SWMU 14 can be reduced to Zone H background levels by excavating or otherwise 3
treating the areas of greatest contamination at a site — soil with arsenic concentrations above 4
10.0 mg/kg and/or BEQs concentrations above 1.0 mg/kg will be removed . 5

Under Alternative 5b, approximately 105,000 ft² of contaminated soil would be excavated to a 6
depth of about 1 foot and disposed of offsite at a non-hazardous waste landfill. According to the 7
site risk reduction analysis developed and discussed in Section 3.3 and presented in Appendix B, 8
Alternative 5b would result in a residual residential site risk of 1.9E-05, which is slightly less than 9
the residential Zone H background inorganic risk of 2.0E-05. 10

To achieve a site-wide residual residential Zone H arsenic background risk, approximately 11
4,000 yd³ of soil would require removal, disposal, and replacement with clean backfill 12
(Figure 5.3). 13

Alternative 5c: Address all points greater than background UCL 14

All soil in which contaminants exceed calculated background UCL concentrations (arsenic: 15
7.5 mg/kg and BEQs: 0.2 mg/kg) would be excavated down to one foot below ground surface and 16
disposed of in an offsite landfill. Lead concentrations exceeding 400 mg/kg would be excavated 17
during the DET ISM in Summer of 1999. To achieve calculated background conditions for all 18
Combined SWMU 14 COCs, approximately 7,500 yd³ of soil would require removal/disposal. 19
Sample points requiring removal are shown on Figure 5.4. 20



LEGEND

- ▲ Sample Points w/ ID
- Lead Shot - Contaminated Sampling Point (Addressed During DET ISM - Quantity of Soil Removed Based on Confirmation Sampling.)
- BUILDING BOUNDARY
- - - FENCE
- ROAD
- - - SIDE-WALKS
- Already Excavated by the DET and Replaced with Clean Fill
- ▨ Areas Requiring Excavation (Removed During DET ISM Addressing Lead - Contaminated Soil)
- Areas Requiring Excavation

* All excavation areas based on Risk-Thiessen Polygons



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Figure 5.4
Alternative 5c: Excavation with Offsite Disposal of all Sample Points Exceeding Background UCL Concentrations

Excavation Locations

Since contaminated soil would be addressed on a concentration cleanup goal, more soil would require excavation and disposal than the site risk remedial scenarios presented in the other excavation alternatives, 5a and 5b.

For all three versions of the excavation alternative, excavated soil would be placed in discrete stockpiles for TCLP sampling and analysis. Based on the sampling results, the stockpiles would be designated as either hazardous or nonhazardous and disposed of accordingly. Based on the rule of thumb that TCLP results will be less than or equal to 20 times less the total soil concentration of a contaminant and the fact that none of the three TCLP samples collected for TCLP analysis by the DET exhibited toxicity characteristics, all excavated soil is expected to be nonhazardous.

5.2.5.1 Excavation with Offsite Disposal: Primary Criteria
Protection of Human Health and the Environment

Excavation with offsite disposal protects human health and the environment by removing contaminated soil above remedial goals. This alternative would reduce risk to future site residents and the environment due to dermal and gastrointestinal contact according to remedial goals established by the Project Team.

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 remedial objectives.

Attainment of Cleanup Standards

Excavation would attain media cleanup standards as described above in the introduction to Section 5.2.5. Contaminated soil would be excavated at select locations until confirmation samples satisfy Project Team-selected remedial objectives (maximum residual concentration

cleanup goals). This alternative is the most aggressive remedial technology and would likely require the least time to attain cleanup standards.

Source Control

This alternative would effectively control the source by eliminating contaminated media which exceeds remedial goals.

Compliance with Applicable Waste Management Standards

This alternative would meet site-wide remedial objectives protective of potential future receptors. 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. Although it is anticipated that excavated soil is nonhazardous (three TCLP samples were collected and analyzed by the DET; none of the samples exhibited toxicity characteristics based on the TCLP results), TCLP analysis would be performed for verification. No location-specific regulations would be triggered by this alternative.

5.2.5.2 Excavation with Offsite Disposal: Secondary Criteria

Long-Term Reliability and Effectiveness

This alternative would reduce the quantity of soil in which contaminant concentrations exceed remedial objectives. A residual site wide residential risk of 3.2E-05 would remain following the completion of the least stringent excavation alternative (5a); 1.3E-05 would remain following the most stringent excavation scenario (5c) (Zone H inorganic background risk is 2.0E-05). Removal to a landfill is an established and reliable 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 source area and therefore, eliminate contaminants exceeding project-team selected remedial objectives. This alternative includes the removal of contaminated soil from the site and disposal in a secure Subtitle C or D landfill (based on TCLP analysis of the waste). Because the source would no longer remain onsite after this technology is employed, excavation is considered to be irreversible. However, the waste’s overall toxicity, mobility, or volume would not be reduced with this alternative.

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 could be reduced by implementing dust control technologies and a site-specific health and safety plan which specifies PPE, respiratory protection, etc. It is anticipated that the time frame until remedial objectives are satisfied would be relatively brief (less than three months). Consequently, worker exposure to the contaminants would be minimal.

Implementability

Excavation with offsite disposal is technically and administratively feasible at Combined SWMU 14. Removal and offsite disposal are common remedial alternatives that have 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). Areas to be excavated are readily accessible. No future remedial actions would be required after this alternative is completed.

This alternative would not require any extraordinary services or materials. The Bee's Ferry Road Landfill in Charleston, South Carolina is a Class D facility, which has accepted nonhazardous soil

from interim removal actions on the base. The Safety-Kleen (Pinewood) Inc. Landfill is a Subtitle C facility in Pinewood, South Carolina that would accept hazardous waste.

Cost

Costs associated with this alternative are presented in Tables 5.6a to 5.6c. The total cost for excavation and disposal to a nonhazardous, Subtitle D landfill would range from \$77,400 to \$562,400 depending on the stringency of the Project Team-selected remedial objectives — alternatively, the total cost for excavation and disposal to a hazardous, Subtitle C landfill would range from \$219,900 to \$1,631,100. If the excavated soil were distributed between the nonhazardous and hazardous landfills based on TCLP characterization, the actual total cost would fall between the two extremes of \$77,400 and \$1,631,100. There are no O&M costs associated with this alternative.

Table 5.6a
Excavation with Offsite Disposal Costs:
Alternative 5a: Point Risk and Point Hazard Remedial Objectives

Action	Quantity	Cost per Unit	Total Cost
Removal Action			
Excavation	1,000 yd ³	\$10/yd ³	\$10,000
Confirmation/TCLP samples	50 samples	\$100/sample	\$5,000
Backfill	1,000 yd ³	\$7/yd ³	\$7,000
Engineering/oversight	LS	20% cost	\$4,400
Contingency/miscellaneous	LS	25% cost	\$5,500
Subtotal			\$31,900
Subtitle D Disposal Facility			
Transportation	1,000 yd ³	\$8/yd ³	\$8,000
Soil disposal*	1,500 tons	\$25/ton	\$37,500
Subtotal			\$45,500
Total (Subtitle D)			\$77,400

Table 5.6a
Excavation with Offsite Disposal Costs:
Alternative 5a: Point Risk and Point Hazard Remedial Objectives

Action	Quantity	Cost per Unit	Total Cost
<i>Subtitle C Disposal Facility</i>			
Transportation	1,000 yd ³	\$8/yd ³	\$8,000
Soil disposal ^a	1,500 tons	\$120/ton	\$180,000
Subtotal			\$188,000
Total (Subtitle C)			\$219,900

Notes:

- LS — lump sum
 a — assumes soil density of 1.5 tons/yd³

Table 5.6b
Excavation with Offsite Disposal Costs:
Alternative 5b: Residual Site Risk Reduction to Zone H Background Risk Remedial Objectives

Action	Quantity	Cost per Unit	Total Cost
<i>Removal Action</i>			
Excavation	4,000 yd ³	\$10/yd ³	\$40,000
Confirmation/TCLP samples	150 samples	\$100/sample	\$15,000
Backfill	4,000 yd ³	\$7/yd ³	\$28,000
Engineering/oversight	LS	20% cost	\$16,600
Contingency/miscellaneous	LS	25% cost	\$20,800
Subtotal			\$120,400
<i>Subtitle D Disposal Facility</i>			
Transportation	4,000 yd ³	\$8/yd ³	\$32,000
Soil disposal ^a	6,000 tons	\$25/ton	\$150,000
Subtotal			\$182,000
Total (Subtitle D)			\$302,400
<i>Subtitle C Disposal Facility</i>			
Transportation	4,000 yd ³	\$8/yd ³	\$32,000
Soil disposal ^a	6,000 tons	\$120/ton	\$720,000
Subtotal			\$752,000
Total (Subtitle C)			\$872,400

Notes:

- LS — lump sum
 a — assumes soil density of 1.5 tons/yd³

Table 5.6c
Excavation with Offsite Disposal Costs:
Alternative 5c: Background UCL Remedial Objectives

Action	Quantity	Cost per Unit	Total Cost
<i>Removal Action</i>			
Excavation	7,500 yd ³	\$10/yd ³	\$75,000
Confirmation/TCLP samples	250 samples	\$100/sample	\$25,000
Backfill	7,500 yd ³	\$7/yd ³	\$52,500
Engineering/oversight	LS	20% cost	\$30,500
Contingency/miscellaneous	LS	25% cost	\$38,100
Subtotal			\$221,100
<i>Subtitle D Disposal Facility</i>			
Transportation	7,500 yd ³	\$8/yd ³	\$60,000
Soil disposal ^a	11,250 tons	\$25/ton	\$281,300
Subtotal			\$341,300
Total (Subtitle D)			\$562,400
<i>Subtitle C Disposal Facility</i>			
Transportation	7,500 yd ³	\$8/yd ³	\$60,000
Soil disposal ^a	11,250 tons	\$120/ton	\$1,350,000
Subtotal			\$1,410,000
Total (Subtitle C)			\$1,631,100

Notes:

- LS — lump sum
- a — assumes soil density of 1.5 tons/yd³

5.3 Development and Evaluation of Groundwater Remedial Alternatives

Development and evaluation of groundwater remedial alternatives was not required during the CMS. Because the source was removed by the DET and based on the results of additional groundwater sampling performed during the CMS, Combined SWMU 14 shallow groundwater is in compliance with all MCLs and thus requires *ISM Completion with No Further Remedial Action*.

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 the evaluation criteria 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 5.3 are technically feasible, implementable, and have been developed and used at other sites. All alternatives generally provide additional protection of human health and the environment except *ISM Completion with No Further Remedial Action*, which provides no additional protection. 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 mobility, toxicity, or 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, *ISM Completion with No Further Remedial Action*, provides no additional protection of human health and the environment beyond the DET ISM.

Alternatives 2 and 3, *Phytoremediation* and *In Situ Landfarming*, protect human health and the environment by slowly removing, transforming, or immobilizing contaminants that contribute to site risk. Coupled with minor institutional controls, these alternatives eliminate dermal contact and ingestion pathways over time.

Alternative 4, *Low-Permeability Surface Cap*, protects human health and the environment through containment and land-use restrictions, and prevents completion of dermal and gastrointestinal pathways.

The three excavation scenarios under Alternative 5, *Excavation with Offsite Disposal*, protect human and health and the environment through removal of affected soil media based on Project Team-selected remedial goals. Risk and hazard reduction can be achieved by (1) eliminating all soil associated with sampling points exceeding 1.0E-04 residential risk and 1.0 hazard (Alternative 5a), (2) decreasing site risk to Zone H inorganic background levels by maximizing contaminant removal and minimizing soil removal (Alternative 5b), or (3) addressing all soil associated with sampling points exceeding arsenic and/or BEQs background concentrations based on UCLs (Alternative 5c). Each scenario is increasingly more stringent.

Attainment of Cleanup Standards

Alternative 1, *ISM Completion with No Further Remedial Action*, does not comply with the risk-based goals developed in Section 3. However, as is, the residential site risk (6.1E-05) is within USEPA’s acceptable range of 1.0E-06 to 1.0E-04 following the implementation of ISM; the residential site hazard (0.63) is below USEPA’s hazard threshold of 1.0, which is often used as the remediation "trigger" (USEPA, 1995).

Alternatives 2 and 3, *Phytoremediation* and *In Situ Landfarming*, comply with Project Team-selected remedial objectives; however, these technologies would require months or years to attain cleanup standards.

Alternative 4, *Low-Permeability Surface Cap*, complies with remedial objectives for protection of human health and the environment because the risk pathway is eliminated by capping the contaminated soil. However, the contaminated soil would remain onsite.

Alternative 5, *Excavation with Offsite Disposal*, complies with Project Team-selected remedial objectives by removing affected soil. Residual site risk and hazard for each version is shown in Table 5.7.

**Table 5.7
 Excavation with Offsite Disposal Scenarios Residual Residential Risk and Hazard**

Version	Excavation Scenario	Residual Residential Risk	Residual Residential Hazard
5a	Eliminate all soil associated with sample points exceeding 1.0E-04 risk and 1.0 hazard.	3.2E-05	0.5
5b	Decrease site risk to Zone H inorganic background levels by maximizing contaminant removal and minimizing soil removal.	1.9E-05	0.3
5c	Address all soil associated with points exceeding arsenic and/or BEQs background concentrations based on UCL concentrations.	1.3E-05	0.2

Source Control

Alternative 1, *ISM Completion with No Further Remedial Action*, does not address source control beyond ISM completion. Arsenic- and BEQ-contaminated soil would remain above remedial objectives. However, VOC-contaminated soil was removed by the DET in 1998 when the former DANC burial area was excavated; lead-contaminated soil will be removed during the final DET ISM (Summer 1999).

Alternatives 2 and 3, *Phytoremediation* and *In Situ Landfarming*, would provide effective source control by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk. For Alternative 2, phytoremediation, disposal of resulting affected plant material would eliminate the contaminants from the site.

Alternative 4, *Low-Permeability Surface Cap*, does not remove the source. However, this alternative would provide effective source control by limiting further exposure that might threaten human health or the environment. In addition, capping reduces the infiltration potential of rain water and potential soil to groundwater transport. Contaminated soil does remain on site though.

Alternative 5, *Excavation with Offsite Disposal*, would provide effective source control by excavating and removing contaminated soil based on Project Team-selected cleanup goals.

Compliance with Applicable Waste Management Standards

No waste would be managed under Alternative 1, *ISM Completion with No Further Remedial Action*. Therefore, waste management standards do not apply.

Alternative 2, *Phytoremediation*, meets remedial objectives and thus satisfies this criterion. Transportation and land disposal restrictions might be triggered if contaminated harvested materials required offsite disposal.

Alternative 3, *In Situ Landfarming*, meets remedial objectives and thus satisfies this criterion. No waste would be managed under this alternative; therefore, waste management standards do not apply.

The cover implemented as Alternative 4, *Low-Permeability Surface Cap*, 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.

Alternative 5, *Excavation with Offsite Disposal*, meets specific remedial objectives and thus satisfies this criterion. Onsite excavation activities might require federal, state, and local air emissions and storm water control regulation compliance. 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 to determine proper disposal options.

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

Long-term reliability and effectiveness of Alternative 1, *ISM Completion with No Further Remedial Action*, is minimal. Soil volumes and concentrations would remain unchanged and this alternative does not reduce the magnitude of current site risk or hazard following completion of ISM activities.

Alternative 2, *Phytoremediation*, 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.

In Situ landfarming, Alternative 3, has proven itself to be an effective and economical remediation technology. Contaminants would be degraded to nontoxic elemental compounds through biodegradation. Future risk or hazard due to exposure to surface soil would be reduced by landfarming.

A cover would effectively reduce site worker contact with the contaminated soil during Alternative 4, *Low-Permeability Surface Cap*. However, institutional controls and routine O&M would be required to ensure that any exposure to human and environmental receptors is within protective levels.

Alternative 5, *Excavation with Offsite Disposal*, would effectively eliminate soil that exceeded Project Team-selected remedial objectives thus offering long-term protection of human health and the environment.

Reduction of Toxicity, Mobility, or Volume

Alternative 1, *ISM Completion with No Further Remedial Action*, does not reduce contaminant toxicity, mobility, or volume.

Alternatives 2 and 3, *Phytoremediation* and *In Situ Landfarming*, effectively reduce toxicity, mobility, or volume by slowly removing, transforming, or immobilizing contaminants in the soil that contribute to site risk or hazard. With appropriate monitoring and maintenance, these processes would be irreversible.

Alternative 4, *Low-Permeability Surface Cap*, does 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.

Alternative 5, *Excavation with Offsite Disposal*, eliminates the contaminants that affect site remedial objectives. However, the waste’s overall toxicity, mobility, or volume would not be reduced with this alternative since the contaminated soil would merely be transferred to another location (Subtitle C or D landfill).

Short-Term Effectiveness

No short-term effects are associated with Alternative 1, *ISM Completion with No Further Remedial Action*.

Alternatives 2, 3, 4, and 5 include exposure to workers, which can be effectively controlled using engineering controls and appropriate PPE during planting, harvesting, grading, tilling, capping, or excavating activities. Remedial time frames for Alternatives 2 and 3, *Phytoremediation* and *In Situ Landfarming*, are relatively long (likely months to years) since they rely on biological and assimilative processes. However, worker exposure during O&M activities would be minimal. Remedial time frames for Alternatives 4 and 5, *Low-Permeability Surface Cap* and *Excavation with Offsite Disposal*, are relatively short (likely less than three to four months).

Implementability

All five alternatives can be implemented at Combined SWMU 14 and are technically and administratively feasible.

Cost

Capital (indirect and direct), O&M, and net present worth for all six alternatives are presented in Table 5.8. Alternatives range in cost from \$0 for *ISM Completion with No Further Remedial Action* to \$1,631,100 for *Excavation with Offsite Disposal* at a Subtitle C landfill.

**Table 5.8
 Soil Alternatives Cost Comparison**

Alternative	Capital Costs	Annual O&M	Net Present Worth
1 ISM Completion with No Further Remedial Action	none	none	\$0
2 Phytoremediation	\$373,400	\$52,000	\$1,089,200
3 In Situ Landfarming	\$181,300	\$43,500	\$780,100
4a Low-Permeability Soil Cap	\$605,600	\$6,000	\$688,200
4b Low-Permeability Soil and Asphalt Concrete Cap	\$1,047,200	\$7,000	\$1,143,600
5a Excavation with Offsite Disposal of All Areas Exceeding 1.0E-04 Risk and 1.0 Hazard	Subtitle D \$77,400	none	\$77,400
	Subtitle C \$219,900	none	\$219,900
5b Excavation to Residential Zone H Background Inorganic Site Risk with Offsite Disposal	Subtitle D \$302,400	none	\$302,400
	Subtitle C \$872,400	none	\$872,400
5c Excavation with Offsite Disposal of All Areas Exceeding Zone H Background Concentrations (UCL)	Subtitle D \$562,400	none	\$562,400
	Subtitle C \$1,631,100	none	\$1,631,100

5.4.2 Comparative Analysis of Groundwater Alternatives

There are no groundwater remedial alternatives to compare.

5.5 Summary and Ranking of Alternatives

Per the 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
- **1** — criteria may be met 2
- **2** — criteria met 3
- **3** — criteria exceeded 4

For secondary criteria, the scoring methodology is presented as: 5

- **0** — poor 6
- **1** — below average 7
- **2** — average 8
- **3** — above average 9

The primary criteria scores are multiplied by a larger weighting factor to emphasize their importance compared to 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 five remedial alternatives and provide a tool for selecting the final site remedy. The results are provided in Tables 5.9a to 5.9e, and summarized in Table 5.10. 10
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The scoring system is applicable for evaluating active remedial alternatives (i.e., excavation, phytoremediation, etc.). However, this evaluation may not accurately assess the viability and applicability of Alternative 1, *ISM Completion with No Further Remedial Action*, because it does not actively address the primary criteria. As such, this scoring system is only one part of the overall remedial alternative evaluation. 16
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19
20

The recommended final site remedy is discussed in Section 6. 21

Table 5.9a
Soil Alternative 1 Evaluation Summary:
ISM Completion with No Further Remedial Action

Evaluation Criteria	Weighting Factor ¹	Comments	Score ²	Score x WF
Primary Criteria				
Protection of human health and the environment	2	Provides no additional protection of human health and the environment. However, residual residential site risk is within the USEPA acceptable range.	1	2
Attainment of cleanup standards	2	Does not comply with remedial objectives. However, as is, the residential site risk is within USEPA's acceptable range and the residential site hazard is below USEPA's hazard threshold of 1.0.	2	4
Source control	2	Does not address source control beyond ISM completion.	2	4
Compliance with applicable waste management standards	2	No waste is managed under this alternative. Therefore, waste management standards do not apply.	2	4
Secondary Criteria				
Long-term reliability and effectiveness	1	Long-term reliability and effectiveness is minimal.	1	1
Reduction in toxicity, mobility, or 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	PW = \$0	3	3
Ranking Score				24

Notes:

- PW** — Present worth
1 — Weighting factor (WF) assigned by Project Team consensus
2 — Criteria-specific evaluation score:
- | | |
|-------------------------|-------------------|
| Primary: | Secondary: |
| 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 5.9b
Soil Alternative 2 Evaluation Summary:
Phytoremediation

Evaluation Criteria	Weighting Factor ¹	Comments	Score ²	Score x WF
Primary Criteria				
Protection of human health and 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 source.	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
Secondary Criteria				
Long-term reliability and effectiveness	1	Limited to research and limited field testing.	1	1
Reduction in toxicity, mobility, or volume	1	Effective reduction of toxicity, mobility, or 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.	1	1
Cost	1	PW = \$1,089,200	1	1
Ranking Score				23

Notes:

- PW** — Present worth
1 — Weighting factor (WF) assigned by Project Team consensus
2 — Criteria-specific evaluation score:
- | | |
|-------------------------|-------------------|
| Primary: | Secondary: |
| 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 5.9c
Soil Alternative 3 Evaluation Summary:
In Situ Landfarming

Evaluation Criteria	Weighting Factor ¹	Comments	Score ²	Score x WF
Primary Criteria				
Protection of human health and 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 source.	2	4
Compliance with applicable waste management standards	2	Meets remedial objectives. No waste would be managed under this alternative. Therefore, waste management standards do not apply.	2	4
Secondary Criteria				
Long-term reliability and effectiveness	1	Effective and economical technology. Contaminants would be degraded to nontoxic elemental compounds through biodegradation.	2	2
Reduction in toxicity, mobility, or volume	1	Effective reduction of toxicity, mobility, or 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.	1	1
Cost	1	PW = \$780,100	2	2
Ranking Score				25

Notes:

- PW** — Present worth
1 — Weighting factor (WF) assigned by Project Team consensus
2 — Criteria-specific evaluation score:
- | | |
|-------------------------|-------------------|
| Primary: | Secondary: |
| 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 5.9d
Soil Alternative 4 Evaluation Summary:
Low-Permeability Surface Cap

Evaluation Criteria	Weighting Factor ¹	Comments	Score ²	Score x WF
Primary Criteria				
Protection of human health and 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.	2	4
Source control	2	Source not removed. However, the cap would provide effective source control by eliminating further releases.	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
Secondary Criteria				
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 in toxicity, mobility, or 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 concrete cover is amenable to industrial reuse scenarios.	2	2
Cost	1	PW = \$688,200 (soil cover)	2	2
		PW = \$1,143,600 (soil and asphalt concrete cover)	1	1
Ranking Score			23 to 24	

Notes:

- PW** — Present worth
1 — Weighting factor (WF) assigned by Project Team consensus
2 — Criteria-specific evaluation score:
- | | |
|--|---|
| <p>Primary:
 0 — criteria not met
 1 — criteria may be met
 2 — criteria met
 3 — criteria exceeded</p> | <p>Secondary:
 0 — poor
 1 — below average
 2 — average
 3 — above average</p> |
|--|---|

**Table 5.9e
 Soil Alternative 5 Evaluation Summary:
 Excavation with Offsite Disposal**

Evaluation Criteria	Weighting Factor ¹	Comments	Score ²	Score x WF
Primary Criteria				
Protection of human health and 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 source control by eliminating most contaminated media. Soil with acceptable residual risk would remain onsite.	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
Secondary Criteria				
Long-term reliability and effectiveness	1	Eliminates soil that exceeds Project Team-selected remedial objectives.	2	2
Reduction in toxicity, mobility, or volume	1	Eliminates soil that exceeds Project Team-selected 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. Potentially most rapid alternative to implement.	3	3
Cost	1	PW range = \$77,400 to \$562,400 (nonhazardous soil) PW range = \$219,900 to \$1,631,100 (hazardous soil)	0 to 3	0 to 3
Ranking Score				28 to 31

Notes:

- PW** — Present worth
- 1** — Weighting factor assigned by Project Team consensus
- 2** — Criteria-specific evaluation score:

Primary:	Secondary:
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 5.10
Soil Alternative Evaluation Summary

Evaluation Criteria	WF ¹	Alternative 1 ISM Completion with NFRA ²		Alternative 2 Phytoremediation		Alternative 3 In Situ Landfarming		Alternative 4 Low-Permeability Surface Cap		Alternative 5 Excavation with Offsite Disposal	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Primary Criteria											
Protection of human health and environment	2	1	2	2	4	2	4	2	4	3	6
Attainment of cleanup standards	2	2	4	2	4	2	4	2	4	3	6
Source control	2	2	4	2	4	2	4	2	4	2	4
Compliance with applicable waste management standards	2	2	4	2	4	2	4	2	4	2	4
Secondary Criteria											
Long-term reliability and effectiveness	1	1	1	1	1	2	2	2	2	2	2
Reduction in toxicity, mobility, or volume	1	0	0	2	2	2	2	0	0	1	1
Short-term effectiveness	1	3	3	2	2	2	2	2	2	2	2
Implementability	1	3	3	2	2	2	2	2	2	3	3
Cost	1	3	3	1	1	2	2	1 or 2	1 or 2	0 to 3	0 to 3
Ranking Score	—	—	24	—	24	—	26	—	23 to 24	—	28 to 31

Notes:

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

6.0 RECOMMENDATIONS

Recommendations for the soil and groundwater remedial alternatives are outlined below. The proposed final alternatives were based on primary and secondary criteria evaluation, remedial alternative comparative analysis, and professional judgment.

6.1 Soil Remedial Alternative

Based on the rationale and decision factors in the previous sections, *ISM Completion with No Further Remedial Action* is the recommended remedial alternative for soil at Combined SWMU 14. This alternative was selected for several key reasons:

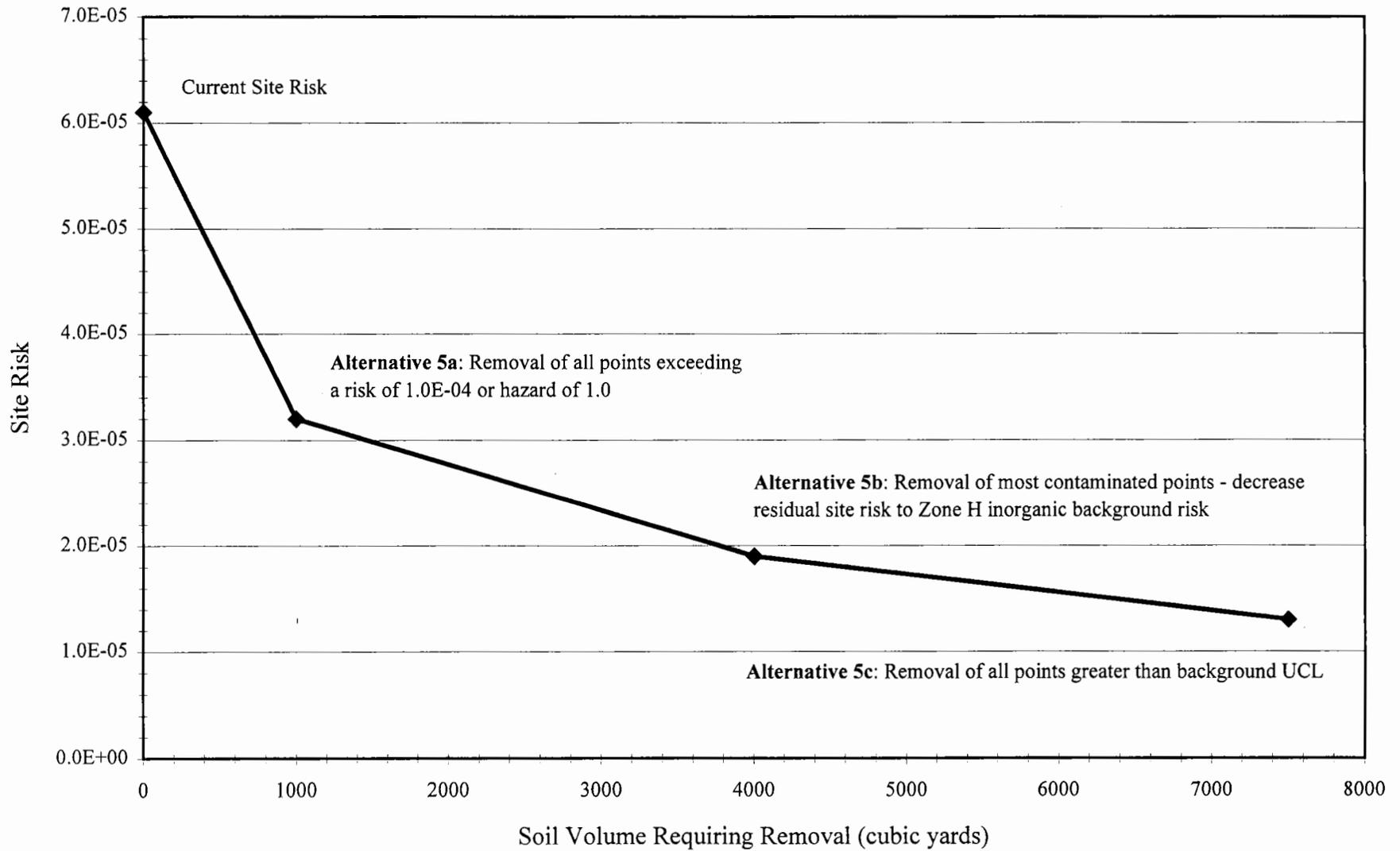
- Residual residential site risk would be 6.1E-05 (background residential risk of BEQs and inorganics at Combined SWMU 14 is 2.3E-05; inorganics alone: 2.0E-05) — residual risk is in USEPA’s acceptable residential risk range (1.0E-06 to 1.0E-04).
- Residential hazard would be 0.63, which is less than the USEPA threshold of 1.0 for site hazard.
- It would be the least expensive alternative (\$0) and easiest to implement.
- The DET has performed an ISM at the Combined SWMU 14 (removal of empty DANC containers, affected soil, and construction debris) and is scheduled to remove lead-contaminated soil from Combined SWMU 14 and the berm in the southern portion of the site in Summer 1999.
- No O&M would be required — no remaining liabilities.

- It allows for unrestricted reuse and redevelopment of the site — a US Navy and Charleston Naval Complex Redevelopment Authority preference. 1 2

If additional site risk or hazard reduction beyond the current USEPA acceptance range is required by the Project Team, then *Excavation with Offsite Disposal* of all areas with point risk greater than 1.0E-04 and point hazard greater than 1.0 is the recommended remedial alternative for Combined SWMU 14. This alternative is presented as a secondary remedy because: 3 4 5 6

- It achieved the highest score (31) on the *Project Team Evaluation Table* (see Tables 5.9e and 5.10). 7 8
- Residual residential site risk would be 3.2E-05. 9
- It would be the least expensive alternative, other than *ISM Completion with No Further Remedial Action*, for managing nonhazardous soil (\$77,400). The other excavation scenarios do not provide exceptional risk reduction relative to the amount of increased costs. This is illustrated on Figure 6.1 — risk reduction as a function of soil volume removed (directly related to costs). 10 11 12 13 14
- It would be the most rapid *active* remedial alternative — least site impact. 15
- No O&M would be required — no remaining liabilities once initial remedial activities are completed. 16 17
- It protects human health and the environment overall. 18

Figure 6.1
Excavation with Offsite Disposal: Risk Reduction Curve



- No institutional controls and encumbrances on the property would be required because impacted media exceeding site background risk will be removed from the site. 1
2
- It allows for unrestricted reuse and redevelopment of the site — a US Navy and Charleston Naval Complex Redevelopment Authority preference. 3
4

6.2 Groundwater Remedial Alternative 5

Based on the rationale and decision factors in the previous sections, there is no groundwater contamination which requires remedial action. 6
7

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 USEPA’s guidance on RCRA CMS. This PIP reflects and summarizes information prepared and presented in the US Navy’s Community Relations Plan (CRP), prepared for the CNC in 1995.

Under RCRA, there is no required interaction with the community during the CMS process. Public input is required to be solicited only at the beginning of the permitting process, or during certain permit modifications. Therefore, the US 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 CNC.

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. As described in Section 7.4, the request for public input is typically made during the SOB process.

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.

- Update and publicize the information repository. 1
- Continue to publicize the point of contact. 2
- Update the mailing list. 3
- Distribute fact sheets and/or write articles to explain RFI findings. 4
- Inform community leaders of the completion and results of the RFI. 5
- Update and continue to provide, whenever possible, presentations for informal community groups. 6
7
- Update the community on results of the RFI through public RAB meetings. 8

7.3 CMS Public Involvement Plan 10

During the CMS, the following activities will be carried out as part of the US Navy’s current and ongoing community involvement program. 11
12

- Distribute a fact sheet and/or write articles for publication that report CMS recommendations. 13
14
- Continue to update the mailing list. 15
- Continue to respond to requests for speaking engagements. 16
- Update the community on CMS status through public RAB meetings. 17

7.4 Statement of Basis Public Involvement Plan 1

Upon completion of the Corrective Measures Study (when the preferred alternative has been proposed) the following activities are required: 2 3

- A Statement of Basis will be prepared, explaining the proposed remedy and the method by which it was chosen. 4 5
- A 45-day comment period will be provided to allow community members the opportunity to review and comment on the preferred alternative. 6 7
- The availability of the comment period and Statement of Basis will be announced in a public notice. 8 9
- The community will be provided an update on the preferred remedy through the informal and publicized Restoration Advisory Board meetings. 10 11

In addition, the following activities will be carried out, as identified in the CRP: 12

- Update and publicize the information repository. 13
- Publicize the environmental point of contact. 14
- Continue to update the mailing list. 15

7.5 Restoration Advisory Board

The RAB is a key component of this community outreach program. It is through the RAB that the US 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 US Navy.

1
2
3
4
5
6
7

8.0 REFERENCES

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Cauwenberghe, L.V. (1997) *Technology Overview Report: Electrokinetics*, Groundwater Remediation Technologies Analysis Center, Pittsburgh, PA.

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Fountain, J.C. (1998) *Technology Overview Report: Technologies for Dense Nonaqueous Phase Liquid Source Zone Remediation*, Groundwater Remediation Technologies Analysis Center, Pittsburgh, PA.

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

Miller, R.R. (1996) *Technology Overview Report: Phytoremediation*, Groundwater Remediation Technologies Analysis Center, Pittsburgh, PA. 1
2

Remedial Technology Network: Remediation Information Management System (1999). 3

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5
April 4, 1998. 6

USEPA. (1994) *RCRA Corrective Action Plan (Final)*, Office of Waste Programs Enforcement Office of Solid Waste. May 1994. 7
8

USEPA (1995) *Development of Risk-Based Remedial Goals, Human Health Risk Assessment Bulletin No. 5*, Supplemental Guidance to RAGS: Region 4 Bulletins, Office of Health Assessment, Waste Management Division. November 1995. 9
10
11

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.

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

Date

Appendix A
Analytical Reports, Chain of Custodies, and
Validated Data from Corrective Measures Investigation

SOIL CONSULTANTS, INC.		LEAD DISTRIBUTION	
Project and State: Naval Base Charleston, Zone H CMS Charleston, South Carolina	Date: 6-23-98		
	E/A & H Purchase Order No. 000001759		
	E/A&H Prime Contract: N62467-89-D-0318		
Type of Sample: 1'x1'x4" plots			

LEAD SHOT ANALYSIS

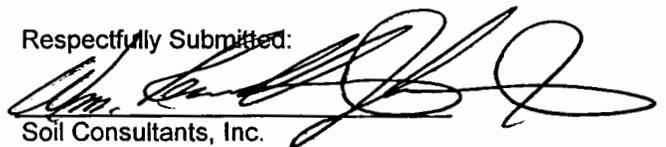
SAMPLE ID	INITIAL Wet Weight (kilograms)	INITIAL Dry Weight (kilograms)	Shot Size Sieve & Inches	WEIGHT SHOT (milligrams)	TOTAL SAMPLE SHOT WEIGHT (milligrams)
0101	7.0974	4.99890		0	0
0201	8.3175	7.52040		0	0
0301	9.29960	7.29590		0	0
0401	8.46440	7.29470		0	0
0501	7.26440	6.28440		0	0
0601	9.79390	7.37860		0	0
0701	7.49000	5.37230		0	0
0801	8.71510	6.95370		0	0
0901	8.36010	6.11620	No. 16 (0.469)	300	300
1001	9.51730	8.12750		0	0
1101	11.55700	8.14260		0	0
1201	6.21770	5.32660		0	0
1301	8.48070	7.84320		0	0
1401	10.56550	8.27900		0	0
1501	11.77100	8.42800		0	0
1601	8.82730	7.04530	No. 16 (0.469)	6,300	6,300

*THE FOLLOWING SIEVES WERE USED FOR THE REQUESTED ANALYSES:

SIEVE NO. SIEVE OPENING IN INCHES

4 0.187
 8 0.0937
 16 0.0469 (lead shot was retained on this sieve only)
 30 0.02340

Respectfully Submitted:



Soil Consultants, Inc.

SOIL CONSULTANTS, INC.		LEAD DISTRIBUTION
Project and State: Naval Base Charleston, Zone H CMS Charleston, South Carolina	Date: 8-21-98	
	Type of Sample: 1'x1'x4" plots	
E/A & H Purchase Order No. 0000001759		
E/A&H Prime Contract: N62467-89-D-0318		

LEAD SHOT ANALYSIS

SAMPLE ID	INITIAL Wet Weight (kilograms)	INITIAL Dry Weight (kilograms)	Shot Size Sieve & Inches	WEIGHT SHOT (milligrams)	TOTAL SAMPLE SHOT WEIGHT (milligrams)
014LSD1701	6.62220	5.33990	No.16 (0.469)	300	300
014LSD1801	6.68980	5.38860	No.16 (0.469)	1600	1600
014LSD1901	7.28340	6.05790		0	0
014LSD2001	5.86270	4.86220		0	0
014LSD2101	6.97650	5.79900	No.16 (0.469)	17000	17000
014LSD2201	7.04760	5.36420		0	0

*THE FOLLOWING SIEVES WERE USED FOR THE REQUESTED ANALYSES:

SIEVE NO. SIEVE OPENING IN INCHES

4	0.187
8	0.0937
16	0.0469 (lead shot was retained on this sieve only)
30	0.02340

Respectfully Submitted:

Jeanne M. Sturt
Soil Consultants, Inc.

SOIL CONSULTANTS, INC.		LEAD DISTRIBUTION	
Project and State:	Naval Base Charleston, Zone H CMS Charleston, South Carolina	Date:	11-3-98
	E/A & H Purchase Order No. 0000001759	Type of Sample:	Bag (2 bags per smpl.)
	E/A&H Prime Contract: N62467-89-D-0318		

LEAD SHOT ANALYSIS

SAMPLE ID	INITIAL Wet Weight (kilograms)	INITIAL Dry Weight (kilograms)	Shot Size Sieve & inches	WEIGHT SHOT (milligrams)	TOTAL SAMPLE SHOT WEIGHT (milligrams)
014LSD02301	4.16650	3.71630		0	0
014LSD02401	3.24310	2.33890	No.16 (0.469)	10	10
014LSD02501	2.72090	1.81220		0	0
014LSD02601	4.21110	2.92150		0	0
014LSD02701	3.35930	2.40850		0	0
014LSD02801	4.17240	2.83670		0	0
014LSD02901	4.14860	3.04340	No.16 (0.469)	3100	3100
014LSD03001	4.49230	3.53980		0	0
014LSD03101	3.82570	2.81920		0	0
014LSD03201	3.04220	2.16740		0	0
014LSD03301	5.08780	3.59580		0	0

*THE FOLLOWING SIEVES WERE USED FOR THE REQUESTED ANALYSES:

SIEVE NO.	SIEVE OPENING IN INCHES
4	0.187
8	0.0937
16	0.0469 (lead shot retained on this sieve only)
30	0.02340
50	0.0117

Respectfully Submitted,



Soil Consultants, Inc.

Amend Chain 7/28/98 *[Signature]*



**NAVY CLEAN
ENSAFE/ALLEN&HOSHAL**
(901) 383-9115

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1
CTO-TASK: 2908
COC #: _____
BPA/SO: PO4REL52

CLIENT: WAVE BASE CHL PROJECT MANAGER: CHRIS VERNOY
ADDRESS: ZONE 4 CMS TELEPHONE NO. 1-800-888-9622 (843) 884-0029
PROJECT NAME/NUMBER: 2908 001 1409000 FAX NO. (843) 856-0107
SAMPLERS: (SIGNATURE) *[Signature]*

NO. OF CONTAINERS	ANALYSIS REQUIRED				REMARKS
	TOX	PCB	PAH	OTHER	
VOCs					

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	X
					TEMP.	CHEMICAL		
014GW00105	7-24-98	1022	H ₂ O	2x40ml	4°C	HCl	2	X
014GW01005	7-24-98	1210						X
014GW01005	7-24-98	1210						X
014GW00205		1515						X
014GW02005		1507						X
014T002498				1x40ml			1	X
014T00205								

7/24/98

RELINQUISHED BY: <i>[Signature]</i>	DATE: 7/24/98	RECEIVED BY: _____	DATE: _____	RELINQUISHED BY: _____	DATE: _____	RECEIVED BY: _____	DATE: _____
SIGNATURE: _____	TIME: _____	SIGNATURE: _____	TIME: _____	SIGNATURE: _____	TIME: _____	SIGNATURE: _____	TIME: _____
PRINTED: BLANKIN	COMPANY: ENSAFE	PRINTED: _____	COMPANY: _____	PRINTED: _____	COMPANY: _____	PRINTED: _____	COMPANY: _____
REASON: FUSE		REASON: _____		REASON: _____		REASON: _____	

METHOD OF SHIPMENT: FUSE
SHIPMENT NO. 1286-4181-8
SPECIAL INSTRUCTION: SWL

COMMENTS: DQ03
4848854986

AFTER ANALYSIS, SAMPLES ARE TO BE:
 DISPOSED OF
 STORED (90 DAYS MAX)
 STORED OVER 90 DAYS
 RETURNED TO CUSTOMER



NAVY CLEAN
ENSAFETY/ALLEN & HOSHAL
(801) 383-9115

CHAIN OF CUSTODY RECORD

PAGE 2 OF 2

CTO-TASK: 2908-001-14-090-00
COG: PO4REL5290
BPA/SO:

CLIENT: Navy Base Charleston PROJECT MANAGER: Chuck Vernon
ADDRESS: 1014 CMS TELEPHONE NO.: (843) 884-0559
PROJECT NAME/NUM: _____ FAX NO.: _____
SAMPLERS: (SIGNATURE) [Signature]

NO. OF CONTAINERS	ANALYSIS REQUIRED				REMARKS
<u>VOC</u>					

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS				
					TEMP.	CHEMICAL					
<u>NRA EDHTW00305</u>	<u>7-27-98</u>	<u>1150</u>	<u>H₂O</u>	<u>40-ml glass</u>	<u>40C</u>	<u>HCL</u>	<u>2</u>	<u>X</u>			

[Signature]
7/27/98

RELINQUISHED BY: <u>[Signature]</u>	DATE: <u>7/27/98</u>	RECEIVED BY: _____	DATE: _____	RELINQUISHED BY: _____	DATE: _____	RECEIVED BY: _____	DATE: _____
SIGNATURE: <u>[Signature]</u>		SIGNATURE: _____		SIGNATURE: _____		SIGNATURE: _____	
PRINTED: <u>Don Bradford</u>		PRINTED: _____		PRINTED: _____		PRINTED: _____	
COMPANY: <u>FedEx</u>	TIME: <u>1300</u>	COMPANY: _____	TIME: _____	COMPANY: _____	TIME: _____	COMPANY: _____	TIME: _____
REASON: <u>Delivery</u>		REASON: _____		REASON: _____		REASON: _____	

METHOD OF SHIPMENT: <u>FedEx</u>	COMMENTS: <u>AIT Samples DQ03 + TICs</u>	AFTER ANALYSIS, SAMPLES ARE TO BE:
SHIPMENT NO.: <u>4348854990</u>		<input checked="" type="checkbox"/> DISPOSED OF
SPECIAL INSTRUCTIONS: <u>SWLCP</u>		<input type="checkbox"/> STORED (90 DAYS MAX)
		<input type="checkbox"/> STORED FOR 90 DAYS
		<input type="checkbox"/> RETURNED TO CUSTOMER

ANALYTICAL DATA RECEIVED BY (INITIALS/DATE)

CLNCDOR

Amendca Chain

7/29/98

PAGE 1 OF 2



NAVY CLEAN
ENSAF/ALLEN&HOSHALL
(901) 383-9115

CHAIN OF CUSTODY RECORD

CTO-TASK: 208-001-14090-00
COC #: _____
BPA/SO: PO4REL52

CLIENT: Naval Base Charleston
ADDRESS: Zone H CMS
PROJECT NAME/NUMBER: _____
SAMPLERS: (SIGNATURE) [Signature]
PROJECT MANAGER: C. Verroy
TELEPHONE NO.: (843) 884-0029
FAX NO.: _____

NO. OF CONTAINERS	ANALYSIS REQUIRED					REMARKS
	VOC	SVOC	Pest/PCB	CN	Asbestos/Benzene	

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	VOC	SVOC	Pest/PCB	CN	Asbestos/Benzene	REMARKS
					TEMP.	CHEMICAL							
NBCH\014FW03D05	7-28-98	0730	H ₂ O	40 ml vials; 1/2 amber; 2nd poly; 1/2 poly	4°C	HCL/NACH/HNO ₃	8	X	X	X	X	X	
NBCH\014FW03D05		0735		" "		"	8	X	X	X	X	X	
NBCH\017DW00405		0740		" "		"	8	X	X	X	X	X	
NBCH\017GW00605		0855		1 L Poly		NaOH	1				X		✓
NBCH\017GN00801		0900		1 L Glass Ambers		—	2		X	X			✓
NBCH\017GN00405		0908		" "		—	2		X	X			✓
NBCH\178GW00205		1100				HCL/HNO ₃	5	X	X			X	
NBCH\178HW00205		1100				HCL/HNO ₃	5	X	X			X	
NBCH\014GW04D01		1215		40 ml glass vials		HCL	2	X					
NBCH\017GN01001		1335		1 L Glass amber		—	2			X			✓

RELINQUISHED BY:	DATE	RECEIVED BY:	DATE	RELINQUISHED BY:	DATE	RECEIVED BY:	DATE
SIGNATURE: <u>[Signature]</u>	7-28-98	SIGNATURE: _____		SIGNATURE: _____		SIGNATURE: _____	
PRINTED: <u>[Signature]</u>		PRINTED: _____		PRINTED: _____		PRINTED: _____	
COMPANY: <u>EnSaf</u>	TIME: 1700	COMPANY: _____	TIME: _____	COMPANY: _____	TIME: _____	COMPANY: _____	TIME: _____
REASON: <u>Deby Priority</u>		REASON: _____		REASON: _____		REASON: _____	

METHOD OF SHIPMENT: FedEx
SHIPMENT NO.: 4848175371
SPECIAL INSTRUCTION: SWL
COMMENTS: All Samples DQO 3 + TICs
AFTER ANALYSIS, SAMPLES ARE TO BE:
 DISPOSED OF
 STORED (90 DAYS MAX)
 STORED OVER 90 DAYS
 RETURNED TO CUSTOMER

ANALYTICAL DATA RECEIVED BY (INITIALS/DATE)

CLNCCRCI

07/28/98 16:57 TEL 7477306

ENSAF ALLEN HOS CHARSARF

001



NAVY CLEAN
ENSAFÉ/ALLEN & HOSHAL
 (901) 383-9115

CHAIN OF CUSTODY RECORD

PAGE 2 OF 2

CTO-TASK: 2908-001-14-090-00

COC #: _____

BPA/SO: PO4REL52

CLIENT Naval Base Charleston

PROJECT MANAGER C. Vernon

ADDRESS Zone # CMS

TELEPHONE NO. (845) 884-0029

PROJECT NAME/NUMBER _____

FAX: NO. _____

SAMPLERS: (SIGNATURE) [Signature]

NO. OF CONTAINERS	ANALYSIS REQUIRED				REMARKS
VOC					

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION					
					TEMP.	CHEMICAL				
NECH014GW03D05	7-28-98	1535	H ₂ O	40ml glass vial	4°C	HCL	2	X		
NECH014TW03D05	"	-	"	" "	"	"	2	X		
[Signature] 7/28/98										

RELINQUISHED BY: [Signature]	DATE: 7-28-98	RECEIVED BY: [Signature]	DATE:	RELINQUISHED BY: [Signature]	DATE:	RECEIVED BY: [Signature]	DATE:
SIGNATURE		SIGNATURE		SIGNATURE		SIGNATURE	
PRINTED: [Name]		PRINTED:		PRINTED:		PRINTED:	
COMPANY: ENSAFÉ	TIME: 1700	COMPANY:	TIME:	COMPANY:	TIME:	COMPANY:	TIME:
REASON: Delivery Party		REASON:		REASON:		REASON:	

METHOD OF SHIPMENT: <u>Fedex</u>	COMMENTS: <u>All Samples DG03 + TICs</u>	AFTER ANALYSIS, SAMPLES ARE TO BE:
SHIPMENT NO. <u>484315371</u>		<input checked="" type="checkbox"/> DISPOSED OF
SPECIAL INSTRUCTION: <u>SWL</u>		<input type="checkbox"/> STORED (90 DAYS MAX)
		<input type="checkbox"/> STORED OVER 90 DAYS
		<input type="checkbox"/> RETURNED TO CUSTOMER

07/28/98 16:57 TEL 7477306 ENSAFÉ ALLEN HOS +++ CHARSAFÉ 02



800-588-7962

MEMPHIS, TENNESSEE

CHARLESTON, SC; CINCINNATI, OH; DALLAS, TX; JACKSON, TN; KNOXVILLE, TN;
LANCASTER, PA; NASHVILLE, TN; NORFOLK, VA; PADUCAH, KY; PENSACOLA, FL;
RALEIGH, NC; COLOGNE, GERMANY

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

PROJECT/JOB NO: 2908-00.-08-014-00

COC NO: _____

PO NO: 1759 LINE 3

REL NO: _____

LAB NAME: SOIL CONSULTANTS INC.

SUZANNE STROH - CONTACT

CLIENT NAVAL BASE CHAR. ZONE H CMS PROJECT MANAGER TED BLAHNIK

LOCATION LEAD SHOT DISTRIBUTION TELE/FAX NO. _____

SAMPLERS: (SIGNATURE) Michael Perlmutter

ANALYSIS REQUIRED

NO. OF CONTAINERS
LEAD SHOT

REMARKS

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	LEAD SHOT	ANALYSIS REQUIRED	REMARKS
					TEMP.	CHEMICAL				
NBCA/0145B02301	10/21/98	—	SOIL	ZIPL0C BAG	AMB.	NONE	2	X		
NBCA/0145B02401		—					2	X		
NBCA/0145B02501		—					2	X		
NBCA/0145B02601		—					2	X		
NBCA/0145B02701		—					2	X		
NBCA/0145B02801		—					2	X		
NBCA/0145B02901		—					2	X		
NBCA/0145B03001		—					2	X		
NBCA/0145B03101		—					2	X		
NBCA/0145B03201		—					2	X		
NBCA/0145B03301		—					2	X		
<i>MLP</i>										

RELINQUISHER: <u>MLP</u>	DATE: <u>10/21/98</u>	RECEIVER: _____	DATE: _____	RELINQUISHER: _____	DATE: _____	RECEIVER: _____
PRINTED: <u>MIKE PERLMUTTER</u>	TIME: <u>1100</u>	PRINTED: _____	TIME: _____	PRINTED: _____	TIME: _____	PRINTED: _____
COMPANY: <u>ENSAFE</u>	COMPANY: _____	COMPANY: _____	COMPANY: _____	COMPANY: _____	COMPANY: _____	COMPANY: _____

METHOD OF SHIPMENT: HAND DELIVERY

SHIPMENT NO. _____

SEND RESULTS TO: TED BLAHNIK

COMMENTS: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1
PROJECT/JOB NO: 2908-0 08-014-00
COC NO: _____
PO NO: 4
REL NO: 87
LAB NAME: Southwest

CLIENT Naval Base Charleston PROJECT MANAGER Charlie Verroy
LOCATION Zone H TELE/FAX NO. 843-884-0029 / 856-0107
SAMPLERS: (SIGNATURE) [Signature]

ANALYSIS REQUIRED

NO. OF CONTAINERS VOC

REMARKS

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	ANALYSIS REQUIRED	REMARKS
					TEMP.	CHEMICAL			
NBCH\159GWC0101	3-23-99	1115	W	40ml Voa	4°C	HCL	2	X	
NBCH\014GWC6D01	3-24-99	1110	W	40 ml Voa	4°C	HCL	2	X	
NBCH\014TWC6D01	3-24-99	—	W	40ml Voa	4°C	HCL	2	X	
Area crossed out with diagonal line and signature									

RELINQUISHER: <u>[Signature]</u>	DATE: <u>3/24/99</u>	RECEIVER: _____	DATE: _____	RELINQUISHER: _____	DATE: _____	RECEIVER: _____	DATE: _____
PRINTED: <u>Todd B Temple</u>	TIME: <u>1730</u>	PRINTED: _____	TIME: _____	PRINTED: _____	TIME: _____	PRINTED: _____	TIME: _____
COMPANY: <u>ENSAFE</u>		COMPANY: _____		COMPANY: _____		COMPANY: _____	

METHOD OF SHIPMENT: FedEx
SHIPMENT NO. 808625948790
SEND RESULTS TO: _____

COMMENTS: DQO III

CHARLESTON - ZONE H
CHARLESTON ZONE H - CMS SWMU 14
SITE 14 GROUNDWATER SAMPLES

SMB46_VOA		SAMPLE ID ----->	014-G-W001-05	014-G-W002-05	014-G-W003-05	014-G-W004-05	014-G-W005-05	014-G-W006-01			
		ORIGINAL ID ----->	014GW00105	014GW00205	014GW00305	014GW00405	014GW00505	014GW00601			
		LAB SAMPLE ID ---->	34988.01	34988.04	35007.03	35007.01	35007.04	35007.05			
		ID FROM REPORT -->	014GW00105	014GW00205	014GW00305	014GW00405	014GW00505	014GW00601			
		SAMPLE DATE ----->	07/24/98	07/24/98	07/25/98	07/25/98	07/26/98	07/26/98			
		DATE ANALYZED ---->	08/03/98	08/04/98	08/04/98	08/04/98	08/05/98	08/05/98			
		MATRIX ----->	Water	Water	Water	Water	Water	Water			
		UNITS ----->	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L			
CAS #	Parameter	34942	VAL	34942	VAL	35007	VAL	35007	VAL	35007	VAL
74-87-3	Chloromethane	5.	U	5.	U	5.	U	5.	U	5.	U
74-83-9	Bromomethane	5.	UJ	5.	U	5.	U	5.	U	5.	U
75-01-4	Vinyl chloride	5.	U	5.	U	5.	U	5.	U	17.	U
75-00-3	Chloroethane	5.	U	5.	U	5.	U	5.	U	5.	U
75-35-4	1,1-Dichloroethene	5.	U	5.	UJ	5.	U	5.	UJ	5.	U
75-09-2	Methylene chloride	5.	U	5.	U	5.	U	5.	U	5.	U
75-34-3	1,1-Dichloroethane	5.	U	5.	U	5.	U	5.	UJ	5.	U
67-66-3	Chloroform	5.	U	5.	U	5.	U	5.	U	5.	U
71-55-6	1,1,1-Trichloroethane	5.	U	5.	U	5.	U	5.	U	5.	U
56-23-5	Carbon tetrachloride	5.	U	5.	U	5.	U	5.	U	5.	U
71-43-2	Benzene	5.	U	5.	U	5.	U	5.	U	5.	U
107-06-2	1,2-Dichloroethane	5.	UJ	5.	U	5.	U	5.	U	5.	U
79-01-6	Trichloroethene	5.	U	5.	U	5.	U	5.	U	5.	U
78-87-5	1,2-Dichloropropane	5.	U	5.	U	5.	U	5.	U	5.	U
75-27-4	Bromodichloromethane	5.	U	5.	U	5.	U	5.	U	5.	U
108-88-3	Toluene	5.	U	5.	U	5.	U	5.	U	5.	U
79-00-5	1,1,2-Trichloroethane	5.	U	5.	U	5.	U	5.	U	5.	U
127-18-4	Tetrachloroethene	5.	U	5.	U	5.	U	5.	U	5.	U
124-48-1	Dibromochloromethane	5.	U	5.	U	5.	U	5.	U	5.	U
108-90-7	Chlorobenzene	5.	U	5.	U	5.	U	5.	U	5.	U
100-41-4	Ethylbenzene	5.	U	5.	U	5.	U	5.	U	5.	U
100-42-5	Styrene	5.	U	5.	U	5.	U	5.	U	5.	U
75-25-2	Bromoform	5.	UJ	5.	U	5.	U	5.	U	5.	U
79-34-5	1,1,2,2-Tetrachloroethane	5.	U	5.	U	5.	U	5.	U	5.	U
67-64-1	Acetone	5.	UR	5.	UR	5.	UR	5.	UR	5.	UR
75-15-0	Carbon disulfide	5.	U	5.	UJ	5.	UJ	5.	UJ	5.	UJ
108-05-4	Vinyl acetate	5.	U	5.	U	5.	U	5.	U	5.	U
78-93-3	2-Butanone (MEK)	5.	U	5.	U	5.	U	5.	UJ	5.	UJ
110-75-8	2-Chloroethyl vinyl ether	5.	UR	5.	UR	5.	UR	5.	UR	5.	UR
108-10-1	4-Methyl-2-Pentanone (MIBK)	5.	U	5.	U	5.	U	5.	U	5.	U
10061-01-5	cis-1,3-Dichloropropene	5.	U	5.	U	5.	U	5.	UJ	5.	U
10061-02-6	trans-1,3-Dichloropropene	5.	U	5.	U	5.	U	5.	U	5.	U
591-78-6	2-Hexanone	5.	U	5.	U	5.	U	5.	U	5.	U
1330-20-7	Xylene (Total)	5.	U	5.	U	5.	U	5.	UJ	5.	UJ
540-59-0	1,2-Dichloroethene (total)	5.	U	5.	U	5.	U	5.	UJ	5.	UJ

CHARLESTON - ZONE H
CHARLESTON ZONE H - CMS SWMU 14
SITE 14 GROUNDWATER SAMPLES

SW846_VOA		SAMPLE ID ----->	014-G-W007-01	014-G-W010-05	014-H-W010-05	014-G-W020-05	014-G-W030-05	014-G-W040-05					
		ORIGINAL ID ----->	014GW00701	014GW01005	014HW01005	014GW02005	014GW03005	014GW04005					
		LAB SAMPLE ID ----->	37570.01	34988.02	34988.03	34988.05	35019.10	35007.02					
		ID FROM REPORT ----->	014GW00701	014GW01005	014HW01005	014GW02005	014GW03005	014GW04005					
		SAMPLE DATE ----->	03/01/99	07/24/98	07/24/98	07/24/98	07/28/98	07/25/98					
		DATE ANALYZED ----->	03/03/99	08/03/98	08/03/98	08/04/98	08/10/98	08/04/98					
		MATRIX ----->	Water	Water	Water	Water	Water	Water					
		UNITS ----->	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L					
CAS #	Parameter		37570	34942	VAL	34942	VAL	34942	VAL	34991	VAL	35007	VAL
74-87-3	Chloromethane		5. U	5. U		5. U		5. U		5. U		5. U	
74-83-9	Bromomethane		5. U	5. UJ		5. UJ		5. U		5. U		5. U	
75-01-4	Vinyl chloride		5. U	5. U		5. U		5. U		5. U		5. U	
75-00-3	Chloroethane		5. U	5. U		5. U		5. U		5. U		5. U	
75-35-4	1,1-Dichloroethene		5. U	5. U		5. U		5. U		5. U		5. U	
75-09-2	Methylene chloride		5. U	5. U		5. U		5. U		5. U		5. U	
75-34-3	1,1-Dichloroethane		5. U	5. U		5. U		5. U		5. U		5. U	
67-66-3	Chloroform		5. U	5. U		5. U		5. U		5. U		5. U	
71-55-6	1,1,1-Trichloroethane		5. U	5. U		5. U		5. U		5. UJ		5. U	
56-23-5	Carbon tetrachloride		5. U	5. U		5. U		5. U		5. UJ		5. U	
71-43-2	Benzene		5. U	5. U		5. U		5. U		5. U		5. U	
107-06-2	1,2-Dichloroethane		5. U	5. UJ		5. UJ		5. U		5. U		5. U	
79-01-6	Trichloroethene		5. U	5. U		5. U		5. U		5. U		5. U	
78-87-5	1,2-Dichloropropane		5. U	5. U		5. U		5. U		5. U		5. U	
75-27-4	Bromodichloromethane		5. U	5. U		5. U		5. U		5. U		5. U	
108-88-3	Toluene		5. U	5. U		5. U		5. U		5. U		5. U	
79-00-5	1,1,2-Trichloroethane		5. U	5. U		5. U		5. U		5. U		5. U	
127-18-4	Tetrachloroethene		5. U	5. U		5. U		5. U		5. U		5. U	
124-48-1	Dibromochloromethane		5. U	5. U		5. U		5. U		5. U		5. U	
108-90-7	Chlorobenzene		5. U	5. U		5. U		5. U		5. U		5. U	
100-41-4	Ethylbenzene		5. U	5. U		5. U		5. U		5. U		5. U	
100-42-5	Styrene		5. U	5. U		5. U		5. U		5. U		5. U	
75-25-2	Bromoform		5. U	5. UJ		5. UJ		5. U		5. U		5. U	
79-34-5	1,1,2,2-Tetrachloroethane		5. U	5. U		5. U		5. U		5. U		5. U	
67-64-1	Acetone		5. U	5. UR		5. UR		5. UR		12. U		5. UR	
75-15-0	Carbon disulfide		5. U	5. U		5. U		5. UJ		2. J		5. UJ	
108-05-4	Vinyl acetate		5. U	5. U		5. U		5. U		5. U		5. U	
78-93-3	2-Butanone (MEK)		5. U	5. U		5. U		5. U		5. U		5. U	
110-75-8	2-Chloroethyl vinyl ether		5. U	5. UJ		5. UR		5. UR		5. U		5. UR	
108-10-1	4-Methyl-2-Pentanone (MIBK)		5. U	5. U		5. U		5. U		5. U		5. U	
10061-01-5	cis-1,3-Dichloropropene		5. U	5. U		5. U		5. U		5. U		5. U	
10061-02-6	trans-1,3-Dichloropropene		5. U	5. U		5. U		5. U		5. U		5. U	
591-78-6	2-Hexanone		5. U	5. U		5. U		5. U		5. U		5. U	
1330-20-7	Xylene (Total)		5. U	5. U		5. U		5. U		5. U		5. U	
540-59-0	1,2-Dichloroethene (total)		5. U	5. U		5. U		5. U		5. U		5. U	

CHARLESTON - ZONE H
CHARLESTON ZONE H - CMS SWMU 14
SITE 14 GROUNDWATER SAMPLES

SW846_VOA		SAMPLE ID ----->	014-G-W05D-05	014-G-W06D-01	014-G-WC06-01	014-G-WC6D-01			
		ORIGINAL ID ----->	014GW05D05	014GW06D01	014GWC0601	014GWC6D01			
		LAB SAMPLE ID ---->	35007.10	35019.12	37814.01	37839.02			
		ID FROM REPORT -->	014GW05D05	014GW06D01	014GWC0601	014GWC6D01			
		SAMPLE DATE ----->	07/27/98	07/28/98	03/22/99	03/24/99			
		DATE ANALYZED ---->	08/05/98	08/06/98	03/25/99	03/26/99			
		MATRIX ----->	Water	Water	Water	Water			
		UNITS ----->	UG/L	UG/L	UG/L	UG/L			
CAS #	Parameter	35007	VAL	34991	VAL	37814	VAL	37839	VAL
74-87-3	Chloromethane	5.	U	5.	U	5.	U	5.	U
74-83-9	Bromomethane	5.	U	5.	U	5.	U	5.	U
75-01-4	Vinyl chloride	5.	U	5.	U	5.	U	5.	U
75-00-3	Chloroethane	5.	U	5.	U	5.	U	5.	U
75-35-4	1,1-Dichloroethene	5.	U	5.	U	5.	U	5.	U
75-09-2	Methylene chloride	5.	U	5.	U	5.	U	5.	U
75-34-3	1,1-Dichloroethane	5.	U	5.	U	5.	U	5.	U
67-66-3	Chloroform	5.	U	5.	U	5.	U	5.	U
71-55-6	1,1,1-Trichloroethane	5.	U	5.	U	5.	U	5.	U
56-23-5	Carbon tetrachloride	5.	U	5.	U	5.	U	5.	U
71-43-2	Benzene	5.	U	5.	U	5.	U	5.	U
107-06-2	1,2-Dichloroethane	5.	U	5.	U	5.	U	5.	U
79-01-6	Trichloroethene	5.	U	5.	U	5.	U	5.	U
78-87-5	1,2-Dichloropropane	5.	U	5.	U	5.	U	5.	U
75-27-4	Bromodichloromethane	5.	U	5.	U	5.	U	5.	U
108-88-3	Toluene	5.	U	5.	U	5.	U	5.	U
79-00-5	1,1,2-Trichloroethane	5.	U	5.	U	5.	U	5.	U
127-18-4	Tetrachloroethene	5.	U	5.	U	5.	U	5.	U
124-48-1	Dibromochloromethane	5.	U	5.	U	5.	U	5.	U
108-90-7	Chlorobenzene	5.	U	5.	U	5.	U	5.	U
100-41-4	Ethylbenzene	5.	U	5.	U	5.	U	5.	U
100-42-5	Styrene	5.	U	5.	U	5.	U	5.	U
75-25-2	Bromoform	5.	U	5.	U	5.	U	5.	U
79-34-5	1,1,2,2-Tetrachloroethane	5.	U	5.	U	5.	U	5.	U
67-64-1	Acetone	5.	UR	5.	UR	5.	UR	5.	UR
75-15-0	Carbon disulfide	5.	UJ	5.	UJ	5.	U	5.	U
108-05-4	Vinyl acetate	5.	U	5.	U	5.	U	5.	U
78-93-3	2-Butanone (MEK)	5.	UJ	5.	UJ	5.	UR	5.	UR
110-75-8	2-Chloroethyl vinyl ether	5.	UR	5.	UR	5.	UR	5.	UR
108-10-1	4-Methyl-2-Pentanone (MIBK)	5.	U	3.	J	5.	U	5.	U
10061-01-5	cis-1,3-Dichloropropene	5.	U	5.	U	5.	U	5.	U
10061-02-6	trans-1,3-Dichloropropene	5.	U	5.	UJ	5.	U	5.	U
591-78-6	2-Hexanone	5.	U	5.	U	5.	U	5.	U
1330-20-7	Xylene (Total)	5.	UJ	5.	UJ	5.	U	5.	U
540-59-0	1,2-Dichloroethene (total)	5.	UJ	5.	UJ	5.	U	5.	U

VALIDATA

Chemical Services, Inc.

P. O. Box 930422, Norcross, GA 30003

(770) 923-3890

(770) 923-8769 (Fax)

DATA VALIDATION SUMMARY REPORT

COMPANY: Ensafe / Allen & Hoshall
SITE NAME: Charleston Naval Base, Zone H
SERVICE ORDER NUMBER: 0303
CONTRACTED LAB: Southwest Laboratories, Inc.
QA/QC LEVEL: EPA Level III
EPA METHOD: EPA SOW 3-90 or SW-846
VALIDATION GUIDELINES: USEPA CLP National Functional Guidelines for Organic Data Review, 1994; USEPA CLP National Functional Guidelines for Inorganic Data Review, 1994
SAMPLE MATRIX: Water
TYPES OF ANALYSES: Total Volatiles, Semivolatiles, Pesticides / PCB's, Cyanide
SDG NUMBER: 34942

Client	Lab		Volatile	Semi-	Pesticides/	
<u>Sample #</u>	<u>Sample #</u>	<u>Matrix</u>	<u>Organics</u>	<u>volatiles</u>	<u>PCB's</u>	<u>Cyanide</u>
014GW00105	34988.01	Water	X			
014GW00205	34988.04	Water	X			
014GW01D05	34988.02	Water	X			
014HW01D05	34988.03	Water	X			
014GW02D05	34988.05	Water	X			
017GW00105	34942.01	Water	X	X	X	X
017GW00205	34942.02	Water	X	X	X	X
017GW00205DL	34942.02DL	Water	+	+	+	
017GW00305	34942.03	Water	X	X	X	X
017GW02D01	34942.04	Water	X	X	X	X
017GW02D01RE	34942.04RE	Water	+			
014TW00205	34988.06	Water	X			
017TW02D01	34942.05	Water	X			
014GW00205MS	64988.04MS	Water	+			
014GW00205MSD	64988.04MSD	Water	+			
017GW02D01MS	64942.04MS	Water		+		
017GW02D01MSD	64942.04MSD	Water		+		
017GW00305MS	34942.03MS	Water			+	
017GW00305MSD	34942.03MSD	Water			+	
017GW00105MS	34942.01MS	Water				+

DL = DILUTION, MS = MATRIX SPIKE, MSD = MATRIX SPIKE DUPLICATE,
RE = REANALYSIS, T = TRIP BLANK

DATA REVIEWER(S): Amy L. Hogan, Marvin L. Smith, Jean M. Delashmit

RELEASE SIGNATURE:

A handwritten signature in black ink, appearing to read "Jean M. Delashmit". The signature is written in a cursive style with a large initial "J" and "M".

Data Qualifier Definitions

- J - The associated numerical value is an estimated quantity.
- R - The data are unusable (the compound/analyte may or may not be present). Resampling and reanalysis are necessary for verification.
- U - The compound/analyte was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
- UJ - The compound/analyte was analyzed for, but not detected. The sample quantitation limit is an estimated quantity.

DATA QUALIFICATION SUMMARY

Southwest Laboratories of Oklahoma, Inc. - 34942 CLP Organics and Inorganics

SAMPLES: 014GW00105, 014GW00205, 014GW01D05, 014HW01D05, 014GW02D05,
017GW00105, 017GW00205, 017GW00205DL, 017GW00305, 017GW02D01,
017GW02D01RE, 014TW00205, 017TW02D01, 014GW00205MS,
014GW00205MSD, 017GW02D01MS, 017GW02D01MSD, 017GW00305MS,
017GW00305MSD, 017GW00105MS

VOLATILE ORGANICS

I.) Holding Times:

All Holding Time criteria were met, so no action was taken.

II.) GC/MS Tuning:

All GC/MS Tuning criteria were met, so no action was required.

III.) Calibration:

Initial Calibration:

The Average Relative Response Factor (RRF) for 2-chloroethyl vinyl ether was 0.013 for the standards run on 7/14/98 on instrument U, which was below the 0.050 QC limit. All results for this compound in the samples for this SDG, which consisted entirely of non-detects, were rejected (R).

Continuing Calibration:

The Relative Response Factors (RRF's) for acetone (0.035) and 2-chloroethyl vinyl ether (0.003) were below the 0.050 QC limit for the standards run on 7/31/98 at 14:25 on instrument U. All results for acetone in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated samples were 017GW00105, 017GW00205, 017GW02D01 and 017TW02D01. The results for 2-chloroethyl vinyl ether were previously rejected, so no further action was required.

The Percent Differences (%D's) exceeded the 25% QC limit for the standards run on 7/31/98 at 14:25 on instrument U for the following compounds:

acetone	45.6%
bromomethane	49.9%
carbon disulfide	29.6%
1,2-dichloroethene	89.8%
carbon tetrachloride	25.6%

bromodichloromethane	29.2%
2-chloroethyl vinyl ether	77.4%
bromoform	37.8%

All results for these compounds in the associated samples, which consisted entirely of non-detects, were flagged as estimated (UJ) unless previously rejected. The associated samples were 017GW00105, 017GW00205 and 017GW02D01.

The Relative Response Factors (RRF's) for acetone (0.028) and 2-chloroethyl vinyl ether (0.001) were below the 0.050 QC limit for the standards run on 7/31/98 at 09:24 on instrument U. All results for acetone in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated sample was 017GW00305. The results for 2-chloroethyl vinyl ether in the associated samples were previously rejected, so no further action was required.

The Percent Differences (%D's) exceeded the 25% QC limit for the standards run on 7/31/98 at 09:24 on instrument U for the following compounds:

acetone	70.6%
bromomethane	42.9%
carbon disulfide	39.0%
1,2-dichloroethene	88.0%
2-butanone	27.6%
2-chloroethyl vinyl ether	96.5%

All results for these compounds in associated sample 017GW00305, which consisted entirely of non-detects, were flagged as estimated (UJ) unless previously rejected.

The Relative Response Factors (RRF's) for acetone (0.034) and 2-chloroethyl vinyl ether (0.003) were below the 0.050 QC limit for the standards run on 8/3/98 at 08:37 on instrument U. All results for acetone in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated samples were 014GW00105, 014GW01D05, 014HW01D05. The results for 2-chloroethyl vinyl ether in the associated samples were previously rejected, so no further action was required.

The Percent Differences (%D's) exceeded the 25% QC limit for the standards run on 8/3/98 at 08:37 on instrument U for the following compounds:

acetone	48.9%
bromomethane	55.4%
1,2-dichloroethene	108%
2-chloroethyl vinyl ether	80.8%
bromoform	38.4%

All results for these compounds in the associated samples, which consisted entirely of non-detects, were flagged as estimated (UJ) unless previously rejected. The associated samples were 014GW00105, 014GW01D05 and 014HW01D05.

The Relative Response Factors (RRF's) for acetone (0.029) and 2-chloroethyl vinyl ether (0.004) were below the 0.050 QC limit for the standards run on 8/4/98 at 08:55 on instrument U. All results for

acetone in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated samples were 014GW00205, 014GW02D05 and 014TW00205. The results for 2-chloroethyl vinyl ether in the associated samples were previously rejected, so no further action was required.

The Percent Differences (%D's) exceeded the 25% QC limit for the standards run on 8/4/98 at 08:55 on instrument U for the following compounds:

acetone	67.0%
carbon disulfide	60.2%
2-chloroethyl vinyl ether	68.3%

All results for these compounds in the associated samples, which consisted entirely of non-detects, were flagged as estimated (UJ) unless previously rejected. The associated samples were 014GW00205 and 014GW02D05.

IV.) Blanks:

Method Blanks:

There were no positive detections in the associated method blanks. No action was required.

Trip Blanks:

Chlorobenzene was detected at 2 ug/L in trip blank 017TW02D01. The positive result for this compound in associated sample 017GW02D01, which was less than 5X the blank amount, was flagged as undetected (U) with the result being raised to the CRQL.

TIC's:

There were no TIC's detected in the method or trip blanks. No action was required.

V.) Surrogate Recoveries:

The Percent Recoveries (%R's) of toluene-d8 exceeded the 88-110% QC limits for samples 017GW00205 (112%) and 017GW02D01 (114%). All positive results for these samples were flagged as estimated (J).

VI.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recovery (%R) of 1,1-dichloroethene in spiked sample 014GW00205MS was 75%, which was below the 76-125% QC limits. The non-detect result for this compound in associated sample 014BW00205 was flagged as estimated (UJ).

VII.) Laboratory Control Samples (LCS):

Four LCS's were analyzed for this SDG. Several Recoveries were outside the QC limits. Data validation action based on LCS criteria was not required. No action was taken.

VIII.) Field Duplicates:

There were no calculable Relative Percent Differences (RPD's) for the field duplicate samples identified in this SDG. No action was required.

IX.) Internal Standards Performance (ISTD):

All ISTD criteria were met. No action was required.

X.) TCL Compound Identification:

The result for chlorobenzene in sample 017GW00205 was taken from a dilution analysis of the sample since the original analysis result was above the instrument's linear calibration range. All other criteria were met. No further action was required.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

All CRQL criteria were met, so no action was necessary.

XII.) Tentatively Identified Compounds (TIC's):

All TIC Identification criteria were met, so no action was required. Blank qualifications were performed in Section IV.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

The non-detect results for acetone and 2-chloroethyl vinyl ether in the samples in this SDG were rejected based on low Relative Response Factors in the initial and continuing calibrations.

The original analysis of sample 017GW02D01 was considered by the validator to be of preferable data quality to the reanalysis based on holding time criteria.

All other laboratory data were acceptable with qualifications.

SEMIVOLATILE ORGANICS

I.) Holding Times:

All Holding Time criteria were met. No action was required.

II.) GC/MS Tuning:

All GC/MS Tuning criteria were met, so no action was required.

III.) Calibration:

Initial Calibration:

All Initial Calibration criteria were met. No action was required.

Continuing Calibration:

The Percent Difference (%D) exceeded the 25% QC limit for the standards run on 8/01/98 at 17:32 on instrument F for diethylphthalate (41.5%). The results for this compound in the samples in this SDG, which consisted entirely of non-detects, were flagged as estimated (UJ).

IV.) Blanks:

Method Blanks:

Diethylphthalate was detected at 9 ug/L in method blank SBLK1. Since there were no positive results for this compound in the associated samples, no action was required.

TIC's:

There were no TIC's detected in the method blanks. No action was required.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was required.

VI.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

All MS / MSD criteria were met. No action was required.

VII.) Laboratory Control Samples (LCS):

All LCS criteria were met. No action was taken.

VIII.) Field Duplicates:

There were no field duplicate samples for this fraction of the SDG. No action was required.

IX.) Internal Standards Performance (ISTD):

All ISTD criteria were met. No action was required.

X.) TCL Compound Identification:

The results for 1,2-dichlorobenzene, 1,4-dichlorobenzene and 1,3-dichlorobenzene in sample 017GW02D05 were taken from a dilution analysis of the sample since the original analysis results were above the instrument's linear calibration range. All other criteria were met. No further action was required.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

All CRQL criteria were met, so no action was necessary.

XII.) Tentatively Identified Compounds (TIC's):

All TIC Identification criteria were met, so no action was required. Blank qualifications were performed in Section IV.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualification.

PESTICIDES/PCB's

I.) Holding Times:

All Holding Time criteria were met. No action was required.

II.) Instrument Performance:

All Instrument Performance criteria were met. No action was required.

III.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was required.

IV.) Blanks:

There were no positive detections in the method blanks. No action was required.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was required.

VI.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Relative Percent Differences (RPD's) for spiked samples 017GW00305MS and 017GW00305MSD exceeded the 20% QC limit for the following compounds:

alpha-BHC	45%
beta-BHC	43%
gamma-BHC	43%

delta-BHC	32%
heptachlor	34%
aldrin	60%
heptachlor epoxide	41%
endosulfan I	26%
4,4'-DDE	41%
dieldrin	42%
endrin	46%
endosulfan II	43%
4,4'-DDD	40%
endosulfan sulfate	36%
4,4'-DDT	38%
endrin aldehyde	54%
methoxychlor	42%
alpha-chlordane	28%
gamma-chlordane	62%
endrin ketone	40%

The results for these compounds in associated unspiked sample 017GW00305, which consisted entirely of non-detects, were flagged as estimated (UJ).

The Percent Recoveries (%R's) for spiked sample 017GW00305MS were below their respective QC limits for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>QC Limits</u>
4,4'-DDE	64	70-122%
4,4'-DDD	60	70-133%
endosulfan sulfate	20	22-126%

The results for these compounds in associated sample 017GW00305 were previously flagged, so no further action was necessary.

VII.) TCL Compound Identification:

Pesticide/PCB Identification Summary (PIS):

The Percent Differences (%D's) between column 1 and column 2 exceeded the 70% QC limit for the following sample:

<u>Sample</u>	<u>Compound</u>	<u>Col., %D</u>
017GW00205	heptachlor epoxide	93.3%
	dieldrin	999%
	4,4'-DDE	746%
	4,4'-DDT	190%
	methoxychlor	900%

The results for compounds with %D's between 70% and 300% were flagged as estimated (J). Results for compounds with %D's above 300% were rejected (R).

VIII.) Field Duplicates:

There were no field duplicate samples for this SDG. No action was required.

IX.) Pesticide Cleanup Check:

Florisol Cartridge Check:

Florisol Cleanup data was not submitted for this SDG. No action was taken.

Gel Permeation Chromatography (GPC):

GPC data were not submitted for this SDG. No action was taken.

X.) Overall Assessment of Data/General:

The result for 4,4'-DDT in sample 017GW00205 was taken from a dilution analysis of the sample since the original analysis result was above the instrument's linear calibration range.

The non-detect results for dieldrin, 4,4'-DDE and methoxychlor were rejected in sample 017GW00205 based on Pesticide Identification criteria. All other laboratory data were acceptable with qualifications.

CYANIDE

I.) Holding Times:

All Holding Time criteria were met, so no action was taken.

II.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was required.

III.) Blanks:

There were no blanks containing results greater than the IDL. No action was required.

IV.) ICP Interference Check Sample Results:

All Percent Recovery criteria were met, so no action was taken.

V.) ICP Serial Dilution Analysis:

Serial Dilution Analysis was not performed for this SDG. No action was required.

VI.) Laboratory Control Samples (LCS):

All LCS Recovery criteria were met. No action was required.

VII.) Duplicate Sample Analysis:

Duplicate Sample Analysis was not performed for this fraction of the SDG. No action was required.

VIII.) Matrix Spike Recoveries:

All Matrix Spike criteria were met. No action was required.

IX.) Field Duplicates:

There were no field duplicate samples identified for this fraction of the SDG. No action was required.

X.) Graphite Furnace Atomic Absorption QC (GFAA):

Graphite Furnace analyses were not used for the samples in this SDG. No action was required.

XI.) Sample Result, Calculation/Transcription Verification:

All criteria were met. No action was required.

XII.) Quarterly Verification of Instrumental Parameters:

All criteria were met, so no action was taken.

XIII.) Overall Assessment of Data/General:

All laboratory data were acceptable without qualification.

VALIDATA

Chemical Services, Inc.

P. O. Box 930422, Norcross, GA 30003

(770) 923-3890

(770) 923-8769 (Fax)

DATA VALIDATION SUMMARY REPORT

COMPANY: Ensafe/Allen & Hoshall
SITE NAME: Charleston Navel Base, Zone H
SERVICE ORDER NUMBER: 0304
CONTRACTED LAB: Southwest Laboratory of Oklahoma, Inc.
QA/QC LEVEL: EPA Level IV
EPA METHOD: EPA SOW 3-90 / SW846
VALIDATION GUIDELINES: USEPA CLP National Functional Guidelines for Organic Data Review, 1994; USEPA CLP National Functional Guidelines for Inorganic Data Review, 1994

SAMPLE MATRIX: Water
TYPES OF ANALYSES: Volatile Organics, Semivolatiles, Pesticides, Total Metals, Cyanide

SDG NUMBER: 34991 (Level III)

SAMPLES:

Client Sample #	Lab Sample #	Matrix	Volatile Organics	Semi- volatiles	Pesticides/ PCBs	Total Metals	Cyanide
014GW03D05	35019-10	Water	X				
014GW06D01	35019-12	Water	X				
017GW00405	34991-01	Water	X	X	X		X
017GW00405RE	34991-01RE	Water		+			
017GW00505	34991-02	Water	X				X
017GW00605	34991-03	Water	X	X	X		X
017HW00605	34991-07	Water	X	X	X		
017GW00801	34991-04	Water	X	X	X		X
017GW01001	34991-05	Water	X	X	X		X
178GW00205	35019-07	Water	X	X		X	
178GW00205RE	35019-07RE	Water		+			
178HW00205	35019-08	Water	X	X		X	
178HW00205RE	35019-08RE	Water		+			
014EW03D05	35019-01	Water	X	X	X	X	X
014EW03D05RE	35019-01RE	Water		+			
014FW03D05	35019-02	Water	X	X	X	X	X
014FW03D05RE	35019-02RE	Water		+			
017DW00405	35019-03	Water	X	X	X	X	X
017DW00405RE	35019-03RE	Water		+			

Client Sample #	Lab Sample #	Matrix	Volatile Organics	Semi- volatiles	Pesticides/ PCBs	Total Metals	Cyanide
017EW00405	34991-06	Water	X	X			
014TW03D05	35019-11	Water	X				
017TW00405	3499108	Water	X				
014EW03D05MS	35019-01MS	Water	+			+	+
014EW03D05MSD	35019-01MSD	Water	+			+	
014EW03D05MD	35019-01MD	Water				+	+
014EW03D05REMS	35019-01REMS	Water		+			
014EW03D05REMSD	35019-01REMSD	Water		+			
017GW00801MS	34991-04MS	Water		+			
017GW00801MSD	34991-04MSD	Water		+			
017HW00605MS	34991-07MS	Water			+		
017HW00605MSD	34991-07MSD	Water			+		
017GW00405MS	34991-01MS	Water					+
017GW00405MD	34991-01MD	Water					+

+ = Non-billable analysis

Note: Total metals consisted of analyses for arsenic and beryllium only.

DW = DEIONIZED WATER BLANK, EW = EQUIPMENT RINSATE BLANK, FW = FIELD BLANK,
 HW = FIELD DUPLICATE, MD = MATRIX DUPLICATE, MS = MATRIX SPIKE, MSD = MATRIX
 SPIKE DUPLICATE, RE = REANALYSIS, T = TRIP BLANK

DATA REVIEWER(S): Marvin L. Smith, Jean M. Delashmit

RELEASE SIGNATURE:



Data Qualifier Definitions

- J - The associated numerical value is an estimated quantity.
- R - The data are unusable (the compound/analyte may or may not be present). Resampling and reanalysis are necessary for verification.
- U - The compound/analyte was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
- UJ - The compound/analyte was analyzed for, but not detected. The sample quantitation limit is an estimated quantity.

DATA QUALIFICATION SUMMARY

Southwest Laboratory of Oklahoma, Inc - 34991 CLP Organics and Inorganics

SAMPLES: 014GW03D05, 014GW06D01, 017GW00405, 017GW00405RE, 017GW00505, 017GW00605, 017HW00605, 017GW00801, 017GW01001, 178GW00205, 178GW00205RE, 178HW00205, 178HW00205RE, 014EW03D05, 014EW03D05RE, 014FW03D05, 014FW03D05RE, 017DW00405, 017DW00405RE, 017EW00405, 014TW03D05, 017TW00405, 014EW03D05MS, 014EW03D05MSD, 014EW03D05MD, 014EW03D05REMS, 014EW03D05REMSD, 017GW00801MS, 017GW00801MSD, 017HW00605MS, 017HW00605MSD, 017GW00405MS, 017GW00405MD

VOLATILE ORGANICS

I.) Holding Times:

All Holding Time criteria were met. No action was taken.

II.) GC / MS Tuning:

All GC / MS Tuning criteria were met. No action was required.

III.) Calibration:

Initial Calibration:

The average Relative Response Factor (RRF) was 0.014 for 2-chloroethyl vinyl ether for the standards analyzed on 7/14/98 on instrument U, which was below the 0.050 QC limit. All results for this compound in the associated samples and field blanks, which consisted entirely of non-detects, were rejected (R). The associated samples were 017GW00405, 017GW00505, 017GW00605, 017HW00605, 017GW00801, 017GW01001, 017EW00405 and 017TW00405.

Continuing Calibration:

The Percent Differences (%D's) were 29.5% and 25.9%, respectively, for 1,1,1-trichloroethane and carbon tetrachloride for the standard analyzed on 8/10/98 at 08:44 on instrument K, which exceeded the 25% QC limit. The non-detect results for these two compounds in associated samples 014GW03D05 and 178HW00205 were flagged as estimated (UJ).

The Relative Response Factors (RRF's) were 0.034 and 0.003, respectively, for acetone and 2-chloroethyl vinyl ether for the standard analyzed on 8/3/98 at 08:37 on instrument U, which were below the 0.050 QC limit. The non-detect results for acetone in the associated samples and field blanks were rejected (R). The associated samples were 017GW00405, 017GW00505, 017GW00605, 017HW00605, 017GW00801, 017GW01001, 017EW00405 and 017TW00405. All results for 2-chloroethyl vinyl ether were previously rejected because of a low RRF in the initial calibration. No further action was taken.

The Percent Differences (%D's) of the following compounds exceeded the 25% QC limit for the standard analyzed on 8/3/98 at 08:37 on instrument U:

acetone	48.9%
1,2-dichloroethene	109%
2-chloroethyl vinyl ether	80.8%
total xylenes	122%

All results for total xylenes and 1,2-dichloroethene, which consisted entirely of non-detects, were flagged as estimated (UJ). The associated samples were 017GW00405, 017GW00505, 017GW00605, 017HW00605, 017GW00801 and 017GW01001. All results for acetone and 2-chloroethyl vinyl ether were previously rejected (R) in the associated samples because of low RRF's in the initial and continuing calibrations. No further action was necessary.

The Relative Response Factors (RRF's) were 0.032 and 0.002, respectively, for acetone and 2-chloroethyl vinyl ether for the standard analyzed on 8/6/98 at 10:08 on instrument U, which were below the 0.050 QC limit. All results for these two compounds in the associated samples and field blanks, which consisted entirely of non-detects, were rejected (R). The associated samples were 014GW06D01, 178GW00205, 014EW03D05, 014FW03D05 and 017DW00405.

The Percent Differences (%D's) of the following compounds exceeded the 25% QC limit for the standard analyzed on 8/6/98 at 10:08 on instrument U:

acetone	57.2%
1,2-dichloroethene	109%
2-chloroethyl vinyl ether	83.1%
total xylenes	128%
trans-1,3-dichloropropene	27.3%
carbon disulfide	67.2%
2-butanone	26.2%

All results for 1,2-dichloroethene, total xylenes, trans-1,3-dichloropropene, carbon disulfide and 2-butanone in the associated samples, which consisted entirely of non-detects, were flagged as estimated (UJ). The associated samples were 014GW06D01 and 178GW00205. All results for acetone and 2-chloroethyl vinyl ether were previously rejected (R) in the associated samples because of low RRF's in this calibration. No further action was necessary.

IV.) Blanks:

Method Blanks:

There were no detections in the method blanks. No action was required.

Field Blanks:

1,2-Dichloroethene and trans-1,3-dichloropropene were detected at 32 ug/L and 2 ug/L, respectively, in equipment rinsate blank 014EW03D05. Since these two compounds were not detected in the associated samples, no action was taken.

Trip Blanks:

Methylene chloride was detected at 4 ug/L in trip blank 014TW03D05. The detections of this compound in associated samples 014GW03D05 and 178HW00205, which were less than 10X the blank amount, were flagged as undetected (U), with detections less than the CRQL, being raised to the CRQL.

Tentatively Identified Compounds (TIC):

There were no TIC's detected in the method, field or trip blanks. No action was necessary.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was required.

VI.) Laboratory Control Samples (LCS):

Six LCS's were analyzed by the laboratory. Eighteen LCS recoveries were outside their respective QC limits. Data validation action based on LCS Recovery criteria was not required. No action was taken.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) in spiked samples equipment rinsate blanks 014EW03D05MS and 014EW3D05MSD were outside the QC limits for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %R</u>
acetone	55		60-140
carbon disulfide	58	56	60-140
vinyl acetate	257	260	60-140
2-chloroethyl vinyl ether	19	9	60-140

Since the equipment rinsate blank was used for the MS / MSD samples, no action was taken.

VIII.) Field Duplicates:

Two sets of field duplicate samples were analyzed in this SDG. There were no calculable Relative Percent Differences (RPD's) in either set. No action was required.

IX.) Internal Standards Performance (ISTD):

All ISTD criteria were met. No action was required.

X.) TCL Compound Identification:

All TCL Compound Identification criteria were met. No action was taken.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

All CRQL criteria were met. No action was necessary.

XII.) Tentatively Identified Compounds (TIC's):

All TIC Identification criteria were met. No action was required.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

Twenty-six non-detect results for acetone and 2-chloroethyl vinyl ether were rejected in the SDG samples and field blanks because of low RRF's in the initial and continuing calibrations. All other laboratory data were acceptable with qualifications.

SEMIVOLATILE ORGANICS

I.) Holding Times:

The ten days between sample date and reextraction date exceeded the 7 day QC limit for all reextractions (6 samples) in this fraction of the SDG. Since the original sample data for the six samples were used instead of the reextraction data, no action was necessary.

II.) GC / MS Tuning:

All GC / MS Tuning criteria were met, so no action was taken.

III.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was required.

IV.) Blanks:

Method Blanks:

Bis(2-ethylhexyl)phthalate was detected at 3 ug/L and 1 ug/L, respectively, in method blanks SBLK1 and SBLK3. Detections of this compound in associated samples 17GW00605, 17HW00605, 17GW00801 and 17GW01001, which were less than 10X the blank amounts, were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL. In addition benzoic acid was detected at 8 ug/L in method blank SBLK2, and 7 ug/L in method blank SBLK3. The detection of this compound in associated sample 17GW00405 less than 5X the blank amount (SBLK2), was flagged as undetected (U) with the analytical result below the CRQL being replaced with the CRQL.

Equipment Rinsate Blanks:

Benzoic acid, di-n-butylphthalate and bis(2-ethylhexyl)phthalate were detected at 6 ug/L, 1 ug/L and 6 ug/L, respectively, in equipment rinsate blank 014EW03D05. The detections of benzoic acid in

associated samples 178GW00205 and 178HW00205, which were less than 5X the blank amount were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL. The detection of di-n-butylphthalate in associated sample 178HW00205, which was less than 10X the blank amount was flagged as undetected (U) with the analytical result below the CRQL being replaced with the CRQL. The detection of bis(2-ethylhexyl) phthalate in associated sample 17GW00405 less than 10X the blank amount, was flagged as undetected (U) with the analytical result below the CRQL being replaced with the CRQL. All other detections of this compound were previously qualified using the method blanks.

Phenol was detected at 7 ug/L in equipment rinsate blank 017EW00405. The detections of phenol in associated samples 017GW00605, 017HW00605 and 017GW01001, which were less than 5X the blank amount were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL.

Field Blank:

There were no detections in the field blank. No action was required.

Deionized Water Blank:

Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were detected at 2 ug/L and 1 ug/L, respectively, in deionized water blank 017DW00405. Since these two compounds were previously qualified using the method and equipment rinsate blanks, no further action was required.

TIC's:

Trimethyl hexene was detected in the method and field blanks at sufficient concentrations to eliminate all detections in the SDG samples by applying the 10X Blank Rule.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was necessary.

VI.) Laboratory Control Samples (LCS):

Five LCS samples were analyzed by the laboratory. Three LCS recoveries were below their respective QC limits. Data validation based on LCS recoveries was not required, so no action was necessary.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) in spiked samples 017GW00801MS and 017GW00801MSD exceeded the QC limits for the following compound:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %R</u>
pentachlorophenol	120	112	9-103

Since this compound was not detected in unspiked sample 017GW00801, no action was required.

VIII.) Field Duplicates:

Two sets of field duplicate samples were analyzed in this SDG. There were no calculable Relative Percent Differences (RPD's) in either set. No action was required.

IX.) Internal Standards Performance:

All Internal Standards Performance criteria were met. No action was required.

X.) TCL Compound Identification:

All TCL Compound Identification criteria were met. No action was required.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

The original analyses of samples 017GW00405, 178GW00205, 178HW00205, 014EW03D05, 014FW03D05 and 017DW00405 were considered by the validator to be of preferable data quality as compared to the reextractions because of better holding times.

XII.) Tentatively Identified Compounds (TIC's):

All TIC criteria were met. No action was necessary.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualifications.

PESTICIDES/PCB's

I.) Holding Times:

All Holding Time criteria were met. No action was required.

II.) Instrument Performance:

All Pesticide Instrument Performance criteria were met. No action was taken.

III.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was necessary.

IV.) Blanks:

There were no detections in the method or field blanks. No action was required.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was taken.

VI.) Laboratory Control Sample (LCS):

Four LCS's were analyzed by the laboratory. Four LCS Percent Recoveries (%R's) of endosulfan II were below the 54-122% QC limits. Data validation based on LCS Recovery criteria was not required. No action was necessary.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) in spiked samples 017HW00605MS and 017HW00605MSD were below the QC limits for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %R</u>
endosulfan I	36	40	46-134
4,4'-DDE	57	63	70-122
4,4'-DDD	60	67	70-133

The non-detect results for these three compounds in unspiked sample 017HW00605 were flagged as estimated (UJ).

VIII.) Field Duplicates:

One set of field duplicate samples was analyzed in this SDG. There were no calculable Relative Percent Differences (RPD's) for the set. No action was required.

IX.) TCL Compound Identification:

Pesticide/PCB Identification Summary (PIS):

All PIS Identification criteria were met. No action was required.

X.) Pesticide Cleanup Check:

Florisil Cartridge Check:

All criteria were met. No action was taken.

Gel Permeation Chromatography (GPC):

GPC cleanup was not required for this SDG. No action was necessary.

XI.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualification.

TOTAL METALS AND CYANIDE

I.) Holding Times:

All Holding Time criteria were met. No action was taken.

II.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was necessary.

III.) Blanks:

The following blank results represent the highest detections associated with the samples and were used for data qualification:

<u>Blank Type/ID#</u>	<u>Analyte</u>	<u>Max. Conc.</u>	<u>Action Level ug/L</u>
FB	arsenic	12.4 ug/L	62.0
CCB3	beryllium	0.30 ug/L	1.50

CCB = Continuing Calibration Blank, FB = Field Blank 014FW03D05

All results greater than the IDL but less than 5X the blank amounts (Action Level, ug/L for water samples) for which the contaminated blank was an associated calibration or field blank were flagged as undetected (U).

IV.) ICP Interference Check Sample Results:

All Percent Recovery criteria were met, so no action was taken.

Arsenic (3 ug/L) was detected in ICS Solution A at a positive concentration greater than the IDL. This analyte should not be present. Since neither aluminum, calcium, iron nor magnesium results were available in the data package, no action was taken.

V.) ICP Serial Dilution Analysis:

All Serial Dilution Analysis criteria were met. No action was required.

VI.) Laboratory Control Samples (LCS):

All LCS Recovery criteria were met. No action was required.

VII.) Duplicate Sample Analysis:

All Duplicate Sample Analysis criteria were met. No action was required.

VIII.) Matrix Spike Recoveries (MS / MSD):

All MS / MSD criteria were met. No action was required.

IX.) Field Duplicates:

One set of field duplicate samples was analyzed in this SDG. There were no calculable Relative Percent Differences (RPD's) for the set. No action was required.

X.) Graphite Furnace Atomic Absorption QC (GFAA):

Graphite Furnace analyses were not used for the samples in this SDG. No action was taken.

XI.) Sample Result, Calculation/Transcription Verification:

All criteria were met for a Level III package. No action was required.

XII.) Quarterly Verification of Instrumental Parameters:

All criteria were met. No action was taken.

XIII.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualifications.

VALIDATA

Chemical Services, Inc.

P. O. Box 930422, Norcross, GA 30003

(770) 923-3890

(770) 923-8769 (Fax)

DATA VALIDATION SUMMARY REPORT

COMPANY: Ensafe, Inc.
SITE NAME: Charleston Navel Base, Zone H
SERVICE ORDER NUMBER: 0311
CONTRACTED LAB: Southwest Laboratory of Oklahoma, Inc.
QA/QC LEVEL: EPA Level III
EPA METHOD: EPA SOW 3-90 / SW846
VALIDATION GUIDELINES: USEPA CLP National Functional Guidelines for Organic Data Review, 1994; USEPA CLP National Functional Guidelines for Inorganic Data Review, 1994
SAMPLE MATRIX: Water
TYPES OF ANALYSES: Volatile Organics, Semivolatiles, Pesticides/PCB's, Total Metals, Cyanide
SDG NUMBER: 35007 (Level III)

SAMPLES:

Client	Lab		Volatile	Semi-	Pesticides/	Total	
<u>Sample #</u>	<u>Sample #</u>	<u>Matrix</u>	<u>Organics</u>	<u>volatiles</u>	<u>PCBs</u>	<u>Metals</u>	<u>Cyanide</u>
009GW02401	35182-01	Water	X	X	X	X	X
009GW24D01	35182-02	Water	X	X	X	X	X
009HW24D01	35182-03	Water	X	X	X	X	X
014GW00305	35007-03	Water	X				
014GW00405	35007-01	Water	X				
014GW00505	35007-04	Water	X				
014GW00601	35007-05	Water	X				
014GW04D05	35007-02	Water	X				
014GW05D05	35007-10	Water	X				
017GW00501	25067-01	Water		X	X	X*	
GDHW00305	35007-09	Water	X			X*	
GDHW00605	35007-08	Water	X			X*	
GDHW03D05	35007-06	Water	X			X*	
GDHW06D05	35007-07	Water	X				
009EW24D01	35182-04	Water	X	X	X	X	X
009FW02401	35182-05	Water	X	X	X	X	X
009TW02401	35182-06	Water	X				
GDHTW00305	35007-11	Water	X				
014GW00505MS	35007-04MS	Water	+				

<u>Client</u> <u>Sample #</u>	<u>Lab</u> <u>Sample #</u>	<u>Volatile</u> <u>Matrix</u>	<u>Semi-</u> <u>Organics</u>	<u>Pesticides/</u> <u>volatiles</u>	<u>Total</u> <u>PCBs</u>	<u>Metals</u>	<u>Cyanide</u>
014GW00505MSD	35007-04MSD	Water	+				
009GW02401MS	35182-01MS	Water		+	+		
009GW02401MSD	35182-01MSD	Water		+	+		

* Total metals consisted of analyses for arsenic and beryllium only.

+ Non-billable analysis

EW = EQUIPMENT RINSATE BLANK, FW = FIELD BLANK, HW = FIELD DUPLICATE,
MS = MATRIX SPIKE, MSD = MATRIX SPIKE DUPLICATE, TW = TRIP BLANK

DATA REVIEWER(S): Marvin L. Smith, Jean M. Delashmit

RELEASE SIGNATURE:

Data Qualifier Definitions

- J - The associated numerical value is an estimated quantity.
- R - The data are unusable (the compound/analyte may or may not be present). Resampling and reanalysis are necessary for verification.
- U - The compound/analyte was analyzed for, but not detected. The associated numerical value is the sample quantitation limit.
- UJ - The compound/analyte was analyzed for, but not detected. The sample quantitation limit is an estimated quantity.

DATA QUALIFICATION SUMMARY

Southwest Laboratory of Oklahoma, Inc - 35007 CLP Organics and Inorganics

SAMPLES: 009GW02401, 009GW24D01, 009HW24D01, 014GW00305, 014GW00405, 014GW00505, 014GW00601, 014GW04D05, 014GW05D05, 017GW00501, GDHGW00305, GDHGW00605, GDHGW03D05, GDHGW06D05, 009EW24D01, 009FW02401, 009TW02401, GDHTW00304, 014GW00505MS, 014GW00505MSD, 009GW02401MS, 009GW02401MSD

VOLATILE ORGANICS

I.) Holding Times:

All Holding Time criteria were met. No action was taken.

II.) GC / MS Tuning:

All GC / MS Tuning criteria were met. No action was required.

III.) Calibration:

Initial Calibration:

The average Relative Response Factor (RRF) was 0.014 for 2-chloroethyl vinyl ether in the standards analyzed on 7/14/98 on instrument U, which was below the 0.050 QC limit. All results for this compound in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated samples were 014GW00305, 014GW00405, 014GW00505, 014GW00601, 014GW04D05, 014GW05D05, GDHGW00305, GDHGW00605, GDHGW03D05, GDHGW06D05, and trip blank GDHTW00305.

Continuing Calibration:

The Relative Response Factors (RRF's) were 0.029 and 0.004, respectively, for acetone and 2-chloroethyl vinyl ether in the standard analyzed on 8/4/98 at 08:55 on instrument U, which were below the 0.050 QC limit. The non-detect results for acetone in the associated samples 014GW00305, 014GW00405 and 014GW04D05 were rejected (R). All results for 2-chloroethyl vinyl ether were previously rejected because of a low RRF in the initial calibration. No further action was taken.

The Percent Differences (%D's) of the following compounds exceeded the 25% QC limit for the standard analyzed on 8/4/98 at 08:55 on instrument C:

acetone	67.0%
carbon disulfide	60.2%
2-chloroethyl vinyl ether	68.3%

The non-detect results for acetone and 2-chloroethyl vinyl ether were previously rejected because of low RRF's in the initial and continuing calibrations. The non-detect results for carbon disulfide in associated samples 014GW00305, 014GW00405 and 014GW04D05 were qualified as estimated (UJ).

The Relative Response Factors (RRF's) were 0.028 and 0.002, respectively, for acetone and 2-chloroethyl vinyl ether in the standard analyzed on 8/5/98 at 10:40 on instrument U, which were below the 0.050 QC limit. The non-detect results for acetone in associated samples 014GW00505, 014GW00601, 014GW05D05, GDHGW00605, GDHGW03D05, GDHGW06D05, and trip blank GDHTW00305 were rejected (R). The detection of acetone in sample GDHGW00305 was flagged as estimated (J). All results for 2-chloroethyl vinyl ether were previously rejected because of a low RRF in the initial calibration. No further action was taken.

The Percent Differences (%D's) of the following compounds exceeded the 25% QC limit for the standard analyzed on 8/4/98 at 08:55 on instrument C:

acetone	70.8%
carbon disulfide	68.7%
1,2-dichloroethene	103%
2-butanone	26.7%
2-chloroethyl vinyl ether	86.8%
total xylenes	29.4%

All results for acetone and 2-chloroethyl vinyl ether in the associated samples were previously qualified because of low RRF's in the initial and continuing calibrations. The non-detect results for the four other compounds in the associated samples were flagged as estimated (UJ). The associated samples were 014GW00505, 014GW00601, 014GW05D05, GDHGW00305, GDHGW00605, GDHGW03D05 and GDHGW06D05.

The Relative Response Factor (RRF) was 0.030 for acetone in the standard analyzed on 8/12/98 at 10:21 on instrument U, which was below the 0.050 QC limit. All results for acetone in the associated samples, which consisted entirely of non-detects, were rejected (R). The associated samples were 009GW02401, 009GW24D01, 009HW24D01, and blanks 009EW24D05, GDHFW02401 and GDHTW00305.

The Percent Differences (%D's) of the following compounds exceeded the 25% QC limit for the standard analyzed on 8/12/98 at 10:21 on instrument U:

carbon disulfide	52.5%
1,2-dichloroethene	80.2%

All results for the two compounds in the associated samples, which consisted entirely of non-detects, were flagged as estimated (UJ). The associated samples were 009GW02401, 009GW24D01 and 009HW24D01.

IV.) Blanks:

Method Blanks:

There were no detections in the method blanks. No action was required.

Field Blanks:

Chloroform was detected at 3 ug/L and 1 ug/L, respectively, in equipment rinsate blank 009EW24D01 and field blank 009FW02401. Since this compound was not detected in the associated samples, no action was taken.

Trip Blanks:

There were no detections in the trip blanks. No action was required.

Tentatively Identified Compounds (TIC):

There were no TIC's detected in the method, field or trip blanks. No action was necessary.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was required.

VI.) Laboratory Control Samples (LCS):

Six LCS's were analyzed by the laboratory. Eighteen LCS recoveries were below their respective QC limits. Data validation action based on LCS Recovery criteria was not required. No action was taken.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) were below the QC limits in spiked samples 014GW00505MS and 014GW00505MSD for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %</u>
1,1-dichloroethene	64	61	76-125
acetone	12	12	60-140
carbon disulfide	22	22	60-140
1,1-dichloroethane	72	70	78-127
2-chloroethyl vinyl ether	12	10	60-140
cis-1,3-dichloropropene		59	60-140
2-butanone		57	60-140

The non-detect results for acetone and 2-chloroethyl vinyl ether in unspiked sample 014GW00505 were previously rejected because of low RRF's in the initial and continuing calibrations. The associated sample results for the other compounds, which consisted entirely of non-detects, were flagged as estimated (UJ).

VIII.) Field Duplicates:

There were no calculable Relative Percent Differences (RPD's) in the set of field duplicate samples analyzed in this SDG. No action was required.

IX.) Internal Standards Performance (ISTD):

All ISTD criteria were met. No action was required.

X.) TCL Compound Identification:

All TCL Compound Identification criteria were met. No action was taken.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

All CRQL criteria were met. No action was necessary.

XII.) Tentatively Identified Compounds (TIC's):

All TIC Identification criteria were met. No action was required.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

Twenty-seven non-detect results for acetone and 2-chloroethyl vinyl ether were rejected in the SDG samples, field blanks and trip blanks because of low RRF's in the initial and continuing calibrations. All other laboratory data were acceptable with qualifications.

SEMIVOLATILE ORGANICS

I.) Holding Times:

All Holding Time criteria were met. No action was required.

II.) GC / MS Tuning:

All GC / MS Tuning criteria were met, so no action was taken.

III.) Calibration:

Initial Calibration:

All Initial Calibration criteria were met. No action was required.

Continuing Calibration:

The Percent Difference (%D) for 2,4-dinitrotoluene was 32.7% for the standard analyzed on 8/10/98 at 08:25 on instrument O, which exceeded the 25% QC limit. The non-detect result for this compound in associated sample 017GW00501 was flagged as estimated (UJ).

IV.) Blanks:

Method Blanks:

The following compounds were detected in method blank SBLK1:

phenol	5 ug/L
benzoic acid	4 ug/L
di-n-butyl phthalate	3 ug/L
bis(2-ethylhexyl)phthalate	2 ug/L

The detections of di-n-butylphthalate and bis(2-ethylhexyl)phthalate in sample 017GW00501, which were less than 10X the blank amounts, were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL. The detections of phenol and benzoic acid in this sample, which were less than 5X the blank amounts, were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL.

Field Blanks:

Benzoic acid was detected at 6 ug/L in equipment rinsate blank 009EW24D01. The detections of this compound in associated samples 009GW02401, 009GW24D01 and 009HW24D01, which were less than 5X the blank amount, were flagged as undetected (U) with the analytical results below the CRQL being replaced with the CRQL.

Bis(2-ethylhexyl)phthalate was detected at 1 ug/L in blank 009FW02401. The detections of this compound in associated sample 017GW00501 was previously qualified using method blank SBLK1. No further action was necessary.

Tentatively Identified Compounds (TIC's):

Trimethyl heptene and ethylmethyl heptene were detected in the field blanks. Since these two compounds were not detected in the samples, no action was taken.

V.) Surrogate Recoveries:

The Percent Recoveries (%R's) were 34% and 39%, respectively, for nitrobenzene-d5 and 2-fluorobiphenyl in sample 009GW02401, which were below their respective 35-114% and 43-116% QC limits. All positive and non-detect results in the base/neutral fraction of this sample were flagged as estimated (J) and (UJ).

The Percent Recovery (%R) was 15% 2-fluorophenol in sample 009HW24D01, which was below the 21-100% QC limits. Since only one surrogate was outside the QC limits in the acid fraction, no action was necessary.

VI.) Laboratory Control Samples (LCS):

Four LCS samples were analyzed by the laboratory. All LCS Recovery criteria were met. No action was taken.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) were below the QC limits in spiked samples 009GW02401MS and 009GW02401MSD for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %</u>
n-nitroso-di-n-propylamine		38	41-116
1,4-dichlorobenzene		32	36-97
1,2,4-trichlorobenzene		36	39-98
acenaphthene		41	46-118
2,4-dinitrotoluene	21	20	24-96

The results for these compounds in unspiked sample 009GW02401, which consisted entirely of non-detects, were flagged as estimated (UJ).

VIII.) Field Duplicates:

There were no calculable Relative Percent Differences (RPD's) for the set of field duplicate samples analyzed in this SDG. No action was required.

IX.) Internal Standards Performance:

All Internal Standards Performance criteria were met. No action was taken.

X.) TCL Compound Identification:

All TCL Compound Identification criteria were met. No action was required.

XI.) Compound Quantitation and Reported Contract Required Quantitation Limits (CRQL's):

All CRQL criteria were met. No action was necessary.

XII.) Tentatively Identified Compounds (TIC's):

All TIC criteria were met. No action was necessary.

XIII.) System Performance:

All System Performance criteria were met. No action was taken.

XIV.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualifications.

PESTICIDES/PCB's

I.) Holding Times:

All Holding Time criteria were met. No action was required.

II.) Instrument Performance:

The Percent Differences (%D's) were 33.0% and 29.0%, respectively, for beta-BHC and gamma-BHC in the PEM2F standard analyzed on 8/17/98 at 21:16 on the secondary columns, which exceeded the 25% QC limit. The non-detect results for these two compounds in associated samples 009GW24D01 and 009HW24D01 were flagged as estimated (UJ).

III.) Calibration:

Initial Calibration:

The Percent Relative Standard Deviation (%RSD) was 21.8% for methoxychlor in the standards analyzed on 8/9/98 on the secondary column, which exceeded the 20% QC limit. Since only one compound was outside the QC limit with a %RSD of less than 30%, no action was necessary.

Continuing Calibration:

All Continuing Calibration criteria were met. No action was necessary.

IV.) Blanks:

There were no detections in the method or field blanks. No action was required.

V.) Surrogate Recoveries:

All Surrogate Recovery criteria were met. No action was taken.

VI.) Laboratory Control Sample (LCS):

Four LCS's were analyzed by the laboratory. Four LCS Percent Recoveries (%R's) were below their respective QC limits. Since data validation action based on LCS Recovery criteria was not required, no action was necessary.

VII.) Matrix Spike / Matrix Spike Duplicate (MS / MSD):

The Percent Recoveries (%R's) were below the QC limits in spiked samples 009GW02401MS and 009GW02401MSD for the following compounds:

<u>Compound</u>	<u>MS, %R</u>	<u>MSD, %R</u>	<u>QC Limits, %</u>
4,4'-DDE	59	58	70-122
4,4'-DDD		68	70-133
endrin aldehyde	2	2	47-178

The non-detect results for 4,4'-DDE and 4,4'-DDD in unspiked sample 009GW02401 were flagged as estimated (UJ). The non-detect result for endrin aldehyde was rejected (R) because the %R was less than 10%.

VIII.) Field Duplicates:

There were no calculable Relative Percent Differences (RPD's) in the set of field duplicate samples analyzed in this SDG. No action was required.

IX.) TCL Compound Identification:

Pesticide/PCB Identification Summary (PIS):

All PIS criteria were met. No action was taken.

X.) Pesticide Cleanup Check:

Florisil Cartridge Check:

Florisil Cartridge Check data was not included in the SDG package. No action was taken.

Gel Permeation Chromatography (GPC):

GPC cleanup was not required for this SDG. No action was necessary.

XI.) Overall Assessment of Data/General:

The non-detect result for endrin aldehyde in sample 009GW02401 was rejected because of low recoveries (less than 10%) in the MS / MSD samples. All other laboratory data were acceptable with four qualifications.

TOTAL METALS AND CYANIDE

I.) Holding Times:

All Holding Time criteria were met. No action was taken.

II.) Calibration:

All Initial and Continuing Calibration criteria were met. No action was necessary.

III.) Blanks:

The following blank results represent the highest detections associated with the samples and were used for data qualification:

<u>Blank ID</u>	<u>Analyte</u>	<u>Max. Conc.</u>	<u>Action Level</u>
CCB3	arsenic	8.10 ug/L	40.5 ug/L
CCB3	beryllium	0.30 ug/L	1.50 ug/L
ERB	barium	1.60 ug/L	8.00 ug/L
FB	calcium	1020 ug/L	5100 ug/L
ERB	copper	18.8 ug/L	94.0 ug/L
ERB	iron	156 ug/L	780 ug/L
ERB	magnesium	79.0 ug/L	395 ug/L
CCB5	selenium	4.10 ug/L	20.5 ug/L
ERB	sodium	21300 ug/L	107000 ug/L
ERB	tin	28.7 ug/L	144 ug/L
ERB	zinc	20.7 ug/L	104 ug/L

CCB = Continuing Calibration Blank, ERB = Equipment Rinsate Blank (009EW24D01),
 FB = Field Blank (009FW02401)

All results greater than the IDL but less than 5X the blank amounts (Action Level, ug/L for water samples) for which the contaminated blank was an associated calibration or field blank were flagged as undetected (U).

The following analytes had negative results with absolute values greater than the IDL:

<u>Blank ID</u>	<u>Analyte</u>	<u>Neg. Conc.</u>	<u>5X Conc.</u>
CCB4	copper	-2.10 ug/L	10.5 ug/L
ICB	mercury	-0.10 ug/L	0.50 ug/L
CCB2	tin	-32.6 ug/L	163 ug/L

CCB = Continuing Calibration Blank, ICB = Initial Calibration Blank

All associated sample results, which consisted entirely of non-detects after blank qualification, were flagged as estimated (J) and (UJ).

IV.) ICP Interference Check Sample Results:

The following analytes were detected in ICS Solution A at concentrations greater than the IDL:

antimony	3 ug/L
arsenic	3 ug/L
barium	5 ug/L
copper	2 ug/L
manganese	4 ug/L
vanadium	1 ug/L

These analytes should not be present. The concentrations of calcium and magnesium in samples 009GW24D01 and 009HW24D01 exceeded that of ICS Solution A. All positive results for the above analytes in these two samples were flagged as estimated (J). Since neither aluminum, calcium, iron nor magnesium was detected in the other SDG samples at a concentration comparable to or greater than that of ICS Solution A, no further action was taken.

Negative results were observed for the following analytes in ICS Solution A at absolute concentrations greater than the IDL:

cadmium	-2 ug/L
cobalt	-2 ug/L
manganese	-2 ug/L
potassium	-1060 ug/L
selenium	-5 ug/L
sodium	-140 ug/L
thallium	-15 ug/L
tin	-24 ug/L
vanadium	-19 ug/L

The concentrations of magnesium in samples GDIGW07D06, GDIHW07D06, GDIGW08D06 and GDIGW13D06 exceeded that of ICS Solution A. All non-detect results for these analytes in the four samples were flagged as estimated (UJ). Since neither aluminum, calcium, iron nor magnesium was present in the other SDG samples at a concentration comparable to or greater than the amount in Solution A, no further action was required.

V.) ICP Serial Dilution Analysis:

Serial Dilution Analysis was not performed in this SDG. No action was required.

VI.) Laboratory Control Samples (LCS):

All LCS Recovery criteria were met. No action was required.

VII.) Duplicate Sample Analysis:

Duplicate Sample Analysis was not performed in this SDG. No action was taken.

VIII.) Matrix Spike Recoveries (MS / MSD):

MS / MSD samples were not analyzed in this SDG. No action was required.

IX.) Field Duplicates:

One set of field duplicate samples was analyzed in this SDG. The calculable Relative Percent Differences (RPD's) were:

Analyte	009GW24D01 (ug/L)	009HW24D01 (ug/L)	RPD
arsenic	54.6	48.9	11%
barium	42.0	40.9	2.7%
calcium	526000	513000	2.8%
iron	29200	28400	2.5%
magnesium	585000	580000	0.9%
manganese	2560	2540	0.8%
potassium	94900	94500	0.4%

<u>Analyte</u>	<u>009GW24D01 (ug/L)</u>	<u>009HW24D01 (ug/L)</u>	<u>RPD</u>
sodium	5960000	5750000	3.6%

Since all RPD's were within the 30% QC limit for water samples, no action was taken.

X.) Graphite Furnace Atomic Absorption QC (GFAA):

Graphite Furnace analyses were not used for the samples in this SDG. No action was taken.

XI.) Sample Result, Calculation/Transcription Verification:

All criteria were met. No action was required.

XII.) Quarterly Verification of Instrumental Parameters:

All criteria were met. No action was taken.

XIII.) Overall Assessment of Data/General:

All laboratory data were acceptable with qualifications.



HEARTLAND

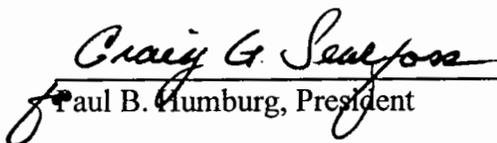
ENVIRONMENTAL SERVICES, INC.

Data Validation Report

SDG#: 37814
Date: April 23, 1999
Client Name: Ensafe
Project/Site Name: Charleston Zone H
Date Sampled: March 22, 1999
Number of Samples: 2 Aqueous Sample(s) with 0 MS/MSD(s)
Laboratory: Southwest Laboratory of Oklahoma
Validation Guidance: National Functional Guidelines for Organic and Inorganic Data, February, 1994
QA/QC Level: DQO Level III
Method(s) Utilized: SW846 Third Edition
Analytical Fractions: Volatiles

Analytical data in this report were screened to determine usability of results and also to determine contractual compliance relative to these requirements and deliverables. This screening assumes analytical results are correct as reported and merely provides an interpretation of the reported quality control results. A minimum of 10% of all laboratory calculations have been verified as part of this validation. All instrument output, i.e. spectra, chromatograms, etc., for each sample have been carefully reviewed. The end-user is urged to review the Specific Findings and associated Data Qualifications presented in this report. Annotated Form 1s or spreadsheets for all samples reviewed are included after the Data Assessment Narratives. Form 1s for MS/MSD samples or spreadsheets are not annotated.

The release of this Data Validation Report is authorized by the following signature:


Paul B. Humburg, President

4-26-99
Date

SDG# 37814

Samples and Fractions Reviewed

Sample Identifications Analytical Fraction

ENSAFE ID	MATRIX	VOA	
014GWC0601	WATER	X	
014TWC0601	WATER	X	
Total Billable Samples (Water/Soil)		2	0

VOA= Volatiles

DATA ASSESSMENT AND NARRATIVE

VOLATILE ORGANICS

General

The organic findings offered in this screening report assumes that all analytical results are correct as reported and is based upon the examination of the reported holding times, blank analysis results, surrogate and matrix spike recoveries, GC/MS performance, tuning results, calibration results and internal standard areas. This report was prepared in compliance relative to the analytical and deliverable requirements specified in the SW846 Method 8260B; the National Functional Guidelines for Organic Data Review, and DQO Level III. All comments made within this report should be considered when examining the analytical results.

SDG # 37814

A validation was performed on the Volatile Data from SDG 37814. The data was evaluated based on the following parameters.

- * Data Completeness
- * Holding Times
- * GC/MS Tuning
- Calibrations
- * Internal Standard Performance
- * Blanks
- * Surrogate Recoveries
- * Laboratory Control Samples
- * Matrix Spike / Matrix Spike Duplicate
- * Field Duplicates
- * Compound Identification /Quantitation

* - All criteria were met for this parameter

DATA ASSESSMENT AND NARRATIVE

VOLATILE ANALYSIS

PAGE - 2

Initial Calibration

The initial calibration analyzed on 03-24-99, contained compounds with RRFs less than 0.050. For the samples and non-compliant compounds listed below, qualify all positive results as estimated (J) and non detects as rejected (UR).

014-G-WC06-01	acetone (0.02785)
	2-chloroethyl vinyl ether (0.01106)

Continuing Calibration

The continuing calibration, UL8654.D, contained compounds with RRFs less than 0.050. For the samples and non-compliant compounds listed below, qualify all positive results as estimated (J) and non detects as rejected (UR).

014-G-WC06-01	acetone (0.026)
	2-butanone (0.047)
	2-chloroethyl vinyl ether (0.009)

System Performance and Overall Assessment

The data as presented requires qualifications.

GLOSSARY OF DATA QUALIFIERS

QUALIFICATION CODES

U = Not detected

J = Estimated value

UJ = Reported quantitation limit is qualified as estimated

UR = Result is rejected and unusable

D = Result value is based on dilution analysis

METHOD BLANK QUALIFICATION CODES

CRQL = The sample result for the blank contaminant is less than the sample CRQL and is less than 10X the method blank value. The sample result for the blank contaminant is rejected and the CRQL for that compound is reported.

U = The sample result for the blank contaminant is greater than the sample CRQL and is less than 10X the method blank value. The sample result for the blank contaminant is qualified as non detected at the compound value reported.

No Action = The sample result for the blank contaminant is greater than the sample CRQL and is greater than 10X the method blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.

SUMMARY OF DATA QUALIFICATIONS

<u>SAMPLE ID</u>	<u>COMPOUND ID</u>	<u>DL</u>	<u>QL</u>
014-G-WC06-01	acetone 2-chloroethyl vinyl ether	+/-	J/UR
014-G-WC06-01	acetone 2-butanone 2-chloroethyl vinyl ether	+/-	J/UR

- * DL denotes the Form I qualifier supplied by the laboratory
QL denotes the qualifier used by the data validation firm
+ in the DL column denotes a positive result
- in the DL column denotes a non detect result



HEARTLAND

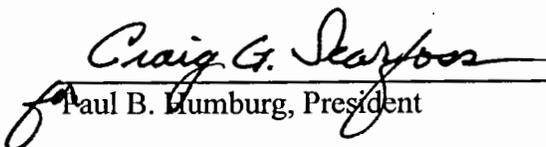
ENVIRONMENTAL SERVICES, INC.

Data Validation Report

SDG#: 37839
Date: April 23, 1999
Client Name: Ensafe
Project/Site Name: Charleston Zone H
Date Sampled: March 23-24, 1999
Number of Samples: 3 Aqueous Sample(s) with 0 MS/MSD(s)
Laboratory: Southwest Laboratory of Oklahoma
Validation Guidance: National Functional Guidelines for Organic and Inorganic Data, February, 1994
QA/QC Level: DQO Level III
Method(s) Utilized: SW846 Third Edition
Analytical Fractions: Volatiles

Analytical data in this report were screened to determine usability of results and also to determine contractual compliance relative to these requirements and deliverables. This screening assumes analytical results are correct as reported and merely provides an interpretation of the reported quality control results. A minimum of 10% of all laboratory calculations have been verified as part of this validation. All instrument output, i.e. spectra, chromatograms, etc., for each sample have been carefully reviewed. The end-user is urged to review the Specific Findings and associated Data Qualifications presented in this report. Annotated Form 1s or spreadsheets for all samples reviewed are included after the Data Assessment Narratives. Form 1s for MS/MSD samples or spreadsheets are not annotated.

The release of this Data Validation Report is authorized by the following signature:


Paul B. Lumburg, President

4-26-99.
Date

SDG# 37839

Samples and Fractions Reviewed

Sample Identifications Analytical Fraction

ENSAFE ID	MATRIX	VOA	
014GWC6D01	WATER	X	
014TWC6D01	WATER	X	
159GWC0101	WATER	X	
Total Billable Samples (Water/Soil)		3	0

VOA= Volatiles

DATA ASSESSMENT AND NARRATIVE

VOLATILE ORGANICS

General

The organic findings offered in this screening report assumes that all analytical results are correct as reported and is based upon the examination of the reported holding times, blank analysis results, surrogate and matrix spike recoveries, GC/MS performance, tuning results, calibration results and internal standard areas. This report was prepared in compliance relative to the analytical and deliverable requirements specified in the SW846 Method 8260; the National Functional Guidelines for Organic Data Review, and DQO Level III. All comments made within this report should be considered when examining the analytical results.

SDG # 37839

A validation was performed on the Volatile Data from SDG 37839. The data was evaluated based on the following parameters.

- * Data Completeness
- * Holding Times
- * GC/MS Tuning
- Calibrations
- * Internal Standard Performance
- * Blanks
- * Surrogate Recoveries
- * Laboratory Control Samples
- * Matrix Spike / Matrix Spike Duplicate
- * Field Duplicates
- * Compound Identification / Quantitation

* - All criteria were met for this parameter

DATA ASSESSMENT AND NARRATIVE

VOLATILE ANALYSIS

PAGE - 2

Initial Calibration

The initial calibration, analyzed on 03-24-99, contained compounds with RRFs less than 0.050. For the samples and non-compliant compounds listed below, qualify all positive results as estimated (J) and non detects as rejected (UR).

All samples	acetone (0.02785)
	2-chloroethyl vinyl ether (0.01106)

Continuing Calibration

The continuing calibration, UL8673.D, contained compounds with RRFs less than 0.050. For the samples and non-compliant compounds listed below, qualify all positive results as estimated (J) and non detects as rejected (UR).

All samples	acetone (0.022)
	2-butanone (0.047)
	2-chloroethyl vinyl ether (0.009)

System Performance and Overall Assessment

The data as presented requires qualifications.

GLOSSARY OF DATA QUALIFIERS

QUALIFICATION CODES

U = Not detected

J = Estimated value

UJ = Reported quantitation limit is qualified as estimated

UR = Result is rejected and unusable

D = Result value is based on dilution analysis

METHOD BLANK QUALIFICATION CODES

CRQL = The sample result for the blank contaminant is less than the sample CRQL and is less than 10X the method blank value. The sample result for the blank contaminant is rejected and the CRQL for that compound is reported.

U = The sample result for the blank contaminant is greater than the sample CRQL and is less than 10X the method blank value. The sample result for the blank contaminant is qualified as non detected at the compound value reported.

No Action = The sample result for the blank contaminant is greater than the sample CRQL and is greater than 10X the method blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.

SUMMARY OF DATA QUALIFICATIONS

<u>SAMPLE ID</u>	<u>COMPOUND ID</u>	<u>DL</u>	<u>QL</u>
All samples	acetone 2-chloroethyl vinyl ether	+/-	J/UR
All samples	acetone 2-butanone 2-chloroethyl vinyl ether	+/-	J/UR

- * DL denotes the Form I qualifier supplied by the laboratory
QL denotes the qualifier used by the data validation firm
+ in the DL column denotes a positive result
- in the DL column denotes a non detect result

Appendix B
CMS Risk and Hazard Assessment

APPENDIX B: CMS RISK AND HAZARD ASSESSMENT

B.1 Introduction

This appendix describes the methodology and results of the CMS surface soil risk and hazard assessment for Combined SWMU 14. This assessment is needed due to interim corrective measures completed at the site since completion of the July 1996 Zone H RFI risk assessment.

B.2 Methodology

This assessment used the same assumptions and equations as those used in the RFI for this site. The primary differences in the RFI and CMS assessments are (1) the CMS assessment uses additional data collected since the completion of the RFI assessment and (2) the CMS evaluated data only for the chemicals of concern (COCs) identified in the RFI. Several chemicals not identified as COCs in the RFI were evaluated in the original RFI baseline assessment and were determined to have negligible effect on site risk ($< 1.0E-06$) and hazard (< 0.1 HQ).

B.2.1 Risk and Hazard Equations

The following equations for soil ingestion and dermal contact are derived from those used in the RFI baseline risk assessment for the residential re-use scenario.

Non-Carcinogens (Hazard Quotient), Child, Residential Scenario:

$$HQ = \frac{(EPC_s)(EF_{res})(F)(ED_c)}{(AT_{nc-c})(BW_c)(RfD)} [(IR_c)(FI) + (CF_c)(FC)(AF)(ABS)(ADJ)] \quad (1)$$

Carcinogens (Cancer Risk), Residential Scenario:

$$RISK = \left(\frac{(EPC_s)(EF_{res})(F)(SF)}{AT_c} \right) \left[(FI) \left(\frac{(IR_c)(ED_c)}{BW_c} + \frac{(IR_a)(ED_a)}{BW_a} \right) + (FC)(AF)(ABS)(ADJ) \left(\frac{(CF_c)(ED_c)}{BW_c} + \frac{(CF_a)(ED_a)}{BW_a} \right) \right] \quad (2)$$

Where:

ABS	Absorbance factor (unitless)
ADJ	Dermal to absorbed adjustment factor (unitless)
AF	Adherence factor (1 mg/cm ²)
ATc	Averaging time (carcinogen)
ATnc-c	Averaging time (non-carcinogen, child)
BWa	Average body weight (adult, kg)
BWc	Average body weight (child, ages 1-6, kg)
CFa	Soil dermal contact factor (adult, mg•day ⁻¹)
CFc	Soil dermal contact factor (child, mg•day ⁻¹)
EDa	Exposure duration (adult, ages 7-31, years)
EDc	Exposure duration (child, ages 1-6, years)
EFres	Exposure frequency (days•yr ⁻¹)
EPCs	Exposure point concentration in surface soil (mg•kg ⁻¹)
F	Conversion factor (1.0E-06 kg•mg ⁻¹)
FC	Fraction contacted from contaminated source
FI	Fraction ingested from contaminated source (unitless = 1)
HQ	Hazard quotient (unitless)
IRa	Intake rate (adult, mg•day ⁻¹)
IRc	Intake rate (child, mg•day ⁻¹)
RfD	Oral Reference Dose (mg•kg ⁻¹ •day ⁻¹)
SF	Cancer slope factor (kg•day•mg ⁻¹)

B.2.2 Chemicals of Concern

COCs — arsenic, BEQs, antimony, thallium, and aluminum — were initially taken from Table 10.5.29 of the RFI. This table lists only chemicals with calculated exposure point concentrations (EPC) contributing to greater than 1.0E-06 site risk or 0.1 residential Hazard Quotient (HQ). For reasons cited in Section 3 of this CMS, only arsenic and BEQs were retained as COCs in this CMS. Beryllium was removed from this assessment because a post-RFI USEPA change in beryllium's slope factor dropped beryllium's contribution to residential risk from 1.3E-06 to 1.3E-07 and the USEPA RBC changed from 0.15 mg/kg to 160 mg/kg.

B.2.3 Data Selection

Assessment data includes all relevant surface soil data collected during the RFI and CMS investigations. As in the RFI, ½ the reported quantification limit was used for the arsenic concentration in samples in which arsenic was not detected. Unlike in the RFI, ½ the 10th percentile value derived from all Zone H J-flagged BEQs values was used in samples in which BEQs were not detected. The RFI had used ½ the lowest J-flagged value observed in any zone. But, recognizing that J-flagged values are fairly imprecise estimates, the 10th-percentile value is more representative of the lower range of values than the single lowest sample.

B.2.4 Zone Background and Current Site Risk and Hazard

Zone H background and existing Combined SWMU 14 risk and hazard were calculated by applying the Zone H background EPC (95% UCL of the mean Zone H background concentration) for arsenic and BEQs to the same risk and hazard formulas in section B.2.1. Tables B.1 through B.4 present the Zone H background and Combined SWMU 14 data and results. There is no published Oral Reference Dose for BEQs, therefore they do not drive any hazard.

B.2.5 Residual Risk and Hazard Reduction

Residual risk reduction calculations were made by sequentially recalculating risk and hazard as points were removed in order of greatest to least risk and hazard. To simulate the value of replacing treated or excavated contaminated soils with clean backfill, sample data points were

removed one at a time, and each was replaced with ½ the zone background concentration reported for each chemical. Site risk and hazard were recalculated after each point removal.

Table B.5 displays the greatest point contributors to residential risk at each site within Combined SWMU 14 excluding lead-contaminated points scheduled for removal by the DET. Figure B.1 shows the reduction in residential site risk as the area associated with each point is removed or otherwise remediated. Hazard results are presented on Table B.6 and graphed on Figure B.2. The graphs also show which points and corresponding areas of the site which must be remediated in order to achieve a residual site risk and hazard equal to or less than Zone H background risk.

The area associated with each sample point was determined automatically using the Thiessen polygon method with a geographic information system (GIS).

B.2.6 Equation Constants and Scenario Assumptions

Equation constants listed in Table B.7 were taken from the most recent available USEPA published values. Scenario assumptions in Table B.8 were taken directly from the RFI baseline risk assessment. Exposure point concentrations used in calculating risk and hazard represent the 95% UCL where more than 9 sample data points are available and the maximum observed value where 9 or less data points are available.

Table B.1 Zone H Background Data Summary

Compound or Element: Background Conc. (mg/kg):	BEQ 0.19	Arsenic 7.49	Antimony 1.86	Thallium 0.24	Aluminum 9801.48	Lead 35.56	Vanadium 27.11
Number of Samples (n):	104.00	104.00	104.00	104.00	104.00	104.00	104.00
Standard Deviation of Ln Transformed Data:	0.76	0.86	0.89	0.60	0.71	1.08	0.73
Sample Mean of Ln Transformed Data:	-2.11	1.47	0.03	-1.70	8.80	2.74	2.89
H-Stat Interpolation							
n(low)	51.00	51.00	51.00	51.00	51.00	51.00	51.00
n(high)	105.00	105.00	105.00	105.00	105.00	105.00	105.00
S(low)	0.70	0.80	0.80	0.50	0.70	1.00	0.70
S(high)	0.80	0.90	0.90	0.60	0.80	1.25	0.80
H(NL,SL)	2.03	2.11	2.11	1.88	2.03	2.31	2.03
H(NL,SH)	2.11	2.21	2.21	1.95	2.11	2.58	2.11
H(NH,SL)	1.96	2.04	2.04	1.83	1.96	2.21	1.96
H(NH,SH)	2.04	2.12	2.12	1.89	2.04	2.45	2.04
NL Interp	2.08	2.17	2.20	1.95	2.04	2.39	2.05
NH Interp	2.01	2.08	2.11	1.89	1.97	2.28	1.98
H-stat:	2.01	2.09	2.11	1.89	1.97	2.29	1.98
95% UCL:	0.19	7.49	1.86	0.24	9801.48	35.56	27.11
Maximum_Value:	2.40	18.40	9.45	1.10	32700.00	172.00	74.80
Exposure Point Concentration (mg/kg):	0.19	7.49	1.86	0.24	9801.48	35.56	27.11

BORING_ID	CONCENTRATION (mg/kg)											
GDHSB00101	1.960	3.30	0.70	UJ	0.17	U	3070.00	U	69.50	17.90		
GDHSB00201	0.092	U	15.30	0.65	U	0.15	U	1500.00	U	47.80	16.80	
GDHSB00301	0.092	U	6.30	0.75	U	0.18	U	8420.00	U	45.90	24.30	
GDHSB00401	0.092	U	8.60	6.05	U	0.15	U	5690.00	U	7.80	U	22.50
GDHSB00501	0.092	U	5.70	0.50	U	0.13	U	4630.00	U	29.20	16.90	
GDHSB00601	0.092	U	1.70	1.10	J	0.13	U	4840.00	U	5.70	6.90	
GDHSB00701	0.289	6.20	0.70	U	0.17	U	8510.00	U	78.70	25.10		
GDHSB00801	0.092	U	6.40	0.70	U	0.16	U	10200.00	U	31.70	26.30	
GDHSB00901	0.092	U	2.80	0.70	U	0.16	U	4260.00	U	15.80	12.20	
GDHSB01001	0.092	U	14.80	1.40	UR	0.17	UJ	13400.00	UJ	31.10	J	42.30
GDHSB01101	0.091	1.90	J	0.60	U	0.18	U	6460.00	U	35.80	17.50	
GDHSB01201	0.570	U	3.50	J	0.60	U	0.19	U	5060.00	U	40.30	13.90
GDHSB01301	0.092	U	2.50	0.70	U	0.16	UJ	4240.00	UJ	26.20	7.70	
GDHSB01401	0.092	U	2.20	0.50	U	0.13	UJ	3550.00	UJ	78.50	9.90	
GDHSB01501	0.147	U	3.80	0.65	U	0.15	UJ	5880.00	UJ	172.00	25.30	
GDHSB01601	0.092	U	1.20	0.50	U	0.13	U	3440.00	U	29.20	8.40	
GDHSB01701	0.417	11.300	2.200	J	0.165	UJ	9210.000	UJ	11.600	U	35.500	
GDHSB01801	0.092	U	10.100	0.500	U	0.120	UJ	10100.000	UJ	12.200	U	31.600
GDHSB01901	0.092	U	2.200	0.750	U	0.170	UJ	4240.000	UJ	5.650	U	12.400
GDHSB02001	0.092	U	3.200	0.550	U	0.130	UJ	5710.000	UJ	3.600	U	10.000
GDHSB02101	0.182	2.60	0.65	U	0.16	UJ	6520.00	UJ	11.00	U	20.60	
GDHSB02201	0.092	U	1.90	0.60	U	0.15	UJ	4580.00	UJ	35.00	17.40	
GDHSB02301	0.137	2.20	U	0.49	UJ	0.12	U	5360.00	U	26.30	19.40	
GDHSB02401	0.310	7.80	0.65	U	0.13	U	11700.00	U	47.00	29.90		
GDHSB02501	2.400	2.90	0.50	U	0.11	U	9720.00	U	12.40	18.20		
GDHSB02601	1.790	1.15	U	0.65	U	0.16	U	7940.00	U	53.30	20.30	
GDHSB02701	1.070	1.25	U	1.00	U	0.17	U	3970.00	U	109.00	46.60	
GDHSB02801	2.010	1.30	U	0.55	U	0.13	U	6040.00	U	26.30	24.50	
GDHSB02901	0.092	U	0.39	U	0.45	U	0.11	U	6100.00	U	8.70	24.80
GDHSB03001	0.092	U	0.55	U	0.45	U	0.11	U	6470.00	U	12.60	11.60
GDHSB03101	0.092	5.40	0.60	U	0.14	U	12800.00	U	10.90	25.60		
GDHSB03201	0.311	U	8.90	0.75	U	0.18	U	16900.00	U	70.50	48.70	
GDHSB03301	0.092	8.50	0.85	U	0.20	U	9310.00	U	15.80	31.40		
GDHSB03401	0.092	17.20	0.60	U	0.29	U	23400.00	U	28.40	60.10		
GDHSB03501	0.092	17.60	1.10	U	0.24	U	20200.00	U	37.40	69.10		

BORING_ID	CONCENTRATION (mg/kg)												
GDHSB03601	0.092	13.70	0.75	U	1.10	J	20700.00	J	20.60	55.50			
GDHSB03701	0.092	4.00	7.15	U	0.17	UJ	2560.00	UJ	27.50	J	13.10		
GDHSB03801	0.092	11.80	0.65	U	0.15	UJ	5640.00	UJ	36.20	14.30			
GDHSB03901	0.092	U	8.40	0.80	U	0.92	J	14900.00	J	21.10	35.40		
GDHSB04001	0.092	U	1.60	0.70	UJ	0.17	UJ	4030.00	UJ	4.30	J	7.20	
GDHSB04101	0.092	U	18.40	0.90	U	1.10	J	32700.00	J	33.60	74.80		
GDHSB04201	0.092	U	9.10	0.65	U	0.63	J	5760.00	J	0.80	U	19.30	
GDHSB04301	0.092	U	5.20	0.65	U	0.16	UJ	11500.00	UJ	12.60	21.00		
GDHSB04401	0.092	U	1.50	0.43	U	0.10	UJ	6350.00	UJ	3.50	5.80		
GDHSB04501	0.092	U	4.50	0.49	U	0.12	UJ	7900.00	UJ	11.70	15.10		
GDHSB04601	0.092	U	5.70	0.60	U	0.14	UJ	14800.00	UJ	14.40	27.30		
GDHSB04701	0.092	U	9.70	0.60	U	0.14	U	17100.00	U	11.30	35.90		
GDHSB04801	0.092	U	13.20	1.00	U	0.24	U	20000.00	U	35.30	49.80		
GDHSB04901	0.092	U	15.70	0.90	U	0.21	U	29600.00	U	24.60	68.30		
GDHSB05001	0.092	U	6.20	6.35	U	0.15	U	5150.00	U	8.15	U	20.40	
GDHSB05101	0.092	U	3.90	0.48	U	0.11	U	9280.00	U	7.20	14.10		
GDHSB05201	0.092	U	7.70	0.55	U	0.14	U	11300.00	U	13.10	23.60		
GDHSB05301	0.092	U	0.73	J	0.60	U	0.14	U	4710.00	U	11.40	4.80	
GDHSB05401	0.092	U	7.30	0.60	U	0.14	U	10100.00	U	19.50	25.30		
GDHSB05501	0.092	U	3.70	0.50	U	0.12	U	3810.00	U	16.80	7.90		
GDHSB05601	1.260	U	5.10	0.41	U	0.10	U	5480.00	U	24.00	15.20		
GDHSB05701	0.092	U	3.80	4.55	U	0.11	UJ	1610.00	UJ	5.85	U	6.90	
GDHSB05801	0.092	U	5.90	5.90	U	0.14	U	9070.00	U	24.60	J	23.60	
GDHSB05901	0.092	U	4.10	1.40	J	0.10	UJ	5060.00	UJ	63.80	17.90		
GDHSB06001	0.092	U	9.80	0.80	U	0.19	UJ	16200.00	UJ	23.70	36.30		
GDHSB06101	0.092	U	5.30	0.55	UJ	0.14	U	5960.00	U	9.30	12.60		
GDHSB06201	0.092	U	14.40	0.65	U	0.15	UJ	15200.00	UJ	25.00	44.40		
GDHSB06301	0.092	U	11.30	1.70	J	0.13	UJ	9290.00	UJ	151.00	19.10		
GDHSB06401	0.092	U	7.90	1.50	J	0.17	UJ	1090.00	UJ	79.80	11.70		
GDHSB06501	0.092	U	7.60	4.05	U	0.10	UJ	2630.00	UJ	21.20	J	12.00	
GDHSB06601	0.092	U	2.80	1.90	J	0.13	UJ	7260.00	UJ	4.50	17.10		
GDHSB06701	0.092	U	9.00	0.47	U	0.11	UJ	2380.00	UJ	77.10	10.10		
GDHSB06801	0.092	U	6.60	0.60	U	0.14	UJ	5850.00	UJ	19.80	16.60		
GDHSB06901	0.092	U	1.10	0.50	U	0.12	UJ	4330.00	UJ	4.40	8.10		
GDHSB07001	0.092	U	1.20	0.60	UJ	0.14	UJ	2840.00	UJ	1.80	J	4.10	
GDHSB07101	0.092	U	2.10	0.55	U	0.13	UJ	2780.00	UJ	11.50	9.60		
GDHSB07201	0.092	U	9.80	0.80	U	0.19	U	11300.00	U	20.30	38.70		
GDHSB07301	0.092	U	2.90	0.40	U	0.10	UJ	3240.00	UJ	2.40	J	5.40	
GDHSB07401	0.092	U	5.00	4.05	UJ	0.55	U	5000.00	U	3.90	J	14.80	
GDHSB07501	0.095	U	8.40	4.45	UJ	0.55	U	8180.00	U	89.70	30.80		
GDHSB07601	0.092	U	6.20	4.15	UJ	0.50	U	8510.00	U	6.30	21.70		
GDHSB07701	0.092	U	8.50	5.55	UJ	0.55	U	5640.00	U	7.40	28.50		
GDHSB07801	0.092	U	2.80	3.95	UJ	0.46	U	4420.00	U	18.80	12.20		
GDHSB07901	0.092	U	13.50	4.10	UJ	0.55	U	26600.00	U	69.60	66.50		
GDHSB08001	0.301	U	3.50	3.40	UJ	0.46	U	8490.00	U	42.70	24.10		
GDHSB08101	0.809	U	4.40	3.40	UJ	0.46	U	10600.00	U	9.20	21.80		
GDHSB08201	0.092	U	7.40	6.80	UJ	0.49	U	10800.00	U	12.90	23.00		
GDHSB08301	0.092	U	8.50	4.60	UJ	0.46	U	3160.00	U	7.60	17.50		
GDHSB08401	0.092	U	6.35	U	7.95	U	0.47	J	9390.00	J	13.60	U	38.10
GDHSB08501	0.092	U	4.00	U	9.45	U	0.55	J	8550.00	J	16.15	U	39.00
GDHSB08601	0.092	U	7.30	5.35	U	0.39	UJ	4400.00	UJ	0.80	UJ	28.60	
GDHSB08701	0.092	U	6.70	4.80	U	0.35	UJ	10800.00	UJ	4.35	UJ	32.10	
GDHSB08801	0.092	U	5.70	0.95	U	0.35	UJ	8670.00	UJ	19.60	J	19.70	
GDHSB08901	0.092	U	8.00	U	0.90	U	0.32	UJ	17400.00	UJ	20.30	45.90	
GDHSB09001	0.092	U	8.05	U	1.15	U	0.42	UJ	22300.00	UJ	41.30	71.70	
GDHSB09101	0.092	U	1.65	U	0.55	U	0.20	UJ	4630.00	UJ	4.10	U	8.50
GDHSB09201	0.092	U	9.60	J	0.85	UJ	0.12	J	17700.00	J	12.00	33.50	
GDHSB09301	0.092	U	1.30	J	0.60	UJ	0.04	UJ	4470.00	UJ	4.90	3.40	U
GDHSB10401	0.092	U	1.40	J	0.60	U	0.20	U	6650.00	U	16.60	J	27.20
GDHSB10501	0.092	U	5.40	J	0.50	U	0.16	U	7600.00	U	17.90	J	19.40
GDHSB10701	0.092	U	0.64	J	0.60	U	0.18	U	3300.00	U	2.30	J	4.10
SGC-001	0.092	U	2.10	3.80	U	0.09	UJ	1030.00	UJ	4.90	U	5.10	J
SGC-002	0.092	U	1.00	0.45	U	0.11	UJ	8760.00	UJ	2.00	J	8.30	
SGC-003	0.092	U	8.30	6.25	U	0.15	UJ	874.00	UJ	8.05	U	4.10	J
SGC-004	0.092	U	1.3	0.455	U	0.105	UJ	3980	UJ	1.6	J	4	
SGC-005	0.092	U	4	0.55	U	0.135	UJ	8990	UJ	5.5	15.4		
SGC-006	0.092	U	1.2	0.55	U	0.13	UJ	3940	UJ	10.5	5.5		
SGC-007	0.092	U	2.9	0.7	U	0.165	UJ	4010	UJ	19.8	6.6		
SGC-008	0.092	U	3.2	0.6	U	0.15	UJ	2150	UJ	25.7	11.4		

Table B.3 Combined SWMU 14 Site Data Summary

Compound or Element: Background Conc. (mg/kg):	BEQ 0.19	Arsenic 7.49
Number of Samples (n):	96.00	77.00
Standard Deviation of Ln Transformed Data:	1.80	0.79
Sample Mean of Ln Transformed Data:	-1.63	2.01
H-Stat Interpolation		
n(low)	51.00	51.00
n(high)	105.00	105.00
S(low)	1.75	0.70
S(high)	2.00	0.80
H(NL,SL)	3.20	2.03
H(NL,SH)	3.53	2.11
H(NH,SL)	3.00	1.96
H(NH,SH)	3.30	2.04
NL Interp	3.27	2.10
NH Interp	3.06	2.03
H-stat:	3.09	2.06
95% UCL:	1.77	12.31
Maximum_Value:	29.87	69.00
Exposure Point Concentration (mg/kg):	1.77	12.31

<u>BORING_ID</u>	<u>CONCENTRATION (mg/kg)</u>		
014SB01	0.046	U	7.10
014SB02	0.046	U	8.40
014SB03	0.046	U	5.50
014SB04	0.046	U	11.90
014SB05	0.096		9.60
014SB06	0.046	U	8.40
014SB07	0.123		6.60
014SB08	0.046	U	8.10
014SB09	0.046	U	6.60
014SB10			9.65
014SB11			5.35
014SB106	1.475		13.60
015SB01	0.158		6.40
015SB02	0.046	U	3.60
015SB03	0.445		15.00
015SB04	2.028		53.10
015SB05	0.294		
015SB06	0.448		
015SB07	0.156		
015SB08	0.046	U	
670SB01	0.046	U	15.60
670SB02	0.351		9.70
670SB03	4.252		4.95
670SB04	1.023		11.30
670SB05	1.591		15.20
670SB06	0.046	U	13.8
670SB07	0.046	U	8.90
670SB08	0.958		9.70
670SB09	0.046	U	9.10
670SB10	0.046	U	10.40
670SB11	0.046	U	8.90
670SB12	0.705		23.70
670SB13	0.108		4.65

<u>BORING_ID</u>	<u>CONCENTRATION (mg/kg)</u>	
670SB14	0.092	9.50
670SB15	0.148	9.70
670SB16	0.254	12.10
670SB17	0.046 U	8.20
670SB18	0.046 U	10.10
670SB19	0.127	7.00
670SB20	0.046 U	8.40
670SB21	0.096	7.90
670SB22	0.046 U	9.30
670SB23	0.046 U	69.00
670SB24	0.046 U	13.00
670SB25		6.85
670SB26	0.046 U	12.30
670SB27	0.046 U	8.30
670SB28	0.046 U	
670SB29	7.525	
670SB30	0.212	
670SB31	27.751	15.40
670SB32	0.917	17.2
670SB33	0.046 U	
670SB34	2.136	
670SB35	0.046 U	
684SB01	0.046 U	1.70
684SB02	0.046 U	7.00
684SB03	8.567	8.50
684SB04	4.408	12.70
684SB05	0.122	7.40
684SB06	0.046 U	0.28 J
684SB07	0.046 U	9.00
684SB08	0.046 U	1.90
684SB09	0.046 U	12.90
684SB10	0.046 U	5.20
684SB11	0.046 U	1.40
684SB12	0.046 U	0.89
684SB13	0.046 U	2.80
684SB14	0.046 U	11.70
684SB15	1.516	13.50
684SB16	0.046 U	4.80
684SB17	0.167	3.60
684SB18	0.169	6.40
684SB19	0.242	2.55
684SB20	2.154	5.65
684SB21	25.501	1.90
684SB22	0.395	5.80
684SB23	1.237	8.10
684SB24	4.270	8.10
684SB25	0.329	5.30
684SB26	1.963	16.30
684SB27	0.545	9.90
684SB28	0.274	5.60
684SB29	0.046 U	4.50
684SB30	0.046 U	3.70
684SB31	0.046 U	9.30
684SB32	0.218	
684SB33	0.301	
684SB34	0.238	
684SB35	29.871	
684SB36	1.162	11.70
684SB37	0.046 U	
684SB38	0.046 U	
684SB39	0.046 U	
684SB40	0.696	
684SB41	0.096	
684SB42	0.046 U	
684SB43	4.267	
684SB44	9.215	

Table B.4 Combined SWMU 14 Site Risk and Hazard Summary

Surface Soil Ingestion

Residential Scenario (Child)

	BEQ	Arsenic	Site Totals
Hazard Quotient (HQ):	0.0E+00	5.2E-01	5.2E-01
Background HQ:	0.0E+00	3.2E-01	3.2E-01
HQ Above Background:	0.0E+00	2.1E-01	2.1E-01
Site Risk:	2.0E-05	2.9E-05	4.9E-05
Background Risk:	2.2E-06	1.8E-05	2.0E-05
Site Risk above Background:	1.8E-05	1.1E-05	2.9E-05

Industrial Scenario (Adult Site Worker)

Hazard Quotient (HQ):	0.0E+00	2.0E-02	2.0E-02
Background HQ:	0.0E+00	1.2E-02	1.2E-02
HQ Above Background:	0.0E+00	7.9E-03	7.9E-03
Site Risk:	2.3E-06	3.2E-06	5.5E-06
Background Risk:	2.4E-07	2.0E-06	2.2E-06
Site Risk above Background:	2.0E-06	1.3E-06	3.3E-06

Surface Soil Dermal Contact

Residential Scenario (Child)

Hazard Quotient (HQ):	0.0E+00	1.0E-01	1.0E-01
Background HQ:	0.0E+00	6.4E-02	6.4E-02
HQ Above Background:	0.0E+00	4.1E-02	4.1E-02
Site Risk:	9.1E-06	3.2E-06	1.2E-05
Background Risk:	9.7E-07	2.0E-06	2.9E-06
Site Risk above Background:	8.1E-06	1.3E-06	9.4E-06

Industrial Scenario (Adult Site Worker)

Hazard Quotient (HQ):	0.0E+00	4.0E-03	4.0E-03
Background HQ:	0.0E+00	2.4E-03	2.4E-03
HQ Above Background:	0.0E+00	1.6E-03	1.6E-03
Site Risk:	3.7E-06	1.3E-06	5.0E-06
Background Risk:	4.0E-07	8.0E-07	1.2E-06
Site Risk above Background:	3.3E-06	5.2E-07	3.8E-06

Ingestion and Dermal Contact Combined Totals

	BEQ	Arsenic	Site Totals
Residential Scenario (Child)			
Hazard Quotient (HQ):	0.0E+00	6.3E-01	6.3E-01
Background HQ:	0.0E+00	3.8E-01	3.8E-01
HQ Above Background:	0.0E+00	2.5E-01	2.5E-01
Site Risk:	2.9E-05	3.2E-05	6.1E-05
Background Risk:	3.1E-06	2.0E-05	2.3E-05
Site Risk above Background:	2.6E-05	1.3E-05	3.9E-05
Industrial Scenario (Adult Site Worker)			
Hazard Quotient (HQ):	0.0E+00	2.4E-02	2.4E-02
Background HQ:	0.0E+00	1.5E-02	1.5E-02
HQ Above Background:	0.0E+00	9.4E-03	9.4E-03
Site Risk:	5.9E-06	4.5E-06	1.0E-05
Background Risk:	6.4E-07	2.8E-06	3.4E-06
Site Risk above Background:	5.3E-06	1.8E-06	7.1E-06

Table B.5 Risk Reduction Summary

Point to be Removed	Estimated Area	Cumulative Area	Residential Point Risk	Industrial Point Risk	Site Risk Remaining After Point Removal		Background	
					Residential	Industrial	BEQ/arsenic	arsenic
None	0	0	NA	NA	6.1E-05	1.1E-05	2.3E-05	2.0E-05
670SB31	2338	2338	5.0E-04	9.9E-05	5.5E-05	9.2E-06	2.3E-05	2.0E-05
684SB35	3268	5606	4.9E-04	1.0E-04	5.0E-05	8.2E-06	2.3E-05	2.0E-05
684SB21	2142	7748	4.3E-04	8.7E-05	4.6E-05	7.4E-06	2.3E-05	2.0E-05
670SB23	2580	10328	1.8E-04	2.6E-05	4.3E-05	7.0E-06	2.3E-05	2.0E-05
015SB04	488	10816	1.7E-04	2.6E-05	4.0E-05	6.6E-06	2.3E-05	2.0E-05
684SB03	2496	13312	1.6E-04	3.2E-05	3.8E-05	6.1E-06	2.3E-05	2.0E-05
684SB44	4694	18006	1.5E-04	3.1E-05	3.6E-05	5.7E-06	2.3E-05	2.0E-05
670SB29	3732	21738	1.2E-04	2.5E-05	3.5E-05	5.4E-06	2.3E-05	2.0E-05
684SB04	2616	24354	1.1E-04	2.0E-05	3.3E-05	5.2E-06	2.3E-05	2.0E-05
684SB24	2062	26416	9.2E-05	1.7E-05	3.2E-05	5.0E-06	2.3E-05	2.0E-05
670SB03	2715	29131	8.3E-05	1.6E-05	3.1E-05	4.8E-06	2.3E-05	2.0E-05
684SB26	3066	32197	7.5E-05	1.3E-05	3.0E-05	4.6E-06	2.3E-05	2.0E-05
670SB12	2486	34683	7.4E-05	1.1E-05	2.9E-05	4.4E-06	2.3E-05	2.0E-05
684SB43	3024	37707	7.1E-05	1.4E-05	2.8E-05	4.3E-06	2.3E-05	2.0E-05
670SB05	2499	40206	6.6E-05	1.1E-05	2.7E-05	4.1E-06	2.3E-05	2.0E-05
684SB15	3413	43619	6.0E-05	1.0E-05	2.7E-05	4.0E-06	2.3E-05	2.0E-05
670SB32	5000	48619	6.0E-05	9.4E-06	2.6E-05	3.9E-06	2.3E-05	2.0E-05
014SB106	10000	58619	6.0E-05	1.0E-05	2.5E-05	3.8E-06	2.3E-05	2.0E-05
684SB20	1882	60501	5.0E-05	9.3E-06	2.5E-05	3.7E-06	2.3E-05	2.0E-05
684SB36	3468	63969	5.0E-05	8.2E-06	2.4E-05	3.6E-06	2.3E-05	2.0E-05
015SB03	762	64731	4.7E-05	7.0E-06	2.4E-05	3.5E-06	2.3E-05	2.0E-05
670SB04	2454	67185	4.6E-05	7.6E-06	2.3E-05	3.4E-06	2.3E-05	2.0E-05
684SB23	1612	68797	4.2E-05	7.2E-06	2.3E-05	3.4E-06	2.3E-05	2.0E-05
670SB01	3724	72521	4.2E-05	5.9E-06	2.2E-05	3.3E-06	2.3E-05	2.0E-05
670SB08	2438	74959	4.1E-05	6.8E-06	2.2E-05	3.2E-06	2.3E-05	2.0E-05
670SB06	4145	79104	3.7E-05	5.3E-06	2.1E-05	3.1E-06	2.3E-05	2.0E-05
670SB16	2435	81539	3.6E-05	5.3E-06	2.1E-05	3.1E-06	2.3E-05	2.0E-05
670SB34	2942	84481	3.5E-05	7.2E-06	2.0E-05	3.0E-06	2.3E-05	2.0E-05
684SB27	2592	87073	3.5E-05	5.5E-06	2.0E-05	3.0E-06	2.3E-05	2.0E-05
670SB24	4000	91073	3.5E-05	5.0E-06	2.0E-05	2.9E-06	2.3E-05	2.0E-05
684SB09	2664	93737	3.4E-05	4.9E-06	1.9E-05	2.9E-06	2.3E-05	2.0E-05
670SB26	2613	96350	3.3E-05	4.7E-06	1.9E-05	2.8E-06	2.3E-05	2.0E-05
014SB04	7149	103499	3.2E-05	4.6E-06			2.3E-05	2.0E-05
684SB14	2604	106103	3.1E-05	4.5E-06			2.3E-05	2.0E-05
670SB02	3837	109940	3.1E-05	4.8E-06			2.3E-05	2.0E-05
670SB10	4636	114576	2.8E-05	4.0E-06			2.3E-05	2.0E-05
670SB15	3373	117949	2.8E-05	4.1E-06			2.3E-05	2.0E-05
670SB18	6288	124237	2.7E-05	3.9E-06			2.3E-05	2.0E-05
014SB05	2569	126806	2.7E-05	3.9E-06			2.3E-05	2.0E-05
670SB14	5640	132446	2.6E-05	3.8E-06			2.3E-05	2.0E-05
014SB10	4000	136446	2.5E-05	3.6E-06			2.3E-05	2.0E-05
670SB22	4000	140446	2.5E-05	3.6E-06			2.3E-05	2.0E-05
684SB31	3000	143446	2.5E-05	3.6E-06			2.3E-05	2.0E-05
670SB09	2493	145939	2.5E-05	3.5E-06			2.3E-05	2.0E-05
684SB07	2446	148385	2.4E-05	3.5E-06			2.3E-05	2.0E-05
670SB07	2172	150557	2.4E-05	3.4E-06			2.3E-05	2.0E-05
670SB11	2724	153281	2.4E-05	3.4E-06			2.3E-05	2.0E-05
014SB02	3854	157135	2.3E-05	3.3E-06			2.3E-05	2.0E-05
014SB06	2532	159667	2.3E-05	3.3E-06			2.3E-05	2.0E-05
670SB20	2571	162238	2.3E-05	3.3E-06			2.3E-05	2.0E-05
670SB27	4000	166238	2.2E-05	3.2E-06			2.3E-05	2.0E-05
670SB21	2662	168900	2.2E-05	3.2E-06			2.3E-05	2.0E-05
670SB17	2597	171497	2.2E-05	3.2E-06			2.3E-05	2.0E-05
014SB08	4938	176435	2.2E-05	3.1E-06			2.3E-05	2.0E-05
684SB22	2996	179431	2.2E-05	3.5E-06			2.3E-05	2.0E-05
684SB05	2568	181999	2.1E-05	3.1E-06			2.3E-05	2.0E-05
670SB19	2502	184501	2.0E-05	3.0E-06			2.3E-05	2.0E-05
684SB18	2274	186775	2.0E-05	2.9E-06			2.3E-05	2.0E-05
015SB01	3108	189883	1.9E-05	2.9E-06			2.3E-05	2.0E-05
014SB01	4942	194825	1.9E-05	2.8E-06			2.3E-05	2.0E-05
684SB25	3263	198088	1.9E-05	3.1E-06			2.3E-05	2.0E-05
014SB07	5280	203368	1.9E-05	2.9E-06			2.3E-05	2.0E-05
684SB28	2714	206082	1.9E-05	3.0E-06			2.3E-05	2.0E-05
684SB02	2407	208489	1.9E-05	2.7E-06			2.3E-05	2.0E-05
014SB09	3000	211489	1.8E-05	2.6E-06			2.3E-05	2.0E-05
670SB25	3606	215095	1.8E-05	2.5E-06			2.3E-05	2.0E-05
014SB03	4393	219488	1.5E-05	2.2E-06			2.3E-05	2.0E-05
684SB10	2470	221958	1.4E-05	2.1E-06			2.3E-05	2.0E-05
014SB11	10000	231958	1.4E-05	2.0E-06			2.3E-05	2.0E-05
684SB16	2636	234594	1.3E-05	1.9E-06			2.3E-05	2.0E-05
670SB13	2509	237103	1.3E-05	1.9E-06			2.3E-05	2.0E-05
684SB29	3560	240663	1.3E-05	1.8E-06			2.3E-05	2.0E-05
684SB17	5861	246524	1.2E-05	1.9E-06			2.3E-05	2.0E-05
684SB40	5000	251524	1.2E-05	2.3E-06			2.3E-05	2.0E-05

Point to be Removed	Estimated Area	Cumulative Area	Residential Point Risk	Industrial Point Risk	Site Risk Remaining After Point Removal		Background	
					Residential	Industrial	BEQ/arsenic	arsenic
684SB19	2292	253816	1.1E-05	1.8E-06			2.3E-05	2.0E-05
684SB30	3000	256816	1.0E-05	1.5E-06			2.3E-05	2.0E-05
015SB02	3773	260589	1.0E-05	1.5E-06			2.3E-05	2.0E-05
684SB13	2577	263166	8.1E-06	1.2E-06			2.3E-05	2.0E-05
015SB06	1481	264647	7.4E-06	1.5E-06			2.3E-05	2.0E-05
684SB08	9505	274152	5.7E-06	8.6E-07			2.3E-05	2.0E-05
684SB01	5000	279152	5.2E-06	7.8E-07			2.3E-05	2.0E-05
684SB33	5141	284293	5.0E-06	1.0E-06			2.3E-05	2.0E-05
015SB05	1997	286290	4.9E-06	9.9E-07			2.3E-05	2.0E-05
684SB11	2133	288423	4.4E-06	6.7E-07			2.3E-05	2.0E-05
684SB34	5097	293520	3.9E-06	8.0E-07			2.3E-05	2.0E-05
684SB32	3475	296995	3.6E-06	7.3E-07			2.3E-05	2.0E-05
670SB30	7056	304051	3.5E-06	7.1E-07			2.3E-05	2.0E-05
684SB12	2966	307017	3.1E-06	4.8E-07			2.3E-05	2.0E-05
015SB07	1453	308470	2.6E-06	5.3E-07			2.3E-05	2.0E-05
684SB41	7000	315470	1.6E-06	3.2E-07			2.3E-05	2.0E-05
684SB06	2423	317893	1.5E-06	2.6E-07			2.3E-05	2.0E-05
015SB08	2722	320615	7.6E-07	1.5E-07			2.3E-05	2.0E-05
670SB28	7140	327755	7.6E-07	1.5E-07			2.3E-05	2.0E-05
670SB33	5141	332896	7.6E-07	1.5E-07			2.3E-05	2.0E-05
670SB35	5000	337896	7.6E-07	1.5E-07			2.3E-05	2.0E-05
684SB37	7205	345101	7.6E-07	1.5E-07			2.3E-05	2.0E-05
684SB38	4000	349101	7.6E-07	1.5E-07			2.3E-05	2.0E-05
684SB39	3000	352101	7.6E-07	1.5E-07			2.3E-05	2.0E-05
684SB42	7000	359101	7.6E-07	1.5E-07			2.3E-05	2.0E-05

Table B.6 Hazard Reduction Summary

Point to be Removed	Estimated Area	Cumulative Area	Residential Point Hazard	Industrial Point Hazard	Site Hazard Remaining After Point Removal		Background arsenic
					Residential	Industrial	
None	0	0	NA	NA	0.63	0.024	0.38
670SB23	2580	2580	3.53	0.045	0.58	0.022	0.38
015SB04	488	3068	2.72	0.035	0.54	0.021	0.38
670SB12	2486	5554	1.21	0.015	0.52	0.020	0.38
670SB32	5000	10554	0.88	0.011	0.51	0.020	0.38
684SB26	3066	13620	0.83	0.011	0.50	0.019	0.38
670SB01	3724	17344	0.80	0.010	0.49	0.019	0.38
670SB31	2338	19682	0.79	0.010	0.48	0.018	0.38
670SB05	2499	22181	0.78	0.010	0.47	0.018	0.38
015SB03	762	22943	0.77	0.010	0.46	0.017	0.38
670SB06	4145	27088	0.71	0.009	0.45	0.017	0.38
014SB11	10000	37088	0.70	0.009	0.44	0.017	0.38
684SB15	3413	40501	0.69	0.009	0.44	0.017	0.38
670SB24	4000	44501	0.66	0.008	0.43	0.016	0.38
684SB09	2664	47165	0.66	0.008	0.42	0.016	0.38
684SB04	2616	49781	0.65	0.008	0.41	0.016	0.38
670SB26	2613	52394	0.63	0.008	0.40	0.015	0.38
670SB16	2435	54829	0.62	0.008	0.39	0.015	0.38
014SB04	7149	61978	0.61	0.008	0.39	0.015	0.38
684SB14	2604	64582	0.60	0.008	0.38	0.014	0.38
684SB36	3468	68050	0.60	0.008	0.37	0.014	0.38
670SB04	2454	70504	0.58	0.007	0.36	0.014	0.38
670SB10	4636	75140	0.53	0.007	0.36	0.014	0.38
670SB18	6288	81428	0.52	0.007			0.38
684SB27	2592	84020	0.51	0.006			0.38
670SB02	3837	87857	0.50	0.006			0.38
670SB08	2438	90295	0.50	0.006			0.38
670SB15	3373	93668	0.50	0.006			0.38
014SB10	4000	97668	0.49	0.006			0.38
014SB05	2569	100237	0.49	0.006			0.38
670SB14	5640	105877	0.49	0.006			0.38
670SB22	4000	109877	0.48	0.006			0.38
684SB31	3000	112877	0.48	0.006			0.38
670SB09	2493	115370	0.47	0.006			0.38
684SB07	2446	117816	0.46	0.006			0.38
670SB07	2172	119988	0.46	0.006			0.38
670SB11	2724	122712	0.46	0.006			0.38
684SB03	2496	125208	0.43	0.006			0.38
014SB02	3854	129062	0.43	0.005			0.38
014SB06	2532	131594	0.43	0.005			0.38
670SB20	2571	134165	0.43	0.005			0.38
670SB27	4000	138165	0.42	0.005			0.38
670SB17	2597	140762	0.42	0.005			0.38
014SB08	4938	145700	0.41	0.005			0.38
684SB23	1612	147312	0.41	0.005			0.38
684SB24	2062	149374	0.41	0.005			0.38
670SB21	2662	152036	0.40	0.005			0.38
684SB05	2568	154604	0.38	0.005			0.38
014SB01	4942	159546	0.36	0.005			0.38
670SB19	2502	162048	0.36	0.005			0.38
684SB02	2407	164455	0.36	0.005			0.38
670SB25	3606	168061	0.35	0.004			0.38
014SB07	5280	173341	0.34	0.004			0.38
014SB09	3000	176341	0.34	0.004			0.38
015SB01	3108	179449	0.33	0.004			0.38
684SB18	2274	181723	0.33	0.004			0.38
684SB22	2996	184719	0.30	0.004			0.38
684SB20	1882	186601	0.29	0.004			0.38
684SB28	2714	189315	0.29	0.004			0.38
014SB03	4393	193708	0.28	0.004			0.38
014SB106	10000	203708	0.27	0.003			0.38
684SB25	3263	206971	0.27	0.003			0.38
684SB10	2470	209441	0.27	0.003			0.38
670SB03	2715	212156	0.25	0.003			0.38
684SB16	2636	214792	0.25	0.003			0.38
670SB13	2509	217301	0.24	0.003			0.38
684SB29	3560	220861	0.23	0.003			0.38
684SB30	3000	223861	0.19	0.002			0.38

Point to be Removed	Estimated Area	Cumulative Area	Residential		Industrial		Background arsenic
			Point Hazard	Point Hazard	Residential	Industrial	
015SB02	3773	227634	0.18	0.002			0.38
684SB17	5861	233495	0.18	0.002			0.38
684SB13	2577	236072	0.14	0.002			0.38
684SB19	2292	238364	0.13	0.002			0.38
684SB08	9505	247869	0.10	0.001			0.38
684SB21	2142	250011	0.10	0.001			0.38
684SB01	5000	255011	0.09	0.001			0.38
684SB11	2133	257144	0.07	0.001			0.38
684SB12	2966	260110	0.05	0.001			0.38
684SB06	2423	262533	0.01	0.000			0.38
015SB05	1997	264530	0.00	0.000			0.38
015SB06	1481	266011	0.00	0.000			0.38
015SB07	1453	267464	0.00	0.000			0.38
015SB08	2722	270186	0.00	0.000			0.38
670SB28	7140	277326	0.00	0.000			0.38
670SB29	3732	281058	0.00	0.000			0.38
670SB30	7056	288114	0.00	0.000			0.38
670SB33	5141	293255	0.00	0.000			0.38
670SB34	2942	296197	0.00	0.000			0.38
670SB35	5000	301197	0.00	0.000			0.38
684SB32	3475	304672	0.00	0.000			0.38
684SB33	5141	309813	0.00	0.000			0.38
684SB34	5097	314910	0.00	0.000			0.38
684SB35	3268	318178	0.00	0.000			0.38
684SB37	7205	325383	0.00	0.000			0.38
684SB38	4000	329383	0.00	0.000			0.38
684SB39	3000	332383	0.00	0.000			0.38
684SB40	5000	337383	0.00	0.000			0.38
684SB41	7000	344383	0.00	0.000			0.38
684SB42	7000	351383	0.00	0.000			0.38
684SB43	3024	354407	0.00	0.000			0.38
684SB44	4694	359101	0.00	0.000			0.38

Table B.7 Chemical Specific Risk and Hazard Constants

COPC	Dermal Absorption Factor	Dermal Adjustment Factor	Oral RfD	Oral Slope Factor	Inhalation Slope Factor
1,1,2,2-Tetrachloroethane	0.01	0.8	0	0.2	0.203
1,1-Dichloroethene	0.01	0.8	0.009	0.6	0.175
1,4-Dichlorobenzene	0.01	0.8	0	0.024	0
4,4'-DDD	0.01	0.5	0	0.024	0
4,4'-DDE	0.01	0.5	0	0.34	0
4,4'-DDT	0.01	0.5	0.0005	0.34	0
Aluminum	0.001	0.2	1	0	0
Aluminum (Al)	0.001	0.2	1	0	0
Antimony (Sb)	0.001	0.2	0.0004	0	0
Aroclor-1254	0.01	0.5	0	2	2
Aroclor-1260	0.01	0.5	0	2	0
Arsenic	0.001	0.2	0.0003	1.5	15.1
Arsenic (As)	0.001	0.2	0.0003	1.5	15.1
BEQ	0.01	0.5	0	7.3	3.1
Benzo(a)pyrene Equivalents	0.01	0.5	0	7.3	3.1
Beryllium	0.001	0.2	0.005	4.3	8.4
Beryllium (Be)	0.001	0.2	0.005	4.3	8.4
Chloromethane	0.01	0.8	0.257	1.012	0.0063
Chloromethane	0.01	0.8	0.257	1.012	0.0063
Chromium	0.001	0.2	1	0	0
Chromium (Cr)	0.001	0.2	1	0	0
DCE	0.01	0.8	0.009	0.6	0.175
DDD	0.01	0.5	0	0.024	0
DDE	0.01	0.5	0	0.34	0
DDT	0.01	0.5	0.0005	0.34	0
Heptachlor	0.01	0.5	0.0005	4.5	4.55
Lead (Pb)	0.001	0.2	0	0	0
Manganese (Mn)	0.001	0.2	0.047	0	0
Manganese (food)	0.001	0.2	0.047	0	0
Manganese (water)	0.001	0.2	0.023	0	0
PCA	0.01	0.8	0	0.2	0.203
PCB Aroclor-1260	0.01	0.5	0	2	0
PCE	0.01	0.8	0.01	0.052	0.00203
TCE	0.01	0.8	0.006	0	0.006
Tetrachloroethene	0.01	0.8	0.01	0.052	0.00203
Thallium	0.001	0.2	0.00008	0	0
Trichloroethene	0.01	0.8	0.006	0	0.006
Vanadium	0.001	0.2	0.007	0	0
Vanadium (V)	0.001	0.2	0.007	0	0
alpha-BHC	0.01	0.5	0	6.3	6.3
alpha-Chlordane	0.01	0.5	0.0005	0.35	0.35
beta-BHC	0.01	0.5	0	1.8	1.8
delta-BHC	0.01	0.5	0	6.3	6.3
gamma-BHC (Lindane)	0.01	0.5	0.0003	1.3	1.3
gamma-Chlordane	0.01	0.5	0.0005	0.35	0.35

Table B.8 Risk and Hazard Scenario Assumptions

	Resident Child	Adult Site Resident	Adult Site Worker
Ingestion Rate (mg/day)	200	100	50
Exposure Frequency (days/yr)	350	350	250
Exposure Duration (yrs)	6	24	25
Dermal Contact area (cm ²)	2900	4100	4100
Skin Adherence Factor (mg/cm ²)	1	1	1
Conversion Factor	0.000001	0.000001	0.000001
Body Weight (kg)	15	70	70
Averaging time, days (non-cancer)	2190	8760	9125
Averaging time, days (cancer)	25550	25550	25550
Fraction contacted from source	1	1	1

Figure B.1 Combined SWMU 14 Residual Risk Reduction Curve

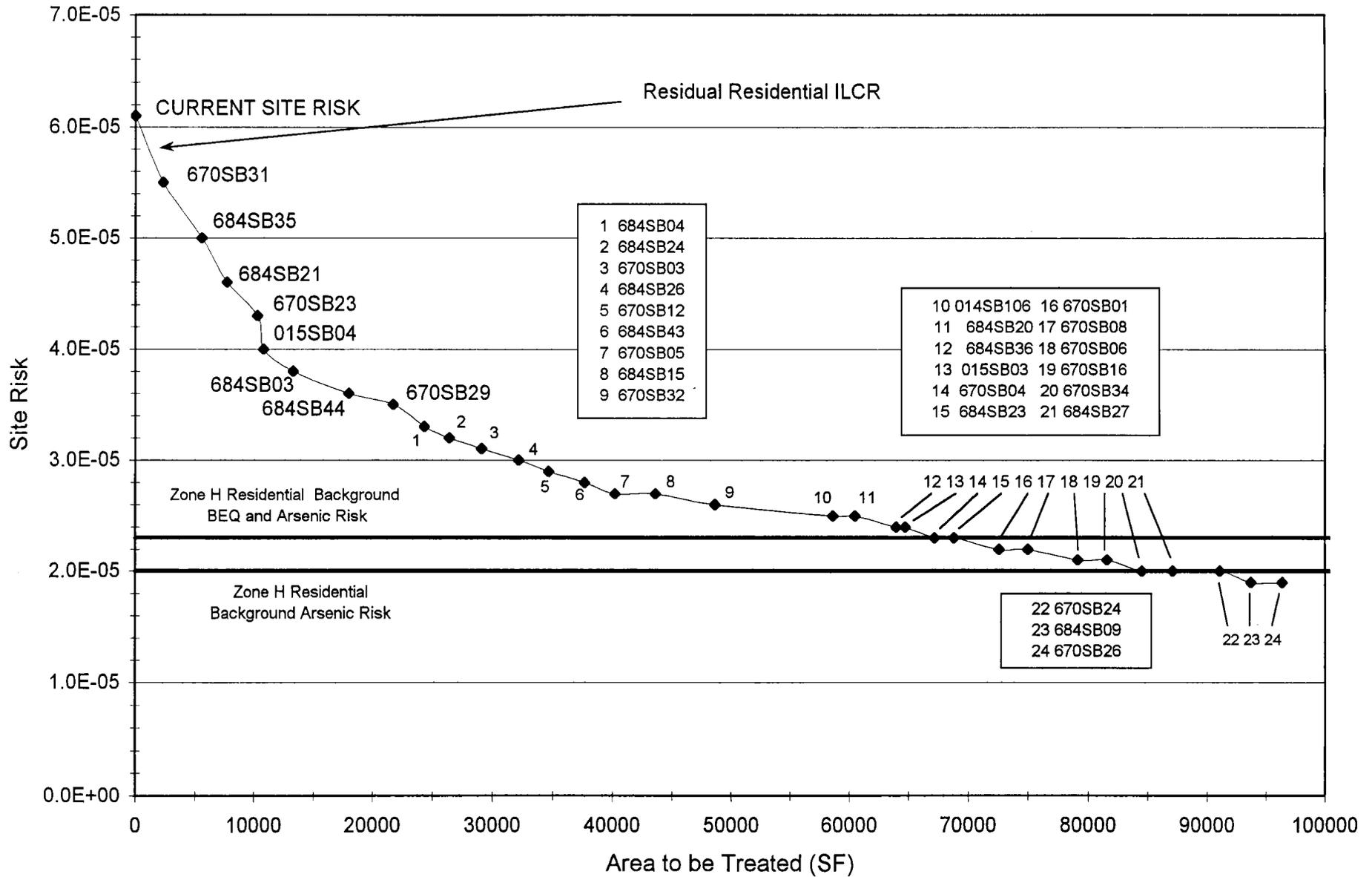
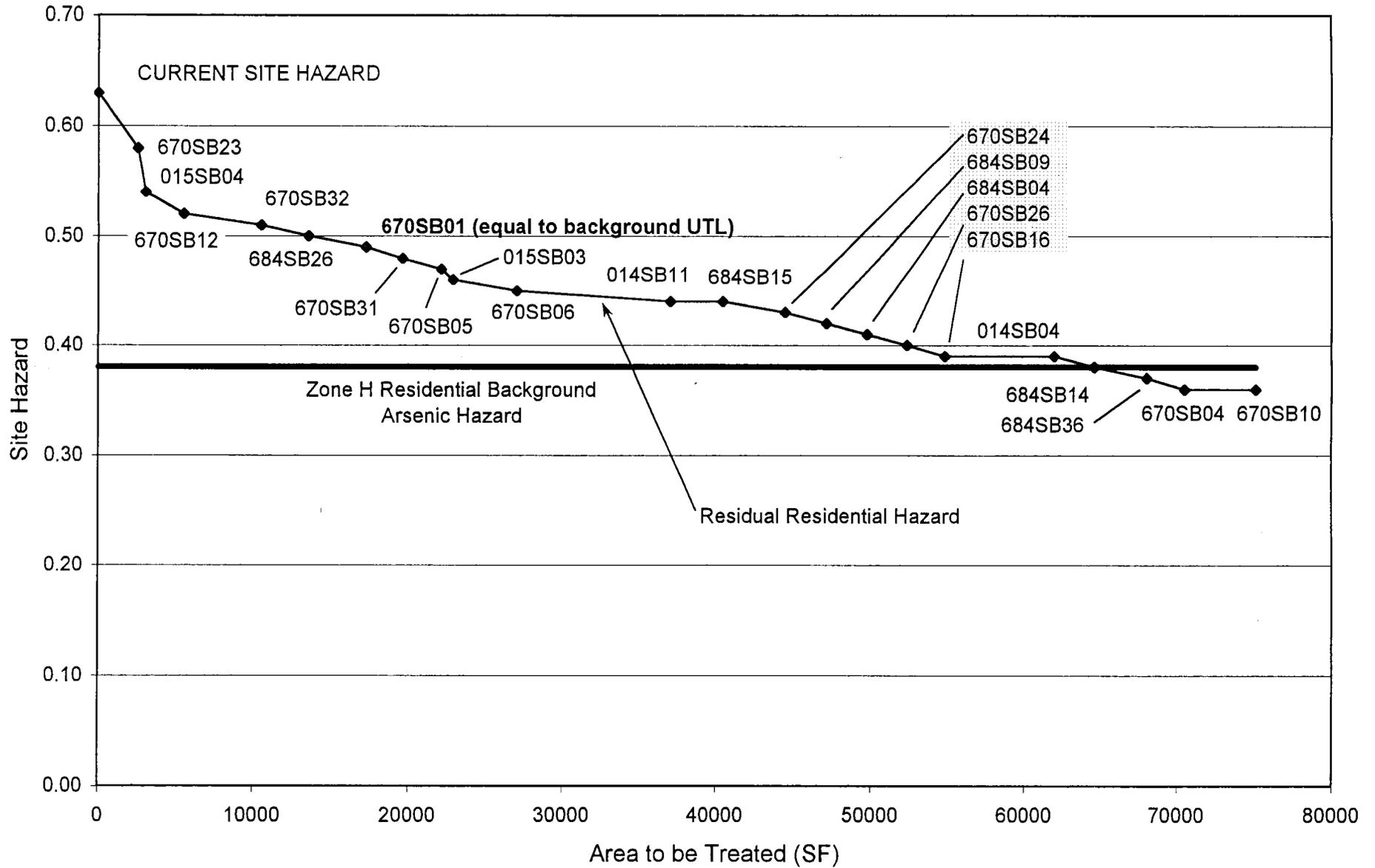


Figure B.2
Combined SWMU 14 Residual Hazard Reduction Curve





DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
P.O. BOX 190010
2155 EAGLE DRIVE
NORTH CHARLESTON, S.C. 29419-9010

5090/11
Code 1877
18 August 1998

Mr. John Litton, P.E.
Director, Division of Hazardous and Infectious Waste Management
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201

Subj: SUBMITTAL OF CHANGES TO THE FINAL COMPREHENSIVE CORRECTIVE
MEASURES STUDY WORK PLAN

Dear Mr. Litton:

The purpose of this letter is to submit changes to the Final Comprehensive Corrective Measures Study (CMS) Work Plan for Naval Base Charleston. The changes are submitted to provide additional treatability study information that may be considered during the CMS.

Please make the page changes as described in the enclosure. Approval of these changes is not considered necessary since this is only additional information to supplement the treatability study information already provided. If you should have any questions, please contact Billy Drawdy or Matthew Hunt at (843) 743-9985 and (843) 820-5525 respectively.

Sincerely,

A handwritten signature in black ink that reads "M. A. Hunt".

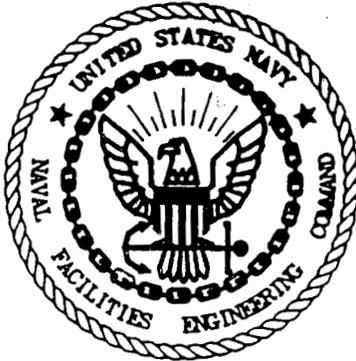
M.A.HUNT, P.E.
Environmental Engineer
Installation Restoration III

Encl: (1) Final Comprehensive Corrective Measures Study Work Plan, page changes, dated August 12, 1998

Copy to:
SCDHEC (Paul Bergstrand, Johnny Tapia), USEPA (Dann Spariosu),
Caretaker Site Office (Billy Drawdy),
SPORTENVDETCNASN (Bobby Dearhart)

VOLUME II

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
CTO-029

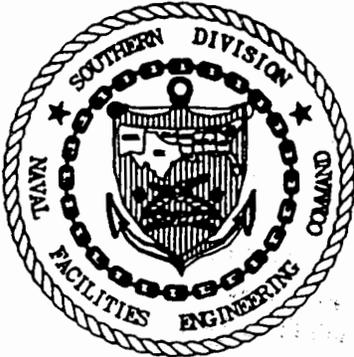


FINAL COMPREHENSIVE
CORRECTIVE MEASURES STUDY
WORK PLAN

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

SOUTHDIV CONTRACT NUMBER: N62467-89-D-0318



Prepared by:

ENSAFE/ALLEN & HOSHALL
5720 SUMMER TREES DRIVE, SUITE 8
MEMPHIS, TENNESSEE 38134
(901) 383-9115

June 25, 1997

Release of this document requires the prior notification of the Commanding Officer of the Naval Base Charleston, Charleston, South Carolina.

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
CHARLESTON NAVAL WEAPONS STATION
CHARLESTON, SOUTH CAROLINA
CTO-0115**



**FINAL COMPREHENSIVE
CORRECTIVE MEASURES STUDY
WORK PLAN**

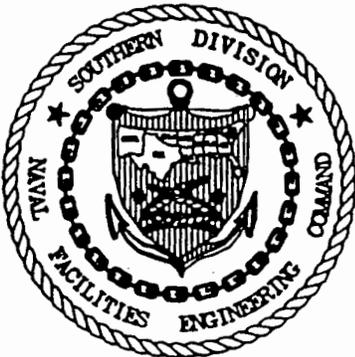
Prepared for:

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

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

Prepared by:

**EnSafe/Allen & Hoshall
5720 Summer Trees Drive, Suite 8
Memphis, Tennessee 38134
(901) 383-9115**



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

Date 6/24/97
Signature Todd Haverkost, P.E.
Name: Todd Haverkost
Title: Task Order Manager

June 25, 1997

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Appendix A	Analytical Methods, Sample Containers, Preservation, and Holding Times
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ACRONYM LIST

ACGIH	American Conference of Governmental Industrial Hygienists
AL	Action Level
AOC	Area of Concern
APEG	Alkaline Polyethylene Glycol
AST	Above Ground Storage Tank
ASTM	American Society of Testing and Materials
BCP	BRAC Cleanup Plan
BCT	BRAC Cleanup Team
BEQ	Bachelor Enlisted Quarters
BNA	Business and National Affairs
BOD	Biological Oxygen Demand
BRAC	Base Realignment and Closure
BTU	British Thermal Unit
CAMU	Corrective Action Management Unit
CAMP	Corrective Action Management Plan
cc	Cubic Centimeter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
CH ₄	Methane
CHASP	Comprehensive Health and Safety Plan
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Procedures
CM	Corrective Measures
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CNSY	Charleston Naval Shipyard
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COC	Contaminant of Concern
COD	Chemical Oxygen Demand
COLIWASA	Composite Liquid Waste Sampler
COPC	Contaminant of Potential Concern
CRP	Community Relations Plan
CRZ	Contaminant Reduction Zone
CSAP	Comprehensive Sampling and Analysis Plan
CSI	Confirmatory Sampling Investigation
CSV	Chlorinated Semivolatiles
CV	Chlorinated Volatiles
°C	Degree Centigrade

DANC	Decontaminating Agent Noncorrosive
DMP	Data Management Plan
DNAPL	Dense Non-aqueous Phase Liquid
DO	Dissolved Oxygen
DOD	Department of Defense
DRMO	Defense Reutilization and Marketing Office
DQO	Data Quality Objective
E/A&H	EnSafe/Allen & Hoshall
EBS	Environmental Baseline Survey
E_h	Redox Potential
EIC	Engineer in Charge
ENR	Engineering News Record
EOD	Explosive Ordnance Detachment
EPA	Environmental Protection Agency
ESDLOPQCM	USEPA Environmental Services Division <i>Laboratory Operations and Quality Control Manual</i> (1990)
(ev) ₃	Ionization Potential
EZ	Exclusion Zone
°F	Degree Fahrenheit
FIA	Flame Ionization Analyzer
FID	Flame Ionization Detector
FISC	Fleet Industrial Supply Center
ft ²	Square Feet
GC	Gas Chromatograph
GIS	Geographic Information System
gm	Gram
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCL	Hydrochloric Acid
HASP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendment
IDLH	Immediately Dangerous to Life and Health
IDW	Investigation-Derived Waste
IM	Interim Measure
IR	Installation Restoration
KPEG	Potassium Polyethylene Glycol
L	Liter
LDR	Land Disposal Restriction
LEL	Lower Explosion Limit
LFG	Landfill Gas
LTTD	Low Temperature Thermal Desorption

M&S	Marshall & Stevens
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MD	Maryland
mil	One-thousands of an Inch
ml	Milliter
mg/L	Milligram per Liter
mg/m ³	Milligram per Cubic Meter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
MSW	Municipal Solid Waste
N/A	Not Applicable
NaOH	Sodium Hydroxide
NAVBASE	Naval Base Charleston
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substances Contingency Plan
NCR	NEESA Contract Representative
NCSD	North Charleston Sewer District
NCSV	Non-chlorinated Semivolatile
NCV	Non-chlorinated Volatile
NEESA	Naval Energy and Environmental Support Activity
NFA	No Further Action
NFESC	Naval Facilities Engineering Support Center
NIOSH	National Institute for Occupational Safety and Health
NMOC	Non-methane Organic Compound
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRRC	Naval Reserve Readiness Center
NTU	Nephelometric Turbidity Unit
O ₂	Oxygen
OB/OD	Open Burn/Open Detonation
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenyl
PEL	Permissible Exposure Limit
pH	Hydrogen Ion Measurement
PAH	Polyaromatic Hydrocarbons
PHSO	Project Health and Safety Officer

PID	Photoionization Detector
PMO	Project Management Office
PMP	Project Management Plan
POL	Petroleum, Oil, and Lubricants
Poly	Polyethylene
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
ppm	Parts per Million
PRG	Preliminary Remedial Goal
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAP	Quality Assurance Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAB	Restoration Advisory Board
RAC	Response Action Contractor
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
redox	Oxidation/Reduction Potential
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RGO	Remedial Goal Option
R_f	Radius of Influence
rpm	Revolutions per Minute
RTC	Response to Comments
SAP	Sampling and Analysis Plan
SAR	Supplied Air Respirator
SCBA	Self-contained Breathing Apparatus
SCD	South Carolina Department
SCDHEC	South Carolina Department of Health and Environmental Control
SDIV	Southern Division Naval Facilities Engineering Command
SESE	Shipboard Electronic Systems Evaluation
SHSO	Site Health and Safety Officer
SIOH	Supervision, Inspection and Overhead
SOP QAM	USEPA Environmental Services Division <i>Standard Operations and Quality Assurance Manual</i> (1996)
SOUTHNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SOW	Statement of Work
S/S	Stabilization and Solidification
SSL	Soil Screening-Level
STEL	Short Term Exposure Limit
SVE	Soil Vapor Extraction
SVOC	Semivolatile

SW-846	USEPA <i>Test Methods for Evaluating Solid Waste</i> , 3rd. Ed. (1986)
SWMU	Solid Waste Management Unit
SZ	Support Zone
TBA	To Be Announced
TCLP	Toxicity Characteristic Leaching Procedure
TDC	Thermal Conductivity
TDS	Total Dissolved Solids
TGNMO	Total Gaseous Non-Methane Organic
TIC	Target Indicator Compounds
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TSDF	Treatment, Storage and Disposal Facility
TPH	Total Petroleum Hydrocarbon
TSP	Treatability Study Plan
TSS	Total Suspended Solids
TU	Temporary Unit
UCL	Upper Confidence Limit
USCS	Unified Soil Classification Scheme
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet
UXO	Unexploded Ordnance
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This work plan has been written as a plan addendum to the *Final Comprehensive Sampling and Analysis Plan RCRA Facility Investigation* (E/A&H, August, 1994). It references approved procedures of the final comprehensive RFI sampling and analysis plan and work plan and summarizes proposed treatment technologies, data needs, sampling and analysis procedures and methods, pilot studies, laboratory studies, and bench scale studies. This work plan contains a sampling and analysis plan, a quality assurance plan, data management plan, treatability study plan, and health and safety plan.

Unless otherwise noted, the sampling strategy and procedures will be implemented in accordance with the USEPA Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual*, February 1, 1991 (SOP QAM), included in Volume V of the final comprehensive RFI work plan and revised version dated May 1996. All references to SOP QAM in this document will be based on the May 1996 version, which will be kept onsite to supplement this work plan during all field operations. Sample analyses will be conducted in accordance with the guidance in USEPA *Test Methods for Evaluating Solid Waste, SW-846, 3rd ed.*, Office of Solid Waste and Emergency Response (SW-846), the USEPA Environmental Services Division *Laboratory Operations and Quality Control Manual* (included in Volume V of the comprehensive RFI work plan).

Due to the number and diversity of SWMUs and AOCs to be evaluated at NAVBASE, this work plan does not address site-specific sampling strategies. Instead, that information will be presented in a series of zone-specific work plans to be used in conjunction with this work plan. Each zone-specific work plan will document any deviations from this work plan. The zone-based evaluation rationale is described in greater detail in the comprehensive CMS project management plan. The intent of this approach is to develop a work plan that is independent of the number of evaluation sites, and therefore will not require iterative revisions.

The evaluations will consist of various activities depending upon the nature of the subject site and the work previously completed by Navy contractors. Tasks will likely include, but not be limited to, physical surveys, field sampling, laboratory analysis, bench-scale studies, laboratory treatability studies, and full-scale treatability studies. At a minimum, physical surveys will be conducted at USEPA Data Quality Objective Level II protocol. The field sampling will generally be used to collect samples for treatability. However, field sampling may be needed to further delineate the extent or magnitude of contamination in selected media to evaluate risk. Media to be sampled and analyzed may include soil, groundwater, surface water, sediment, air, and biota.

The laboratories to be used are approved under the Navy's approval program; the QAPs were previously submitted to SCDHEC and USEPA for approval. Laboratories and subcontractors to be used for treatability will be identified on an as-needed basis. Once identified, their QAPs will be submitted to SCDHEC and USEPA for approval. Sample analysis and data collection efforts will satisfy USEPA DQO Level III. Samples submitted may be analyzed at USEPA DQO Level IV for confirmation purposes. Zone-specific work plans will identify when this level is needed. Samples submitted may also be analyzed at USEPA DQO Level IV for treatability purposes. Any laboratory screening procedures will be performed at USEPA DQO Level II. DQO procedures are detailed in Section 5.12 of the SOP QAM and USEPA *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, 1994.

General Facility Information

General information on the facility is provided in the final comprehensive RFI sampling and analysis plan. Information presented includes topography, geology, soil characteristics, surface hydrology, hydrogeology, climatology (temperatures, winds, rainfall, humidity, cloud cover, and climate extremes), and ecological setting (sensitive environments and threatened and endangered species). This information is unchanged.

However, additional information is being added about the facility's geology and hydrogeology as the RFI investigation progresses. This information will be incorporated as each zone is evaluated in the CMS process.

2.0 SAMPLING AND ANALYSIS PLAN

2.1 Sampling Strategy

Before any sampling is conducted, a sampling strategy will be developed. The sampling strategy will consider:

- The possibility of environmental contamination migrating onto and/or off of the facility.
- Specific data needs for various potential presumptive remedies.
- Specific data needs for treatability and technology evaluation.
- Data needs of other related activities such as the risk assessment.
- The specific need for each piece of data.

2.2 Orientation Meeting

Before performing any field activities, personnel will attend an orientation meeting summarizing general and site-specific requirements for sampling, testing, and documentation at NAVBASE. General topics to be discussed will include the base location, the locations of the site office trailer, subject site, decontamination areas within the base, and the comprehensive health and safety plan. Sampling requirements to be discussed will include general sampling protocol, use of proper sampling devices, the sample numbering system, quality assurance/quality control sampling requirements, sample packaging, sample quantities, treatability testing, and investigation-derived wastes. Documentation requirements to be discussed will include the use of field forms, field logbooks, and documentation of photographs.

2.3 General Sampling Requirements

Sampling and analysis procedures and methods which may be used to evaluate data for the CMS and were not included in the comprehensive RFI sampling and analysis plan are specified in Appendix A. Based upon the data needs for the individual treatment technologies, a list of potential treatability studies was compiled, including laboratory, bench-scale, and pilot-scale testing. These studies are outlined in Section 5. In addition, procedures for various physical

measurements that may be required to assess the proposed treatment technologies are outlined in Section 2.3.2 and Section 2.3.3, and air sampling as outlined in Section 2.3.4.

2.3.1 Corrective Measures Technology Matrix

Treatment technologies, including data quality needs, are summarized in Tables 2-1 and 2-2.

2.3.2 Sampling Procedures

General procedures for field personnel to follow when collecting environmental samples and performing treatability testing are included in this section. Detailed surveying, well installation, aquifer testing, and sampling procedures are discussed in Sections 4 to 10 of the comprehensive RFI sampling and analysis plan and Sections 5 through 14 of the SOP QAM. These general procedures are designed to prevent cross-contamination of samples and valid samples which are representative of the site conditions. All forms cited in the comprehensive RFI work plans will be used accordingly. Table 2-3 lists the procedures presented in the final comprehensive RFI sampling and analysis plan and their respective section and page numbers.

2.3.3 Water Measurements

Measurement of Open Channel (Non-Pressure) Flow

The most common way to measure an open channel's flow rate is to insert a hydraulic structure into the channel which changes the level of liquid in or near the structure. By selecting the shape and dimensions of the hydraulic structure, the rate of flow through or over the restriction will be related to the liquid level in a known manner. Thus, the flow rate through the open channel can be derived by measuring the liquid level.

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Table 2-1
 Treatment Technologies Screening Matrix

Applicable
 Zone #
 5.105

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Soil and Sediment</i>			
Natural Attenuation	N/A	Nonhalogenated VOCs; SVOCs; Fuel Hydrocarbons; PCBs	Temperature; Moisture Content; Permeability; pH; Soil Homogeneity and Isotropy; Humic Content; Total Organic Content; Biochemical Oxygen Demand; Redox Potential; Nutrient Level; Flow Gradient
Incineration	N/A	CV; NCV; CSV; NCSV; PCBs; Pesticides/Herbicides; Dioxins	Moisture Content; Soil Classification; Soil Fusion Temperature; BOD; COD; TOC; Soil Heating Value; Permeability; Particle-Size Distribution
Thermal Treatment	Thermal Destruction	PCBs; SVOCs	Organic/Inorganic Water Chemistry; Particle Size; Moisture Content; Btu Content; TCLP
	Thermal Desorption	CV; NCV; CSV; NCSV; PCBs; Pesticides/Herbicides; Dioxins; TPH	Organic/Inorganic Water Chemistry; Particle Size; Moisture Content; TCLP
	Steam Extraction	CV; NCV	Permeability; Moisture Content; Soil Homogeneity and Isotropy; Soil Texture; Bulk Density; Depth to Groundwater
	Vitrification (In situ/Ex situ)	CSV; NCSV; PCBs; Dioxins; Inorganics; Pesticides/Herbicides	Moisture Content; Soil Classification; Soil Fusion Temperature; Particle Size; Alkali Content; Depth to Groundwater

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Soil and Sediment</i>			
Biological Treatment	Ex situ (Landfarming, Composting)	NCV; CSV; NCSV; Pesticides/Herbicides; TPH	Organic/Inorganic Water Chemistry; Moisture Content; Soil Texture; Temperature; pH; Soil Microorganisms; Total Nitrogen; Total Phosphorus; Total Organic Carbon
	In situ (Bioventing, Biodegradation)	NCV; CSV; NCSV; Pesticides/Herbicides; TPH	Organic/Inorganic Water Chemistry; Moisture Content; Soil Texture; Permeability; Temperature; pH; Total Nitrogen; Soil Microorganisms; Methane; Total Phosphorus; Depth to Groundwater; Total Organic Carbon
Physical Treatment	Soil Washing	CV; NCV; CSV; NCSV; PCBs; Pesticides/Herbicides; Inorganics	Soil Type; Particle-Size Distribution; Moisture Content; Soil Texture; pH; Organic Content; Bulk Density; Permeability; Oil and Grease
	Solidification/ Stabilization	CSV; NCSV; PCBs; Dioxins; Pesticides/Herbicides; Inorganics	Organic/Inorganic Water Chemistry; Moisture Content; Soil Texture; Temperature; pH; Suspended Solids; Bulk Density; Grain-Size Analysis; Atterberg Limits; Cone Index; Unconfined Compressive Strength

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Soil and Sediment</i>			
Physical Treatment	Vacuum Extraction	NCV, CV	Organic/Inorganic Water Chemistry; Moisture Content; Air Permeability; Temperature; Depth to Groundwater; pH
	Solvent Extraction	NCV; CSV; NCSV; TPH	Organic/Inorganic Water Chemistry; Total Organic Carbon; Total Recoverable Hydrocarbons; Moisture Content; Soil Texture; Permeability; Bulk Density; Grain-Size Analysis; Clay Content; pH; Temperature; Chemical Oxygen Demand; Cation-Exchange Capacity; Depth to Groundwater; TCLP
	Soil-Vapor Extraction (SVE)	CV; NCV; TPH	Wet Density; Dry Density; Moisture Content; Coefficient of Permeability; Depth to Groundwater; Soil Texture; Soil Homogeneity and Isotropy
	Filter Press	Inorganics	Wet Density; Moisture Content; Soil Texture; Solids Content
Chemical Treatment	Dehalogenation (Base-Catalyzed Decomposition/Glycolate)	Pesticides/Herbicides; PCBs; Dioxins	Total Organic Halides; Humic Content; Moisture Content; Permeability
	Chemical Oxidation/Reduction	Inorganics; Pesticides; PCBs	Organic/Inorganic Water Chemistry; Indicator Parameters; Bicarbonate; Calcium; Chemical Oxygen Demand; Chloride; Zinc; Copper; Iron; Manganese; Nickel; Magnesium; Oil and Grease; pH; Potassium; Sodium; Sulfate; Total Organic Carbon Total Suspended Solids; (Pilot- reagent consumption, optimal pH, and reaction time)
<i>Groundwater/Leachate</i>			
Natural Attenuation	N/A	Nonhalogenated VOCs; SVOCs; Fuel Hydrocarbons; PCBs	Temperature; Moisture Content; pH; TOC; BOD; COD; Oil and Grease; Suspended Solids

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Groundwater/Leachate</i>			
Biological Treatment	Ex situ (Bioreactors)	CV; NCV; CSV; NCSV; TPH; Pesticides/Herbicides	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Metals, dissolved; Ammonia; Kjeldahl; Nitrate- nitrite; Total Organic Carbon; Phosphorus; Total Solids; Specific Conductance; Temperature; pH; Dissolved Oxygen; Chemical Oxygen Demand
	In situ (Air Sparging)	CV; NCV; CSV; NCSV; TPH; Pesticides/Herbicides	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Metals, dissolved; Ammonia; Kjeldahl; Nitrate- nitrite; Total Organic Carbon; Phosphorus; Total Solids; Specific Conductance; pH; Dissolved Oxygen; Chemical Oxygen Demand
	Natural Wetlands	CV; NCV; CSV; NCSV; TPH; Pesticides/Herbicides	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Metals, dissolved; Ammonia; Kjeldahl; Nitrate- nitrite; Total Organic Carbon; Phosphorus; Total Solids; Specific Conductance; pH; Dissolved Oxygen; Chemical Oxygen Demand; Toxicity Test
Chemical Treatment	Ion Exchange	Inorganics	Organic/Inorganic Water Chemistry; Indicator Parameters; Bicarbonate; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Zinc; Copper; Iron; Manganese; Nickel; Magnesium; Oil and Grease; pH; Potassium; Sodium; Sulfate; Total Organic Carbon Total Suspended Solids

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Groundwater/Leachate</i>			
Chemical Treatment	Oxidation/ Reduction	CV; NCV; CSV; NCSV; PCBs; Pesticides/Herbicides; Dioxins; TPH	Organic/Inorganic Water Chemistry; Indicator Parameters; Bicarbonate; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Zinc; Copper; Iron; Manganese; Nickel; Magnesium; Oil and Grease; pH; Potassium; Sodium; Sulfate; Total Organic Carbon Total Suspended Solids; (Pilot- reagent consumption, optimal pH, and reaction time)
	Metal Precipitation	Inorganics	Organic/Inorganic Water Chemistry; Indicator Parameters; Bicarbonate; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Zinc; Copper; Iron; Manganese; Nickel; Magnesium; Oil and Grease; pH; Potassium; Sodium; Sulfate; Total Organic Carbon Total Suspended Solids; (Pilot- chemical dosage, contact time, mixing rate, optimal pH, and sludge handling)
	pH Adjustment	N/A	Indicator Parameters; Bicarbonate; Calcium; Chloride; Iron; Sodium; Magnesium; Manganese; Potassium; Sulfate; Total Suspended Solids; pH; (Pilot-titration curve)
	UV/Ozone Oxidation and UV Reduction	Petroleum Hydrocarbons; Chlorinated Hydrocarbons; Ordnance Compounds; Organic Compounds; Aromatic Compounds	pH; Temperature; BOD; TOC; COD; E ₂ (redox potential)

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Groundwater/Leachate</i>			
Physical Treatment	Adsorption (granular activated carbon)	CV; NCV; CSV; NCSV; Inorganics; Pesticides/Herbicides	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Dissolved Oxygen; Hardness; Iron; Metals, dissolved; Manganese; Ammonia; Kjeldahl; pH; Nitrate-nitrite; Oil and Grease; Organic Carbon; Sulfide; Phosphorus; Sulfate; Suspended Solids
	Filtration	Inorganics	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Dissolved Oxygen; Hardness; Iron; Metals, dissolved; Manganese; Ammonia; Kjeldahl; pH; Nitrate-nitrite; Oil and Grease; Organic Carbon; Sulfide; Phosphorus; Sulfate; Suspended Solids
	Sedimentation/Dissolve Air Floatation	Inorganics	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Dissolved Oxygen; Hardness; Iron; Metals, dissolved; Manganese; Ammonia; Kjeldahl; pH; Nitrate-nitrite; Oil and Grease; Organic Carbon; Sulfide; Phosphorus; Sulfate; Suspended Solids
	Air Stripping	CV; NCV; CSV; TPH	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Chemical Oxygen Demand; Hardness; Iron; Manganese; Metals, dissolved; Oil and Grease; pH
	Oil/Water Separation	CV; NCV; CSV; TPH; Inorganics	General Water Chemistry; Flow Rates; Phase; Droplet Size

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
Groundwater/Leachate			
Thermal Treatment	Wet Air Oxidation	CV; NCV; CSV; TPH; Inorganics	Btu Value; Moisture Content; Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Organic Carbon; Sulfide; Phosphorus; Sulfate; Total Solids
Wells	Directional Wells	None	General Geological Parameters; Groundwater Table; Underground Utilities
	Passive Wells	CSV; Inorganics	Hydraulic Permeability; Water Table Depth; Contaminant Phase; Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chemical Oxygen Demand; Chloride; Dissolved Oxygen; Hardness; Iron; Metals, dissolved; Manganese; Ammonia; Kjeldahl; pH; Nitrate-nitrite; Oil and Grease; Organic Carbon; Sulfide; Phosphorus; Sulfate; Suspended Solids
Extraction	Dual Phase/Free Product	None	Depth to Water Table; Product Phase; Product Density
Air			
Chemical Treatment	Oxidation/Reduction	CV; NCV; CSV; NCSV; PCBs; TPH; Pesticides/Herbicides; Dioxins	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Residual Contaminant Composition
Biological Treatment	Biofilters	NCV; NCSV; TPH;	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Residual Contaminant Composition
Physical Treatment	Adsorption	CV; NCV; CSV; NCSV; Inorganics	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Residual Contaminant Composition
Physical Treatment	Filtration	Inorganics	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Residual Contaminant Composition

**Table 2-1
 Treatment Technologies Screening Matrix**

Technology	Process Option	Contaminants Treated	Data Quality Needs
<i>Air</i>			
Physical Treatment	Scrubbers	Inorganics	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Residual Contaminant Composition
	Electrostatic Precipitators	Inorganics	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates;
	Condensers	NCV; CV; NCSV; CSV	Air/Oxygen Supply; Flow Rates; Mass Transfer Rates; Contaminant Density
	Dust Suppressants	None	Particle Size; Moisture Content

Notes:

- | | |
|--|-------------------------------------|
| CV - Chlorinated Volatiles | BOD - Biological Oxygen Demand |
| NCV - Nonchlorinated Volatiles | COD - Chemical Oxygen Demand |
| CSV - Chlorinated Semivolatiles | TOC - Total Organic Carbon |
| NCSV - Nonchlorinated Semivolatiles | TCLP - Toxicity Leachate Procedures |
| PCBs - Polychlorinated Biphenyls | |
| TPH - Total Petroleum Hydrocarbons | |
| SVOCs - Semivolatile Organic Compounds | |
| N/A - Not Applicable | |

**Table 2-2
 Removal/Containment/Disposal Options**

Action	Process Option	Data Quality Needs
<i>Soil and Sediment</i>		
Cap	Native Soil Single Barrier Double Barrier	Moisture Content; Permeability; In-situ Density; Atterberg Limits; Grain-Size Analysis; Porosity; Depth
Excavation	Dig Up	Organic/Inorganic Water Chemistry; Moisture Content; Permeability; In-situ Density; Atterberg Limits; Porosity; Depth; Grain Size Analysis
Surface Water Controls	Erosion and Runon/Runoff Controls	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Phosphorus; Ammonia; Kjeldahl; Nitrate and Nitrite; Total Suspended Solids
Disposal	Consolidation	Organic/Inorganic Water Chemistry; Moisture Content; Permeability; In-situ Density; Atterberg Limits; Grain-Size Analysis; Depth to Groundwater; TCLP
	RCRA TSDF and Landfills	Organic/Inorganic Water Chemistry; Moisture Content; Soil Texture; Temperature; pH; TCLP; Soil Microorganisms; Total Nitrogen; Total Phosphorus; Depth to Groundwater; Dissolved Oxygen
<i>Groundwater/Leachate</i>		
Vertical Barrier	Slurry Wall	Organic/Inorganic Water Chemistry; Soil Type; Soil Moisture; Particle-Size Distribution; Porosity; Hydraulic Conductivity (saturated and unsaturated); Relative Permeability; Clay Content; Soil Sorptive Capacity; Cation Exchange Capacity; Organic Carbon Content; Soil pH; Depth to Groundwater; Groundwater Velocity and Direction; Depth to Aquitard; (Pilot-compatibility testing with slurry wall material)

**Table 2-2
 Removal/Containment/Disposal Options**

Action	Process Option	Data Quality Needs
<i>Groundwater/Leachate</i>		
Groundwater Collection	Vertical Extraction Wells	Use of Aquifer; Depth to Water Table; Direction of Flow; Rate of Flow; Hydraulic Conductivity (vertical and horizontal); Effective Porosity; Aquifer Type; Hydraulic Gradient; Identification of Recharge and Discharge Areas; Identification of Aquifer Boundaries; Aquitard Characteristics; (Pilot-slug test)
Leachate Collection	Subsurface Drains	Use of Aquifer; Depth to Water Table; Direction of Flow; Rate of Flow; Hydraulic Conductivity (vertical and horizontal); Effective Porosity; Aquifer Type; Hydraulic Gradient; Identification of Recharge and Discharge Areas; Identification of Aquifer Boundaries; Aquitard Characteristics; (Pilot-slug test)
Disposal	POTW and NPDES	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chloride; Hardness; Metals, dissolved; Manganese; Ammonia; Kjeldahl; Nitrate and Nitrite; Oil and Grease; Organic Carbon; Phosphorus; Total Solids; Specific Conductance; Sulfate; Sulfide; Suspended Solids; Dissolved Oxygen; Chemical Oxygen Demand

**Table 2-2
 Removal/Containment/Disposal Options**

Action	Process Option	Data Quality Needs
<i>Groundwater/Leachate</i>		
Disposal	RCRA TSDF	Organic/Inorganic Water Chemistry; Indicator Parameters; Acidity-Alkalinity; Biochemical Oxygen Demand; Calcium; Chloride; Hardness; Metals, dissolved; Manganese; Nitrogen, ammonia; Nitrogen, kjeldahl; Nitrogen, nitrate-nitrite; Oil and Grease; Organic Carbon; Phosphorus; Total Solids; Specific Conductance; Sulfate; Sulfide; Suspended Solids; Dissolved Oxygen; Chemical Oxygen Demand
	Land Application	Depth to Water Table; Total Phosphorus; Chloride; Ammonia; Nitrate; Alkalinity; pH; Sodium; Total Dissolved Solids; Soil Type; Hydraulic Conductivity; Application Rate
	Injection	Depth to Water Table; Total Phosphorus; Chloride; Ammonia; Nitrate; Alkalinity; pH; Sodium; Total Dissolved Solids; Total Organic Carbon; Soil Type; Hydraulic Conductivity; Application Rate (2.5 gallons/ft ² /day or 5/square root of slowest percolation rate)

Notes:

Other technologies included are: dredging, sewer line inspection, long-term monitoring, institutional controls, and intrinsic remediation.

**Table 2-3
 List of Approved Sampling Procedures**

Procedure	Comprehensive RFI Sampling & Analysis Plan Section Number	Comprehensive RFI Sampling & Analysis Plan Page Number
Well Inventory	3.1	3-1
Magnetometer Survey	3.2.1	3-2
Electromagnetic Induction Survey	3.2.2	3-7
Cadastral Survey/Geodetic Survey	3.3	3-8
Designating Soil Collection Locations	4.1	4-1
Soil Description	4.2	4-2
Dexsil Cl- Screening	4.3.1	4-2
Immunoassay Screening	4.3.2	4-8
Surface Soil Sample Collection	4.4	4-8
Hand-Augering Sample Collection	4.5	4-10
Sample Collection by Drill Rig/Backhoe	4.6	4-11
Split-Barrel Sampling	4.6.1	4-12
Shelby Tube Sampling	4.6.2	4-14
Test Trenching	4.6.3	4-16
Monitoring Well Permitting	5.1	5-1
Monitoring Well Designations	5.2	5-2
Drilling Methods	5.3	5-2
Monitoring Well Construction	5.4	5-3
Filter Pack Material and Screen Slot Size Design	5.4.1	5-4
Monitoring Well Installation (Unconfined Aquifers)	5.4.2	5-4
Monitoring Well Installation (Confined Aquifers)	5.4.3	5-16

**Table 2-3
 List of Approved Sampling Procedures**

Procedure	Comprehensive RFI Sampling & Analysis Plan Section Number	Comprehensive RFI Sampling & Analysis Plan Page Number
Temporary Monitoring Well Installation for Groundwater Screening (Unconfined Aquifers)	5.4.4	5-20
Developing Monitoring Wells	5.5	5-21
Groundwater Sampling	6.0	6-1
Hydropunch	6.1.1	6-1
Temporary Monitoring Wells	6.1.2	6-2
Purging Static Water	6.2	6-2
Groundwater Sampling	6.3	6-7
Sediment/Surface Water Sampling Procedures	7.0	7-1
Designating Sediment/Surface Water Sample Collection Locations	7.1	7-1
Sediment Sampling	7.2	7-1
Dredge Samples	7.2.1	7-2
Core Samples	7.2.2	7-3
Scoop Samples	7.2.3	7-5
Surface Water Sampling	7.3	7-6
Submerging Laboratory Bottles	7.3.1	7-8
Kemmerer Sampler	7.3.2	7-9
Air Sampling	8.0	8-1
Soil-Gas Survey	8.1	8-1
Passive Soil Gas	8.2	8-3
Ambient and Indoor Air	8.3	8-6
Miscellaneous Sampling Techniques	9.0	9-1
Wipe Sampling	9.1	9-1
Waste Sampling	9.2	9-2

Table 2-3
List of Approved Sampling Procedures

Procedure	Comprehensive RFI Sampling & Analysis Plan Section Number	Comprehensive RFI Sampling & Analysis Plan Page Number
Soil and Sludge Sampling	9.2.1	9-4
Thin-Walled Tube Sampler	9.2.2	9-4
Aqueous Liquid Sampling	9.2.3	9-5
Ancillary Data Collection	10.0	10-1
Hydrolab Datasonde	10.1	10-1
Current Meter	10.2	10-1
Rain Gauge	10.3	10-1
Water Level Indicator	10.4	10-1
Secchi Disk	10.5	10-2
Hydrological Assessment	10.6	10-2
Slug Testing	10.6.1	10-5
Pumping Tests	10.6.2	10-8
Tidal Influence Study	10.6.3	10-9
Radioactivity Screening - Gamma Sources	10.7	10-9

The hydraulic structures used in measuring flow in open channels are referred to as primary measuring devices, and may be separated into two categories—weirs and flumes. A weir is essentially a dam built across an open channel over which the liquid flows, usually through some type of opening or notch. Each type of weir has an associated equation for determining the flow rate through it. A flume is a specially shaped open channel flow section with an area or slope, or both, that is different from that of the channel. This results in an increased velocity and change in the level of the liquid flowing through the flume.

A secondary measuring device (or open channel flow meter) is used in conjunction with a primary measuring device to measure liquid flow rate in an open channel. The secondary measuring device has two purposes: (1) to measure the liquid level in the primary measuring device, and (2) to convert this liquid level into an appropriate flow rate. Some of the more commonly used methods for liquid level measurements are: floats, electrical, ultrasonic, bubbler, mechanical cam, electronic analog function generator, electronic digital function generator, electronic memory device, and software.

Measurement of Open-Channel (Pressure) Flow

The following methods/devices for measuring open-channel pressure flow were adapted from the SOP QAM:

Venturi Meter: The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is given at 1 to 2%.

Orifice Meter: This pressure differential device measures flow by the difference in static head. Orifice meters require from 40 to 60 pipe diameters of straight pipe upstream of the installation. They can be quite accurate (i.e., within 0.5%), although their usable range is limited.

Flow Nozzle: The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat, but lacks the diverging section of the Venturi. Flow nozzle accuracies can approach those of Venturi meters.

Electromagnetic Flow Meter: The electromagnetic flow meter operates according to Faraday's law of induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within $\pm 1\%$ of full scale.

2.3.4 Air Measurements

The following air test methods were adapted from Title 40 CFR 60, Appendix A and should be followed when conducting tests for these specific parameters.

Method 2E: Determination of landfill gas and gas production flow rate.

Principle: Extraction wells are installed either in a cluster of three or at five locations dispersed throughout the landfill. A blower is used to extract landfill gas from the landfill. Landfill gas composition, landfill pressures near the extraction well, and volumetric flow rate of landfill gas extracted from the wells are measured, and the landfill gas production flow rate is calculated.

Method 25: Determination of total gaseous nonmethane organic emissions as carbon in source emissions.

Principle: An emission sample is withdrawn from the stack at a constant rate through a heated filter and a chilled condensate trap by an evacuated sample tank. After sampling is completed, the total gaseous nonmethane organics are determined by independently analyzing the condensate trap and sample tank fractions and combining the analytical results.

Method 25A: Determination of total gaseous organic concentration using a flame ionization analyzer.

Principle: A gas sample is extracted from the source through a heated sample line, if necessary, and glass fiber filter to a flame ionization analyzer (FIA). Results are reported as volume concentration equivalents of the calibration gas or as carbon equivalents.

Method 25C: Determination of nonmethane organic compounds (NMOC) in municipal solid waste landfill gases.

Principle: A sample probe perforated at one end is driven or augered to a depth of 1.0 meter below the bottom of the landfill cover. A sample of the landfill gas is extracted with an evacuated cylinder. The NMOC content of the gas is determined by injecting a portion of the gas into a gas chromatographic column to separate the NMOC from carbon monoxide (CO), carbon dioxide (CO₂), and methane (CH₄); the NMOCs are oxidized to CO₂, reduced to CH₄, and measured by a flame ionization detector (FID).

Method 25D: Determination of the volatile organic concentration of waste samples.

Principle: A sample of waste is obtained at a point which is most representative of the unexposed waste (where the waste has had minimum opportunity to volatilize to the atmosphere). The sample is suspended in an organic/aqueous matrix, then heated and purged with nitrogen for 30 minutes to separate certain organic compounds. Part of the sample is analyzed for carbon concentration, as methane, with an FID, and part of the sample is analyzed for chlorine concentration, as chloride, with an electrolytic conductivity detector. The volatile organic concentration is the sum of the carbon and chlorine content of the sample.

Method 3C: Determination of carbon dioxide, methane, nitrogen, and oxygen from stationary sources.

Principle: Sample collection procedures described in Method 25C should be used to collect samples of landfill gas. A portion of the sample is injected into a gas chromatograph and the CO₂, CH₄, N₂, and O₂ concentrations are determined by using a thermal conductivity detector and integrator.

2.4 Managing Samples

Samples will be managed in accordance with Sections 3 and 5.13 of the SOP QAM and Section 11 of the final comprehensive RFI sampling and analysis plan. In addition, analytical

methods, sample containers, preservatives, and hold times for other likely parameters are presented in Appendix A of this report.

Sample packaging will follow both SOP QAM's Appendix D and the U.S. Department of Transportation regulations, 49 Code of Federal Regulations, Parts 172 and 173. Treatability samples generally have a larger volume samples than environmental samples, but require the same care as environmental samples. Treatability samples do not always require preservation.

All samples will be labeled as shown in Section 11.4 of the final comprehensive RFI work plan. Sample custody or possession will be traceable from the time the sample is collected to its delivery at the analytical laboratory. Refer to Sections 3.2 and 5.13 of the SOP QAM and Section 11.5 of the final comprehensive RFI sampling and analysis plan. Samples will be transferred in accordance with Section 3.3.4 of the SOP QAM and Section 11.6 of the final comprehensive RFI sampling and analysis plan.

2.5 Analysis

The quality assurance and quality control objectives for parameters to be measured in the field and in the laboratory for environmental samples were provided in Section 12 of the final comprehensive RFI sampling and analysis plan. Treatability sample parameters may require different field and laboratory QA/QC objectives, which will be identified in zone-specific work plans.

2.6 Decontamination

Decontamination procedures will be performed in accordance with Section 4.3.6 and Appendices B and C of the SOP QAM and Section 15 of the final comprehensive RFI sampling and analysis plan. Decontamination will apply to equipment and personnel.

2.7 Investigation-Derived Waste

Investigation activities and decontamination procedures will generate a quantity of hazardous waste (e.g., contaminated solvents, disposable equipment) called investigation-derived waste. This waste will be handled and disposed of in accordance with Section 5.15 of the SOP QAM and Section 16 of the final comprehensive RFI sampling and analysis plan.

3.0 QUALITY ASSURANCE/QUALITY CONTROL PLAN

3.1 Introduction

The policies, project organization, objectives, and functional activities, along with QA/QC measures contained in the final comprehensive RFI work plan are adopted. Additions or changes are provided below.

This document is intended to fulfill requirements for ensuring all work will be conducted in accordance with QA/QC protocols and field procedural protocols for environmental monitoring and measurement data.

Applicable Guidance Documents:

The U.S. Environmental Protection Agency's *Standard Operating Procedures and Quality Assurance Manual*, May 1996 is the only applicable guidance document added or changed.

3.2 QA/QC Objectives

The quality assurance objectives provided in the final comprehensive RFI work plan remain applicable and will be followed unless specific reasons are given in zone-specific work plans.

3.3 Organization and Responsibilities

Organization and responsibilities remain the same as those in the final comprehensive RFI work plan unless changed in a zone-specific work plan.

Applicable Regulations:

USEPA's regulations for Hazardous Waste, Title 40 Code of Federal Regulations, Parts 260 through 280 specifically apply. South Carolina Hazardous Waste Management Regulations (SCWHMR R.61-79) of December 27, 1996, also apply.

4.0 DATA MANAGEMENT PLAN

This section describes the methods to be used throughout the technology evaluation process to document field work, treatability work, and modeling work, and manage collected data. The procedures and polices provided in the final comprehensive RFI work plan are to be followed. The following sections provide additional procedures to be followed.

4.1 Field Documentation

The field project manager will be thoroughly familiar with appropriate documentation procedures. In addition to general field documentation, master site logbook, field logbook, and sample logbook procedures, the field manager will be familiar with treatability logbook procedures.

Treatability Logbook: A treatability logbook will be used to compile a record of events, procedures, and samples collected and shipped (including QA/QC samples), analyses requested, the air bill number of the shipment, and any pertinent information concerning sample status. This logbook will also be used to record the observations made while conducting the treatability study.

The final comprehensive RFI work plan sections on field data record forms, sample labels, chain-of-custody records, subsurface boring logs, monitoring well construction diagrams, and photographs apply. In addition, treatability and modeling record management procedures are added.

Treatability Records: Records generated as a result of performing treatability studies will explain how the study was performed, observations made, and any other necessary information which would allow the study to be duplicated.

Modeling Records: Model records will include procedures, assumptions used, calibration run results and final run results, and any other information which would allow a reviewer to adequately review the modeling efforts.

4.2 Data Deliverables

The final comprehensive RFI work plan data deliverables elements apply. In addition, CMS-specific data deliverables (eg, results of treatability studies or additional soil/groundwater sampling activities) apply.

4.3 Analytical Data Validation

The final comprehensive RFI work plan analytical data validation elements apply.

4.4 Other Related Data

The final comprehensive RFI work plan other related data elements apply.

4.5 Reports

Progress Reports: Monthly progress reports prepared by the project manager will include the number of samples collected, sites investigated, monitoring wells installed, any deviations from approved field or laboratory procedures, technology evaluation progress, treatability study status, modeling status, and other appropriate information. These reports will be directed to the EIC.

Zone Reports: The zone CMS report will be written after the technology has been evaluated, treatability studies have been completed, modeling has been completed, sampling is completed, and all laboratory analyses have been validated. The report will consolidate and summarize collected data and document the unit evaluation. An initial draft report will be submitted for comment by the Navy, USEPA and SCDHEC. Where appropriate, comments will be incorporated into the final document.

Final Report: Final zone CMS reports will be prepared and submitted to the Navy, USEPA and SCDHEC addressing draft comments. A comprehensive final CMS report will be written after all the zone reports have been submitted to USEPA and SCDHEC for review and comment. The final report will be comprehensive, addressing the NAVBASE as a whole. The report will consolidate and summarize the results and conclusions presented in each zone report.

Interim reports or technical memorandums will be completed as necessary to describe significant divergence of site conditions from those anticipated, secure concurrence on the need for emergency or interim corrective measures, or to gain regulatory input on unanticipated issues.

Tables, Graphs, and Illustrations: Data obtained from sampling and analysis procedures will be summarized and presented in tables, supported by raw laboratory reports submitted to the EIC under separate cover. The EIC is Mr. Matthew A. Hunt of SOUTHNAVFACENCOM who is responsible for the technical and financial management of the Installation Restoration Project at Charleston Naval Base. Several formats will be used to present sampling results graphically. Isoconcentration maps will be developed for soil and groundwater parameters, if possible. In addition, maps showing sample locations and results will also be completed. Groundwater surface contours, along with flow direction and gradient will also be displayed on the site base maps. Cross-sectional plots may be used if they would enhance understanding of the site.

Diagrams and schematics of technologies and/or treatment trains will present general flow diagrams and system controls. Cost will be presented in tabular format. Forms completed during the investigation will be included in appendices of the report.

Accumulated data and analytical results will be interpreted as a project team effort. The expertise of each project team member will be used to develop proper conclusions and recommendations. The final decision about interpretation of data for the report will lie with the task order manager and the South Carolina-registered Professional Engineer and Geologist.

5.2.4 Steam Injection

Purpose: In this process, steam is forced into the subsurface through injection wells to vaporize volatile and semi-volatile contaminants. Vaporized components rise to the Vadose zone where they are removed by vacuum extraction and then treated. This process can be used to remediate large areas of oily waste accumulations and to retard downward and lateral migration of the organic contaminants. The process is applicable to shallow and deep contaminated soils.

Steam injection technology can be applied at gas plants, wood treating sites, petroleum-refining facilities and other sites with soil containing light to dense organic liquids. Factors that may limit the applicability and effectiveness of the process include soil type, geology, and hydrogeology.

Methodology: When steam is initially injection into a well, it heats the well bore and the formation around the injection zone of the well. The steam condenses as the latent heat of vaporization of water is transferred from the steam to the well bore and porous media where it enters the formation. As more steam is injected the hot water moves into the formation, pushing the water initially in the formation further into the porous media. When the porous media at the point of steam injection has absorbed enough heat to reach the temperature of the injected steam, steam itself actually enters the media, pushing the cold water and the bank of condensed steam in front of it.

As these free flowing fluids approach a region that contains the volatile contaminant at saturations greater than the residual saturation, the contaminant is displaced. First to come in contact with the contaminant is cold water, then the hot water bank, and finally the steam front. The cold water will flush the mobile contaminant from pores. The hot water will reduce the viscosity of the contaminants, making it easier to be displaced by viscous forces. When the steam reaches the contaminated area, no additional contaminant can be recovered by viscous forces. Additional

recovery is achieved by volatilization, evaporation and steam injection distillation of the volatile and semi-volatile contaminants.

Evaluation: The bench scale testing will be performed on three undisturbed samples collected using thin-walled sampling tubes and standard drilling techniques. The samples will be set up in the lab so that steam can be applied at the base of the sample and a vacuum applied at the top to collect and remove volatilized hydrocarbons. Continued steam injection and vacuum extraction then produces a fractional distillation of the contaminants with the most volatile compounds being recovered first. Vapor and aqueous samples will be collected at regular intervals and analyzed to determine the amount of contaminants removed. Data compilation of the details of the steam injection bench study such as steam injection rate, injection pressure, temperature, steam quality, contaminant recovery, and injection depth will be evaluated by laboratory experimentation.

Equipment requirements for bench-scale steam injection test are soil contaminant units, steam generator, the distribution system for injection, extraction system, coolers/condensers for the extracted fluids, and contaminant/sampling vessels for organic hydrocarbons that are recovered.

5.2.5 Bench-Scale Aerobic Bioremediation Study

Purpose: The bioremediation treatability study is the precursor to the biosparging groundwater pilot study. Biosparging is the gentle introduction of air into the groundwater to supply oxygen for aerobic degradation of organic compounds. Introduction of air at low flow rates and pressures minimizes volatilization and maximizes biodegradation. Along with air, nutrients and exogenous microorganisms can also be added to stimulate and enhance the aerobic remediation process. Aerobic mechanisms may be either direct microbially-mediated oxidation of the contaminant which is the primary substrate; or, often takes the form of cometabolic oxidation in which the contaminant of concern is not the primary substrate but gets fortuitously degraded along with a simultaneous aerobic degradation process of other organic compounds in the aquifer. The purpose

of the bench-scale study is to measure the potential of biodegradation of site groundwater contamination by aerobic mechanisms, biostimulation, and bioaugmentation before implementing biosparging in the field.

Methodology: Soil column testing is the technique by which potential for aerobic bioremediation of groundwater is examined in the laboratory. Soil column testing provides the required information to evaluate the feasibility of in situ bioremediation (biosparging) of groundwater. It is also used to determine the oxygen, nutrient, and exogenous microbe addition for in situ bioremediation. Soil column studies are to be performed from soil obtained from a subsurface location representative of the site. The location is preferably from the saturated portion of the subsurface.

Evaluation: Triplicate columns are set up for the soil samples collected from the saturated subsurface. Soil is packed in the columns to a bulk density that simulates the bulk density and the porosity in the field. Water which is enriched with oxygen will be continuously flushed through the three soil columns. In addition, water being flushed through one of the columns will have nutrients; and through the third column will have nutrients and exogenous microorganisms. The soil columns will remain in the saturated state throughout the study by being operated in the upflow mode. Peristaltic pumps will be used to pump water through the columns at an accelerated flow rate in order to achieve maximum treatment in the available time. Effluent water will be monitored weekly for dissolved oxygen, pH, redox potential, inorganic nutrients, microbial plate counts, and chemicals of concern. Soil samples from the columns will be tested periodically during the study. The results of the study will enable the proper design of pilot and full-scale biosparging and determine the most suitable conditions under which biosparging will occur at the site.

5.2.6 Bench-Scale Anaerobic-Aerobic Sequential Bioremediation Study

Purpose: This technology is designed to treat a mixture of chlorinated and non-chlorinated solvents in saturated soil and groundwater by applying its 2-zone plume interception in-situ biological treatment. The purpose of the bench-scale study is to: (a) understand the factors that affect the development of the bio-active zones; (b) demonstrate the treatment of chlorinated and non-chlorinated solvent mixtures using the 2-phase process; and (c) develop a model for use in the design of field remediation.

Theory: The first zone in the treatment system is anaerobic and promotes the reductive dechlorination of highly chlorinated solvents, such as perchloroethylene. Immediately downgradient is the second zone, where special aerobic conditions encourage the biological oxidation of the partially dechlorinated products from the first zone, as well as other compounds.

The first step of the treatment for compounds such as perchloroethylene and trichloroethane is to encourage partial dechlorination by stimulating the growth of methanogenic bacteria in the saturated soil. This is accomplished by providing the bacteria with a primary carbon source such as glucose, and with mineral nutrients, such as ammonia and phosphate. Methanogenic bacteria are considered to be ubiquitously distributed in a saturated soil.

At the completion of the first step (the anaerobic step) in the treatment process, all of the more highly chlorinated ethenes and ethanes (PCE, TCE, and TCA) in a contaminated plume are converted to less chlorinated forms (DCE, DCA) by methanogenic bacteria. At a point downgradient, oxygen is reintroduced to the groundwater. Following this, methanogenic bacteria growing on methane and oxygen are expected to oxidize the DCE and DCA to carbon dioxide and biomass.

Evaluation: The bench-scale study to evaluate this technology is performed in PVC or plexiglass bioreactors which have two chambers and a flow through process. The first chamber is strictly anaerobic while air is gently sparged into the second. The required nutrients such as nitrogen and phosphate and glucose are supplied to the two reactors. If required, a sacrificial reactor is run which is a control that estimates the contaminant reduction due to volatilization. The rate of flow of contaminated water through the system is decided based on the expected degradation rate. The efficiency of the system is evaluated from analytical testing for contaminants of concern in the influent and effluent water.

5.2.7 Permeable Barrier Bench-Scale Study for Chlorinated Compounds

Purpose: This study is a precursor to the field scale application of a permeable barrier (or "reactive wall") technology using media such as iron filings. A permeable barrier generally consists of a zone of reactive material such as granular iron in the subsurface. As the groundwater flows through this permeable barrier, the chlorinated organics come in contact with the reactive medium and are degraded by chemical reductive dehalogenation to potentially nontoxic organic compounds and inorganic chloride. The bench scale study is used to: (a) screen and select a suitable medium for the reactive cell; (b) estimate the half-life of the degradation reaction and determine flow through thickness of the reactive wall; and, (c) evaluate the longevity of the wall.

Methodology: Continuous mode treatability testing in the form of a column study is the accepted test at the bench-scale level. Column tests enable evaluation of design parameters under dynamic flow conditions. The water to be tested in the soil column is either contaminated groundwater or deionized water spiked with the contaminants of concern. Generally, a single column with multiple sampling ports is used to measure changes in concentration of contaminants and inorganics as they travel through the column.

Evaluation: The column made of plexiglass containing the reactive media (iron, sand, iron and sand, or other combinations) is set up to enable water flow in the vertical upflow mode. The reactive medium is packed in such a way to ensure a homogenous matrix. Several columns with different combinations of media can be tested if required. The test water is pumped from a collapsible teflon bag through a peristaltic pump. Precautions are taken to reduce headspace in the bag and minimize aeration of the water. Sampling ports along the sides of the column are equipped with gastight and watertight fittings. After the concentration distribution in the column has reached steady state (which generally takes several pore volumes), sampling of the water through the sampling ports begins.

Concentration reductions over time are obtained periodically throughout the column by collecting samples from the influent, effluent, and the sampling ports after every 5 to 10 pore volumes are run through the column. Other inorganic and physical parameters can also be measured and plotted. Concentration profile diagrams can then be used to determine half lives and residence times. This data is used to select the reactive media in the field and design an appropriate flow through thickness for the reactive cell.

5.3 Pilot-Scale Testing

The purpose of pilot-scale testing is to evaluate the performance of a technology and to obtain detailed cost and design information. It provides the most accurate scale-up information of the three levels of treatability testing. As with bench-scale-testing, the objectives of pilot-scale testing should be clearly stated. In addition to identifying the critical parameters, other variables (e.g., materials handling, treatment of residuals) should also be investigated at this testing level.

The pilot-scale tests outlined in the following sections represent proposed technologies to be evaluated for NAVBASE.

5.3.1 Soil Bioremediation Pilot Testing for In Situ and Ex Situ Technologies

Ex Situ: Land Treatment

Purpose: Land treatment or landfarming is the tilling and cultivation of soil to enhance the biodegradation of hazardous compounds. Prior to constructing a landfarming system at a hazardous waste site, pilot tests are performed on a smaller scale to evaluate optimum conditions for biological treatment. Information obtained from pilot tests is then used to design a full-scale remedial system.

Methodology: Operating parameters that are evaluated during pilot testing are nutrient needs (nitrogen and phosphorus), bioaugmentation (the addition of commercially available microorganisms capable of degrading the hazardous material), and other amendments such as pH adjusters and soil amendments to improve soil quality. In addition, a control unit is also evaluated where operations are restricted to tilling and moisture control.

Pilot systems can be unlined or lined to collect leachate. Contaminated soil is generally placed in 8- to 10-inch lifts. Pilot testing units average a few hundred square feet in area. Tilling, the single most important operation and the major oxygen enhancer, is performed once or twice per week. Moisture control is the second important controlling factor. Small garden spray systems are used to supply water to the treatment cells when needed.

Nutrient addition to one of the test units generally involves addition of designed quantities of fertilizer or organic nutrients in the form of manures, such as chicken manure. Nitrogen and phosphorus are the main components of the nutrient amendment. Nutrient addition can be performed either at the beginning of the pilot study or in stages, depending on the requirements. Bioaugmentation is performed by adding specific microorganisms that can be purchased from microbial product suppliers. At some contaminated sites, especially those with recent spills, indigenous microorganisms may not have developed the enzymes capable of degrading the waste.

In such cases, exogenous microorganisms could be beneficial. The pilot test will examine this need.

Other parameters evaluated during pilot testing are pH adjusters and soil amendments such as sawdust. Microorganisms thrive under a narrow pH range and some soils could either be acidic or alkaline, making microorganism survival difficult. In such cases, it is essential to add adjusters such as lime to alter the pH to a suitable level. Such testing is performed during pilot testing before implementation of the technology. Some soils also need amendments to make them more workable, specifically for tilling. Such amendments are also evaluated in the pilot tests.

Evaluation: The contaminants of concern are periodically tested analytically during the pilot study. Analytical testing can be used to estimate the rates of degradation. Degradation rates for the different pilot units can then be compared to decide which remedial alternative is to be implemented. In addition, the pilot test can be used to estimate treatment and amendments costs, if needed. Tilling, moisture control, and irrigation requirements can also be estimated from pilot study operations.

In Situ Treatment: Bioventing

Purpose: Bioventing is the process of advecting gases through unsaturated subsurface soils to stimulate in situ biological activity and enhance bioremediation of contaminants. It generally involves supplying oxygen in situ to oxygen-deprived indigenous microbes by injecting air in unsaturated contaminated soil at low flow rates. Pilot testing for bioventing is required to estimate the areal influence (also known as the radius of influence, R_i) of air injection and the soil-gas permeability (k) into the subsurface, determine the air permeability, and estimate the rate of biological degradation of soil contaminants.

An estimate of the soil's permeability to fluid flow (k) and the radius of influence (R_i) of venting wells are both important elements of a full-scale bioventing design. Onsite testing provides the most accurate estimate of the soil-gas permeability, k . Onsite testing can also be used to determine the radius of influence that can be achieved for a given well configuration and its flow rate and air pressure. Soil-gas permeability, or intrinsic permeability, can be defined as a soil's fluid flow capacity, and varies according to grain-size, soil uniformity, porosity, and moisture content. The value of k is a physical property of the soil: k does not change with different extraction/injection rates or different pressure levels. These data are used to design full-scale systems, specifically to space vent wells, to size blower equipment, and to ensure that the entire site receives a supply of oxygen-rich air to sustain in situ biodegradation.

Methodology: Equipment for pilot bioventing testing generally consists of a vent well and a blower system to provide airflow through the subsurface, creating a pressure gradient for a air permeability testing and increasing subsurface oxygen levels for in situ respiration testing. The diameter of the vent well may vary between 2 and 4 inches and be placed with the screened interval in the contaminated soil. Soil-gas monitoring points will be used for pressure and soil-gas (oxygen and carbon dioxide) measurements and will be installed at least three locations. Ideally, these will be in a straight line at 5- to 10-foot intervals depending on the soil type.

Evaluation: Evaluation of a bioventing pilot study includes determination of soil-air permeability, radius of influence, performing in situ respiration tests, periodic soil sampling to estimate changes in contaminant concentrations, and periodically measuring soil-gas pressure and oxygen.

The radius of influence and soil-air permeability are estimated from measurements of soil-gas pressure at the monitoring points. Soil-gas pressure is generally measured in the transient phase or at steady state. The value of R_i can be determined by actually measuring the outer limit of pressure influence under steady-state conditions, or by plotting pressure at each monitoring

point vs. the log of the radial distance from the vent well and extrapolating the straight line to zero pressure.

The estimated radius of influence (R_I) is actually an estimate of the radius in which measurable soil-gas pressure is affected and does not always equate to gas flow. In highly permeable gravel, for example, significant gas flow can occur well beyond the measurable radius of influence. On the other hand, in a low-permeability clay, a small pressure gradient may not result in significant gas flow. In general, if the R_I is greater than the depth of the vent well, the site is probably suitable for bioventing. If the R_I is less than the vent well depth, the question of practicality arises. Scaling up a bioventing project at such a site may require more closely spaced vent wells than is either economically feasible or physically possible. The decision to proceed with bioventing will be site-specific and somewhat subjective.

The following formula is used to calculate the soil air permeability, k :

$$k = \frac{Q\mu \ln(R_w/R_I)}{H\pi P_w [(1 - P_{atm}/P_w)^2]}$$

where:

Q	=	average flow of air into bioventing well
μ	=	air viscosity
R_w	=	radius of vent well
R_I	=	measured radius of influence of bioventing
H	=	depth of screen of vent well
P_{atm}	=	ambient pressure
P_w	=	average absolute pressure at vent well.

The general accepted limiting value of air permeability at which bioventing is not a viable alternative is 10^{-8} cm². At values lower than this, bioventing is unlikely to be the optimal remedial approach. At values marginally higher, bioventing efficiency is best verified through pilot studies.

The in situ respiration test can be used to determine if in situ microbial activity is occurring and if it is oxygen limited. It also provides a quick estimate of in situ biodegradation rates so that a full-scale bioventing system can be designed. To perform the test, air with 1 to 2% oxygen is injected into the monitoring points. Following injection, the change in oxygen and carbon dioxide is measured over time. Typically, air is measured at two, four, six, and eight hours and then every 4 to 12 hours, depending on the rate at which oxygen is utilized. The in situ respiration test is terminated when the oxygen level is about 5%, or about 5 days after sampling. Oxygen use rate will be determined from the data obtained during the test as the percent of oxygen changes over time. Biodegradation rates can be obtained from standard stoichiometric relationships for oxidation of the contaminants of concern and the oxygen use rate. The contaminants of concern are analytically tested periodically during the bioventing pilot study from subsurface samples collected from different radial points around the vent well. Analytical testing can be used to estimate degradation rates.

Finally, the data and results from the pilot study tests can be used to estimate the feasibility of bioventing, requirements for full-scale design, and cost of implementation.

5.3.2 Groundwater Bioremediation Pilot Testing for In Situ and Ex Situ Technologies

Ex Situ: Bioreactors

Purpose: Bioreactors are aboveground treatment systems used to treat contaminated water that is pumped out of the ground as part of a remedial system such as a pump-and-treat system. Bioreactors are generally limited to treatment of groundwater contaminated with organic wastes. Bench-scale studies can be performed on a laboratory scale prior to installing a bioreactor system

onsite. These bench-scale systems simulate a remedial system and provide design data needed to implement a full-scale system.

Methodology: Bench-scale study requirements for bioreactors vary depending on the contaminant type and the biological mechanism. A simple set-up would involve a container of approximately one gallon capacity made of PVC or plexiglass. For a continuous flow system, a continuous feed pump moves the waste water from the source through a pH adjuster and into the bioreactor. Nutrient supplementation may be required. A continuous source of air supply to maintain oxygen-rich conditions is installed if the remedial system is aerobic. The air often serves the purpose of mixing the contaminated water. Provisions are made in the reactor for removal of sludge which forms from contaminant removal and biomass production.

Evaluation: The efficiency of a bioreactor system can be evaluated from the rate of flow at which a desirable effluent concentration (usually the cleanup concentration) can be sustained. The bench-scale study can also estimate the sludge quantities during full-scale treatment. The size of the bioreactor to be used for full-scale treatment and the air system can also be estimated from the bench-scale study.

In Situ Treatment: Air sparging

Purpose: In situ air sparging of groundwater increases the water's dissolved oxygen content and enhances the growth of indigenous microbes which consume the aquifer's organic contaminants. Air is sparged directly into the groundwater to saturate water near the air-water interface with dissolved oxygen, which increases by advection (the flow of water containing dissolved oxygen) or by dispersion through the water. Pilot tests are used to determine the efficacy of air sparging and the feasibility of reducing contaminants of concern to cleanup levels. Information from a pilot study can be used to design and implement a remedial system to clean up the aquifer and to estimate cost.

Methodology: The setup for performing a pilot air sparging test generally consists of a blower to supply air, an air injection well to supply air to the aquifer, and a series of upgradient and downgradient wells (observation wells) to evaluate the system. The air sparging well is generally from 2 to 4 inches in diameter with a 2- to 3-foot long screen at the bottom. Several downgradient wells can be installed 5 to 20 feet apart in the direction of groundwater flow. The air injection rate for air sparging is generally 5 to 10 standard cubic feet per minute. The air injection well can also be used to inject nutrients or exogenous microorganisms if needed.

Evaluation: The pilot air sparging system is evaluated by periodic collection and analysis of groundwater samples from the observation wells. These samples are analyzed for the contaminants of concern, microbial populations, and nutrients such as nitrogen and phosphorus. In addition, dissolved oxygen and pH are generally field tested throughout the study. Trends in dissolved oxygen can be used to evaluate the remediation progress. Microbial populations and nutrient measurements are used to evaluate the need to amend the aquifer with exogenous microorganisms or addition of nutrients. Analytical results of the contaminants of concern are used to estimate degradation rates at different aquifer locations.

Finally, the data and results from the pilot study tests can be used to estimate the feasibility of air sparging, requirements for full-scale design, and implementation cost.

5.3.3 Natural Attenuation Pilot Test

Natural subsurface processes (i.e., dilution, volatilization, biodegradation, adsorption, and chemical reactions) reduce contaminant concentrations. Consideration of this technology requires modeling and evaluation of contaminant degradation rates and pathways. The primary modeling objective is to demonstrate that natural processes will reduce contaminant concentrations below regulatory standards before potential exposure pathways are completed. Sampling and analysis

must also be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

A pilot study for this technology would consist of installing observation wells (upgradient, downgradient and at the source) to monitor for all contaminants of concern. Geochemical parameters (DO, pH, microbial populations, nutrients) would be analyzed over a period of time (approximately 12-18 months) to assess the degradation rate. Determining the feasibility of employing natural attenuation at a site would rely largely on the results obtained from the treatability test which was conducted.

5.3.4 Soil-Vapor Extraction (SVE) Pilot Test

Purpose: Soil-vapor extraction pilot tests are typically conducted prior to design of SVE systems to assess soil permeability to gas, vapor flow rates, subsurface vacuum distribution, contaminant concentration locations, etc. This information can then be used in SVE remediation modeling to determine SVE design parameters such as contaminant removal rates, effective radius of influence, the design wellhead vacuum, and total system vapor flow rate.

Test Objectives: Soil containing varying concentrations of volatile organic compounds can be remediated using the SVE mass-transfer technique. The feasibility and design of such remedial systems, however, requires information regarding the in situ contaminant characteristics, concentration, and formational flow characteristics. To acquire this data, SVE pilot tests are conducted.

Formations of varying thicknesses and varying permeabilities are placed under the influence of a vacuum source. Surrounding piezometers placed at various distances (generally at the same depth and screened interval) are sampled for vacuum influence using a magnahelic gauge, or other low vacuum measuring instrument. SVE testing is performed to acquire actual in situ data which may

be used for SVE systems design. In situ data are more accurate than the use of tables or graphs for the estimation of gas permeability and conductivity.

Materials and Methods:

Well Installation and Construction — Vacuum extraction well(s) are installed to serve as the source well where the vacuum is applied. They are typically constructed in the same manner as a monitoring well, although not completed in a water-bearing zone. It is important to create a positive surface seal at the surface (cement-bentonite grout seal) to prevent short-circuiting of air. Piezometers are placed at varying distances away from the extraction well. These distances depend on the soil type (e.g., in a tight, less permeable soil, the piezometers would be spaced closer than in a more permeable formation). The piezometers are constructed and completed in the same manner as the SVE extraction well. However, they are typically only 1-inch diameter wells (for cost purposes). The number of piezometers again depend on soil type and the area in which the test is to be conducted. In general, the more monitoring points and the more directions away from the extraction well, the better. A perfect set-up would be to have more than three monitoring points at varying distances, in each direction away from the extraction well.

Also, during the installation of the SVE well and monitoring points, Shelby tube samples should be collected for each target soil type. Wet density, dry density, percent moisture, and coefficient of permeability may be necessary to evaluate flow characteristics of the soil type.

Vacuum Source — A regenerative or positive displacement blower is typically used as the vacuum source. The blower should be able to produce enough vacuum/flow to gather good data and be equipped with a vacuum gauge to monitor generated vacuum. Depending on the local air emission requirements, an off-gas control system may be needed. This is typically just the exhaust (effluent) piped to a carbon canister. The blower should also be equipped with a valve that can

vary the vacuum to the well, that is, a valve installed to the atmosphere on the blower. By opening and closing this valve, the blower vacuum is increased/decreased.

Laboratory Analysis — Some SVE tests use a PID or FID to measure vapor concentrations extracted. However, a more accurate analysis is obviously obtained through laboratory analysis. Therefore, the SVE pilot-test equipment should be equipped with sample ports which will allow soil vapor to be withdrawn from different locations. The two most important locations are before and after any necessary off-gas control device. In general, soil vapor should be withdrawn before to allow calculation of off-gas emissions for the full-scale SVE system. Soil vapor is withdrawn through a standard septum (Pete's port installed in the piping), using a 20-cc syringe connected via an on-off valve. The first 40-cc of gas are discarded to flush the syringe and fill it with in situ soil vapor. The next 20-cc of gas is withdrawn in the syringe, plugged (valve off), and immediately transferred to an evacuated 20-cc glass container for laboratory analysis.

Monitoring Instrumentation — Vacuum gauges are used to measure vacuum influence at the monitoring points. Flow measurement devices, which are used to measure the system flow rate, are typically pitot tubes installed in the piping; however, other instruments are available for measurement of flow.

Preliminary Data: Preliminary data, or background data, are necessary for later data correction. This is usually measuring the static conditions at the monitoring points (vacuum readings with no source applied). Examples are outside weather conditions or temperature, or sometimes the atmospheric pressure which can affect gauge readings.

Start — Begin the test at a predetermined vacuum level, usually with the dilution valve completely open and no vacuum stress applied to the wellhead. Again, this depends on soil type, etc. Periodically measure/record vacuum readings at the monitoring points and at the wellhead/vacuum

source. Also, measure the flow rate and the vapor concentration (or take soil vapor samples). The length of running the test at this initial vacuum/flow rate will depend upon how your readings change. Once they do not significantly change, the vacuum can be increased. However, you should gather enough data during this initial phase of the test. Increase the vacuum. Once vacuum is increased, repeat the readings again periodically as before. Ultimately you are trying to reach a point at which the vacuum blower is at a maximum state (or you have completely shut off the dilution source which regulates the blower vacuum) and you are putting the maximum stress on the soil. Be careful to avoid damage to the blower at this point.

Also, if possible, visually inspect the system for evidence of water being pulled into the piping. This can be done by having piping which you can see through (i.e., Plexiglass). If water is being pulled in, the blower could be damaged. During design of the full-scale system, a water knock-out tank would need to be installed.

End — Once the test is completed, or the vacuum source is stopped, continue to monitor/record the vacuum at the monitoring points to see how quickly the vacuum drops back to where it was when the preliminary data were taken.

Data Reduction: Even though flow rates were measured during the test, a flow rate can also be derived from evaluation of pressure vacuum data collected at the defined distances from the extraction well. The value for this constant may be determined by the vacuum readings.

$$P_1, r_1 : P_2, r_2$$

Such that:

$$P_2^2 - P_1^2 = \frac{-Q_m mRT}{pwKh} \ln(r_2 - r_1)$$

where:	Qm	=	Flow rate
	P	=	Pressure
	r	=	Radius
	m	=	Viscosity of Air
	R	=	Gas Constant
	T	=	Temperature, °K
	w	=	MW of air
	K	=	Soil/Air Permeability
	h	=	Formation thickness
	p	=	3.1416

One of the most critical data reductions is determining the intrinsic air permeability. The physical characteristics of the vapor extraction well/monitoring point system, the vacuum pressure data, and the air flow rates obtained during the pilot testing are used as input to determine the relative intrinsic air permeability of the soil strata through which the air flows. The intrinsic air permeability tensor is the matrix of soil air permeability values along specified axes. Based on boring log data and the vacuum pressure measurements at the monitoring points, the air flow pathways within the subsurface are likely to be predominantly in the radial direction. Intrinsic air permeability may be calculated by:

$$k = \frac{10^{-8} r^2 e u}{4P_{atm}} \exp\left(\frac{B}{A} + 0.5772\right)$$

Where:	k	=	Air permeability
	r	=	Radial distance from extraction well
	e	=	Soil porosity
	u	=	Viscosity of air

P = Atmospheric pressure
B = Y intercept
A = Slope

Use this equation to find A and B by graphing, and then calculate k. Calculated permeabilities are compared to criteria to see if SVE is appropriate for the target soil.

5.3.5 Ultraviolet Oxidation Pilot Test

Ultraviolet (UV) oxidation is a destructive process that oxidizes organic and explosive constituents in waste waters by adding oxidizers and irradiation with UV light. If complete mineralization is achieved, the end products of oxidation are CO₂, water, and salts. UV oxidation processes can be configured in batch or continuous flow modes, depending on the throughput being treated. Pilot-scale testing will likely be required to optimize a UV oxidation system.

Single-lamp bench-top reactors that can be operated in batch or continuous modes are available for treatability studies. Parameters to be addressed in the treatability study include the following:

- Contact or Retention Time
- Oxidizer Influent Dosages
- UV Lamp Intensity
- Proper pH and Temperature

5.3.6 Solidification/Stabilization Pilot Test

Solidification/stabilization (S/S) is a technology which reduces the mobility of hazardous substances and contaminants through both physical and chemical means. Unlike other remedial technologies, S/S immobilizes contaminants within the medium (i.e., soil, sand) that they are contained in, instead of removing them or reducing their concentrations.

Pilot-scale testing is required for solidification/stabilization because of its imprecise nature and because most wastes are far from homogeneous.

When selecting the stabilization/solidification treatment technology for a site:

- Review existing chemical and physical interferences between the waste and the binder.
- Identify potential pretreatment options for the waste or the site that would extend the application of solidification/stabilization or improve the containment properties of the product.
- Assess site conditions that could affect the solidification/stabilization of the waste or its ultimate disposal.

During treatability testing, different waste-to-binder ratios are used to stabilize/solidify waste samples. Selection of the optimum ratio is usually based on leach-test and durability-test results. Toxicity leaching procedures, unconfined compressive strength, wet-dry, and freeze-thaw tests may be among those required of a stabilized/solidified product at a given site. Treatability testing can define process control requirements, including mixing requirements, curing time, and quality control parameters, which can save time and money during field operations.

5.3.7 Six-Phase Soil Heating SVE

Purpose: Six-phase soil heating (SPSH) was developed by the Pacific Northwest National Laboratory as a faster and economical method of remediating difficult to treat sites. SPSH is particularly effective at those sites with tight soils, low volatility compounds, or high water content.

Application: This technology is an enhancement of soil vapor extraction (SVE), a proven in-situ technology for removing volatile organic contaminants from permeable soils. However, the effectiveness of conventional SVE is limited if the contaminants cannot be easily vaporized, if the soil is too tight for air to pass through readily, or if the contaminants are below the water table.

The effectiveness of SVE can be extended by heating the soil while venting. Heating effectively increases the vapor pressure of the contaminants. SPSH is capable of providing even heating across large volumes of the subsurface. SPSH creates an in-situ source of steam to strip contaminants from unsaturated and saturated soil.

Methodology: To implement this technology, electrodes are placed in the ground surrounding the contaminated region and voltage is applied. Electric current conducts through the soil, heating the soil resistively. SPSH uses multi-phase electricity to create a more uniform heating pattern throughout the treated soil volume.

The technique works by dividing conventional three-phase electricity into six electrical phases. Each phase is delivered to one of the six electrodes made of steel pipe installed in a circular pattern. Since each electrode is a separate electric phase, each conducts to all the others and to a central neutral electrode. This creates a more uniform heating pattern through the treated soil volume, and on a larger scale, enables a resistive heating system to raise an entire soil treatment volume to the boiling point of water.

Evaluation: Evaluation of this study includes soil temperature data, moisture removal rates, pressure within the soil, off-gas contaminant concentration, and periodic soil and groundwater sampling to estimate changes in contaminant concentration.

5.3.8 Steam Injection Field Study

Purpose: In this process, steam is forced into the subsurface through injection wells to vaporize volatile and semi-volatile contaminants. Vaporized components rise to the vadose zone where they are removed by vacuum extraction and then treated. This process can be used to remediate large areas of oily waste accumulations and to retard downward and lateral migration of the organic contaminants. The process is applicable to shallow and deep contaminated soils.

Steam injection technology can be applied at gas plants, wood treating sites, petroleum-refining facilities and other sites with soil containing light to dense organic liquids. Factors that may limit the applicability and effectiveness of the process include soil type, geology, and hydrogeology.

Methodology: When steam is initially injection into a well, it heats the well bore and the formation around the injection zone of the well. The steam condenses as the latent heat of the vaporization of water is transferred from the steam to the well bore and porous media where it enters the formation. As more steam is injected the hot water moves into the formation, pushing the water initially in the formation further into the porous media. When the porous media at the point of steam injection has absorbed enough heat to reach the temperature of the injected steam, steam itself actually enters the media, pushing the cold water and the bank of condensed steam in front of it.

As these free flowing fluids approach a region that contains the volatile contaminant at saturations greater than the residual saturation, the contaminant is displaced. First to come in contact with the contaminant is cold water, then the hot water bank, and finally the steam front. The cold water will flush the mobile contaminant from pores. The hot water will reduce the viscosity of the contaminants, making it easier to be displaced by viscous forces. When the steam reaches the contaminated area, no additional contaminant can be recovered by viscous forces. Additional

recovery is achieved by volatilization, evaporation and steam injection distillation of the volatile and semi-volatile contaminants.

Evaluation: The pilot setup will consist of a single injection well point and surrounding passive wells for collection of off-gases and monitoring of soil pressures located at a representative area of the contaminated site. Periodic soil samples will be collected from the soil and the groundwater that is within the area of influence of the steam injection and analyzed for contaminants of concern.

5.3.9 Permeable Barrier Pilot-Scale Study for Chlorinated Compounds

Purpose: This study is a follow up to a bench scale column study for the permeable barrier (or "reactive wall") technology using media such as iron filings. A permeable barrier generally consists of a zone of reactive material such as granular iron in the subsurface. As the groundwater flows through this permeable barrier, the chlorinated organics come in contact with the reactive medium and are degraded by chemical reductive dehalogenation to potentially nontoxic organic compounds and inorganic chloride. The pilot study is used to show the reactive media selected is appropriate and obtain actual removal efficiency in the field on a smaller scale. Feasibility of installing and constructing the wall, operation and maintenance problems such clogging of the iron media, etc. can also be studied during the pilot study.

Methodology: A short length of a permeable, reactive wall will be installed at a location such that it intercepts the contaminated plume. The location will be selected such that the plume width is the shortest. The geology and hydrogeology should be studied carefully to prevent the pilot study wall from artificially altering the plume geometry. The barrier geometry can be of several types- the simplest being a rectangular reactive cell that intercepts the plume and the most commonly known application being the "funnel and gate" system. For the purpose of a pilot study, a reactive cell will be sufficient. However, if the pilot study is located where it can be converted to a

full-scale system, a funnel and gate system may be more appropriate and cost-effective in achieving the ultimate objective, namely groundwater remediation.

The reactive material selected from the bench scale study is used for the pilot study. The reactive wall or cell generally consists of a section of pea gravel through which the groundwater flows before contacting the reactive media. After the groundwater flows through the reactive media it flows through a section of pea gravel in the reactive wall before it flows through the natural saturated media.

Evaluation: A series of groundwater monitoring wells is used to evaluate the reactive wall. The well could be located in the reactive wall, in the pea gravel, upgradient of the wall, and downgradient of the wall depending on the scope of the study. Samples are collected before the study begins, and periodically through the study. A drop in quality of the groundwater in downgradient wells warrants an examination of the reactive wall material for operational problems and clogging. Changes in hydraulic gradient and potentiometric levels are also monitored. The pilot study provides information on the capacity of the reactive wall to treat groundwater, the efficiency of the system, and the cost to scale up the system for site-wise remediation.

5.3.10 Air Sparging/SVE Technology

Purpose: Air sparging combined with SVE is a physical removal system for volatile organic compounds in groundwater. Air sparging differs from biosparging in that the air is injected at higher pressures and flow rates to encourage greater volatilization than bioremediation. At higher pressures, it is expected that most of the volatile compounds in groundwater are transferred to the Vadose zone and collected by an SVE process. The controlling factors that govern the efficiency of an air sparging system are contaminant type, hydraulic conductivity, permeability, porosity, homogeneity, and soil type. The efficiency of the technology and feasibility of attaining site groundwater cleanup levels should be ascertained through a field pilot study.

Methodology and evaluation: The pilot study will consist of a 2-inch sparging well connected to a blower for air supply, and a series of 2-inch observation wells (at least 6) and 2 background wells for monitoring the pilot study's progress. The blower will be furnished with the appropriate controls for adjustment of pressure and flow. The sparging well will be installed at a location representative of the groundwater contamination and will be screened in the saturated formation.

At least three vapor probes will be installed in the vadose zone possibly in conjunction with the soil vapor extraction study. The soil vapor probes will be used to examine air flow from the sparged zone to the surface and track air travel pathways, and obtain air samples for VOCs and SVOCs, carbon dioxide, and oxygen. Analytical measurements during the test will include VOC and SVOC concentrations in the emissions and the observation and background wells. Typically, the air sparging testing is conducted at three separate flow rate/pressure levels. The first step is the lowest flow rate while the third step will be the maximum flow rate the equipment is capable of producing. Each combination step test will be run, at a minimum, until the AS system flow rate and pressure and vapor monitoring probe pressures have stabilized. Vapor samples are taken from the effluent of the SVE system in the beginning, midpoint, and end of each combination step test. The pilot test will be used to calculate the air permeabilities, radius of influence, and VOC removal rates. This information will be used in full-scale design and implementation.

5.3.11 Anaerobic-Aerobic Field Pilot Bioremediation Study

Purpose: This technology is designed to treat a mixture of chlorinated and non-chlorinated solvents in saturated soil and groundwater by applying its 2-zone plume interception in-situ biological treatment. The purpose of the pilot study is: (a) understand the factors and subsurface complexities that affect the development of the bio-active zones in the field; (b) demonstrate the treatment of chlorinated and non-chlorinated solvent mixtures using the 2-phase process in the field; and (c) provide scale-up factors for full-scale design and implementation.

Theory: The first zone in the treatment system is anaerobic and promotes the reductive dechlorination of highly chlorinated solvents, such as perchloroethylene. Immediately downgradient is the second zone, where special aerobic conditions encourage the biological oxidation of the partially dechlorinated products from the first zone, as well as other compounds.

The first step of the treatment for compounds such as perchloroethylene and trichloroethane is to encourage partial dechlorination by stimulating the growth of methanogenic bacteria in the saturated soil. This is accomplished by providing the bacteria with a primary carbon source such as glucose, and with mineral nutrients, such as ammonia and phosphate. Methanogenic bacteria are considered to be ubiquitously distributed in a saturated soil.

At the completion of the first step (the anaerobic step) in the treatment process, all of the more highly chlorinated ethenes and ethanes (PCE, TCE, and TCA) in a contaminated plume are converted to less chlorinated forms (DCE, DCA) by methanogenic bacteria. At a point downgradient, oxygen is reintroduced to the groundwater. Following this, methanogenic bacteria growing on methane and oxygen are expected to oxidize the DCE and DCA to carbon dioxide and biomass.

Evaluation: The pilot study will consist of two zones of treatment in a selected location of the saturated subsurface. The upgradient zone will be the anaerobic zone which will consist of a series of wells (or a bioreactor wall) through which a carbon source and the required nutrients are introduced. The downgradient zone will be an aerobic zone which consists of a series of wells (or a bioreactor wall) through which oxygen (air) and nutrients are introduced. Monitoring wells will be installed in the treatment area to collect groundwater analytical samples for SVOC and VOC analysis. Other biological-related parameters such as dissolved oxygen, redox potential, microbial plate counts, and nutrients will also be measured throughout the study. The results of the study will enable the design engineer to evaluate the feasibility of using an in-situ sequential

anaerobic-aerobic bioremediation system to treat chlorinated and other organic compounds in the groundwater.

5.3.12 Bioslurping

Purpose: Bioslurping is a dynamic vacuum-enhanced fluids-pumping technology that simultaneously extracts free product, groundwater, and soil gas in the same process stream. Through this vacuum process, bioslurping simultaneously enhances the natural biodegradation of organic contaminants in the vadose zone.

Bioslurping technology is applicable to volatile organic compounds (VOCs). Vacuum extraction through bioslurping enhances free-product recovery in both medium - to fine-grained soil and coarse soil. Though the vacuuming process results in an increase in the water table level, this increase is offset by removal of excess liquid by the slurping system. Furthermore, since organic compounds are extracted from the formation at pressures below atmospheric, organics trapped due to negative pore pressure also migrate towards the extraction point.

Methodology: A bioslurping system consists of a single or several wells screened at the depth of the saturated formation containing the free product or the highest concentration of VOC contamination. The system also contains a vacuum pump system capable of removing air and liquids, a separation and a treatment system; a collection and metering system to handle the organic compounds, water, free product, and the vapors produced. Soil venting wells are also installed to collect volatile compounds present or diffusing into the vadose zone.

When the vacuum pump is started, free product and groundwater is extracted through the suction tube in the well and transported to the aboveground treatment system. As a result of the vacuum, more free product and groundwater move into the extraction well from the surrounding formation to be recovered. The extraction also creates a partial vacuum in the soil above, which induces a

flow of fresh air toward the contaminated zone for biodegradation. Additional recovery of VOCs is achieved through an installed soil venting system.

Evaluation: Evaluation of a pilot system for bioslurping includes measurement of the volume and composition of fluids and vapor recovered; measurement of pressure in the vadose zone to estimate the zone of influence of vacuuming; measurement of fluid levels in the monitoring wells. The data collected during the pilot study is used to estimate the quantity and quality of recoverable contaminants and provide information on the cost of aboveground treatment, maintenance and operation for scale up and remediation.

6.0 HEALTH AND SAFETY PLAN

6.1 Introduction

The following health and safety plan (HASP) is designed to assure the safety and health of site workers throughout the completion of activities related to the U.S. Navy CLEAN Program, Comprehensive Corrective Measures Study for the designated zones at NAVBASE Charleston. The Navy project contract number with E/A&H is *N62467-89-D-0318*.

USEPA has divided the NAVBASE into individual SWMUs and AOCs referred to as sites. Where SWMUs and AOCs overlap or are very close to one another, they are investigated as one site. For investigative purposes, "sites" have been grouped into "zones." This HASP is written to provide health and safety guidance, and information for activities performed under the comprehensive corrective measures study work plan.

This HASP covers project-specific hazards associated with the corrective measures study. The *E/A&H NAVBASE Charleston Comprehensive Health and Safety Plan (CHASP)* (E/A&H August 1994) provides activity-specific details for general operations at NAVBASE Charleston. Site-specific supplemental information will be provided in each zone-specific HASP. This document is organized as follows to explain conditions and expected hazards to workers.

- Section 6.2, Employee Protection, identifies the chemical and physical hazards expected to be encountered throughout the CMS and specifies procedures and controls to abate these hazards.
- Section 6.3, Decontamination, provides information on decontamination procedures.
- Section 6.4, Authorized Personnel.

- Section 6.5, Emergency Procedures, provides the information on emergency procedures, including where to go, who to contact, and what E/A&H personnel are and are not authorized to do in an emergency

Prior to beginning work at a site, personnel shall review the CHSAP, this HASP, and the corresponding site-specific section of the zone HASP to make sure that they are aware of known and potential hazards. Further the zone-specific HASP for each site shall be reviewed to ensure that all personnel are aware of known and potential site hazards. For each site, it is recommended that a copy of the applicable site-specific section be photocopied and carried into the field. At least one copy of both this plan, zone-specific HASP, and the CHASP shall be available in the field trailer.

6.1.1 Applicability

The provisions of this plan are mandatory for E/A&H field personnel. These personnel must read this plan and sign the acceptance form (see Attachment A) before starting site activities. In addition, personnel will adhere to the most current requirements of Title 29 Code of Federal Regulations 1910.120, Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910.120 [HAZWOPER]), as specified for workers involved with corrective actions under RCRA.

All non-E/A&H personnel present in E/A&H work areas shall either adopt and abide by this HASP and the corresponding CHASP, or shall have their own safety plan which, at least, meets the requirements of E/A&H's plans. Subcontractors who adopt the provisions of this plan will be wholly responsible for enforcing the plan requirement's with their employees and shall provide each employee with personal protective equipment (PPE) and implement controls as specified in the HASP, zone-specific HASP, and the CHASP.

This HASP applies to specific planned activities and procedures such as soil boring; hand augering; installing and developing groundwater monitoring wells; installation and sparging of soil vapor extraction systems; application of in situ chemical treatments; soil surveying; and collecting soil, groundwater, surface water, sediment, air and biota samples. Non-routine procedures and tasks involving non-routine hazards are not adequately addressed in this plan. Examples of such procedures are:

- Confined space entry
- Sampling, handling, or removing unidentified drums
- Unexploded ordinance (UXO), working with, or nearby UXO

Should it be necessary to conduct these or other high-risk tasks, specific health and safety procedures must be developed, approved, and implemented before proceeding.

6.1.2 Work Zones

Section 2.1 of the CHASP describes the function and interrelation of the three work zones which, in combination, comprise the work area. The three work zones are:

- Exclusion Zone (EZ)
- Contaminant Reduction Zone (CRZ)
- Support Zone (SZ)

These work zones will be established and used during field work covered under this HASP. The location of these zones is dependent on the work task, layout of the site, weather, and logistical factors. These zones need to be formally demarcated when working in Level C or B.

For purposes of site control, the entire work zone should be delineated to keep non-authorized personnel a safe distance from field activities.

6.1.3 Work Area Access

Authorized personnel (Section 6.4) will be allowed access to work areas as long as they follow the requirements of this HASP, zone-specific HASP and the CHASP. See also Work Area Access, Section 2.2 of the CHASP.

6.2 Employee Protection

Employee protection appropriate to the work being completed under the comprehensive and zone-specific CMS work plans are determined through knowledge of planned activities, the chemical treatments, and field analysis proposed for the study. The physical and chemical hazards due to site contaminants are addressed in the zone-specific HASP. These hazards and hazard abatement procedures are discussed in general in the following sections:

- Section 6.2.1: Work Limitations
- Section 6.2.2: Physical Hazards
- Section 6.2.3: Chemical Hazards
- Section 6.2.4: Selection of Personal Protective Equipment
- Section 6.2.5: Air Monitoring

6.2.1 Work Limitations

It is expected that all site activities will be conducted during daylight. E/A&H assumes that during this investigation, normal activities will continue; therefore, investigatory work should be coordinated to minimize impacts on non-site-related activities.

6.2.2 Zone Physical Hazards

Field personnel should be aware of the dangers associated with physical hazards typically encountered during environmental investigations, and act in a manner to minimize them. These hazards include heat- and cold-related illnesses, severe weather, above-ground and underground

utilities, working with and around drill rigs and heavy equipment, uneven terrain, slippery surfaces, and lifting.

Some sites could provide habitat for poisonous flora and fauna, such as poison ivy and snakes. Depending on the time of year, and the site location, the use of snake chaps could be prudent. Before working at these sites check with the Site Health and Safety Officer (SHSO) for more definitive information.

Trenching and Excavations

EnSafe is concerned about employee safety while working in or around excavations. Therefore, all operations involving excavation or trenching will adhere to 29 CFR 1926.650. An *excavation* is considered to be any man-made cut, cavity, trench, or depression in an earth surface formed by earth removal. A *trench* is a narrow excavation (in relation to its length) made below the ground surface. In general, the depth is greater than the width, but the width of the trench (measured at the bottom) is not to be greater than 15 feet.

No personnel will be allowed to enter an unshored or unsloped excavation. Personnel must obtain approval from either the project health and safety officer (PHSO) or the SHSO.

Utilities: The estimated location of utilities — such as sewer, telephone, fuel, electric, potable/sanitary water — or any other underground installations that reasonably may be expected to be encountered during excavation work shall be determined before opening an excavation.

When excavation operations approach the estimated location of underground installations, their exact location shall be determined by safe and acceptable means.

Access and Egress: A stairway, ladder, ramp, or other safe means of egress shall be placed in trenches 4 feet or more deep so no more than 25 feet of lateral travel will be required for employees.

To collect samples from landfills, a series of test pits and/or trenches may be excavated. **E/A&H personnel shall not be within 5 feet of the edge of an excavation(s).** When collecting samples, the backhoe operator shall remove soil and groundwater from the excavation and move the bucket a safe distance from its edge, allowing the scientist/geologist to collect a sample from the bucket. Before collecting a sample, the backhoe will be placed in a nonoperating position and the operator will signal that it is safe to approach the bucket. For the geologist/scientist to photograph the excavation, it is recommended that he/she take pictures standing on the backhoe while it is in a nonoperating position. The excavations are to be backfilled as soon as the onsite analysis of the sample is performed. **At no time will an open excavation be left unattended.**

Under no circumstances will any person be permitted to enter an unsloped or unshored excavation. If someone must enter the excavation, the site supervisor shall request the SHSO to develop an acceptable entry procedure, which may include shoring the excavation's sides.

Inspections: A competent person will inspect excavations, the adjacent areas, and protective systems daily to determine if any situations could result in cave-ins, protective system failures, hazardous atmospheres, or other hazardous conditions. The competent person will conduct the inspection before work starts and as needed throughout the shift.

Inspections also will be made after every rainstorm to ensure that no water has accumulated. Employees shall not work in excavations where water has accumulated, unless adequate precautions are taken to protect them. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to

prevent cave-ins, water removal to control the level of accumulating water, or using a safety harness and lifeline.

Underground Utilities and Electrical Safety

One safety concern is underground utilities. To assure site worker's safety during intrusive activities, the following precautions will be taken:

- A subcontractor specializing in utility-location techniques will be employed to assist the field teams in clearing locations for subsurface sampling points.
- Sites covered with asphalt or concrete will be cored before drilling or hand-augering activities begin.
- Subsurface borings will be advanced with a posthole digger or hand auger to 5 feet below ground surface to ensure that the drill rig will not encounter a subsurface utility when the exact location of utilities cannot be determined.
- If a subsurface obstruction is encountered, the boring will be terminated. When a boring is terminated, the borehole will be pressure-grouted to the soil/asphalt or concrete interface, and the asphalt or concrete plug will be cemented back in place flush with the existing surface grade.

Due to the conditions outlined above, all intrusive work will be completed with respect to the requirements specified in 29 CFR 1926.416, including posting the area with appropriate warning signs and using insulated gloves and boots when appropriate.

All non-permanent electrical field equipment powered by a 110 volt or greater source will have a ground fault circuit interrupter or equivalent installed where there is the potential for electrical

shock. The ground fault circuit interrupter or equivalent shall be installed as close to the fixed source of power as possible in order to provide the greatest level of protection to employees.

Procedures and Equipment for Extreme Hot or Cold Weather

The site supervisor and the SHSO shall be aware of the potential for heat stress and other environmental illnesses. When environmental or work conditions dictate, work regimens shall be implemented to minimize the potential for employee illness. Field staff will be responsible for monitoring co-workers for signs or symptoms of heat- or cold-induced illness. For a discussion of the more common heat- and cold-related illnesses and their associated symptoms, see CHASP Section 6.5.1.

Due to the ambient environmental conditions typical for Charleston, South Carolina, the heat index and/or core body temperature (area and/or personal) may be monitored during hot weather and/or when elevated levels of PPE are used. Measures available to prevent the onset of heat related illness include: adjusting work-rest regimens, using cool vests to help control core body temperature, and providing drinks designed to replenish spent electrolytes (Gatorade, Squench, or similar). More radical measures such as working at night with proper lighting will be explored if additional precautions are needed.

Severe Weather

During extreme weather conditions, the site supervisor shall use his/her best judgment and has the authority to stop field work or dismiss workers for the day. Examples of conditions that may warrant work stoppage include: tornado or hurricane warnings, thunder and/or lightning, high winds, hail, flooding, and snow and ice storms.

Field work shall not be conducted when lightning can be seen from the work area. When lightning is observed or thunder is heard, cease work, shut down equipment, perform emergency personal and equipment decontamination (see Section 6.3) as needed, then seek shelter.

Working Around Drill Rigs and Heavy Equipment

Heavy equipment and drill rig operations will adhere to the procedures outlined in the CHASP, Appendix B, Drilling Safety Guide.

Drilling or Coring Within Buildings

In addition to the hazards present during routine drilling and coring operations, drilling or coring in a building presents an additional hazard, the buildup of exhaust gases and, in particular, carbon monoxide. Carbon monoxide, a colorless and odorless gas, can affect a person with little advance warning or physiological indicators. Early symptoms of overexposure include drowsiness, lack of attention, and headaches. While severe cases of overexposure to carbon monoxide can cause death, a more likely scenario is that a lesser exposure would cause a worker to be inattentive, drowsy, or make a poor decision that results in a serious accident.

While drilling within buildings is not planned for this for this CMS, should this change, the following procedures will be followed:

The threshold limit value (TLV) (recommended standard) of carbon monoxide is 25 parts per million (ppm) and Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) is 35 ppm with a ceiling limit (not to exceed) of 200 ppm. When operating an internal-combustion-powered drill or coring rig indoors, even in large open spaces, the TLV and PEL can be reached in a few minutes. To reduce the potential of overexposure whenever drilling or coring in an enclosed structure, regardless of its size, the following minimum procedures shall be followed:

- Exhaust ducts and "smoke ejectors" (or equivalent) shall be attached to the exhaust stack of the drill or coring rig and extended outside the building. (A smoke ejector is a fan that attaches to flexible ducting and is used to draw exhaust gases down through the duct

and exhaust them outside.) The duct exhaust will be located such that the potential for re-entrainment of exhaust gases is negated.

- A real-time, direct-reading carbon monoxide meter shall continuously monitor the EZ. Carbon monoxide readings shall be taken and documented at regular intervals, no more than 30 minutes between readings. The rest of the time the instrument shall be left running in the work area. The audible alarm shall be set to trigger no higher than 25 ppm.
- To the extent practical, additional measures should be taken to assure adequate ventilation. Suggested measures include opening doors and windows to the outside, using exhaust fans to both draw exhaust fumes out of and circulate fresh air into the work area, and setting heating ventilation, and air conditioning systems to 100 percent outside air. Use these ventilation measures **before** initiating drilling operations.
- Should carbon monoxide readings reach 25 ppm, work shall be halted, drilling equipment deactivated, and personnel evacuated from the area. Work may not resume in the area until carbon monoxide concentrations are below 10 ppm.

Confined Space Entry

E/A&H is concerned about employee safety when working in or around confined spaces. Therefore, E/A&H personnel are required to characterize the potential hazards associated with entering any confined space. Refer to the following definitions for space characterization information.

Confined Space: A space that is: (1) large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit; and (3) is not designed for human occupancy. Confined spaces may include, but are not limited

to, storage tanks, manholes, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, trenches, vats, and open-top spaces more than 4 feet deep such as test pits, tubs, vaults, or any place with limited ventilation.

Permit-Required Confined Space (permit space): A confined space with one or more of the following characteristics: (1) contains or has the potential to contain a hazardous atmosphere; (2) contains a material that can engulf an entrant; (3) has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section; or (4) contains any other recognized serious safety or health hazard.

Non-permit Confined Space: A confined space that does not contain or, have the potential to contain any atmospheric hazard capable of causing death or serious physical harm.

NOTE: E/A&H PERSONNEL SHALL NOT PERFORM PERMIT- OR NON-PERMIT-REQUIRED CONFINED SPACE ENTRY WITHOUT FIRST OBTAINING WRITTEN APPROVAL FROM A COMPANY PRINCIPAL AND THE PROJECT HEALTH AND SAFETY MANAGER. ALL CONFINED SPACE ENTRY WILL BE SUPERVISED BY THE PROJECT HEALTH AND SAFETY MANAGER, AND WILL BE CONDUCTED WITH RESPECT TO THE E/A&H CORPORATE CONFINED SPACE ENTRY PROGRAM AND 29 CFR 1910.146.

E/A&H conducted extensive research into identifying sampling locations with respect to underground utilities and other operations or physical obstacles. It is not anticipated, based on that same research, that E/A&H or subcontractor personnel will be required to perform permit- or non-permit-required confined space entry to collect samples. However, if field conditions warrant performance of confined space entry for sample collection or investigation purposes, it

will be conducted under the requirements of the E/A&H corporate confined space entry program and 29 CFR 1910.146.

Radiation Protection

Radioactive materials/hazards are potentially present within zones of natural sources of radiation and as a result of past operational activities at NAVBASE. As part of the base closure process, the Navy has conducted radiological surveys to verify that Naval-related radioactive materials have been removed. The Navy has surveyed and released all accessible areas of NAVBASE. However, all personnel must be aware of the potential to come in contact with naturally occurring radioactive materials.

Once the survey has been completed and the Navy releases the site, work may be performed at that site. This applies to all E/A&H employees and their contractors while conducting field work in each zone, such as walkover investigations, drilling, well development, soil sampling, water sampling, treatability studies and trenching.

Standard Safe Work Practices

- When conducting field work personnel should walk. Running greatly increases the probability of slipping, tripping, and falling.
- Eating, drinking, chewing gum or tobacco, smoking, or any activity that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any area designated as contaminated, unless authorized by the SHSO.
- Hands and face must be thoroughly washed upon leaving the work area.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as practical after leaving the CRZ.

- Contact with contaminated or suspected contaminated surfaces should be avoided. Whenever possible, do not walk through puddles, leachate, or discolored surfaces, or lean, sit, or place equipment on drums, containers, or on soil suspected of being contaminated.

- Medicine and alcohol can exacerbate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel on cleanup or response operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Consumption of alcoholic beverages is prohibited.

- Adequate side and overhead clearance must be maintained to ensure that the drill rig boom does not touch or pass close to any overhead power lines or other overhead obstacles or obstructions.

- Utility lines should be marked using characteristic spray paint or labeled stakes. A buffer zone, 3 yards to either side of a utility line, should be maintained during all subsurface investigations.

- Due to the flammable properties of the potential chemical hazards, all spark or ignition sources should be bonded and/or grounded or mitigated before soil boring advancement or other site activities begin.

General Rules of Conduct

- Liquor, firearms, narcotics, tape recorders, and other contraband items are not permitted on the premises.

- Any violation of local, state, or federal laws, or conduct which is outside the generally accepted moral standards of the community is prohibited.
- Violation of the Espionage Act, willfully hindering or limiting production, or sabotage is not permitted.
- Willfully damaging or destroying property, or removing government records is forbidden.
- Misappropriation or unauthorized altering of any government records is forbidden.
- Securing government tools in a personal or contractor's tool box is forbidden.
- Gambling in any form, selling tickets or articles, taking orders, soliciting subscriptions, taking collections, etc., is forbidden.
- Doing personal work in government shop or office, using government property or material for unauthorized purposes, or using government telephones for unnecessary or unauthorized local or long-distance telephone calls is forbidden.
- Compliance with posted signs and notices is required.
- Boisterousness and noisy or offensive work habits, abusive language, or any verbal, written, symbolic, or other communicative expression which tends to disrupt the work or morale of others is forbidden.
- Fighting or threatening bodily harm to another is forbidden.
- Defacing any government property is forbidden.

- Wearing clothes with offensive logos, pictures, or phrases is forbidden. Appropriate attire is required at all times.
- All persons operating motor vehicles will obey all NAVBASE traffic regulations.

Medical Monitoring Program

See CHASP Section 7.0.

6.2.3 Chemical Hazards

Chemical hazards are selected based to the projected activities defined in the comprehensive CMS work plan. This HASP does not cover the site-specific contaminants of concern. These are defined in detail in each zone-specific HASP. This HASP defines the chemicals selected to complete the corrective measures study. Material safety data sheets (MSDSs) will be obtained whenever a new chemical or treatment product is selected for use in the project. Further, the MSDS must reviewed and approved by the PHSO prior to use at the site. All employees shall read and follow the manufacturers' recommendations for all chemicals and test protocols used during the study.

Chemical hazard information relating to site contaminants are defined in appropriate zone-specific HASP section on chemical hazards. The MSDS for these contaminants are contained in the zone-specific HASP.

Table 6-1 lists chemicals identified for use in the CMS.

**Table 6-1
 CMS Chemical Hazards
 Exposure Information**

Compound	Ionization Potential (ev) ₃	Odor Threshold (ppm)	OSHA PEL ₁	ACGIH TLV ₂	NIOSH REL ₃	Action Level
Aluminum Oxide	N/A	N/A	15 mg/m ³	10 mg/m ³	Not Listed	5 mg/m ³
Calcium Hydroxide	N/A	N/A	15 mg/m ³	5 mg/m ³	5 mg/m ³	2.5 mg/m ³
Calcium Oxide	N/A	N/A	5 mg/m ³	2 mg/m ³	2 mg/m ³	1 mg/m ³
Hydrochloric Acid	N/A	N/A	7 mg/m ³	7 mg/m ³	7 mg/m ³	3.5 mg/m ³
Hydrogen Peroxide	10.54	N/A	Not Listed	1 ppm	1 ppm	0.5 ppm
Magnesium Hydroxide	N/A	N/A	Not Listed	Not Listed	Not Listed	N/A
Nitric Acid	N/A		2 to 4 ppm - STEL	2 to 4 ppm (STEL)	2 ppm	1 ppm
Sodium Bicarbonate	N/A	N/A	Not Listed	Not Listed	Not Listed	N/A
Sodium Carbonate	N/A	N/A	Not Listed	Not Listed	Not Listed	N/A
Sodium Hydroxide	N/A	N/A	2 mg/m ³ - Ceiling	2 mg/m ³ - Ceiling	2 mg/m ³ - Ceiling	1 mg/m ³
Sulfuric Acid	N/A	N/A	1 mg/m ³	1 mg/m ³ 3 mg/m ³ - STEL	1 mg/m ³	0.5 mg/m ³

Notes:

¹29 CFR 1910.1000, Table Z-1-A. Limits For Air Contaminants.

²1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists.

³National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards, June 1990.

⁴Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989, Range of All Reference Values.

STEL - Short-term Exposure Limit

6.2.4 Selection of Personal Protective Equipment

It is important that specified PPE protects against known and suspected site hazards. Selection of protective equipment is based on the types, concentrations, and routes of personal exposure that may be encountered. In situations where the types of materials and possibilities of contact are unknown or the hazards are not clearly identifiable, a more subjective determination must be made of the PPE required, and greater emphasis is placed on experience and sound safety practices.

As is discussed above, PPE for site workers will be based on previous site history and on the activities to be performed there. The zone-specific HASP will describe the site, discuss the work planned there, and assess the hazards and **specify PPE for those activities**, based on the site chemical and physical hazards. PPE requirements are subject to change as site information is updated or changes. **A decision to deviate from specified levels of PPE as contained in the zone-specific HASP must be made or reviewed by the PHSO and SHSO.** Further, the minimum required PPE for each site is Level D with nitrile gloves. Tyvek (or equivalent), though not required with Level D, is available for employee use. Table 6-2 presents the levels of PPE which may be employed and the criteria for upgrading PPE.

6.2.5 Air Monitoring

Air will be monitored for VOCs during all site invasive activities. Air monitoring may also be conducted to evaluate airborne contaminants other than VOCs such as mercury vapors, hydrogen sulfide, carbon monoxide, and combustible gases. When possible, real-time monitoring instruments will be used to measure airborne contaminant levels. If an acceptable real time instrument is not available or appropriate, colorimetric indicating tubes or air sampling pumps and sorbent tubes will be used.

Air monitoring for VOCs will be accomplished using a PID or FID. The PID or FID will be field calibrated to measure VOCs relative to a 100 ppm isobutylene standard. If VOCs are

Table 6-2
 Level of Protection and Criteria

Level of Protection	Criteria for Use	Equipment
Level A	<ul style="list-style-type: none"> • When atmospheres are "immediately dangerous to life and health" (IDLH in the <i>NIOSH/OSHA Pocket Guide to Chemical Hazards</i> or other guides.) • When known atmospheres or potential situations could affect the skin or eyes or be absorbed into the body through these surfaces. Consult standard references to obtain concentrations hazardous to skin, eyes, or mucous membranes. • Potential situations include those where immersion may occur, vapors may be generated, or splashing may occur through site activities. • Where atmospheres are oxygen-deficient. • When the type(s) and/or potential concentration of toxic substances are not known. 	<ul style="list-style-type: none"> • Positive-pressure, full-facepiece, self-contained breathing apparatus (SCBA) or positive-pressure supplied air respirator (SAR) with escape SCBA. • Fully encapsulating chemical protective suit. • Chemical-resistant inner and outer gloves. • Steel toe and steel shank chemical-resistant boots. • Hard hat under suit. • Two-way radios worn inside suit. • Optional: coveralls, long cotton underwear, disposable protective suit, gloves and boots, over fully encapsulating suit.
Level B	<ul style="list-style-type: none"> • When respiratory protection is warranted and cartridge respirators are not appropriate. Examples of these conditions are: <ul style="list-style-type: none"> — when work area may contain less than 19.5 percent oxygen, — when expected contaminants do not have appropriate warning properties, e.g., vinyl chloride, or — when cartridges are not available to protect against all contaminants. • Hazards associated with limited dermal exposure are not significant. 	<ul style="list-style-type: none"> • Chemical-resistant clothes, coveralls. • Positive-pressure, full-face SCBA or SAR with escape bottle. • Hard hat. • Chemical-resistant outer and inner gloves. • Steel toe and steel shank boots. • Chemical-resistant outer boots.
Level C	<ul style="list-style-type: none"> • When respiratory protection is warranted and cartridge respirators are appropriate. • When PID or FID readings exceed the action level. • When air monitoring indicates airborne concentration of a chemical is 50 percent or more of the PEL or TLV and the work area contains at least 19.5 percent oxygen. 	<ul style="list-style-type: none"> • Chemical-resistant coveralls. • Full-face, air-purifying respirator equipped with cartridges suitable for the hazard. • Hard hat. • Chemical-resistant outer and inner gloves. • Steel toe and steel shank boots. • Disposable outer boots.

Table 6-2
Level of Protection and Criteria

Level of Protection	Criteria for Use	Equipment
Modified Level D	<ul style="list-style-type: none"> • When chemical contamination is known or expected to be present, yet inhalation risk is low and respiratory protection is not required. • Site contaminants may be absorbed through the skin. • The "default level" of PPE required when the HASP does not specify another level of PPE and the work area has at least 19.5 percent oxygen. • When minimal or no chemical contamination is expected. • When zone-specific HASP specifies Level D protection is adequate and the work area has at least 19.5 percent oxygen. 	<ul style="list-style-type: none"> • Chemical-resistant coveralls. • Chemical-resistant outer gloves; inner gloves or glove liners, optional. • Steel toe and steel shank boots. • Hard hat. • Safety glasses with side shields or safety goggles. • Optional: chemical-resistant outer boots. • Inner gloves or chemical-resistant gloves needed to handle soil or water samples. • Optional: coveralls and disposable outer boots. • Work clothes.

detected down-hole, colorimetric detector tubes and/or other sampling media may be used to determine the identification and approximate concentration of these compounds.

The PHSO reserves the right to require personal exposure monitoring or other types of air sample collection and analysis. These samples may be required for a variety of reasons including: PID or FID readings exceed or approach the action level, to determine if personal exposures are below OSHA PELs, or to identify a chemical odor. Personal samples will be collected during each site activity in which Level C PPE is prescribed. Sampling strategies will be biased to represent worst-case exposures. Personal monitoring data will be collected and analyzed with respect to National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*.

Air monitoring for respirable dusts may be performed using a real-time aerosol monitor (miniRAM) to measure airborne dust concentrations. In addition to the real-time monitoring, some air samples should be collected to document the actual concentrations measured per a NIOSH-approved method.

A combustible gas indicator (CGI) may be used during soil borings and well installations. The CGI will be field-calibrated to measure flammable gases relative to a methane standard. Downhole CGI readings will be collected periodically during soil-disturbing operations. Field activities will immediately cease if downhole readings exceed 20 percent of the lower explosive limit (LEL). If CGI readings do not subside, the area will be immediately evacuated and the situation re-evaluated to determine how to proceed. The area will be investigated; operations may not proceed until downhole readings are below 20 percent LEL.

Action Level and Ceiling Concentration

Each site at NAVBASE has a designated action level and ceiling concentration. For this project the action level is defined as the PID or FID reading in the breathing zone above which

respiratory protection must be upgraded and; chemical protective clothing may also be upgraded. The action level is determined on a site-by-site basis. To exceed the action level, PID or FID readings should be sustainable. Readings should remain above the action level for at least one or two minutes at a time. Readings that are elevated for only a few seconds every 15 or 20 minutes do not exceed the action level and do not require workers to upgrade their level of PPE.

The general action level, as determined on a properly calibrated PID or FID, is 5 PID or FID units above background. PPE shall be upgraded to Level C (assuming that cartridge respirators are appropriate, otherwise Level B) if airborne VOC concentrations in the breathing zone exceed the action level, or if the concentration of any contaminant exceeds 50 percent of the OSHA PEL. This baseline action level and PPE requirement may be superseded by more stringent site-specific levels, as identified in each site-specific hazard analysis and employee protection section.

If breathing zone levels exceed the action level, or site conditions indicate that additional health and safety precautions are needed, field activities in the area shall stop. Field staff shall notify the site supervisor of the situation and he/she shall contact the project manager and/or the PHSO. The PHSO will be responsible for reassessing the hazards and prescribing revised health and safety requirements as necessary, including upgraded PPE requirements, revised work schedules, and revised decontamination procedures. See Table 6-2 for specific criteria for each protection level.

If PID or FID readings exceed 10 units, the SHSO shall contact the PHSO and discuss the need to identify and quantify airborne contaminants. Work shall not proceed until breathing zone concentrations return to background levels and it is reasonably anticipated that breathing zone readings will stay approximately at background levels, or the chemical constituent(s) are identified and appropriate PPE is donned.

The ceiling concentration is defined as the maximum allowable PID or FID reading in the breathing zone regardless of PPE. A ceiling concentration of 50 PID or FID units has been established. Should VOC concentrations exceed 50 ppm in the breathing zone, field workers should secure their equipment and back off the site. Work shall not resume until the site supervisor understands why VOC concentrations became elevated, knows the major constituents of the VOCs being generated, and the VOCs in the breathing zone are less than 5 ppm or workers have upgraded to Level C or B. The proper PPE upgrade shall be determined by the PHSO based on site-specific chemical information.

Field monitoring values will be recorded in a field logbook and copies must be posted for field personnel review.

Equipment Maintenance

Before being used daily, PIDs, FIDs, CGIs, and other monitoring equipment shall be calibrated or their proper function verified. Throughout the day this equipment shall be periodically checked to ensure that it is working properly. A final calibration shall be conducted at the end of the workday, at which time each instrument will be checked to ensure that it is free from surface contamination. Air monitoring equipment shall detect the calibration standard within a range of plus or minus 10 percent; otherwise, the instrument shall be considered malfunctioning. Field staff shall note in their field notebooks that they conducted these calibrations and checks and note whether the equipment was functioning properly.

When equipment is not functioning properly, it should be brought to the attention of the site supervisor or SHSO, who will arrange to repair or replace that equipment as needed.

6.3 Decontamination

6.3.1 Personnel and Equipment Decontamination

As needed, a contaminated reduction zone will be established adjacent to the exclusion zone established for invasive activities, and will include stations for decontaminating personnel, PPE, and hand tools. Typically, a portion of the contaminated reduction zone will be covered with sheets of 6-mil polyethylene (generally, an area 20 feet by 20 feet is sufficient) with specific stations to accommodate the removal and disposal of the protective clothing, boot covers, gloves, and respiratory protection.

Heavy equipment and field equipment that cannot adequately be decontaminated in the contaminated reduction zone may be decontaminated on a more centrally located decontamination pad. Table 6-3 lists equipment that may be convenient to have onsite to decontaminate heavy equipment and vehicles; this table also explains how this equipment may be used.

**Table 6-3
Equipment Recommended for Decontaminating Heavy Equipment and Vehicles**

Tanks or drums to store collected wash and rinse solutions, alternatively, equipment to treat collected wash and rinse solutions may be substituted.
Pumps, and filters as needed to collect wash and rinsate solutions.
Pressurized steam sprayers for steam cleaning equipment.
Long-handled brushes for general cleaning of exterior surfaces. Also shovels and other equipment may be used to dislodge caked-on contaminated mud on the undercarriage or in the tires.
Wash solutions, selected for their ability to remove (dissolve, etc.) contaminants
Rinse solutions, selected for their ability to remove contaminants and wash solutions.
Pressurized sprayers for washing and rinsing, particularly hard-to-reach areas.
Clean buckets that can hold cleaning and rinsing solutions.
Brooms and brushes that can be used to clean the interior, operator areas of vehicles and equipment.

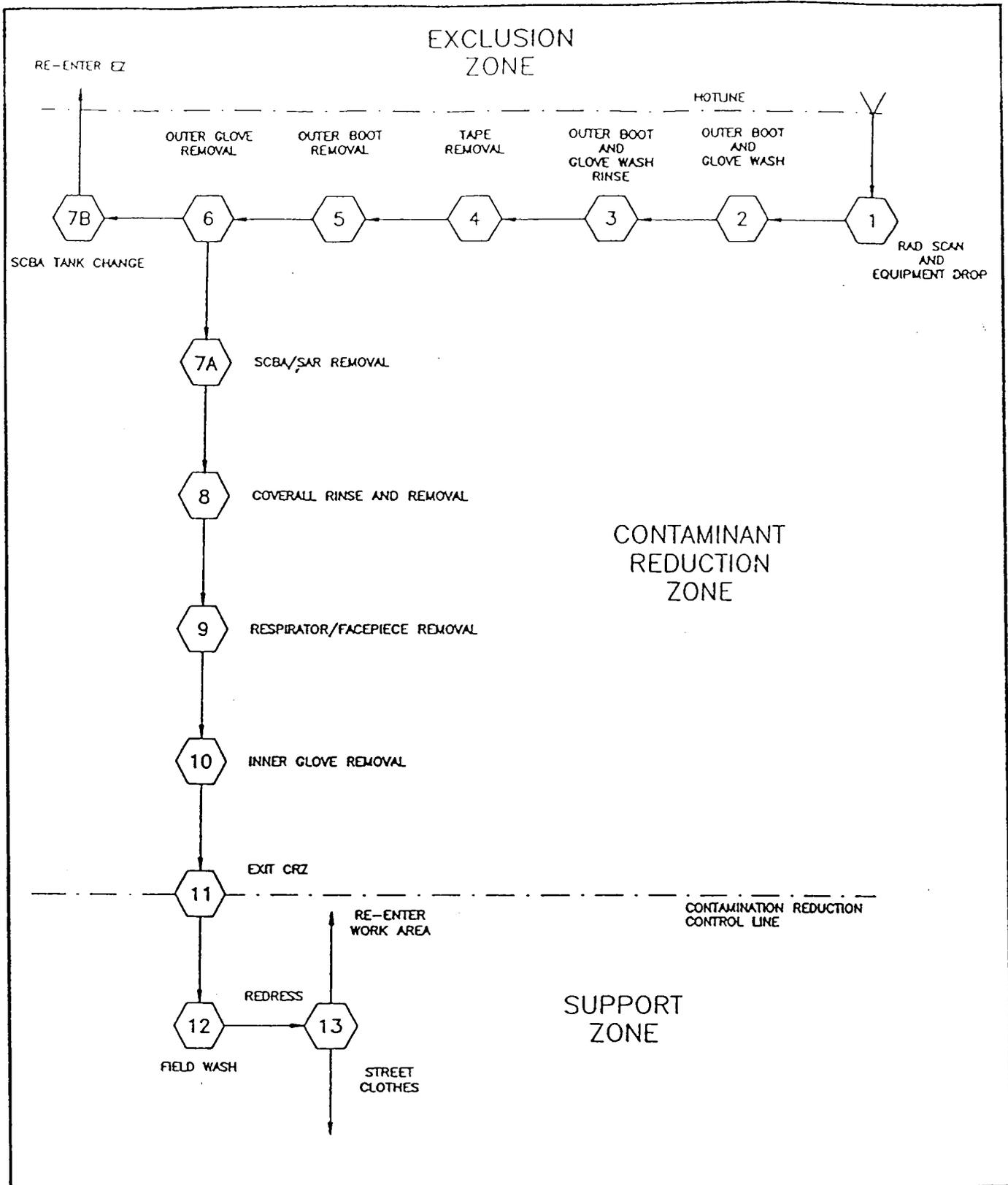
The full contamination layout provided on the following page shows one method of laying out an acceptable decontamination area for Level B PPE (Figure 6-1). There are numerous ways to lay out decontamination areas. Decontamination areas for Level C and Modified D PPE should be based on this concept of decontamination, but can be scaled back in accordance with the decontamination needs of the specific site and level of PPE. As a general rule, people working in the contaminated reduction zone and assisting in the decontamination of workers leaving the exclusion zone, shall be outfitted in PPE that is one protection level below what the existing workers are using. For example, if workers leave the EZ in Level C, personnel in the contaminated reduction zone should be in Modified D.

Often equipment may be adequately decontaminated using a soapy wash solution and following specified rinsing procedures. Normally equipment will be decontaminated in Level D with gloves or Modified D PPE.

In the event of inclement weather (e.g., lightning) or an emergency requiring immediate evacuation, contaminated equipment will be bagged or wrapped and taped in 6-mil polyethylene sheeting and tagged as "contaminated" for later decontamination. Respirators not only need to be decontaminated and cleaned between uses, but also need to be sanitized. Alcohol swabs are generally sufficient.

6.3.2 Full Decontamination Procedures

Workers shall use the following cleaning and decontamination procedures when exiting the EZ. These procedures should be followed when workers are leaving the area for lunch, at the end of their shift, or when work is completed for an EZ. Procedures for rest breaks and changing SCBA tanks and cartridges are described in Section 6.3.3. Not all steps apply to every situation; follow applicable procedures. Decontamination procedures shall start at the EZ/CRZ interface and continue away from the EZ toward the SZ.



COMPREHENSIVE
CMS SAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 6-1
LEVEL B PROTECTION SHEET

Full Decontamination

1. ***Equipment drop.*** Deposit used equipment onto plastic drop cloths or into a plastic-lined tub. All gross contamination should be removed here, fine cleaning and decontamination of equipment may be completed here or elsewhere. Before moving equipment that is still contaminated, wrap and tape it.
2. ***Outer boot and glove wash.*** Wash/remove gross contamination from outer boots, outer gloves, SCBA, and/or airline equipment.
3. ***Tape removal.*** Remove tape from ankles and wrists and dispose of in plastic-lined drum.
4. ***Outer boot removal.*** Remove outer boots; disposable outer boots may be disposed of in the same waste container used in Step 1. Non-disposable boots need a thorough cleaning before they can be removed from the site. (If non-disposable boots are used, it is preferable to have them dedicated to the project.)
5. ***Outer glove removal.*** Remove and dispose of outer gloves. Gloves may be disposed in the same waste container as used in Step 1.
6. ***Removal of Self Contained Breathing Apparatus and Supplied Air Respirator .*** For Level B*.

SCBA — With buddy or other site worker, remove backpack, remove facepiece, and shut off air flow.

SAR — With buddy or other site worker, remove harness and escape bottle, remove face piece, and shut off air flow.

- * If coveralls are significantly contaminated, leave the respirator facepiece on, disconnect the air hose just downstream of the regulator, turn off the flow of air, remove the backpack or equipment harness, and leave the facepiece in place. Remove the facepiece in Step 8.
7. ***Coverall removal.*** Rinse coveralls, if needed; remove coveralls and dispose of them. The same drum may be used as in Step 1. Double-bag non-disposable coveralls with the outer bag clearly labeled "contaminated."
8. ***Respirator removal.*** Remove respirator (or facepiece of Level B equipment, if it is still being worn). Dispose of spent cartridges, clean, disinfect, dry, and properly store respirator or facepiece.
9. ***Inner glove removal.*** Remove and dispose of inner gloves.
10. ***Exit area.*** Exit the CRZ via the SZ.
11. ***Field wash.*** Wash and rinse hands and face.
12. ***Re-dress.*** Re-dress into appropriate PPE for re-entry or change into street clothes.

Notes:

- All wastes (soil and water) generated during personal decontamination will be collected in 55-gallon drums. The drums will be labeled by E/A&H personnel; final disposal will be by the Navy.

- Hard hats and eye protection devices should be washed at the end of each workday with soap and water solution.

6.3.3 Partial Decontamination Procedures

To change a respirator cartridge or SCBA tank:

1. *Outer boot and glove wash.* Wash outer boots and gloves. Wash/remove gross contamination from SCBA and/or airline equipment.
2. *Tape removal.* Remove tape from ankles and wrists and dispose of it in a plastic-lined drum.
3. *Facepiece removal.* Disconnect facepiece and air hose just downstream of regulator. The facepiece may remain in place, or be removed and cleaned. Remove the spent tank from the backpack and replace it with a full tank. Connect air hose and turn on air.
4. *Respirator removal.* Remove respirator, remove used cartridges, clean and disinfect respirator, install new cartridges, and don respirator.
5. *Respirator check.* Check to make sure that respirator still seals properly to your face.
6. *Don clean PPE.* Put on clean outer gloves, tape wrists (as applicable), and re-enter EZ.

When taking a rest break:

1. *Outer boot and glove wash.* Wash outer boots and gloves. Wash/remove gross contamination from SCBA and/or SAR equipment.

2. ***Tape removal.*** Remove tape from ankles and wrists and dispose of in a plastic-lined drum.
3. ***Respirator removal.*** Remove SCBA unit, SAR harness, or respirator, and place in a clean area; plastic sheeting may be needed.
4. ***Coverall removal.*** Remove outer wear if it is ripped or significantly contaminated. In hot weather, at least unzip and pull down upper half of coveralls.
5. ***Inner glove removal.*** Remove and dispose of inner gloves.
6. ***Wash.*** Wash and rinse hands and face at the field wash station.
7. ***Rest break.*** Take rest break. Remember to drink plenty of water, Gatorade, or other similar beverage.
8. ***Don inner gloves.*** Put on inner gloves.
9. ***Don PPE.*** Don coveralls, outer boots, and outer gloves. Tape wrists and ankles (as needed), and re-enter the EZ.

Decontamination procedures, based on Level D protection:

- Brush heavily soiled boots and rinse outer gloves and boots with soap and water.
- Remove gloves and deposit them in a trash container.
- Dispose gloves and other disposable PPE in a trash container.
- Wash hands and face, and preferably shower as soon as practical.

6.3.4 Closure of the Decontamination Station

All disposable clothing and plastic sheeting used during site activities at sites with Level D through Level C will be double-bagged and disposed of in a refuse container. Decontamination and rinse solutions and disposable PPE from Level B sites will be placed in a labeled 55-gallon drum (separate solids and liquids) for later analysis and disposal. All washtubs, pails, buckets, etc., will be washed and rinsed at the end of each workday.

6.4 Authorized Personnel

Only those individuals identified as necessary to the investigative operations at each work site will be considered authorized. The Navy and E/A&H will determine which personnel are necessary and authorized. E/A&H personnel who are to perform work in an E/A&H controlled area shall have current HAZWOPER training certificates on file onsite, shall be under appropriate medical surveillance, and shall be equipped and willing to don all PPE specified by the health and safety plan. Individuals whose current documentation is not on file, or those with more recent documentation (have attended a refresher course), will provide the onsite supervisor copies of their documentation before entering any work area.

Subcontractors, DOD oversight personnel, and other site visitors shall also demonstrate compliance with the requirements specified above, prior to being designated "authorized personnel."

Personnel anticipated to be onsite at various times during site activities include:

- Engineer-in-Charge — Mr. Matthew A. Hunt (SOUTHDIVNAVFACENGCOM)
- Site Contact — Mr. Billy Drawdy (Caretaker Site Office)
- Principal-In-Charge — Mr. Jim Speakman, Ph.D., P.E. (E/A&H)
- Task Order Manager — Mr. Todd Haverkost, P.G. (E/A&H)
- Site Supervisor — TBA (E/A&H)

- Comprehensive CMS Project Manager — Mr. Larry Bowers, P.E. (E/A&H)
- Zone-Specific CMS Project Engineers — TBA (E/A&H engineering staff)
- Zone-Specific CMS Field Personnel — TBA (E/A&H field support staff)
- Site Health and Safety Officer — Mr. Tim McCord (E/A&H)
- Project Health and Safety Officer — Mr. John Borowski, C.I.H. (E/A&H)

Responsibilities of Key Field Staff

Key field staff for this project, in terms of health and safety are:

- Site Supervisor
- Site Health and Safety Officer
- (All) Field Staff

The primary health and safety responsibilities associated with each of these positions are delineated in CHASP, Sections 8.1, 8.2 and 8.3, respectively.

6.5 Emergency Information

All hazardous waste site activities present a potential risk to onsite personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper PPE. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated.

If any situation or unplanned occurrence requires outside emergency, immediately call the appropriate contact from the following list:

Contact	Agency or Organization	Telephone
Mr. Billy Drawdy	Caretaker Site Office, Naval Base Charleston	(803) 743-9985
Mr. Matthew A. Hunt	SOUTHDIV NAVFACENGCOM Engineer-in-Charge	(803) 820-5525
Mr. Todd Haverkost, P.G.	EnSafe/Allen & Hoshall	(803) 884-0029
Law Enforcement	N. Charleston Police	911
Fire Department	N. Charleston Fire Department	911
Ambulance Service	N. Charleston Fire Department	911
Hospital	Roper Hospital	(803) 744-2110
Southern Poison Control Center	_____	(800) 922-1117
Mr. Larry Bowers, P.E.	EnSafe/Allen & Hoshall Comprehensive CMS Project Manager	(757) 766-9556
Mr. John Borowski, C.I.H.	EnSafe/Allen & Hoshall Project Health and Safety Officer	(901) 372-7962
Mr. Tim McCord	EnSafe/Allen & Hoshall Site Health and Safety Officer	(803) 747-0336

As soon as practical, Billy Drawdy, CSO; Matthew Hunt, SOUTHDIVNAVFACENGCOM Engineer-in-Charge; Mr. Todd Haverkost, E/A&H Charleston Office Manager; and Mr. John Borowski, E/A&H PHSO, shall be fully apprised of the situation. Other persons, as appropriate may also need to be contacted.

6.5.1 Site Resources

A cellular telephone will be available in the SZ for routine and emergency communication/coordination with NAVBASE, SOUTHDIVNAVFACENCOM, and the E/A&H field office. First-aid and eye wash equipment will be available at the work area and in each field vehicle.

6.5.2 Emergency Procedures

Examples of an emergency include:

- A fire, explosion, or similar event at or near the site whether related to this project or not;
- A member of the field crew sustains a significant injury, or experiences symptoms of a chemical exposure; or
- The discovery of a condition which suggests that site conditions are imminently more dangerous or hazardous than anticipated.

In an emergency, the following emergency procedures should be followed:

- If it is necessary to evacuate the area, immediately proceed to a rally point and remain there until instructed otherwise.
- Use planned escape routes.
- If a member of the field team experiences effects or symptoms of exposure while on the scene, the field crew will immediately halt work and act according to the instructions provided by the site supervisor or, in his absence, the SHSO.

- For applicable site activities, including all Level B activities, use wind indicators to continuously indicate downwind, preferred escape routes, from upwind routes.

- Investigate condition(s) suggesting that site conditions may be more hazardous than anticipated. The condition observed and the decisions made shall be recorded in the safety logbook, or in the field logbook if a safety logbook is not being maintained. If there are doubts about how to proceed, suspend work and leave the work area until the PHSO has evaluated the situation and provided the appropriate instructions to the field team.

- If an accident occurs, the site supervisor is to complete an Accident Report Form (see Attachment A) for submittal to the managing Principal-in-Charge of the project.

- If a member of the field crew suffers a personal injury, **call 911 if an ambulance is needed**. Next alert appropriate emergency response agencies as the situation dictates. Complete an Accident Report Form for any such incident.

- If a member of the field crew suffers chemical exposure, flush the affected areas immediately with copious amounts of clean water, and if the situation dictates, the SHSO should alert appropriate emergency response agencies, or personally ensure that the exposed individual is transported to the nearest medical treatment facility for prompt treatment. (See Attachment B for directions to the emergency medical facility.) An Accident Report Form will be completed for any such incident.

Additional information on appropriate chemical exposure treatment methods will be provided through MSDS in Attachment C of this HASP. Directions to the nearest emergency medical facility capable of providing general emergency medical assistance and treating chemical burns are provided in Attachment B of this HASP.

6.6 Forms

The following forms will be used in implementing this Health and Safety Plan:

- Plan Acceptance Form
- Accident Report Form

A HASP Plan Acceptance Form will be completed by all employees working onsite before site activities begin. Examples of each form are provided in Attachment A of this plan.

All completed forms must be returned to the Task Order Manager at EnSafe/Allen & Hoshall, Memphis, Tennessee.

7.0 REFERENCES

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8.0 SIGNATORY REQUIREMENT

Condition I.E. of the Hazardous and Solid Waste Amendments (HSWA) portion of the 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 Section 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, 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.



Date 7/1/97

Officer in Charge, Caretaker Site Office
Charleston Naval Base
Southern Division Naval Facilities Engineering Command

APPENDIX A

**ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION,
AND HOLDING TIMES**

**Table A-1
ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES**

Parameter	Analytical Method	Sample Matrix	Minimum Container Size/Material ^a	Sample Preservation^b	Holding Times
Particle Size	ASTM D 422	Soil	Hydrometer and Sieve	None	None
Btu Content	ASTM D 240	Soil	50 gm	None	None
TCLP	SW846 1311	Soil	200 gm/(Glass)	None	14 days - organics 28 days - mercury 180 days - metals
Temperature	Standard Methods 2550 B	Water	10 ml	None	Analyze Immediately
		Soil	2 oz		
pH	USEPA 9040	Water	50 ml	None	Analyze Immediately
	USEPA 9045	Soil	50 gm	None	
Dissolved Oxygen	USEPA 360.1	Water/Soil	300 ml/(Glass)	None	Immediately
Methane	Mod. SW846 8015	Soil	(2) 2 oz jars	None	7 days
Atterberg Limits	ASTM D 4318	Soil	Shelby Tube	None	None
Cone Index	ASTM D3441-79	Soil	Shelby Tube	None	None
Unconfined Compressive Strength	ASTM D2166-85	Soil	Shelby Tube	None	None
Total Recoverable Hydrocarbons	USEPA 418.1 Standard Methods 5520F	Soil	4 oz. Jar (Glass)	Cool, 4 deg Celcius	28 days
Clay Content	ASTM D 422	Soil	Hydrometer and Sieve	None	None

**Table A-1
 ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES**

Parameter	Analytical Method	Sample Matrix	Minimum Container Size/Material ^a	Sample Preservation^b	Holding Times
Calcium; Zinc; Copper; Iron; Manganese; Nickel; Sodium Magnesium; Potassium	SW846 - 6010	Water	1 L (Poly, Glass)	HNO ₃	180 days
Chloride	USEPA 325.1 SW846 - 9250-53	Water	50 ml (Poly or Glass)	None	28 days
Metals, dissolved	SW846 - 6010	Water	1 L (Poly, Glass)	HNO ₃	180 days
Total Nitrogen					
Nitrogen, ammonia	USEPA 350.1 - .3	Soil/Water	50gm/400 ml (Poly, Glass)	None/H ₂ SO ₄	28 days
Nitrogen, nitrate-nitrite	USEPA 353.1 - .3	Soil/Water	50 gm/100 ml (Poly, Glass)	None/H ₂ SO ₄	28 days
Oil and Grease	USEPA 9070	Water	1 L (Glass only)	H ₂ SO ₄	28 days
Organic Carbon	USEPA 415.1 - .2	Water	25 ml (Poly, Glass)	H ₂ SO ₄ or HCl	28 days
Total Solids	USEPA 160.3	Water	100 ml (Poly, Glass)	Cool 4 deg Celcius	7 days
Specific Conductance	USEPA 120.1	Water	100 ml (Poly, Glass)	Cool 4 deg Celcius	28 days
Sulfate	USEPA 375.1-4	Water	50 ml (Poly, Glass)	Cool 4 deg Celcius	28 days
Sulfide	9030 (SW846)	Water	500 ml (Poly, Glass)	Zn Acetate and NaOH pH > 9	7 days
Volatile Suspended Solids	USEPA 160.2 & 160.4	Water	100 ml (Poly, Glass)	Cool 4 deg Celcius	7 days

Table A-1
ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Parameter	Analytical Method	Sample Matrix	Minimum Container Size/Material ^a	Sample Preservation ^b	Holding Times
Bicarbonate	Standard Methods 4500	Water	200 ml (Poly, Glass)	Cool 4 deg Celcius	pH & Temp Immediately TDS - 7 days Alkalinity - 14 days
Organic Carbon	USEPA 415.1-.2	Water	25 ml (Poly, Glass)	H ₂ SO ₄ or Hcl	28 days
In-situ Density	ASTM D 2922	Soil	Nuclear Density Meter	None	None
Soil Type (USCS)	ASTM D 4318	Soil	Shelby Tube	None	None
Saturated Hydraulic Conductivity	SW846-9100	Soil/Water	Shelby Tube	None	None
Relative Permeability	USEPA 9100-SW846	Soil	Shelby Tube	None	None
Ammonia	USEPA 350.1-.3	Water	400 ml (Poly, Glass)	4 degrees Celcius, H ₂ SO ₄	28 days
Acidity	USEPA 305.1	Water	100 ml (Poly, Glass)	Cool, 4 degrees Celcius	14 days
Alkalinity	USEPA 310.1-.2	Water	100 ml (Poly, Glass)	Cool, 4 degrees Celcius	14 days
Lysimeter Test	ASTM D4696	Soil	Lysimeter (not standard)	None	None
Tensiometer Test	ASTM D3404	Soil	Tensiometer (not standard)	None	None

Notes:

USCS = Unified Soil Classification System TDS = Total Dissolve Solids

N/A = Not Applicable

^a Soil samples collected with split-barrel samplers shall be submitted to the laboratory in stainless steel sampling sleeves.

^b Any preserving agents used must be ACS Certified Reagent Grade.

**PLAN ACCEPTANCE FORM
PROJECT HEALTH AND SAFETY PLAN**

INSTRUCTIONS: This form is to be completed by each person working onsite and returned to EnSafe, Memphis, Tennessee.

Project # _____

Project: _____

SITE-SPECIFIC HEALTH AND SAFETY PLAN FOR ALL SITE ACTIVITIES

I represent that I have read and understand the contents of the above plan and agree to perform my work in accordance with it.

Signed

Print Name

Company

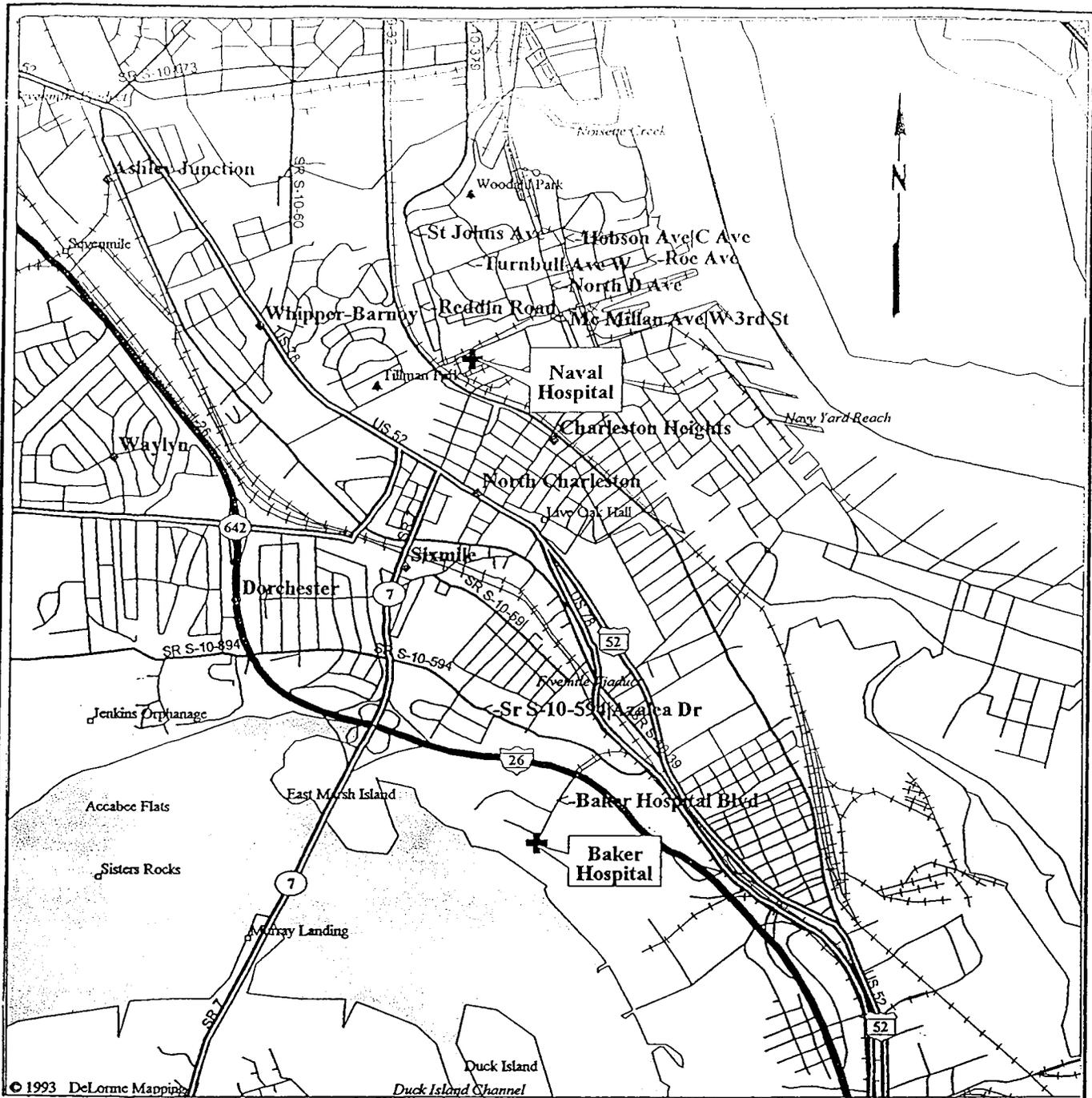
Date

ACCIDENT REPORT FORM

SUPERVISOR'S REPORT OF ACCIDENT		DO NOT USE FOR MOTOR VEHICLE OR AIRCRAFT ACCIDENTS	
TO		FROM	
		TELEPHONE (Include area code)	
NAME OF INJURED OR ILL WORKER AND COMPANY			
WORKER'S SOCIAL SECURITY NUMBER			
DATE OF ACCIDENT	TIME OF ACCIDENT	EXACT LOCATION OF ACCIDENT	
NARRATIVE DESCRIPTION OF ACCIDENT			
NATURE OF ILLNESS OR INJURY AND PART OF BODY INVOLVED		LOST TIME	
		YES <input type="checkbox"/>	
		NO <input type="checkbox"/>	
PROBABLE DISABILITY (Check one)			
FATAL <input type="checkbox"/> LOST WORKDAY <input type="checkbox"/> LOST WORKDAY <input type="checkbox"/> NO LOST WORKDAY <input type="checkbox"/>			
WITH ___ DAYS WITH ___ DAYS OF RESTRICTED FIRST-AID ONLY <input type="checkbox"/>			
AWAY FROM WORK ACTIVITY			
CORRECTIVE ACTION RECOMMENDED (By whom and by when)			
NAME OF SUPERVISOR (Print)		TITLE	
CC:		DATE	

Attachment B

Hospital Route



© 1993 DeLorme Mapping

2000 Feet

1000 Meters



DRAFT
 COMPREHENSIVE
 CMS SAP
 NAVAL BASE CHARLESTON
 CHARLESTON, S.C.

HEALTH AND SAFETY PLAN
 HOSPITAL DIRECTIONS

DWG DATE: 1/29/97

DWG NAME: BOARD

Attachment C

Material Safety Data Sheets

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: ALUMINUM OXIDE
FORMULA: AL2O3
FORMULA WT: 101.96
CAS NO.: 1344-28-1
NIOSH/RTECS NO.: BD1200000
COMMON SYNONYMS: ALUMINA
PRODUCT CODES: 4901,0535,0537,0536,0539,0538,0541,0540
EFFECTIVE: 11/12/86
REVISION #02

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH - 1 SLIGHT
FLAMMABILITY - 0 NONE
REACTIVITY - 0 NONE
CONTACT - 1 SLIGHT

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

SAFETY GLASSES; LAB COAT

PRECAUTIONARY LABEL STATEMENTS

CAUTION

MAY CAUSE IRRITATION
MAY BE HARMFUL IF INHALED

DURING USE AVOID CONTACT WITH EYES, SKIN, CLOTHING. WASH THOROUGHLY AFTER HANDLING. WHEN NOT IN USE KEEP IN TIGHTLY CLOSED CONTAINER.

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

2 - HAZARDOUS COMPONENTS

Table with 3 columns: COMPONENT, %, CAS NO. Row 1: ALUMINUM OXIDE, 90-100, 1344-28-1

3 - PHYSICAL DATA

BOILING POINT: 2977 C (5391 F) VAPOR PRESSURE(MM HG): N/A
MELTING POINT: 2030 C (3686 F) VAPOR DENSITY(AIR=1): N/A
SPECIFIC GRAVITY: 4.00 EVAPORATION RATE: N/A
(H2O=1) (BUTYL ACETATE=1)

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SUITABLE PROTECTIVE CLOTHING. CAREFULLY SWEEP UP AND REMOVE.

DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLV REQUIREMENTS.

RESPIRATORY PROTECTION: NONE REQUIRED WHERE ADEQUATE VENTILATION CONDITIONS EXIST. IF AIRBORNE CONCENTRATION EXCEEDS TLV, A DUST/MIST RESPIRATOR IS RECOMMENDED. IF CONCENTRATION EXCEEDS CAPACITY OF RESPIRATOR, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GLASSES WITH SIDESHIELDS, PROPER GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

SPECIAL PRECAUTIONS
KEEP CONTAINER TIGHTLY CLOSED. SUITABLE FOR ANY GENERAL CHEMICAL STORAGE AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

SOLUBILITY (H2O): NEGLIGIBLE (LESS THAN 0.1 %) % VOLATILES BY VOLUME: 0

APPEARANCE & ODOR: SOFT, ODORLESS SOLID OR CRYSTALS.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP: N/A

FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %

FIRE EXTINGUISHING MEDIA

USE EXTINGUISHING MEDIA APPROPRIATE FOR SURROUNDING FIRE.

5 - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE (TLV/TWA): 5 MG/M3 (PPM)

TOXICITY: LD50 (ORAL-RAT) (MG/KG) - 7340

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE

DUST MAY IRRITATE NOSE AND THROAT.

CONTACT WITH SKIN OR EYES MAY CAUSE IRRITATION.

TARGET ORGANS

NONE IDENTIFIED

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE

NONE IDENTIFIED

ROUTES OF ENTRY

NONE INDICATED

EMERGENCY AND FIRST AID PROCEDURES

CALL A PHYSICIAN.

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH PLENTY OF WATER FOR AT
15 MINUTES. FLUSH SKIN WITH WATER.

6 - REACTIVITY DATA

STABILITY: STABLE

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

INCOMPATIBLES: STRONG ACIDS

7 - SPILL AND DISPOSAL PROCEDURES

MSDS for CALCIUM HYDROXIDE

Page 3

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE

WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING.

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: CALCIUM OXIDE
FORMULA: CAO
FORMULA WT: 56.08
CAS NO.: 01305-78-8
NIOSH/RTECS NO.: EW3100000
COMMON SYNONYMS: LIME; CALX; QUICKLIME; CALCIUM MONOXIDE; BURNT LIME
PRODUCT CODES: 1414,1410,4902
EFFECTIVE: 09/18/86
REVISION #03

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH - 1 SLIGHT
FLAMMABILITY - 0 NONE
REACTIVITY - 1 SLIGHT
CONTACT - 2 MODERATE

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

SAFETY GLASSES; LAB COAT

PRECAUTIONARY LABEL STATEMENTS

WARNING
CAUSES IRRITATION
HARMFUL IF SWALLOWED

AVOID CONTACT WITH EYES, SKIN, CLOTHING.
KEEP IN TIGHTLY CLOSED CONTAINER. WASH THOROUGHLY AFTER HANDLING.

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

2 - HAZARDOUS COMPONENTS

COMPONENT	%	CAS NO.
CALCIUM OXIDE	90-100	1305-78-8

3 - PHYSICAL DATA

BOILING POINT: 2850 C (5162 F) VAPOR PRESSURE(MM HG): N/A
MELTING POINT: 2572 C (4662 F) VAPOR DENSITY(AIR=1): 1.9
SPECIFIC GRAVITY: 3.34 EVAPORATION RATE: N/A
(H2O=1) (BUTYL ACETATE=1)

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: MOISTURE, AIR

INCOMPATIBLES: WATER, FLUORINE, STRONG ACIDS

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE

WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING.
WITH CLEAN SHOVEL, CAREFULLY PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND
COVER; REMOVE FROM AREA. FLUSH SPILL AREA WITH WATER.

DISPOSAL PROCEDURE

DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL
ENVIRONMENTAL REGULATIONS.

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET
TLV REQUIREMENTS.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE
CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP
TO 11 PPM, A DUST/MIST RESPIRATOR IS
RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED
BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GLASSES WITH SIDESHIELDS, UNIFORM, RUBBER
GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

SPECIAL PRECAUTIONS

KEEP CONTAINER TIGHTLY CLOSED. SUITABLE FOR ANY GENERAL CHEMICAL STORAGE
AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: HYDROCHLORIC ACID
FORMULA: HCL
FORMULA WT: 36.46
CAS NO.: 7647-01-0
NIOSH/RTECS NO.: MW4025000
COMMON SYNONYMS: MURIATIC ACID; CHLOROHYDRIC ACID; HYDROCHLORIDE
PRODUCT CODES: 9543,9539,9535,5367,9534,9544,9529,9542,4800,9549,9530,9548
9540,9547,9546,9537
EFFECTIVE: 08/07/86
REVISION #02

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH - 3 SEVERE (POISON)
FLAMMABILITY - 0 NONE
REACTIVITY - 2 MODERATE
CONTACT - 3 SEVERE (CORROSIVE)

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES

PRECAUTIONARY LABEL STATEMENTS

POISON DANGER
CAUSES SEVERE BURNS
MAY BE FATAL IF SWALLOWED OR INHALED

DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
DO NOT BREATHE VAPOR. CAUSES DAMAGE TO RESPIRATORY SYSTEM (LUNGS),
EYES AND SKIN. KEEP IN TIGHTLY CLOSED CONTAINER. LOOSEN CLOSURE CAUTIOUSLY.
USE WITH ADEQUATE VENTILATION. WASH THOROUGHLY AFTER HANDLING. IN CASE
OF SPILL NEUTRALIZE WITH SODA ASH OR LIME AND PLACE IN DRY CONTAINER.

SAF-T-DATA(TM) STORAGE COLOR CODE: WHITE (CORROSIVE)

2 - HAZARDOUS COMPONENTS

Table with 3 columns: COMPONENT, %, CAS NO.
Row 1: HYDROCHLORIC ACID (23 BAUME), 35-40, 7647-01-0

3 - PHYSICAL DATA

BOILING POINT: 110 C (230 F) VAPOR PRESSURE(MM HG): N/A

TARGET ORGANS

RESPIRATORY SYSTEM, EYES, SKIN

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE

NONE IDENTIFIED

ROUTES OF ENTRY

INGESTION, INHALATION, SKIN CONTACT, EYE CONTACT

EMERGENCY AND FIRST AID PROCEDURES

CALL A PHYSICIAN.

IF SWALLOWED, DO NOT INDUCE VOMITING; IF CONSCIOUS, GIVE WATER, MILK, OR MILK OF MAGNESIA.

IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.

WASH CLOTHING BEFORE RE-USE.

6 - REACTIVITY DATA

STABILITY: STABLE

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: HEAT, MOISTURE

INCOMPATIBLES:

MOST COMMON METALS, WATER, AMINES, METAL OXIDES, ACETIC ANHYDRIDE, PROPIOLACTONE, VINYL ACETATE, MERCURIC SULFATE, CALCIUM PHOSPHIDE, FORMALDEHYDE, ALKALIES, CARBONATES, STRONG BASES, SULFURIC ACID, CHLOROSULFONIC ACID

DECOMPOSITION PRODUCTS: HYDROGEN CHLORIDE, HYDROGEN, CHLORINE

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE

WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING. STOP LEAK IF YOU CAN DO SO WITHOUT RISK. VENTILATE AREA. NEUTRALIZE SPILL WITH SODA ASH OR LIME. WITH CLEAN SHOVEL, CAREFULLY PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND COVER; REMOVE FROM AREA. FLUSH SPILL AREA WITH WATER.

J. T. BAKER NEUTRASORB(R) OR NEUTRASOL(R) "LOW NA+" ACID NEUTRALIZERS ARE RECOMMENDED FOR SPILLS OF THIS PRODUCT.

DISPOSAL PROCEDURE

DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

EPA HAZARDOUS WASTE NUMBER:

D002 (CORROSIVE WASTE)

8 - PROTECTIVE EQUIPMENT

MSDS for HYDROCHLORIC ACID

Page 4

VENTILATION:

USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET

TLV REQUIREMENTS.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP TO 100 PPM, A CHEMICAL CARTRIDGE RESPIRATOR WITH ACID CARTRIDGE IS RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GOGGLES AND FACE SHIELD, UNIFORM, PROTECTIVE SUIT, ACID-RESISTANT GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: WHITE (CORROSIVE)

SPECIAL PRECAUTIONS

KEEP CONTAINER TIGHTLY CLOSED. STORE IN CORROSION-PROOF AREA.
ISOLATE FROM INCOMPATIBLE MATERIALS.
DO NOT STORE NEAR OXIDIZING MATERIALS.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	HYDROCHLORIC ACID
HAZARD CLASS	CORROSIVE MATERIAL (LIQUID)
UN/NA	UN1789
LABELS	CORROSIVE
REPORTABLE QUANTITY	5000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	HYDROCHLORIC ACID, SOLUTION
HAZARD CLASS	8
UN/NA	UN1789
LABELS	CORROSIVE

MSDS for MAGNESIUM HYDROXIDE

Page 1

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: MAGNESIUM HYDROXIDE
 FORMULA: MG(OH)2
 FORMULA WT: 58.34
 CAS NO.: 01309-42-8
 NIOSH/RTECS NO.: OM3580000
 COMMON SYNONYMS: MAGNESIUM HYDRATE; MILK OF MAGNESIA
 PRODUCT CODES: 2465
 EFFECTIVE: 05/05/86
 REVISION #01

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH	-	1	SLIGHT
FLAMMABILITY	-	0	NONE
REACTIVITY	-	0	NONE
CONTACT	-	1	SLIGHT

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

SAFETY GLASSES; LAB COAT

PRECAUTIONARY LABEL STATEMENTS

DURING USE AVOID CONTACT WITH EYES, SKIN, CLOTHING. WASH THOROUGHLY AFTER HANDLING. WHEN NOT IN USE KEEP IN TIGHTLY CLOSED CONTAINER.

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

2 - HAZARDOUS COMPONENTS

COMPONENT	%	CAS NO.
NOT APPLICABLE		

3 - PHYSICAL DATA

BOILING POINT:	N/A	VAPOR PRESSURE(MM HG):	N/A
MELTING POINT:	350 C (662 F)	VAPOR DENSITY(AIR=1):	N/A
SPECIFIC GRAVITY:	2.36	EVAPORATION RATE:	N/A
(H2O=1)		(BUTYL ACETATE=1)	
SOLUBILITY(H2O):	NEGLIGIBLE (LESS THAN 0.1 %)	% VOLATILES BY VOLUME:	0

MSDS for MAGNESIUM HYDROXIDE

Page 2

DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE ADEQUATE GENERAL OR LOCAL EXHAUST VENTILATION TO KEEP FUME OR DUST LEVELS AS LOW AS POSSIBLE.

RESPIRATORY PROTECTION: NONE REQUIRED WHERE ADEQUATE VENTILATION CONDITIONS EXIST. IF AIRBORNE CONCENTRATION IS HIGH, USE AN APPROPRIATE RESPIRATOR OR DUST MASK.

EYE/SKIN PROTECTION: SAFETY GLASSES WITH SIDESHIELDS, PROPER GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

SPECIAL PRECAUTIONS
KEEP CONTAINER TIGHTLY CLOSED. SUITABLE FOR ANY GENERAL CHEMICAL STORAGE AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

MELTING POINT: -42 C (-44 F) VAPOR DENSITY(AIR=1):
SPECIFIC GRAVITY: 1.41 EVAPORATION RATE: N/A
(H2O=1) (BUTYL ACETATE=1)
SOLUBILITY(H2O): COMPLETE (IN ALL PROPORTIONS) % VOLATILES BY VOLUME: 100
APPEARANCE & ODOR: COLORLESS LIQUID, WITH CHOKING ODOR.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP N/A NFPA 704M RATING: 3-0-0 OXY
FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %
FIRE EXTINGUISHING MEDIA
USE WATER SPRAY.

SPECIAL FIRE-FIGHTING PROCEDURES
FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED
BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE.
MOVE EXPOSED CONTAINERS FROM FIRE AREA IF IT CAN BE DONE WITHOUT RISK.
USE WATER TO KEEP FIRE-EXPOSED CONTAINERS COOL; DO NOT GET WATER INSIDE
CONTAINERS.

UNUSUAL FIRE & EXPLOSION HAZARDS
STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE.

TOXIC GASES PRODUCED
NITROGEN OXIDES, HYDROGEN GAS

5 - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE (TLV/TWA): 5 MG/M3 (2 PPM)
SHORT-TERM EXPOSURE LIMIT (STEL): 10 MG/M3 (4 PPM)
PERMISSIBLE EXPOSURE LIMIT (PEL): 5 MG/M3 (2 PPM)
CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE
INHALATION OF VAPORS MAY CAUSE NAUSEA, VOMITING, LIGHTHEADEDNESS OR
HEADACHE.
INHALATION OF VAPORS MAY CAUSE SEVERE IRRITATION OF THE RESPIRATORY SYSTEM.
INHALATION OF VAPORS MAY CAUSE COUGHING, CHEST PAINS, DIFFICULTY BREATHING,
OR UNCONSCIOUSNESS.
CONTACT WITH LIQUID OR VAPOR MAY CAUSE SEVERE IRRITATION OR BURNS OF THE
SKIN, EYES, AND MUCOUS MEMBRANES.
INGESTION MAY CAUSE SEVERE BURNS TO MOUTH, THROAT, AND STOMACH. MAY HAVE
ADVERSE EFFECT ON KIDNEY FUNCTION AND MAY BE FATAL.

INGESTION IS HARMFUL AND MAY BE FATAL.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP TO 100 PPM, A CHEMICAL CARTRIDGE RESPIRATOR WITH ACID CARTRIDGE IS RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GOGGLES AND FACE SHIELD, UNIFORM, PROTECTIVE SUIT, ACID-RESISTANT GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: YELLOW (REACTIVE)

SPECIAL PRECAUTIONS

KEEP CONTAINER TIGHTLY CLOSED. STORE SEPARATELY AND AWAY FROM FLAMMABLE AND COMBUSTIBLE MATERIALS.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	NITRIC ACID (OVER 40%) POISON - INHALATION HAZARD
HAZARD CLASS	OXIDIZER
UN/NA	UN2031
LABELS	OXIDIZER, CORROSIVE, POISON
REPORTABLE QUANTITY	1000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	NITRIC ACID
HAZARD CLASS	8
UN/NA	UN2031
LABELS	CORROSIVE

SOLUBILITY(H2O): MODERATE (1 TO 10 %) % VOLATILES BY VOLUME: 0

APPEARANCE & ODOR: ODORLESS WHITE CRYSTALLINE POWDER.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP N/A

FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %

FIRE EXTINGUISHING MEDIA

USE EXTINGUISHING MEDIA APPROPRIATE FOR SURROUNDING FIRE.

SPECIAL FIRE-FIGHTING PROCEDURES

FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE.

TOXIC GASES PRODUCED

CARBON MONOXIDE, CARBON DIOXIDE

5 - HEALTH HAZARD DATA

TOXICITY: LD50 (ORAL-RAT) (MG/KG) - 4220

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE

DUST MAY IRRITATE SKIN OR EYES.

TARGET ORGANS

NONE IDENTIFIED

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE

NONE IDENTIFIED

ROUTES OF ENTRY

NONE INDICATED

EMERGENCY AND FIRST AID PROCEDURES

INGESTION: IF SWALLOWED AND THE PERSON IS CONSCIOUS, IMMEDIATELY GIVE LARGE AMOUNTS OF WATER. GET MEDICAL ATTENTION.

INHALATION: IF A PERSON BREATHE IN LARGE AMOUNTS, MOVE THE EXPOSED PERSON TO FRESH AIR. GET MEDICAL ATTENTION.

EYE CONTACT: IMMEDIATELY FLUSH WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.

SKIN CONTACT: IMMEDIATELY WASH WITH PLENTY OF SOAP AND WATER FOR AT LEAST 15 MINUTES.

6 - REACTIVITY DATA

MSDS for SODIUM BICARBONATE

Page 3

STABILITY: STABLE

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

MSDS for SODIUM CARBONATE, ANHYDROUSPage 1

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: SODIUM CARBONATE, ANHYDROUS
 FORMULA: NA₂CO₃
 FORMULA WT: 105.99
 CAS NO.: 497-19-8
 NIOSH/RTECS NO.: VZ4050000
 COMMON SYNONYMS: SODA ASH; DISODIUM CARBONATE
 PRODUCT CODES: 5151,4502,5134,4923,5605,5198,3605,5154,3604,5179,3602
 EFFECTIVE: 11/24/86
 REVISION #02

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH	-	1	SLIGHT
FLAMMABILITY	-	0	NONE
REACTIVITY	-	1	SLIGHT
CONTACT	-	1	SLIGHT

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

SAFETY GLASSES; LAB COAT

PRECAUTIONARY LABEL STATEMENTS

CAUTION

MAY CAUSE IRRITATION

MAY BE HARMFUL IF SWALLOWED

DURING USE AVOID CONTACT WITH EYES, SKIN, CLOTHING. WASH THOROUGHLY AFTER HANDLING. WHEN NOT IN USE KEEP IN TIGHTLY CLOSED CONTAINER.

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

2 - HAZARDOUS COMPONENTS

COMPONENT	%	CAS NO.
SODIUM CARBONATE, ANHYDROUS		00497-19-8

3 - PHYSICAL DATA

BOILING POINT: N/A	VAPOR PRESSURE(MM HG): N/A
MELTING POINT: 851 C (1564 F)	VAPOR DENSITY(AIR=1): N/A
SPECIFIC GRAVITY: 2.53 (H ₂ O=1)	EVAPORATION RATE: N/A (BUTYL ACETATE=1)

MSDS for SODIUM CARBONATE, ANHYDROUSPage 2

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR
CONDITIONS TO AVOID: HUMIDITY
INCOMPATIBLES: STRONG ACIDS, ALUMINUM, FLUORINE, OXIDES OF PHOSPHORUS,
LITHIUM
DECOMPOSITION PRODUCTS: CARBON MONOXIDE, CARBON DIOXIDE

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SUITABLE PROTECTIVE CLOTHING. CAREFULLY SWEEP UP AND REMOVE.

DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL
ENVIRONMENTAL REGULATIONS.

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE ADEQUATE GENERAL OR LOCAL EXHAUST VENTILATION
TO KEEP FUME OR DUST LEVELS AS LOW AS POSSIBLE.

RESPIRATORY PROTECTION: NONE REQUIRED WHERE ADEQUATE VENTILATION
CONDITIONS EXIST. IF AIRBORNE CONCENTRATION IS
HIGH, USE AN APPROPRIATE RESPIRATOR OR DUST MASK.

EYE/SKIN PROTECTION: SAFETY GLASSES WITH SIDESHIELDS, RUBBER GLOVES ARE
RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: ORANGE (GENERAL STORAGE)

SPECIAL PRECAUTIONS
KEEP CONTAINER TIGHTLY CLOSED. SUITABLE FOR ANY GENERAL CHEMICAL STORAGE
AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME CHEMICALS, N.O.S. (NON-REGULATED)

SPECIFIC GRAVITY: 2.13 (H2O=1) EVAPORATION RATE: N/A (BUTYL ACETATE=1)
SOLUBILITY(H2O): APPRECIABLE (MORE THAN 10 %) % VOLATILES BY VOLUME: 0
APPEARANCE & ODOR: WHITE, ODORLESS SOLID.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP N/A NFPA 704M RATING: 3-0-1
FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %

FIRE EXTINGUISHING MEDIA
USE EXTINGUISHING MEDIA APPROPRIATE FOR SURROUNDING FIRE.

SPECIAL FIRE-FIGHTING PROCEDURES
FLOOD WITH WATER, DO NOT SPLATTER OR SPLASH THIS MATERIAL.

UNUSUAL FIRE & EXPLOSION HAZARDS
CONTACT WITH MOISTURE OR WATER MAY GENERATE SUFFICIENT HEAT TO
IGNITE COMBUSTIBLE MATERIALS.
REACTS WITH MOST METALS TO PRODUCE HYDROGEN GAS, WHICH CAN FORM AN
EXPLOSIVE MIXTURE WITH AIR.

5 - HEALTH HAZARD DATA

TLV LISTED DENOTES CEILING LIMIT.

THRESHOLD LIMIT VALUE (TLV/TWA): 2 MG/M3 (PPM)

PERMISSIBLE EXPOSURE LIMIT (PEL): 2 MG/M3 (PPM)

TOXICITY: LD50 (IPR-MOUSE) (MG/KG) - 40

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE
EXCESSIVE INHALATION OF DUST IS IRRITATING AND MAY BE SEVERELY DAMAGING
TO RESPIRATORY PASSAGES AND/OR LUNGS.
CONTACT WITH SKIN OR EYES MAY CAUSE SEVERE IRRITATION OR BURNS.
INGESTION IS HARMFUL AND MAY BE FATAL.
INGESTION MAY CAUSE SEVERE BURNING OF MOUTH AND STOMACH.
INGESTION MAY CAUSE NAUSEA AND VOMITING.

TARGET ORGANS
EYES, SKIN, RESPIRATORY SYSTEM

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE
NONE IDENTIFIED

ROUTES OF ENTRY
INHALATION, INGESTION, EYE CONTACT, SKIN CONTACT

EMERGENCY AND FIRST AID PROCEDURES

SAF-T-DATA(TM) STORAGE COLOR CODE: WHITE STRIPE (STORE SEPARATELY)

SPECIAL PRECAUTIONS

KEEP CONTAINER TIGHTLY CLOSED. STORE IN CORROSION-PROOF AREA.
STORE IN A DRY AREA.
ISOLATE FROM INCOMPATIBLE MATERIALS.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	SODIUM HYDROXIDE, DRY SOLID
HAZARD CLASS	CORROSIVE MATERIAL (SOLID)
UN/NA	UN1823
LABELS	CORROSIVE
REPORTABLE QUANTITY	1000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	SODIUM HYDROXIDE, SOLID
HAZARD CLASS	8
UN/NA	UN1823
LABELS	CORROSIVE

MELTING POINT: -2 C (28 F) VAPOR DENSITY(AIR=1): 3.4
SPECIFIC GRAVITY: 1.84 EVAPORATION RATE: <1
(H2O=1) (BUTYL ACETATE=1)
SOLUBILITY(H2O): COMPLETE (IN ALL PROPORTIONS) % VOLATILES BY VOLUME: N/A
APPEARANCE & ODOR: CLEAR, COLORLESS TO LIGHT YELLOW, OILY ODORLESS LIQUID.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP N/A NFPA 704M RATING: 3-0-2 W
FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %
FIRE EXTINGUISHING MEDIA
USE DRY CHEMICAL OR CARBON DIOXIDE. DO NOT USE WATER.

SPECIAL FIRE-FIGHTING PROCEDURES
FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED
BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE.
DO NOT GET WATER INSIDE CONTAINERS.

UNUSUAL FIRE & EXPLOSION HAZARDS
REACTS WITH MOST METALS TO PRODUCE HYDROGEN GAS, WHICH CAN FORM AN
EXPLOSIVE MIXTURE WITH AIR.
A VIOLENT EXOTHERMIC REACTION OCCURS WITH WATER. SUFFICIENT HEAT
MAY BE PRODUCED TO IGNITE COMBUSTIBLE MATERIALS.

TOXIC GASES PRODUCED
SULFUR DIOXIDE

5 - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE (TLV/TWA): 1 MG/M3 (PPM)
PERMISSIBLE EXPOSURE LIMIT (PEL): 1 MG/M3 (PPM)
TOXICITY: LD50 (ORAL-RAT) (MG/KG) - 2140
CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE
INHALATION OF VAPORS MAY CAUSE SEVERE IRRITATION OF THE RESPIRATORY SYSTEM.
LIQUID MAY CAUSE SEVERE BURNS TO SKIN AND EYES.
INGESTION IS HARMFUL AND MAY BE FATAL.
INGESTION MAY CAUSE NAUSEA AND VOMITING.
INGESTION MAY CAUSE SEVERE BURNS TO MOUTH, THROAT, AND STOMACH. MAY HAVE
ADVERSE EFFECT ON KIDNEY FUNCTION AND MAY BE FATAL.

MSDS for SULFURIC ACID Page 3

CHRONIC OVEREXPOSURE MAY RESULT IN LUNG DAMAGE.

TARGET ORGANS

RESPIRATORY PROTECTION: NONE REQUIRED WHERE APPROPRIATE VENTILATION
CONDITIONS EXIST. IF THE TLV IS EXCEEDED, A SELF-
CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GOGGLES AND FACE SHIELD, UNIFORM,
PROTECTIVE SUIT, RUBBER GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: WHITE (CORROSIVE)

SPECIAL PRECAUTIONS

KEEP CONTAINER TIGHTLY CLOSED. STORE IN CORROSION-PROOF AREA.
KEEP CONTAINERS OUT OF SUN AND AWAY FROM HEAT.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME SULFURIC ACID
HAZARD CLASS CORROSIVE MATERIAL (LIQUID)
UN/NA UN1830
LABELS CORROSIVE
REPORTABLE QUANTITY 1000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME SULPHURIC ACID
HAZARD CLASS 8
UN/NA UN1830
LABELS CORROSIVE