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CORRECTIVE MEASURES STUDY REPORT SOLID WASTE MANAGEMENT UNIT 17 (SWMU 17) ZONE H CNC CHARLESTON SC
11/30/2004
CH2M HILL

CORRECTIVE MEASURES STUDY REPORT

SWMU 17, Zone H

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

CH2M-Jones

November 2004

Contract N62467-99-C-0960

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CH2MHILL

November 30, 2004

Mr. David Scaturo
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: Corrective Measures Study Report (Revision 0) – SWMU 17, Zone H

Dear Mr. Scaturo:

Enclosed please find two copies of the Corrective Measures Study Report (Revision 0) for SWMU 17 in Zone H of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

Please contact me at 352/335-5877, ext. 2280, if you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson, P.E.

cc: Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CH2MHILL TRANSMITTAL

To: Mr. David Scaturo
South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

From: Dean Williamson/CH2M-Jones

Date: February 13, 2006

Re: Responses to SCDHEC Comments on the *Corrective Measures Study Report, SWMU 17, Zone H, Revision 0* – Originally Submitted on November 30, 2004

We Are Sending You:

X	**Attached**	Under separate cover via	
	Shop Drawings	Documents	Tracings
	Prints	Specifications	Catalogs
	Copy of letter	Other:	

Quantity	Description
2	CH2M-Jones' Responses to SCDHEC Comments on the *Corrective Measures Study Report, SWMU 17, Zone H, Revision 0* – Originally Submitted on November 30, 2004

If material received is not as listed, please notify us at once.

Copy To:

Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CORRECTIVE MEASURES STUDY REPORT

SWMU 17, Zone H

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

PREPARED BY
CH2M-Jones

November 2004

Revision 0
Contract N62467-99-C-0960
158814.ZH.PR.09

Certification Page for Corrective Measures Study Report (Revision 0) – SWMU 17, Zone H

I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

P.E. No 21428

Dean Williamson, P.E.

11/18/2004

Date

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Appendices

Acronyms and Abbreviations

AST	Aboveground Storage Tank
BCT	BRAC Cleanup Team
BEQ	Benzo(a)pyrene Equivalents
bls	Below Land Surface
BRAC	Base Realignment and Closure Act
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CA	Corrective Action
CMS	Corrective Measures Study
CNC	Charleston Naval Complex
COC	Chemical of Concern
COPC	Chemical of Potential Concern
DAF	Dilution Attenuation Factor
DNAPL	Dense Nonaqueous Phase Liquid
DPT	Direct Push Technology
EBSL	Environmental Baseline Survey for Lease
EnSafe	EnSafe Inc.
EPA	U.S. Environmental Protection Agency
FBM	Fleet Ballistic Missile
ft/day	Feet Per Day
HI	Hazard Index
IM	Interim Measure
LNAPL	Light Nonaqueous Phase Liquid
LUC	Land Use Control
µg/kg	Microgram Per Kilogram
µg/L	Microgram Per Liter
MCL	Maximum Contaminant Level
MCS	Media Cleanup Standard
mg/kg	Milligram Per Kilogram

Acronyms and Abbreviations, Continued

MNA	Monitored Natural Attenuation
NAPL	Nonaqueous Phase Liquid
NAVBASE	Naval Base
O&M	Operation and Maintenance
ORC®	Oxygen Release Compound®
OWS	Oil/Water Separator
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RGO	Remedial Goal Option
SCDHEC	South Carolina Department of Health and Environmental Control
scfm	Standard Cubic Feet Per Minute
SSL	Soil Screening Level
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TEQ	TCDD (dioxin isomer) Equivalent
TV	Transformer Vault
UCL_{95}	95% Upper Confidence Limit
USBP	U.S. Border Patrol
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound

Section 1.0

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure Act, which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

CNC corrective action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA). The South Carolina Department of Health and Environmental Control (SCDHEC) is the lead agency for CA activities at the site. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560). In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at CNC. This Corrective Measures Study (CMS) has been prepared by CH2M-Jones to identify and evaluate the potential remedial alternatives for soil and groundwater at Solid Waste Management Unit (SWMU) 17 in Zone H at the CNC. The location of SWMU 17 within the CNC is shown on Figure 1-1. An aerial view of the site is provided on Figure 1-2.

1.1 Regulatory Background

CH2M-Jones has prepared this CMS to comply with the RCRA Hazardous and Solid Waste Amendments Permit for the CNC. A RCRA Facility Investigation (RFI) Report, a baseline risk assessment, and an RFI Report Addendum prepared by EnSafe Inc. (EnSafe) have been completed for SWMU 17 and approved by SCDHEC. A CMS Work Plan was prepared by CH2M-Jones and approved by SCDHEC. The CMS Work Plan described the results of the risk assessment, chemicals of concern (COCs), media cleanup standards (MCSs), remedial action objectives (RAOs) and potential remediation approaches for the site. An Interim Measure (IM) Work Plan to address polychlorinated biphenyl (PCB)-impacted soil and assess the recoverability of light nonaqueous phase liquid (LNAPL) was also prepared. The IM Work Plan refined the target MCSs for PCB-soil under various land use scenarios.

The next step in the RCRA CA program for SWMU 17 is the CMS process, which consists of this CMS Report and implementation of the selected corrective measure alternative. This CMS Report summarizes the COCs, MCSs, RAOs, and results of several IM activities completed since the submittal of the CMS Work Plan. It then identifies and evaluates various remedial approaches for achieving the RAOs and MCSs for the site.

1.2 Site Background

SWMU 17 is located at Building Fleet Ballistic Missile (FBM) 61 within Zone H at the CNC. Building FBM 61 is the former Fleet Ballistic Missile Training Center that was used by the Navy from 1962 until June 1996. It is leased by the U.S. Border Patrol (USBP) and is used as a law enforcement training facility. The site is expected to continue to be used by USBP for the foreseeable future.

The proposed zoning for SWMU 17 is B-2, which allows for various commercial business activities but does not provide for long-term or permanent residential use. The CNC Reuse Plan designates the future land use of this area for government offices and a training campus. The USBP's use of this area for law enforcement training is compatible with the zoning and future land use provided for in the CNC Reuse Plan.

Four known sources of contamination have been identified at SWMU 17. These four source areas, designated as A through D, are described below and shown on Figure 1-3.

A: Two No. 5 fuel oil fired boilers inside Building FBM 61 were formerly operated by the Navy. A 30,000-gallon aboveground storage tank (AST), AST NS600, located on the north side of Building FBM 61 within a containment area, supplied fuel for these boilers. In June 1987, a leak occurred in the boiler fuel oil line that ran from NS600 underneath the storage addition on the north side of Building FBM 61 to Room 111. Approximately 14,400 gallons of No. 5 fuel oil leaked, of which approximately 7,300 gallons were recovered within days of the release using test pits. Three oil recovery sumps, constructed from open-ended 55 gallon drums, were installed around the building to facilitate recover of the residual oil. Residual No. 5 fuel oil remains in the soil beneath the building but has not been observed to be migrating.

B: An emergency electrical generator was also located in the boiler room within Building FBM 61. The No. 2 diesel fuel used to run this generator was stored in a 250-gallon steel underground storage tank (UST) (UST FBM 61-1) installed in 1961 and located in the courtyard area adjacent to Transformer Vault 1 (TV1). Due to leaks in this tank, it was removed in September 1997. The amount of No. 2 diesel fuel that leaked from this UST is unknown.

C: In 1984, a line pole capacitor reportedly ruptured and spilled PCB oils at the northern end of the paved courtyard. The Navy cleaned up the PCB oils. Documentation regarding the cleanup of this spill is not available. It is possible that some of the observed PCB-impacted soil and groundwater at SWMU 17 is a result of this spill.

D: Two former TVs (TV1 and TV2) are located on the north side of Building FBM 61. TV1 is located within the paved courtyard. Soils collected from beneath drains from TV1 in 1982 were determined to be impacted by PCBs. There is no information as to whether samples were collected from the soils near TV2 at that time, but subsequent sampling during the RFI did not indicate that releases had occurred from TV2. Both PCB-filled transformers were removed in the early 1990s.

In addition to these sources, two other potential sources of contamination are present at SWMU 17. However, neither of these potential sources has been found to have caused a release of contamination. These potential sources are described herein for completeness in describing site conditions at SWMU 17.

- An oil/water separator (OWS), which is no longer in service, is located within the paved courtyard area below grade in a concrete containment structure. This OWS was used to treat water from the boiler room bilges and sumps. Oil recovered from the separator was collected in UST FBM 61-2 adjacent to the OWS. UST FBM 61-2 was removed in September 1997 and no contamination was detected in excavated soils. The OWS is reportedly no longer connected to the boiler room bilges and sumps.
- A submarine diesel engine/electrical generator was located in Room 2-167 (Diesel Lab) as part of Navy simulation training. The generator engine uses No. 2 diesel fuel. According to the Environmental Baseline Survey for Lease (EBSL) Building Phase 1 assessment, an AST co-located with the diesel engine provided fuel to the unit. However, conflicting anecdotal information from an EnSafe site visit in March 2000 indicated that the diesel fuel storage was in a UST located beneath the building floor just outside the doors of Room 2-167 (see Figure 1-3). Fill line connections for this UST were reportedly located in the building exterior. No other records or evidence of the presence of this UST could be found.

1.3 Site Conceptual Model

Based on the available information regarding the past releases and previous site investigations and evaluations at SWMU 17, the following site conceptual model has been developed that describes the general sources and migration characteristics of the contamination at SWMU 17. More detailed information is also provided later in this CMS.

> *PCBs, No. 2 diesel fuel, and No. 5 fuel oil have been released to the environment at SWMU 17. These releases have impacted soil and groundwater at the site. The No. 5 fuel oil leaked from a buried conveyance line beneath the building. Some of the No. 5 fuel oil remains present as an LNAPL in the area near where the original release occurred beneath Building FBM 61. However, the LNAPL has not migrated from this area. The lack of migration is believed to be due to relatively high viscosity of No. 5 fuel oil. Most of the remaining hydrocarbons beneath Building FBM 61 are likely related to the No. 5 fuel oil. A lesser amount of No. 2 diesel is also present, due to a release from UST FBM 61-1.*
>
> *Low levels of fuel-related polycyclic aromatic hydrocarbons (PAHs) found in groundwater samples collected downgradient of the fuel-impacted area indicate that the residual fuels (both No. 2 diesel and No. 5 fuel oil) may act as a source for dissolved phase hydrocarbon contamination. Benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, at relatively low concentrations, have been observed in groundwater downgradient of the fuel-impacted area. This is consistent with the known composition of No. 5 fuel oil and diesel, which contain much less BTEX than light fuels such as gasoline.*
>
> *PCB contamination is the result of transformer fluid leaks in the paved courtyard area on the north side of the building, both from the transformer previously located at TV1 and from the line pole capacitor that ruptured in 1984. Aroclor 1260 is the main PCB contaminant exceeding screening levels in soil. Chlorinated benzenes are also present as contaminants associated with the leaking transformer dielectric fluid. Some of the leaking transformer fluids have migrated vertically downward through the soil and have impacted the shallow aquifer. A small amount of PCB dense nonaqueous phase liquid (DNAPL) has been observed in well H017002. However, DNAPL was not found in four wells installed around well H017002, indicating that DNAPL's extent is limited. Additionally, DNAPL occurrence in well H017002 is intermittent and was not found in a test recovery well installed at this location.*
>
> *Some recovered LNAPL samples had detectable concentrations of PCBs, indicting that some of the PCBs have partitioned into LNAPL. Given the relatively high organic carbon partitioning factor for PCBs, this is not unexpected and the*

partitioning of the PCBs into the hydrocarbon should act to retard migration of the PCBs and reduce their tendency to migrate in groundwater.

The dielectric fluid from the transformer also provides a source of dissolved phase constituents such as chlorinated benzenes. Chlorobenzene is the most widespread contaminant in groundwater related to the dielectric fluid and has been detected in groundwater at elevated concentrations downgradient (northeast) of the PCB-impacted area.

Surface soil at the site contains concentrations of PCBs above risk-based levels for unrestricted and industrial land use in several locations. All of the locations where individual sample concentrations exceed the industrial target cleanup level are covered by asphaltic pavement or structures and there is no direct exposure pathway or surface runoff pathway for these impacted soils. Generally, subsurface soil is less impacted by PCBs than surface soil, and subsurface soil does not present significant potential leaching or exposure risks, due to the presence of paving and buildings above impacted areas.

Shallow groundwater at the site is migrating slowly in a northeast direction across the parking lot. The extent of contamination extends into the parking lot behind Building FBM 61, approximately 100 feet from the edge of the building extension. The shallow aquifer at the site is underlain by low permeability clayey sediments located approximately 15 feet below land surface (bls), which appear to form an effective aquitard that has prevented downward migration of contamination. Monitoring wells installed beneath the clay in the area did not show that the deeper groundwater has been impacted.

The general site conceptual model described above provides a useful framework from which potential sets of corrective measures can be developed for managing risks and reducing contamination at the site. As additional information becomes available, the site conceptual model can be revised and updated to reflect new information.

1.4 Summary of RFI Activities to Date

Extensive RFI activities to investigate the nature and extent of contamination at SWMU 17 have been conducted over the past 10 years and occurred in five separate phases. These investigations were described in the RFI Report and RFI Report Addendum, were summarized in the CMS Work Plan, and are summarized briefly below.

1.4.1 Soil Sampling

A total of 36 surface soil samples were collected from the top foot of the soil interval in 1994 to 1995, and 33 subsurface soil samples were collected in 1994 and 1995 at a depth of approximately 3 to 5 feet bls. Generally, these samples were analyzed for the full suite of analytes (volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs], pesticides, PCBs, metals, and cyanide). Tables 2.5.12 and 2.5.13 in the RFI Report Addendum list the analyses performed for each of the samples collected (EnSafe, 2000).

Six surface, 10 subsurface, and 16 saturated soil samples were also collected in 1999 using direct push technology (DPT). The saturated zone samples were collected to provide a comparison to groundwater samples in areas of the site with LNAPL and DNAPL. Saturated soil samples were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and cyanide. Figure 1-4 shows surface soil sampling locations. Figure 1-5 shows subsurface soil sampling locations.

1.4.2 Groundwater Sampling

A total of 10 shallow groundwater monitoring wells were installed in 1994 and 1998 to a typical depth of approximately 15 feet bls. In 1998, one deep monitoring well was installed to a depth of 44 feet bls at SWMU 17. In 1999, 27 temporary wells were installed to a depth of approximately 15 feet bls using DPT. These wells were installed to investigate other potential sources of contamination at SWMU 17 and to better delineate the extent of specific contaminants in groundwater. Figure 1-6 shows groundwater monitoring wells, recovery wells, and DPT locations.

Soil samples collected from SWMU 17 borings indicate that the site geology consists of unconsolidated coastal sediments. Four cross-sections of the site were provided in the RFI Report Addendum, illustrating the interbedded nature of these sediments, which consist of silty sands and marsh clays. These figures are included in Appendix A (see Figures 2.5.5A and 2.5.5B).

The water table is approximately 5 feet bls at SWMU 17, and the aquifer materials consist of interbedded sands and clays that range from 5 to 15 feet in thickness. The shallowest portion of the water-bearing zone on the northern side of Building FBM 61, where most of the shallow groundwater contamination occurs, consists generally of fine to very fine sand with varying amounts of silt. Beneath this zone lies an organic clayey silt (Qm1) that appears to be laterally continuous at SWMU 17, since it is detected in the bottom portions of all of the groundwater wells installed at the site. This clay unit is approximately 15 feet thick in the one well that fully penetrated it (H01702D) and appears to provide an effective barrier in preventing shallow groundwater contamination from reaching the deeper aquifer that lies beneath the clay. Groundwater elevations are shown on Figure 2.5.7A, Appendix A.

As described earlier, a significant number of surface and subsurface soil samples and groundwater samples were collected at the site and analyzed for VOCs, SVOCs, PCBs/pesticides, and metals. The RFI Report Addendum contained 53 figures showing the lateral extent of these chemicals across the site and 10 tables listing the concentrations of the chemicals detected in the samples (EnSafe, 2000).

Based on the results of this extensive sampling and analysis, a risk assessment was completed in the RFI report and several COCs for SWMU 17 were identified. An additional risk evaluation of all analytical results was performed in the CMS Work Plan, as summarized in Section 2 of this CMS Report, to further refine the list of COCs for SWMU 17. On the basis of that evaluation, RAOs and MCSs for most of the COCs at the site were identified. The MCSs for PCBs in soil were further refined in the IM Work Plan for Soil and NAPL Removal, dated June 2001. These RAOs and MCSs are discussed in this report, along with various remedial approaches for achieving the remedial objectives for the site.

1.5 Summary of Interim Measure Activities

In order to expedite remedial planning activities for SWMU 17, several IM activities were conducted. These activities are summarized in this section and referred to throughout this document, as appropriate.

1.5.1 Monitored Natural Attenuation Assessment

A monitored natural attenuation (MNA) assessment was performed on groundwater within the northernmost portion of the plume. The purpose of the assessment was to evaluate geochemical conditions in the shallow aquifer to assess whether natural attenuation via biodegradation was likely to be a potentially effective treatment for reducing concentrations of chlorobenzenes in groundwater. Groundwater samples were collected and analyzed for typical MNA and geochemical indicator parameters. The data collected from this assessment indicated that the groundwater at SWMU 17 was generally anaerobic, with iron- and sulfate reducing conditions present. Because chlorobenzenes are amenable to aerobic biodegradation and less amenable to anaerobic biodegradation, it was concluded that natural attenuation, without supplementary addition of oxygen, was not likely to be highly effective. However, if more aerobic conditions are established in the aquifer, biodegradation could be an effective process for chlorobenzenes.

1.5.2 Work Plan for Soil and Nonaqueous Phase Liquid Removal Interim Measure

An IM Work Plan was prepared to address PCB-impacted soil and nonaqueous phase liquid (NAPL) at the site. The proposed approach for addressing PCB-impacted soil was to perform excavations at four localized areas. Three of these areas were located in the paved area where Aroclor 1260 concentrations were below the target MCS for the paved industrial scenario (57.4 milligrams per kilogram [mg/kg]) but above the target MCS for the unpaved industrial use scenario (10 mg/kg). The fourth area was in the area near AST NS600 where a single sample exceeded the target MCS for the unpaved industrial land use scenario of 10 mg/kg. The proposed IM approach for NAPL was to assess the effectiveness of Aggressive Fluid Vacuum Recovery (AFVR) for recovering NAPL from wells at the site.

In the IM Work Plan, statistical exposure point concentrations for PCBs in surface soil were estimated for two separate areas: 1) the paved area in the courtyard, and 2) the unpaved grassy area to the east of the Building FBM 61 extension (including the samples collected around AST NS600, which was believed to be unpaved).

For the paved area, all 19 surface soil samples had Aroclor 1260 concentrations below the target MCS for the paved industrial scenario of 57.4 mg/kg (based on the site-specific soil screening level [SSL] calculation for the paved scenario). The exposure point concentration (95 percent Upper Confidence Limit [UCL_{95}]) for Aroclor 1260 for the paved area defaulted to the maximum value of the data set (23.1 mg/kg) due to its log normal distribution. The arithmetic mean of the data set was 3.7 mg/kg and the geometric mean was 0.24 mg/kg. Even though all values were below the target MCS of 57.4 mg/kg, the work plan proposed that three locations at which Aroclor 1260 concentrations exceeded the unpaved industrial use MCS be excavated as a conservative measure and that confirmatory sampling be conducted prior to this excavation to confirm the validity of the previous detections and determine the extent of the elevated concentrations at those locations.

For the unpaved area, of the 20 surface soil samples analyzed for PCBs, all Aroclor 1260 values were below the target MCS for the unpaved industrial use scenario of 10 mg/kg, except for a single value reported for a sample collected adjacent to AST NS600, which had a reported value of 180 mg/kg. The UCL_{95} value defaulted to the highest value, while the arithmetic mean for the data set was 9.7 mg/kg and the geometric mean was 0.18 mg/kg. Confirmatory sampling of this single high value near the AST was proposed, with subsequent removal of the hot spot upon successful confirmation.

1.5.3 Soil and Nonaqueous Phase Liquid Removal Interim Measure Completion Report

Based on the proposed approach described in the IM Work Plan, confirmatory soil samples were collected to confirm the concentrations of PCBs in soil, as previously described. The results of this confirmatory sampling were presented in the IM Completion Report.

The IM confirmatory sampling in the paved area indicated that all Aroclor 1260 concentrations in the confirmatory samples were below the paved industrial land use MCS of 57.4 mg/kg. Samples at one of the target locations could not be collected due to the presence of a new AST located in the paved courtyard.

The sampling location adjacent to AST NS600 was found to be paved, rather than unpaved as believed during evaluation of the exposure point concentration in the IM Work Plan. The confirmatory samples at this location did not indicate the presence of elevated PCBs, with Aroclor 1260 results all below 0.3 mg/kg.

Based on the confirmatory sampling results and difficulty in accessing some of the target excavations locations in the paved courtyard, a decision was made not to attempt to excavate PCB-impacted soils in this area since concentrations were below the target MCS for the paved industrial land use scenario. The report concluded that maintaining the existing pavement with land use controls (LUCs) would likely provide an acceptable remedy for the soil and that this alternative would be evaluated in the CMS Report.

Additionally, because the resampling of soil near AST NS600 did not confirm the presence of Aroclor 1260 above the unpaved industrial MCS and because the area inside the AST containment wall was found to be paved, no Aroclor 1260 concentrations in surface soil in the unpaved area exceed the target MCS for that area, indicating that excavation of soil is unnecessary.

1.6 Corrective Measures Study Report Organization

This CMS Report consists of the following sections, including this introduction:

1.0 Introduction—Describes the site and summarizes the general nature of contamination and site investigations.

2.0 Summary of COCs and Current Site Conditions—Summarizes the COC refinement process from the CMS Work Plan and describes the extent of contamination.

3.0 Remedial Goal Objectives and Evaluation Criteria—Presents RAOs and MCSs and the criteria to be used to evaluate potential remedial alternatives.

4.0 Description of Candidate Corrective Measure Alternatives—Describes candidate remedial alternatives for contaminated soil and groundwater.

5.0 Detailed Evaluation of Alternatives—Describes best-suited alternatives in more detail.

6.0 Recommendations—Presents recommended remedial alternative approaches for SWMU 17.

7.0 References— Lists the references used in this document.

Appendix A contains figures from the RFI Report and RFI Report Addendum.

Appendix B contains cost estimates.

All tables and figures are found at the end of their respective sections.

NOTE: Original figure created in color

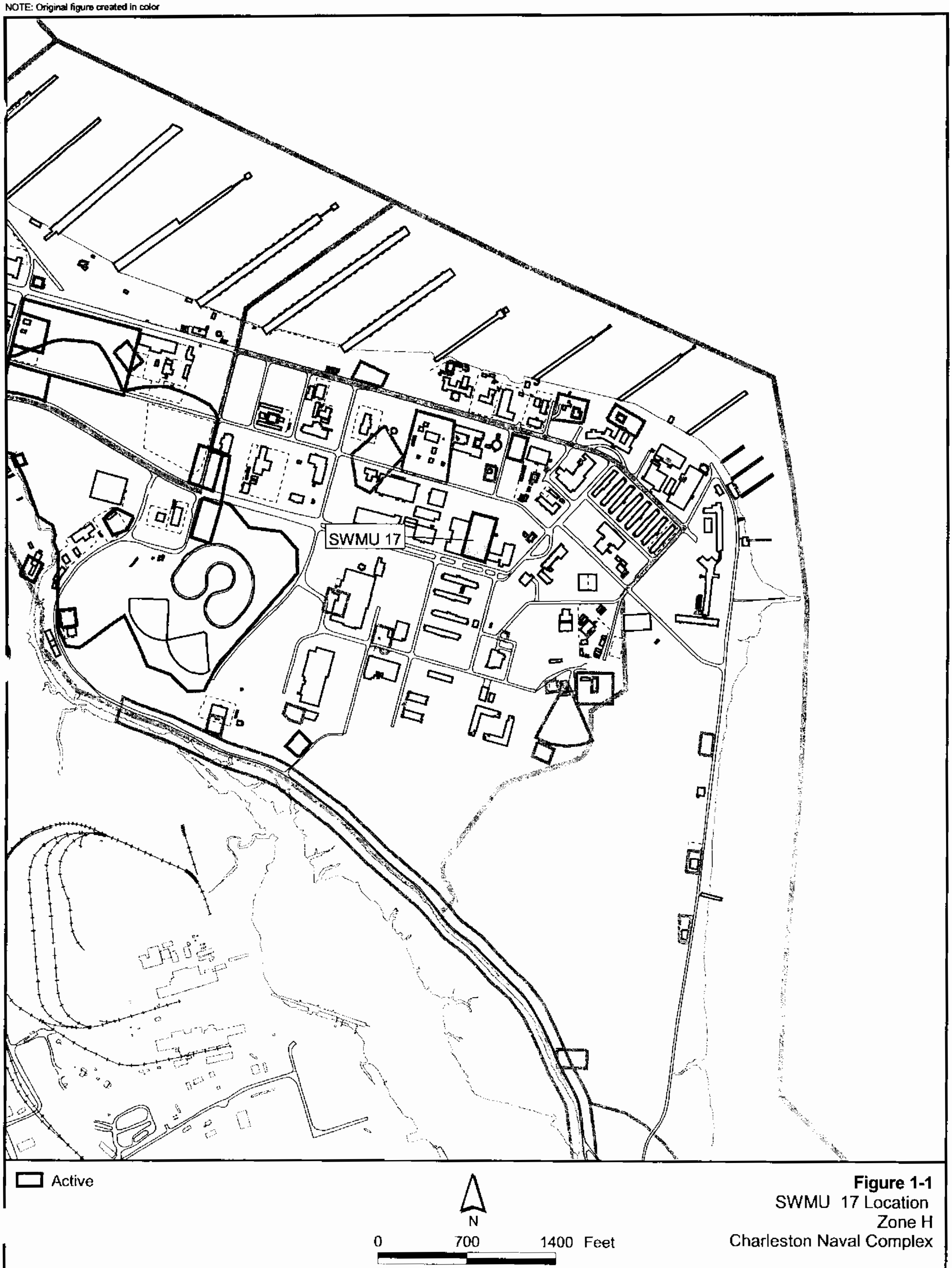


Figure 1-1
SWMU 17 Location
Zone H
Charleston Naval Complex

NOTE: Aerial Photo Date Is 1997
NOTE: Original figure created in color

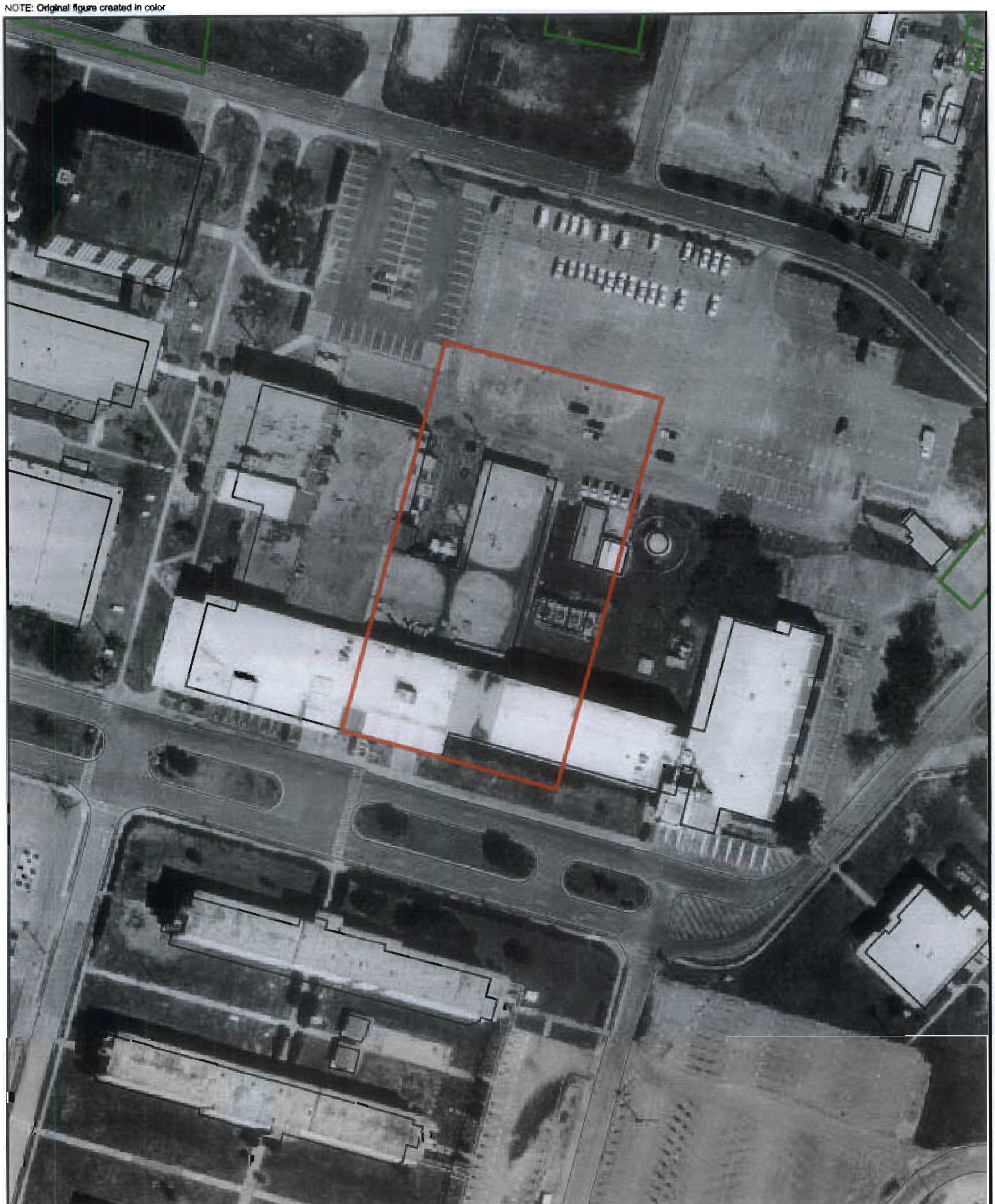
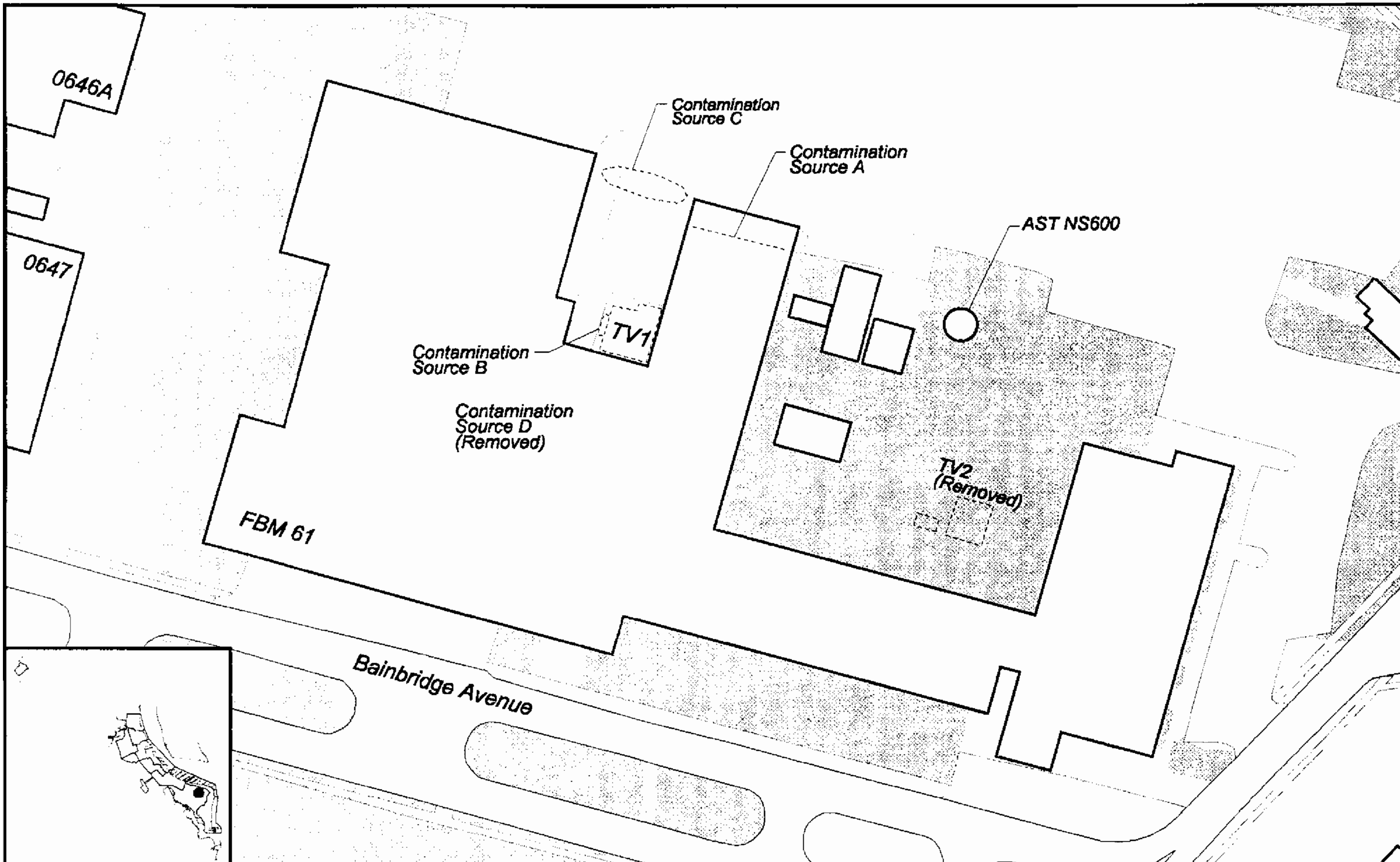


Figure 1-2
SWMU 17 Aerial Photograph
Zone H
Charleston Naval Complex

N
0 90 180 Feet
1 inch = 112.475 feet

File Path: c:\18gis\cnc\cnc-egis.apr, Date: 02 Nov 2004 16:10, User: DWILLIAM, EGIS: Charleston Naval Complex - Figure 1-2 SWMU 17 Aerial Photograph



LEGEND
Non-paved Surfaces
Existing Structure
Contamination Source

N

0 75 150 Feet

Figure 1-3
Sources of Contamination
SWMU 17, Zone H
Charleston Naval Complex

File Path: C:\18gis\CNC\cnc-egis-DEN.apr, Date: 20 Nov 2000 10:53, User: GHALL

NOTE: Aerial Photo Date is [illegible]
NOTE: Original figure created in color

● Surface Soil

N

0 30 60 Feet

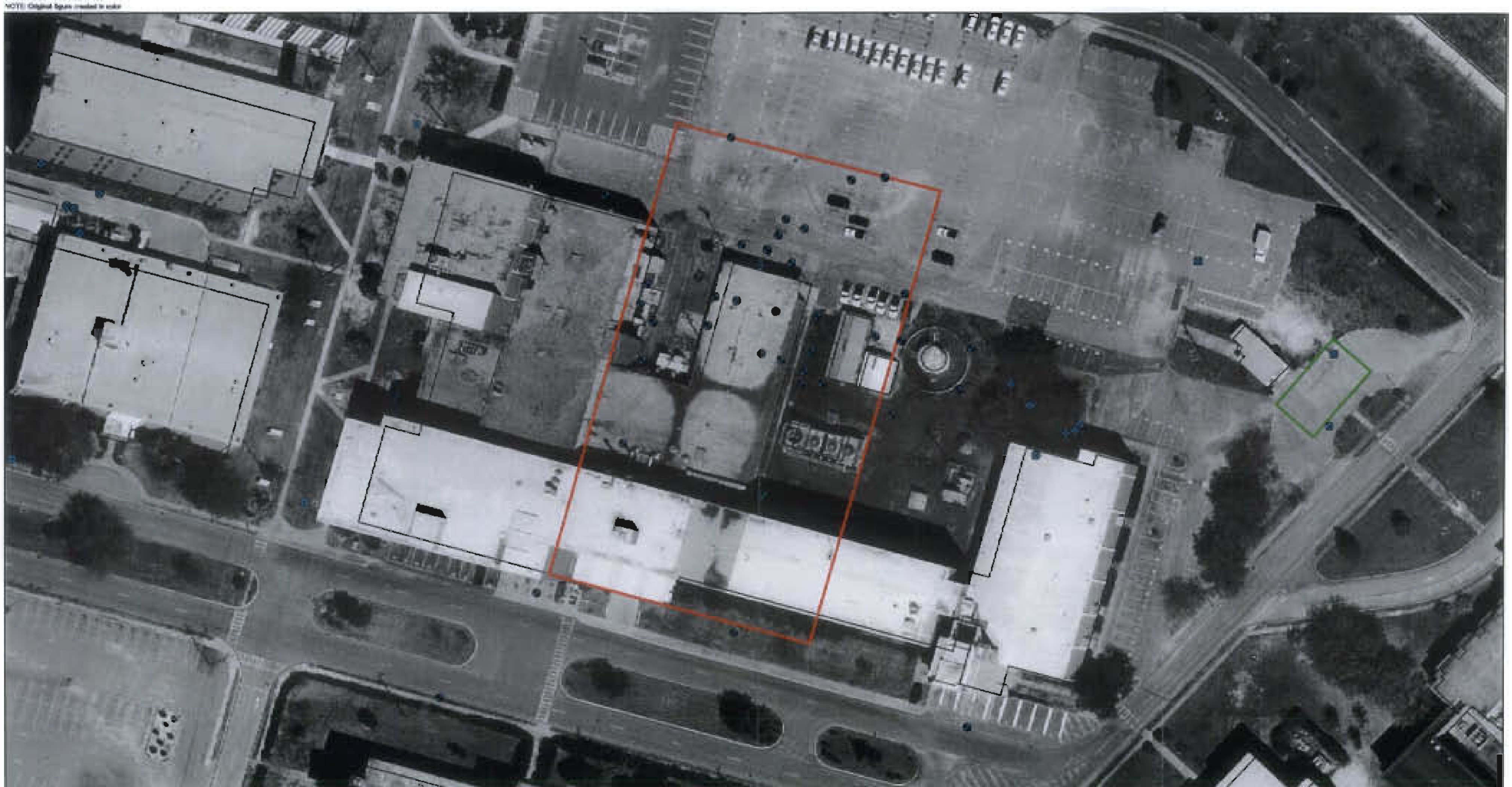
1 inch = 35.4468 feet

Figure 1-4
Surface Soil Sampling Locations
SWMU 17 CMS Report
Charleston Naval Complex

NOTE: Aerial Photo Date is 1997

Figure 1-5
Subsurface Soil Sampling Locations
SWMU 17 CMS Report
Charleston Naval Complex

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



- Groundwater Probe
- Abandoned
- Active

N

0 30 60 Feet

1 inch = 42.936 feet

Figure 1-6
Groundwater Sampling Locations
SWMU 17 CMS Report
Charleston Naval Complex

2.0 Summary of Chemicals of Concern and Current Site Conditions

A risk assessment for SWMU 17 was performed and documented in the Zone H RFI Report Addendum (see Volume II of IV, Sections 2.5 to 4.0) for chemicals of potential concern (COPCs) identified in the preliminary screening process. According to the RFI and risk assessment, environmental media at SWMU 17 that have been excessively impacted include surface and subsurface soils and groundwater. Potential offsite impacts were evaluated as part of the fate and transport analysis; it was concluded that offsite sediment or surface water impacts are not occurring at the present time and are not anticipated to occur in the future. There are no sediments or surface water associated with this SWMU; therefore, these media do not need to be remediated or considered in the CMS.

Preliminary COCs that were identified in the RFI for soils and groundwater were further refined in the CMS Work Plan. The following sections summarize the refinement process, results, and final COCs for SWMU 17.

2.1 Surface Soil Chemicals of Concern

Three chemicals were identified in the RFI Report as potential surface soil COCs: Aroclor 1260, PAHs, and dioxins. All three of these were identified as COPCs based on potential carcinogenic effects; no COPCs were identified due to non-carcinogenic effects.

PAHs—As discussed in the CMS Work Plan, the highest PAH concentration of 0.28 mg/kg (expressed as benzo(a)pyrene eqiuvalents [BEQs]), was detected at 017SB002, next to the extension of Building FBM 61, within the asphalt-paved area. The detected BEQs were above the unrestricted use risk level (1E-06) risk-based concentration (RBC) value of 0.088 mg/kg, but below an industrial scenario (1E-05) RBC of 0.78 mg/kg. More importantly, the maximum detected BEQ concentrations within SWMU 17 are well below the CNC basewide reference value of 1.304 mg/kg for surface soils. On this basis, BEQs were determined not to be COCs in surface soil at SWMU 17.

Dioxins—The action level for tetrachlorodibenzo-p-dioxin (dioxin isomer) equivalents (TEQs) is 1 microgram per kilogram (μg/kg). None of the detected TEQs were above this criterion, although they were above residential and industrial RBCs. On this basis and consistent with previous Base Realignment and Closure Act (BRAC) Cleanup Team (BCT) agreements for the CNC, dioxins (TEQs) were determined not to be COCs in surface soil at SWMU 17.

Aroclor 1260—Aroclor 1260 was reported in surface soil at concentrations ranging between 0.036 to 180 mg/kg, contributing a risk of 2×10^{-5} for industrial land use, and 7×10^{-5} for unrestricted land use. Because Aroclor 1260 appeared to be site-related and is a contributor to the cumulative risk, it was retained as a COC for both the unrestricted and industrial land use scenarios.

Based on the RFI, risk assessment, and COC refinement presented in the CMS Work Plan, Aroclor 1260 is the only surface soil COC that needs further evaluation for remediation in the CMS to protect human health and the environment at SWMU 17. MCSs for Aroclor 1260 were presented in the IM Work Plan for Soil and NAPL Removal and are summarized in Section 3 of this CMS Report.

2.2 Subsurface Soil Chemicals of Concern

Subsurface soil is not a direct exposure concern under normal industrial operation conditions or residential use. However, subsurface contaminants may indirectly influence other media through migration over time. Therefore, they were evaluated for the potential to migrate downward to shallow groundwater and the potential to volatilize into air.

2.2.1 Subsurface Soil Leachability to Groundwater

Organic chemicals that exceeded the default U.S. Environmental Protection Agency (EPA) soil SSLs for leachability to groundwater, with a dilution attenuation factor of 1.0 (dilution attenuation factor [DAF]=1), were initially identified as COPCs (see Section 2.5.6 of RFI Report Addendum, EnSafe, 2000). Most of the contaminated subsurface soils are located under the newer extension of Building FBM 61 and asphalt pavement, although some of the contaminated subsurface soils are in the unpaved area. Site-specific SSLs for both the paved and unpaved scenarios were then calculated for each COPC to determine whether the soil concentrations would serve as a potential source of groundwater contamination at SWMU 17.

In the CMS Work Plan, site-specific DAF values were estimated for each chemical in a manner consistent with EPA SSL guidance and as agreed to by the BCT. Calculation spreadsheets that describe the assumptions made to calculate site-specific DAFs were included in Appendix C of the CMS Work Plan. The site-specific DAFs calculated for SWMU 17 for industrial land use (paved scenario) is 63.8, and the site-specific DAF for hypothetical unrestricted land use (unpaved scenario) is 17.4. The maximum detected subsurface soil concentrations were compared to the SSLs estimated using the site-specific DAFs to identify an initial list of subsurface soil COCs that pose a leachability concern.

Based on the discussion above, the following COCs were identified for subsurface soil to protect groundwater from potential leaching of contaminants from soil:

- Aroclor 1260
- Benzene
- Chlorobenzene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,2,4-Trichlorobenzene

2.2.2 Evaluation of Potential Subsurface Soil Releases to Air

Because several of the subsurface soil COPCs are volatile, they could migrate from the subsurface environment into ambient air and into the indoor air of buildings above or adjacent to the contaminated area. A screening evaluation for such potential was conducted by comparing maximum and average detected subsurface soil concentrations with SSLs for air releases from two state environmental agencies. These maximum and mean concentrations were compared with industrial land use-based SSL-air values. Of the VOCs and SVOCs detected in the subsurface soil, only chlorobenzene and benzene exceed their SSL air values.

Based on guidance provided by the EPA, the Johnson and Ettinger (1991) model was also used to predict indoor air concentrations resulting from the volatilization of contaminants from soil, as described in the CMS Work Plan. The results are the same as those obtained from the SSL-air comparison described above and indicate that only benzene and chlorobenzene are COCs for the air migration pathway at SWMU 17. These two chemicals exceeded the recommended levels in soil with regard to the indoor air migration pathway at only a single location located outside of the footprint of the building. No other soil samples exceeded the target concentrations for this pathway. Thus, the overall migration potential via the indoor air pathway does not appear to be highly likely. However, consideration of this potential migration pathway will be included in remedy evaluation and selection.

2.2.3 Summary of Subsurface Soil Chemicals of Concern

Based on the previous discussion, the following COCs are proposed for subsurface soil to protect groundwater from the leaching of contaminants from soil and to protect industrial workers from potential exposure to COCs that may volatilize into air:

- Aroclor 1260
- Benzene
- Chlorobenzene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,2,4-Trichlorobenzene

2.3 Groundwater Chemical of Concern Evaluation

Groundwater contaminants that exceeded their drinking water maximum contaminant level (MCL) or, for those chemicals that did not have MCLs, tap water RBCs, were evaluated to determine whether they should be considered COCs based on an ingestion pathway. Additionally, to assess the potential for indoor air migration, the maximum detected groundwater concentrations were compared to groundwater RBCs for air emissions. These criteria were selected from State of Connecticut Department of Environmental Protection guidance tables (Appendix E to Sections 22a-133k-1 through 22a-133k, of Regulation of Connecticut State Agencies Volatilization Criteria for Groundwater). The results indicate that the groundwater concentrations are below these criteria for all COPCs except Aroclor 1260; thus, the remainder of the COPCs do not appear to be of concern for migration from groundwater to air.

Based on the previous discussions and as described in the CMS Work Plan, the following COCs were identified for groundwater at SWMU 17:

- Aroclor 1260
- Benzene
- Chlorobenzene
- 2-Chlorophenol
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- Naphthalene
- 1,2,4-Trichlorobenzene

In addition, LNAPL and DNAPL are included as groundwater COCs for the site.

2.4 Current Site Conditions

This section briefly summarizes the extent of contamination at SWMU 17 based on recent data.

2.4.1 Extent of Light Nonaqueous Phase Liquid and Dense Nonaqueous Phase Liquid

The extent of LNAPL and DNAPL has not changed significantly over the past 5 years. The NAPL at the site is immobile, held in place by viscosity and capillary forces. Figure 2-1 shows the extent of LNAPL and DNAPL at the site based on data collected during 2003. The extent of NAPL is very similar to that observed in 2000. Table 2-1 presents the thickness of NAPL measured in SWMU 17 wells since 1999. The thickness of the NAPL observed in most well varies somewhat, likely due to such factors as seasonal variations in the water table depth. Some wells do not have NAPL consistently observed in them.

DNAPL has only been detected in a single well, H017GW002, located on the northern side of Building FBM 61. During past investigation activities, four wells (H017GW01D, -02D, -03D, and -04D) were installed around H017GW002 to evaluate the extent of DNAPL. DNAPL has not been detected in these wells since their installation, indicating that the extent of DNAPL is limited.

As discussed in the SWMU 17 IM Completion Report, a DNAPL recovery attempt was performed by pumping the DNAPL from well 017GW002 with a peristaltic pump during two events (February 3 and March 5, 2003). Less than 1 pint of liquids (DNAPL/groundwater) was removed from the well. The liquids were solidified with absorbent rags for disposal purposes. The well was gauged on April 11, 2003, and a small amount of DNAPL was present but not at a measurable quantity. No DNAPL was encountered in the four wells (017GW01D, -02D, -03D, and -04D) surrounding 017GW002. Thus, what little DNAPL is present is not migrating, and limited in quantity, isolated to a small area around 017GW002.

LNAPL has been detected only in wells near or beneath Building FBM 61. Like the DNAPL, the LNAPL is not migrating. This is due to the viscous nature of the No. 5 fuel oil that comprises the LNAPL and its presence within fine-grained media at the site, where it is held immobile due to capillary and viscosity forces.

2.4.2 Extent of Aroclor 1260 in Surface Soil

The residential RBC for Aroclor 1260 is 0.2 mg/kg. More commonly, a target cleanup level for unrestricted land use of 1 mg/kg for PCBs is often established for surface soil. Figure 2-2 presents surface soil concentrations of PCBs exceeding 1 mg/kg. It can be seen in this figure that most of these exceedances occur beneath the paved areas or beneath Building FBM 61. However, a few exceedances occur along the eastern side of the extension of Building FBM 61 in an unpaved area.

The MCS identified for Aroclor 1260 for surface soil under the unpaved industrial scenario is 10 mg/kg. Figure 2-3 presents surface soil concentrations of PCBs exceeding 10 mg/kg. Most exceedances of this value occur beneath the paved areas or beneath Building FBM 61. Only two values above 10 mg/kg occur in the unpaved area along the eastern side of the extension of Building FBM 61. Overall, there is limited potential for exposure to PCB concentrations above 10 mg/kg.

The MCS for Aroclor 1260 for surface and subsurface soil under the paved industrial scenario is 57.4 mg/kg, based on the site-specific SSL calculated for SWMU 17. Figure 2-4 presents surface soil concentrations of PCBs exceeding 57.4 mg/kg. Only five samples had PCB detections over this value; all of these were found beneath paved areas.

2.4.3 Extent of Chemicals of Concern in Subsurface Soil

Figure 2-5 presents the exceedances of subsurface soil COCs above the unpaved SSLs. It can be seen in this figure that all of the exceedances occur beneath paved areas at SWMU 17. Thus, the leaching potential for subsurface soil COCs at the site under current conditions is minimal. Only five subsurface soil sampling locations had COCs that exceeded their respective site-specific unpaved SSL values.

The COCs exceeding their unpaved SSLs were as follows:

- Aroclor 1260 (four locations)
- Benzene (one location)
- Chlorbenzene (one location)
- 1,3-Dichlorbenzene (one location)
- 1,4-Dichlorbenzene (one location)
- 1,2,4-Trichlorbenzene (one location)

Table 2-2 presents the subsurface soil concentrations for these six COCs, using half the detection limit for non-detects. It can be seen in Table 2-2 that the mean concentrations of all of these COCs are below the site-specific paved SSL. The mean concentrations of only Aroclor 1260 and benzene exceed their respective site-specific unpaved SSL. For Aroclor 1260, if the greatest detected value in the data set (810 mg/kg) is removed, the mean concentration of Aroclor 1260 in subsurface soil drops to 7.8 mg/kg, which is below its unpaved SSL. Thus, the subsurface soil concentrations of Aroclor 1260 do not pose a widespread leaching hazard under unpaved conditions. For benzene, inspection of Table 2-2 indicates that only a single detection above the unpaved SSL is noted. This location, shown on Figure 2-5, is beneath the Building FBM 61 extension. The calculated mean value for benzene is above the unpaved SSL, due in part to two elevated non-detect values where the detection limit exceeded the SSL. If those two values are eliminated from the data set, the calculated benzene mean value is 0.014 mg/kg, which is below the unpaved SSL.

Thus, for all subsurface soil COCs, existing site conditions (i.e., presence of pavement over impacted subsurface soil) are adequately protective to prevent significant leaching to groundwater. Even under unpaved conditions, the amount of soil exceeding the unpaved SSL is limited. However, evaluation of corrective measures to reduce contamination to achieve unpaved SSLs will also be considered in this CMS.

2.4.4 Extent of Chemicals of Concern in Groundwater

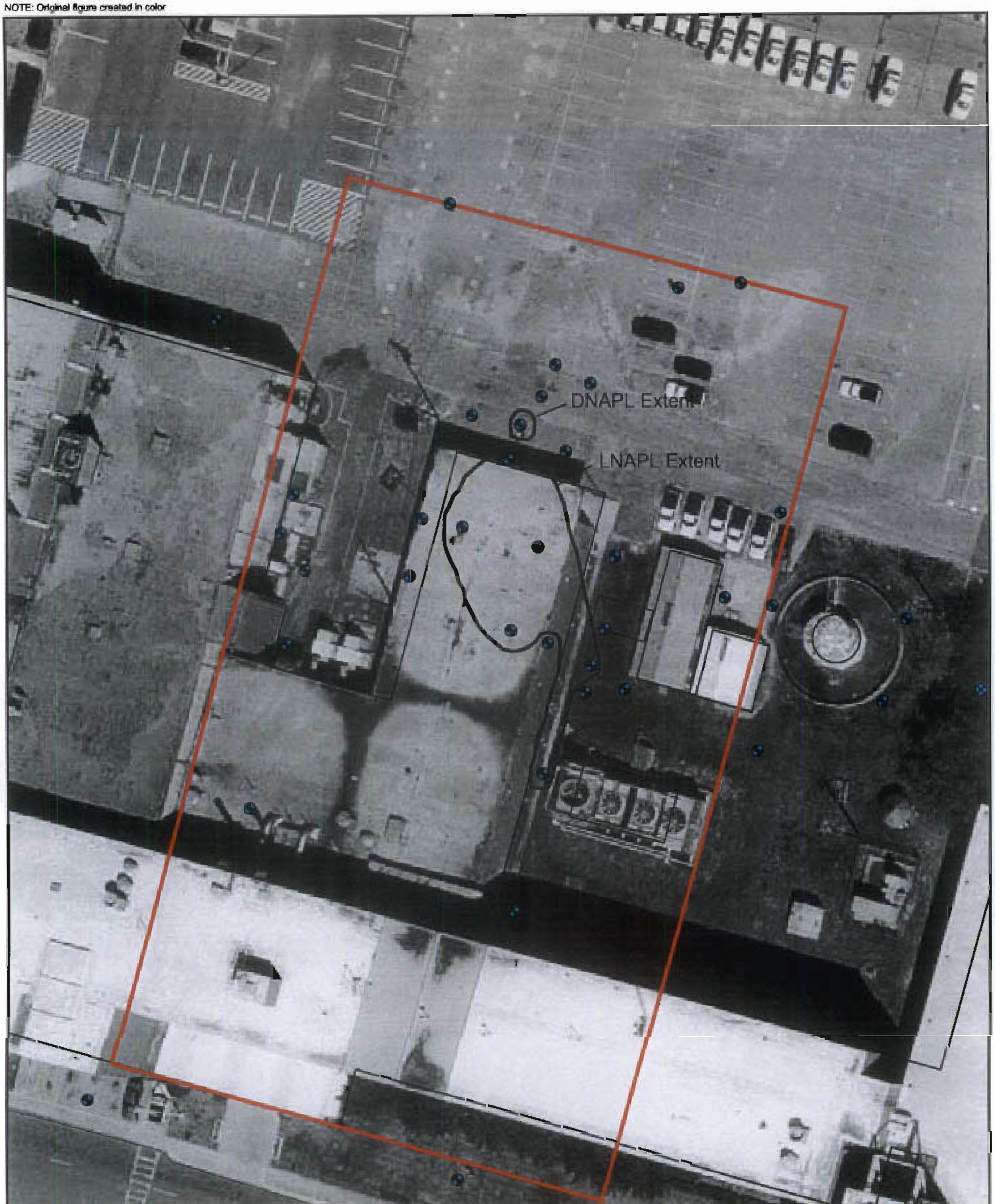
Figure 2-6 presents COC detections in groundwater since 1999. Figure 2-7 presents the COC detections in groundwater above their respective MCS since 1999. It can be seen in these figures that the extent of COCs in groundwater above the target MCSs is limited to the relatively close vicinity of Building FBM 61. Overall, the dissolved contaminants do not appear to be migrating at a significant rate. Chlorobenzene occurs the most frequently above its target cleanup level. Other chlorinated benzenes and the hydrocarbon-related chemicals benzene and naphthalene also occur in a number of wells above their target cleanup levels.

TABLE 2-1
Historical NAPL Thickness at SWMU 17
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Well Location	NAPL Thickness (feet) [a]							
	Sept 22, 1998	**Dec 22, 1999**	**Jan 6, 2000**	**July 2000**	**Feb 26, 2002**	**July 8, 2002**	**July 22, 2002**	**Jan 2, 2003**
H017GW001	NE	0.17 LNAPL	0.05 LNAPL	0.6 LNAPL	LNAPL	LNAPL	LNAPL	LNAPL
H017GW002	NE	0.10 DNAPL	0.04 DNAPL	>1.0 DNAPL	DNAPL	NE	0.09 DNAPL[b]	DNAPL
H017GWB03	NI	0.07 LNAPL	1.31 LNAPL	NE	NM	NM	NM	LNAPL
H017GWB04	NI	NE	NE	NE	LNAPL	LNAPL	LNAPL	LNAPL
H017GWD04	NI	Trace LNAPL	0.09 LNAPL	NE	0.43 LNAPL	LNAPL	LNAPL	0.02 LNAPL
H017GWL03	NI	0.57 LNAPL	1.52 LNAPL	NE	LNAPL	LNAPL	LNAPL	NE [c]
H017GWL04	NI	Trace LNAPL	NE	NE	NE	NE	NE	NE
H017GWL06	NI	NE	NE	NE	LNAPL	LNAPL	LNAPL	LNAPL
H017GWL07	NI	NE	0.65 LNAPL	NE	1.55 LNAPL	LNAPL	LNAPL	LNAPL
H017RW01	NI	NI	NI	NI	NI	NI	NI	NE
H017RW02	NI	NI	NI	NI	NI	NI	NI	NE

[a] Thickness value could not be measured on select measurement due to viscosity of NAPL.
[b] Measurement from July 11, 2002.
[c] Monitoring well H017GWL03 was abandoned and replaced with recovery well H017RW02 on October 23, 2002.
NE not encountered
NI not installed

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



Abandoned
Active

N

0 40 80 Feet

1 inch = 49.0972 feet

Figure 2-1
NAPL Extent in 2003
SWMU 17 CMS Report
Charleston Naval Complex

File Path: c:\18gis\cnc\swmu 17 napl extent.apr, Date: 12 Aug 2004 13:51, User: DWILLIAM, EGIS Charleston Naval Complex - Figure 2-1 NAPL Extent In 2003

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color

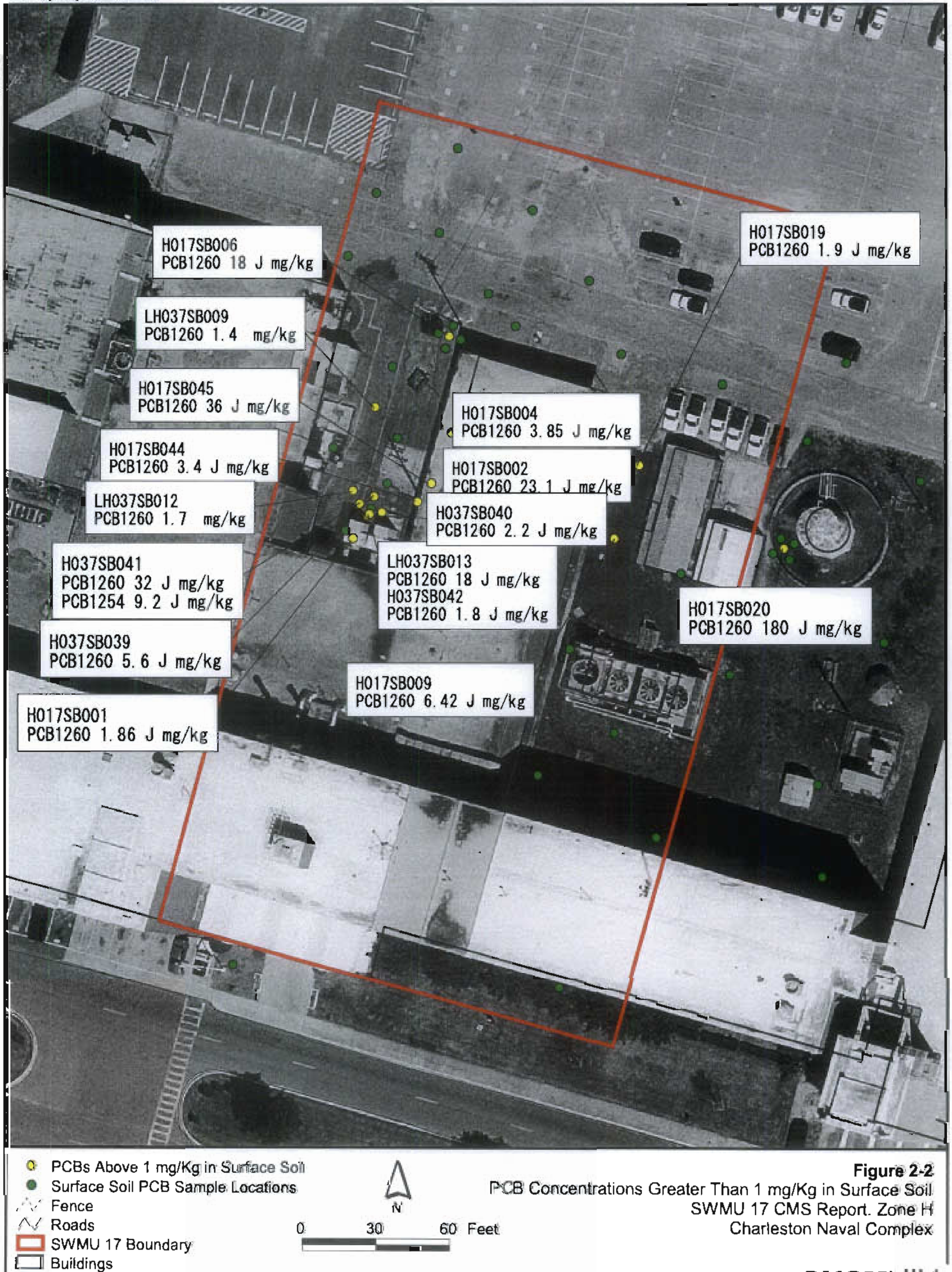


Figure 2-2
PCB Concentrations Greater Than 1 mg/Kg in Surface Soil
SWMU 17 CMS Report. Zone H
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_h\swmu_17\apr\pcb.apr, Date: 03 Nov 2004 10:28, User: JEDENS, EGIS: Charleston Naval Complex - Figure 2-2 PCB Concentrations Greater Than 1 mg/Kg in Surface Soil

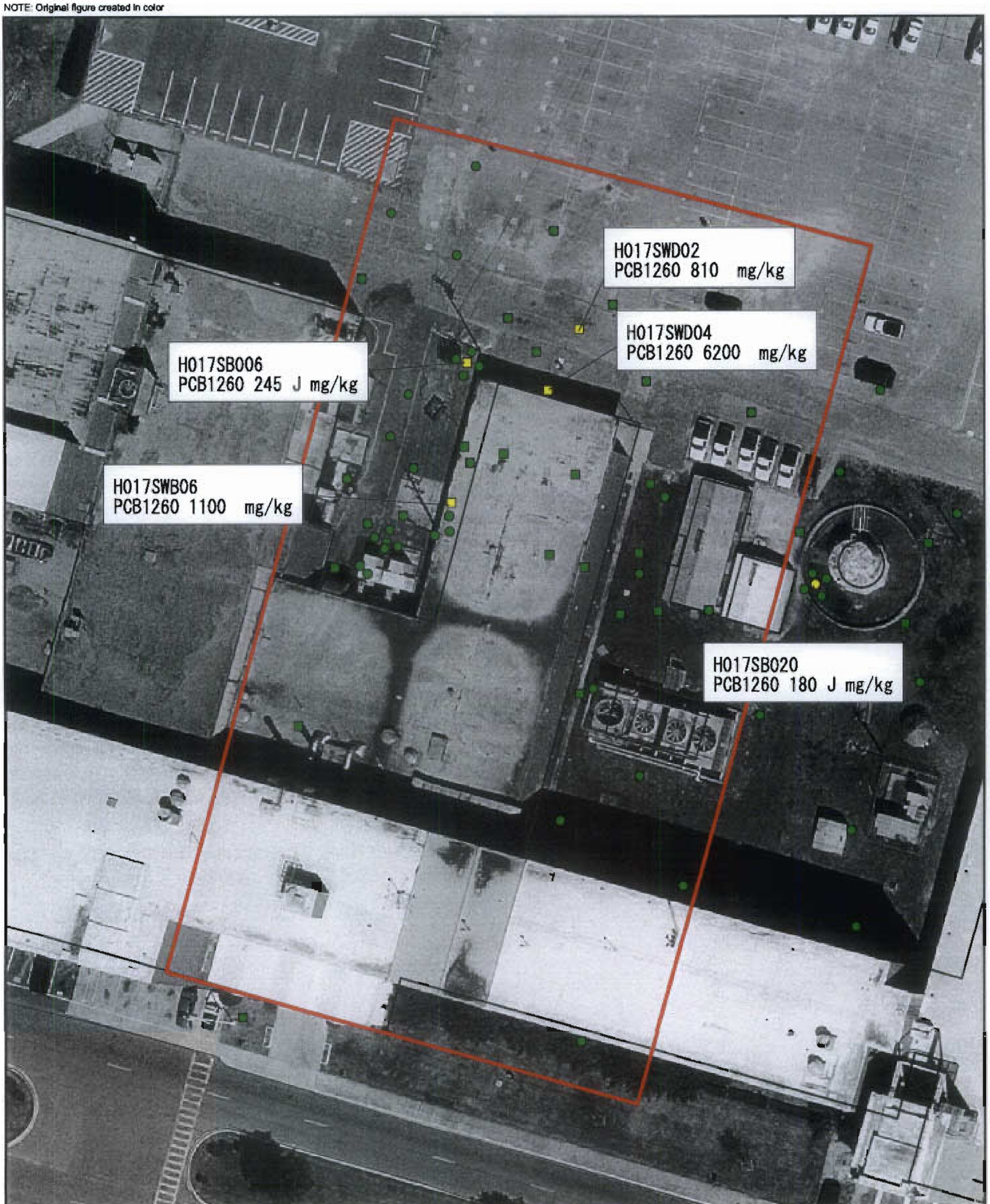
NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color

Figure 2-3
PCB Concentrations Greater Than 10 mg/Kg in Surface Soil
SWMU 17 CMS Report. Zone H
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_h\swmu_17\a prs\pcb.apr, Date: 03 Nov 2004 10:29, User: JEDENS, EGIS: Charleston Naval Complex - Figure 2-2 PCB Concentrations Greater Than 1 mg/Kg in Surface Soil

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



- PCBs Above 57.4 mg/Kg in Surface Soil
- Surface Soil PCB Sample Locations
- PCBs Above 57.4 mg/Kg in Subsurface Soil
- Subsurface Soil PCB Sample Locations
- SWMU 17 Boundary
- Buildings
- Fence
- Roads

N

0 30 60 Feet

Figure 2-4
PCB Concentrations Greater Than 57.4 mg/Kg in Surface and Subsurface Soil
SWMU 17 CMS Report. Zone H
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_h\swmu_17\aprs\pcb.apr, Date: 03 Nov 2004 10:29, User: JEDENS, EGIS: Charleston Naval Complex - Figure 2-2 PCB Concentrations Greater Than 1 mg/Kg in Surface Soil

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color

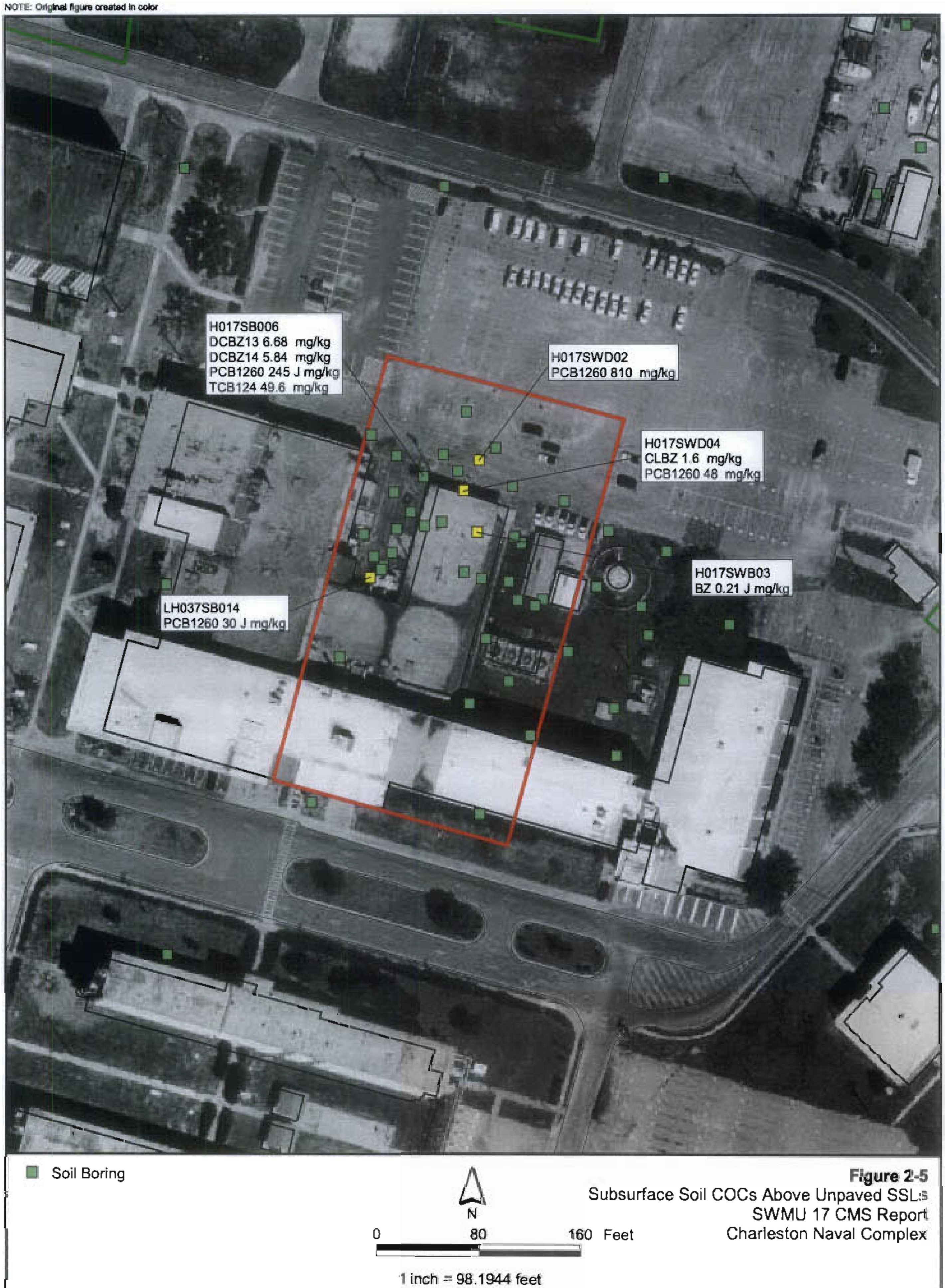
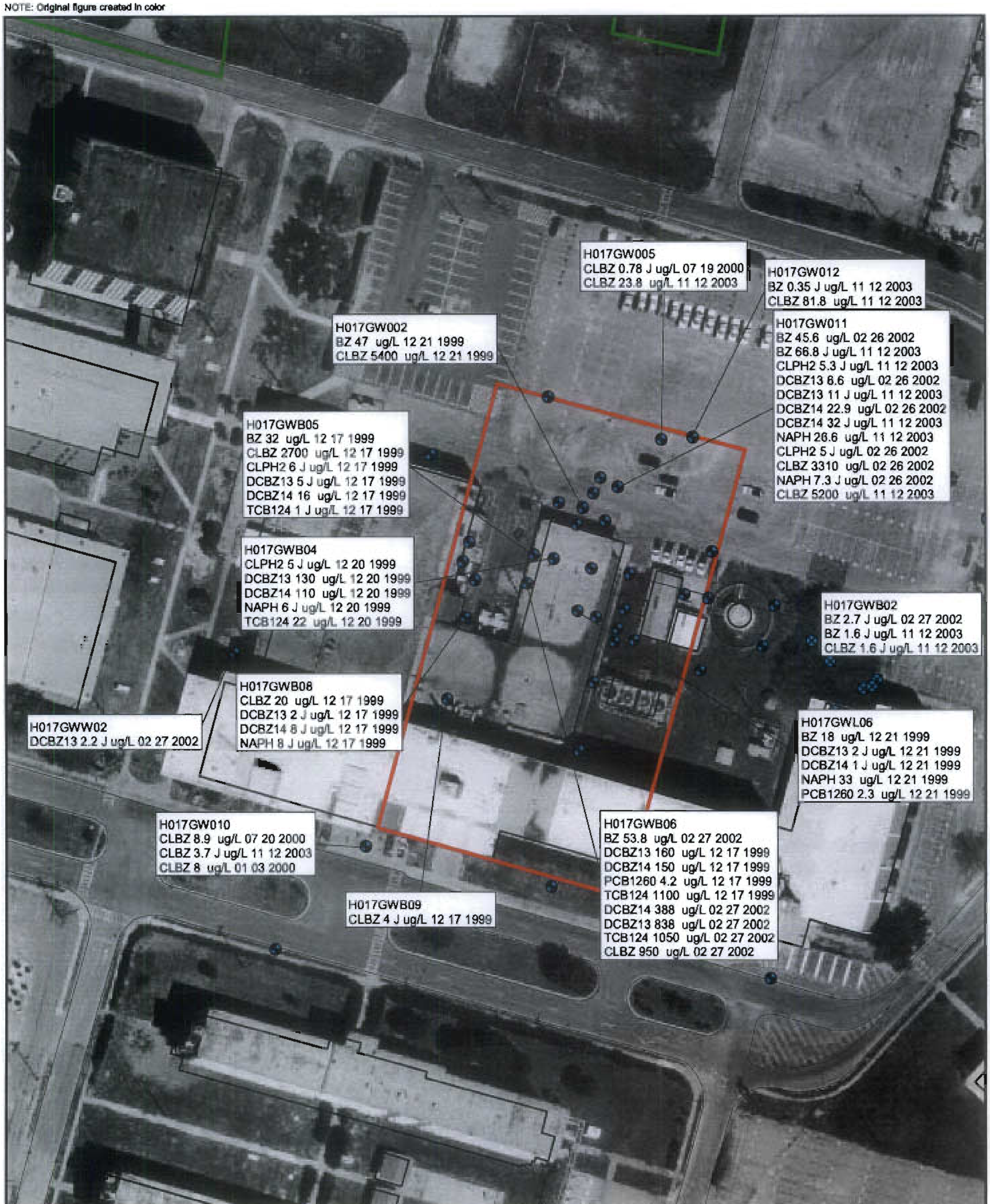


Figure 2-5
Subsurface Soil COCs Above Unpaved SSLs
SWMU 17 CMS Report
Charleston Naval Complex

File Path: c:\18gis\cnc\cnc-egis.apr, Date: 03 Sep 2004 11:07, User: DWILLIAM, EGIS: Charleston Naval Complex - Figure 2-5 Subsurface Soil COCs Above Unpaved SSLs

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



- Abandoned
- Active

N

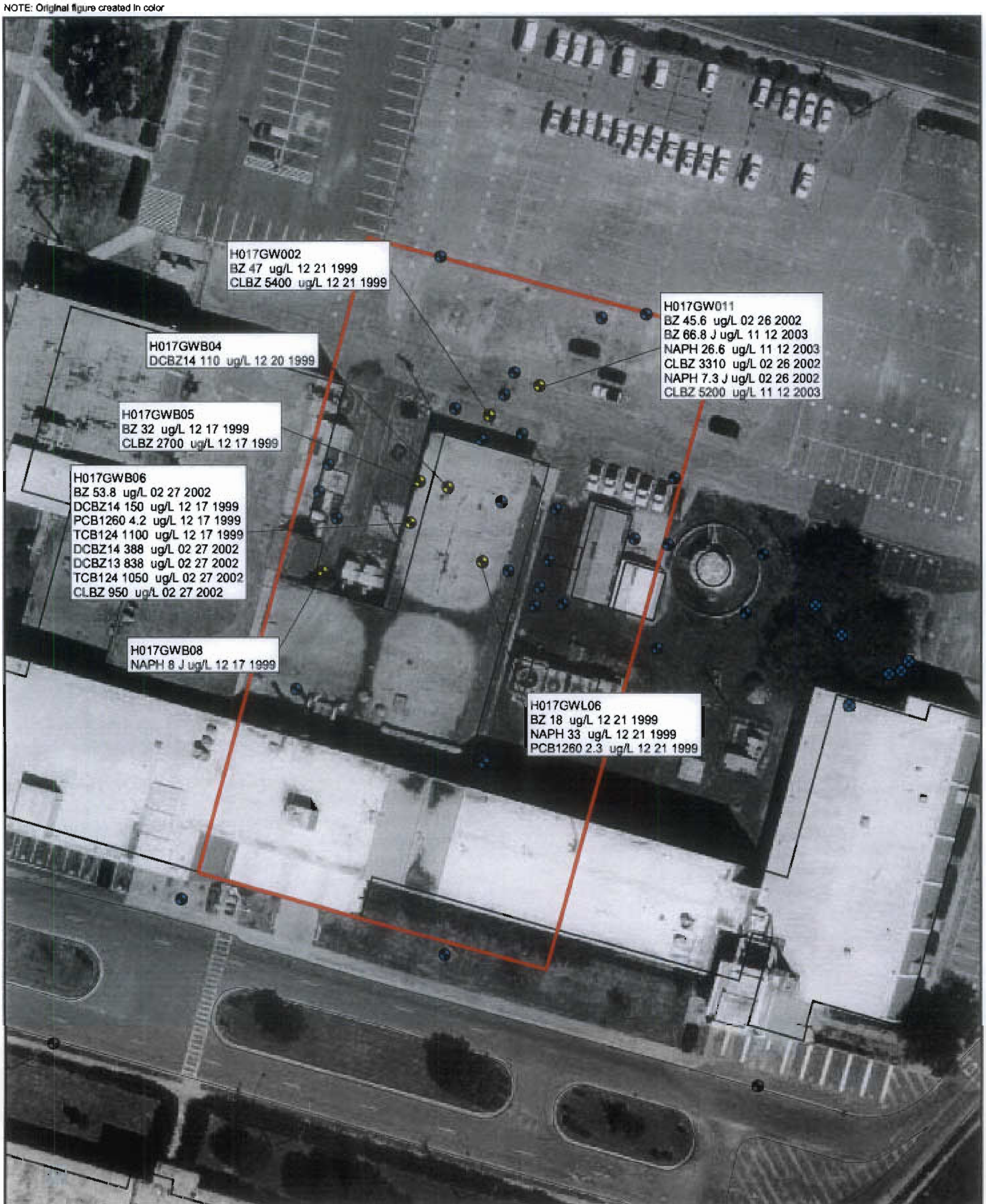
0 80 160 Feet

1 inch = 98.1944 feet

Figure 2-6
COC Detections in Groundwater Since 1999
SWMU 17 CMS Report
Charleston Naval Complex

File Path: c:\18gis\cnc\cnc-egis apr, Date: 12 Aug 2004 11:42, User: DWILLIAM, EGIS: Charleston Naval Complex - Figure 2-6 COC Detections in Groundwater Since 1999

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



● Abandoned
● Active

N

0 50 100 Feet

1 inch = 68.7361 feet

Figure 2-7
COC Exceedances in Groundwater Since 1999
SWMU 17 CMS Report
Charleston Naval Complex

File Path: c:\18gis\cnc\cnc-egis.apr, Date: 12 Aug 2004 12:35, User: DWILLIAM, EGIS: Charleston Naval Complex - Figure 2-7 COC Exceedances in Groundwater Since 1999

Section 3.0

3.0 Remedial Action Objectives and Media Cleanup Standards

RAOs are medium-specific goals that the remedial actions are designed to accomplish in order to protect human health and the environment by preventing or reducing exposures under current and future land use conditions. The following RAOs have been identified for the media at SWMU 17.

- **Surface Soil—Protection of Onsite Industrial Workers**: Prevent ingestion, direct dermal contact, or exposure by inhalation of contamination via vapors or soil particulates with unacceptable carcinogenic or non-carcinogenic risk.
- **Subsurface Soil—Protection of Groundwater and Indoor Air Quality**: Prevent migration of contamination from soil into groundwater in excess of drinking water standards or tap water RBCs, and to control volatile emissions of contaminants into buildings such that indoor air concentrations do not pose an unacceptable risk to onsite industrial workers.
- **Groundwater—Protection and Restoration of Beneficial Use**: Prevent ingestion and direct dermal contact with groundwater having unacceptable carcinogenic or non-carcinogenic risk and to restore the aquifer to beneficial use.

3.1 Remedial Goal Options and Proposed Media Cleanup Standards

Throughout the process of remediating a hazardous waste site, a risk manager uses a progression of increasingly acceptable site-specific media levels in considering remedial alternatives. Remedial goal options (RGOs) and MCSs under RCRA are developed at the end of the risk assessment in the RFI.

RGOs can be based on a variety of criteria, such as specific incremental cancer risk levels (e.g., 1E-04, 1E-05, or 1E-06), hazard index (HI) levels (e.g., 0.1, 1.0, 3.0), or site background concentrations. For a particular RGO, specific MCSs can be determined as target concentration values. Achieving these MCSs is accepted as demonstrating that RGOs and RAOs have been achieved. Achieving these goals should promote the protection of human health and the environment, while achieving compliance with applicable state and federal standards.

Preliminary MCSs and RGOs were selected from EPA Region IX Preliminary Remediation Goal (PRG) tables (EPA, 2000), established drinking water MCLs, and other available guidance for COCs. The exposure media of concern for SWMU 17 are surface and subsurface soils and groundwater. Because SMWU 17 is located within a highly developed area of the CNC and there are no surface water bodies in the immediate vicinity of the site, ecological exposures were not considered necessary for evaluation.

As previously indicated, a variety of criteria can be used to develop target options such as incremental carcinogenic risks of 10E-06, 10E-05, and 10E-04; target HIs of 0.1, 1, and 3; or background concentrations. It is also important to specify the assumed land use and exposure conditions in the RGOs.

3.1.1 Surface Soil Media Cleanup Standards

Aroclor 1260 was the only COC identified for surface soil. The RGOs for direct exposure were presented in the SWMU 17 CMS Work Plan; these values are shown in Table 3-1. As described previously, target MCSs for Aroclor 1260 were subsequently developed in the IM Work Plan for Soil and NAPL Removal. The MCSs identified for Aroclor 1260 are presented below:

Land Use Scenario	MCS, mg/kg
Unrestricted (residential), unpaved	1
Industrial, unpaved, worker exposure	10
Industrial, paved	57.4

3.1.2 Subsurface Soil Media Cleanup Standards

Compounds identified as COCs in subsurface soil were based on leachability to groundwater, with two COCs identified on the basis of exceeding SSL-air values. The target concentrations based on releases to air are much higher than those based on the leachability to groundwater. Therefore, the lower of these two values, the SSL for protection against leachability to groundwater, was selected as the MCS. Table 3-2 presents the MCSs for subsurface soil COCs for both the industrial and unrestricted land use scenarios. Table 3-2 includes the MSCs as the target subsurface soil concentrations estimated on the basis of a site-specific DAF of 17.4 for the future residential scenario and 63.8 for the industrial scenario for the alternatives analysis in the CMS.

3.1.3 Groundwater Media Cleanup Standards

For groundwater, U.S. Drinking Water MCLs have been generally selected as target MCSs for chemicals for which MCLs have been promulgated. Table 3-3 presents a list of groundwater COCs and proposed MCSs. For chemicals that do not have an MCL, the proposed MCS is generally based on a HI of 1.

TABLE 3-1
Remedial Goal Options - Surface Soil at SWMU 17
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

				Residential RGOs/MCSs Based on Carcinogenic Risks			Industrial RGOs/MCSs Based on Carcinogenic Risks		
	Minimum Detection	Maximum Detection	COC	1E-6	1E-5	1E-4	1E-6	1E-5	1E-4
COC	(mg/kg)	(mg/kg)		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aroclor 1260	0.036	180	Yes	0.2	2	20	1	10	100

TABLE 3-2
Subsurface Soil MCSs/RGOs for SWMU 17
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Chemical	Detected Concentration Range (mg/kg)	MCS – Industrial[a] (mg/kg)	MCS – Residential[a] (mg/kg)
Aroclor 1260	0.035-6,200	57.4	15.7
Benzene	0.002-7.2	0.095	0.026
Chlorobenzene	0.004-790	3.14	0.87
1,3-dichlorobenzene	0.058-22	6.38b	1.74[b]
1,4-dichlorobenzene	0.024-40	6.38	1.74
1,2,4-trichlorobenzene	0.32-410	15.84	4.37

[a] All the criteria are leachability to groundwater-based SSLs. The SSLs are selected from EPA Region IX PRG tables, (EPA, 2000), with a site-specific DAF calculated as 63.8 for industrial land use and 17.4 for residential land use (see Appendix B).

[b] 1,4 dichlorobenzene SSL value is used for 1,3-dichlorobenzene.

TABLE 3-3
Groundwater MCSs/RGOs for SWMU 17
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

						RGOs Based on Noncarcinogenic Risks		
	Minimum Concentration	Maximum Concentration	Proposed MCS	MCL	Explanation	HI=0.1	HI=1	HI=3
COC	(µg/L)	(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)
Aroclor 1260	2.3	520	0.5	0.5	MCL is proposed cleanup goal.	NA	NA	NA
Benzene	2	130	5	5	MCL is proposed cleanup goal.	NA	NA	NA
Chlorobenzene	.78	6,900	110	NA	Not a carcinogen; cleanup goal for HI=1 is 110 µg/L.	11	110	330
2-chlorophenol	5	18	30	NA	Not a carcinogen; cleanup goal for HI=1 is 30 µg/L.	3	30	90
1,3-dichlorobenzene	2	1,400	600	600#	MCL is proposed cleanup goal.	0.6	6	17
1,4-dichlorobenzene	1	2,700	75	75	MCL is proposed cleanup goal.	NA	NA	NA
Naphthalane	6	33	6.2	NA	Not a carcinogen; cleanup goal for HI=1 is 6.2 µg/L.	0.62	6.2	19
1,2,4-trichlorobenzene	1	1,400	70	70	MCL is proposed cleanup goal.	19	190	570

NA Not applicable (not a carcinogen)
µg/L microgram per liter

Value for 1,3-dichlorobenzene is based on 1,2-dichlorobenzene.

4.0 Corrective Measures Study Approach

4.1 Approach to Evaluating Corrective Measure Alternatives

Corrective measure technologies that pass the initial screening will be assembled into alternatives. According to the RCRA permit issued by SCDHEC (SCDHEC, 1998), the alternatives will be evaluated with the following five standards:

1. Protect human health and the environment.
2. Attain MCSs (RGOs).
3. Control the source of releases to minimize future releases that may pose a threat to human health and the environment.
4. Comply with applicable standards for the management of wastes generated by remedial activities.
5. Other factors include (a) long-term reliability and effectiveness; (b) reduction in toxicity, mobility, or volume of wastes; (c) short-term effectiveness; (d) implementability; and (e) cost.

Each of the five standards is defined in more detail below:

1. **Protect human health and the environment.** The alternatives will be evaluated on the basis of their ability to protect human health and the environment. The ability of an alternative to achieve this standard may or may not be independent on its ability to achieve the other standards. For example, an alternative may be protective of human health, but may not be able to attain the MCSs if the MCSs are not directly tied to protecting human health.
2. **Attain media cleanup standards (RGOs).** The alternatives will be evaluated on the basis of their ability to achieve RGOs. The RGOs were defined in Section 2.0 of this work plan. Since there is some uncertainty with this evaluation, this uncertainty will be qualitatively characterized. Another aspect of this standard is the time frame to achieve the RGOs. Estimates of the time frame for the alternatives to achieve RGOs will be provided.
3. **Control the source of releases.** This standard deals with the control of releases of contamination from the source (the area in which the contamination originated). There

are four known sources of contamination at SWMU 17 that were the result of accidental releases of contaminants. This standard will apply to NAPL- and contaminated soils at the site, which if left unaddressed, may continue to act as sources of contaminants to groundwater.

4. **Comply with any applicable standards for management of wastes.** This standard deals with the management of wastes derived from implementing the alternatives; for example, groundwater from pump and treatment operations. Alternatives will be designed to comply with all standards for management of wastes. Consequently, this standard will not be explicitly included in the detailed evaluation presented in the CMS.

5. **Other factors.** Five other factors are to be considered if an alternative is found to meet the four standards described above. These other factors are as follows:

   5a. Long-term reliability and effectiveness

   Alternatives will be evaluated on the basis of their reliability, and the potential impact should the alternative fail. In other words, a qualitative assessment will be made as to the chance of the alternative's failing and the consequences of that failure. An assessment also will be made of the useful life of the technologies in the alternative.

   5b. Reduction in the toxicity, mobility, or volume of wastes

   Alternatives with technologies that reduce the toxicity, mobility, or volume of the contamination will be generally favored over those that do not. Consequently, a qualitative assessment of this factor will be performed for each alternative.

   5c. Short-term effectiveness

   Alternatives will be evaluated on the basis of the risk they create during the implementation of the remedy. Factors that may be considered include fire, explosion, and exposure of workers to hazardous substances.

   5d. Implementatiblity

   The alternatives will be evaluated for their implementability by considering any difficulties associated with constructing the systems (such as the construction disturbances they may create), operation of the alternatives, and the availability of equipment and resources to implement the technologies comprising the alternatives.

   5e. Cost

A net present value of each alternative is typically developed. The cost estimates are used for the relative evaluation of the alternatives, not to bid or budget the work. The estimates are based on information available at the time of the CMS and on a conceptual design of the alternative. They are "order-of-magnitude" estimates with a generally expected accuracy of -50 percent to +50 percent for the scope of action described for each alternative. The estimates are typically categorized into capital costs and operations and maintenance costs for each alternative.

4.2 Identification of Best Suited Candidate Corrective Measure Technologies

The first step of the CMS process related to selecting the best suited corrective measures is to identify those technologies that have the greatest potential to eliminate, control, and/or reduce unacceptable risk to human health or the environment to acceptable levels at a reasonable cost. Technologies that have the greatest potential applicability for SWMU 17, based on the various investigations completed to date, site conditions, and nature of the contaminant are summarized below by the media and COCs that they are designed to address.

4.2.1 Aroclor 1260 in Surface and Subsurface Soils

Surface soil at SWMU 17 are impacted by Aroclor 1260 above its the target MCS. Subsurface soil also contains Aroclor 1260 at a limited number of locations above the leachability-based MCS. Based on the site conditions, the remediation approaches that are likely to be the most efficient and cost-effective for addressing Aroclor 1260-impacted soil include the following:

- Excavation—This technology would involve excavation of surface and/or subsurface soils with appropriate disposal or treatment, and backfilling of the excavation. As was observed during the IM for PCB-impacted soil and NAPL removal, excavation of soil containing Aroclor 1260 above the target MCSs in some areas of the paved courtyard would be difficult or impossible due to the presence of structures and utilities. However, this approach is conceptually feasible and excavation has been effectively implemented previously at the CNC for PCB-impacted soil.
- Soil Cap/LUCs—This technology would involve the maintenance of the existing pavement cover or installation of a new impermeable barrier over Aroclor 1260-impacted soils to reduce the potential of COC exposure to humans and to reduce leaching of contaminants from surface and subsurface soils to groundwater. LUCs would be an essential ancillary requirement with a cap or cover to ensure that the site remains paved in the areas where soil concentrations of COCs exceed the MCSs. Because most of the locations where Aroclor 1260 exceeds its target MCS are already

paved, this remedy would be relatively easy to implement and the existing pavement has functioned effectively in the past in minimizing leaching and preventing exposure of site workers to Aroclor 1260.

4.2.2 Benzene and Chlorinated Benzenes in Subsurface Soil

Subsurface soil concentrations of benzene and chlorinated benzenes (chlorobenzene, dichlorobenzenes, and trichlorobenzene) exceed their target leachability-based MCSs at a limited number of locations. Based on the site conditions, the remediation approaches that are likely to be the most efficient and cost-effective for addressing these exceedances include the following:

- **Soil Vapor Extraction (SVE)**—SVE involves applying a vacuum or suction to vadose zone soil via vapor extraction wells connected to the suction end of a blower. As soil vapor is removed from subsurface soil, volatile contaminants in the vapor are removed from the subsurface. The lower pressure induces desorption of volatile contaminants from soil into soil gas; these VOCs migrate into the vapor phase for subsequent removal in soil vapor. SVE has been widely applied and is a commonly used technology for VOC contamination in soil. It is generally considered a physical removal treatment process, rather than a biological or chemical process.
- **Bioventing**—Bioventing involves the introduction of air or oxygen into the vadose zone to promote aerobic biodegradation of contaminants in soil. Bioventing is only feasible for contaminants that are aerobically biodegradable. It has been widely used at hydrocarbon contaminated sites. Bioventing is most frequently accomplished by the introduction of air into the vadose zone via air injection wells connected to the discharge end of a small fan or blower. For some systems, SVE is coupled with bioventing to recover injected air. Typically, the rate of air injection in bioventing systems is relatively low since the purpose is not to strip VOCs out of the subsurface but simply to provide enough oxygen to the subsurface so naturally occurring bacteria can degrade the contaminants in situ. This in situ biodegradation reduces or eliminates the release of VOCs to the surface via offgas. Because chlorobenzenes can be biodegraded under aerobic conditions, bioventing is expected to be effective in promoting in situ biodegradation of these contaminants at SWMU 17.
- **Soil Cap/LUCs**—The locations where subsurface soil concentrations of chlorobenzenes exceed their leachability-based MCSs are paved. Maintaining the pavement in these areas may be a useful ancillary technology to reduce the amount of infiltration and may be effective as a primary remediation strategy as well.

4.2.3 Groundwater

The groundwater COCs that have been detected most consistently above their target MCSs are the chlorinated benzenes. Benzene, naphthalene and 2-chlorobenzene have also been detected above their respective MCSs. Therefore, the selection of a groundwater remedy will focus on identifying a technology that will have a significant impact on these key chemicals at a reasonable cost. The intent of the corrective measures implementation will be to ultimately address all groundwater COCs with the goal of achieving the MCSs for each groundwater COC.

- **Air Sparging/Biosparging**—Air sparging involves the introduction of air into the saturated zone of the aquifer via air injection wells for the purpose of physically stripping VOCs out of groundwater. Biosparging is similar to air sparging in that it also involves the injection of air into the aquifer but its objective is to increase the dissolved oxygen concentration such that aerobic biodegradation of the contaminants is stimulated. The air injection rate is lower for biosparging than for air sparging.
  Air sparging is effective in stripping volatile contaminants. Because the groundwater COCs largely consist of VOCs, air sparging would be expected to be capable of reducing groundwater concentrations of the COCs to some degree. In addition, because the VOCs at SWMU 17 are also aerobically biodegradable, the increase in dissolved oxygen from the injection of air will also stimulate aerobic biodegradation of the contaminants; thus, an air sparging system will also function as a biosparging system.

- **In Situ Aerobic Biodegradation via Oxygen Addition Using Oxygen Release Compound®**—This technology involves the introduction of oxygen into groundwater to enhance aerobic biodegradation. Oxygen can be delivered in a variety of ways, including using Oxygen Release Compound® (ORC®), diffusing oxygen gas into groundwater via wells, or using equipment to generate oxygen within a monitoring well. ORC® is a magnesium peroxide-based compound that is injected into the aquifer and slowly dissolves, releasing oxygen that promotes aerobic biodegradation. It must be replaced periodically, since it typically only lasts up to 6 months after injection. Because the VOCs in groundwater are aerobically biodegradable, this approach would be expected to have the potential for success at SWMU 17.

4.2.4 Light Nonaqueous Phase Liquid Beneath Building

The LNAPL at SWMU 17 is comprised largely of No. 5 fuel oil. No. 5 fuel oil is a relatively heavy hydrocarbon, comprised mainly of hydrocarbons with 19 to 25 carbons. No. 5 fuel oil also has a relatively high viscosity. Because of its high viscosity, it has not migrated significantly from the its original release point at the site. Additionally, the high viscosity will reduce the effectiveness of physical removal technologies. The location of the LNAPL beneath Building FBM 61 impacts the accessibility of the area for implementation of technologies to address the LNAPL.

Based on the site conditions and type of hydrocarbon present, the most practicable and best-suited technologies for addressing the LNAPL include the following:

- Free Product Bailing—This technology involves the removal of free product (mobile NAPL) by bailing the various wells within the LNAPL-impacted area in which LNAPL accumulates. Currently, this would include approximately six wells and the free product removal sumps installed after the release occurred.
- Bioventing/Biosparging—Because most hydrocarbons are amenable to aerobic biodegradation to some degree, it is likely that in situ treatment of the LNAPL can be achieved by delivery of air or oxygen into the LNAPL-impacted area. Such treatment would most likely have the greatest impact initially on the more volatile and mobile constituents in the NAPL, such as naphthalenes and BTEX, which have been detected in the shallow groundwater downgradient of the LNAPL area. However, over time, the medium and heavier molecular weight hydrocarbons present would also be expected to slowly biodegrade. Thus, bioventing/biosparging of the LNAPL area is expected to reduce concentrations of the hydrocarbon most likely to impact groundwater as well as provide for long-term treatment of the LNAPL contamination beneath the building.

4.2.5 Dense Nonaqueous Phase Liquid

DNAPL has been observed in only a single well at the site (H017GW002). The amount of DNAPL observed in this well has declined over time. Based on the nature of the DNAPL present and its limited extent and thickness in the well, the best-suited treatment approaches include the following:

- DNAPL Product Bailing—This technology involves the removal of recoverable product (DNAPL), which has been observed in a single well (H017GW002), by bailing. Alternatively, an adsorbent material could also be placed into well H017GW002 to capture any DNAPL that migrates into the well. Based on the relatively low quantities of DNAPL observed and recovered to date at the site, recovery of significant DNAPL quantities is not expected at the site.
- Physical removal (excavation)—Because the areal extent of the DNAPL is limited, physical removal of DNAPL-impacted soil in this area via excavation is conceptually feasible. However, the location of the well is within only 15 feet of Building FBM 61, in an area with frequent vehicular traffic. The proximity of the building would require that

appropriate geotechnical measure be implemented (such as sheet piling) to prevent the structural integrity of the building from being compromised. Dewatering and management and disposal of the recovered groundwater will also be necessary. Excavation to the required depth (approximately 15 feet) might be disruptive to facility operations. The presence of underground utilities in the area may also pose restrictions to the excavation that may render this approach unfeasible from practical considerations.

4.2.6 Other Ancillary Technologies–All Media

LUCs involves the implementation of various measures to control the exposure to COCs under an industrial land use scenario. Other LUCs would include maintaining the existing pavement and preventing installation of wells for potable use. Based on site conditions and intended land use, LUCs are expected to be incorporated into the corrective measures for SWMU 17 regardless of the particular corrective measures selected for specific media.

1

TABLE 4-1
Mean Aroclor 1260 Concentration in Subsurface Soil
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Station ID	Sample ID	Date Collected	Result	Qualifier	Mean Concentration[1, 2]
H017SWD04	017SWD0404	12/03/1999	6200	=	134.5
H017SWB06	017SWB0605	12/02/1999	1100	=	36.6
H017SWD02	017SWD0206	12/04/1999	810	=	19.2
H017SB006	017SB00602	08/16/1994	245	J	6.0
H017SWD04	017SWD0422	12/03/1999	48.0	=	2.0
LH037SB014	037SB014H2	06/05/1997	30.0	J	1.2
H017SB004	017SB00402	08/16/1994	9.55	J	0.69
H017SWB08	017SWB0806	12/04/1999	7.50	=	0.53
LH037SB011	037SB011H2	06/05/1997	2.80	=	0.40
H017SB020	017SB02002	01/11/1995	2.70	J	
H017SWB03	017SWB0307	11/23/1999	2.50	=	
H017SB003	017SB00302	08/16/1994	1.96	=	
H017SWL01	017SWL0104	11/18/1999	1.60	J	
LH037SB013	037SB013H2	06/05/1997	1.40	=	
H017SWB03	017SWB0302	11/23/1999	1.40	=	
H017SB051	017SB05104	08/16/2002	1.40	J	
H017SWB04	017SWB0402	11/22/1999	1.10	=	
H017SWL06	017SWL0602	11/23/1999	1.10	J	
LH037SB012	037SB012H2	06/05/1997	0.750	=	
H017SWL07	017SWL0708	12/05/1999	0.370	J	
H017SB009	017SB00902	08/17/1994	0.341	=	
H017SWB05	017SWB0504	12/06/1999	0.300	J	
H017SWL03	017SWL0307	11/18/1999	0.220	J	
H017SB019	017SB01902	01/11/1995	0.190	=	
H017SB010	017SB01002b	08/17/1994	0.165	=	
H017SB029	017SB02902	03/24/1995	0.300	U	
H017SB046	017SB04603	08/16/2002	0.130	J	
H017SB023	017SB02302	01/11/1995	0.120	=	
H017SWL04	017SWL0402	11/22/1999	0.120	J	

TABLE 4-1
Mean Aroclor 1260 Concentration in Subsurface Soil
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

H017SWB03	017SWB0314	11/23/1999	0.098	J
H017SWB06	017SWB0610	12/02/1999	0.084	J
H017SWT03	017SWT0308	11/17/1999	0.071	J
H017SB016	017SB01602	01/12/1995	0.063	=
HGDHSB040	GDHSB04002	10/05/1994	0.058	=
H017SB011	017SB01102a	08/17/1994	0.100	U
H017SB008	017SB00802	08/17/1994	0.100	UJ
H017SB007	017SB00702	08/17/1994	0.100	UJ
H017SB051	017SB05103	08/16/2002	0.088	UJ
H017SB046	017SB04604	08/16/2002	0.085	UJ
LH037SB010	037SB010H2	06/05/1997	0.083	U
H017SB022	017SB02202	01/11/1995	0.080	U
H017SB030	017SB03002	03/24/1995	0.080	U
H017SB015	017SB01502	01/12/1995	0.040	J
H017SB031	017SB03102	03/23/1995	0.080	U
H017SWT01	017SWT0105	11/17/1999	0.076	U
H017SB028	017SB02802	03/23/1995	0.070	U
H017SWB09	017SWB0904	12/01/1999	0.035	=
H017SB033	017SB03302	03/23/1995	0.060	U
H017SB027	017SB02702	03/23/1995	0.060	U
H017SB032	017SB03202	03/23/1995	0.060	U
H017SB026	017SB02602	02/02/1995	0.050	U
H017SB018	017SB01802	01/12/1995	0.050	U
H017SB024	017SB02402	01/13/1995	0.050	U
H017SB017	017SB01702	01/12/1995	0.050	U
H017SB021	017SB02102	01/11/1995	0.050	U
H017SWL04	017SWL0409	11/22/1999	0.050	U
H017SWB04	017SWB0409	11/22/1999	0.046	UJ
H017SWL02	017SWL0206	11/19/1999	0.041	U
H017SWL06	017SWL0610	11/23/1999	0.041	U
H017SB025	017SB02502	01/13/1995	0.040	U
H017SB012	017SB01202b	01/12/1995	0.040	U

TABLE 4-1
Mean Aroclor 1260 Concentration in Subsurface Soil
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

H017SWT03	017SWT0311	11/17/1999	0.040	U
H017SWT02	017SWT0213	11/17/1999	0.039	U
H017SWB02	017SWB0211	11/19/1999	0.039	U
H017SWL01	017SWL0111	11/18/1999	0.038	U
H017SWB09	017SWB0902	12/01/1999	0.035	U

Units are in mg/kg.
[1] The mean concentrations are calculated based on removal of results above the row reported.
1 1/2 the reported value was used in the calculation of mean concentration for non-detects (U & UJ).

TABLE 4-2
Comparison of Alternatives for Aroclor 1260 In Soil
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Evaluation Criteria	Alternative 1 Excavation	Alternative 2 Capping and LUCs
Protection of Human Health and the Environment	Adequately protective	Adequately protective
Attainment of MCSs	Will attain industrial MCSs for surface soil	Will not attain industrial MCSs for surface soil in a limited number of locations
Control of the Source of Release	Source has been removed	Source has been removed
Compliance with Applicable Waste Management Standards	Can be implemented in compliance with applicable standards	Can be implemented in compliance with applicable standards
Long-term Reliability and Effectiveness	Reliable and effective in the long term	Reliable and effective in the long term
Reduction of Toxicity, Mobility, or Volume of Waste	Reduces volume of waste in SWMU 17 soil to some degree	Does not reduce volume of waste at SWMU 17
Short term Effectiveness	Effective in short term	Effective in short term
Implementability	Low implementability, would require demolition and reconstruction of existing AST facility; many utilities to work around	High implementability, area is already paved
Estimate Cost ($)		
Capital	$89,000	$0
Annual O&M	$2000	$1000
Present Worth	$98,000	$4000

O&M operation and maintenance

TABLE 4-3
Comparison of Alternatives for VOCs in Subsurface Soil
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Evaluation Criteria	Alternative 1 SVE	Alternative 2 Bioventing	Alternative 3 Capping/LUCs
Protection of Human Health and the Environment	Adequately protective	Adequately protective	Adequately protective
Attainment of MCSs	Expected to attain MCS for unpaved scenario	Expected to attain MCS for unpaved scenario	Not expected to attain MCS for unpaved scenario, however, site is paved and already meets MCS for paved scenario
Control of the Source of Release	Source has been removed	Source has been removed	Source has been removed
Compliance with Applicable Waste Management Standards	Can be implemented in compliance with applicable waste management standards	Can be implemented in compliance with applicable waste management standards	Can be implemented in compliance with applicable waste management standards
Long-term Reliability and Effectiveness	Expected to be reliable and effective in long term	Expected to be reliable and effective in long term	Expected to be reliable and effective in long term
Reduction of Toxicity, Mobility, or Volume of Waste	Reduces mobility of waste by physical removal from soil	Reduces mobility of waste by biodegradation in soil	Does not reduce mobility of waste in soil
Short term Effectiveness	Expected to be effective in short term	Expected to be effective in short term	Expected to be effective in short term
Implementability	Moderately easy to implement	Moderately easy to implement	Moderately easy to implement
Estimate Cost ($)			
Capital	$59,000	$52,000	$0
Annual O&M	$15,000	$15,000	$1,000
Present Worth	$125,000	$117,000	$4000

TABLE 4-4
Comparison of Alternatives for VOCs in Groundwater
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Evaluation Criteria	Alternative 1 Air Sparging/Biosparging	Alternative 2 Oxygen Addition via ORC®
Protection of Human Health and the Environment	Adequately protective	Adequately protective
Attainment of MCSs	Expected to attain MCLs	Expected to attain MCLs
Control of the Source of Release	Source has been removed	Source has been removed
Compliance with Applicable Waste Management Standards	Can be implemented in compliance with applicable standards	Can be implemented in compliance with applicable standards
Long-term Reliability and Effectiveness	Reliable and effective in the long term	Reliable and effective in the long term
Reduction of Toxicity, Mobility, or Volume of Waste	Reduces volume of waste in SWMU 17 groundwater via air stripping and biodegradation	Reduces volume of waste in SWMU 17 groundwater via biodegradation
Short term Effectiveness	Effective in short term	Effective in short term
Implementability	Moderately implementable; will require trenching through pavement to install air lines	Moderately implementable; will require periodic reinjection via Geoprobe equipment
Estimated Cost ($)		
Capital	$98,000	$207,000
Annual O&M	$15,000	$54,000
Present Worth	$163,000	$354,000

TABLE 4-5
Comparison of Alternatives for LNAPL Removal
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Evalaution Criteria	Alternative 1 Free Product Removal From Wells	Alternative 2 Bioventing
Protection of Human Health and the Environment	Adequately protective	Adequately protective
Attainment of MCSs	Will not attain cleanup objectives throughout LNAPL impacted area	Expected to attain cleanup objectives throughout LNAPL impacted area
Control of the Source of Release	Source has been removed	Source has been removed
Compliance with Applicable Waste Management Standards	Can be implemented in compliance with applicable standards	Can be implemented in compliance with applicable standards
Long-term Reliability and Effectiveness	Reliable in the long term; not expected to be effective throughout LNAPL impacted area	Reliable and effective in the long term
Reduction of Toxicity, Mobility, or Volume of Waste	Reduces volume of LNAPL near monitoring wells	Reduces volume of LNAPL throughout LNAPL impacted area
Short term Effectiveness	Effective in short term	Effective in short term
Implementability	Easily implemented	Moderately difficult to implement, will require trenching in underground air lines beneath pavement
Estimate Cost ($)		
Capital	$0	$74,000
Annual O&M	$5,000	$15,000
Present Worth	$21,000	$139,000

TABLE 4-6
Comparison of Alternatives for DNAPL Removal
Corrective Measures Study Report, SWMU 17, Zone H, Charleston Naval Complex

Evalaution Criteria	Alternative 1 Free Product Removal From Wells	Alternative 2 Excavation of DNAPL Area
Protection of Human Health and the Environment	Adequately protective	Adequately protective
Attainment of MCSs	Expected to attain cleanup objectives throughout LNAPL impacted area	Will attain cleanup objectives throughout DNAPL impacted area
Control of the Source of Release	Source has been removed	Source has been removed
Compliance with Applicable Waste Management Standards	Can be implemented in compliance with applicable standards	Can be implemented in compliance with applicable standards
Long-term Reliability and Effectiveness	Reliable in the long term since DNAPL impacted area is limited to one well	Reliable and effective in the long term
Reduction of Toxicity, Mobility, or Volume of Waste	Reduces volume of DNAPL	Reduces volume of DNAPL
Short term Effectiveness	Effective in short term	Effective in short term
Implementability	Easily implemented	Very difficult to implement, will require excavation in congested area, sheet piling dewatering and treatment of groundwater
Estimate Cost ($)		
Capital	$0	$73,000
Annual O&M	$2,000	$2000
Present Worth	$8,000	$82,000

NOTE: Original figure created in color

Figure 4-1
Conceptual Layout of AS/SVE System
SWMU 17, Zone H
Charleston Naval Complex

File Path: c:\18gis\projects\zone_h\swmu_17\aprs\orc inj.apr, Date: 02 Nov 2004 14:21, User: JEDENS, EGIS: Charleston Naval Complex - Figure 4-1 Conceptual Layout of AS/SVE System

5.0 Detailed Analysis of Alternatives

In this section, the candidate technologies identified in Section 3 are evaluated in more detail to identify the best-suited remedial approach for the COCs at SWMU 17.

5.1 Aroclor 1260 in Surface and Subsurface Soils

The best-suited candidate remedial action alternatives for addressing Aroclor 1260 in surface and subsurface soil are: 1) excavation and 2) capping and LUCs. Because the volume of Aroclor 1260-impacted soil is relatively small, other remedial alternatives such as onsite low temperature thermal desorption are not cost effective.

5.1.1 Excavation

Excavation of the surface and subsurface soil containing Aroclor 1260 is conceptually feasible, although there are some practical constraints that affect whether it could be cost effectively performed. The presence of pavement, underground utilities, and a new AST and its containment structure above soil that would require excavation would make excavation significantly more costly than a typical excavation project, due to the need to remove/replace pavement, work around utilities, and demolish and replace the new AST and its containment structure to allow excavation beneath it.

For this alternative, surface soil locations exceeding the unpaved MCS of 10 mg/kg would be excavated. This would provide adequate removal of PCB-impacted soil such that the site is suitable for industrial land use under unpaved conditions. Subsurface soil would also be excavated such that the average unpaved subsurface soil concentrations would be below the unpaved SSL of 15.7 mg/kg.

Assumptions for implementation of this approach include the following:

- Excavation would not be performed beneath any buildings or within the containment area of the AST.
- Three areas of surface soil (in the vicinity of borings H017SB013, H017SB041, H017SW045, H017SB002, and H017SB006) would be excavated.
- Subsurface soil at three locations (H017SWB06, H017SWD04, and H017SWD02c) would also be removed to achieve the target cleanup level such that the average remaining subsurface soil concentration would be below the unpaved SSL. Calculation of the average subsurface soil Aroclor 1260 concentrations are shown in Table 4-1.

Based on these assumptions, this approach would result in the excavation of approximately 175 cubic yards (in situ) of Aroclor-impacted soil.

An evaluation of the excavation alternative with respect to the various criteria is presented below.

5.1.1.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment because the surface soil concentrations of Aroclor 1260 would be reduced to concentrations that pose an acceptable risk to industrial receptors under an unpaved scenario. The subsurface soil concentrations of Aroclor 1260 would be reduced such that subsurface soil would not pose a leaching risk to groundwater under unpaved land use conditions. LUCs would be in place to ensure that less restrictive exposure scenarios, such as residential exposure, do not occur.

5.1.1.2 Attainment of Media Cleanup Standards

This alternative would attain the MCSs for the unpaved industrial land use scenario.

5.1.1.3 Control of the Source of Releases

The historical sources of Aroclor 1260 no longer exist at SWMU 17 due to the removal of the PCB-containing transformers.

5.1.1.4 Compliance with Applicable Waste Management Standards

This approach would generate several waste materials, such as pavement and excavated soil during implementation. The soil would require disposal in accordance with applicable regulations (such as the Toxic Substances Control Act). The waste disposal requirements for these materials are well known and compliance with applicable waste management standards would be readily achievable.

5.1.1.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the contaminated soil would be permanently removed from the site.

5.1.1.6 Reduction of Toxicity, Mobility, or Volume of Wastes

The physical removal of the waste from the site would reduce the volume of waste at SWMU 17. Disposal of the excavated soil in an approved landfill would reduce its potential mobility. If treatment of the excavated soil were required prior to disposal, the treatment would reduce its toxicity.

5.1.1.7 Short-Term Effectiveness

Through implementation of the LUCs, this alternative would be effective in the short term at controlling exposure and reducing risk. Because excavation can be typically completed relatively quickly, this alternative is considered to have good short-term effectiveness.

5.1.1.8 Implementability

Excavation of the soil at SWMU 17 is expected to be relatively difficult to implement due to the presence of pavement, structures, and underground utilities above, close to, and in the immediate vicinity of the contaminated soil. The implementability of this alternative is low and the site constraints are expected to increase the cost of this alternative considerably, compared to excavation at sites without these constraints.

5.1.1.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-2. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. Detailed cost estimate tables are provided in Appendix B. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.1.2 Capping/Land Use Controls

As shown previously on Figure 2-3, all of the soil containing Aroclor above the MCS for the unpaved industrial scenario (10 mg/kg) is beneath existing pavement and thus a capping system capable of protecting human health and the environment is already in place. Additionally, all of the locations where Aroclor 1260 exceeded the unpaved site-specific SSL of 15.4 mg/kg are beneath existing pavement or structure. Therefore, no additional capping at the site is needed for the capping alternative to be implemented; the existing pavement can function adequately for this purpose, as long as it is effectively maintained.

5.1.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the pavement would prevent unacceptable exposure of industrial workers to Aroclor 1260-impacted soil. LUCs would be in place to ensure that less restrictive exposure scenarios, such as residential exposure, do not occur. The average subsurface soil concentrations of Aroclor 1260 are below the paved site-specific SSL; thus, subsurface soil does not pose an unacceptable leaching risk to groundwater.

5.1.2.2 Attainment of Media Cleanup Standards

This alternative would attain the MCS for the paved industrial land use scenario.

5.1.2.3 Control of the Source of Releases

The historical sources of Aroclor 1260 no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.1.2.4 Compliance with Applicable Waste Management Standards

This approach would not generate any waste material. Thus, compliance with applicable waste management standards would be readily achievable.

5.1.2.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the pavement can be readily inspected and maintained to ensure its effectiveness.

5.1.2.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will not result in reduction of toxicity, mobility, or volume.

5.1.2.7 Short-Term Effectiveness

Through implementation of the LUCs and because the site is already paved, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.1.2.8 Implementability

This alternative would be easily implemented.

5.1.2.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-2. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

Table 4-2 compares the various alternatives for addressing Aroclor 1260 in soil.

5.2 Volatile Organic Compounds in Subsurface Soil

As discussed in Section 2, six COCs at SWMU 17 exceeded their respective unpaved SSL at one location at least. The mean concentrations of all six COCs are below their respective site-specific paved SSL. Only the mean concentrations of benzene and Aroclor 1260 exceeded their unpaved SSL. All locations where these exceedances occur are paved; thus, site conditions provide adequate protective of groundwater for the soil-to-groundwater leaching pathway.

The three corrective measure technologies identified as best suited for addressing the VOCs in subsurface soil at SWMU 17 are SVE, bioventing, and capping/LUCs.

5.2.1 Soil Vapor Extraction

An SVE system would involve the use of a small fan or blower to pull soil vapor from the subsurface in the area where COC concentrations exceed the unpaved SSL. The locations at SWMU 17 where subsurface soil VOCs exceed their unpaved SSL are shown on Figure 2-5. This is generally limited to the vicinity of the northern end of the Building FBM 61 extension.

The most practical way to perform SVE at SWMU 17 would be to use several vertical vapor recovery wells screened in the vadose zone. The wells would be connected to the blower via a manifold and the exhaust would be discharged to the atmosphere. Given the limited size of the impacted area and relatively small number of soil borings at which the SSLs were exceeded, it is unlikely that concentrations of VOCs in the offgas would be sufficiently high such that air phase treatment of the offgas is required. However, such treatment could be implemented relatively easily.

Conceptually, an SVE system at SWMU 17 to address VOC-impacted subsurface soil would probably need to include only a few SVE well locations, due to the limited areal extent of subsurface soil exceeding unpaved SSLs. For the purpose of this CMS Report, the following assumptions regarding a SVE system configuration are made:

- Each SVE well would achieve a radius of influence of approximately 20 feet, would be installed to a depth no greater than 5 feet bls, and would have a 2-foot well screen installed in the vadose zone.
- Seven SVE wells would be installed at SWMU 17. Three SVE wells would be installed approximately 20 feet apart in a line running approximately from soil boring H017BS006 to H017SWD04 (see Figure 2-5 for these borings' locations). Two SVE wells would also be installed near soil borings H017SWD05 and H017SWB06, and two SVE wells would be installed near soil boring H017SWL07. The SVE wells would be installed in small flush-mount, traffic-bearing vaults.

- A SVE vacuum pressure of approximately -1 pounds per square inch (psi) would be applied; the recovered soil vapor rate is assumed to be in the range of 70 to 105 standard cubic feet per minute (scfm) total (10 to 15 scfm/well).
- The recovered soil vapor would not require offgas treatment.
- A manifold would connect the three SVE wells to a small package blower unit with relatively simple process controls. Because of the location of SVE wells adjacent to the Building FBM 61 extension, the manifold would need to be installed below grade.

5.2.1.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the pavement would prevent unacceptable infiltration of precipitation until the target cleanup levels are achieved and because the SVE process would safely remove VOCs from the vadose zone. LUCs would be in place to ensure that less restrictive exposure scenarios, such as removing the pavement, do not occur. The average subsurface soil concentrations of all VOCs are below the paved site-specific SSL; thus, subsurface soil does not currently pose an unacceptable leaching risk to groundwater under existing conditions.

5.2.1.2 Attainment of Media Cleanup Standards

This alternative is expected to be able to attain the MCS for the unpaved land use scenario.

5.2.1.3 Control of the Source of Releases

The historical sources of VOCs no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.2.1.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Soil cuttings generated during installation of the SVE wells would be properly disposed of. Compliance with applicable waste management standards would be readily achievable.

5.2.1.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the VOCs will be permanently removed from the vadose zone.

5.2.1.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via physical removal of the VOCs from the subsurface soil.

5.2.1.7 Short-Term Effectiveness

Through implementation of the LUCs and because the site is already paved, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.2.1.8 Implementability

This alternative would be moderately easy to implement. Because of the need to install belowgrade piping to connect the wells together and to the blower, some disruption to site activities could occur.

5.2.1.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-3. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.2.2 Bioventing

Bioventing involves a process similar to SVE. A small blower or fan would be used to add air to the vadose zone through several wells screened in the vadose zone to promote the biodegradation of contamination. As for the SVE alternative, bioventing would be applied where COC concentrations exceed the unpaved SSL, in the vicinity of the northern end of the Building FBM 61 extension. Because the air injection rates for bioventing are low and intended only to stimulate biodegradation, no recovery of injected air is typically required.

Conceptually, a bioventing system at SWMU 17 to address VOC-impacted subsurface soil would need only a few air injection well locations, due to the limited areal extent of subsurface soil exceeding unpaved SSLs. For the purpose of this CMS Report, the following assumptions regarding a bioventing system configuration are made:

- Each bioventing well would achieve a radius of influence of approximately 20 feet, would be installed to a depth no greater than 5 feet bls, and would have a 2-foot well screen.
- Seven bioventing wells would be installed at SWMU 17. Three bioventing wells would be installed approximately 20 feet apart in a line running approximately from soil boring H017BS006 to H017SWD04 (see Figure 2-5 for these borings' locations). Two bioventing wells would also be installed near soil borings H017SWD05 and H017SWB06, and two bioventing wells would be installed near soil boring H017SWL07. These wells would be installed in small flush-mount, traffic-bearing vaults.

- An air injection rate of approximately 30 to 45 scfm would be applied.
- No recovery of soil vapor would be required.

A manifold would connect the three bioventing wells to a small package blower unit with relatively simple process controls. Because of the location of bioventing wells adjacent to the Building FBM 61 extension, the manifold would need to be installed below grade.

5.2.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the pavement would prevent unacceptable infiltration of precipitation until the target cleanup levels are achieved and because the bioventing process would result in biodegradation of VOCs in the vadose zone. LUCs would be in place to ensure that less restrictive exposure scenarios, such as removing the pavement, do not occur. The average subsurface soil concentrations of all VOCs are below the paved site-specific SSL; thus, subsurface soil does not pose an unacceptable leaching risk to groundwater under current conditions.

5.2.2.2 Attainment of Media Cleanup Standards

This alternative is expected to be able to attain the MCS for the unpaved land use scenario.

5.2.2.3 Control of the Source of Releases

The historical sources of VOCs no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.2.2.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Soil cuttings generated during installation of the SVE wells would be properly disposed of. Compliance with applicable waste management standards would be readily achievable.

5.2.2.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the VOCs will be permanently removed via biodegradation from the vadose zone.

5.2.2.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via biodegradation of the VOCs in the subsurface soil.

5.2.2.7 Short-Term Effectiveness

Through implementation of the LUCs and because the site is already paved, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.2.2.8 Implementability

This alternative would be easily implemented.

5.2.2.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-3. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.2.3 Capping/Land Use Controls

Because the area in which concentrations of subsurface soil COCs exceed their unpaved SSLs is already paved, the capping alternative would simply involve maintaining the existing pavement. LUCs would be used to ensure that pavement is not removed in these areas.

5.2.3.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the pavement would prevent unacceptable infiltration of precipitation, thus reducing or preventing the leaching of COCs to groundwater. The average subsurface soil concentrations of all VOCs are below the paved site-specific SSL; thus, subsurface soil does not pose an unacceptable leaching risk to groundwater under current conditions until the target cleanup levels are achieved and because the bioventing process would result in biodegradation of VOCs in the vadose zone. LUCs would be in place to ensure that less restrictive exposure scenarios, such as removing the pavement, do not occur.

5.2.3.2 Attainment of Media Cleanup Standards

This alternative is expected to be able to attain the MCS for the unpaved land use scenario.

5.2.3.3 Control of the Source of Releases

The historical sources of VOCs no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.2.3.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Soil cuttings generated during installation of the SVE wells would be properly disposed of. Compliance with applicable waste management standards would be readily achievable.

5.2.3.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the VOCs will be permanently removed via biodegradation from the vadose zone.

5.2.3.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via biodegradation of the VOCs in the subsurface soil.

5.2.3.7 Short-Term Effectiveness

Through implementation of the LUCs and because the site is already paved, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.2.3.8 Implementability

This alternative would be easily implemented.

5.2.3.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-3. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

Table 4-3 compares the various alternatives for addressing VOCs in subsurface soil.

5.3 Volatile Organic Compounds in Groundwater

Groundwater COCs at SWMU 17 include the following:

- Aroclor 1260
- Benzene
- Chlorobenzene
- 2-Chlorophenol
- 1,3-Dichlorobenzene

- 1,4-Dichlorobenzene
- Naphthalene
- 1,2,4-Trichlorobenzene

All of these COCs except Aroclor 1260 are aerobically biodegradable. Aroclor 1260 has not been observed to be migrating in groundwater and its presence in groundwater has been limited to only a few wells that have DNAPL or LNAPL. The remedial actions for LNAPL and DNAPL are expected to address the presence of Aroclor 1260 in groundwater. Therefore the focus of the remedial approach for groundwater will be to select a technology that addresses the other groundwater COCs.

5.3.1 Air Sparging/Biosparging

Air sparging/biosparging, previously described in Section 3, involves the injection of air into the contaminated groundwater to remove VOCs by physically stripping them from the groundwater and stimulating aerobic biodegradation of the VOCs. The VOCs migrate into the air and the air subsequently moves into the vadose zone, then atmosphere, or it may be recovered using an SVE system and treated prior to discharge.

A variety of approaches may be used to inject air into the groundwater. At SWMU 17, the most practicable approach would involve shallow wells installed to approximately 13 to 15 feet bls. Typical air injection rates for air sparging systems are approximately 10 scfm. Injection rates for bio-sparging generally range from 0.5 to 3 scfm. For shallow applications such as SWMU 17, a fan is often adequate to provide the required air flow and pressure.

At SWMU 17, an air sparging system would have a conceptual configuration as shown on Figure 4-1. The sparging wells would be installed to address dissolved contamination that is migrating downgradient of Building FBM 61 into the parking lot, as well as the VOCs detected in groundwater in the vicinity of the paved courtyard.

For the purpose of this CMS Report, the following assumptions regarding a bioventing system configuration are made:

- Each air sparging well would achieve a radius of influence of approximately 20 feet, would be installed to a depth no greater than 15 feet bls, and would have a 3-foot well screen.
- 10 air sparging wells would be installed approximately 20 feet apart in an arrangement as shown on Figure 4-1. These wells would be installed in small flush-mount, traffic-bearing vaults.
- An air injection rate of approximately 5 to 10 scfm per well would be applied.

- Soil vapor recovery would be performed to recovery injected air. SVE recovery wells would be co-located with the air sparging wells.
- A manifold would connect the air sparging wells to a small package blower unit with relatively simple process controls. A separate manifold would connect the SVE wells to a fan, and recovered air would be passed through a simple treatment system such as an activated carbon filter prior to discharge. Because of the location of air sparging and SVE wells adjacent to the Building FBM 61 extension and in the parking lot, the manifolds would need to be installed below grade.

5.3.1.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the groundwater concentrations would be reduced by physical removal of the VOCs as well as by biodegradation. LUCs would be in place to ensure that less restrictive exposure scenarios, such as allowing for installation of drinking water wells, do not occur. The SVE system would recover injected air and ensure that unacceptable exposure of receptors to air containing VOCs does not occur.

5.3.1.2 Attainment of Media Cleanup Standards

This alternative is expected to be able to attain the MCSs for groundwater for the VOCs.

5.3.1.3 Control of the Source of Releases

The historical sources of VOCs no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.3.1.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Soil cuttings generated during installation of the air sparging and SVE wells would be properly disposed of. Compliance with applicable waste management standards would be readily achievable.

5.3.1.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the VOCs will be permanently removed via air stripping and biodegradation from the groundwater.

5.3.1.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via removal and biodegradation of the VOCs in groundwater.

5.3.1.7 Short-Term Effectiveness

Through implementation of the LUCs and because receptors are not currently being exposed to contaminated groundwater, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.3.1.8 Implementability

This alternative would be moderately easy to implement. Because the manifolds for supply air and recovered soil vapor will need to be installed below ground in trenches, some disruption to the site operations may occur.

5.3.1.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-4. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.3.2 Aerobic Biodegradation Using Oxygen Release Compound®

Injection of ORC® into the shallow contaminated aquifer would promote aerobic biodegradation by increasing the dissolved oxygen content of the groundwater, thus promoting aerobic biodegradation of the VOCs. For the purpose of this CMS Report, the following assumptions are made to evaluate this alternative:

- ORC® would be added via a Geoprobe at spacings of approximately 10-foot centers throughout the dissolved plume area.
- The total number of injection points would be approximately 50.
- It would be necessary to reinject ORC® every 6 months to ensure continued performance. Injections would need to continue for at least 3 years to achieve the MCSs for groundwater.

5.3.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the groundwater concentrations would be reduced by biodegradation of the VOCs. LUCs would be in place to ensure that less restrictive exposure scenarios, such as allowing for installation of drinking water wells, do not occur.

5.3.2.2 Attainment of Media Cleanup Standards

This alternative is expected to be able to attain the MCSs for groundwater for the VOCs.

5.3.2.3 Control of the Source of Releases

The historical sources of VOCs no longer exist at SWMU 17, due to the removal of the PCB-containing transformers.

5.3.2.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Because Geoprobe equipment would be used to inject the ORC®, no soil cuttings would be generated. Compliance with applicable waste management standards would be readily achievable.

5.3.2.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the VOCs will be permanently removed via biodegradation from the groundwater.

5.3.2.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via biodegradation of the VOCs in groundwater.

5.3.2.7 Short-Term Effectiveness

Through implementation of the LUCs and because receptors are not currently being exposed to contaminated groundwater, this alternative will be effective in the short term at controlling exposure and reducing risk.

5.3.2.8 Implementability

This alternative would be moderately easy to implement. Although the ORC® injections would be performed in areas through which vehicular traffic occurs, the injections can be done quickly with a Geoprobe and any disruptions to site operations would be minimal.

5.3.2.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-4. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

Table 4-4 compares the various alternatives for addressing VOCs in groundwater.

5.4 Light Nonaqueous Phase Liquid in Groundwater

The two candidate corrective measures identified for LNAPL at SWMU 17 in Section 3 of this report are free product bailing (passive recovery) and bioventing. Each of these are evaluated below.

5.4.1 Free Product Bailing

Free product bailing has been performed at SWMU 17 since the original release of No. 5 fuel oil. Small amounts of LNAPL continue to accumulate in a limited number of wells (approximately six wells) at SWMU 17. Under this approach, adsorbent pads will be placed in wells in which LNAPL has been found to accumulate, as well as in the LNAPL recovery sumps located adjacent to the Building FBM 61 extension. These pads will be checked for LNAPL periodically and replaced when they have reached their capacity. For the purpose of this evaluation, pads are assumed to be replaced every 2 months.

5.4.1.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the LNAPL is not currently migrating or causing exposure concerns.

5.4.1.2 Attainment of Media Cleanup Standards

The MCS for LNAPL is typically considered to be removal until LNAPL accumulations no longer exceed 1/8 inch. Free product bailing is expected to achieve this MCS eventually.

5.4.1.3 Control of the Source of Releases

The source of release of LNAPL was a broken pipeline and leaking UST. Both of these sources have been addressed and LNAPL releases are no longer occurring at the site.

5.4.1.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. The spent pads would be appropriately disposed of. Compliance with applicable waste management standards would be readily achievable.

5.4.1.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the LNAPL would be permanently removed from the groundwater.

5.4.1.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via removal of LNAPL from groundwater.

5.4.1.7 Short-Term Effectiveness

This alternative will be effective in the short term at controlling exposure and reducing risk.

5.4.1.8 Implementability

This alternative would be easy to implement. Adsorbent pads can be easily placed in existing wells.

5.4.1.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-5. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.4.2 Bioventing

As described in Section 3, bioventing would involve the introduction of air into the vadose zone to stimulate biodegradation of the hydrocarbons comprising the LNAPL. Most of the hydrocarbons in No. 5 fuel oil have some amenability to aerobic biodegradation, thus bioventing is expected to be effective in promoting remediation of the LNAPL.

Conceptually for this bioventing system, various air injection system configurations are feasible. Because much of the LNAPL is located beneath the Building FBM 61 extension, one practical way to achieve air flow beneath the building would be to inject air on one side and withdraw it from the other side, thus inducing a cross-flow ventilation system beneath the building. This approach has been assumed for the purpose of evaluating this approach in this CMS. Other assumptions used to evaluate and estimate the cost for this approach include the following:

- Up to 6 air injection wells will be located at approximately 15-foot centers along the eastern side of the Building FBM 61 extension. The wells will be up to 5 feet deep with 2 feet of well screen. A blower will provide up to 5 scfm per well.
- Up to 5 air recovery/SVE wells will be placed along the western side of Building FBM 61 to recover SVE and induce movement of the injected air beneath the building. The recovered air will be treated, if necessary, by passing it through an activated carbon filter.

5.4.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the LNAPL is not currently migrating or causing exposure concerns.

5.4.2.2 Attainment of Media Cleanup Standards

The MCS for LNAPL is typically considered to be removal until LNAPL accumulations no longer exceed 1/8 inch. Bioventing is expected to achieve this MCS eventually.

5.4.2.3 Control of the Source of Releases

The source of release of LNAPL was a broken pipeline and leaking UST. Both of these sources have been addressed and LNAPL releases are no longer occurring at the site.

5.4.2.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Drill cuttings would be appropriately disposed of. Compliance with applicable waste management standards would be readily achievable.

5.4.2.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the LNAPL would be biodegraded.

5.4.2.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via biodegradation of LNAPL.

5.4.2.7 Short-Term Effectiveness

This alternative will be effective in the short term at controlling exposure and reducing risk.

5.4.2.8 Implementability

This alternative would be moderately difficult to implement. Because of the location of the air injection wells and recovery wells near the building, the air lines to and from the wells will need to be installed below grade and therefore will need to be trenched in.

5.4.2.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-5. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

Table 4-5 compares the various alternatives for addressing LNAPL in groundwater.

5.5 Dense Nonaqueous Phase Liquid

The two candidate corrective measures identified for DNAPL at SWMU 17 in Section 3 of this report are DNAPL bailing (passive recovery) and physical removal (excavation). Each of these are evaluated below.

5.5.1 Passive Recovery

This alternative is similar to LNAPL bailing in that any observed product is removed from the well. Adsorbent pads can also be placed into a well to recovery product.

Only a single well has exhibited DNAPL and the amounts observed have been relatively small and decreasing. This approach would involve periodic checking of the well and bailing or placing of an absorbent pad into the well to adsorb product.

5.5.1.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the DNAPL is not currently migrating or causing exposure concerns.

5.5.1.2 Attainment of Media Cleanup Standards

The MCS for NAPL is typically considered to be removal until NAPL accumulations no longer exceed 1/8 inch. This alternative is expected to achieve this MCS eventually.

5.5.1.3 Control of the Source of Releases

The sources of release of DNAPL (PCB-containing transformers) have been removed.

5.5.1.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Recovered DNAPL would be appropriately disposed of. Compliance with applicable waste management standards would be readily achievable.

5.5.1.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the DNAPL would be removed from groundwater.

5.5.1.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via removal of DNAPL.

5.5.1.7 Short-Term Effectiveness

This alternative will be effective in the short term at controlling exposure and reducing risk.

5.5.1.8 Implementability

This alternative would be easy to implement.

5.5.1.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-6. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

5.5.2 Excavation

DNAPL removal via excavation would involve abandonment of well H017GW002 and excavation of soil at this location to a depth of approximately 15 feet bls. The location of this well approximately 15 feet from the Building FBM 61 extension would require that the excavation be sheet-piled to ensure the structural integrity of the building is not compromised. Dewatering and treatment and disposal of the recovered groundwater would also be required. Additionally, the location of well H017GW002 is in an area that experiences a significant amount of vehicular traffic. Some disruption to site operations would be expected to occur during implementation of this corrective measure.

For the purpose of this evaluation, the following assumptions are made:

- Soil within 10 feet of well H017GW002 would be excavated to a depth of approximately 15 feet bls. The soil would be placed in standard roll-offs and disposed of following characterization. A total of 63.5 tons of soil is expected to be excavated. It is assumed that 61.3 tons will be characterized as non-hazardous and subsequently disposed of in a Subtitle D facility. The remaining 2.2 tons is assumed to require disposal at a Toxic Substances Control Act facility.
- Sheet piling would be installed around the excavation area prior to excavation to ensure structural integrity of the adjacent building.
- The excavation would be backfilled with clean fill.

5.5.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment, because the DNAPL is not currently migrating or causing exposure concerns.

5.5.2.2 Attainment of Media Cleanup Standards

This alternative would attain the MCS for NAPL.

5.5.2.3 Control of the Source of Releases

The sources of release of DNAPL (PCB-containing transformers) have been removed.

5.5.2.4 Compliance with Applicable Waste Management Standards

This alternative could be implemented in compliance with applicable waste management standards. Soil would be appropriately disposed of. Compliance with applicable waste management standards would be readily achievable.

5.5.2.5 Long-Term Reliability and Effectiveness

This approach is expected to have long-term reliability and effectiveness, since the DNAPL would be removed from the site.

5.5.2.6 Reduction of Toxicity, Mobility, or Volume of Wastes

This approach will result in reduction of toxicity, mobility, and volume of contamination via removal of DNAPL.

5.5.2.7 Short-Term Effectiveness

This alternative will be effective in the short term at controlling exposure and reducing risk.

5.5.2.8 Implementability

This alternative would be difficult to implement. Because of the location of the area targeted for removal adjacent to the building, sheet piling would need to be installed. The area would impact vehicular traffic around the facility.

5.5.2.9 Estimated Cost

A summary of the estimated cost for this alternative is provided in Table 4-6. The summary table presents the estimated capital and O&M costs, along with the calculated present worth. The order-of-magnitude level cost estimates are based on conceptual descriptions of the alternatives, not detailed design information. These estimates have an expected accuracy of -50 percent to +100 percent.

Table 4-6 compares the various alternatives for addressing DNAPL.

Section 6.0

6.0 Recommendations

Based on the evaluation of alternatives in the preceding sections, CH2M-Jones has selected an integrated set of corrective measures for SWMU 17 that address the various COCs in the impacted soil and groundwater. These corrective measures will work together in a complimentary manner to reduce contaminant concentrations, cutoff exposure pathways, and maintain the site in a manner that is protective of human health and the environment. The corrective measures are expected to ultimately achieve the MCSs for the various site contaminants. The integrated set of corrective measures is as follows:

- **Aroclor 1260 in Surface Soil—Capping.** As described previously, current site conditions provide a protective environment for industrial site workers due to the extensive pavement and presence of structures covering most of the Aroclor 1260-impacted soil. Soil concentrations of Aroclor 1260 do not present a leaching concern. Excavation of the impacted surface soil would be excessively costly due to the presence of structures overlying some of the Aroclor 1260-impacted soil and the presence of utilities throughout the area. Additionally, maintenance of the existing pavement and structures will be complimentary to the remedies selected for subsurface soil and groundwater.
- **VOCs in Subsurface Soil—SVE.** SVE is selected for subsurface soil impacted with VOCs. SVE will expedite removal of VOCs from subsurface soil and be a complimentary technology for the remedies selected for groundwater and LNAPL.
- **VOCs in Groundwater—Air Sparging/Biosparging/SVE.** Air sparging/biosparging is selected for groundwater impacted with VOCs. SVE will be included in this corrective measure alternative to ensure that contaminants stripped out of the groundwater are controlled.
- **LNAPL—Bioventing/SVE and Passive LNAPL Recovery.** For the LNAPL, two corrective measure alternatives are selected. Bioventing will be implemented to address the LNAPL beneath the building, which is largely immobile. SVE will be used to assist in drawing air beneath the building to achieve greater impact on the distribution of air beneath the building. Passive LNAPL recovery using adsorbent pads will be used to recover small amounts of LNAPL that accumulates in monitoring wells near the building.

- **DNAPL—Passive Recovery/Monitoring.** Passive recovery of DNAPL and monitoring are recommended since the amount of DNAPL observed is low, is limited in areal extent, and is not migrating. Attempting to excavate the small amount of DNAPL-impacted soil present at 15 feet bls would be excessively expensive as well as disruptive to site operations.

These remedies will, in general, work together in an integrated manner. The combination of maintaining the existing pavement as a cap, air sparging/biosparging, SVE, and bioventing will work together to address the PCB-impacted soil, VOC-impacted subsurface soil, VOC-impacted groundwater, and LNAPL.

In addition to these corrective measures, LUCs will be implemented at the site to maintain the pavement, prevent use of the site for residential purposes, prevent the installation of drinking water wells, and prevent use of groundwater for potable purposes. The LUCs will be developed and implemented in accordance with the site-specific Land Use Control Implementation Plan agreed to by the Navy and SCDHEC. Periodic visual inspections and reviews will be conducted for the purpose of verifying that all necessary LUCs have been implemented and are being properly maintained. An annual report will be prepared and forwarded to the SCDHEC, signed by the Navy, certifying the continued retention of all LUCs implemented at SWMU 17. Additionally, the recommendation for implementing LUCs will be incorporated into the RCRA Part B Permit for the CNC.

7.0 References

EnSafe/Allen & Hoshall. *Final RCRA Facility Investigation Report for Zone H Naval Base Charleston*. Prepared for the Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D0318. July 1996.

EnSafe. *RCRA Facility Investigation Addendum*. NAVBASE Charleston. 2000.

Johnson and Ettinger. *http://www.epa.gov/oerrpage/superfund/programs/risk/airmodel/johnson_ettinger.htm*. 1991.

South Carolina Department of Health and Environmental Control (SCDHEC). RCRA Permit SC0 170 022 560. Charleston Naval Complex, Charleston, South Carolina. August 17, 1988.

U.S. Environmental Protection Agency. *http://www.epa.gov/region09/waste/sfund/prg*. November 1, 2000.

Appendix A

LITHOSTRATIGRAPHIC UNITS

FILL UNITS

Unit	Description
Fc	FILL CLAY: INORGANIC CLAYS AND SILTS. MAY CONTAIN THIN SAND INTERVALS.
Fs	FILL SAND: TYPICALLY A VERY-FINE GRAINED ORANGE SAND.

QUATERNARY AGE UNITS

Unit	Description
Qm_4	THE MOST RECENTLY DEPOSITED DARK GREY TO BLACK, ORGANIC RICH CLAYEY SILT (MARSH CLAY).
Qm_3	A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY) THAT IS ASSOCIATED WITH DEPOSITION OF THE Qs3 SAND UNIT.
Qs_3	A YELLOW-BROWN TO OLIVE-BROWN, VERY-FINE TO FINE GRAINED SAND, MAY HAVE SOME VERY-FINE BLACK GRAINS AND VARYING SILT CONTENT.
Qst_2	A YELLOW-BROWN TO OLIVE-BROWN, CLAYEY SILT.
Qm_2	A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY) THAT IS ASSOCIATED WITH DEPOSITION OF THE Qs2 SAND UNIT.
Qs_2	A GREY, VERY FINE TO FINE SAND WITH TRACE TO SOME SILT. TYPICALLY CONTAINING VERY FINE BLACK GRAINS AND/OR WHITE SHELL FRAGMENTS.
Qst_1	A YELLOW-BROWN TO OLIVE-BROWN, SOMETIMES CLAYEY SILT.
[illegible]	A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY) WITH AN OCCASIONAL THIN SAND (Qms).
Qc	A GREY-GREEN TO BLUE-GREEN, FIRM TO STIFF, PLASTIC, INORGANIC CLAY.
[illegible]	LIGHT TO DARK BROWN/GREY, VERY FINE TO FINE SAND WITH TRACE SILT CONTENT. THERE IS A PHOSPHATE PEBBLE LAG AT THE BASAL CONTACT WITH THE UNDERLYING ASHLEY FORMATION.

TERTIARY AGE UNITS

Unit	Description
Ta	AN OLIVE-BROWN TO YELLOW-BROWN, CALCAREOUS CLAYEY SILT - ASHLEY FORMATION.

LEGEND:

DEEP MONITORING WELL I.D. NUMBER

SHALLOW MONITORING WELL I.D. NUMBER

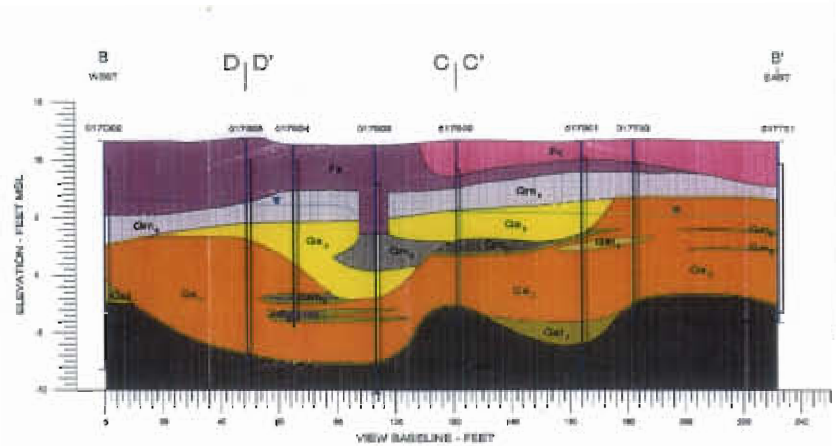
GEOLOGIC CONTACTS - DASHED WHERE INFERRED

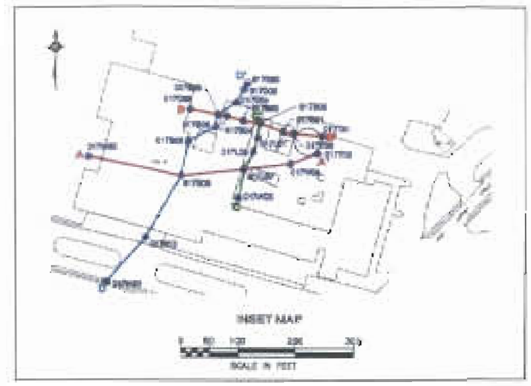
GROUNDWATER ELEVATION SURFACE

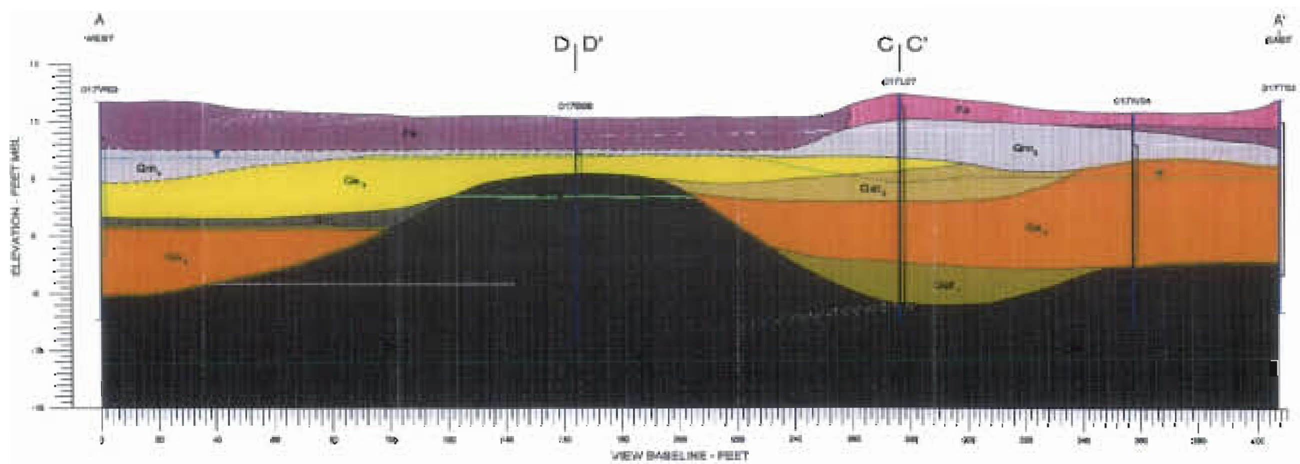
WELL SCREEN/SCREENED INTERVAL

D | D' INTERSECTING CROSS-SECTION

VERTICAL SCALE: 1"=5'
HORIZONTAL SCALE: 1"=20'
VERTICAL EXAGGERATION = 4







REVISIONS

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CHARLESTON, SC

GEOLOGIC CROSS-SECTIONS

LITHOSTRATIGRAPHIC UNITS

FILL UNITS

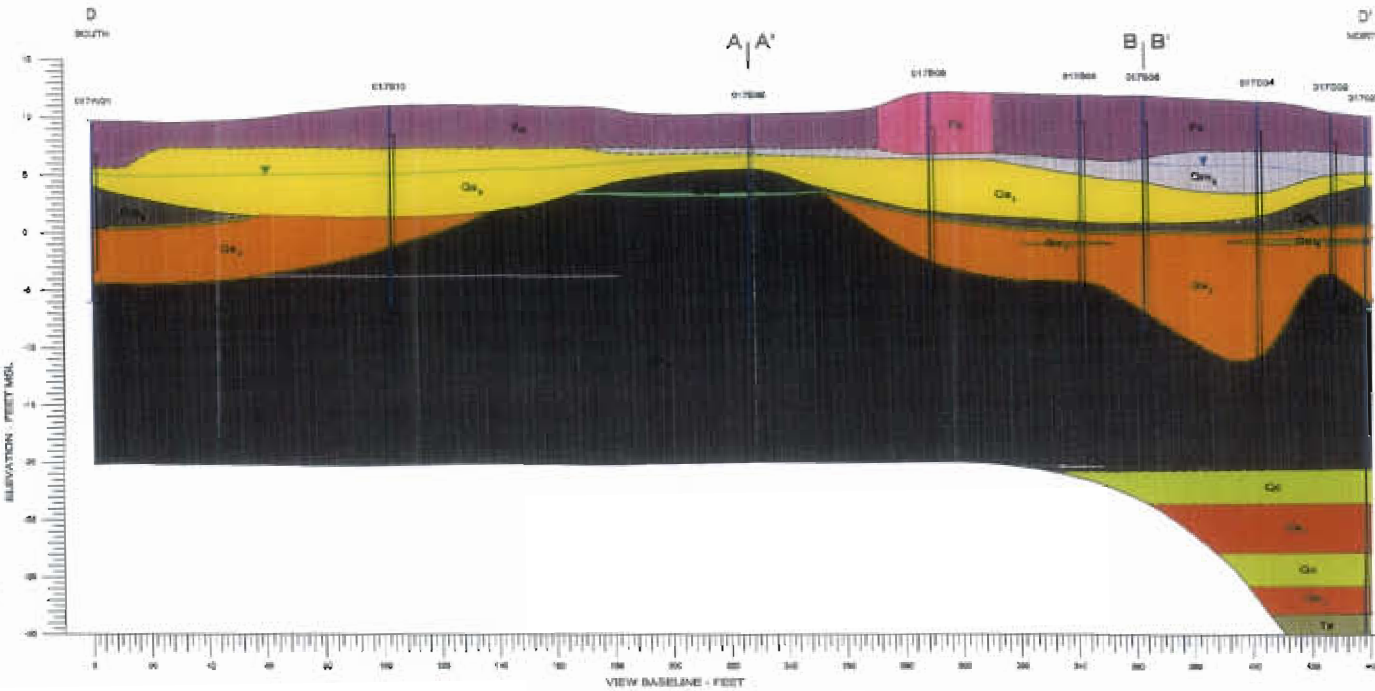
- **Fc** — FILL CLAY: INORGANIC CLAYS AND SILTS. MAY CONTAIN THIN SAND INTERVALS.
- **Fs** — FILL SAND: TYPICALLY A VERY-FINE GRAINED ORANGE SAND.

QUATERNARY AGE UNITS

- **Qm_4** — THE MOST RECENTLY DEPOSITED DARK GREY TO BLACK, ORGANIC RICH CLAYEY SILT (MARSH CLAY).
- **Qm_3** — A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY) THAT IS ASSOCIATED WITH DEPOSITION OF THE Qs3 SAND UNIT.
- **Qs_3** — A YELLOW-BROWN TO OLIVE-BROWN, VERY-FINE TO FINE GRAINED SAND. MAY HAVE SOME VERY-FINE BLACK GRAINS AND VARYING SILT CONTENT.
- **Qst_2** — A YELLOW-BROWN TO OLIVE-BROWN, CLAYEY SILT.
- **Qm_2** — A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY) THAT IS ASSOCIATED WITH DEPOSITION OF THE Qs2 SAND UNIT.
- **Qs_2** — A GREY, VERY FINE TO FINE SAND WITH TRACE TO SOME SILT. TYPICALLY CONTAINING VERY FINE BLACK GRAINS AND/OR WHITE SHELL FRAGMENTS.
- **Qst_1** — A YELLOW-BROWN TO OLIVE-BROWN, SOMETIMES CLAYEY SILT.
- **Qm** — A DARK GREY TO BLACK, ORGANIC RICH, CLAYEY SILT (MARSH CLAY), WITH AN OCCASIONAL THIN SAND (Qms).
- **Qc** — A GREY-GREEN TO BLUE-GREEN, FIRM TO STIFF, PLASTIC, INORGANIC CLAY.
- **Qs_1** — LIGHT TO DARK BROWN/GREY, VERY FINE TO FINE SAND WITH TRACE SILT CONTENT. THERE IS A PHOSPHATE PEBBLE LAG AT THE BASAL CONTACT WITH THE UNDERLYING ASHLEY FORMATION.

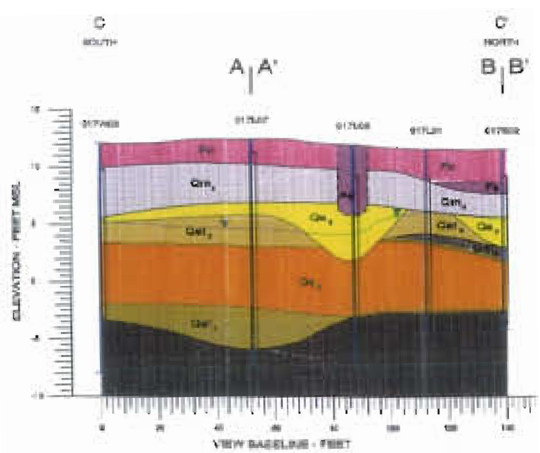
TERTIARY AGE UNITS

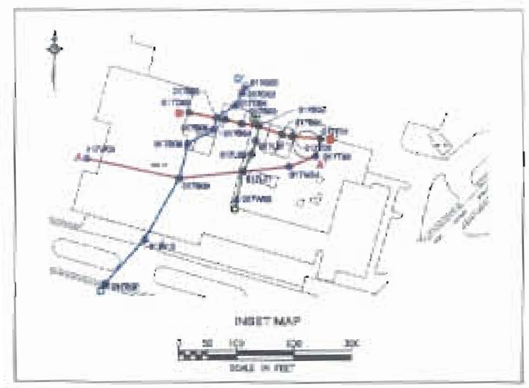
- **Ta** — AN OLIVE-BROWN TO YELLOW-BROWN, CALCAREOUS CLAYEY SILT - ASHLEY FORMATION.



LEGEND:

- DEEP MONITORING WELL W/ ID NUMBER
- SHALLOW MONITORING WELL W/ ID NUMBER
- GEOLOGIC CONTACTS - DASHED WHERE INFERRED
- GROUNDWATER ELEVATION SURFACE
- WELL BORING/SCREENED INTERVAL
- A | A' INTERSECTING CROSS-SECTION
- VERTICAL SCALE 1"=5' HORIZONTAL SCALE 1"=20' VERTICAL EXAGGERATION = 4





REVISIONS

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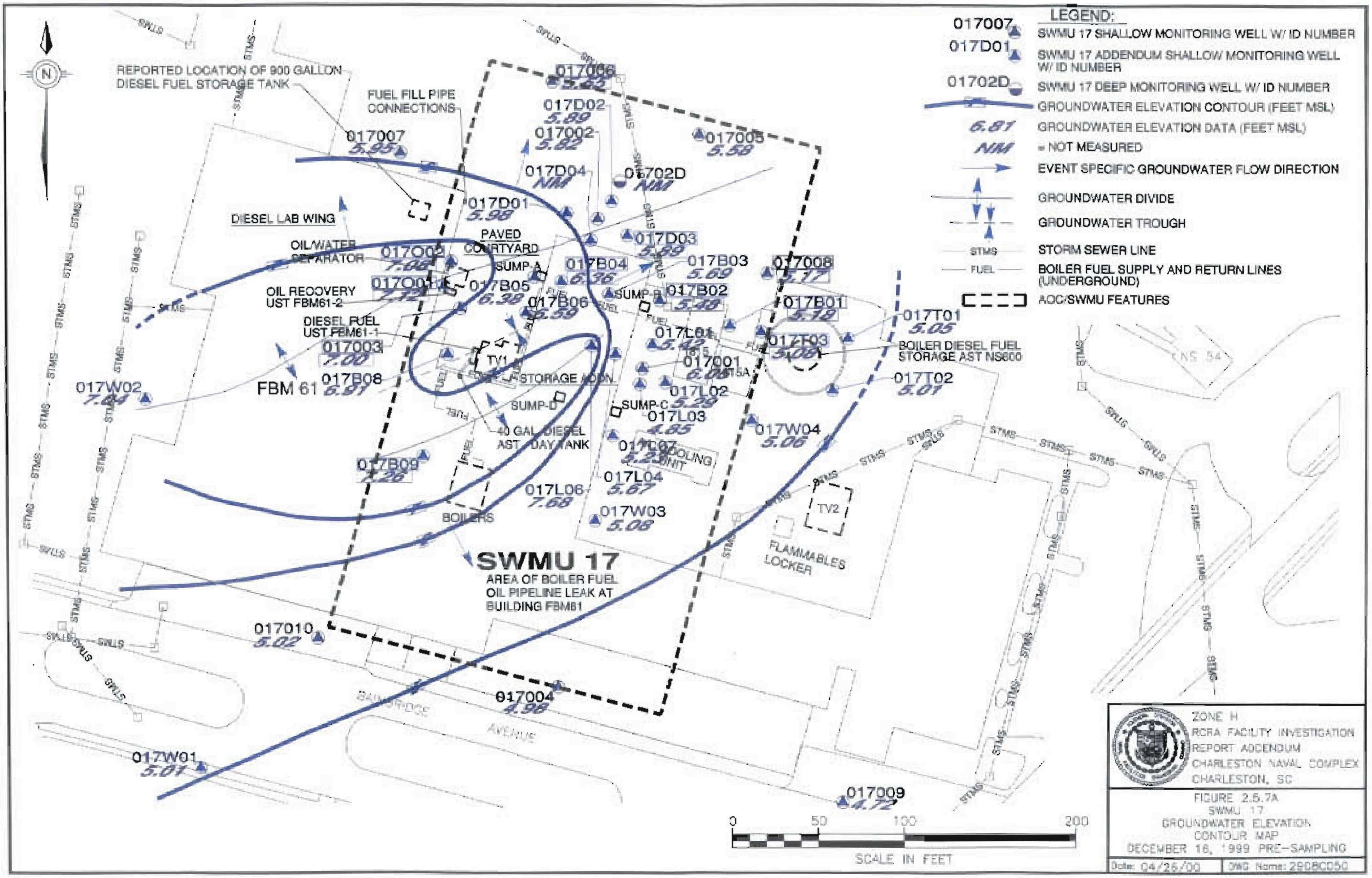
CHARLESTON, SC

SWMU 17
GEOLOGIC CROSS-SECTIONS
C-C' AND D-D'


LEGEND:
017007 SWMU 17 SHALLOW MONITORING WELL W/ ID NUMBER
017D01 SWMU 17 ADDENDUM SHALLOW MONITORING WELL W/ ID NUMBER
01702D SWMU 17 DEEP MONITORING WELL W/ ID NUMBER
GROUNDWATER ELEVATION CONTOUR (FEET MSL)
6.87 GROUNDWATER ELEVATION DATA (FEET MSL)
NM = NOT MEASURED
EVENT SPECIFIC GROUNDWATER FLOW DIRECTION
GROUNDWATER DIVIDE
GROUNDWATER TROUGH
STMS STORM SEWER LINE
FUEL BOILER FUEL SUPPLY AND RETURN LINES (UNDERGROUND)
AOC/SWMU FEATURES
REPORTED LOCATION OF 900 GALLON DIESEL FUEL STORAGE TANK
FUEL FILL PIPE CONNECTIONS
DIESEL LAB WING
OIL/WATER SEPARATOR
OIL RECOVERY UST FBM61-2
DIESEL FUEL UST FBM61-1
PAVED COURTYARD
SUMP-A
SUMP-B
SUMP-C
SUMP-D
STORAGE ADDN.
40 GAL DIESEL AST - DAY TANK
COOLING UNIT
BOILERS
FBM 61
BOILER DIESEL FUEL STORAGE AST NS600
FLAMMABLES LOCKER
TV1
TV2
SWMU 17
AREA OF BOILER FUEL OIL PIPELINE LEAK AT BUILDING FBM61
BAINBRIDGE AVENUE
017006 5.52
017D02 5.89
017002 5.82
017005 5.58
017007 5.95
017D04 NM
01702D NM
017D01 5.98
017D03 5.89
017002 7.08
017001 7.72
017B04 6.36
017B05 6.38
017B06 6.59
017B03 5.69
017B02 5.48
017008 5.17
017B01 5.18
017T01 5.05
017T03 5.08
017T02 5.07
017003 7.00
017B08 6.91
017W02 7.64
017L01 5.42
017001 6.08
017L02 5.29
017L03 4.85
017W04 5.06
017L07 5.23
017B09 7.26
017L04 5.67
017L06 7.68
017W03 5.08
017010 5.02
017004 4.98
017W01 5.01
017009 4.72
SCALE IN FEET
0 50 100 200
ZONE H
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CHARLESTON, SC
FIGURE 2.5.7A
SWMU 17
GROUNDWATER ELEVATION
CONTOUR MAP
DECEMBER 16, 1999 PRE-SAMPLING
Date: 04/26/00
DWG Name: 2908C050

Appendix B

Appendix B1

Groundwater Sampling Cost Analysis

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Groundwater Sampling (per event)							
Number of Wells		ea			10		
Number of Sampling Events					1		
Sample Analysis	-	-	-	-	-	-	
Pesticides and PCBs (608, 8081, 8082)	$179	ea	1	33-02-7208	10	$1,790	
SVOCs (8270B)	$469	ea	1	33-02-7425	10	$4,690	
VOCs (8260B)	$221	ea	1	33-02-7426	10	$2,210	
Equipment Rental (YSI 650, Geopump)	$300	day	Estimated	CH2M HILL	1	$300	
Organic Vapor Analyzer Rental	$119	day	1	33-02-0303	1	$120	
Decontaminate Materials Per Sample	$17	ea	1	33-02-6434	10	$170	Using Alconox Soap
DOT Steel Drum, 55-Gallon	$80	ea	1	33-19-9922	1	$80	For development water
Labor	$75	hr	Actual	CH2M HILL	16	$1,200	2 people, 1 day at 8 hrs/day
Per Diem	$141	per person-day	Actual	CH2M HILL	2	$280	Rate effective 10/1/04
			Initial Groundwater Sampling Cost			**$10,800**	
Additional Capital Costs							
Data Management	$100	hr	Estimated	CH2M HILL	8	$800	
Contingency	$15	%	Estimated	CH2M HILL	1	$1,620	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$1,700	
			Additional Capital Costs Subtotal			**$4,100**	
			Total Capital Costs			**$14,900**	

Notes:

[1] ECHOS.Environmental Remediation Cost Data - Assemblies. 8th Annual Edition, 2002.

Appendix B2

Summary of Remedial Costs for VOCs in Subsurface Soil

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

	Alternative 1, Soil Vapor Extraction System for VOCs in Subsurface Soil	Alternative 2, Bio Venting System for VOCs in Subsurface Soil	Alternative 3, Soil Capping of VOCs in Subsurface Soil
Capital Costs	$59,600	$52,000	$0
Annual O&M	$15,000	$15,000	$1,000
O&M Period	5	5	5
Escalation Rate	5%	5%	5%
Present Worth of O&M	$65,000	$65,000	$4,000
Total Present Worth	$124,600	$117,000	$4,000

Appendix B2

Alternative 1, Soil Vapor Extraction System for VOCs in Subsurface Soil

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
SVE System							
SVE System Installation Duration		day			5		
Number of Vapor Extraction Wells		each			3		5' bls, 2' screen, ROI = 20', flush mounted,traffic bearing vaults.
Volume of soil removed from trench		yd3			30		Assume 200' trench by 2' deep and 2' wide
Vapor Extraction Well Installation	$300	each	1		3	$900	
Concrete pad (4' x 4' x 4")	$209	ea	1	33-23-1502	1	$210	
Connection Piping	$4	LF	1	33-26-0413	700	$2,670	2" PVC, Schedule 40, Connection Piping
Miscellaneous Fittings	$50	per well	Estimated	CH2M HILL	3	$150	Tees, elbows, reducers
Concrete Saw Rental	$126	day	1	33-23-1184	2	$250	Includes 14" blade, assume trenching in 2 days
Trenching	$2	yd3	1	17-03-0265	30	$50	Cat 245, 3.0 yd3 soil/sand trenching, 14-20" deep, 194 yd3/hr, assume 2 days at 10 hr/day
Trenching labor (2 technicians)	$75	hr (ea)	Actual	CH2M HILL	40	$3,000	Assume 2 days for trenching and laying lines
Roll Off Box Rental for Trench Soil	$3	day	Vendor	Waste Management	10	$30	Assume 2 days in box for sampling, etc.
Drop Charge for Roll Off Boxes	$75	per	Vendor	Waste Management	5	$380	Drop charge anytime not swapping out roll off boxes, 10 ton capacity
Analysis of Soil	-	-	-	-	-	-	
PCBs	$179	ea	1	33-02-1717	5	$890	1 sample per roll off box
TCLP	$643	ea	1	33-02-1702	5	$3,220	1 sample per roll off box
Flush mounted well vault	$322	ea	1	33-23-2210	3	$965	12" x 7.5" manhole cover, includes labor and equipment
Pressure Guage	$115	ea	1	33-31-0209	3	$345	
Vapor Extraction Blower	$2,563	ea	1	33-13-2338	1	$2,563	5 HP, 90 SCFM
Vapor Recovery System	$4,191	each	1	33-13-2302	I	$4,191	1HP, 230V, 98SCFM, Level D, carbon filter, liquid/vapor separator
Organic Vapor Analyzer (OVA) Rental	$1,000	month	Estimated	CH2M HILL	3	$3,000	
Oversight Engineer	$75	hr	Actual	CH2M HILL	50	$3,750	1 person for 5 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	5	$710	Rate effective 10/1/04
Decontamination (rig, augers, screen)	$115	day	1	33-17-0808	2	$229	Decontaminate rental equipment
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	2	$1,286	TCLP
IDW Management	$375	EA	Vendor	Jameson Environmenta	3	$1,125	
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	2	$160	For drill cuttings and development water
Transportation of Well Cuttings	$460	LOAD	Vendor	Jameson Environmenta	1	$460	20 drums/load
Dispose Well Cuttings	$29	DRUM	1	02083-6142	2	$58	Assumes non-hazardous waste
Security Fencing	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Labor and equipment to backfill, compact, and pave
				SVE System Installation Subtotal		**$33,500**	
Operation and Maintenance							
Power Consumption	$6,500	per year	Experience	CH2M HILL	1	$6,500	Assume 5 hp and $0.10 per KWHr, runs 24 hr/day
Labor	$75	hr	Experience	CH2M HILL	100	$7,500	Weekly Inspections (2 hr/week for 50 weeks)
Miscellaneous Operations & Maintenance	$1,000	per year	Experience	CH2M HILL	1	$1,000	Carbon canister replacement, maintenance
				Operation and Maintenance Subtotal		**$15,000**	
Additional Capital Costs							
Engineering	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Permiting	2	%	Estimated	CH2M HILL	1	$700	
Project Management/Work Plan Preparation	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Contingency	15	%	Estimated	CH2M HILL	1	$5,030	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$5,400	
				Additional Capital Costs Subtotal		**$26,100**	
				Total Capital Costs		**$59,600**	
				Annual Operation and Maintenance		**$15,000**	

Notes:

[1] ECHOS Environmental Remediation Cost Data - Assemblies. 8th Annual Edition, 2002.

Appendix B2

Alternative 2, Bio Venting System for VOCs in Subsurface Soil

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Bio Venting System							
Number of Air Injection Wells		each			3		5' bls, 2' well screen, ROI=20', flush mounted, and traffic-bearing vaults.
System Installation Duration		day			5		
Volume of soil removed from trench		yd3			43		Assume 300' trench by 2' deep and 2' wide
Air Injection Well Installation	$300	each	1		3	$900	
Concrete pad (4' x 4' x 4")	$209	ea	1	33-23-1502	1	$210	
Connection Piping	$4	LF	1	33-26-0413	700	$2,670	2" PVC, Schedule 40, Connection Piping
Miscellaneous Fittings	$50	per well	Estimated	CH2M HILL	3	$150	Tees, elbows, reducers
Concrete Saw Rental	$126	day	1	33-23-1184	2	$250	Includes 14" blade, assume trenching in 2 days
Trenching	$2	yd3	1	17-03-0265	3	$0	Cat 245, 3.0 yd3 soil/sand trenching, 14-20" deep, 194 yd3/hr, assume 2 days at 10 hr/day
Trenching labor (2 technicians)	$75	hr (ea)	Actual	CH2M HILL	40	$3,000	Assume 2 days for trenching and laying lines
Roll Off Box Rental for Trench Soil	$3	day	Vendor	Vaste Managemen	10	$30	Assume 2 days in box for sampling, etc.
Drop Charge for Roll Off Boxes	$75	per	Vendor	Vaste Managemen	5	$380	Drop charge anytime not swapping out roll off boxes, 10 ton capacity
Analysis of Soil	-	-	-	-	-	-	
PCBs	$179	ea	1	33-02-1717	5	$890	1 sample per roll off box
TCLP	$643	ea	1	33-02-1702	5	$3,220	1 sample per roll off box
Flush mounted well vault	$322	ea	1	33-23-2210	3	$965	12" x 7.5" manhole cover, includes labor and equipment
Pressure Guage	$115	ea	1	33-31-0209	3	$345	
Air Flow Monitoring System (Orifice Plate)	$150	ea	Estimated	CH2M HILL	1	$150	
Positive Displacement Blower	$1,026	ea	1		1	$1,026	111CFM, 5.6HP, Blower, positive displacement with motor
Organic Vapor Analyzer (OVA) Rental	$1,000	month	Estimated	CH2M HILL	3	$3,000	
Oversight Engineer	$75	hr	Actual	CH2M HILL	50	$3,750	1 person for 5 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	5	$705	Rate effective 10/1/04
Decontamination (rig, augers, screen)	$115	day	1	33-17-0808	2	$229	Decontaminate rental equipment
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	2	$1,286	TCLP
IDW Management	$375	EA	Vendor	meson Environmer	3	$1,125	
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	2	$160	For drill cuttings and development water
Transportation of Well Cuttings	$460	LOAD	Vendor	meson Environmer	1	$460	20 drums/load
Dispose Well Cuttings	$29	DRUM	1	02083-6142	2	$58	Assumes non-hazardous waste
Security Fencing	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Labor and equipment to backfill, compact, and pave
				Bio Venting System Installation Subtotal		**$27,800**	
Operation and Maintenance							
Power Consumption	$6,500	per year	Experience	CH2M HILL	1	$6,500	Assume 5 hp and $0.10 per KWHr, runs 24 hr/day
Labor	$75	hr	Experience	CH2M HILL	100	$7,500	Weekly Inspections (2 hr/week for 50 weeks)
Miscellaneous Operations & Maintenance	$1,000	per year	Experience	CH2M HILL	1	$1,000	Carbon canister replacement, maintenance
				Operation and Maintenance Subtotal		**$15,000**	
Additional Capital Costs							
Engineering	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Permiting	2	%	Estimated	CH2M HILL	1	$600	
Project Management/Work Plan Preparation	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Contingency	15	%	Estimated	CH2M HILL	1	$4,170	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$4,400	
				Additional Capital Costs Subtotal		**$24,200**	
				Total Capital Costs		**$52,000**	
				Annual Operation and Maintenance		**$15,000**	

Notes:

[1] ECHOS.Environmental Remediation Cost Data - Assemblies, 8th Annual Edition, 2002.

Appendix B2

Alternative 3, Soil Capping of VOCs in Subsurface Soil

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Capping System							
Operations and Maintenance	$1,000	per year	Experience	CH2M Hill	1	$1,000	Inspections, pavement repair
				Capping System Subtotal		**$1,000**	
				Annual Operation and Maintenance		**$1,000**	

Assumptions:

Existing pavement will act as capping system, therefore, no additional capping is needed.

Appendix B3
Summary of Remedial Costs for VOCs in Groundwater
CMS Report, SWMU 17, Zone H, Charleston Naval Complex

	Alternative 1, Air Sparging/Bioventing for Removal of VOCs in Groundwater	Alternative 2, Aerobic Biodegradation Using ORC Injection for Removal of VOCs in Groundwater
Capital Costs	$98,200	$206,800
Annual O&M	$15,000	$54,230
O&M Period	5	3
Escalation Rate	5%	5%
Present Worth of O&M	$65,000	$148,000
Total Present Worth	$163,200	$354,800

Appendix B3

Alternative 1, Air Sparging/Bioventing for Removal of VOCs in Groundwater

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Air Sparging/Bioventing System							
Installation Duration		day			10		
Volume of soil removed from trench		yd3			72		Assume 500' trench by 2' deep and 2' wide
Number of Air Injection Wells		ea			10		Wells installed 15' deep, 3' screen interval, ROI = 20', wells installed below grade with vaults. Air requirement = 0.5 to 3
Number of air recovery/SVE wells		ea			5		
Installation of Air Injection and SVE Wells	$300	ea	1		15	$4,500	
Concrete pad (4' x 4' x 4")	$209	ea	1	33-23-1502	1	$210	
Connection Piping	$4	LF	1	33-26-0413	2000	$7,630	2" PVC, Schedule 40, Connection Piping
Miscellaneous Fittings	$50	per well	Estimated	CH2M HILL	15	$750	Tees, elbows, reducers
Concrete Saw Rental	$126	day	1	33-23-1184	2	$250	Includes 14" blade, assume trenching in 2 days
Trenching	$2	yd3	1	17-03-0265	72	$120	Cat 245, 3.0 yd3 soil/sand trenching, 14-20" deep, 194 yd3/hr, assume 2 days at 10 hr/day
Trenching labor (2 technicians)	$75	hr (ea)	Actual	CH2M HILL	100	$7,500	Assume 5 days for trenching and laying lines
Roll Off Box Rental for Trench Soil	$3	day	Vendor	Waste Management	55	$170	Assume 5 days in box for sampling, etc.
Drop Charge for Roll Off Boxes	$75	per	Vendor	Waste Management	11	$830	Drop charge anytime not swapping out roll off boxes, 10 ton capacity
Analysis of Soil	-	-	-	-	-	-	
PCBs	$179	ea	1	33-02-1717	11	$1,970	1 sample per roll off box
TCLP	$643	ea	1	33-02-1702	11	$7,080	1 sample per roll off box
Security Fencing	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Flush mounted well vault	$322	ea	1	33-23-2210	15	$4,825	12" x 7.5" manhole cover, includes labor and equipment
Pressure Guage	$115	ea	1	33-31-0209	1	$110	
Air Flow Monitoring System (Orifice Plate)	$150	ea	Estimated	CH2M HILL	1	$150	
Vapor Recovery System	$4,191	each	1	33-13-2302	1	$4,190	1HP, 230V, 98SCFM, Level D
Organic Vapor Analyzer (OVA) Rental	$1,000	month	Estimated	CH2M HILL	3	$3,000	
Decontamination (rig, augers, screen)	$115	day	1	33-17-0808	2	$230	Decontaminate rental equipment
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	2	$1,290	TCLP
IDW Management	$375	EA	Vendor	Jameson Environmental	11	$4,130	
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	2	$160	For drill cuttings and development water
Transportation of Well Cuttings	$460	LOAD	Vendor	Jameson Environmental	1	$460	20 drums/load
Dispose Well Cuttings	$29	DRUM	1	02083-6142	2	$60	Assumes non-hazardous waste
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Labor and equipment to backfill, compact, and pave top 6"
Oversight Engineer	$75	hr	Actual	CH2M HILL	100	$7,500	1 person for 5 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	10	$1,410	Rate effective 10/1/04 for Charleston
				Installation of Bio Venting System		**$62,500**	
Operation and Maintenance							
Power Consumption	$6,500	per year	Experience	CH2M HILL	1	$6,500	Assume 5 hp and $0.10 per KWHr, runs 24 hr/day
Labor	$75	hr	Experience	CH2M HILL	100	$7,500	Weekly Inspections (2 hr/week for 50 weeks)
Miscellaneous Operations & Maintenance	$1,000	per year	Experience	CH2M HILL	1	$1,000	Carbon canister replacement, maintenance
				Operation and Maintenance Subtotal		**$15,000**	
Additional Capital Costs							
Engineering	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Permiting	2	%	Estimated	CH2M HILL	1	$1,300	
Project Management/Work Plan Preparation	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Contingency	$15	%	Estimated	CH2M HILL	1	$9,380	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$10,000	
				Additional Capital Costs Subtotal		**$35,700**	
				Total Capital Costs		**$98,200**	
				Annual Operation and Maintenance		**$15,000**	

Notes:

[1] ECHOS Environmental Remediation Cost Data - Assemblies, 8th Annual Edition, 2002.

Appendix B3

Alternative 2, Aerobic Biodegradation Using ORC Injection for Removal of VOCs in Groundwater

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
ORC Treatment (2 injection events per year)							
Number of Injection Points		ea			50		Direct push using Geoprobe, injection pts at 10' centers, depth of 5-15' bls
Injection Duration		day			4		
ORC Slurry Injection	$62,380	ea	Vendor	Regenesis	2	$124,760	7170 lbs ORC
Mob/Demob Cost for Injection Subcontractor	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Daily Rate for Injection Subcontractor	$1,500	day	Estimated	CH2M HILL	8	$12,000	
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	
Injection Labor (1 Technician)	$75	hr	Actual	CH2M HILL	80	$6,000	1 person for 4 days at 10 hrs/day, 2 events
Per Diem	$141	per person-day	Actual	CH2M HILL	8	$1,130	Rate effective 10/1/04, 2 events
				Initial ORC Treatment Cost		**$147,900**	
Subsequent Year ORC Treatments (1 injection event per year)							
Injection Duration		day			4		
Number of Injection Points		ea			50		
ORC Slurry Injection	$43,666	ea	Estimated	Vendor	1	$43,670	5020 lbs (Assume 70% of original requirement)
Mob/Demob Cost for Injection Subcontractor	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Daily Rate for Injection Subcontractor	$1,500	day	Estimated	CH2M HILL	4	$6,000	
Injection Labor (1 Technician)	$75	hr	Actual	CH2M Hill	40	$3,000	1 person for 4 days at 10 hrs/day
Per Diem	$141	per person-day	Estimated	CH2M Hill	4	$560	
				Subsuquent Year ORC Treatment Cost		**$54,230**	
Additional Capital Costs							
Permiting	2	%	Estimated	CH2M HILL	1	$3,000	
Project Management/Work Plan Preparation	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Contingency	$15	%	Estimated	CH2M HILL	1	$22,190	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$23,700	
				Additional Capital Costs Subtotal		**$58,900**	
				Total Capital Costs		**$206,800**	
				Annual Operation and Maintenance		**$54,230**	

Notes:

Regenesis Time Release Compound Design Software, US Version 3.1: Updated September 2002

ORC Design Software for Grid Applications Using Slurry Injection

US Version 3.1

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: Charleston Naval Complex
Location: SWMU 17
Consultant: CH2M HILL

Site Conceptual Model/Extent of Plume Requiring Remediation

Width of plume (intersecting gw flow direction)	50	ft			
Length of plume (parallel to gw flow direction)	100	ft	=	5,000	sq. ft.
Depth to contaminated zone	10	ft			
Thickness of contaminated saturated zone	10	ft			
Nominal aquifer soil (gravel, sand, silty sand, silt, clay)	silty sand				
Total porosity	0.3		Eff. porosity	0.25	
Hydraulic conductivity	4	ft/day	=	1.4E-03	cm/sec
Hydraulic gradient	0.01	ft/ft			
Seepage velocity	58.4	ft/yr	=	0.160	ft/day
Treatment Zone Pore Volume	15,000	ft^3	=	112,215	gallons

Dissolved Phase Oxygen Demand:

Individual species that represent oxygen demand:	Contaminant Conc (mg/L)	Contaminant Mass (lb)	Stoich. (wt/wt) O_2/contam.	ORC (lb) (10% O_2)
benzene	0.04	0.0	3.1	1
toluene	0.00	0.0	3.1	0
ethylbenzene	0.00	0.0	3.2	0
xylenes	0.00	0.0	3.2	0
MTBE	0.00	0.0	2.7	0
dichloroethene	0.00	0.0	0.7	0
vinyl chloride	0.00	0.0	1.3	0
1,2,4- trichlorobenzene	0.50	0.5	4.0	19
dichlorobenzene (total)	0.70	0.7	4.0	26
reduced metals: Fe (+2) and Mn(+2)	0.00	0.0	0.10	0
Measures of total oxygen demand				
Total Petroleum Hydrocarbons	1.00	0.9	3.1	29
Biological Oxygen Demand (BOD)	5.00	4.7	1	47
Chemical Oxygen Demand (COD)	73.00	68.3	1	683

Estimates for Sorbed Phase Oxygen Demand:

Soil bulk density	1.76	g/cm^3	=	110	lb/cf
Fraction of organic carbon: foc	0.005	range: 0 to 0.01			

(Estimated using Soil Conc=foc*Koc*Cgw)
(Adjust Koc as nec. to provide realistic est.)

Individual species that represent oxygen demand:	Koc (L/kg)	Contaminant Conc (mg/kg)	Contaminant Mass (lb)	Stoich. O_2/contam.	ORC (lb) (10% O_2)
benzene	62	0.01	0.1	3.1	2
toluene	135	0.00	0.0	3.1	0
ethylbenzene	95	0.00	0.0	3.2	0
xylenes	240	0.00	0.0	3.2	0
MTBE	12	0.00	0.0	2.7	0
dichloroethene	80	0.00	0.0	0.7	0
vinyl chloride	2.5	0.00	0.0	1.3	0
1,2,4- trichlorobenzene	1659.0	4.15	22.8	4.0	911
dichlorobenzene (total)	616.0	2.16	11.8	4.0	474
Measures of total oxygen demand					
Total Petroleum Hydrocarbons	178	0.89	4.9	3.1	152
Biological Oxygen Demand (BOD): Use a multiple of dissolved phase -> 1.00			4.7	1	47
Chemical Oxygen Demand (COD): Use a multiple of dissolved phase -> 1.00			68.3	1	683

Summary of Estimated ORC Requirements	ORC for Dissolved Phase (lbs)	ORC for Sorbed Phase (lbs)	Add Dem Factor (1 to 10x)	ORC Total w/ Add Dem Factor	ORC Cost at $ 10.00
Individual Species: Total BTEX, MTBE	46	1,387	5	7,167	$ 71,667 <-
Total Petroleum Hydrocarbons	29	152	2	361	$ 3,611
Biological Oxygen Demand (BOD)	47	47	2	187	$ 1,871
Chemical Oxygen Demand (COD)	683	683	1	1,366	$ 13,661

Select above measure (button) to specify required ORC quantity (in 30 lb increments) ------> 7,170 **pounds ORC**

Delivery Design for ORC Slurry

Spacing within rows (ft)	10.0	feet
# points per row	5	points/row
Spacing between rows (ft)	10.0	ft
# of rows	10	rows
Advective travel time bet. rows (days)	63	days
Number of points in grid	50	points
Required ORC per foot	14.3	lbs/foot
Total ORC	7,170	lbs of ORC

Slurry Mixing Volume for Injections

Pounds per location	143
Buckets per location	4.8
Design solids content (20-40% by wt. for injections)	30%
Volume of water required per hole (gal)	40
Total water for mixing all holes (gal)	2006
Simple ORC Backfilling: min hole dia. for 67% slurry	6.3
Feasibility for slurry injection in sand: ok up to 15 lb/ft	(ok)
Feasibility for slurry injection in silt: ok up to 10 lb/ft	(call Regenesis)
Feasibility for slurry injection in clay: ok up to 5 lb/ft	(call Regenesis)

Project Summary			
ORC bulk material for slurry injection (lbs)			7,170
Number of 30 lb ORC buckets			239.0
ORC bulk material cost		$	8.50
Cost for bulk ORC material		$	60,945
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost		$	60,945
Shipping (call for amount)		$	1,434
Total Regenesis Material Cost		**$**	**62,379**

Cost is relatively high. Please call Regenesis to confirm design.

ORC Slurry Injection Cost Est. (responsibility of customer to contract work)		
Footage for each inj. point = uncontaminated + HRC inj. interval (ft)		20
Total length for direct push for project (ft)		1,000
Estimated daily installation rate (ft per day: 400 for push, 150 for drilling)		400
Estimated points per day (15 to 30 is possible for direct push)		20.0
Required number of days		3
Mob/demob cost for injection subcontractor	$	1,000
Daily rate for inj. Sub. ($1-2K for push $3-4K for drill rig)	$	1,500
Total injection subcontrator cost for application	$	5,500
Total Install Cost (not including consultant, lab, etc.)	**$**	**67,879**

Other Project Cost Estimates		
Design	$	-
Permitting and reporting	$	-
Construction management	$	-
Groundwater monitoring and rpts	$	-
Other	$	-
Other	$	-
Other	$	-
Other	$	-
Total Project Cost	**$**	**67,879**

Appendix B4

Summary of Remedial Costs for DNAPL Removal

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

	Alternative 1, Bailing/Passive Recovery of DNAPL	Alternative 2, Excavation of DNAPL Area
Capital Costs	$0	$72,900
Annual O&M	$1,900	$2,000
O&M Period	5	5
Escalation Rate	5%	5%
Present Worth of O&M	$8,000	$9,000
Total Present Worth	$8,000	$81,900

Appendix B4

Alternative 1, Bailing/Passive Recovery of DNAPL

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Annual Operations and Maintenance							
Labor	$75	hr	Actual	CH2M HILL	24	$1,800	Change out adsorbents every 2 months, 1 well 1 person, 4 hours per event, 6 events per year
Well Adsorbent Socks	$69	ea	Vendor	New Pig	2	$140	Monitoring well adsorbent sock, 18"L x 1.5" D, 30 socks/box, adsorbs 17 oz/sock. Will need 2 boxes per year.
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	2	$1,290	TCLP, analyze used adsorbent pads at start and prior to disposal
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	1	$80	For used adsorbent pads and socks, assume nonhazardous
Waste Disposal	$29	Drum	1	02083-6142	1	$30	Disposal of bulk solids into 55 gallon drum, nonhazardous
				Operation and Maintenance Subtotal		**$1,900**	
				Annual Operations & Maintenance		**$1,900**	

Vendor:

www.newpig.com

Appendix B4
Alternative 2, Excavation of DNAPL Area
CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Excavation of Contaminated Area							
Excavation Duration		day			2		
Volume of Excavated Soil		ton			83		Density =1.5 ton/yd3
Excavation Equipment	-	-	-	-	-	-	
- Excavator	$120	hr	1	17-03-0230	20	$2,400	1.0 CY, includes labor, 10hr/day for 2 days
- Wheel Loader	$80	hr	1	17-03-0221	20	$1,600	1.5 CY, includes labor, 10hr/day for 2 days
Dust Suppresant	$2	yd2	1	33-08-0574	11	$20	Tree-sap based
Oversight Engineer	$75	hr	Actual	CH2M HILL	20	$1,500	1 person for 2 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	2	$280	Rate effective 10/1/04 in Charleston, SC
Temporary Dewatering of Excavation Area	-	-	-	-	-	-	
Contractor's Trash Pump	$46	day	1	17-03-1002	2	$93	2" diameter, 75 GPM, rental
Frac Tank for Development Water	$1,760	month	Vendor	Jameson Environmental	1	$1,760	17,000 gal, $1,760/month rental
Labor (Technician)	$75	hr	Actual	CH2M HILL	20	$1,500	
Water Analysis	$1,300	ea	Vendor	Jameson Environmental	1	$1,300	TCLP, Ignitability, Reactivity, Corrosivity
Transport and Dispose Development Water	$0.30	gal	Vendor	Jameson Environmental	4039	$1,210	
Analysis of Soil	-	-	-	-	-	-	
PCBs	$179	ea	1	33-02-1717	9	$1,550	Estimated number of samples
TCLP	$643	ea	1	33-02-1702	9	$5,570	Estimated number of samples
Disposal of Excavated Soil (Nonhazardous)	$27	ton	Vendor	Waste Management	87	$2,340	Assume 30% swell
Transportation of Nonhazardous Soil	$195	per load	Vendor	Waste Management	9	$1,690	10 tons per load using roll off boxes (additional $3/day for rental not included)
Drop Charge for Roll Off Boxes	$75	per	Vendor	Waste Management	9	$650	Drop charge anytime not swapping out roll off boxes.
Disposal of Excavated Soil (Hazardous)	$125	ton	Vendor	Waste Management	22	$2,710	Assume last 20% will be hazardous
Transportation of Hazardous Soil	$1 800	per load	Vendor	Waste Management	2	$3,900	10 tons per load using roll off boxes (If not swapping out then double the cost)
One Time ADM Fee	$125	ea	Vendor	Waste Management	1	$130	One time fee
Backfill	$18	yd3	1	17-03-0407	72	$1,330	Import and place backfill with sand, assume 30% swell
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Labor and equipment to backfill and compact
Replacement of Groundwater Well	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Soil Containment Cell	-	-	-	-	-	-	Stock pile soil until soil analysis is final
- Base protection from soil	$1,000	roll	Estimated	CH2M HILL	1	$1,000	20 mil HDPE liner, 23' W x 200' L (4600 ft2)
- Perimeter protection (hay bales)	$10	per	Estimated	CH2M HILL	37	$370	hay bales (3' x 2' x 2')
Decontaminate Equipment	$198	ea	1	33-17-0802	2	$400	Decontaminate medium equipment
Shoring	$11.12	ft2	1	17-03-0904	900	$10,010	Steel sheeting, install, pull & salvage to 40', depth is 3 times excav (45')
					Excavation Cost	**$47,300**	
Operation and Maintenance							
Miscellaneous Operation and Maintenance	$2,000	ea	Estimated	CH2M HILL	1	$2,000	
					Operation and Maintenance Subtotal	$2,000	
Additional Capital Costs							
Survey	$2,000	ea	Estimated	CH2M HILL	1	$2,000	
Engineering	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Permiting	2	%	Estimated	CH2M HILL	1	$900	
Project Management/Work Plan Preparation	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Contingency	$15	%	Estimated	CH2M HILL	1	$7,100	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$7,600	
					Additional Capital Costs Subtotal	**$25,600**	
					Total Capital Costs	**$72,900**	
					Annual Operations & Maintenance	**$2,000**	

Assumptions:
No excavation beneath buildings
[1] ECHOS.Environmental Remediation Cost Data - Assemblies. 8th Annual Edition, 2002.
Vendor: Waste Management (Ray Mattice, 843-830-1473), costing is for Charleston, SC area

Appendix B5

Summary of Remedial Costs for LNAPL Removal from Groundwater

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

	Alternative 1, Free Product Bailing for LNAPL Removal in Groundwater	Alternative 2, Bioventing System for LNAPL Removal in Groundwater
Capital Costs	$0	$73,700
Annual O&M	$4,900	$15,000
O&M Period	5	5
Escalation Rate	5%	5%
Present Worth of O&M	$21,000	$65,000
Total Present Worth	$21,000	$138,700

Appendix B5

Alternative 1, Free Product Bailing for LNAPL Removal in Groundwater

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Operations and Maintenance							
Labor	$75	hr	Actual	CH2M HILL	24	$1,800	Change out adsorbents every 2 months, 6 wells and sumps 1 Person, 4 hours per event, 6 events per year
Sump Adsorbent Pad	$61	ea	Vendor	New Pig	4	$244	Sump adsorbent pads (oil only), 20" L x 16" W, adsorbs 24gal/bag, 100 pads/bag. Will need 4 boxes per year.
Well Adsorbent Socks	$69	ea	Vendor	New Pig	2	$138	Monitoring well adsorbent sock, 18"L x 1.5" D, 30 socks/box. Will need 2 boxes per year.
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	4	$2,570	TCLP, analyze used adsorbent pads and socks at start and prior to disposal
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	1	$80	For used adsorbent pads and socks, assume nonhazardous
Waste Disposal	$29	Drum	1	02083-6142	1	$30	Disposal of bulk solids into 55 gallon drum, nonhazardous
				Operation and Maintenance Subtotal		**$4,900**	
				Annual Operations & Maintenance		**$4,900**	

Vendor:

www.newpig.com

Appendix B5

Alternative 2, Bioventing System for LNAPL Removal in Groundwater

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Bioventing System							
Installation Duration		day			7		
Volume of soil removed from trench		yd3			43		Assume 300' trench by 2' deep and 2' wide
Number of Air Injection Wells		ea			6		Into Vadose Zone in north central section (beneath SB 62) to introduce cross flow ventilation. 15' centers, 5' deep, 2' screen
Number of air recovery/SVE wells		ea			5		Placed on western side of facility 61.
Installation of Air Injection and SVE Wells	$300	ea	1	ECHOS	11	$3,300	
Concrete pad (4' x 4' x 4")	$209	ea	1	33-23-1502	1	$210	
Connection Piping	$4	LF	1	33-26-0413	800	$3,050	2" PVC, Schedule 40, Connection Piping
Miscellaneous Fittings	$50	per well	Estimated	CH2M HILL	11	$550	Tees, elbows, reducers
Concrete Saw Rental	$126	day	1	33-23-1184	2	$250	Includes 14" blade, assume trenching in 2 days
Trenching	$2	yd3	1	17-03-0265	43	$70	Cat 245, 3.0 yd3 soil/sand trenching, 14-20" deep, 194 yd3/hr, assume 2 days at 10 hr/day
Trenching labor (2 technicians)	$75	hr (ea)	Actual	CH2M HILL	60	$4,500	Assume 3 days for trenching and laying lines
Roll Off Box Rental for Trench Soil	$3	day	Vendor	Waste Management	15	$50	Assume 3 days in box for sampling, etc.
Drop Charge for Roll Off Boxes	$75	per	Vendor	Waste Management	5	$380	Drop charge anytime not swapping out roll off boxes, 10 ton capacity
Analysis of Soil	-	-	-	-	-	-	
PCBs	$179	ea	1	33-02-1717	5	$890	1 sample per roll off box
TCLP	$643	ea	1	33-02-1702	5	$3,220	1 sample per roll off box
Flush mounted well vault	$322	ea	1	33-23-2210	11	$3,536	12" x 7.5" manhole cover, includes labor and equipment
Pressure Guage	$115	ea	1	33-31-0209	1	$110	
Vapor Recovery System	$4,191	each	1	33-13-2302	1	$4,190	1HP, 230V, 98SCFM
Organic Vapor Analyzer (OVA) Rental	$1,000	month	Estimated	CH2M HILL	3	$3,000	
Air Flow Monitoring System	$200	ea	Estimated	CH2M HILL	1	$200	
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Labor and equipment to backfill, compact, and pave top 6"
Security Fencing	$1,000	ea	Estimated	CH2M HILL	1	$1,000	
Oversight Engineer	$75	hr	Actual	CH2M HILL	70	$5,250	1 person for 7 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	7	$990	Rate effective 10/1/04
Decontamination (rig, augers, screen)	$115	day	1	33-17-0808	2	$230	Decontaminate rental equipment
Waste Characterization (TCLP)	$643	ea	1	33-02-1702	2	$1,290	TCLP
IDW Management	$375	EA	Vendor	Jameson Environmental	11	$4,130	
DOT Steel Drum, 55-Gallon	$80	EA	1	33-19-9922	2	$160	For drill cuttings and development water
Transportation of Well Cuttings	$460	LOAD	Vendor	Jameson Environmental	1	$460	20 drums/load
Dispose Well Cuttings	$29	DRUM	1	02083-6142	2	$60	Assumes non-hazardous waste
						$44,100	
Operation and Maintenance							
Power Consumption	$6,500	per year	Experience	CH2M HILL	1	$6,500	Assume 5 hp and $0.10 per KWHr, runs 24 hr/day
Labor	$75	hr	Experience	CH2M HILL	100	$7,500	Weekly inspections (2 hr/week for 50 weeks)
Miscellaneous Operations & Maintenance	$1,000	per year	Experience	CH2M HILL	1	$1,000	Carbon canister replacement, maintenance
				Power to Bio Venting System Subtotal		**$15,000**	
Additional Capital Costs							
Engineering	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Permitting	2	%	Estimated	CH2M HILL	1	$900	
Project Management/Work Plan Preparation	$5,000	ea	Estimated	CH2M HILL	1	$5,000	
Contingency	15	%	Estimated	CH2M HILL	1	$6,620	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$7,100	
				Additional Capital Costs Subtotal		**$29,600**	
				Total Capital Costs		**$73,700**	
				Annual Operation and Maintenance		**$15,000**	

Notes:

[1] ECHOS Environmental Remediation Cost Data - Assemblies, 8th Annual Edition, 2002.

Appendix B6

Summary of Remedial Costs for PCBs in Surface and Subsurface Soil

CMS Report, SWMU 17, Zone H, Charleston Naval Complex

	Alternative 1, Excavation for PCB Area	Alternative 2, Soil Capping of PCB Area
Capital Costs	$89,000	$0
Annual O&M	$2,000	$1,000
O&M Period	5	5
Escalation Rate	5%	5%
Present Worth of O&M	$9,000	$4,000
Total Present Worth	$98,000	$4,000

Appendix B6
Alternative 1, Excavation for PCB Area
CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Excavation of Contaminated Area							
Excavation Duration		day			4		Excavate to depth of 5'
Excavation Equipment							
Volume of Excavated Soil		ton			250		Density =1.5 ton/yd3
- Excavator	$121.14	hr	1	17-03-0230	40	$4,850	1.0 CY, includes labor, 10hr/day for 4 days
- Wheel Loader	$78.16	hr	1	17-03-0221	40	$3,130	1.5 CY, includes labor, 10hr/day for 4 days
Dust Suppresant	$2.23	1/yd2	1	33-08-0574	163	$360	Tree-sap based
Oversight Engineer	$75	hr	Actual	CH2M HILL	40	$3,000	1 person for 4 days at 10 hrs/day
Per Diem	$141	day	Actual	CH2M HILL	4	$560	Rate effective 10/1/04 in Charleston, SC
Analysis of Soil							
PCBs	$179	ea	1	33-02-1717	5	$890	5 areas to be sampled
TCLP	$643	ea	1	33-02-1702	5	$3,220	5 areas to be sampled
Disposal of Excavated Soil (Nonhazardous)	$27	ton	Vendor	Waste Management	325	$8,780	Assume 30% swell
Transportation of Nonhazardous Soil	$195	per load	Vendor	Waste Management	33	$6,340	10 tons per load using roll off boxes (additional $3/day for rental not included)
Drop Charge for Roll Off Boxes	$75	per	Vendor	Waste Management	33	$2,440	Drop charge anytime not swapping out roll off boxes.
Backfill	$18	1/yd3	1	17-03-0407	217	$4,000	Import and place backfill with sand, assume 30% swell
Soil Containment Cell	-	-	-	-	-	-	
- Base protection from soil	$1,000	roll	Estimated	CH2M HILL	1	$1,000	20 mil HDPE liner, 23' W x 200' L (4600 ft2)
- Perimeter protection	$10	per	Estimated	CH2M HILL	53	$530	hay bales (3' x 2' x 2')
Site Restoration	$3,000	ea	Experience	CH2M HILL	1	$3,000	Compact and pave area
Shoring	$9.33	ft2	1	17-03-0901	1050	$9,790	Steel sheeting, install, pull & salvage to 15', assume 3 times excav. Depth (15')
				Excavation of Contaminated Area Subtotal		**$51,900**	
Operations and Maintenance							
Miscellaneous Operations and Maintenance	$2,000	ea	Estimated	CH2M HILL	1	$2,000	
				Operation and Maintenance Subtotal		**$2,000**	
Additional Capital Costs							
Engineering	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Permiting	2	%	Estimated	CH2M HILL	1	$1,000	
Project Management/Work Plan Preparation	$10,000	ea	Estimated	CH2M HILL	1	$10,000	
Contingency	15	%	Estimated	CH2M HILL	1	$7,790	
G&A, Profit, & PMO	16	%	Estimated	CH2M HILL	1	$8,300	
				Additional Capital Costs Subtotal		**$37,100**	
				Total Capital Costs		**$89,000**	
				Annual Operation and Maintenance		**$2,000**	

Assumptions:
No excavation beneath buildings
[1] ECHOS.Environmental Remediation Cost Data - Assemblies. 8th Annual Edition, 2002.
Vendor: Waste Management (Ray Mattice, 843-830-1473), costing is for Charleston, SC area

Appendix B6
Alternative 2, Soil Capping of PCB Area
CMS Report, SWMU 17, Zone H, Charleston Naval Complex

Item	Unit Cost	Units	Source	Code	Number of Units	Cost	Notes
Capping System							
Operations and Maintenance	$1,000	per year	Experience	CH2M HILL	1	$1,000	Inspections, pavement repair
				Capping System Subtotal		**$1,000**	
				Annual Operation and Maintenance		**$1,000**	

Assumptions:
Existing pavement will act as capping system, therefore, no additional capping is needed.

This document presents CH2M-Jones' responses to the South Carolina Department of Health and Environmental Control's (SCDHEC's) comments on the *CMS Report, SWMU 17, Zone H, Revision 0* (CH2M-Jones, 2004).

Engineering Comments Made by Jerry Stamps – January 17, 2006

1. **<u>Section 1.2, Page 1-3</u>**

   This section discusses the existence of an Oil Water Separator (OWS) in the paved courtyard associated with SWMU 17; however, the figures do not appear to identify the location of this unit. Please revise the figures to identify the location of the OWS to verify that that the environmental samples collected to date adequately investigate any potential releases from the OWS.

   Additionally, it is unclear if the contents of the unit were removed and the unit cleaned. If not, these actions should be performed to ensure that the OWS does not serve as a continuing source. Please clarify.

   CH2M-Jones Response:

   The OWS is located along the western side of the courtyard area. A figure will be revised or new figure will be included in Section 1.0 to show the location of this OWS. Several wells (i.e., H017GW001 and H017GW002) are directly adjacent to and on opposite sides of the OWS do not show significant groundwater contamination. Additional information regarding whether the unit has been cleaned will be provided in the revised report. If the unit is in operation, the responsibility for the unit's integrity is with the new property owner, rather than the Navy.

2. **<u>Section 2.1, Page 2-1, Dioxins</u>**

   Historically, the Department has not relied solely on the TEQ action level of 1 ppb. Instead, the Department requires that the risk posed by these constituents be evaluated and the EPA action level be used to make a risk management decision. The text should be revised to reflect this.

   CH2M-Jones Response:

   The text in Section 2.0 will be revised as requested. A brief paragraph will be included in Section 3.0 indicating that 1 ppb (1 micrograms per kilogram [μg/kg]) will be used as the media cleanup standard for dioxins.

3. **<u>Section 2.4.1, Page 2-5, 3rd paragraph</u>**

   This section states that DNAPL was identified in well 017GW002. It further states that the surrounding wells 017GW01D, -02D, -03D and -04D did not show signs of DNAPL. Based upon the well nomenclature, it appears that 017GW002 is a shallow well surrounded by a series of deep wells. If so, given the highly viscous nature of the DNAPL and difference in screen depths, the Department questions if the deep wells are adequate to characterize the horizontal extent of the DNAPL. The question remains as to whether the DNAPL remains as a "slug" of viscous material in the shallow portion of the aquifer. CNAV should address this issue by explaining the difference in the screened intervals between the shallow and deep wells, the distances between these wells, and why it is felt that groundwater has been adequately characterized. There should also be some discussion about the question of a "slug" of viscous material in the shallow portion of the aquifer, based upon the analytical data presented. Whether or not a slug of DNAPL will persist in groundwater should also be discussed.

CH2M-Jones Response:
The only observation of DNAPL at SMWU 17 was in well 017GW002 on a limited number of occasions. The screened interval for well 017GW002 is from approximately 3 to 13 feet below land surface (bls). The boring log for this well (see attached) indicates that a black sludge with strong solvent odor was detected on the auger flights during well installation in 1995 just above the clay layer at approximately 8 feet bls. This is likely the depth at which the DNAPL was encountered.

As part of the RFI Addendum field work, EnSafe installed temporary wells 17GW01D, -02D, -03D, and -04D to total depths of 17, 17, 15, and 20 feet bls respectively, in December 1999. These wells were installed for the specific intention by the BCT of assessing the areal extent of DNAPL in the vicinity of well 017GW002, as part of the RFI.

The depths of the temporary wells were appropriate for assessing the potential presence and extent of DNAPL around well 017GW002, since if DNAPL were present at these locations, these wells would be deep enough to reasonably expect them to detect it. The lithologic and construction logs for these wells are attached. No DNAPL was detected in these temporary wells. The black sludge with the solvent odor was also not found at these drilling locations.

Based on these results, the BCT accepted that the delineation of DNAPL around well 017GW002 for the purpose of the RFI was acceptably completed. There do not appear to be any new data indicating that the conclusions regarding the delineation of DNAPL were incorrect. Accordingly, CH2M-Jones suggests that the previous conclusions of the BCT that the DNAPL extent around 017GW002 was adequately delineated should still be acceptable.

Appendix A of the CMS Report shows several geologic cross-sections of SWMU 17. Based on cross-section D-D′, a marsh clay layer ranging in thickness from 10 to 25 feet underlies the shallow aquifer zone in which the contamination has been found at SWMU 17. This clay would be expected to provide a barrier to the downward migration of the PCB-containing dielectric fluid that appears to comprise the small amount of DNAPL present at the site.

Some additional discussion about the persistence of the DNAPL slug can be included in the revised report.

4. <u>Figure 2-6, Table 3-3</u>
   The maximum detections provided in Table 3-3 do not appear to be listed on Figure 2-6. Please clarify.

   CH2M-Jones Response:
   The table and figure will be corrected.

5. <u>Section 4.2.6</u>
   This section should state that the LUCs are to remain in place until such time as the remedial objectives are met. In light of the comment from the Division of Hydrogeology,

the Department recommends incorporating a bulleted list of the risk exposure assumptions used in developing the LUCs including the means for which the Navy intends to ensure those assumptions remain valid.

CH2M-Jones Response:
The text will be clarified as requested. It should be noted that the responsibility for ensuring that the risk exposure assumptions remain valid are shared by the new property owner.

6. **<u>Section 5.4.1.2</u>**
It is stated that LNAPL is considered removed when accumulations no longer exceed 1/8 inch. Upon achievement of this standard, clearly there will be residual LNAPL remaining in place. Please clarify if it is anticipated that the SVE will remediate the residual LNAPL.

CH2M-Jones Response:
The remediation system installed at the site is expected to achieve significant treatment of the residual LNAPL over time. The removal of soil gas via the SVE system will slowly remove the more volatile fractions of the LNAPL. Because the LNAPL is comprised of a No. 5 fuel oil, the volatility of the compounds in it is relatively low. However, over an extended period of treatment, SVE should achieve a significant effect on the LNAPL. Additionally, the system to be installed (including the air sparging portion for the dissolved-phase plume) is expected to promote movement of more oxygen-rich air into the vadose zone in the vicinity of the LNAPL. The increase in oxygen will stimulate biodegradation of the remaining hydrocarbons. Along with SVE, these processes are expected to achieve significant LNAPL treatment beneath the building over time.

7. **<u>Section 6.0, DNAPL</u>**
Though the Department prefers the complete removal of the DNAPL, the Department understands the difficulties associated with this action considering the location relative to the building and underground utilities. Please note that if the proposed remedy is not performing as expected and conditions become such that removal of the DNAPL is practical, the Department may require the excavation of the DNAPL.

CH2M-Jones Response:
Comment noted.

8. **<u>Section 6.0, last paragraph</u>**
Rather than stating that the LUCs will be implemented in accordance with the Land Use Control Implementation Plan, the Department recommends stating that the specific LUCs will be implemented in accordance with the Corrective Measure Implementation Work Plan.

CH2M-Jones Response:
The text will be revised as requested. The Corrective Measure Implementation Plan (CMIP) will include the requested information.

Hydrogeology Comments Made by Donald Hargrove – January 19, 2006

1. **Section 6.0, Recommendations:**
   This section states that land use controls (LUCs) will be implemented to prevent the use of groundwater for potable purposes. This stipulation is too generic to assume efficacy. There is no language restricting groundwater use for irrigation purposes, or for industrial purposes. Using the statement as written, it would be easy to see someone constructing a well for irrigation purposes, or industrial use, and not be violating the LUCs. However, use of groundwater for irrigation does pose a certain degree of exposure risk that might not be known to the user in question (the public). Using a well specifically designated for non-potable use such as equipment washing or equipment cooling, carries the same amount of exposure risk as a potable use well in this area, again, without necessarily making the public aware of the risk.

   It is suggested that discussions about LUCs with respect to groundwater use be as explicit as possible, and come as early as possible in the corrective action process. This discussion should expressly state restrictions on groundwater use or extraction for any/all purposes, and not allow the installation of wells whose purpose is for potable use, irrigation, or any other non-potable uses. Groundwater extraction for monitoring purposes can be allowed using adequate disclaimers/exclusions during this discussion.

   CH2M-Jones Response:
   Per discussions with the BCT, the specific land use controls will be discussed in the CMIP. The text of the CMS in Section 6.0 will be revised to indicate that groundwater restrictions will be imposed to preclude use of all shallow groundwater for any purpose until the remedial action objectives have been achieved.

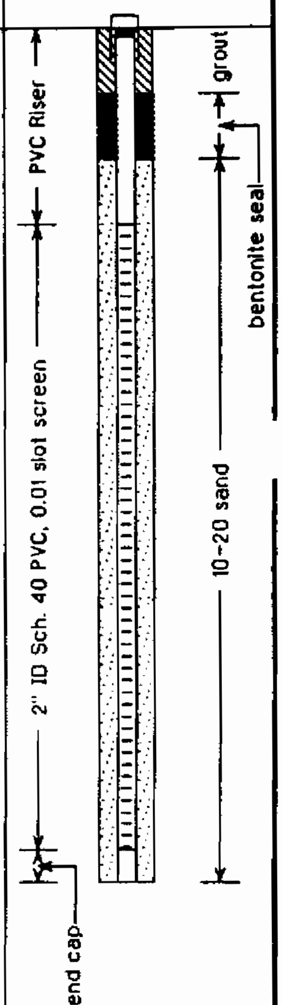
ENSAFE

Monitoring Well NBCH017002

Project: *Zone H-Naval Base Charleston*	Coordinates: *2324930.77 E, 370399.29 N*
Location: *Charleston, SC*	Surface Elevation: *10.8 feet msl*
Started at *0825 on 9-8-94*	TOC Elevation: *10.47 feet msl*
Completed at *0915 on 9-8-94*	Depth to Groundwater: *4.66 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *5.81 feet msl*
Drilling Company: *Alliance Environmental*	Total Depth: *13 feet*
Geologist: *S. Howard*	Well Screen: *3 to 12.5 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	OVA (ppm)	% RECOVERY	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
							SP	Sand: brown, fine to medium with gravel, poorly sorted.	7.8 / 7.3
5			1	0	13				
				25				*Black sludge on auger flights with strong solvent-like odor.*	2.8
							OH	Clay: black to dark gray, fat, minor sand and shell hash at base, no odor.	
10			2	0	100				.8
									-2.4
							OH	Silt: green-brown, organic-rich with plant fragments and dark gray to black, soft clay with occasional small plant roots, sulfurous odor.	
15			3	0	100				-4.4
20									

WELL DIAGRAM



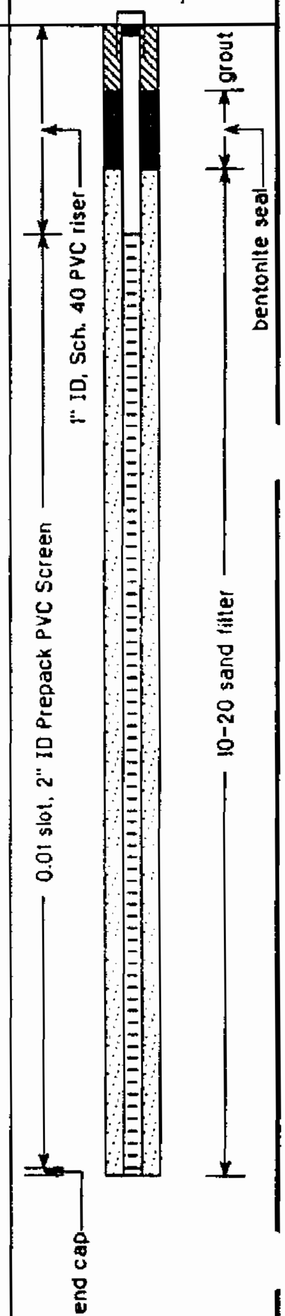
ENSAFE

Monitoring Well NBCH017D01

Project: *Zone H–Charleston Naval Complex*	Coordinates: *2324912.9 E, 370402.7 N*
Location: *Charleston, SC*	Surface Elevation: *11.0 feet msl*
Started at *1130 on 03 Dec 99*	TOC Elevation: *10.87 feet msl*
Completed at *1440 on 03 Dec 99*	Depth to Groundwater: *4.89 feet TOC* Measured: *16 Dec 99*
Drilling Method: *DPT Continuous Sampler w/3.5" OD Boring*	Groundwater Elevation: *5.98 feet msl*
Drilling Company: *Precision SC Cert #57*	Total Depth: *17.5 feet*
Geologist: *P. Bayley*	Well Screen: *3.2 to 17.4 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	OVA (ppm)	% RECOVERY	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface Conditions: Asphalt	
							GM	Gravel: ROC	10
			1		0				
							GM SM	Gravel: grey; size to 1cm; w/Sand: orange-brown; very fine, silty, trace clay; as matrix.	8 7.4
							OL OH	Silt: dark grey-black; clayey; wet, soft, plastic.	7
5									
			2		33		OL OH	Silt: as at 4.8 ft; w/woody fibers.	5.9
			3		3		SM	Sand: dark grey; very fine, silty, w/trace to some very fine black grains; wet, loose.	2 1.8
10									
			4		13				
							OL SM	Silt: dark grey; some sand to sandy-very fine, clayey; trace vegetation; wet, soft, plastic.	-2 -2.9
							OL	Silt: dark grey-black, slight mottle; clayey; wet, soft, plastic. @14.2 to 14.3 ft.: traces of yellow-brown vegetation. @14.3 ft.: 1cm sand parting.	-3.6
15			5		66		SM	Sand: yellow-brown; very fine, silty; wet, loose-sticky.	-4
			6		100		OL OH	Silt: dark grey-black w/slight greenish cast; clayey; wet, soft, plastic. @18.1 to 18.2, and 18.5 to 19.1 ft.: trace brown vegetation. @17.7 to 19.7 ft.: brown mottle.	
20									

WELL DIAGRAM



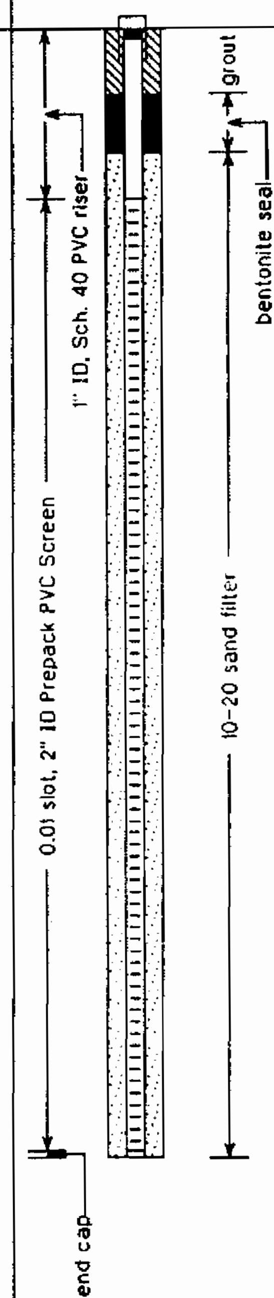
ENSAFE

Monitoring Well NBCH017D02

Project: *Zone H–Charleston Naval Complex*	Coordinates: *2324938.8 E, 370409.8 N*
Location: *Charleston, SC*	Surface Elevation: *10.5 feet msl*
Started at *1715 on 04 Dec 99*	TOC Elevation: *10.34 feet msl*
Completed at *0835 on 05 Dec 99*	Depth to Groundwater: *4.45 feet TOC* Measured: *16 Dec 99*
Drilling Method: *DPT Continuous Sampler w/3.5"OD Boring*	Groundwater Elevation: *5.89 feet msl*
Drilling Company: *Precision SC Cert #57*	Total Depth: *17.2 feet*
Geologist: *P. Bayley*	Well Screen: *2.8 to 16.9 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	OVA (ppm)	% RECOVERY	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface Conditions: Asphalt	
							GM	Gravel: ROC	9.5
								No Sample Recovery: only traces of Gravel/ROC.	
5			1		0				5.5
							OL/OH	Silt: dark grey-black; clayey; wet, soft, plastic.	5.1
							SM	Sand: olive; very fine, silty; wet, loose-sticky; chemical/fuel odor.	3.8
							OL/OH	Silt: dark grey-black; clayey; wet, soft, plastic.	3.2
			2		77				2.5
							OL/OH		
10									.4
			3		100		SP/SM	Sand: grey; very fine, some silt to silty, trace very fine black grains; wet, loose.	-.5
							OL/OH	Silt: dark grey-black; clayey; wet, soft, plastic.	-1.1
							SM	Sand: olive; very fine, silty; wet, loose-sticky; H2S odor.	-1.8
			4		43		OL/OH	Silt: dark grey-black; clayey; wet, soft, plastic. @15.8 to 16.5 ft.: peaty vegetation.	-3.5
15									
			5		100				-6.5
20									

WELL DIAGRAM



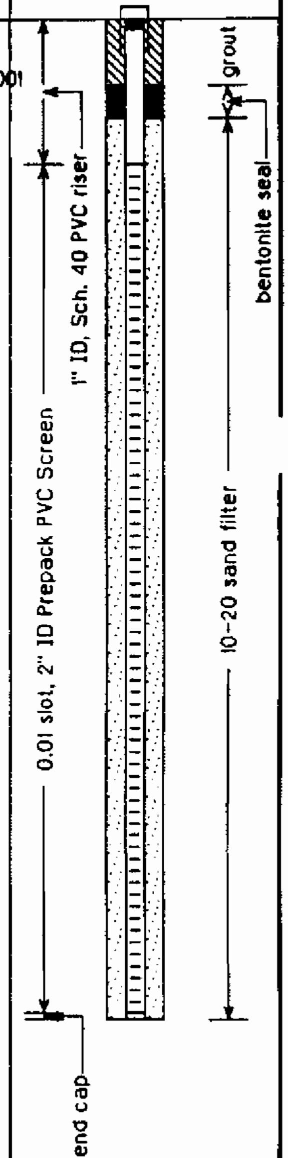
ENSAFE

Monitoring Well NBCH017D03

Project: *Zone H–Charleston Naval Complex*	Coordinates: *2324947.8 E, 370389.5 N*
Location: *Charleston, SC*	Surface Elevation: *10.8 feet msl*
Started at *1015 on 21 Nov 99*	TOC Elevation: *10.62 feet msl*
Completed at *1100 on 21 Nov 99*	Depth to Groundwater: *4.73 feet TOC* Measured: *18 Dec 99*
Drilling Method: *DPT Continuous Sampler w/3.5"OD Boring*	Groundwater Elevation: *5.89 feet msl*
Drilling Company: *Precision SC Cert #57*	Total Depth: *15.2 feet*
Geologist: *P. Bayley*	Well Screen: *2.2 to 15.1 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	OVA (ppm)	% RECOVERY	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface Conditions: Asphalt	
							GM	Gravel: ROC	9.900001
								No Sample Recovery.	6.8
			1		0		ML CL	Silt: yellow-brown; clayey; wet, soft, plastic.	6.5
5							SP SM	Sand: yellow-brown w/some thin black laminae (very fine black grains), and disseminated very fine black grains; very fine, some silt to silty; wet, loose.	5.2
			2		53				3.8
							SP SM	Sand: yellow-brown; as at 4.3 ft.	3.4
							OL OH	Silt: dark grey-black w/slight greenish cast; clayey; wet, soft, plastic.	1.8
							SP	Sand: grey; very fine to fine, trace silt; trace very fine mica, trace very fine black grains, occasional very thin silty laminae; wet, loose; very faint fuel odor.	1.3
10			3		83		SP		.8
								Sand: dark grey; very fine to fine, trace to some silt, trace very fine white shell fragments, trace to some very fine black grains; wet, loose.	.3
			4		37				2.5
							SP SM	Sand: yellow-brown; very fine, some silt to silty; wet, loose, plastic.	2.8
							OL	Silt: yellow-brown and dark grey-black; clayey; wet, soft, plastic.	3.3
15							OL OH	Silt: dark grey-black; clayey; wet, soft to firm, plastic. @15.3 to 1.8 ft.: some yellow-brown vegetation.	
			5		90				5.2
20									

WELL DIAGRAM



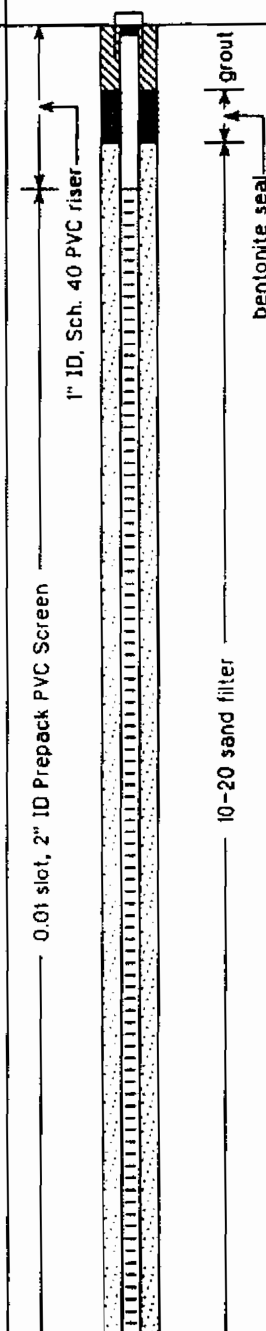
ENSAFE

Monitoring Well NBCH017D04

Project: Zone H-Charleston Naval Complex	Coordinates: 2324926.8 E, 370386.7 N
Location: Charleston, SC	Surface Elevation: 11.5 feet msl
Started at 1515 on 03 Dec 99	TOC Elevation: 11.18 feet msl
Completed at 1725 on 03 Dec 99	Depth to Groundwater: 5.15 feet TOC Measured: 16 Dec 99
Drilling Method: DPT Continuous Sampler w/3.5"OD Boring	Groundwater Elevation: 6.03 feet msl
Drilling Company: Precision SC Cert #57	Total Depth: 24.4 feet
Geologist: P. Bayley	Well Screen: 2.5 to 24.4 feet

DEPTH IN FEET	SAMPLE NO.	% RECOVERY	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
				Surface Conditions: Asphalt	10.5
			GM	Gravel: ROC	10
			ML CL	Silt: brown and grey; clayey w/occasional pebble; moist, soft, plastic; faint fuel odor.	9.7
	1	15	SP SM	Sand: yellow-brown, occasional grey; very fine to fine, some silt to silty; wet, loose, slight plasticity; very faint fuel odor.	8
5			OL OH	Silt: dark grey-black; clayey; wet, soft to firm, plastic.	7.5 / 7.1
			SP SM	Sand: brown; very fine to fine, some silt to silty; wet, loose, slight plasticity; some oil, strong fuel odor. @4.9 to 5.5 ft.: color change to grey w/some olive-yellow; faint fuel odor.	6 / 5
	2	68	OL OH	Silt: dark grey-black; clayey; wet, soft, plastic. @7.1 and 7.8 ft.: olive-yellow color.	3.5 / 3
	3	68	SP SM	Sand: yellow-brown; very fine; some silt to silty; wet, loose; very faint fuel odor. 9.5 to 10.0 ft.: no fuel odor.	2 / 1.5
10			OL OH	Silt: dark grey-black; clayey; wet, soft, plastic.	1
			SP	Sand: grey; very fine to fine, trace to some silt, trace very fine white shell fragments; wet, loose.	.3
	4	77		No Sample Recovery	
15	5	0	SP	Sand: grey; very fine to fine, trace silt, trace to some very fine black grains, trace very fine white shell fragments; wet, loose.	-4
	6	58		No Sample Recovery	-5.7
20					

WELL DIAGRAM



ENSAFE

Monitoring Well NBCH017D04

Project: Zone H-Charleston Naval Complex	Coordinates: 2324926.6 E, 370386.7 N
Location: Charleston, SC	Surface Elevation: 11.5 feet msl
Started at 1515 on 03 Dec 99	TOC Elevation: 11.18 feet msl
Completed at 1725 on 03 Dec 99	Depth to Groundwater: 5.15 feet TOC Measured: 16 Dec 99
Drilling Method: DPT Continuous Sampler w/3.5"OD Boring	Groundwater Elevation: 8.03 feet msl
Drilling Company: Precision SC Cert #57	Total Depth: 24.4 feet
Geologist: P. Bayley	Well Screen: 2.5 to 24.4 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	OVA (ppm)	% RECOVERY	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
			7		0		SP	Sand: grey-brown; very fine to fine, trace to some silt, trace very fine black grains, trace very fine white shell fragments; wet, loose; faint fuel odor.	10 / 10.7
			8		100		OL OH	Silt: dark grey-black w/slight greenish cast; clayey; wet, soft, plastic. @23.0 to 24.2 ft.: trace to some peaty vegetation.	13
25									
30									
35									
40									

WELL DIAGRAM