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FINAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WORK PLAN ZONE H CNC CHARLESTON SC
10/27/1994
ENSAFE

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
CTO-029

FINAL
ZONE H RFI WORK PLAN

Prepared for:

DEPARTMENT OF THE NAVY

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

SOUTHDIV CONTRACT NUMBER:
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Prepared by:

ENSAFE/ALLEN & HOSHALL
5720 SUMMER TREES DRIVE, SUITE 8
MEMPHIS, TENNESSEE 38134
(901) 383-9115

October 27, 1994

DEPARTMENT OF THE NAVY
CHARLESTON NAVAL SHIPYARD
CHARLESTON, S.C. 29408-6100

5090
Ser 106/0393
02 NOV 1994

Mr. Joseph R. Franzmathes
Director, Waste Management Division
U. S. Environmental Protection Agency
Region IV
345 Courtland Street, N. E.
Atlanta, GA 30365

Re: SUBMITTAL OF THE APPROVED ZONE H RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WORK PLAN

Dear Mr. Franzmathes:

As approved per the correspondence from the United States Environmental Protection Agency (USEPA) Region IV dated October 27, 1994, enclosure (1) is submitted to the USEPA. If you have any questions, please contact Bill Brasel at (803) 743-5519.

Sincerely,

W. F. NOLD
Captain USN
Commander,
Charleston Naval Shipyard

Encl:
(1) Zone H Resource Conservation and Recovery Act Facility Investigation Work Plan

Copy to:
SCDHEC (Attn: Ann Ragan)
USEPA (Attn: Doyle Brittain)
COMNAVBASE (N34)
COMNAVBASE (N4BEC, Dearhart)
SOUTHNAVFACENGCOM (187, Mr. Tony Hunt)
E/H&H

ACRONYM LIST

ACGIH	American Conference for Governmental Industrial Hygientists
AL	Action Level
AOC	Areas of Concern
bgs	Below Ground Surface
CAMP	Corrective Action Management Plan
CEC	Cation Exchange Capacity
CFR	Code of Federal Regulations
CHASP	Comprehensive Health and Safety Plan
CLEAN	Comprehensive Long-term Environmental Action Navy
COPC	Contaminants of Potential Concern
CRZ	Contaminant Reduction Zone
CSI	Confirmatory Sampling Investigation
DANC	Decontaminating Agent Non-corrosive
DNAPL	Dense Non-Aqueous Phase Liquid
DOD	Department of Defense
DQO	Data Quality Objective
E/A&H	EnSafe/Allen & Hoshall
EM	Electromagnetic
EZ	Exclusion Zone
HAZWOPER	Hazardous Waste Operations and Emergency Response
LEL	Lower Explosive Limit
LNAPL	Light Non-aqueous Phase Liquid
MSDS	Material Safety Data Sheet
MWR	Morale, Welfare, and Recreation Department
NAVBASE	Naval Base Charleston
NE	Northeast
NFI	No Further Investigation
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
PID	Photoioinzation Detector
PPE	Personal Protective Equipment
PWC	Public Works Center
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAA	Satellite Accumulation Area
SCBA	Self-contained Breathing Apparatus
SCDHEC	South Carolina Department of Health and Environmental Control
SOUTHDIV	Southern Division
STEL	Short-term Exposure Limit

SVOA	Semivolatile Organic Analysis
SVOC	Semivolatile Organic Compounds
SWMU	Solid Waste Management Unit
SZ	Support Zone
TIC	Tentatively Identified Compounds
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
ZHHASP	Zone H Health and Safety Plan

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1.0 INTRODUCTION

As part of the U.S. Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program, the following Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Work Plan has been prepared for Zone H at Naval Base Charleston (NAVBASE). This work plan addresses sampling and analysis requirements specific to sites within Zone H and is intended to be used in conjunction with the *Final Comprehensive RFI Work Plan* prepared for NAVBASE by EnSafe/Allen & Hoshall (E/A&H). The Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) to be investigated within Zone H are presented in Appendix A and in Figure 1-1, which illustrates the location of each.

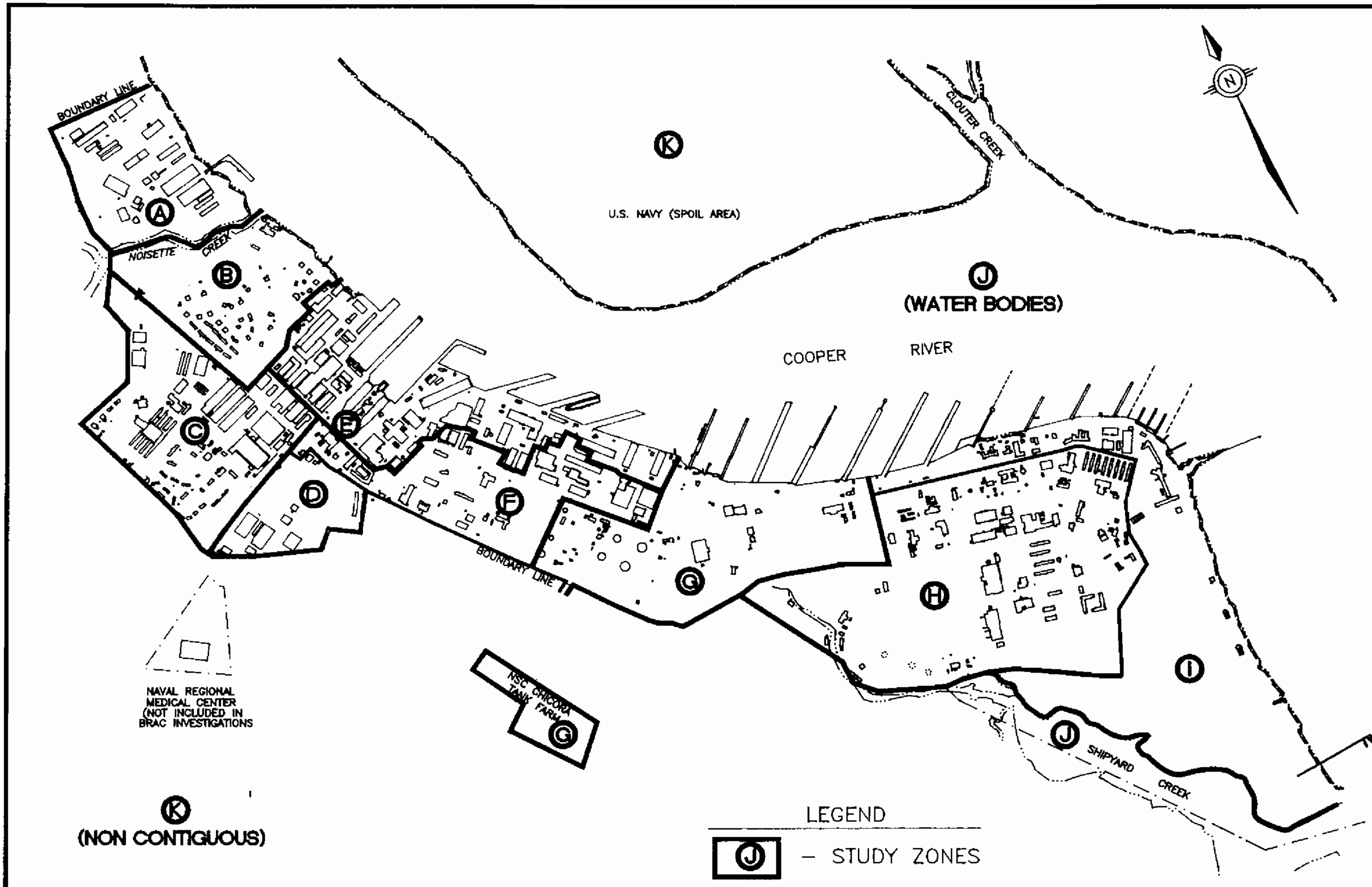
1.1 Environmental Setting

Physiography

Zone H is in the southern portion of the peninsula formed by Shipyard Creek and the Cooper River. The zone is bounded by Hobson Avenue to the north; Shipyard Creek to the south; Osprey Street, C.B. Lane, and the spoil area to the east; and Halsey Street, Bainbridge Avenue, and property boundaries to the west. Figure 1-2 identifies the boundary of Zone H in relation to NAVBASE boundaries and the remaining investigative zones.

Geologic and Hydrogeologic Information

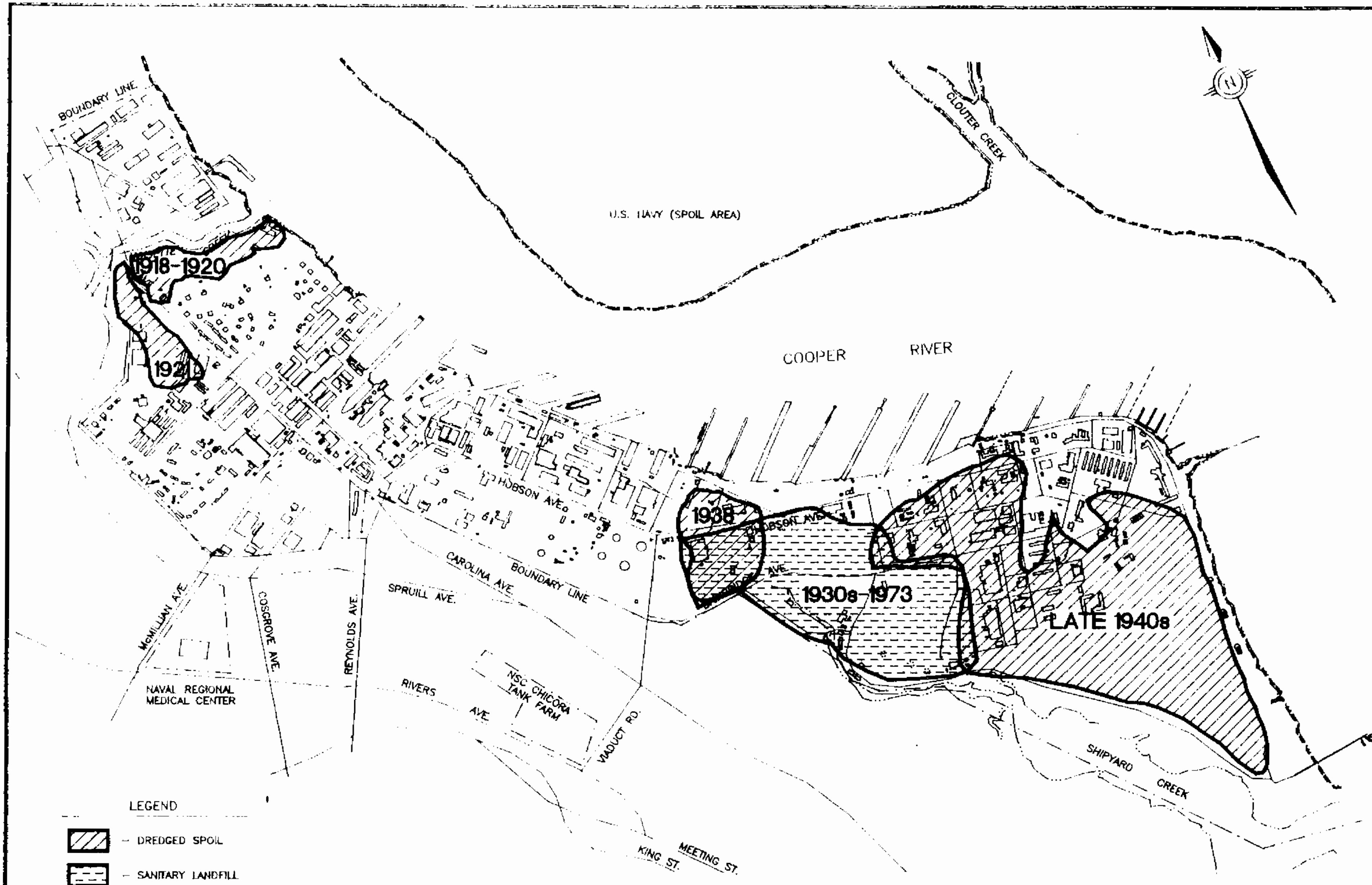
The local and regional geologic/hydrogeologic characteristics are described in Volume II, Sections 1.2 through 1.5 of the *Final Comprehensive RFI Work Plan*. Of particular relevance for Zone H is the origin of soil throughout this area. NAVBASE, like most of the Charleston peninsula bordering the Ashley, Cooper and Wando Rivers, was low-lying marsh when the base was established in the early 1900s. Portions of the northern end and almost the entire southern end of the base were filled with a wide variety of known and unknown materials to make the property suitable for development. The majority of the filling activity took place during the 1930s and 1940s. Figure 1-3 indicates extent of fill activities.



DRAFT RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1-2
ZONE BOUNDARIES

DWG DATE: 06/23/94 | DWG NAME: 029ZONE



NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1-3
AREAS FILLED AND
APPROXIMATE DATES
OF FILLING OPERATIONS

DWG DATE: 08/08/94 | DWG NAME: 029FILCH

Climatology

The climatological setting of NAVBASE is described in Volume II, Section 1.6 of the *Final Comprehensive RFI Work Plan*.

1.2 Investigative Strategy

The proposed investigative approach for each of the sites was developed in accordance with the overall investigative strategy presented in Section 2, Volume I of the *Final Comprehensive RFI Work Plan,* which places emphasis on the "Fast-track Cleanup" program.

Central to this idea is a phased approach to data collection that will ultimately identify constituents of potential concern (COPC) if present, define nature and extent, and support data collection for a corrective measures study (CMS). To meet these objectives, sampling methods and locations discussed in this Work Plan are designed to be as complete as possible.

If the proposed sampling efforts do not achieve this goal, collection will continue until sufficient data are obtained. In order to determine the necessity for additional sampling not specified in this Work Plan, data collected under this plan will be evaluated regarding potential human health impacts expressed as preliminary remedial goals, ecological risks, and technical requirements for a CMS. For some chemicals, additional information regarding background concentrations will be required, which may necessitate onsite and offsite data collection. Background, migration pathways, human and ecological receptors, and preliminary remedial goals (PRGs) are discussed in Section 1, Volume III of the *Final Comprehensive RFI Work Plan*. Sampling efforts will continue until extent is determined, which is defined for this investigation as the horizontal and vertical area in which the concentrations of COPCs in the investigated media are above either PRGs or background concentrations, whichever is appropriate. Background concentrations for inorganics will be determined using the 2X rule. This rule simply states background will be regarded as concentrations less than or equal to the mean concentration of the designated background sampling locations multiplied by two. Establishment of background is discussed further in the following sections.

The zone-specific work plans outline the data collection process for each SWMU and AOC in the particular zones. The *Final Comprehensive RFI Work Plan* discusses how these data will be used to fulfil the goals of the investigation. An RFI report and Baseline Risk Assessment (BRA) will be generated at the conclusion of the investigation of each zone, and a final RFI report and final RFI BRA will address NAVBASE as a single entity once all zone investigations are completed.

The proposed schedule for conducting the Zone H investigation is included in the Corrective Action Management Plan (CAMP) prepared for the NAVBASE RFI. Scheduling of activities during the Zone H investigation will be closely coordinated with United States Environmental Protection Agency (USEPA) Region IV and South Carolina Department of Health and Environmental Control (SCDHEC).

1.3 Other Relevant Investigations

The RFI to be conducted in Zone H is only a part of an overall investigative strategy for the NAVBASE RFI. Some elements of other investigative activities will generate information relevant to Zone H but not necessarily part of Zone H. For example, Volume III of the Final Comprehensive RFI Work Plan describes data needs for determining background or reference concentrations, and the likely need to evaluate impacts on ecological receptors. Because of the suspected heterogeneity of the dredge materials, it is premature to designate any onsite areas within Zone H as representing of background. Offsite investigation to determine background concentrations for some chemicals relevant to the Zone H Work Plan may need to be conducted as stated in the *Final Comprehensive RFI Work Plan*. Sediment and surface water sampling of Shipyard Creek and the associated wetland proposed in this plan are an attempt to identify point sources. Measures of potential impacts will be addressed within the Zone J investigation. The industrial sewer system will be addressed by the Zone L investigation. Groundwater flow and hydrology depend upon basewide conditions. Information gathered in this investigation will contribute to characterizing of groundwater, but will not fully characterize all groundwater processes. Finally, results from other investigations may influence the scope of work proposed in this plan because the zone boundaries are not physical barriers to contaminant migration. The results of the investigations discussed above will be necessary in order to fully understand the significance of the results of the proposed Zone H investigation.

Within Zone H, a portion of the investigation will be expedited to address specific concerns related to the possibility of soil-gas migration from landfills into nearby buildings. The accelerated efforts have been generically described as a Focused Field Investigation or (FFI) because of immediate data needs and the concentrated scope of work. Upon completion of sampling, data validation, and evaluation, a technical memo will be produced presenting the findings. These data will also be incorporated into the Zone H RFI report. The scope of the FFI is discussed further in Appendix G.

2.0 SWMU and AOC SPECIFIC INVESTIGATORY APPROACH

The SWMUs and AOCs located in Zone H requiring either a Confirmatory Sampling Investigation (CSI) or a RFI, as determined in the RFA, are presented in the following sections. Tables A.1 and A.2 (Appendix A) are provided as a reference indicating the location of each site within Zone H, the site's location and proximity to existing structures, as well as each site's investigative approach as proposed by the RCRA Facility Assessment (RFA). The sites identified may not represent all hazardous waste activity that has occurred in Zone H, and the systematic sampling plan outlined in Section 3 was designed in part to help identify any sites that have not been identified in the RFA process. The investigation in Zone H will be based upon the investigative strategy outlined in the *Final Comprehensive RFI Project Management Plan*.

2.1 SWMU 9, Closed Landfill (Includes SWMUs 19, 20, and 121, and AOCs 649, 650, 651, and 654)

SWMU 9 is a closed landfill at the southwest end of NAVBASE. Seven additional sites situated within the boundary of the landfill will be investigated concurrently. Table 2.1 briefly describes each site. SWMU 9 is bounded to the southwest by Shipyard Creek, which is a tributary of the Cooper River. A marshy area that is tidally influenced by the creek is also in this area. To the southeast of SWMU 9 is an area designated as a wildlife viewing area.

Table 2.1
SWMU 9 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
SWMU 9 CLOSED LANDFILL	Solid, industrial, and domestic waste landfill used from the 1930s until 1973. The landfill was an area fill and many wastes were burned to reduce volume. Wastes were deposited directly into a tidal marsh.[a]	Asbestos, varnish sludge, mercury, electroplating waste, paint wastes, PCBs, medical waste.	Soil Sediment Soil-gas Surface water Groundwater

Table 2.1
SWMU 9 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
SWMU 19 SOLID WASTE TRANSFER STATION	Solid waste transfer station for temporary storage prior to transport and disposal offsite. Waste was formerly stored on bare ground. At present all waste is containerized.[a]	Wastes have included dry trash, tires, and empty 55-gallon drums.	Soil Soil-gas Groundwater
SWMU 20 WASTE DISPOSAL AREA	Area adjacent to SWMU 19 where wastes were stored on bare ground beginning in 1985 but is currently no longer in use. No containment existed to prevent surface runoff from entering a tributary of Shipyard Creek.[a]	Batteries, wood, concrete, sandblasting residue.	Soil Soil-gas Sediment Surface water Groundwater
SWMU 121 BLDG. 801 SAA	Building 801; collection, sorting, and storage point for recyclable material for past six years; hazardous wastes accumulated at associated satellite accumulation area (SAA); SAA was 8 foot x 8 foot sheet metal building with concrete floor with no containment structures.[b]	Paint, used oil, and automotive batteries	Soil Soil-gas Groundwater
AOC 649 BRASWELL STORAGE AREA	Braswell Shipyards storage area for ship repair supplies and sandblasting media during the 1970s.[c] East of Building 672.	Sandblast media, welding supplies, and other unknown supplies used in ship repair.	Soil Soil-gas Groundwater
AOC 650 METAL TRADES STORAGE AREA	Storage area for Metal Trades, Inc. East of Building 672. The exact dates of operation are unknown but base maps indicate the 1970s.[c]	Unknown supplies used in ship repair.	Soil Soil-gas Groundwater
AOC 651 SANDBLASTERS STORAGE AREA	Sandblasters, Inc. storage area east of Building 672 operated in the approximate area of AOC 649 from the 1970s until 1991.[c]	Abrasive blast media.	Soil Soil-gas Groundwater

Table 2.1
SWMU 9 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 654 BLDG. 661 SEPTIC TANK DRAIN FIELD	Abandoned septic tank and associated drain field connected to Building 661; used from 1968 until 1978; known to back up during periods of high use, releasing raw sewage.[c]	Solvents Oils Antifreeze Detergents Organic Wastes	Soil Soil-gas Groundwater

Notes:
[a] Described in the *RCRA Facility Assessment, August 1987*
[b] Described in the *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)
[c] Described in the *Draft RCRA Facility Assessment, June 13, 1994* (To be revised by November 3, 1994)

2.1.1 Previous Investigations

SWMU 9 and its associated sites have been the focus of several previous assessments and/or investigations. These included geophysical surveys, an extensive soil-gas survey, trenching based on the results of the soil-gas survey, soil sampling, monitoring well installation, groundwater sampling, and sediment sampling. Table 2.2 summarizes these investigations. Figure 2-1, included in Appendix B, identifies soil, sediment, trenching, and groundwater sampling locations from previous sampling efforts. Also included in Appendix B is an isopleth map depicting total volatile organics in soil-gas. Appendix C contains the analytical results for these samples. The construction details for the monitoring wells previously installed, and still intact, which are proposed to be used for sample collection during the proposed RFI field activities are included in Appendix D. In addition, Table D.1 (Appendix D) lists all the wells previously installed in Zone H, including those which have not been visually confirmed and are not proposed for use. Based on review of the data, the highest concentrations of contaminants are generally near SWMU 20 in the northeastern portion of the landfill area.

Table 2.2
SWMU 9 and Associated Sites
Previous Investigations

Number	Previous Investigations	Activities	Contaminants Identified
SWMU 9	Initial Assessment Study, 1981; Confirmation Study, 1982[a]; Environmental Investigation Fire Fighting Training Facility, 1991[b]; Preliminary geophysical, soil-gas, soil, sediment, and groundwater studies, 1992 and 1993[c].	Geophysical and soil-gas surveys; trenching; soil, groundwater, and sediment sampling.	VOCs, pesticides/PCBs SVOCs, metals[d]
SWMU 19	Preliminary geophysical, soil-gas, soil, sediment, and groundwater studies, 1992 and 1993[c].	Geophysical and soil-gas surveys; trenching; soil, groundwater, and sediment sampling.	Insufficient data to confirm whether contamination is present
SWMU 20	Preliminary geophysical, soil-gas, soil, sediment, and groundwater studies, 1992 and 1993[c].	Geophysical and soil-gas surveys; trenching; soil, groundwater, and sediment sampling.	VOCs
SWMU 121	None	None	None at present
AOC 649	None	None	None at present
AOC 650	None	None	None at present
AOC 651	None	None	None at present
AOC 654	None	None	None at present

Notes:
[a] See Table C.1, Appendix C for analytical results.
[b] See Tables C.2 and C.3, Appendix C for analytical results.
[c] See Tables C.4 and C.5, Appendix C for analytical results.
[d] Elevated metal concentrations are suspected; however, background concentrations have not yet been thoroughly assessed.
PCB = Polychlorinated biphenyls
VOC = Volatile organic compounds
SVOC = Semivolatile organic compounds

2.1.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Data collection efforts will support the evaluation of these alternatives. Tables E.1 through E.3 in Appendix E list treatment alternatives for the landfill that address soil, soil-gas, groundwater, leachate, and waste material. Alternatives presented here are for preliminary evaluation only.

2.1.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support a detailed BRA or evaluation of remedial alternatives where necessary. The data gaps are as follows:

- No information regarding the presence of light or dense non-aqueous phase liquids (LNAPLs or DNAPLs) at interface of the surficial aquifer and the Cooper Formation, which is the underlying confining unit.
- The source and extent of groundwater and sediment contamination at SWMU 20 has not been identified.
- Soil data are either absent or insufficient to confirm whether contamination is present at SWMUs 19, 20, and 121. In addition, no soil data are available to confirm if releases have occurred at AOCs 649, 650, 651, and 654.
- The impacts (potential point sources) of SWMU 9 and the associated sites on Shipyard Creek and nearby wetlands have not been fully defined.
- Insufficient data to support detailed evaluation of treatment alternatives.
- Insufficient data regarding rate and extent of contaminant migration, including ambient air.
- Insufficient data regarding contaminant migration to or from offsite sources.
- No information can be located concerning materials stored or generated at some sites. Additionally, information pertaining to releases associated with those areas is also

generally unavailable, thereby limiting present knowledge of contaminants and migration pathways.

2.1.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE workers, personnel using recreational facilities onsite, and any future users this area might support. Data will be generated during the RFI to support the determination of level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider any ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil, soil gas, sediment, surface water, and groundwater. The wetlands and Shipyard Creek are potentially subject to receiving contaminated sediment runoff and groundwater discharges, which could expose biological receptors other than humans.

2.1.5 Objectives

The objective of the proposed field investigation is to fill the identified data gaps by delineating the horizontal and vertical extent and rate of migration of any soil, soil gas, groundwater, sediment, and surface water contamination at SWMU 9 and the associated sites. Delineating the nature and extent of contamination should identify any onsite point sources for potential contaminants to enter Shipyard Creek and bordering wetlands, as well as determining contaminant impact from potential offsite sources. Data collection efforts should support the technical evaluation of the identified treatment alternatives.

2.1.6 Screening Alternatives

Groundwater screening using cone penetrometer technologies such as the Hydropunch, Geoprobe, or temporary monitoring well installations are applicable for preliminarily defining the extent of contamination at SWMUs 20 and 121. A previous sampling event indicated the presence of chlorinated hydrocarbons in the uppermost portion of the shallow aquifer at monitoring well CNSY-09-07. Additionally, a soil-gas survey indicated the presence of volatile organics in excess of 100 micrograms per liter (μg/L) in this area and in the immediate vicinity of SWMU 121. A groundwater sample from monitoring well CNSY-09-01, which is suspected to be downgradient of SWMU 121, contained volatile organic compounds (VOCs) above instrument detection limits. The proposed groundwater screening locations will cover these areas in an attempt to optimize future permanent monitoring well locations for delineating the extent of this contamination. Efforts will focus on the collecting of samples at the uppermost portion of the shallow aquifer near both SWMU 20 and 121. All data resulting from the collection and subsequent analyses of samples using such devices are considered Data Quality Objectives (DQO) Level II and must be confirmed by higher quality data. The proposed screening locations are depicted on Figure 2-2. Permanent monitoring well locations (shallow/deep well pairs) will be selected upon review of the screening data.

A photoionzation detector (PID) will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.1.7 Sampling and Analysis Plan

To fulfill the RFI objectives, site-specific sampling and analysis requirements have been proposed. Table 2.3 summarizes the types of samples to be collected and the analytical parameters. Additional soil or waste material sampling from within SWMU 9 is not expected to provide any new information that will be of benefit to the RFI and the evaluation of remedial alternatives considering the wide variety of wastes that have previously been identified. Collecting of these types of samples will generally be reserved for "hot spots" or suspected groundwater contamination sources. Monitoring well locations for SWMU 9 have been oriented toward the perimeter of the landfill boundary and will generally be deep wells paired with existing shallow wells in order to clearly identify the rate and extent of previously determined

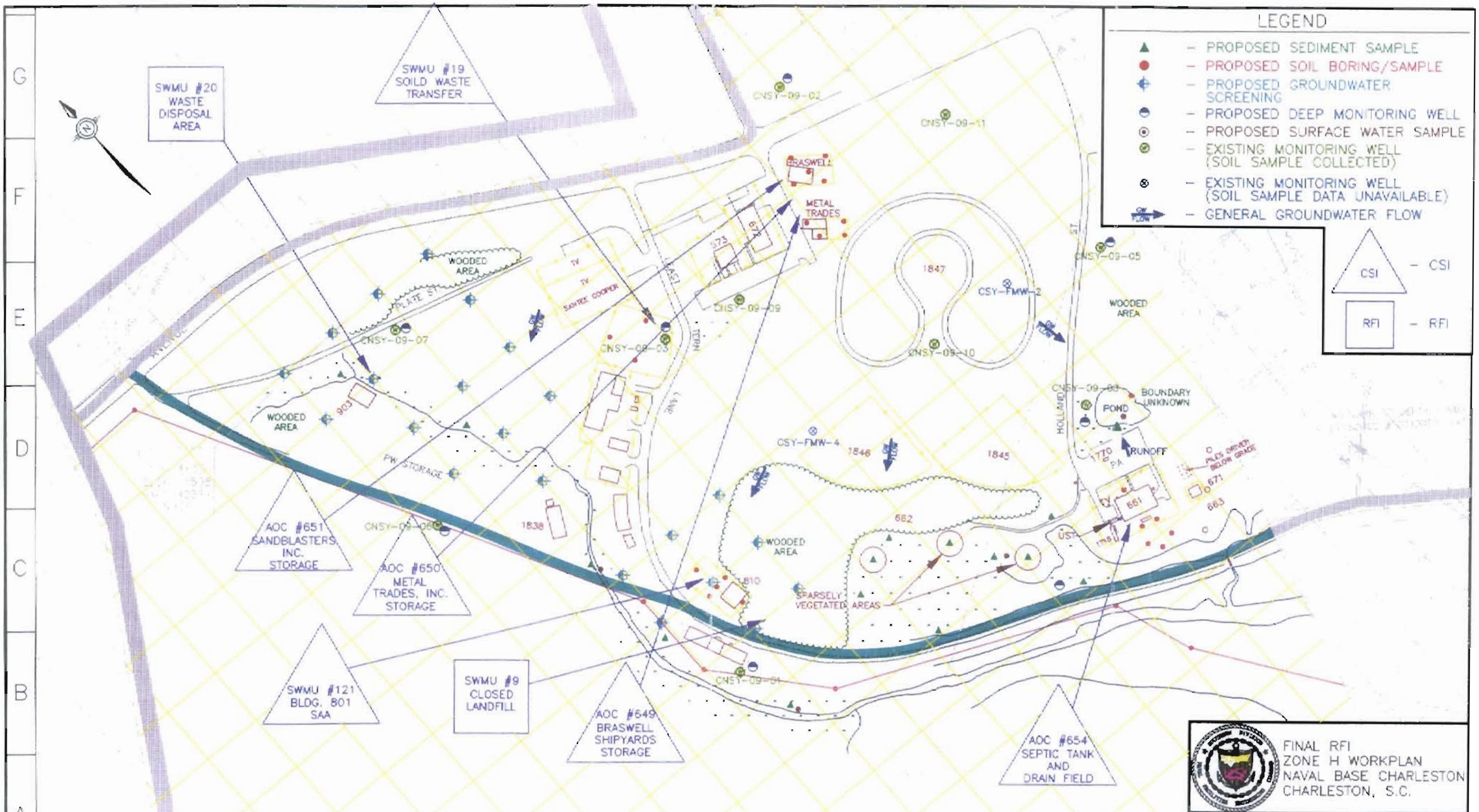


FIGURE 2-2
PROPOSED SAMPLING LOCATIONS
SWMU 9
ZONE H

Table 2.3
SWMU 9 and Associated Sites
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1′ below ground surface (bgs))	24	VOAs and SVOAs w/ TICs, Metals (including organotins), cyanide, pesticides, and PCBs
Soil (3-5′ bgs)	24	
Sediment	15	Groundwater screening samples will be analyzed for volatile organics only.
Groundwater		
(existing wells)	11	
(Deep wells)	8	Sediment samples will also be analyzed for total organic carbon (TOC), and grain size.
(Shallow screening)	16	
Surface water	4	

Engineering Parameters:
Engineering parameters will be dictated by the field data collected.

Slug tests will be performed on 25% of the shallow/deep well pairs. During the installation of the deep wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and cation exchange capacity (CEC). Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities presented do not include Quality Assurance/Quality Control (QA/QC) samples.

contaminant migration, as well as supporting treatment alternatives. Sediment sampling locations proposed in Shipyard Creek tributary were selected to establish concentration gradients, if possible, for the COPCs identified in three previous sediment sampling locations. The sediment sample locations proposed in the wetlands around SWMU 9 were selected based on their proximity to main water courses within the wetlands, and in areas with signs of stressed (or obvious lack of) vegetation. Surface water samples will be collected from the water column sediment sampling locations that are submerged to establish effects of potential contaminated groundwater discharges on the wetlands and evaluate surface water quality concurrently with the sediments. Proposed soil sample locations at AOCs 649, 650, and 651 were selected using historic base maps to locate former building "footprints" and work yards. Sample locations at both of these sites have been distributed in a manner that should detect any residual contamination resulting from those operations. Soil sampling points at SWMUs 20 and 121 were chosen using similar rationale. Each of the proposed sample locations is illustrated on Figure 2-2. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

2.1.8 Radiological Potential

This site has been determined to have a potential for radiological contamination due to unknown disposal practices prior to the 1960s.

Contamination sources may include discarded equipment containing radium dials as well as items that fluoresce, such as deck markers. Sampling at this site will require beta/gamma survey of surface and subsurface samples, a personnel frisk for alpha, beta and gamma activity, and equipment decontamination in the event radionuclides other than those naturally occurring are found. Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger levels. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

2.2 SWMU 13, Current Fire Fighting Training Area

The Fire Fighting Training facility is at the northern boundary of Zone H. The site includes buildings 1302, 1303, 1306, 1308, 1309, 1310, and 1313 as well as several other structures. SWMU 13 is described in Table 2.4.

Table 2.4
SWMU 13
Site Description

Number	Description	Materials Generated or Stored	Potential Pathways
SWMU 13 CURRENT FIRE FIGHTING TRAINING AREA	Fire Fighting Training Area for surface and submarine fleet personnel operating from 1973 to present; diesel fuel and gasoline are ignited during training in a contained paved and bermed area; water and fuel drainage is directed into drains and then oil/water separators, which enter the sewer system; recovered petroleum products are recycled; UST is located in NW portion of SWMU[a].	Petroleum products	Soil Groundwater Soil-gas Surface Runoff

Notes:
[a] Described in *RCRA Facility Assessment, August 1987*

2.2.1 Previous Investigations

SWMU 13 has not been previously investigated.

2.2.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Data collection efforts will support evaluating these alternatives. Tables E.7 through E.9 in Appendix E list treatment alternatives for the site that address soil, soil-gas, and groundwater. Alternatives are presented for preliminary evaluation only.

2.2.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support a detailed BRA or evaluation of remedial alternatives where necessary. The data gaps are as follows:

- No soil and/or groundwater data exist to confirm if a release to these media has occurred.
- Insufficient data to evaluate treatment alternatives in detail.
- Insufficient data exist to determine if site operations are adversely affecting the sanitary sewer drainage system.

2.2.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider any ecological receptors which may be present. This will include characterizing of all potential pathways of exposure at this site, including soil, soil gas, groundwater, and surface runoff. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, then ecological receptors in these water bodies could be impacted.

2.2.5 Objectives

The objective of the proposed field investigation is to collect the data needed to delineate the horizontal and vertical extent and rate of migration of any soil and/or groundwater contamination. Data collection efforts will support the technical evaluation of identified treatment alternatives.

2.2.6 Screening Alternatives

No sampling has yet been conducted to determine COPCs; therefore, selecting a quantitative screening alternative would be premature. If the proposed collection of high-quality samples is inadequate to define the areal extent of contamination (if present), the feasibility of employing screening methods will be reevaluated.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.2.7 Sampling and Analysis Plan

The sampling strategy is intended to assess the entire area possibly impacted by the fire fighting activities. Generally, the soil boring/monitoring well locations are proposed for the perimeter of the expected area of contamination. The soil boring-only locations are generally within the training area where contamination is most likely to have occurred due to cracks in the asphalt surface. Sediment samples are proposed to be collected from the two storm drains. In addition, two monitoring wells (CSY-1313-1 and CSY-1313-2) at the site shall be used for sampling relative to the UST. The construction details for these wells are provided in Appendix D. The locations in Figure 2-3 are expected to closely represent the actual sample locations in number and placement. Table 2.5 summarizes the sampling plan for SWMU 13. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

2.2.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Table 2.5
SWMU 13
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	21	VOAs and SVOAs w/ TICs, cyanide, metals, pesticides, and PCBs, TPH
Soil (3-5' bgs)	21	
Groundwater		Measure free product if found
(shallow wells)	7	
(existing wells)	2	
Sediment		
(if accessible)	3	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

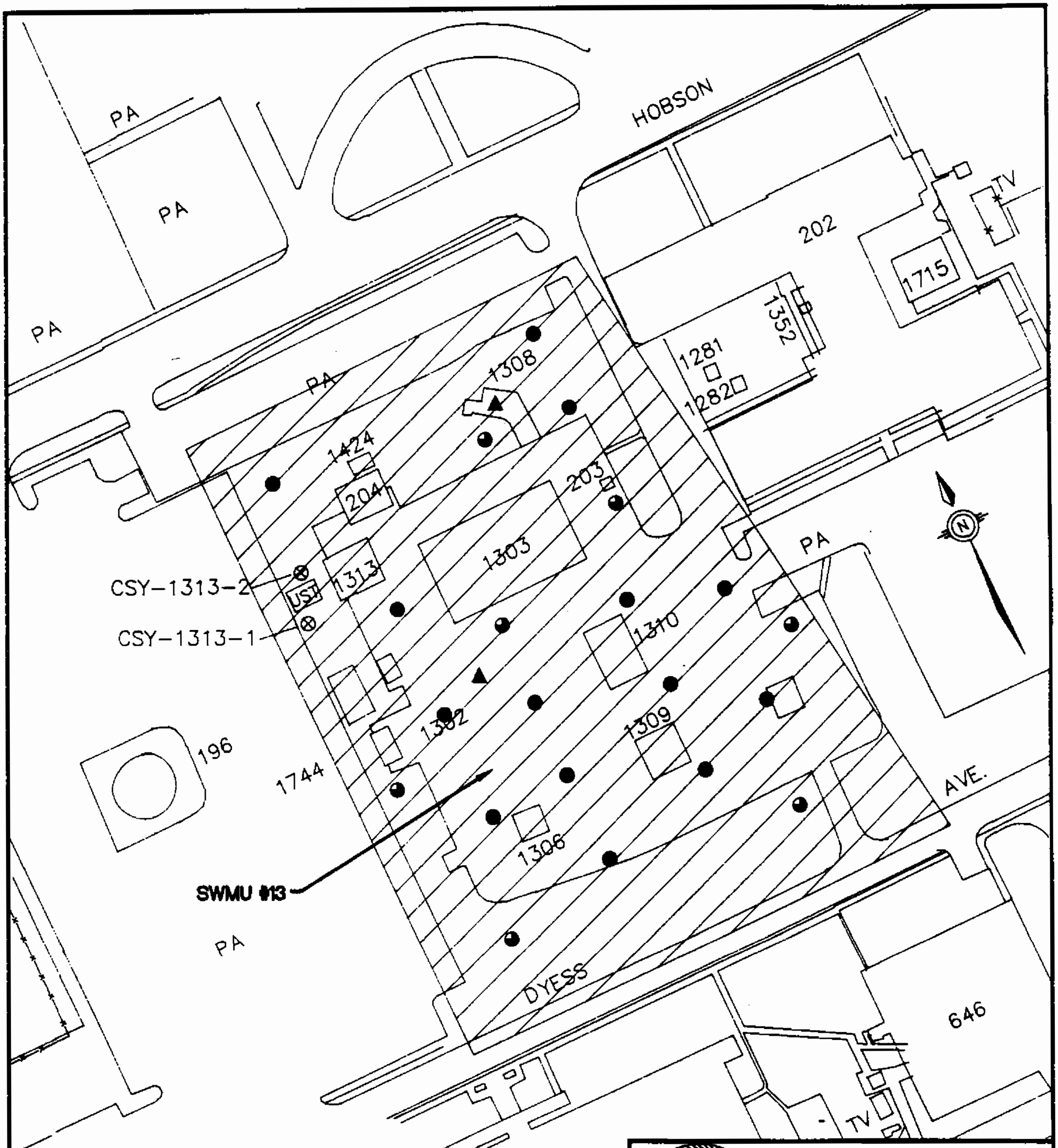
Slug tests will be performed on 25% of the wells. During the installation of the wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

Sediment in pipeline between fire fighting pad and initial oil/water separator, between the two oil/water separators, and in the sewer pipe and overflow storm drain pipe will be sampled.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities presented do not include QA/QC samples.



100 0 100
SCALE FEET

LEGEND

- ● – SOIL BORING
- ◕ – SOIL BORING TO BE COMPLETED AS GROUNDWATER MONITORING WELL
- ⊗ – EXISTING MONITORING WELL (NO SOIL SAMPLE COLLECTED)
- ▲ – SEDIMENT SAMPLE

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FIGURE 2–3
SWMU 13
PROPOSED SAMPLE LOCATIONS

DWG DATE: 08/24/94 | DWG NAME: 29SWMU13

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

2.3 SWMU 14, Chemical Disposal Area (Includes SWMU 15, AOCs 669, 670, and 684)

SWMU 14 is near the southern end of NAVBASE, where several sites are either adjacent to or occupy common tracts of land. Because these sites are near each other, they will be investigated concurrently. Table 2.6 briefly describes each site.

2.3.1 Previous Investigations

SWMU 14 and its associated sites have been previously assessed and/or investigated. These activities include geophysical surveys, soil-gas surveys, soil sampling, and groundwater sampling. Table 2.7 summarizes these investigations. Appendix B contains maps of the previous soil-gas sampling locations. Figure 2-4 identifies groundwater sample locations from previous sampling efforts, and the results of previous geophysical surveys conducted at the site.

Table 2.6
SWMU 14 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
SWMU 14 CHEMICAL DISPOSAL AREA	Chemical disposal area where miscellaneous chemicals and warfare decontaminating agents non-corrosive (DANC), and possibly industrial wastes were buried.[a]	DANC-DS-2 and DANC-M4 which contain diethylene triamine, ethyl cellosolve, and 1,1,2,2-tetrachloroethane	Soil Groundwater Soil-gas
SWMU 15 INCINER-ATOR	Propane-fired incinerator reportedly used only to destroy classified documents. The unit was constructed in 1983 and retired in 1992. Only the concrete foundation slab and concrete propane tank saddles remain.[a]	Ash	Soil Groundwater
AOC 669 CURRENT INDOOR PISTOL RANGE	Current pistol range constructed in 1981 inside Building 1888. Lead bullets are trapped by a steel bullet trap, which is emptied weekly. The waste is sealed in 55-gallon drums, staged on a concrete pad adjacent to the building, and removed from the AOC within 72 hours. Initially lead waste was disposed of in the sewer system via floor drains in the building which have since been sealed.	Lead	Soil Groundwater Surface water

Table 2.6
SWMU 14 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 670 FIELD SO. OF BLDG. 1897	Former outdoor trap and skeet range operated from 1960 until the late 1970s. Lead bullets and broken clay targets were not recovered during operation.[b]	Lead Calcium carbonate Asphalt pitch Brass	Soil Groundwater
AOC 684 FORMER PISTOL RANGE	Former outdoor pistol range in operation from early 1960s until 1981. Lead bullets were fired into a soil berm and were not recovered.[b]	Lead	Soil Groundwater Surface water Sediment

Notes:
[a] Described in the *RCRA Facility Assessment, August, 1987*
[b] Described in the *Draft RCRA Facility Assessment, June 13, 1994* (To be revised by November 3, 1994)

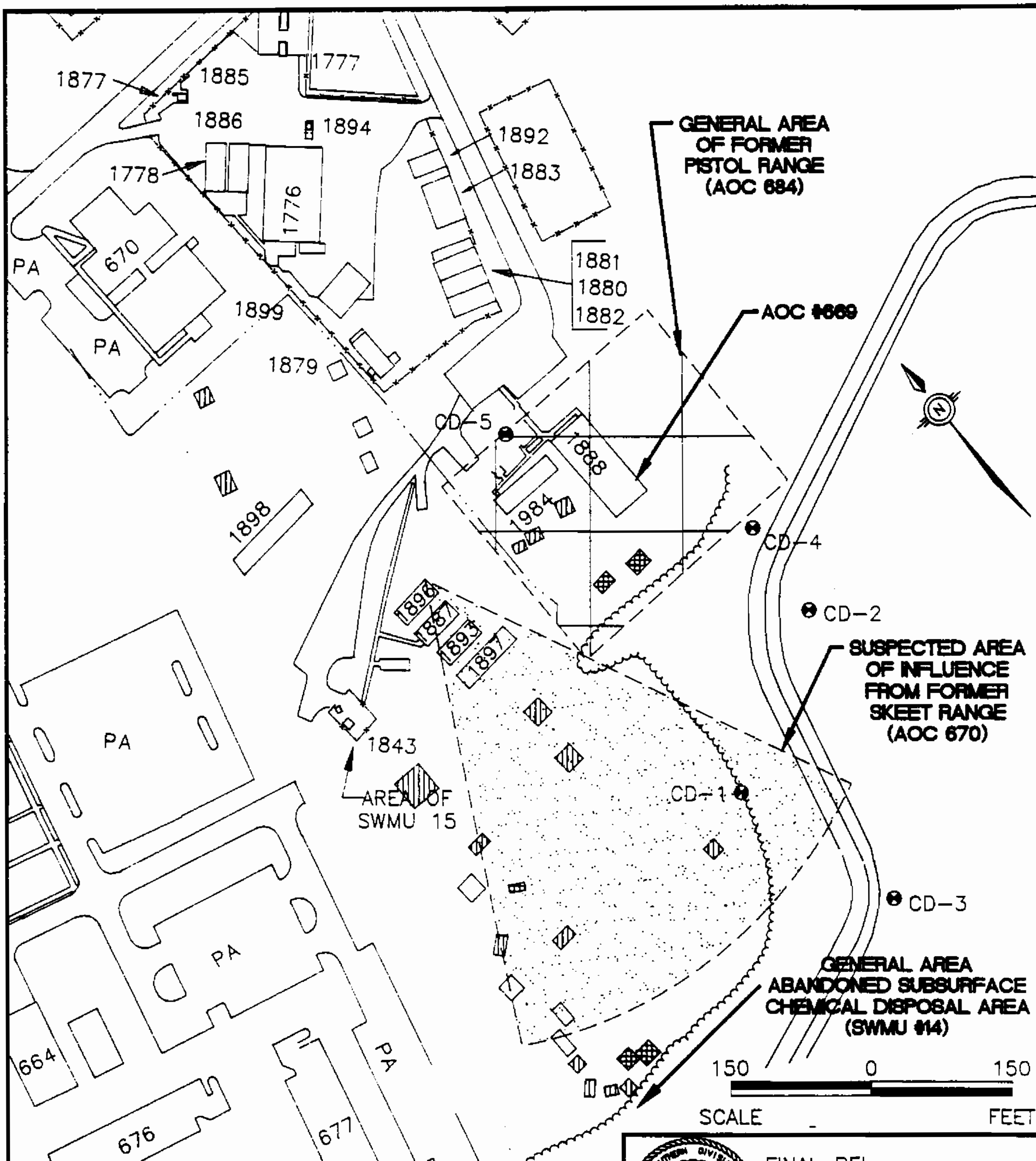
Table 2.7
SWMU 14 and Associated Sites
Previous Investigations

Number	Previous Investigation	Contaminants Identified
SWMU 14	Confirmation Study, 1982[a]; preliminary geophysical and soil-gas study, 1992.	Tetrachlorethane (Soil-gas)
SWMU 15	None	None at present
AOC 670	None	None at present
AOC 684	None	None at present

Notes:
[a] See Table C.6, Appendix C for analytical results.

2.3.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Tables E.1 through E.3 in Appendix E list treatment



LEGEND

- PREVIOUS MONITORING WELL
- MAGNETIC ANOMALY, HIGH PRIORITY
- MAGNETIC ANOMALY, MED. PRIORITY
- MAGNETIC ANOMALY, LOWER PRIORITY

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CHARLESTON, S.C.

FIGURE 2-4
SWMU 14, SWMU 15,
AOC 684, 669 AND AOC 670
PREVIOUS SAMPLE LOCATIONS

DWG DATE: 08/24/94	DWG NAME: 29SWM14A

alternatives for the landfill that address soil, soil-gas, groundwater, leachate, and waste material. Data collection efforts will support evaluating these alternatives. Alternatives are presented for preliminary evaluation only.

2.3.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support BRA a and detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- The impact of lead from the skeet and pistol ranges on site media is unknown.
- The available data are insufficient to confirm or precisely identify all chemicals reportedly buried at SWMU 14.
- The precise number and locations of chemical containers reported to be buried at SWMU 14 are unknown.
- Insufficient data regarding rate and extent of contaminant migration.

2.3.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider any ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil, soil-gas, ambient air, surface water, and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.3.5 Objectives

The objectives of the proposed field investigation are to fill the identified data gaps by determining if lead from the skeet and pistol ranges and chemicals have impacted site media. The investigation will focus sampling efforts at SWMU 14 in reported disposal areas to attempt to precisely identify the types of industrial chemical wastes and chemical warfare decontaminating agents. If these chemicals are present in site media, efforts should also focus on locating any buried containers which may be present. Ultimately, the investigation will delineate the horizontal and vertical extent and rate of migration of any soil, groundwater, surface water, and sediment contamination, if present. Data collection efforts should support the technical evaluation of identified remedial treatment alternatives.

2.3.6 Screening Alternatives

Limited soil-gas screening has been performed. A list of COPCs is not available to facilitate selecting a viable screening alternative due to the possibility of COPCs co-mingling as a result of the over lapping site boundaries at SWMU 14.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.3.7 Sampling and Analysis Plan

To fulfill the RFI objectives, site-specific sampling and analysis requirements have been proposed. Table 2.8 summarizes the types of samples and analytical parameters.

In order to fully characterize soil contamination related to SWMU 14 and associated sites, a grid sampling system using approximately 72 sampling points is proposed. The locations of the grids are based on reported occurrences of chemical exposure during excavation, the expected location

Table 2.8
SWMU 14 and Associated Sites
Sampling Plan

Matrix	**Quantity**	**Analysis**
Soil (0-1' bgs)	72	VOAs and SVOAs w/ TICs, metals, cyanide, pesticides, sediment, and PCBs. Appendix IX (47 sampling points, refer to Figure 2-5 for specific locations)
Soil (3-5' bgs)	72	
Groundwater		
(Shallow wells)	5	
(Deep wells)	5	
Surface water	1	
Sediment	1	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

Slug tests will be performed on three shallow/deep well pairs. While installing deep wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:

Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities presented do not include QA/QC samples.

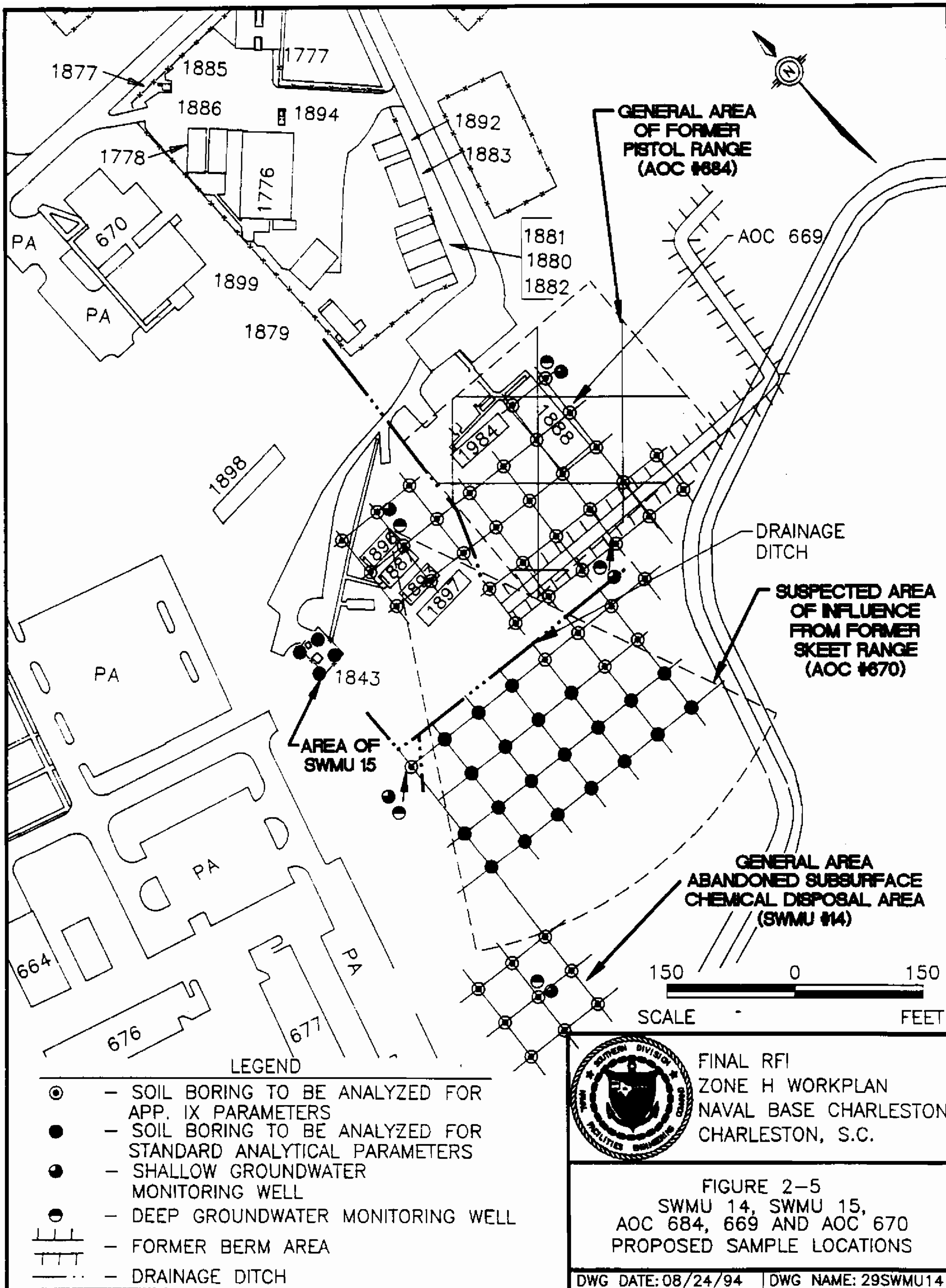
of lead shot and bullets associated with the former pistol and skeet ranges and previously detected geophysical targets. Consequently, the portion of the sample locations within the grids that are proposed to be analyzed for Appendix IX constituents represent areas where chemical warfare decontaminating agents are most strongly suspected of having been disposed. These areas were selected based on descriptions of the burial areas presented in the RFA, soil-gas data, and geophysical targets. Soil samples will be collected at the base of the drainage ditches which receive runoff during periods of heavy rainfall. One sediment and one surface water sample will be collected from the drainage ditch between Buildings 1896 and 1984, which frequently contains standing water. In addition, five soil boring locations within the grid network will be converted into shallow monitoring wells to assess groundwater quality within the site. Subsequently, five deep wells (to monitor the base of the water table aquifer at its contact with the Cooper formation) shall be paired with each of the shallow monitoring wells. Given the relatively flat gradient of the water table surface near Zone H, the proposed well coverage is intended to detect any impact to the groundwater which may have occurred at the site regardless of groundwater flow direction. Four biased soil sample locations are proposed in the immediate vicinity of SWMU 15 to determine if incinerator activities impacted the site.

Each of the proposed sample locations is illustrated on Figure 2-5. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

2.3.8 Radiological Potential

This site has been determined to have a potential for radiological contamination due to unknown disposal practices before the 1960s.

Contamination sources may include discarded equipment containing radium dials as well as items that fluoresce, such as deck markers. Sampling at this site will require beta/gamma survey of surface and subsurface samples, a personnel frisk for alpha, beta and gamma activity, and equipment decontamination in the event radionuclides other than those naturally occurring are found. Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger levels. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–5
SWMU 14, SWMU 15,
AOC 684, 669 AND AOC 670
PROPOSED SAMPLE LOCATIONS

DWG DATE: 08/24/94 | DWG NAME: 29SWMU14

2.4 SWMU 17, Oil Spill Area

SWMU 17 is the site of an oil spill beneath Building FBM 61. Table 2.9 describes SWMU 17.

Table 2.9
SWMU 17 and Associated Sites
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
SWMU 17 OIL SPILL AREA BLDG. 61	Site of a release in 1987 of approximately 14,000 gallons of No. 5 Fuel Oil beneath Building FBM 61 due to a ruptured underground fuel pipe.[a]	No. 5 Fuel Oil, PCB-Containing Dielectric Fluid	Soil Groundwater Soil-gas

Notes:
[a] Described in *RCRA Facility Assessment, August 1987*

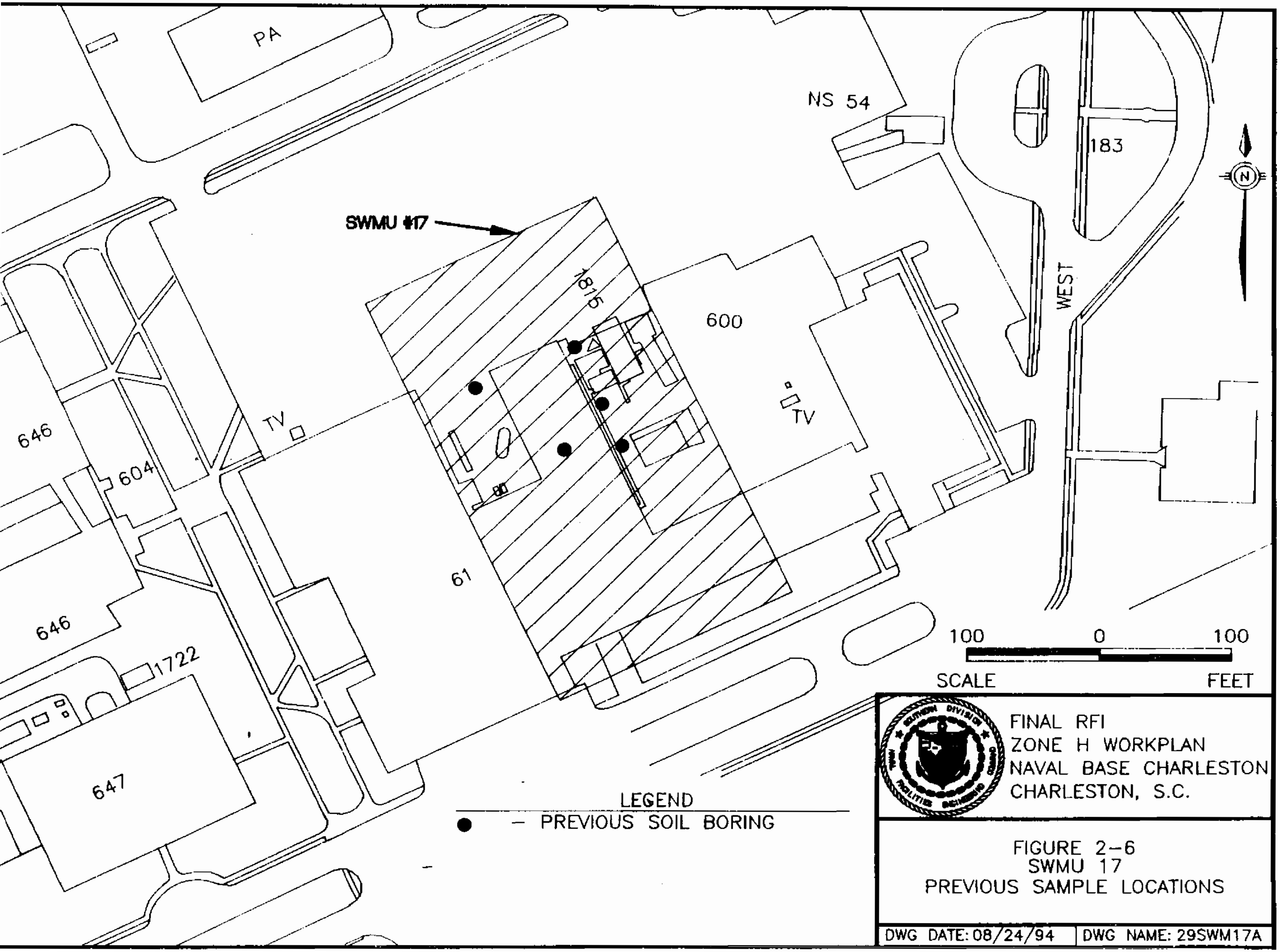
2.4.1 Previous Investigations

Samples collected and analyzed subsequent to the spill indicated the presence of Aroclor 1260, a PCB typically associated with electric transformers. Base personnel suggested that the PCBs may have leaked from transformers in incidents not associated with the fuel oil release. Table 2.10 summarizes previous investigations at SWMU 17. Figure 2-6 illustrates previous sample locations.

Table 2.10
SWMU 17 and Associated Sites
Previous Investigations

Number	Previous Investigations	Contaminants Identified
SWMU 17	Soil samples collected and analyzed following the 1987 fuel oil release.[a]	PCBs Petroleum hydrocarbons

Notes:
[a] Described in Environmental Incident Report filed with Code 106



LEGEND

● – PREVIOUS SOIL BORING

FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2-6
SWMU 17
PREVIOUS SAMPLE LOCATIONS

DWG DATE: 08/24/94	DWG NAME: 29SWM17A

Table 2.11
SWMU 17 Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	12	VOAs and SVOAs w/ TICs, cyanide metals, pesticides, and PCBs
Soil (3-5' bgs)	12	
Groundwater (Shallow wells)	4	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

Slug tests will be performed on one shallow well. While installing the wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

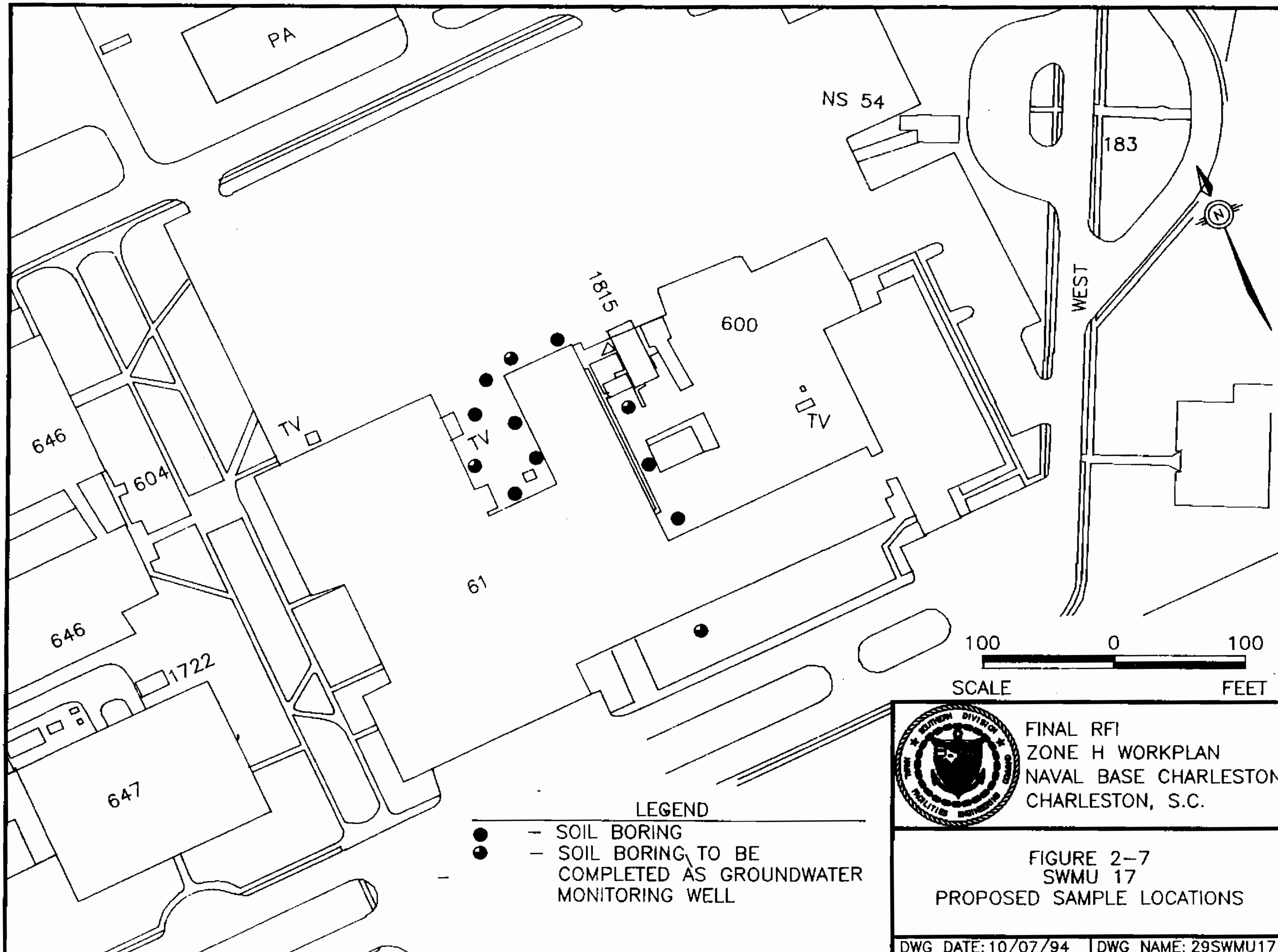
The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities presented do not include QA/QC samples.

2.4.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2-7
SWMU 17
PROPOSED SAMPLE LOCATIONS

DWG DATE: 10/07/94 | DWG NAME: 29SWMU17

2.5 AOC 503, Unexploded Ordnance (UXO) Site South of Building 665

AOC 503 is at the Southern boundary of Zone H at the northeast end of NAVBASE. Table 2.12 describes the site, which is illustrated in Figure 2-8.

Table 2.12
AOC 503
Site Description

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 503 UXO SITE	Two Mark 17-Depth Bombs were reportedly jettisoned from a Naval vessel in 1943. Currently the site is a wooded wetland approximately 300 feet from Shipyard Creek.[a]	Unexploded ordnance	Soil Groundwater

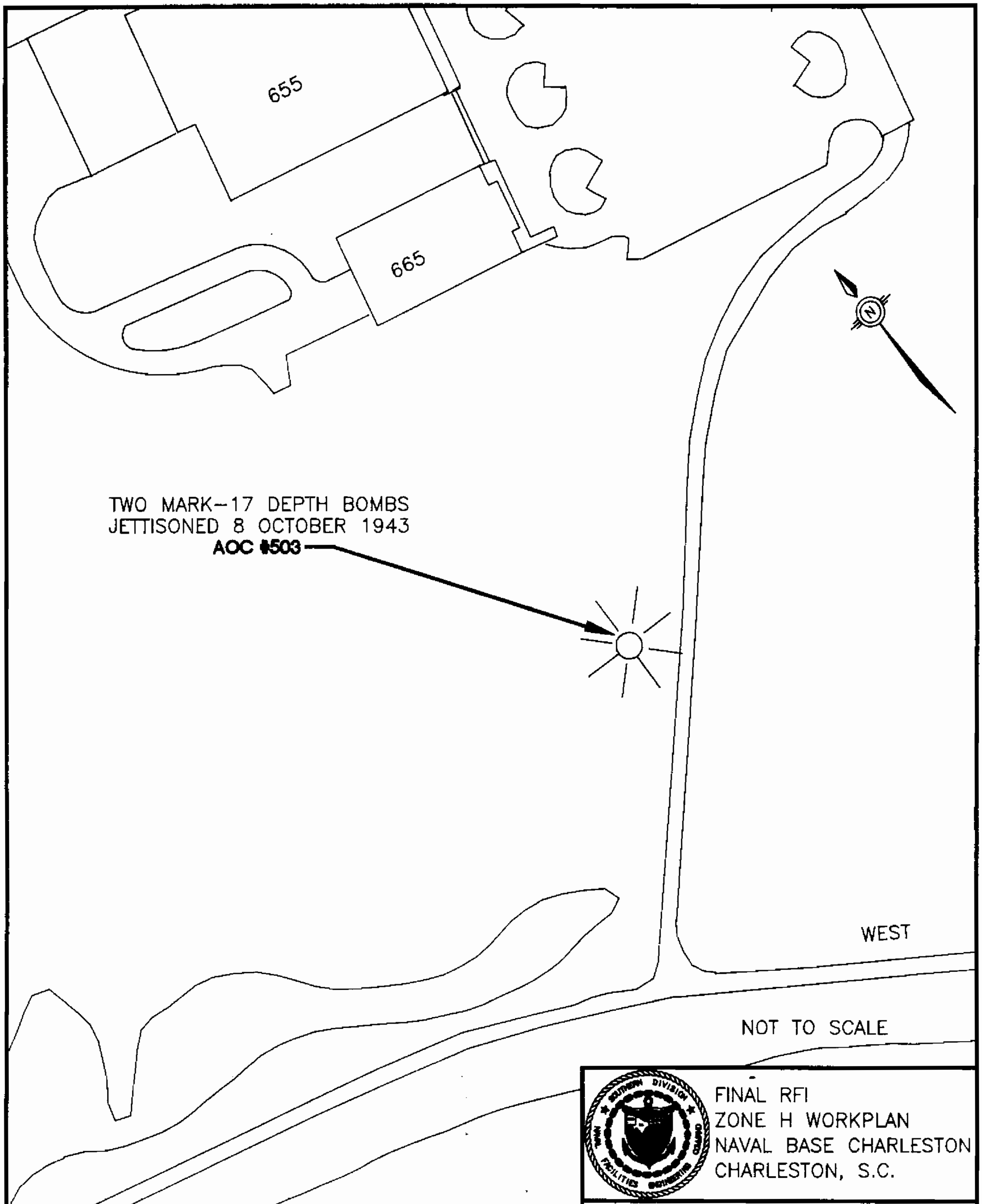
Notes:
[a] Described in the *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)

2.5.1 Previous Investigations

The site has not been previously investigated.

2.5.2 Treatment Alternatives

As outlined in the overall sampling strategy in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Data collection efforts will support evaluating these alternatives. Table E.13 in Appendix E lists the treatment alternatives for AOC 503 if ordnance is located there. Alternatives presented here are for preliminary evaluation only.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2-8
AOC #503
UXO SITE

DWG DATE: 10/24/94 | DWG NAME: 29AOC503

2.5.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support BRA and a detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- Exact location of depth bombs is unknown.
- Integrity of the ordnance is unknown.
- Contaminant migration status is unknown.

2.5.4 Potential Receptors

The most severe threat posed by this AOC is to human safety. Contaminant migration could expose ecological receptors in Shipyard Creek.

2.5.5 Objectives

The objective of the RFI is to identify any contaminants which may have impacted site media. An interim action to remove the ordnance, if found, is warranted due to the danger to human health.

2.5.6 Screening Alternatives

Due to the nature of this site, it is not a viable candidate for screening techniques.

2.5.7 Sampling and Analysis Plan

Due to this site's special nature, an Explosive Ordnance Disposal (EOD) subcontractor will be selected to conduct this investigation. Upon selection, the EOD subcontractor will be tasked to prepare an addendum to the work plan describing specific techniques to locate the ordnance. Soil and groundwater samples will be collected here if the ordnance is located and safely removed or detonated in place. At that time samples shall be collected relative to the site of the ordnance recovery/detonation and analyzed for constituents associated with the specific type of weapon. If ordnance cannot be located, confirmation sampling covering a broader, more general area may still be warranted. Table 2.13 provides a general overview of explosive hazardous waste constituents and Table 2.14 outlines the associated laboratory data quality objectives.

Table 2.13
Explosive Constituents Identified as Hazardous Waste

Description	Name	Chemical Formula	Hazardous Waste ID Number
PROPELLANTS	Nitrocellulose	$C_{12}H_{16}(ONO_2)_4O_6$	D003
	Nitroglycerine	$C_3H_5N_3O_9$	D003
	Nitroguanidine	$CH_4N_4O_2$	D003
	These three primary constituents can be used singularly or in various combinations along with metals, metallic salts, and organic polymer binders.		
PRIMARY EXPLOSIVES	Lead azide	PbN_6 (71% Pb)	D003, D008
	Mercury fulminate	$HgC_2N_2O_2$ (7.05% Hg)	D003, D009
	Diazodinitrophenol (DDNP)	$C_6H_2N_4O_5$	D003
	Lead styphnate	$PbC_6HN_3O_8$ (44.2% Pb)	D003, D008
	Tetracene	$C_2H_8N_{10}O$	D003
	Potassium dinitrobenzofuroxane (KDNBF)	$KC_6H_2N_4O_6$	D003
	Lead mononitroresorcinate (LMNR)	$PbC_6H_3NO_2$ (57.5% Pb)	D003, D008
	Fuels		
	Lead thiocyanate	$Pb(SCN)_2$ (64% Pb)	D008
	Antimony sulfide	S_5Sb_2	D003
	Calcium silicide	$CaSi_2$	D003, D001

Table 2.13
Explosive Constituents Identified as Hazardous Waste

Description	Name	Chemical Formula	Hazardous Waste ID Number
	Oxidizers		
	Potassium chlorate	$KClO_3$	D003
	Ammonium perchlorate	NH_4ClO_4	D003
	Barium nitrate	BaN_2O_6	D003, D005
BOOSTER AND SECONDARY EXPLOSIVES **(HIGH EXPLOSIVES)**	**Aliphatic Nitrate Esters**		
	1,Antimony sulfide trinitrate (BTN)	Sb_2S_5	D003
	Diethyleneglycol dinitrate (DEGN)	$C_4H_8N_2O_7$	D003
	Nitroglycerine (NG)	$C_3H_5N_3O_9$	D003
	Nitrostarch (NS)	$C_6H_{10}O_5NO_2$	D003
	Pentaerythyritol tetranitrate (PETN)	$C_5H_8N_4O_{12}$	D003
	Triethylene glycoldinitrate (TEGN)	$C_6H_{12}O_4N_2O_4$	D003
	1,1,1-Trimethylolethane trinitrate (TMETN)	$C_5H_9O_9N_3$	D003
	Nitrocellulose (NC)	$C_{12}H_{16}(ONO_2)_4O_6$	D003
	Nitramines		
	Cyclotetramethylene-tetranitramine (HMX)	$C_4H_8N_8O_2$	D003
	Cyclotrimethylene-trinitramine (RDX)	$C_3H_6N_6O_6$	D003
	Ethylenediamine dinitrate (EDDN Haleite)	$C_2H_6N_4O_4$	- D003
	Nitroguanidine (NQ)	$CH_4N_4O_2$	D003
	2,4,6-Trinitrophenyl-methylnitramine (Tetryl)	$C_7H_5N_5O_8$	D003

Table 2.13
Explosive Constituents Identified as Hazardous Waste

Description	Name	Chemical Formula	Hazardous Waste ID Number
	Nitroaromatics		
	Ammonium picrate (Explosive D)	$C_6H_3N_3O_7H_3N$	D003
	1,3-Diamina-2,4,6-Trinitrobenzene (DATB)	$C_6H_4N_6O_6$	D003
BOOSTER AND SECONDARY EXPLOSIVES (HIGH EXPLOSIVES)	**Nitroaromatics**		
	2,2'4,4'6,6'-Hexanitroazobenzene (HNAB)	$C_{12}N_8O_{12}$	D003
	Hexnitrostilbene (HNS)	$C_{14}H_2N_6O_{12}$	D003
	1,3,5-Triamino-2,4,6-trinitrobenzene (TATB)	$C_6H_6N_6O_6$	D003
	2,4,6-Trinitrotoluene (TNT)	$C_7H_5N_3O_6$	D003
	Ammonium nitrate	HN_4NO_3	D003
	Compositions		
	Mixtures of the above		
	Plastic Bonded Explosive (PBX)		
	Explosives (see above) and polymer binder, plasticizer, and fuel (aluminum or iron)		
PYROTECHNICS	**Combination of:**		
	Oxidizer: oxygen or fluorine		
	Fuel: powdered aluminum or magnesium		
	Binding Agents: resins, waxes, plastics, oils, retardants, waterproofing, color intensifier		

Table 2.14
Explosives Analytical Data Quality Objectives
SW-846 Method 8330
Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes

Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
Matrix Spikes				
1,3-Dinitrobenzene	0-30	54-166	0-30	54-166
2,4-Dinitrotoluene	0-30	60-140	0-30	60-140
2-Nitrotoluene	0-30	50-144	0-30	50-144
Surrogate Spikes				
2-Fluorobiphenyl	NA	40-140	NA	40-140

2.5.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

2.6 AOC 653, Hobby Shop

The Automotive Hobby Shop containing an hydraulic lift is in the northwest corner of Zone H at the northeast end of NAVBASE. The site includes buildings 1347, 1493, 1508, 1763 and several other structures. Table 2.15 briefly describes the site.

Table 2.15
AOC 653
Site Description

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 653 AUTO HOBBY SHOP	One of four buildings which make up the automotive hobby shop complex. A hydraulic fluid storage tank is at the east end of Building 1508, which is no longer in use due to suspected leakage. In addition, various paints, solvents, thinners and petroleum products have been used and stored at the site .[a]	Oils Paints Solvents Thinners Hydraulic fluid	Soil Groundwater Soil-gas

Notes:
[a] Described in the *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)

2.6.1 Previous Investigations

Previous investigations have determined the hydraulic lift may have leaked and that spilled waste oil and petroleum hydrocarbons have impacted the site. Table 2.16 summarizes the previous investigations at AOC 653.

Table 2.16
AOC 653
Previous Investigations

Number	Previous Investigations	Contaminants Identified
AOC 653	Zone Inspection Report for Zone 22 (July 31, 1991)	Oil residue Petroleum hydrocarbons

2.6.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Tables E.7 through E.9 in Appendix E list treatment alternatives addressing soil, soil-gas, and groundwater. Data collection efforts will support evaluating these alternatives. Alternatives presented here are for preliminary evaluation only.

2.6.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support BRA and a detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- Unknown volume of hydraulic fluid has leaked from 40-gallon underground steel tank.
- Areal extent of the leakage is unknown.
- Soil and groundwater data are absent to confirm contamination from Hobby Shop processes.

2.6.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining the level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil, soil gas, and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.6.5 Objectives

The objectives of the proposed field investigation regarding AOC 653 are to fill the identified data gaps by delineating horizontal and vertical extent of any soil and/or groundwater contamination at the site, as well as determining the chemical nature of the contaminants. Data collection efforts will support the technical evaluation of identified treatment alternatives.

2.6.6 Screening Alternatives

Due to the suspected small nature of the spill, this site is not a good candidate for screening methodologies. Collecting a few highly biased samples is the preferred method. If the higher quality samples fail to fully delineate the areal extent of any contamination, the feasibility of employing screening alternatives will be reevaluated.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.6.7 Sampling and Analysis Plan

To fulfill the RFI objectives, site-specific sampling and analysis requirements have been proposed. Table 2.17 summarizes the types of samples and analytical parameters. Each of the proposed sample locations is illustrated on Figure 2-9. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

The object of investigation is an underground hydraulic fluid tank formerly used with the carlift on the east end of Building 1508. Apparently, due to a history of leakage, use of the tank was discontinued and new aboveground hydraulic fluid tanks were installed with new car-lifting mechanisms. The old tank remains in the ground. Four soil boring/monitoring well locations are proposed in the hydraulic tank's immediate vicinity to identify the presence of contamination near Building 1508. Two of the locations are intended for soil sampling only. The third and fourth locations are intended to be soil boring/monitoring well locations.

Given the relatively flat gradient of the water table surface near Zone H, and the relatively small area of the site, it is anticipated that if any contaminants have reached the water table they will be detectable in groundwater samples collected regardless of its flow direction.

Groundwater flow direction at AOC 653 will be determined from water-level measurements collected from the wells installed to characterize contamination associated with AOC 653 and monitoring wells installed as part of the base-wide grid groundwater monitoring network.

Table 2.17
AOC 653
Sampling Plan

Matrix	**Quantity**	**Analysis**
Soil (0-1′ bgs)	4	TPH, VOAs, SVOAs w/ cyanide, TICs, metals, pesticides, and PCBs
Soil (3-5′ bgs)	4	
Groundwater (shallow well)	2	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

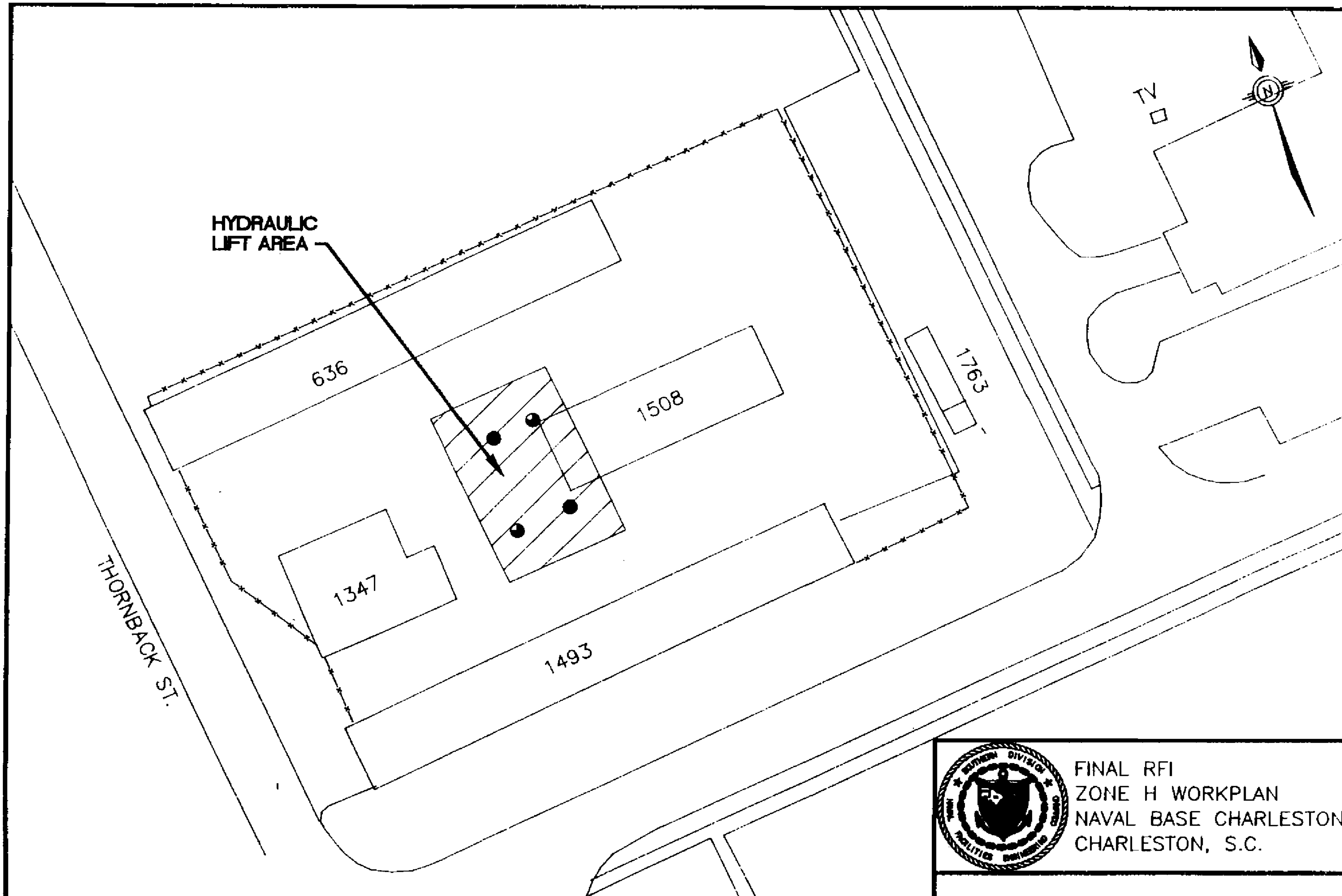
Slug test will be performed on the one shallow well. while installing the well, Shelby tubes will be collected when dramatic changes in lithology occur. One highly biased sample will be analyzed for the design parameters specified in Appendix E.

Notes:

Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantity presented does not include QA/QC samples.



LEGEND

● – SOIL BORING

● – SOIL BORING TO BE COMPLETED AS GROUNDWATER MONITORING WELL

FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–9
AOC 653
PROPOSED SAMPLE LOCATIONS

DWG DATE: 08/24/94 | DWG NAME: 29P–30

2.6.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

2.7 AOC 655, Oil Spill Area and AOC 656, Petroleum Spill Between Buildings 602 and NS-71

AOC 655 is the area behind the base exchange, Building 656, and AOC 656 is the site of an oil spill in 1974. Table 2.18 summarizes the sites.

Table 2.18
AOC 655 and AOC 656
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 655 Oil Spill Area	Area behind base exchange; approximately 300 gallons of No. 2 Fuel Oil spilled from a ruptured fuel line within Building 656 in 1985; about 150 gallons went through a seam in the building to the soil below. Fuel oil is supplied by a nearby 5,800 gallon UST.[a]	Petroleum	Soil Groundwater Soil-gas Air
AOC 656 Petroleum Spill Between Buildings 602 and NS-71	Site of a spill of No. 5 fuel oil in 1974 resulting from a rupture of underground oil lines between Facility 602, containing an 8000-gallon aboveground storage tank (AST), and the boiler in Building 71; 285 gallons leaked, but 275 gallons were recovered; oil entered Cooper River through the storm sewer system.[a]	Petroleum	Soil Groundwater Soil-gas Air

Notes:
[a] Described in the *Draft RCRA Facility Assessment, June 13, 1994* (To be revised by November 3, 1994)

2.7.1 Previous Investigations

As mentioned in Section 1.3, a portion of the RFI described as an FFI is being expedited. The FFI has been associated with AOC 655 in the context of this RFI Work Plan because of the involvement of Building 656, (not to be confused with AOC 656 which is also mentioned in this section). The data collected during a previous phase of the FFI and the strategy are summarized in Appendix G. Table 2.19 summarizes the previous investigations at AOCs 655 and 656 as well.

Table 2.19
AOC 655 and 656
Previous Investigations

Number	Previous Investigations	Contaminants Identified
AOC 655	A soil-gas investigation conducted near Building 656 identified a relatively high response for acetone near the reported spill; significant responses for benzene, toluene, ethylbenzene, and xylene (BTEX) and oil compounds were also reported. Appendix B contains a map depicting the distribution of acetone in soil-gas. Air sampling conducted inside the building detected the presence of anthropogenic compounds but did not conclusively determine a source.[a]	Petroleum hydrocarbons Chlorinated hydrocarbons
AOC 656	The RFA reports several leaks from underground fuel lines have occurred but no specifics given. The same soil-gas survey mentioned above indicates the that these releases may have impacted media near the site in addition to the site itself as it is currently described.	Petroleum hydrocarbons

Notes:
[a] Described in the *Focused Field Investigation,* Appendix G.

2.7.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites some type of remedial action will likely be required. Data collection efforts will support the evaluation of these alternatives. Tables E.11 and E.12 in Appendix E list treatment alternatives for groundwater and soil at AOC 655 and AOC 656. Alternatives presented here are for preliminary evaluation only.

2.7.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient characterize the site(s) and support a BRA and detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- The impacts of the reported releases on soil and groundwater at both sites have not been determined. Soil-gas screening has given a preliminary indication that contamination does exist and that the areal extent of the contamination may go beyond the immediate vicinity of the general site descriptions provided above.
- The potential for a landfill (SWMU 9) approximately 100 yards from the sites to impact groundwater quality has not been fully assessed. Currently the landfill is believed to be hydrogeologically upgradient.
- Fulfill the objectives of the FFI.

2.7.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining the level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing potential pathways of exposure at this site which include soil, ambient air, soil-gas, and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.7.5 Objectives

The objectives of the proposed field investigation are to confirm the presence/absence of VOCs detected in the soil-gas survey and indoor air sampling. The investigation will also fulfill the objectives of the FFI, which are described in Appendix G. If present, the investigation will delineate the horizontal and vertical extent of the COPCs through all affected site media, and determine the source. Data collection efforts will support the technical evaluation of identified treatment alternatives.

2.7.6 Screening Alternatives

Soil-gas screening has been used to assist in selecting a portion of the biased sampling locations proposed below. Once the previous soil-gas data is confirmed with DQO Level III and/or IV soil and groundwater data, additional screening methods may be proposed for these sites.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.7.7 Sampling and Analysis Plan

The sample locations for AOC 655 area include two soil boring locations in the boiler room, where the spill reportedly occurred. Installing these borings will require coring through the concrete floor of the boiler room. One soil boring will be constructed in the open area adjacent to the boiler room. This is an enclosed area that will prohibit a drill rig from entering to construct a monitoring well. Three soil borings will be constructed outside Building 656 in potential groundwater contamination source areas and converted into monitoring wells. One of these locations will be as close to the building as possible in the area of the release and also in the immediate vicinity of a soil-gas "hit." Additionally, this location was selected based on proximity to the piping leading to the boiler room. The other two monitoring wells will be located at opposite ends of the fuel oil underground storage tank (UST) to detect any releases which may have occurred there. The soil-gas survey also detected several anomalies around Building 656 that are not in the immediate area of the release or the UST. The connection (if any) between these areas and the suspected source area is not known; however, as part of the AOC 655 investigation, three soil borings will be installed where the highest "hits" occurred to confirm if anthropogenic compounds are present. The remaining outlying soil-gas "hits" will be investigated as part of the grid-based sampling described in Section 3.0. The scope of work previously completed under the FFI and the remaining data gaps are described in Appendix G. To fill the data gaps, additional air samples from within and underneath Building 655 will be collected to assess the potential for gaseous phase contaminant migration into the structure.

The sample locations proposed for the AOC 656 area include soil-boring locations to be completed as groundwater monitoring wells. The proposed soil-boring locations were oriented in a configuration along the pipes which reportedly ruptured to detect any remaining residual contamination. Additional soil-boring locations are proposed as close as possible to the perimeter of the aboveground storage tank (AST) to determine if any spills/leaks have occurred there as well. To ensure that groundwater contamination will be intercepted by at least one of the proposed monitoring wells, locations were selected based on the reported area of the release and the current understanding of groundwater flow direction in the area.

Table 2.20 summarizes the types of samples and analytical parameters. Each of the proposed sample locations is illustrated on Figure 2-10. All sampling will be performed in accordance with the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

2.7.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and, alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

Table 2.20
AOC 655 and AOC 656
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	18	TPH, VOAs and SVOAs w/TICs, cyanide, metals, pesticides, and PCBs
Soil (3-5' bgs)	18	
Groundwater (shallow well)	6	
Air	Refer to Appendix G	Refer to Appendix G for air analysis.

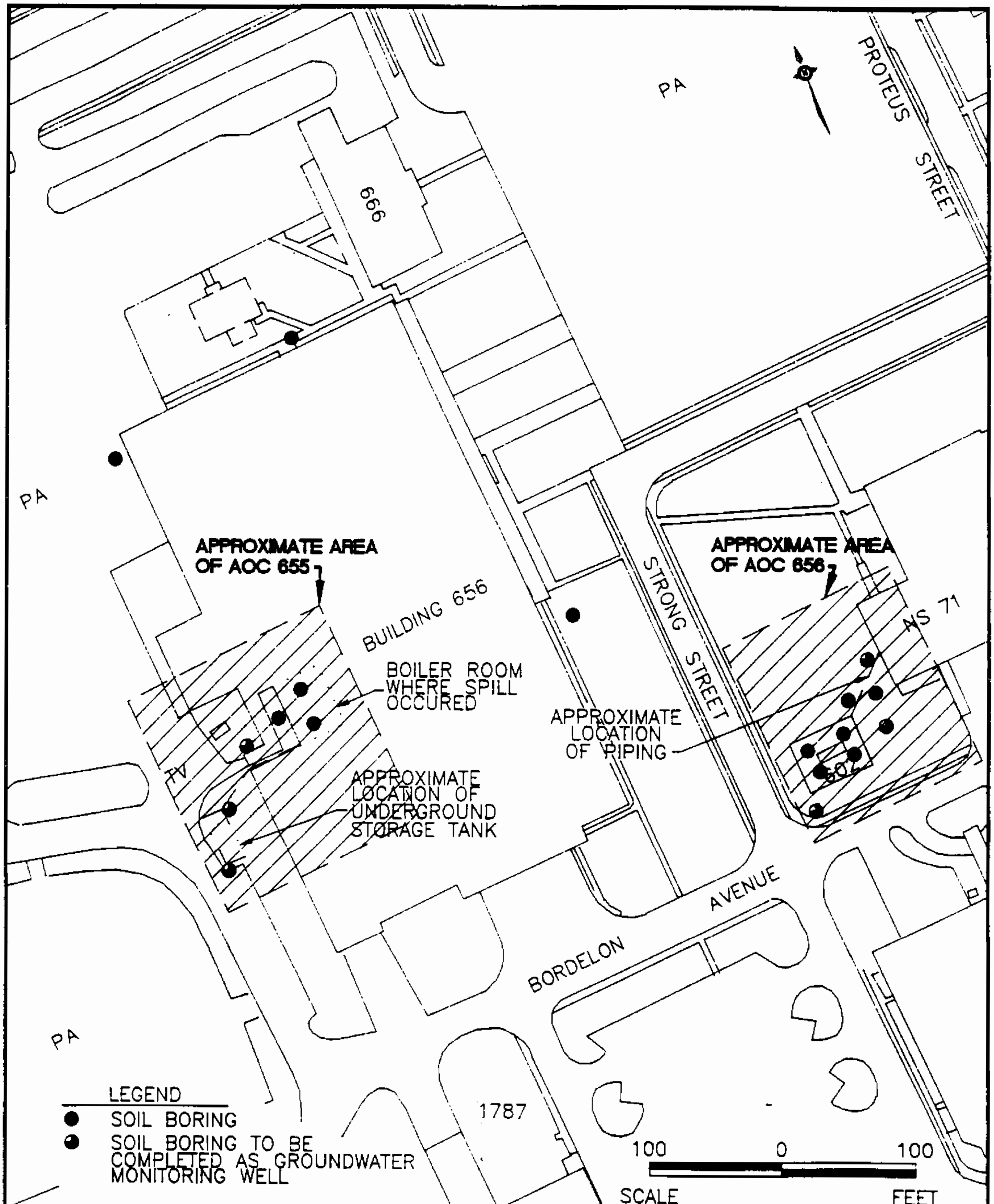
Engineering Parameters:
Engineering parameters will be dictated by field data collected.

Slug tests will be performed on one of the wells. While installing the wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantity presented does not include QA/QC samples.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–10
AOC 655/656
PROPOSED SAMPLE LOCATIONS

DWG DATE: 08/26/94 | DWG NAME: 29655AOC

2.8 AOC 662, Former Gas Station

AOC 662 is the former gas station at the southern end of the base. Table 2.21 describes the site.

Table 2.21
AOC 662
Site Description

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 662 FORMER GAS STATION	Former service station and possible billeting office; used as service station from 1958 until unknown date when it was converted to storage space; currently a non-hazardous material storage area; two unregistered, steel USTs may be present.[a]	Petroleum Lead	Soil Groundwater Soil-gas

Notes:
[a] Described in *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)

2.8.1 Previous Investigations

The site has not been previously investigated.

2.8.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Tables E.7 through E.9 in Appendix E list treatment alternatives for soil, soil-gas, and groundwater. Data collection efforts will support evaluating of these alternatives. Alternatives presented here are for preliminary evaluation only.

2.8.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site and support a BRA and detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- Sufficient information is not available to confirm that contamination exists at AOC 662.
- It is not known whether the USTs are still present.

2.8.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil, soil-gas, and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.8.5 Objectives

The objectives for the site are to fill the data gaps by determining if the USTs are still in place and if so, their locations, and to collect biased soil and groundwater samples in order to confirm contamination is present here. If present, the investigation will delineate the horizontal and vertical extent of the COPCs through all affected site media, and determine the source. Data collection efforts will support the technical evaluation of identified treatment alternatives.

2.8.6 Screening Alternatives

Because it is currently unknown if contamination exists, collecting higher quality samples at biased locations is the preferential method. At the present time no sampling has been conducted to determine COPCs; therefore, selecting a screening alternative (i.e., soil-gas) would be premature. If the proposed collection of high-quality samples is inadequate to define the areal extent of contamination (if present), the feasibility of employing screening methods will be reevaluated. Before collecting samples,existence of the USTs should be verified using an electromagnetic (EM). If successful, the geophysical survey could optimize the biased sampling efforts to confirm contamination and locate tanks for possible remedial action.

A PID will be used to qualitatively screen for volatile compounds using in all soil samples from every soil boring and monitoring well location. Results will be recorded in the field notes and on boring logs.

2.8.7 Sampling and Analysis Plan

To fulfill the objectives of the RFI, site-specific sampling and analysis requirements have been proposed. Table 2.22 summarizes the types of samples and analytical parameters. Each of the proposed sample locations is illustrated on Figure 2-11. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

Four soil sampling locations are proposed relative to the suspected UST locations to identify the presence of contamination associated with AOC 662. Two soil borings are to be completed as monitoring wells.

Given the relatively flat gradient of the water table surface near Zone H, and relatively small area of the site, it is anticipated that if any contaminants have reached the water table, they will be detectable in groundwater samples regardless of flow direction.

Groundwater flow direction near AOC 662 will be determined from water-level measurements from wells installed to characterize contamination associated with AOC 662 and monitoring wells installed as part of the base-wide grid groundwater monitoring network.

Table 2.22
AOC 662
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	4	TPH, VOAs and SVOAs w/ TICs, cyanide, metals, pesticides, and PCBs
Soil (3-5' bgs)	4	
Groundwater (shallow well)	2	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

Slug tests will be performed on one well. While installing the well, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

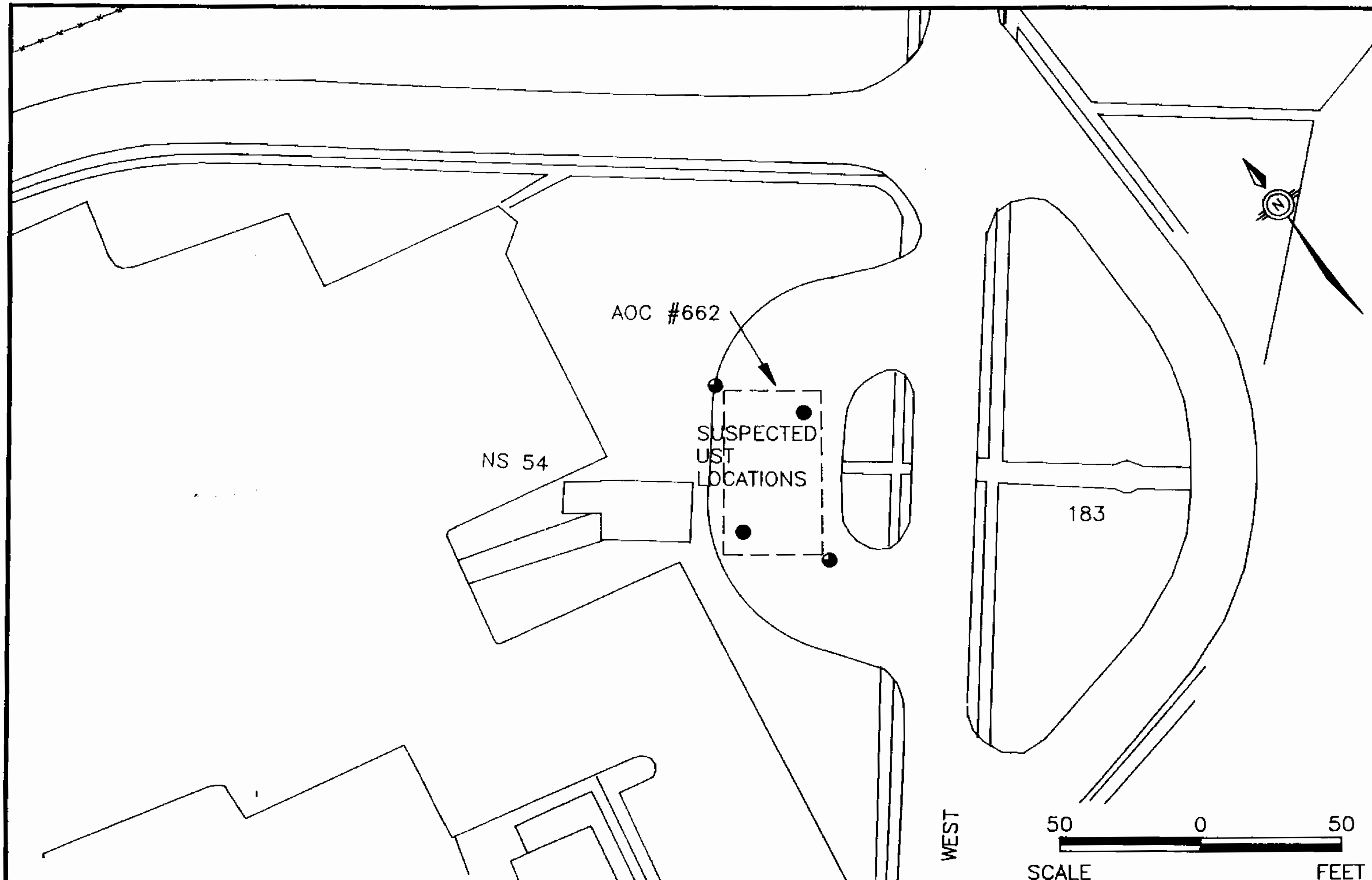
The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities do not include QA/QC samples.

2.8.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.



LEGEND

- ● – SOIL BORING
- ◐ – SOIL BORING TO BE COMPLETED AS GROUNDWATER MONITORING WELL

FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2-11
AOC 662
PROPOSED SAMPLE LOCATIONS

DWG DATE: 10/07/94 | DWG NAME: 29P-36

2.9 AOC 663, Gas/Diesel Pumping Station and SWMU 136

AOC 663 is an active gas and diesel pumping station at Building 851. Table 2.23 describes AOC 663; SWMU 136 is a Satellite Accumulation Area (SAA) that receives waste from both Buildings 851 and NS-53.

Table 2.23
AOC 663 and SWMU 136
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 663 FUEL PUMPING STATION	Active gasoline and diesel pumping station since 1983; contains two 500-gallon USTs; five flammable storage lockers located along west side of facility which store hazardous material from adjacent buildings; stained and cracked asphalt was noted near the pumping areas.[a]	Petroleum Solvents Paints	Soil Soil-gas Groundwater
SWMU 136 SAA# 19	SAA associated with Building NS-53; receives hazardous waste from NS-83 and Facility No. 851.[b]	VOCs Metals Petroleum	Soil Soil Gas Groundwater

Notes:
[a] Described in *Draft RCRA Facility Assessment, June 13, 1994* (To be revised by November 3, 1994)
[b] Described in *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)

2.9.1 Previous Investigations

The site has not been investigated previously.

2.9.2 Treatment Alternatives

As outlined in the overall sampling strategy presented in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Tables E.7 through E.9 in Appendix E list treatment alternatives for the landfill addressing soil, soil-gas, and groundwater. Data collection efforts will support evaluation of these alternatives. Currently, data are insufficient to support extrapolating of treatment alternatives for SWMU 136. Alternatives presented here are for preliminary evaluation only.

2.9.3 Data Gaps

A review of the information available from previous investigations and assessments indicates data are insufficient to characterize the site(s) and support a BRA and detailed evaluation of remedial alternatives where necessary.

2.9.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining the level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.9.5 Objectives

The objectives of the proposed field investigation regarding AOC 663 are to confirm the presence/absence of COPCs. If present, the investigation will delineate the horizontal and vertical extent of any soil and/or groundwater contamination. Data collection efforts will support technical evaluation of identified treatment alternatives.

2.9.6 Screening Alternatives

Presently a limited number of high-quality, highly biased samples are proposed to establish the list of COPCs. The feasibility of employing screening alternatives will be reevaluated after reviewing the data.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well locations. Results will be recorded in the field notes and on boring logs.

2.9.7 Sampling and Analysis Plan

To fulfill the RFI objectives, site-specific sampling and analysis requirements have been proposed. Ten soil sampling locations are proposed as close as possible to the USTs and the hazardous materials locker to characterize contamination associated with AOC 663 and SWMU 136. Three soil borings will be completed as monitoring wells. The proposed sample coverage is intended to detect any impact to soil and or groundwater which may have occurred at the site regardless of groundwater flow direction. Table 2.24 summarizes the types of samples and analytical parameters. The proposed sample locations are illustrated on Figure 2-12. All sampling will adhere to the NAVBASE Charleston, *Final Comprehensive RFI Work Plan* unless otherwise stated.

2.9.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

Table 2.24
AOC 663 and SWMU 136
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	10	VOAs, SVOAs w/ TICs, cyanide, metals, pesticides, PCBs, TPH volatile/semivolatile
Soil (3-5' bgs)	10	
Groundwater (shallow well)	3	

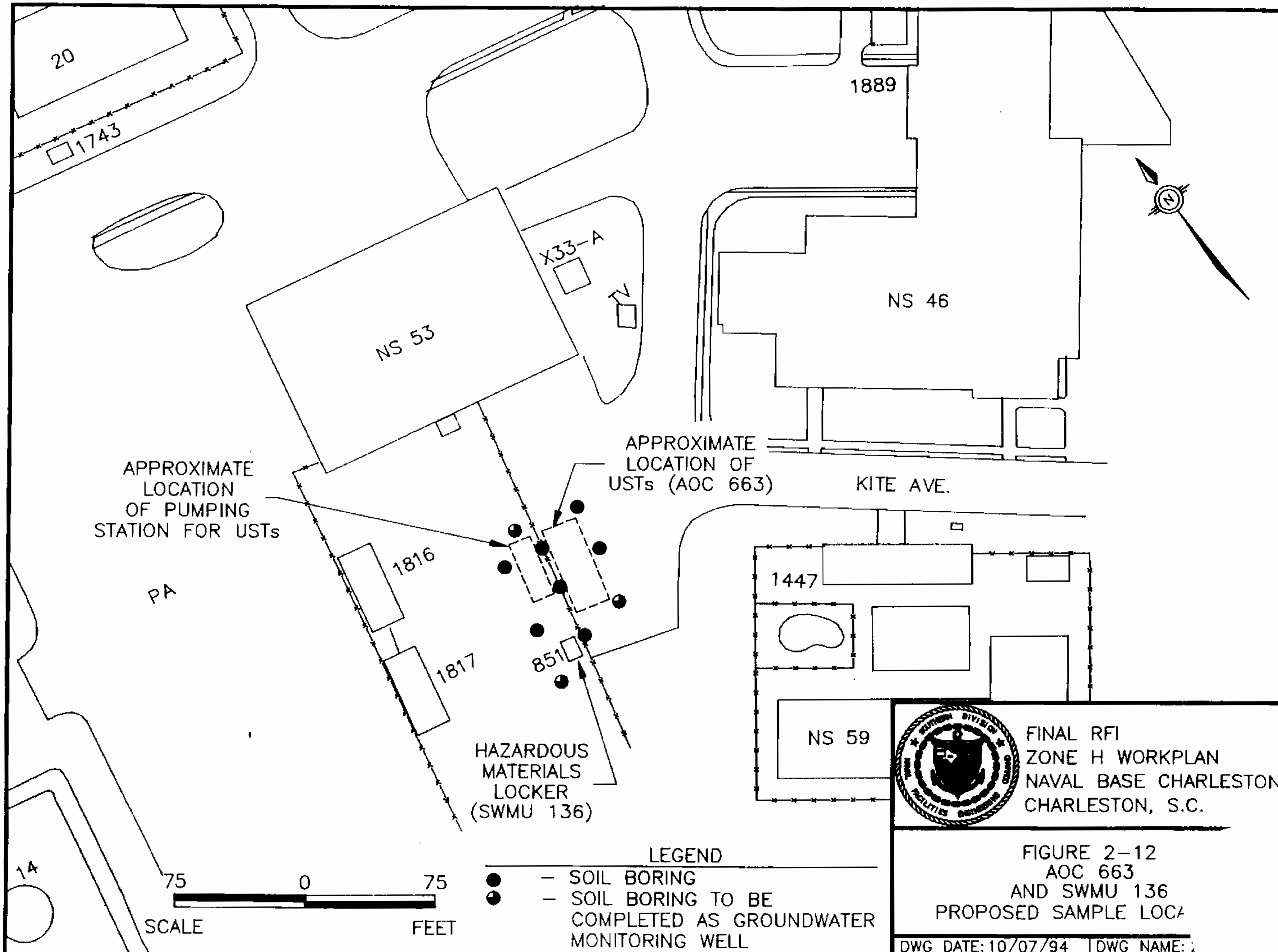
Engineering Parameters:
Engineering parameters will be dictated by field data collected.

A slug test will be performed on one of the wells. While installing the wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities do not include QA/QC samples.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–12
AOC 663
AND SWMU 136
PROPOSED SAMPLE LOCA

DWG DATE: 10/07/94 | DWG NAME:

2.10 AOC 667, Vehicle Maintenance (Includes SWMU 138)

AOC 667 is an area associated with Building 1776; SWMU 138 is approximately 50 feet southwest of AOC 667, due their proximity, the sites shall be investigated together. The below Table 2.25 describes the sites.

Table 2.25
AOC 667 and SWMU 138
Site Descriptions

Number	Description	Materials Generated or Stored	Potential Pathways
AOC 667 VEHICLE MAINTENANCE AREA	A two-story brick structure (Building 1776) which includes an oil/water separator. The site is used for the routine maintenance of automobiles and heavy equipment, including oil changes and repairing hydraulic parts from the equipment. The site employs a 550-gallon portable storage tank to store waste oil. Numerous oil stains have been noted around the building.[a]	Petroleum products	Soil Groundwater Soil-gas
SWMU 138 SAA RELATIVE TO BLDG. 1776	SAA located 50 feet southwest of Bldg. 1776. The SAA stores hazardous waste in 55-gallon drums which are immediately transferred to a permitted hazardous waste storage facility.[a]	VOCs Waste oil Petroleum Antifreeze Oily rags	Soil Groundwater Soil-gas

Notes:
[a] Described in *Draft RCRA Facility Assessment, May 31, 1994* (To be revised November 3, 1994)

2.10.1 Previous Investigations

The site has not been investigated previously.

2.10.2 Treatment Alternatives

As outlined in the overall sampling strategy in the *Final Comprehensive RFI Work Plan*, treatment alternatives are being identified for each of the sites where some type of remedial action will likely be required. Tables E.7 through E.9 in Appendix E list treatment alternatives for the landfill addressing soil, soil-gas, and groundwater. Data collection efforts will support evaluating these alternatives. Alternatives presented here are for preliminary evaluation only.

2.10.3 Data Gaps

SWMU 138 has been designated for a CSI. There is no available measure of potential contaminants or their concentrations. AOC 667 has been designated for an RFI. Evidence suggests that releases have occurred at the site; however, a previous investigations and assessments indicate data are insufficient to characterize the site(s) and support a BRA and detailed evaluation of remedial alternatives where necessary. The data gaps are as follows:

- No information regarding groundwater contamination.
- No information regarding soil contamination both at the surface and at depth.
- Insufficient data to support identifying treatment alternatives.

2.10.4 Potential Receptors

Potential receptors of exposure to contaminants include current land users, such as NAVBASE personnel, and any future users this area might support. Data will be generated during the RFI to support determining the level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.10.5 Objectives

The objectives of the proposed field investigation regarding AOC 667 and SWMU 138 are to fill the identified data gaps by delineating the horizontal and vertical extent of any soil and/or groundwater contamination at the site, as well as determining the contaminants chemical nature. Data collection efforts will support the technical evaluation of identified treatment alternatives.

2.10.6 Screening Alternatives

Presently, a limited number of high quality, highly biased samples are proposed to establish the list of COPCs. The feasibility of employing screening alternatives will be reevaluated after reviewing the data.

A PID will be used to qualitatively screen for volatile compounds in all soil samples collected from every soil boring and monitoring well locations. Results will be recorded in the field notes and on boring logs.

2.10.7 Sampling and Analysis Plan

To fulfill the RFI objectives, site-specific sampling and analysis requirements have been proposed. Table 2.26 summarizes the types of samples and analytical parameters. The proposed sampling locations are illustrated on Figure 2-13. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated.

Seven sampling locations are proposed relative to the storage tank and the SAA to characterize contamination associated with AOC 667 and SWMU 138. Soil samples will be collected from each of the seven locations. Two of the soil borings will be completed as monitoring wells.

Given the relatively flat gradient of the water table surface near Zone H, and relatively small area of the site, it is anticipated that if any contaminants have reached the water table, they should be detectable in groundwater samples collected from at least one of the two monitoring wells.

Table 2.26
AOC 667 and SWMU 138
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1')	7	VOAs and SVOAs w/TICs, metals, cyanide, pesticides, and PCBs
Soil (3-5')	7	
Groundwater (shallow well)	2	

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

A slug test will be performed on the one shallow well. While installing the well, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC. Analysis for any of the remaining design parameters listed in Appendix E will be performed at selected locations when a better understanding of the contaminant distribution (if contamination is present) is developed.

Notes:
Groundwater monitoring wells will be sampled quarterly.

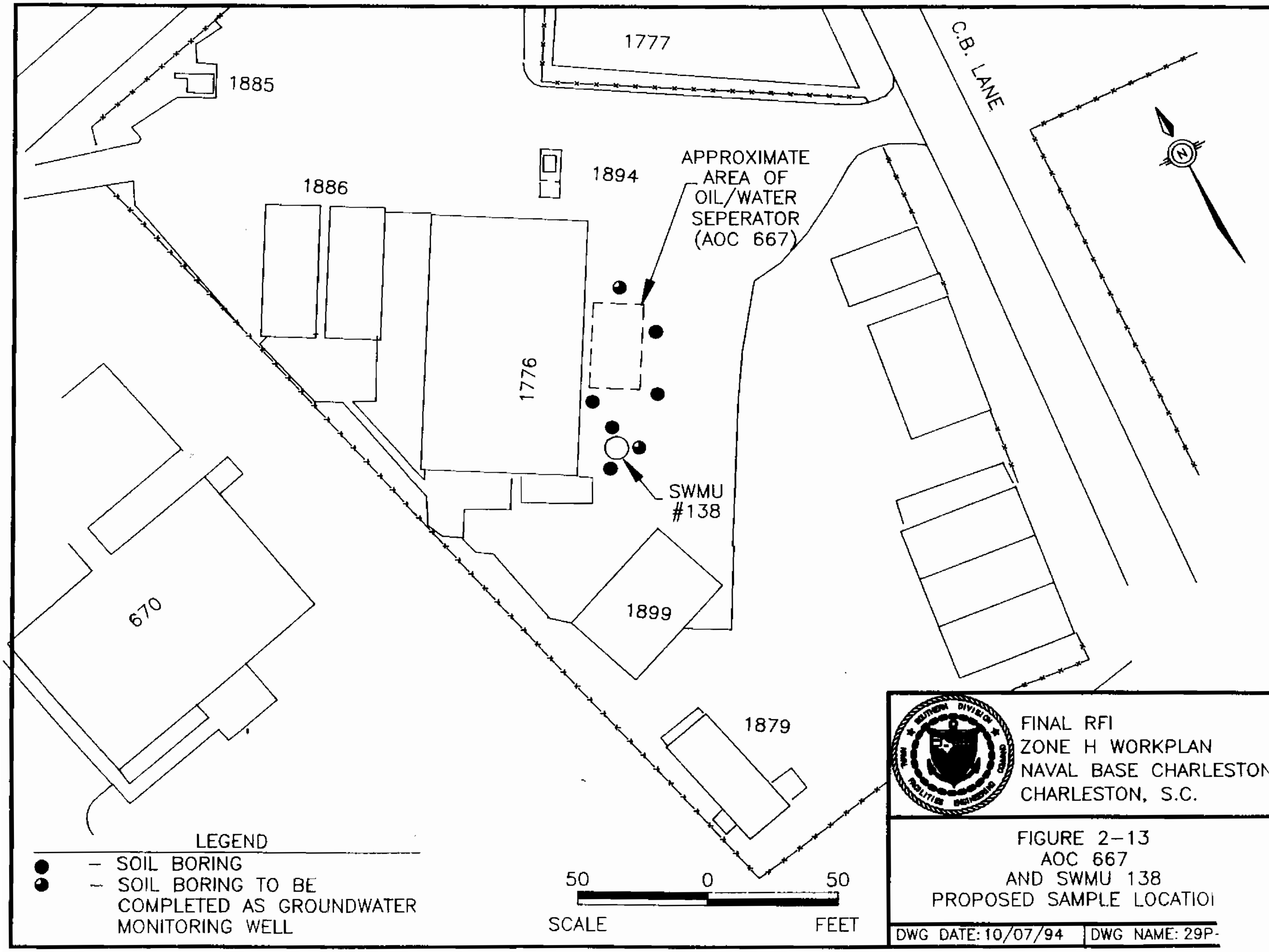
The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities do not include QA/QC samples.

2.10.8 Radiological Potential

This site has been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–13
AOC 667
AND SWMU 138
PROPOSED SAMPLE LOCATIOI

DWG DATE: 10/07/94 | DWG NAME: 29P-

2.11 Other Sites Designated CSI (Includes AOCs 659, 660, 661, 665, 666 and SWMU 178)

This group of sites is characterized by their CSI designation, the lack of information about their current status, and distance from an RFI investigation. These sites have a common investigative strategy and will be discussed as a unit. Each site is described below in Table 2.27.

Table 2.27
Site Descriptions

Number	Description[a]	Materials Generated or Stored	Potential Pathways
AOC 659 DIESEL STORAGE	30,000-gallon steel AST south of Hobson Ave. in a 5-foot-high earthen berm used to store diesel fuel from 1958 until 1990; facility is no longer in use.	Petroleum hydrocarbons	Soil Groundwater Soil-gas
AOC 660 MOSQUITO CONTROL	Used for mosquito control in the 1950s; possibly used for storage, mixing, and rinsing pesticides; currently an asphalt parking lot northwest of Building NS-53.	Pesticides Solvents	Soil Soil Gas Groundwater
AOC 661 EXPLOSIVES STORAGE	Unknown explosives were stored during the 1950s in a now demolished building; currently a grassy area south of Building 601 and northwest of Building 675.	Explosives	Soil
AOC 665 PYROTECHNIC STORAGE	A former shed which stored unknown pyrotechnic explosives from 1943 until its demolition at an unknown date; currently Buildings 1889 and NS-46 are on the site where the pyrotechnic shed was located.	Pyrotechnic explosives	Soil

Table 2.27
Site Descriptions

Number	Description[a]	Materials Generated or Stored	Potential Pathways
AOC 666 FUEL STORAGE AREA	The site is a UST enclosed by creosote-treated railroad ties, approximately 10 x 30 feet (Facility NS-45), which supplies No. 2 fuel oil to the adjacent heating plant (NS-44). The exact capacity of the tank is unknown. The site was constructed in 1958. The surrounding area was an airstrip prior to 1958.	Petroleum (No. 2 Fuel oil)	Soil Groundwater Soil-gas Surface water runoff
SWMU 178 TRANSFORMER LEAK	Site of recently discovered (June 1994) transformer oil leak, approximately 50 feet South of Building X33-A	Transformer oil PCBs	Soil Groundwater

Notes:
[a] Described in the *Draft RCRA Facility Assessment, May 31, 1994* (To be revised by November 3, 1994)

2.11.1 Previous Investigations

These sites have not been investigated previously.

2.11.2 Treatment Alternatives

Given the fact that these sites require CSIs, the data are insufficient to support the evaluating of remedial alternatives for the sites, with the possible exception of AOCs 661 and 665. Should explosives be discovered at either of these sites, the subsequent treatment alternatives are presented in Table E.13 (Appendix E).

2.11.3 Data Gaps

Information from previous investigations and assessments indicate data are insufficient to characterize the site(s) and support a BRA and detailed evaluation of remedial alternatives, where necessary.

2.11.4 Potential Receptors

Characterization of potential receptors is made upon a contaminant-specific basis, and therefore will be made only for sites that are found to need an RFI. The RFI investigation, if needed, will determine the site-specific pathways of exposure for current and future land users. Data will be generated during the RFI to determine the level of risk to the entire spectrum of current and potential users, including any highly sensitive individuals, who might be exposed through invasive or non-invasive activities. The risk evaluation will also consider ecological receptors which may be present. This will include characterizing all potential pathways of exposure at this site, including soil, soil-gas and groundwater. If contamination in groundwater is present and if groundwater flows laterally toward Shipyard Creek or the Cooper River, ecological receptors in these water bodies could be impacted.

2.11.5 Objectives

The goal of the CSI investigations is to classify the site as No Further Investigation (NFI) or RFI using DQO Level III or IV data. If an RFI is required, the objectives of the field investigation would be to fill the identified data gaps by delineating the horizontal and vertical extent of potential media contamination at the sites. Delineating the nature and extent of contamination should identify any onsite point sources for potential contaminants to enter any ecologically sensitive areas such as Shipyard Creek and bordering wetlands. Data collection efforts should support the technical evaluation of identified treatment alternatives.

2.11.6 Screening Alternatives

Presently a limited number of high-quality, highly biased samples are proposed to establish the list of COPCs. The feasibility of employing screening alternatives will be reevaluated after reviewing the data.

A PID will be used to qualitatively screen for volatile compounds in all soil samples from every soil boring and monitoring well locations. Results will be recorded in the field notes and on boring logs.

2.11.7 Sampling and Analysis Plan

To fulfill the CSI objectives, the following site-specific sampling and analysis requirements have been proposed. Table 2.28 summarizes the types of samples and analytical parameters. Proposed sample locations for AOCs 659, 660, 665, 666, and SWMU 178, are illustrated in Figures 2-14, 2-15, 2-16, 2-17, and 2-18. Figure 2-19 illustrates AOC 661. All sampling will adhere to the NAVBASE Charleston *Final Comprehensive RFI Work Plan* unless otherwise stated. Due to the general lack of information regarding these sites, proposed sample locations as illustrated represent the areas most likely to have been impacted if a release has occurred. AOC 661 is to be investigated by a EOD subcontractor as previously described for AOC 503. Samples collected from AOCs 661 and 665 shall include the additional DQO outlined in Table 2.14. The number of samples and sample locations for the above-listed AOCs and SWMUs are based on what is reasonably expected to provide adequate information to identify any COPCs present.

2.11.8 Radiological Potential

These sites have been determined to have a low potential for radiological sources or contamination based on review of historical records and knowledge of past storage or disposal practices. While there is a low potential, the sites cannot be totally excluded until survey data can be established.

Appendix F of this work plan provides instructions for beta, gamma, and alpha screening. Isotopic analysis will be performed if beta/gamma screening exceeds established trigger concentrations. Personnel frisking and equipment decontamination will be addressed in Section 4 of this document.

Table 2.28
Sampling Plan

Matrix	Quantity	Analysis
Soil (0-1' bgs)	28	TPH, VOA and SVOA w/ TICs, cyanide, metals, pesticides, and PCBs
Soil (3-5' bgs)	28	
Groundwater (shallow wells)	6	Pyrotechnics, explosives, and propellants (PEP) at AOCs 661 and 655.

Engineering Parameters:
Engineering parameters will be dictated by field data collected.

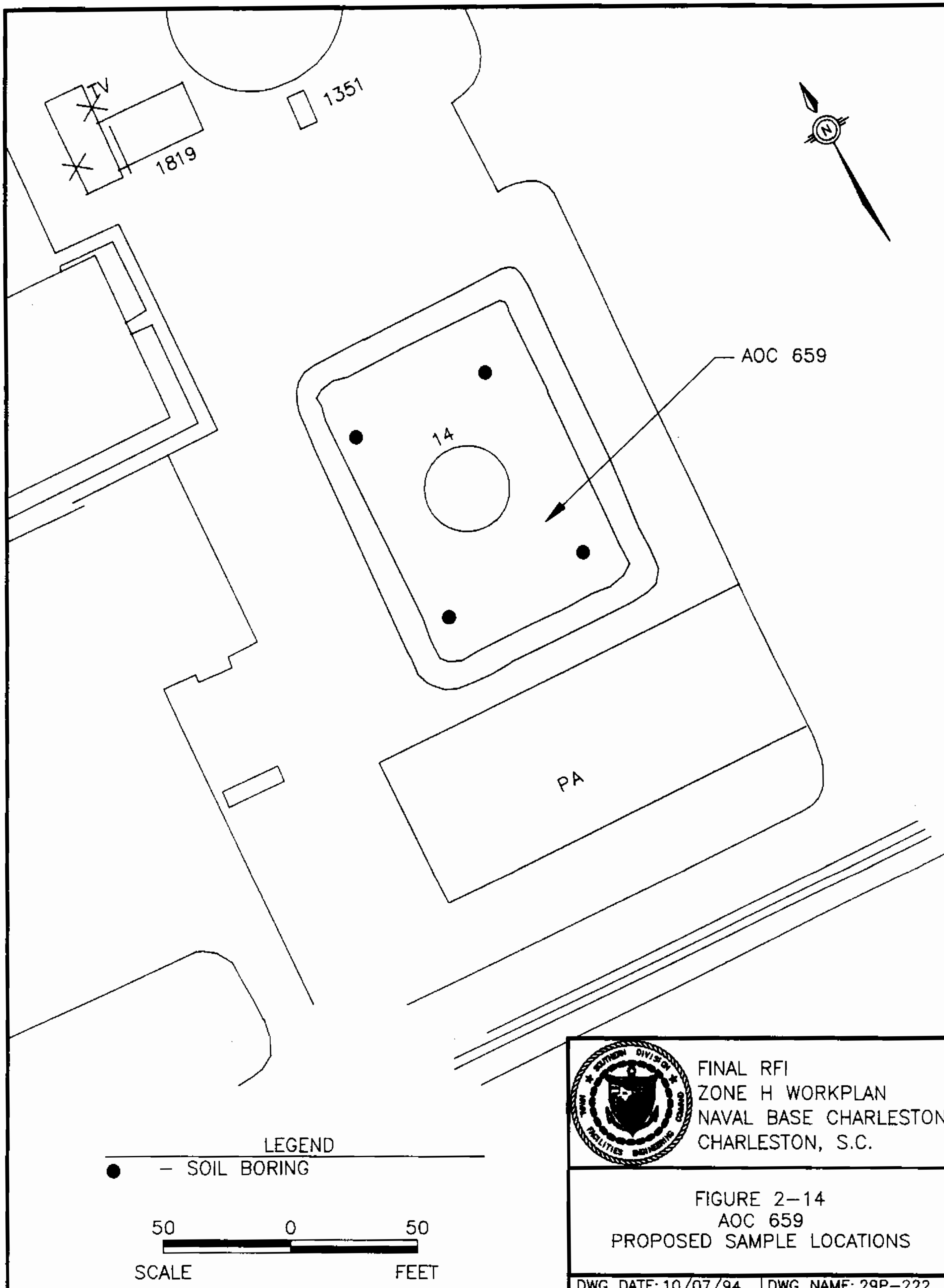
Slug tests will be performed on two of the wells. While installing the wells, Shelby tubes will be collected when dramatic changes in lithology occur. Samples will be tested for permeability, grain size, porosity, TOC, and CEC.

Notes:
Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion of the investigation may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. Samples from AOCs 661 and 665 will be analyzed for explosive constituents listed in Table 2.13.

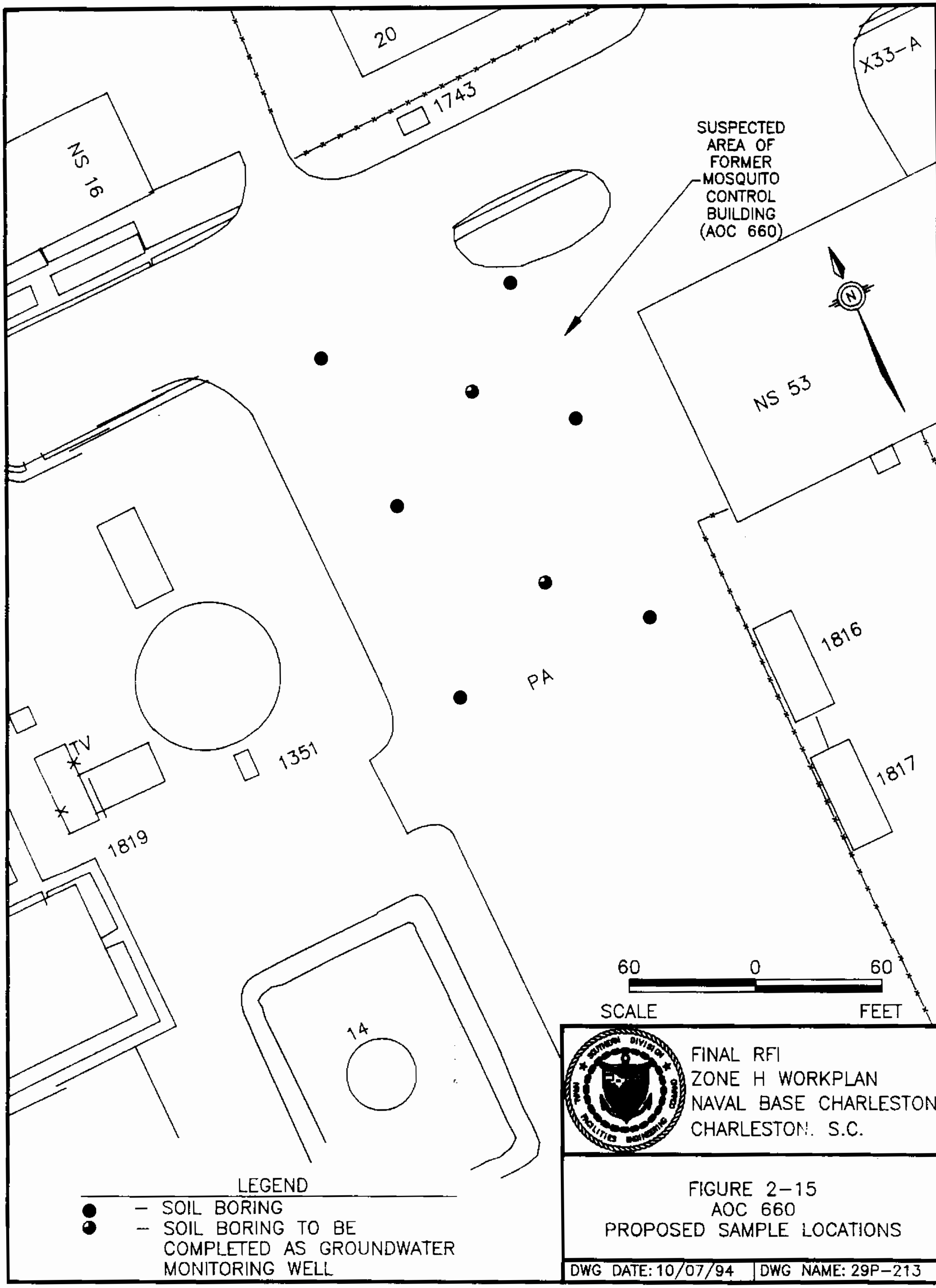
Soil and groundwater samples in the vicinity of AOCs 661 and 665 will be analyzed for explosive constituents listed in Table 2.13.



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–14
AOC 659
PROPOSED SAMPLE LOCATIONS

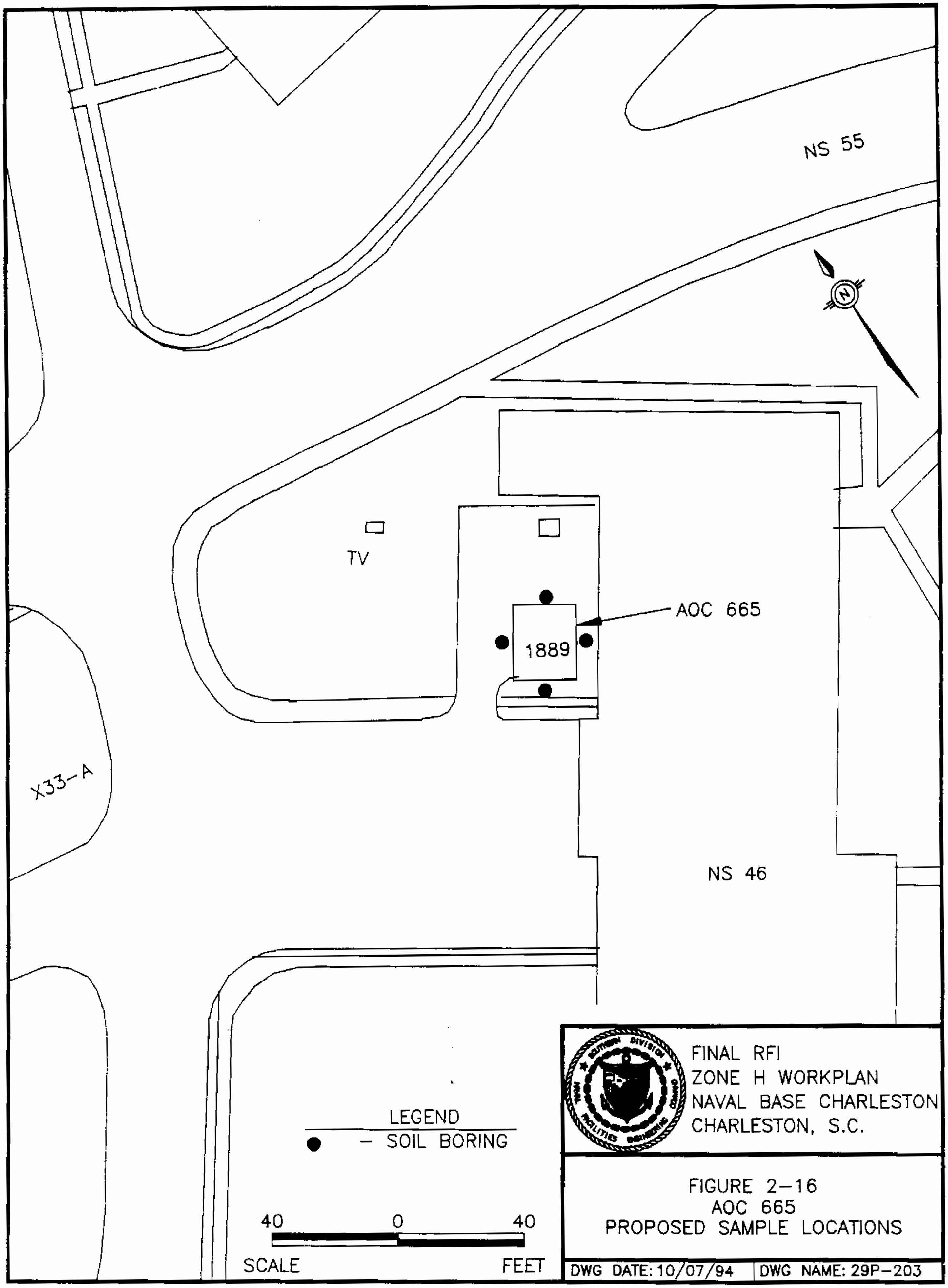
DWG DATE: 10/07/94 | DWG NAME: 29P–222



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–15
AOC 660
PROPOSED SAMPLE LOCATIONS

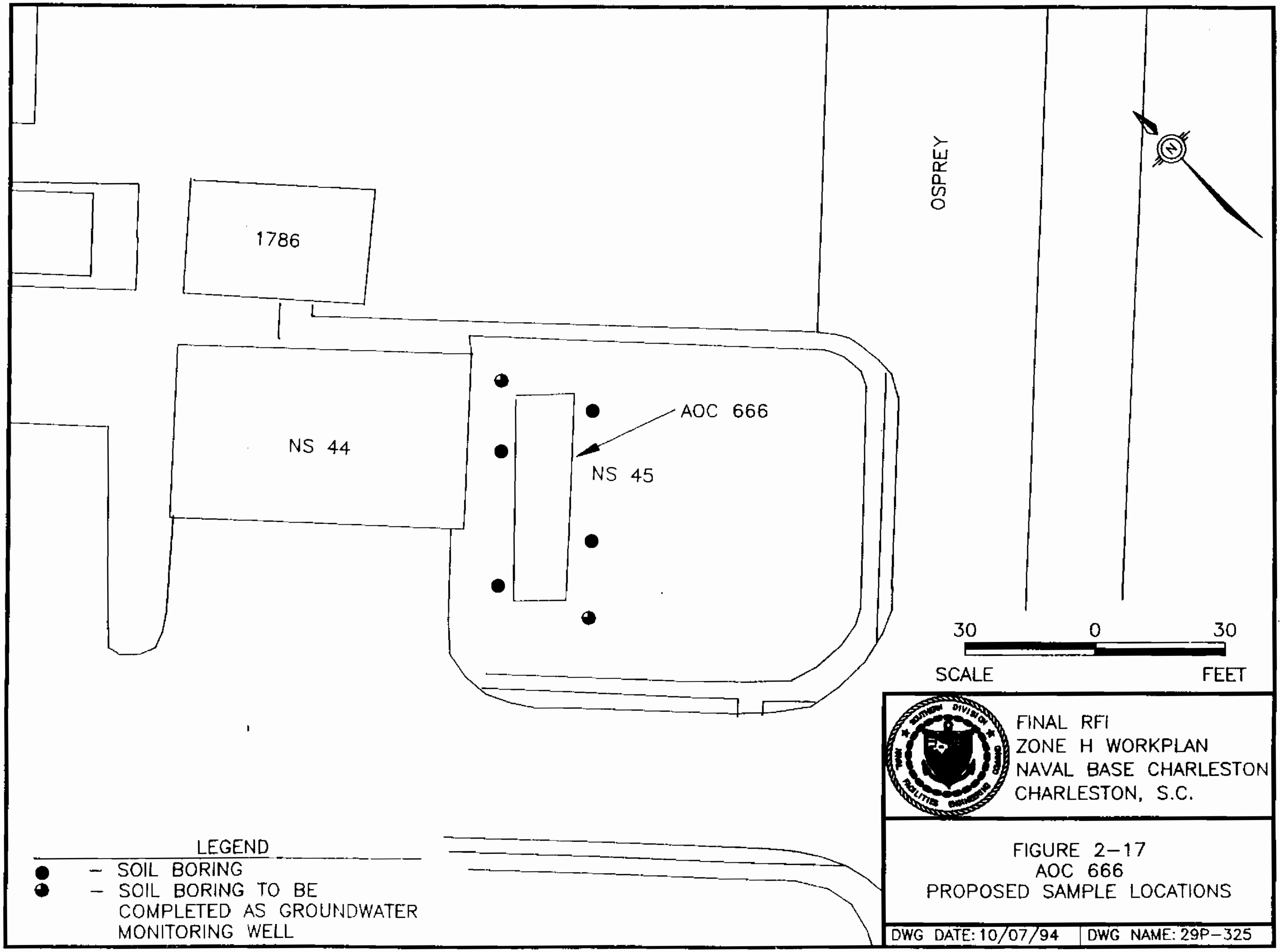
DWG DATE: 10/07/94 | DWG NAME: 29P–213



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2-16
AOC 665
PROPOSED SAMPLE LOCATIONS

DWG DATE: 10/07/94 | DWG NAME: 29P-203


OSPREY
1786
NS 44
NS 45
AOC 666
30
0
30
SCALE
FEET
LEGEND
– SOIL BORING
– SOIL BORING TO BE COMPLETED AS GROUNDWATER MONITORING WELL
FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 2–17
AOC 666
PROPOSED SAMPLE LOCATIONS
DWG DATE: 10/07/94
DWG NAME: 29P–325

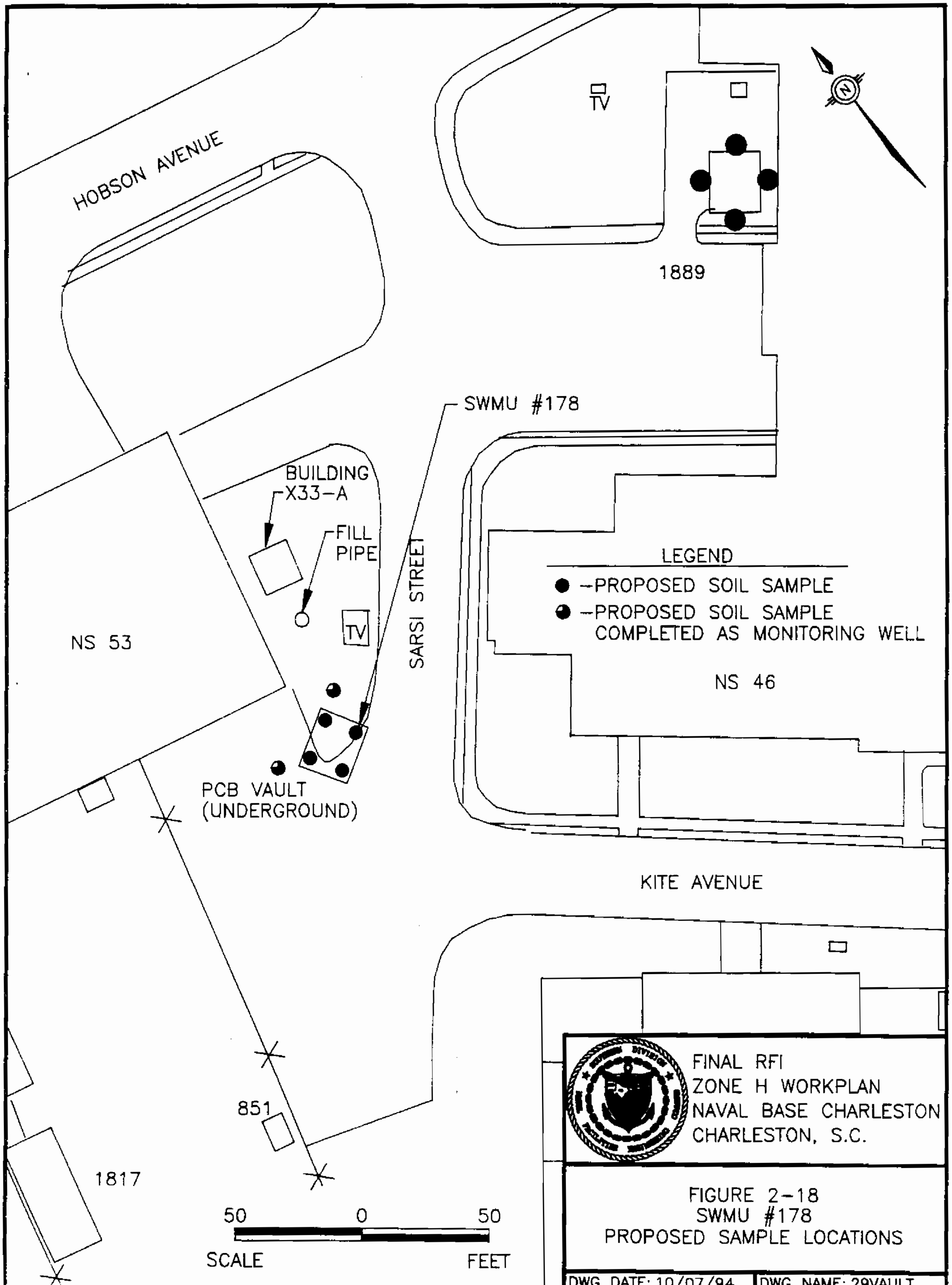
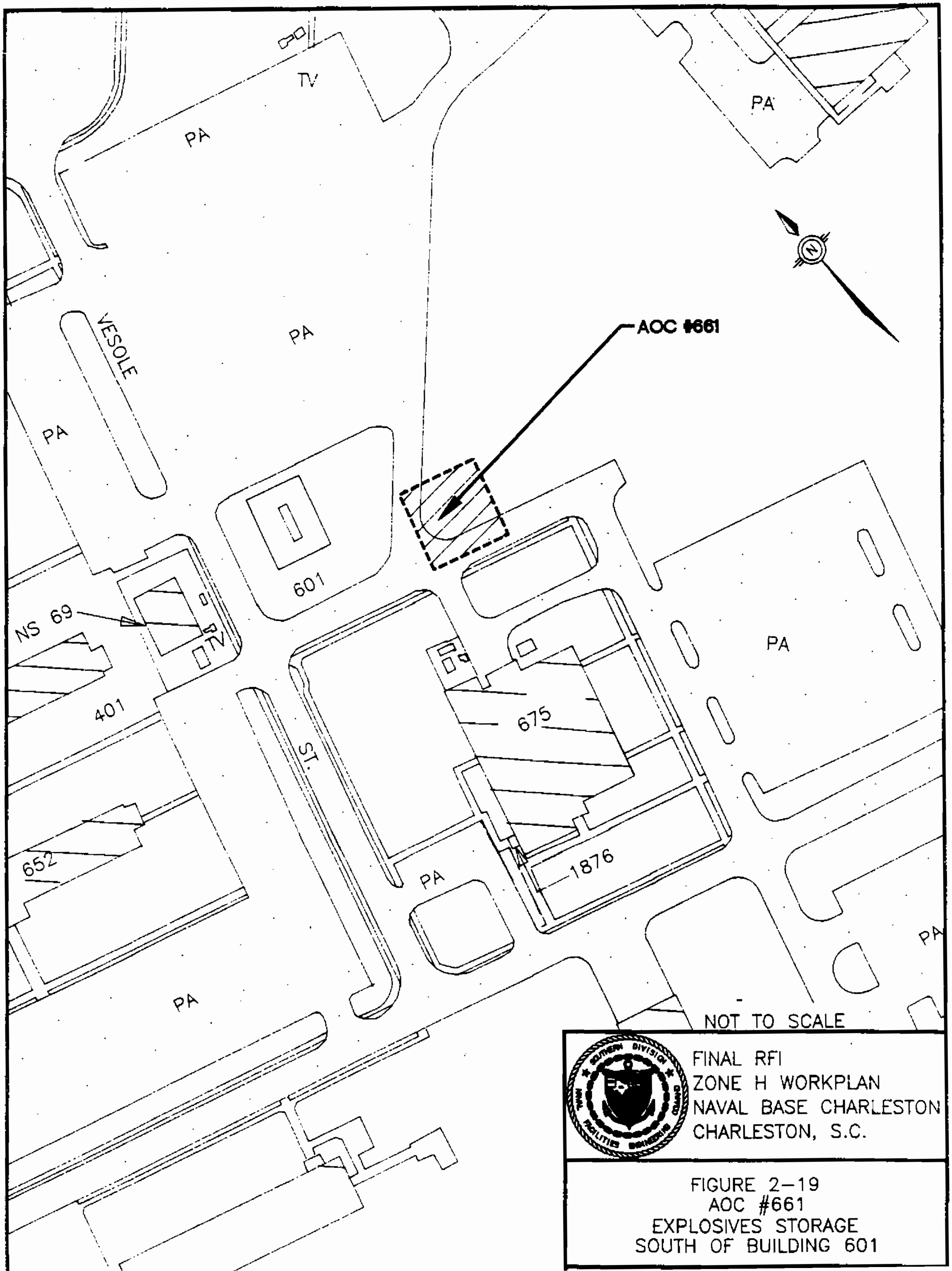


FIGURE 2-18
SWMU #178
PROPOSED SAMPLE LOCATIONS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–19
AOC #661
EXPLOSIVES STORAGE
SOUTH OF BUILDING 601

3.0 SYSTEMATIC (GRID-BASED) SAMPLING PLAN

As noted in the RFA, much of NAVBASE, particularly the southern end that includes Zone H, is built upon a series of dredge spoil depositions, whose composition has been impacted by industrial activities to an unknown extent. It is anticipated that this heterogeneous structure will have a significant impact upon risk management decisions, and therefore a more intensive approach to characterizing of "background" or "reference area" conditions will be required than is typical of RFI investigations.

A systematic, square-grid sampling scheme has been chosen in order to more fully characterize the nature of NAVBASE soil and groundwater contamination. However, as discussed in the *Final Comprehensive RFI Work Plan, Volume III*, an algorithm has been designed to systematically exclude redundant sampling points, yet to focus limited resources near biased field investigations. The grid-based sampling points are intended to supplement the biased locations while delineating site boundaries and provide a basis for comparing site-specific soil and groundwater quality. Initially, none of the grid-based points will be designated as background sampling locations. However, after analytical data are reviewed, specific areas representing background may be identified and designated as such with regulatory agency concurrence. The grid is not specifically intended to be used to establish reference area determinations as needed for the ecological risk assessment conducted under Zone J. Table 3.1 (below) and Figure 3-1 present the proposed sampling descriptions and locations.

The usefulness of grid-based wells in Zone H as background wells may be limited due to the direction of groundwater flow in this part of NAVBASE. The preliminary understanding of groundwater flow direction indicates that most of the proposed grid-based wells are downgradient of many contaminant sources. They most often will be used as reference wells to help delineate the extent of contaminant migration or to detect any point sources that have not been documented in the RFA process.

Table 3.1
Systematic Grid-Based Sampling Plan

Matrix	Quantity	Analysis
Soil (surface)	107	VOAs and SVOA w/ TICs, metals, cyanide, pesticides, and PCBs
Soil (depth)	107	
Groundwater		
(shallow)	12	
(deep)	12	

Notes:
Groundwater monitoring wells will be sampled quarterly.

The quantities presented are estimated numbers of samples believed to be needed to fulfill the objectives of the investigation. Expansion may be necessary to meet the stated objectives.

All analysis to be performed per SW-846 except where other methods are specified. DQO Level III analyses as specified in sampling plan, with a minimum of 10% duplicates analyzed for all Appendix IX constituents at DQO Level IV. The sample quantities presented do not include QA/QC samples.

Groundwater samples will be analyzed for total chlorides, total dissolved solids (TDS), sulfates, and pH for evaluation of a portion of the secondary drinking water standards as promulgated by 40 CFR 143.3.

4.0 HEALTH AND SAFETY PLAN

E/A&H is conducting an environmental monitoring program at various specified locations (sites) within NAVBASE to assess the nature and extent of contamination at these sites and to determine if additional action is required to maintain compliance with environmental regulations. The Navy project contract number with E/A&H is N62467-89-D-0318.

The USEPA has divided the NAVBASE sites into SWMUs and AOCs, which these have been grouped into zones for investigative purposes. This Zone-specific Health and Safety Plan (ZHHASP) has been developed for SWMUs and AOCs located in Zone H.

This ZHHASP was written to complement the E/A&H NAVBASE Comprehensive Health and Safety Plan (CHASP) by providing site-specific details absent in the CHASP. Site-specific details presented in this ZHHASP include: potential site contaminants, proposed site activities, action levels and initial level of personal protective equipment (PPE). Copies of both this plan and the CHASP should be onsite during all field operations.

This ZHHASP uses the term "contaminants of concern" and "constituents of concern." Not all constituents of concern are contaminants of concern. Constituents of concern refers to compounds of analytical interest. The analytical interest may be because of public health, regulatory, ecological, or other concerns. The term contaminant of concern is used to identify (potential) site contaminants that may be present in sufficient concentrations to cause concern about potential occupational exposures to onsite personnel.

4.1 Applicability

The provisions of this plan are mandatory for E/A&H personnel. E/A&H personnel shall read this plan and sign the plan acceptance form (see Appendix J) before starting site activities. In addition, personnel will operate in accordance with the most current requirements of 29 Code of Federal Regulations (CFR) 1910.120, Standards for Hazardous Waste Operations and

Emergency Response (HAZWOPER). These regulations include the following provisions for employees involved in cleanup operations covered by RCRA: training 1910.120(e), medical surveillance 1910.120(f), and PPE 1910.120(g).

All non-E/A&H personnel present in E/A&H work areas shall either adopt and abide by this ZHHASP and the corresponding CHASP or shall have their own safety plan which, at least, meets the requirements of E/A&H's CHASP and ZHHASP.

This ZHHASP applies to standard field procedures and tasks such as drilling; installing and developing monitoring wells; surveying; and collecting soil, groundwater, surface water, and sediment samples. Non-routine procedures and tasks involving non-routine risks are not covered by this plan, examples of procedures that are not covered in this plan are:

- Trenching
- Confined space entry
- Locating and/or recovering unexploded ordnance
- Sampling, handling, or removing unidentified drums

Should it be necessary to conduct these or other "high-risk" tasks specific health and safety procedures must be developed, approved, and implemented before proceeding.

4.2 Zone Characterization

Sites included in this ZHHASP consist of SWMUs and AOCs as identified in the RFI plan for NAVBASE as prepared by E/A&H. These subsections will include site descriptions, chemical hazards, and operational/physical hazards for each site. Each site within Zone H is discussed in the following subsections of this document.

4.2.1 Work Zones

Section 2.1 of the CHASP, describes the function and interrelatedness of the three work zones which, in combination, compose the work area. The three work zones are:

- Exclusion Zone (EZ)
- Contaminant Reduction Zone (CRZ), and
- Support Zone (SZ).

These work zones will be established and used during field work covered under this ZHHASP.

4.2.2 Work Area Access

Authorized personnel will be allowed and in work areas as long as they follow the requirements of this ZHHASP and the CHASP. See also Work Area Access, Section 2.2 of the CHASP.

Authorized Personnel — In order for E/A&H personnel to be authorized to enter an E/A&H controlled work area, they must have a current HAZWOPER training certificate on file onsite. Individuals whose certification is not on file, or those who have more recent certificates (have attended refresher course), will provide the onsite Supervisor with copies before being allowed to enter a work area.

Subcontractors, Department of Defense (DOD) oversight personnel, and other site visitors shall demonstrate compliance with HAZWOPER training requirements before entering a work area.

4.2.3 Zone Investigation

Figure 1-1 is a map of Zone H, showing the locations of each SWMU and AOC. In addition, included in the sampling and analysis section of the Work Plan is a map of each site. The EZ, CRZ, and SZ for each site will be established in the field. The location of these zones is depends on the work task, layout of the site, meteorological conditions, and logistical factors.

Sites covered by this ZHHASP consist of SWMUs and AOCs (see Table A.2 in Appendix A). Sections 4.3 through 4.22 of this ZHHASP describes sites, chemical hazards, and operations/physical hazards for each SWMU or AOC.

4.3 SWMU 9, Closed Landfill (Includes SWMUs 19, 20, and 121 and AOCs 649, 650, 651, and 654)

Refer to Section 2.1 of this Work Plan for background information, summarizing the present level of knowledge for this site including: a description of past uses, previous site investigations, a list of the principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Initial site activities include soil borings, soil sampling, sediment sampling, and installing of monitoring wells. Subsequent activities include well development, purging, and sampling. Field work for this site is described in Section 2.1 of this Work Plan.

Chemical Hazards and PPE Requirements

The major constituents of concern are volatile organic compounds, semivolatile organics, pesticides, PCBs, and heavy metals. As a result of sandblasting, heavy metals may be present; however, NAVBASE records show metal concentrations in waste blast were low. Table 4.1 lists exposure guidelines for expected site contaminants of concern. Material Safety Data Sheets (MSDS) (Appendix H) will only be placed in field copies of the ZHHASP. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial level of PPE for invasive field activities performed at SWMU 9 is modified Level D. The Action Level (AL) for this site is a continuous PID reading of 5 parts per million (ppm) or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.1
Exposure Guidelines For Expected Site Chemical Hazards—SWMU 9

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Kerosene	1 ppm	NA	NA	100 mg/m^3	935	0.7 to 5.0%
Lead	NA	0.05 mg/m^3	0.15 mg/m^3	0.15 mg/m^3	NA	NA
Sulfuric Acid	>1 ppm	1 mg/m^3	1 mg/m^3 3 mg/m^3 STEL	1 mg/m^3	NA	NA
Xylene	NA	100 150 STEL	100 150 STEL	100 150 STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by Occupational Safety, and Health Administration (OSHA) and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-Term Exposure Limits (TLVs and STELs) recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH) and published annually. For this ZHHASP site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for the Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

mg/m^3 = milligrams per cubic meter.

°F = degrees Fahrenheit.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.4 SWMU 13, Current Fire Fighter Training Area

Refer to Section 2.2 of this Work Plan for background information on this site summarizing the present level of knowledge, including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Initial site activities will include soil borings, soil sampling, and installing monitoring wells. Subsequent activities include well development, purging, and sampling. Field work for this site is described in Section 2.2 of this Work Plan.

Chemical Hazards and PPE Requirements

The contaminants of concern at this site are petroleum hydrocarbons. Table 4.2 lists exposure guidelines for representative petroleum hydrocarbons. MSDSs for site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities at SWMU 13 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.2
Exposure Guidelines For Expected Site Chemical Hazards—SWMU 13

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Kerosene	1 ppm	NA	NA	100 mg/m^3	935	0.7 to 5.0%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.5 SWMU 14, Chemical Disposal Area (Includes SWMU 15 and AOCs 669, 670, and 684)

SWMU 14, the chemical disposal area, is at the southern end of NAVBASE near the skeet and pistol ranges. While chemicals have reportedly been disposed of in this area, the range of compounds disposed of, their concentration and their location are unknown. The following summarizes what E/A&H presently knows:

- Between 1972 and 1974 construction crews in the Skeet Range unearthed chemical-containing drums; some workers in this construction project suffered minor chemical burns. E/A&H does not know the identity of the chemicals.

- Unknown amounts of various chemicals including Decontaminating Agent Non-Corrosive (DANC) and DS-2 have reportedly been disposed of onsite. DANC consists of separately packaged components of tetrachloroethane and dichlorodimethyl-hydantoin. DS-2 is a mixture of diethylene triamine, 70 percent; methyl cellosolve, 27 percent and sodium hydroxide, 3 percent. Ten-gallon containers of DS-2 were reportedly buried in the skeet range in 1977. Tetrachloroethane was not detected in groundwater samples collected in 1981; see the following paragraph.

- This area was evaluated in 1982 as part of a Confirmation Study prepared by Geraghty and Miller. A copy of the analytical results for groundwater samples collected at this site (soil samples either were not collected or data were not available) is in Appendix K of the E/A&H *Interim Final RFI Work Plan NSY, Charleston, South Carolina*. Groundwater samples had low concentrations, up to 2 ppm of methylene chloride, chloroform, and bis(2-ethylhexyl)phthalate. Analyses did not detect lead, mercury, cadmium, or tetrachloroethane. Levels of pH were elevated, with a high of 8.6 and a range from 6.7 to 8.6.

SWMU 15 was a propane-fired, classified document incinerator constructed in 1983 and retired in 1992. The incinerator's operation involved burning only paper, with no generation of hazardous residues. AOC 670 is the former outdoor trap and skeet range operated from approximately 1960 until the late 1970s. AOC 684 is the former outdoor pistol range in the present vicinity of Building 1888.

Refer to Section 2.3 of this Work Plan for additional background information on this site, summarizing the present level of knowledge, including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and a potential exposure pathways.

Site Activities
Site activities will include soil borings, soil sampling, and the installing of monitoring wells. Subsequent activities will include well development, purging, and sampling as required. A hand auger will be used to collect samples near the anomalous areas identified by the geophysical investigation. Field work for this site is described in Section 2.3 of this Work Plan.

Chemical Hazards and PPE Requirements
The exact nature of the chemical wastes disposed of in SWMU 14 is unknown. A key health and safety concern is what, if any, chemicals are present at high concentrations, percent levels to pure product. While there are reports of chemicals being disposed of at this site, data are limited. The data indicate that at least low concentrations of several contaminants are present onsite; however, higher concentrations of chemicals, indicating widespread chemical disposal, which are suspected to be present have not yet been found. Site history and previous groundwater monitoring data indicate that chemical contaminants are likely to be present here.

Table 4.3 lists the primary chemicals of concern as well as regulatory and recommended exposure guidelines for this site. The primary chemicals of concern were determined based on an informal evaluation of potential site contaminants looking at such factors as: site history, previous sample results, and the toxicity of known and suspected contaminants. Both sodium hydroxide and dichlorodimethy-hydration could cause the chemical burns construction workers experienced in 1972-1974. Furthermore, for both chemicals the presence of water (sweat) would increase the rate of reaction, i.e., increase the likelihood and severity of burns.

Work activities, such as hand augering and sampling that disturb soil or allow potential contact with groundwater, will be performed in Level C PPE. The AL for this site is a continuous PID reading of 5 ppm or greater. If this occurs, work shall discontinue and the required PPE level upgraded to Level B.

Table 4.3
Exposure Guidelines For Expected Site Chemical Hazards—SWMU 14

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Chloroform	133-276 ppm	50 ppm	25 ppm	2 ppm	NA	NA
Dichlorodimethyl hydantoin	NA	0.2 ppm	0.2 mg/m³	0.2 ppm	NA	NA
Diethylene Triamine	NA	1 ppm	1 ppm	NA	1,241 ppm	1 to 10%
Methylene Chloride	158-227 ppm	500 ppm	50 ppm	Lowest feasible	NA	14 to 22%
Sodium Hydroxide	NA	2 mg/m³ (ceiling)	2 mg/m³	2 mg/m³ (ceiling)	NA	NA
Tetrachloroethane	0.23-7.3 ppm	5 ppm	1 ppm 150 ppm STEL	1 ppm 150 ppm STEL	NA	NA

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

Due to the unknown nature of the materials disposed of at SWMU 14 and the form in which they exist (i.e., buried drums, compressed-gas cylinders, etc.) a hand auger will be used to sample near the anomalous areas the geophysical survey identified. In addition, a magnetometer will be used to approximate the target locations and the samples will be collected at least 4 feet from the strongest reading on the magnetometer.

4.6 SWMU 17, Oil Spill Area

SWMU 17 is where approximately 14,000 gallons of No. 5 fuel oil was released in 1987 beneath Building FMB 61. Samples of recovered oil contained PCBs, which are believed to have been released years earlier from leaking transformers onsite. Refer to Section 2.4 of this Work Plan for additional background information on this site, summarizing the present level of knowledge, including; a description of past uses, a previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.4 of this Work Plan.

Chemical Hazards and PPE Requirements

Some samples of oil collected while remedies of the spill contained PCBs. The suspected site contaminants include petroleum hydrocarbons and transformer oil containing PCBs. Table 4.4 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at SWMU 17 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.4
Exposure Guidelines For Expected Site Chemical Hazards—SWMU 17

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Polychlorinated Biphenyls	NA	0.5 mg/m³	0.5 mg/m³	1.0 mg/m³	NA	NA
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.7 AOC 503, UXO Site South of Building 665

AOC 503 contains two Mark 17-Depth Bombs that were reportedly jettisoned from a naval vessel on October 8, 1943. The exact location of the ordnance is not available. Refer to Section 2.5 for additional background information on this site, summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

The CSI for this AOC will be conducted or coordinated by the Navy EOD team. If the two depth bombs are located, the EOD team will be responsible for removal and disposal of the ordnance.

Chemical Hazards and PPE Requirements

Some igniters contain sufficient concentrations of metals to classify them as hazardous waste. Release of hazardous constituents is unlikely unless the depth bomb casings have been damaged or corroded. Non-invasive field activities for AOC 503 may be performed in Level D PPE; invasive activities require modified Level D.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

The most severe threat posed by this AOC is to human safety from an unwanted explosion. That threat is greatly intensified by attempts to remove the UXO from its present location. The EOD team will be responsible for investigating this AOC.

4.8 AOC 653, MWR Hobby Shop

AOC 653 is the MWR hobby shop. Contaminants known or suspected at AOC 653 are associated with a leaking hydraulic fluid tank, and various materials stored and used at the facility. These material include oils, fuels, solvents, paints, and cleaners. Refer to Section 2.6 of this Work Plan additional background information on this site, summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and a summary of potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installation of a monitoring well. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.6 of this Work Plan.

Chemical Hazards and PPE Requirements

The RFA performed by E/A&H indicated that numerous solvents and cleaners were stored and used at the facility. The major constituents of concern are VOCs and petroleum hydrocarbons. Table 4.5 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

Table 4.5
Exposure Guidelines For Expected Site Chemical Hazards—AOC 653

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a	=	Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.
b	=	Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.
c	=	Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993-1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.
d	=	Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*
NA	=	Substance information not available, or substance unlisted.

The initial PPE level for invasive field activities performed at AOC 653 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.9 AOC 655, Oil Spill Area Behind Base Exchange and AOC 656, Area Between Buildings NS-71

AOC 655 is where approximately 300 gallons of No. 2 fuel oil spilled from a ruptured fuel line in 1985, of which an estimated 150 gallons went into the soil. The remainder was collected and removed with sorbent materials. AOC 656 is the site where oil spills reportedly occurred in 1974 and 1975. An estimated 385 gallons was released the first time and 3,800 gallons the second time. Most of the spilled oil was reportedly recovered.

Refer to Section 2.7 of this Work Plan for additional background information on this site, summarizing the present level of knowledge including: a description of past uses, previous site investigations, a list of the principal hazardous materials (known or presumed to have been) used or stored onsite, and a summary of potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.7 of this Work Plan.

Chemical Hazards and PPE Requirements

The major constituents of concern are petroleum hydrocarbons. Table 4.6 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix F. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 655 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.6
Exposure Guidelines For Expected Site Chemical Hazards—AOC 655

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	N.A.	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) recommended exposure guidelines by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.10 AOC 662, Building NS-54, Former Gas Station

Building NS-54 is a former service station currently being used as a non-hazardous material storage area. A 10,000-gallon loss of oil spill and the release of PCBs occurred at this site. The release resulted from a ruptured pipe at Building 600, which is adjacent to Building NS-54.

Refer to Section 2.8 of this Work Plan for additional background information on this site, summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.8 of this Work Plan.

Chemical Hazards and PPE Requirements

The RFA performed by E/A&H indicated the possibility of two USTs reportedly used to store gasoline. Contaminants of concern associated with this AOC would include petroleum hydrocarbons and possibly lead. The documented release of PCBs at the adjacent Building 600 allows the possibility of PCB contamination in this AOC. Table 4.7 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 662 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.7
Exposure Guidelines For Expected Site Chemical Hazards—AOC 662

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Polychlorinated Biphenyls	NA	0.5 mg/m³	0.5 mg/m³	1.0 mg/m³	NA	NA
Tetraethyl Lead	NA	0.075 mg/m³	0.1 mg/m³	NA	NA	NA
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 -1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

4.11 AOC 663, Gas/Diesel Pumping Station and SWMU 136

Refer to Section 2.9 of this Work Plan for background information, summarizing the present level of knowledge for this site and SWMU 136 including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and a summary of potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.9 of this Work Plan.

Chemical Hazards and PPE Requirements

The contaminants of concern for this AOC include petroleum hydrocarbons, solvents, and paints. Table 4.8 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 663 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Table 4.8
Exposure Guidelines For Expected Site Chemical Hazards—AOC 663

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
PCBs	NA	0.5 mg/m^3	0.5 mg/m^3	1.0 mg/m^3	NA	NA
Tetraethyl Lead	NA	0.075 mg/m^3	0.1 mg/m^3	NA	NA-	NA
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%

Table 4.8
Exposure Guidelines For Expected Site Chemical Hazards—AOC 663

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Kerosene	1 ppm	NA	NA	100 mg/m³	935	0.7 to 5.0%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0 %

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 -1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.12 AOC 667, Vehicle Area (Includes SWMU 138)

The routine maintenance of automotive and heavy equipment is the only activity reported to have occurred here. This SAA is an element of the Naval Shipyard hazardous waste management system. Wastes at this location are stored in a 55-gallon drum.

Refer to Section 2.10 to additional background information on this site summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installing of monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.10 of this Work Plan.

Chemical Hazards and PPE Requirements

The risk RFA performed by E/A&H indicated that numerous automotive fluids — including engine oil, transmission fluid, antifreeze, starting fluid, isopropyl alcohol, corrosion inhibitor, windshield solvent, silicone brake fluid, diesel fuel conditioner, grease, degreaser and propane — have been stored and utilized at the facility. Table 4.9 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 667 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Table 4.9
Exposure Guidelines For Expected Site Chemical Hazards—AOC 667

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%
Lead	NA	0.5 mg/m^3	0.15 mg/m^3	<0.10 mg/m^3	NA	NA

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.13 Other Sites Designated for CSI

4.13.1 AOC 659, Diesel Storage

AOC 659 contains a 5,238-gallon steel AST in a 5-foot-high earthen berm. The AST reportedly stored diesel from 1958 until 1990. The structure is no longer used. There is no information regarding spills in this AOC.

Site Activities

Site activities will include soil borings, and soil sampling. Field work for this site is described in Section 2.11 of this Work Plan.

Chemical Hazards and PPE Requirements

The major constituent of concern at AOC 659 is petroleum hydrocarbon. Table 4.10 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 659 is modified Level D PPE. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the PPE level shall be upgraded to Level C.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.13.2 AOC 660, Mosquito Control

AOC 660 was listed as used for mosquito control operations in the 1950s. Currently, the AOC is an asphalt parking lot northwest of Building NS-53. There is no record of the operations or materials used here. However, it is suspected that the area was used to store, mix, and rinse pesticides. Common practice involved draining rinsate containing pesticides directly onto the ground.

Table 4.10
Exposure Guidelines For Expected Site Chemical Hazards—AOC 659

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Kerosene	1 ppm	NA	NA	100 mg/m^3	935	0.7 to 5.0%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

[a] = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

[b] = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

[c] = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

[d] = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Refer to Section 2.11 for this Work Plan for additional background information on this site, summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will include soil borings, soil sampling, and the installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.11 of this Work Plan.

Chemical Hazards and PPE Requirements

Table 4.11 list exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

Due to the unknown type or quantities of pesticides potentially present in the soil, all field work that will disturb soil or require contact with groundwater should be performed in Level C PPE until analytical data can be evaluated for possible consideration of a downgrading Level D PPE. The AL for this site is a continuous PID reading of 10 ppm or greater. If this occurs, work activities shall be discontinued until arrangements can be made to resume work in Level B.

Table 4.11
Exposure Guidelines For Expected Site Chemical Hazards—AOC 660

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
DDT	NA	1 mg/m^3	1 mg/m^3	0.5 mg/m^3	NA	NA
Chlordane	NA	0.5 mg/m^3	0.5 mg/m^3 2.0 mg/m^3 STEL	potential occupational carcinogen	NA	NA
Dieldrin	0.041 ppm	0.25 mg/m^3	0.25 mg/m^3	potential occupational carcinogen	NA -	NA
Arsenic	NA	0.01 mg/m^3	0.2 mg/m^3	0.002 mg/m^3 potential occupational carcinogen	NA	NA

Table 4.11
Exposure Guidelines For Expected Site Chemical Hazards—AOC 660

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp (°F)	Flammable range (% by volume)
Toxaphene	NA	0.5 mg/m^3 1.0 mg/m^3 STEL	0.5 mg/m^3 1.0 mg/m^3 STEL	potential occupational carcinogen	NA	NA
Malathion	NA	10 mg/m^3	10 mg/m^3	15 mg/m^3	NA	NA

Notes:
a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.
b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.
c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.
d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*
NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.13.3 AOC 661, Former Explosives Storage Site

Unknown explosives were stored during the 1950s in a now demolished building. It is not known exactly when this building was occupied, constructed, or demolished. Section 2.11 provides additional background information on this site summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will be performed by EOD, as described for AOC 503. Field work for this site is described in Section 2.11 of this Work Plan.

Chemical Hazards and PPE Requirements

It is unknown what contaminants may be present in this AOC.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

Because of the risk from explosives stored at this AOC, the investigation will be performed by EOD.

4.13.4 AOC 665, Former Building 159

Unknown pyrotechnic explosives were stored in the now demolished shed. It is not known when this shed was constructed or demolished. The nature of the stored materials and the operational practices are not known for this AOC. Building NS-46 now occupies this site.

Section 2.11 of this Work Plan provides additional background information on this site summarizing the present level of knowledge including: a description of past uses, previous site investigations, principal hazardous materials (known or presumed to have been) used or stored onsite, and potential exposure pathways.

Site Activities

Site activities will be performed by EOD, as described for AOC 503. Field work for this site is described in Section 2.11 of this Work Plan.

Chemical Hazards and PPE Requirements

Table 4.12 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 665 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

Because of the risk from explosives stored at this AOC, the investigation will be performed by EOD.

4.13.5 AOC 666, Facility NS-45 Fuel Storage

NS-45 was constructed in 1958 and stores No. 2 fuel oil. The oil is stored in a UST enclosed by railroad ties. The oil is pumped to NS-44, which generates heat for the base.

Site Activities

Site activities will include soil borings, soil sampling, and the installing monitoring wells. Subsequent activities will include well development, purging, and sampling as required. Field work for this site is described in Section 2.11 of this Work Plan.

Table 4.12
Exposure Guidelines For Expected Site Chemical Hazards—AOC 665

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:
a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.
b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.
c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.
d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*
NA = Substance information not available, or substance unlisted.

Chemical Hazards and PPE Requirements

The contaminant of concern at AOC 666 is petroleum hydrocarbon. Table 4.13 lists exposure guidelines for expected site chemicals. MSDS for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDS will be immediately obtained, reviewed, and incorporated into the ZHHASP.

The initial PPE level for invasive field activities performed at AOC 666 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE shall be upgraded to Level C.

Table 4.13
Exposure Guidelines For Expected Site Chemical Hazards—AOC 688

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

a = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.

b = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.

c = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 - 1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.

d = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*

NA = Substance information not available, or substance unlisted.

Radiological Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.13.6 SWMU 178

SWMU 178 is the site of a recently discovered (June 1994) release of PCB containing transformer oils. The site is just south of Building X33-A.

Site Activities

Site activities will include soil borings and soil sampling. Field work for this site is described in Section 2.11 of this Work Plan.

Chemical Hazards and PPE Requirements

It is likely that PCB-contaminated oil exists in this site. Also, petroleum hydrocarbons may be present. Table 4.14 lists exposure guidelines for expected site chemicals. MSDSs for suspected site contaminants of concern are included in Appendix H. If additional contaminants of concern are discovered during the investigation, MSDSs will be immediately obtained, reviewed, and incorporated into the ZHHASP.

Table 4.14
Exposure Guidelines For Expected Site Chemical Hazards—AOC 665

Chemical Name	Odor[a] Threshold	OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Auto-ignition Temp.(°F)	Flammable range (% by volume)
PCBs	NA	0.5 mg/m³	0.5 mg/m³	1.0 mg/m³	NA	NA
Toluene	40 ppm	100 ppm 150 ppm STEL	50 ppm	100 ppm 150 ppm STEL	996.5	1.3 to 7.1%
Ethylbenzene	140 ppm	100 ppm 125 ppm STEL	100 ppm 125 ppm STEL	NA	860	1.0 to 6.7%
Benzene	4.68 ppm	1 ppm 5 ppm STEL	0.1 ppm Confirmed Human Carcinogen	0.1 ppm 1 ppm STEL Potential Occupational Carcinogen	1,097	1.3 to 7.1%
Xylene	NA	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	100 ppm 150 ppm STEL	NA	1.0 to 7.0%

Notes:

[a] = Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.
[b] = Permissible Exposure Limits (PELs) are legal standards enforced by OSHA and found in 29 CFR 1910.1000.
[c] = Threshold Limit Values, and Short-term Exposure Limits (TLVs and STELs) are recommended exposure guidelines developed by the American Conference for Governmental Industrial Hygienists (ACGIH), and published annually. For this site, *1993 -1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* was used.
[d] = Recommended Exposure Limits (RELs) are non-enforceable exposure guidelines developed by the National Institute for Occupational Safety and Health (NIOSH) to support OSHA. *NIOSH Pocket Guide to Chemical Hazards, June 1990.*
NA = Substance information not available, or substance unlisted.

The initial PPE level for invasive field activities performed at SWMU 178 is modified Level D. The AL for this site is a continuous PID reading of 5 ppm or greater in the breathing zone. If this occurs, the required PPE level shall be upgraded to Level C.

Radialogical Hazards

Radiological screening and frisking procedures relative to the site are described in detail in Appendix F.

Site-specific Operational and Physical Hazards

See Section 4.14.

4.14 General Operational and Physical Hazards

Field personnel should be aware of and act in a manner to minimize the dangers associated with physical hazards typically encountered during environmental investigations. These hazards include heat-related illnesses, uneven terrain, slippery surfaces, lifting, and using heavy equipment. Electrical lines may be present either above or below ground, and underground gas lines may be present. Before drilling activities begin, drilling locations must be cleared by the Naval Public Works Center (PWC).

The Site Supervisor and the Site Health and Safety Officer (SHSO) shall be aware of the potential for heat stress and other environmental illnesses. When necessary, work regimens should be implemented that will minimize the potential for employee illness.

Heavy equipment and drill rig operations will be performed in accordance with the procedures outlined in the CHASP, Appendix F, Drilling Safety Guide. When conducting operations or survey work on foot, personnel will walk. Running greatly increases the probability of slipping, tripping, and falling. If working in areas supporting a habitat for poisonous snakes, personnel should wear protective chaps made of heavy material designed to prevent snake bites to the lower extremities.

4.15 Employee Protection

Employee protection for this project is addressed in several ways including the use of: work limitations, specified PPE air monitoring, decontamination procedures, standard safe work practices, general rules of conduct, procedures for extreme weather conditions, and medical surveillance.

4.15.1 Work Limitations

All site activities will be conducted during daylight only. All personnel scheduled for these activities will have completed initial health and safety training and actual field training as specified in 29 CFR 1910.120(e). All supervisors must complete an additional eight hours of HAZWOPER Site Supervisor training. All personnel must complete an eight-hour refresher training course annually to continue working onsite.

4.15.2 Selecting PPE

It is important that specified PPE protects against known and suspected site hazards. PPE is selected based on the types, concentrations, and routes of personal exposure that may be encountered. In situations where the types of materials and possibilities of contact are unknown or the hazards are not clearly identifiable, a more subjective determination must be made of the PPE required, and a greater emphasis is placed on past experiences and sound safety practices.

PPE requirements are subject to change as site information is updated or changes. A decision to deviate from specified levels of PPE as contained in this ZHHASP must be made or reviewed by the Project Health and Safety Officer (PHSO).

Initial Level of PPE

Based on the best available information, the appropriate level of PPE for initial site entry is modified Level D. Modified Level D shall be the initial PPE for work activities that disturb the soil or could result in personnel coming into contact with contaminated soil, sediment, groundwater, or surface water. This level of protection was selected because the concentrations of contaminants detected in the previous studies were low and free product was not detected. Modified Level D protection consists of a hard hat, chemical-resistant coveralls and gloves (vinyl or nitrile), eye protection, and steel-toed and shank boots.

Examples of activities to be initiated in Modified Level D include: soil boring, well installation and construction, soil sampling, and well development. Collecting groundwater samples and determining water levels are two field activities than can be conducted in Level D as long as field personnel supplement their Level D attire with nitrile gloves (outer gloves, not the 4-mil nitrile inner glove liners). The history and nature of potential contaminants at specific site locations may indicate a higher or lower level of initial PPE. In these cases, the PPE requirements are defined in the Chemical Hazards and PPE Requirements subsections.

4.15.3 Air Monitoring

Air monitoring using a PID and/or other appropriate sampling equipment will be conducted before beginning field activities at a new EZ and during ground- disturbing activities. The PID will be field calibrated to measure VOCs relative to a 100 ppm isobutylene standard. If VOCs are detected downhole, colorimetric detector tubes and/or other sampling media may be used to determine the identification and approximate concentration of these compounds.

The PHSO reserves the right to require personal exposure monitoring or other types of air sample collection and analysis. These samples may be required for a variety of reasons such as: to identify a chemical odor, PID readings exceed or approach the action level, or to determine if personal exposures are below Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).

A combustible gas indicator (CGI) will be used during all soil borings and well installations. The CGI will be field calibrated to measure flammable gases relative to a methane standard.

Downhole CGI readings will be collected periodically during soil disturbing operations. Field activities will immediately cease if downhole readings exceed 20 percent of the lower explosive limit (LEL). If CGI readings do not subside, the area will be immediately evacuated and the situation re-evaluated to determine how to proceed. An investigation of the area will be made; operations may not proceed until downhole readings are below 20 percent LEL.

Action Level and Ceiling Concentration

Each site at NAVBASE has a designated action level and ceiling concentration. For this project the AL is defined as the PID reading in the breathing zone above which respiratory protection must be upgraded; chemical-protective clothing may also be upgraded. The AL is determined on a site-by-site basis. To exceed the AL, PID readings should be sustainable. Readings should remain above the AL for at least one or two minutes at a time. Readings that are elevated for only a couple of seconds every 15 or 20 minutes do not exceed the AL and do not require workers to upgrade their level of PPE.

The general AL for this zone, as determined on a properly calibrated PID, is 5 PID units above background. PPE shall be upgraded to Level C (assuming that cartridge respirators are appropriate, otherwise Level B) if airborne VOC concentrations in the breathing zone exceed the AL, or if the concentration of any contaminant exceeds 50 percent of the OSHA PEL. This baseline AL and PPE requirement may be superseded by more stringent site-specific levels, as identified in each Site Chemical Hazard and PPE requirements section.

If breathing zone levels exceed the AL, or site conditions indicate additional health and safety precautions are needed, field activities in the area shall stop. Field staff shall notify the Site Supervisor of the situation and he/she shall contact the Project Manager and/or the PHSO. The PHSO will be responsible for reassessing the hazards and prescribing revised health and safety requirements as necessary, including upgraded PPE requirements, revised work schedules, and revised decontamination procedures. See Table 4.15 for specific criteria for each protection level.

If PID readings exceed 10 units, the SHSO shall contact the PHSO and discuss the need to identify and quantify airborne contaminants. Work shall not proceed until breathing zone concentrations return to background levels and it is reasonably anticipated that breathing zone readings will stay approximately at background, or the chemical constituent(s) are identified and appropriate PPE is donned.

Table 4.15
Level of Protection and Criteria

Level of Protection	Criteria for Use	Equipment
Level A	• When atmospheres are "immediately dangerous to life and health" (IDLH in the NIOSH/OSHA Pocket Guide to Chemical Hazards or other guides.) • When known atmospheres or potential situations exist that could affect the skin or eyes or be absorbed into the body through these surfaces. Consult standard references to obtain concentrations hazardous to skin, eyes, or mucous membranes. • Potential situations include those where immersion may occur, vapors may be generated, or splashing may occur through site activities. • Where atmospheres are oxygen deficient. • When the type(s) and or potential concentration of toxic substances are not known.	• Positive-pressure full-face piece self-contained breathing apparatus (SCBA) or positive-pressure supplied air respirator (SAR) with escape SCBA. • Fully-encapsulating chemical protective suit. • Chemical-resistant inner and outer gloves. • Steel toe and steel shank chemical resistant boots. • Hard hat under suit. • Two-way radios worn inside suit. • Optional: coveralls, long cotton underwear, disposable protective suit, gloves and boots, over fully encapsulating suit.
Level B	• When respiratory protection is warranted and cartridge respirators are not appropriate. Examples of these conditions are: — when work area may contain less than 19.5 percent oxygen, — when expected contaminants do not have appropriate warning properties, e.g., vinyl chloride, or — when cartridges are not available to protect against all contaminants of concern. • Hazards associated with limited dermal exposure are not significant.	• Chemical-resistant clothes, coveralls. • Positive-pressure full-face SCBA or SAR with escape bottle. • Hard hat • Chemical-resistant outer and inner gloves. • Steel toe and steel shank boots. • Chemical-resistant outer boots.
Level C	• When respiratory protection is warranted and cartridge respirators are appropriate. • When PID readings exceed the Action Level. • When air monitoring indicates airborne concentration of a chemical is 50 percent or more of the PEL or TLV • And the work area contains at least 19.5 percent oxygen.	• Chemical-resistant coveralls. • Full-face, air purifying respirator equipped with cartridges suitable for the hazard. • Hard hat. • Chemical-resistant outer and inner gloves. • Steel toe and steel shank boots. • Disposable outer boots.

Table 4.15
Level of Protection and Criteria

Level of Protection	Criteria for Use	Equipment
Modified Level D	• When chemical contamination is known or expected to be present, yet inhalation risk is low and respiratory protection is not required. • Site contaminants may be absorbed through the skin. • The "default level" of PPE required when the ZHHASP does not specify another level of PPE. • And the work area has at least 19.5 percent oxygen.	• Chemical resistant coveralls. • Chemical resistant outer gloves; inner gloves or glove liners, optional. • Steel toe and steel shank boots. • Hard hat. • Safety glasses with side shields or safety goggles. • Optional: chemical-resistant outer boots.
Level D	• When minimal or no chemical contamination is expected. • When ZHHASP specifies Level D protection is adequate. • The work area has at least 19.5 percent oxygen.	• Inner gloves or chemical-resistant gloves needed to handle soil or water samples. • Steel toe and steel shank boots. • Hard hat. • Safety glasses with side shields or safety goggles. • Optional: coveralls and disposable outer boots. • Work clothes.

The ceiling concentration is defined as the maximum allowable PID reading in the breathing zone regardless of PPE. A ceiling concentration of 50 PID units has been established. Should VOC concentrations exceed 50 ppm in the breathing zone, field workers should secure their equipment and back off the site. Work shall not resume until the Site Supervisor understands why VOC levels became elevated, knows the major constituents of the VOCs being generated, and the VOCs in the breathing zone are less than 5 ppm or workers have upgraded to Level C or B. The proper PPE upgrade shall be determined by the PHSO based on site-specific chemical information, i.e., is there enough information to determine that air-purifying respirators will provide sufficient protection.

Field monitoring values will be recorded in a field logbook and copies must be posted for field personnel review.

Equipment Maintenance

Before being used daily, PIDs, CGIs, and other monitoring equipment shall be calibrated or their proper function verified. Throughout the day this equipment shall be periodically checked to ensure it is working properly. A final calibration shall be conducted at the end of the work day, at which time each instrument will be checked to ensure that it is free from surface contamination. Air monitoring equipment shall detect the calibration standard within a range of plus or minus 10 percent, otherwise the instrument shall be considered malfunctioning. Field staff shall note in their field notebooks that they conducted these calibrations and checks and note whether the equipment was functioning properly.

When equipment is not functioning properly it should be brought to the attention of the Site Supervisor or SHSO, who will arrange to repair or replace that equipment as needed.

4.16 Personnel and Equipment Decontamination

As needed, a CRZ will be established adjacent to EZs established for invasive activities, and will include stations for decontaminating personnel, PPE, and hand tools. Typically, a portion of the CRZ will be covered with sheets of 6-mil polyethylene (generally, an area 20-feet by 20-feet is sufficient) with specific stations to accommodate removing and disposing of the protective clothing, boot covers, gloves, and respiratory protection.

Heavy equipment and field equipment that cannot adequately be decontaminated in the CRZ may be decontaminated on a more centrally located decontamination pad. Table 4.16 lists of equipment that may be convenient to have onsite to decontaminate heavy equipment and vehicles; this table also explains how this equipment may be used.

Table 4.16
Equipment Recommended for Decontaminating Heavy Equipment and Vehicles

- Storage tanks or drums to be used for storing collected wash and rinse solutions, alternatively, equipment for the treatment of collected wash and rinse solutions may be substituted.
- Pumps, and filters as needed to collect wash and rinsate solutions.
- Pressurized steam sprayers for steam-cleaning equipment.
- Long-handled brushes for general cleaning of exterior surfaces. Also shovels and other equipment may be used to dislodge caked-on contaminated mud that may be present on the undercarriage or in the tires.
- Wash solutions, selected for their ability to remove (dissolve, etc.) contaminants
- Rinse solutions, selected for their ability to remove contaminants and wash solutions.
- Pressurized sprayers for washing and rinsing, particularly hard to reach areas.
- Clean buckets that can contain cleaning and rinsing solutions.
- Brooms and brushes that can be used to clean the interior, operator areas of vehicles and equipment.

Figure 4-1 shows one method of laying out an acceptable decontamination area for Level B PPE. There are numerous ways to lay out decontamination areas. Decontamination areas for Level C and Modified D PPE should be based on this concept of decontamination, but can be scaled back in accordance with the decontamination needs of the specific site and level of PPE. As a general rule, people working in the CRZ, helping to decontaminate workers leaving the EZ, shall be outfitted in PPE that is one protection level below what the exiting workers are using. For example, if workers leave the EZ in Level C, personnel in the CRZ should be in Modified D.

Often equipment may be adequately decontaminated using a soapy wash solution and following specified rinsing procedures. Normally equipment decontamination will be completed in Level D with gloves or Modified D PPE.

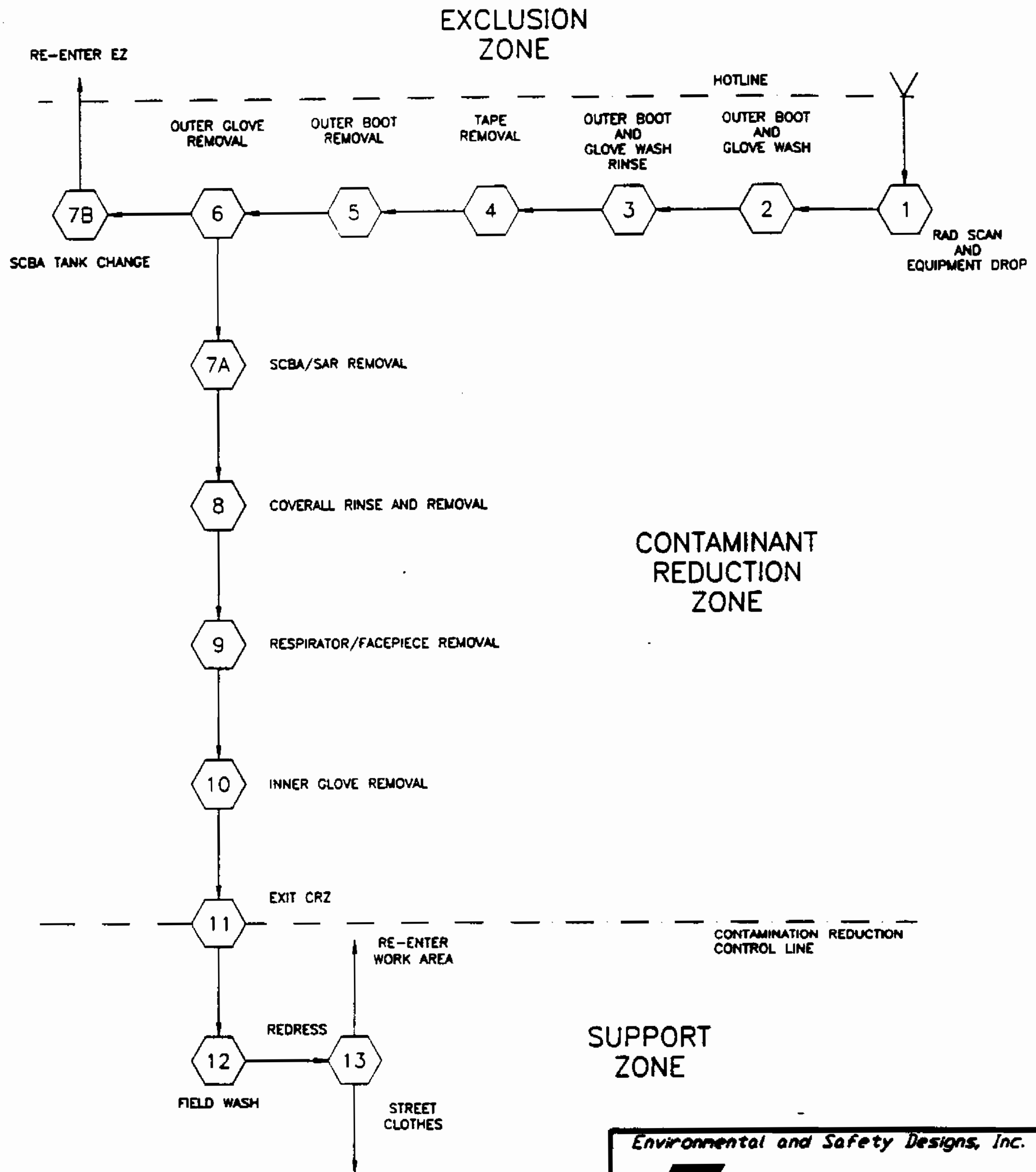


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FIGURE 4-1

FULL DECONTAMINATION LAYOUT
LEVEL B PROTECTION

DATE: 11/22/93	DWG NAME: CNS0001.DWG

In inclement weather (e.g., lightning) or an emergency requiring immediate evacuation, contaminated equipment will be bagged or wrapped and taped in 6-mil polyethylene sheeting and tagged as "contaminated" for later decontamination. Respirators not only need to be decontaminated and cleaned between uses, but also need to be sanitized. Alcohol swabs generally suffice.

4.16.1 Full Decontamination Procedures

Workers shall use the following cleaning and decontamination procedures when exiting the EZ. These procedures should be followed when workers are leaving the area for lunch, at the end of their shift, or when work is completed for an EZ. Procedures for rest breaks, are changing SCBA tanks and cartridges are described in Section 4.16.2. Not all steps apply to every situation; follow applicable procedures. Decontamination procedures shall start at the EZ/CRZ interface and continue away from the EZ toward the SZ.

Full Decontamination

1. ***Radiation monitoring***. If radioactive monitoring is in effect, scan hands, feet, and equipment with radiation detector.

2. ***Equipment drop***. Deposit equipment used onto plastic drop cloths or into a plastic-lined tub. All gross contamination should be removed here, fine cleaning and decontamination of equipment may be completed here or elsewhere. Prior to moving equipment that is still contaminated, it must be wrapped and taped.

3. ***Outer boot and glove wash***. Wash/remove gross contamination from outer boots, outer gloves, SCBA and/or airline equipment.

4. ***Tape removal***. Remove tape from ankles and wrists and dispose of in plastic-lined drum.

5. ***Outer boot removal***. Remove outer boots, disposable outer boots may be disposed of in the same waste container used in Step 4. Non-disposable boots need a thorough cleaning before they can be removed from the site. (If non-disposable boots are used, it is preferable to have them dedicated to the project.)

6. ***Outer glove removal***. Remove and dispose of outer gloves. Gloves may be disposed of in the same waste container as used in Step 4.

7. ***SCBA and SAR removal***. For Level B*.

   SCBA — With buddy or other site worker, remove backpack, remove facepiece, and shut off air flow.

   Sar — With buddy or other site worker, remove harness and escape bottle, remove facepiece, shut off air flow.

   * If coveralls are significantly contaminated, leave the respirator facepiece on, disconnect the air hose just downstream of the regulator, turn off the air flow, remove the backpack or equipment harness, and leave the facepiece in place. Remove the facepiece in Step 9.

8. ***Coverall removal***. Rinse coveralls, if needed; remove coveralls and dispose of them. The same drum may be used as in Step 4. Non-disposable coveralls shall be double-bagged with the outer bag clearly labeled "contaminated."

9. ***Respirator removal***. Remove respirator (or facepiece of Level B equipment, if it is still being worn). Dispose of spent cartridges, clean, disinfect, dry, and properly store respirator or facepiece.

10. ***Inner glove removal***. Remove and dispose inner gloves.

11. ***Exit area***. Exit the CRZ via the SZ.

12. ***Field Wash***. Wash and rinse hands and face.

13. ***Redress***. Redress into appropriate PPE for re-entry or change into street clothes.

Notes:

- All wastes (soil and water) generated during personal decontamination will be collected in 55-gallon drums. The drums will be labeled by E/A&H personnel; final disposal will be done by the Navy.
- Hard hats and eye protection should be washed at the end of each workday with a soap and water solution.

4.16.2 Partial Decontamination Procedures

To change a respirator cartridge or SCBA tank:

1. ***Radiation monitoring***. If radioactive monitoring is in effect, scan hands, feet, and equipment with radiation detector.

2. ***Outer boot and glove wash***. Wash outer boots and gloves. Wash/remove gross contamination from SCBA and/or SAR equipment.

3. ***Tape removal***. Remove tape from ankles and wrists and dispose of it in a plastic lined drum.

4. ***Facepiece removal***. Disconnect facepiece and air hose just downstream of regulator. The facepiece may remain in place, or be removed and cleaned. Remove the spent tank from the backpack and replace it with a full tank. Connect air hose and turn on air.

5. ***Respirator removal.*** Remove respirator, remove used cartridges, clean and disinfect respirator, install new cartridges, and don respirator.

6. ***Respirator check.*** Check to make sure that respirator still seals properly to your face.

7. ***Don clean PPE.*** Put on clean outer gloves, tape wrists (as applicable), and re-enter EZ.

When taking a rest break:

1. ***Radiation monitoring.*** If radioactive monitoring is in effect, scan hands, feet, and equipment with radiation detector.

2. ***Outer boot and glove wash.*** Wash outer boots and gloves. Wash-remove gross contamination from SCBA and/or SAR equipment.

3. ***Tape removal.*** Remove tape from ankles and wrists and dispose of it in a plastic-lined drum.

4. ***Respirator removal.*** Remove SCBA unit, SAR harness, and place in a clean area; plastic sheeting may be needed.

5. ***Coverall removal.*** Remove outer wear if it is ripped or significantly contaminated. In hot weather, at least unzip and pull down upper half of coveralls.

6. ***Inner glove removal.*** Remove and dispose of inner gloves.

7. ***Wash.*** Wash and rinse hands and face at the field wash station.

8. ***Rest break***. Take rest break; remember to drink plenty of water, Gatorade, or similar beverage.

9. ***Don inner gloves***. Put on inner gloves.

10. ***Don PPE***. Don coveralls, outer boots, and outer gloves. Tape wrists and ankles (as needed), and re-enter the EZ.

Decontamination procedures, based on Level D protection:

- Brush heavily soiled boots and rinse outer gloves and boots with soap and water.
- Remove gloves and deposit in a trash container.
- Dispose gloves and other disposable PPE in a trash container.
- Wash hands and face, and preferably shower as soon as practical.

4.16.3 Closure of the Decontamination Station

All disposable clothing and plastic sheeting used during site activities at sites with Level D through Level C will be double-bagged and disposed of in a refuse container. Decontamination and rinse solutions and disposable PPE from Level B site will be placed in a labeled 55-gallon drum (separate solids and liquids) for later analysis and disposal. All washtubs, pails, buckets, etc., will be washed and rinsed at the end of each workday.

4.17 Procedures and Equipment for Extreme Hot or Cold Weather Conditions

For a discussion of the more common heat-and cold-related illnesses and their associated symptoms, see CHASP Section 6.5.1. Monitoring of heat stress conditions (area and personal) will be employed during hot weather conditions and/or when elevated levels of PPE are used.

Severe Weather Conditions

Field work shall not be conducted when lightning can be seen from the work area. When lightning is observed, cease work, perform emergency personal and equipment decontamination (see Section 4.16) if need be, then seek shelter.

4.18 Standard Safe Work Practices:

- Eating, drinking, chewing gum or tobacco, smoking, or any activity that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any area designated as contaminated, unless authorized by the SHSO.
- Hands and face must be thoroughly washed upon leaving the work area.
- No contact lenses will be worn in work areas while invasive activities are conducted.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as practical after leaving the CRZ.
- Contact with contaminated or suspected contaminated surfaces should be avoided. Whenever possible, do not walk through puddles, leachate, or discolored surfaces, or lean, sit, or place equipment on drums, containers, or on soil suspected of being contaminated.
- Medicine and alcohol can exacerbate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel on cleanup or response operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Consumption of alcoholic beverages is prohibited.
- Adequate side and overhead clearance must be maintained to ensure that the drill rig boom does not touch or pass close to any overhead power lines or other overhead obstacles or obstructions.
- NAVBASE Public Works and local utility representatives shall be contacted and requested to identify all underground utility lines. Utility lines should be marked using

characteristic spray paint or labeled stakes. A buffer zone, 3 yards to either side of a utility line, should be maintained during all subsurface investigations.

- Due to the flammable properties of the potential chemical hazards, all spark or ignition sources should be bonded and/or grounded or mitigated before soil boring advancement or other site activities begin.

4.19 General Rules of Conduct

- Liquor, firearms, narcotics, tape recorders, and other contraband items are not permitted on the premises.
- Any violation of local, state, or federal laws, or conduct is outside the generally accepted moral standards of the community is prohibited.
- Violation of the Espionage Act, willfully hindering or limiting production, or sabotage is not permitted.
- Willfully damaging or destroying property, or removing government records is forbidden.
- Misappropriation or unauthorized altering of any government records is forbidden.
- Securing government tools in a personal or contractor's tool box is forbidden.
- Gambling in any form, selling tickets or articles, taking orders, soliciting subscriptions, taking up collections, etc., is forbidden.
- Doing personal work in government shop or office, using government property or material for unauthorized purposes, or using government telephones for unnecessary or unauthorized local or long-distance telephone calls is forbidden.
- Compliance with posted signs and notices is required.
- Boisterousness and noisy or offensive work habits, abusive language, or any verbal, written, symbolic, or other communicative expression which tends to disrupt the work or morale of others is forbidden.
- Fighting or threatening bodily harm to another is forbidden.
- Defacing any government property is forbidden.

- Wearing shorts of any type and/or offensive logos, pictures, or phrases on clothing is forbidden. Shirts, shoes and pants or slacks, or coverall-type garments will be worn at all times on government property.
- All persons operating motor vehicles will obey all NAVBASE traffic regulations.

4.20 Medical Monitoring Program

See CHASP Section 7.0.

4.21 Authorized Personnel

Personnel anticipated to be onsite at various times during site activities include:

- Engineers-in-Charge — Matthew A. Hunt Southern Division, Naval Facilities Engineering Command (SOUTHDIV)
  Thuane Fielding
- Site Contact — Bill Brasel (NAVBASE)
- Principal-In-Charge — James Speakman (E/A&H)
- Task Order Manager/Project Manager — Todd Haverkost (E/A&H)
- Project Health & Safety Officer — David Isenberg (E/A&H)
- Site Supervisor — Britton Dotson (E/A&H)
- Site Health & Safety Officer — TBA

Responsibilities of Key Field Staff

Key field staff for this project, in terms of health and safety are:

- Site Supervisor,
- Site Health and Safety Officer, and
- (All) Field Staff.

The primary health and safety responsibilities associated with each of these positions are delineated in CHASP, Sections 8.1, 8.2 and 8.3, respectively.

4.22 Emergency Information

All hazardous waste site activities present a potential risk to onsite personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper PPE. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated.

If any situation or unplanned occurrence requires outside emergency, immediately call the appropriate contact from the following list:

Contact	**Agency or Organization**	**Telephone**
Bill Brasel	Naval Base Charleston, Site Contact	(803) 743-5519
Matthew A. Hunt Thuane Fielding	SOUTHDIV Engineers-in-Charge	(803) 743-0525 (803) 743-0513
Law Enforcement	NAVBASE Security	(803) 743-5555
Fire Department	NAVBASE Fire Department	(803) 743-5333
Ambulance Service	NAVBASE Ambulance	(803) 743-5444
Hospital	Charleston Naval Hospital Baker Hospital	(803) 743-7000 (803) 744-2110
Southern Poison Control Center	—	(800) 922-1117
Todd Haverkost	EnSafe/Allen & Hoshall Task Order Manager	(803) 747-7937
David Isenberg	EnSafe/Allen & Hoshall PHSO	(615) 399-8800
Britton Dotson	EnSafe/Allen & Hoshall Project Manager	(615) 399-8800

* Use Charleston Naval Hospital for (potentially) life-threatening situations, for medical needs that are less urgent, the naval Hospital will not serve civilians; Baker Hospital is the next closest appropriate medical facility.

As soon as practical, Messrs. Bill Brasel, NAVBASE; Matthew Hunt and Thuane Fielding, SOUTHDIV Engineers-in-Charge; Todd Haverkost, E/A&H Project Manager; and David Isenberg, E/A&H PHSO, shall be fully apprised of the situation. Other persons, as appropriate, may also need to be contacted.

4.22.1 Site Resources

A cellular telephone will be available in the SZ for routine and emergency communication/ coordination with NAVBASE, SOUTHDIV, and the E/A&H field office. First-aid and eye wash equipment will be available at the work area and in each field vehicle.

4.22.2 Emergency Procedures

Examples of an emergency include:

- A fire, explosion or similar event at or near the site whether related to this project or not;
- A member of the field crew sustains a significant injury, or experiences symptoms of a chemical exposure; or
- The discovery of a condition suggests that site conditions are imminently more dangerous or hazardous than anticipated.

In the an emergency, the following procedures should be followed:

- If it is necessary to evacuate the area, immediately proceed to a rally point and remain there until instructed otherwise.
- Use planned escape routes.

- If a member of the field team experiences effects or symptoms of exposure while on the scene, the field crew will immediately halt work and act according to the instructions provided by the Site Supervisor or, in his absence, the SHSO.
- For applicable site activities, including all Level B activities, use wind indicators to continuously indicate downwind, preferred escape routes, from upwind routes.
- Investigate condition(s) suggesting that site conditions may be more hazardous than anticipated. The condition observed and the decisions made shall be recorded in the safety logbook, or in the field logbook if a safety logbook is not being maintained. If there are doubts about how to proceed, suspend work and leave the work area until the PHSO has evaluated the situation and provided the appropriate instructions to the field team.
- If an accident occurs, the Site Supervisor is to complete an Accident Report Form (see Appendix J) for submittal to the managing Principal-in-Charge of the project.
- If a member of the field crew suffers a personal injury, the SHSO will call NAVBASE Fire Department 743-5333 or 5444 if an ambulance is needed. Next, alert appropriate emergency response agencies as the situation dictates. Complete an Accident Report Form for any such incident.
- If a member of the field crew suffers chemical exposure, flush the affected areas immediately with copious amounts of clean water, and if the situation dictates, the SHSO should alert appropriate emergency response agencies, or personally ensure that the exposed individual is transported to the nearest medical treatment facility for prompt treatment. (See Appendix I for directions to the emergency medical facility.) An Accident Report Form will be completed for any such incident.

Additional information on appropriate chemical exposure treatment methods will be provided through MSDS in Appendix H of this ZHHASP. Directions to the nearest emergency medical facility capable of providing general emergency medical assistance and treating chemical burns are provided in Appendix I of this ZHHASP.

4.23 Forms

The following forms will be used in implementing this Health and Safety Plan:

- Plan Acceptance Form
- Plan Feedback Form
- Exposure History Form
- Accident Report Form

A ZHHASP Plan Acceptance Form will be filled out by all employees working onsite before site activities begin. The Plan Feedback Form will be filled out by the SHSO and any other onsite employee who wishes to do so. The Exposure History Form will be completed by both the Field Project Manager and the individual(s) for whom the form is intended. Examples of each form are provided in Appendix J of this plan.

All completed forms must be returned to the Task Order Manager at EnSafe/Allen & Hoshall, Charleston, South Carolina.

5.0 SIGNATORY REQUIREMENT

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

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

11/2/94	
Commander,	**Date**
Charleston Naval Shipyard	

6.0 REFERENCE LIST

Ebasco Services, Inc. August 1987. Interim RCRA Facility Assessment of USN Charleston Naval Shipyard.

Environmental and Safety Designs, Inc. March 26, 1993. *Preliminary RFI Field Activity Report (Soil-Gas, Geophysics).*

EnSafe/Allen & Hoshall. August 30, 1994. *Final Comprehensive Corrective Action Management Plan.*

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EnSafe/Allen & Hoshall. June 13, 1994. *Draft RCRA Facility Assessment for Naval Base Charleston, Volume II.*

Environmental Science and Engineering, Inc. May 1983. *Initial Assessment Study for the Charleston Naval Base.*

Geraghty & Miller, Inc. 1982. *Confirmation Study — Assessment of Potential Oil and Hazardous-Waste Contamination of Soil and Groundwater at the Charleston Naval Shipyard.*

Park, Drennan A., *The Groundwater Resources of Charleston, Berkeley and Dorchester Counties*, South Carolina Water Resources Commission, Report Number 139, 1985.

Westinghouse Environmental and Geotechnical Services, Inc. April 19, 1991. *Environmental Investigation Fire Fighting Training Facility, Charleston Naval Base, Charleston, South Carolina.*

United States Environmental Protection Agency. Permit, USEPA I.D. No. SCD 170 022 260

APPENDIX A
ZONE H SUMMARY

Source: **EnSafe/Allen & Hoshall. May 31, 1994, June 13, 1994. Draft RCRA Facility Assessment for Naval Base Charleston, Volume I and II.**

Table A.1 Zone H SWMU Summary			
SWMU Number	SWMU Name	Investigative Approach	Location
9	Closed Landfill	RFI	Open Area Between Bainbridge and West road
13	Current Fire Fighting Training Area	RFI	Building 1303 Area
14	Chemical Disposal Area	RFI	South of Building 1897
15	Incinerator	RFI Investigate w/SWMU 14	South of Building 1843
17	Oil Spill Area	RFI	North Side of Building 61
19	Solid Waste Transfer Station	RFI Investigate w/SWMU 9	West of Least Tern Lane
20	Waste Disposal Area	RFI Investigate w/SWMU 9	NE of Building 903
121	Building 801 SAA 76	RFI Investigate w/SWMU 9	Building 801
136	Building NS-53 SAA 19	CSI Investigate w/AOC 663	Building 53
138	Building 1776 SAA 51	CSI Investigate w/AOC 667	Building 1776
178	Former Transformer Area	CSI	50 Feet South of Building X-33A

Table A.2 Zone H AOC Summary			
AOC Number	**AOC Name**	**Investigative Approach**	**Location**
503	UXO Site South of Building 665	CSI	South of Building 665
649	Braswell Shipyards, Inc. Storage Area	CSI Investigate w/SWMU 9	East of Building 672
650	Metal Trades, Inc. Storage Area	CSI Investigate w/SWMU 9	East of Building 672
651	Sandblasters, Inc. Storage Area	CSI Investigate w/SWMU 9	East of Building 672
653	Building 1508 MWR Hobby Shop	RFI	Building 1508
654	Septic Tank and Drain Field (1718) (abandoned)	CSI Investigate w/SWMU 9	Building 661 Area
655	Oil Spill Area behind Base Exchange	CSI	Behind Base Exchange
656	Between Buildings 602 & NS-71	CSI	Between Buildings 602 and NS-71
659	Diesel Storage (14)	CSI	South of Hobson Ave.
660	Mosquito Control (31)	CSI	Building NS-6 Area
661	Explosives Storage	CSI	Area South of Building 601
662	Building NS-54 Former Gas Station	RFI	Building NS-54
663	Gas/Diesel Pumping Station (851)	CSI	East of Building 1817
665	Pyrotechnic Storage (159)	CSI	Building 1889 Area
666	Fuel Storage (NS-45)	CSI	By Osprey Street
667	CBU-412 Vehicle Area	RFI	CBU-412
669	Current Indoor Pistol Range	CSI Investigate w/SWMU 14	Building 1888
670	Field South of Building 1897	RFI Investigate w/SWMU 14	Field South of Building 1897
684	Former Outdoor Pistol Range	RFI Investigate w/SWMU 14	Vicinity of Building 1888

APPENDIX B

LOCATION MAPS FROM PREVIOUS INVESTIGATIONS


LEGEND
PREVIOUS TRENCH LOCATIONS
PREVIOUS SEDIMENT SAMPLE
PREVIUOSLY INSTALLED MONITORING WELL (NO SOIL SAMPLE COLLECTED)
PREVIUOSLY INSTALLED MONITORING WELL (SOIL SAMPLE COLLECTED)
GENERAL GROUNDWATER FLOW
RCRA INVESTIGATION ZONES
CSI
RFI
NFI
WATER BODIES
COOPER RIVER
SPOIL AREA
MATCH LINE
NOT TO SCALE
NAVAL BASE CHARLESTON FACILITY LOCATION MAP
GRAPHIC SCALE
DRAFT RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 2-1
PREVIOUS INVESTIGATION SAMPLING LOCATIONS
SWMU 9
ZONES H
Dr by: E.GRIGGS
Tr by: E.GRIGGS
Ck by: E.GRIGGS
App by: E.GRIGGS
Date: 06/30/94
DWG Name: 29SROVG2
Sheet 1
Of 1

FIGURE 2. Total FID Volatiles
(calc'd µg/l)

CHARLESTON NAVAL SHIPYARD
CHARLESTON, SOUTH CAROLINA

ENVIRONMENTAL SERVICES, INC.

This map is integral to a written report and should be viewed in that context.

APPENDIX C

ANALYTICAL DATA FROM PREVIOUS INVESTIGATIONS

July 1981 and February 1982

Table C.1
SWMU 9 Closed Landfill
Summary of Trace Metal and Organic Data in Monitoring Wells
(Source: Environmental Investigation — July 1981 and February 1982)

CONSTITUENT	CONCENTRATION RANGE ($\mu g/L$)
Metals	
Arsenic (As)	<10 - 70
Barium (Ba)	370 - 4620
Chromium (Cr)	<5 - 8.2
Mercury (Hg)	<0.1 - 0.4
Lead (Pb)	<5 - 22
Acid Organics	
Pentachlorophenol	ND-15
Phenol	—
2,4,6-Trichlorophenol	—
2,4-Dichlorophenol	—
4,6-Dinitro-o-cresol	—
Base/Neutral Organics	
1,4 Dichlorobenzene	—
2,4 Dinitrotoluene	—
N-nitrosodiphenylamine	—
Bis(2-ethylhexyl)phthalate	ND-90
Diethyl phthalate	—
Di-n-butyl phthalate	—
Naphthalene	—
Acenaphthene	—
Anthracene/Phenanthrene	—
Indeno(1,2,3-cd)pyrene	—

Table C.1 SWMU 9 Closed Landfill Summary of Trace Metal and Organic Data in Monitoring Wells (Source: Environmental Investigation — July 1981 and February 1982)	
CONSTITUENT	**CONCENTRATION RANGE ($\mu g/L$)**
Volatile Organics	
Methylene chloride	ND-1600
Chlorobenzene	ND-50
Chloroform	ND-5.4
Dibromochloromethane	ND-3.4

Notes:

$\mu g/L$ = micrograms per liter

ND = Not Detected

— = 1 to 9 $\mu g/L$

April 1991

Table C.2
SWMU 9 Fire Fighter Training Facility
Summary of Soil Sample Results
(Source: Environmental Investigation — April 1991)

Test Pit Number	Constituent Identified Above Detection Limit	Concentration
TP-2	Lead	170 mg/kg
	Chromium	11 mg/kg
	Butylbenzlyphthalate	358 μg/L
	1-Methylnaphthalene	380 μg/L
	2-Methylnapgthalene	560 μg/L
	Naphthalene	400 μg/L
	Pyrene	500 μg/L
	Fluoranthene	580 μg/L
TP-5	Lead	15 mg/kg
	p-Dichlorobenzene	17.9 μg/L
	Naphthalene	390 μg/L
TP-8	Lead	3210 mg/kg
	Chromium	49 mg/kg
	Chlorobenzene	154 μg/L
	o-Dichlorobenzene	23.3 μg/L
	p-Dichlorobenzene	97.0 μg/L
	Acenaphthene	160 μg/L
	Acenaphthylene	165 μg/L
	Benzo(a)anthracene	260 μg/L
	Benzo(b)fluoranthene	470 μg/L
	Benzo(k)fluoranthene	470 μg/L
	Benzo(a)pyrene	240 μg/L
	Bis(2- Ethylhexyl)phthalate	8690 μg/L
	Buthylbenzylphthalate	3330 μg/L
	Chrysene	420 μg/L
	1,4 Dichlorobenzene	100 μg/L
	Flourene	210 μg/L
	1-Methylnaphthalene	330 μg/L

Table C.2 SWMU 9 Fire Fighter Training Facility Summary of Soil Sample Results (Source: Environmental Investigation — April 1991)		
Test Pit Number	**Constituent Identified Above Detection Limit**	**Concentration**
TP-8	2-Methylnaphthalene	630 μg/L
	Naphthalene	580 μg/L
	Phenanthrene	1800 μg/L
	Pyrene	1290 μg/L
	Fluoranthene	1920 μg/L

Notes:
mg/kg = milligrams per kilogram

Table C.3
SWMU 9 Fire Fighter Training Facility
Summary of Groundwater Analyses
(Source: Environmental Investigation — April, 1991)

Monitoring Well	Constituent Identified Above Detection Limit	Concentration
CSY-FMW-1	Benzene	1.9 μg/L
	Chlorobenzene	1.7 μg/L
	p-Dichlorobenzene	0.3 μg/L
	Toluene	2.2 μg/L
	Anthracene	1.1 μg/L
	Phenanthrene	1.1 μg/L
	Copper	0.040 mg/L
	Zinc	0.060 mg/L
	Antimony	0.003 mg/L
	Nickel	0.040 mg/L
CSY-FMW-2	Benzene	20.0 μg/L
	Chlorobenzene	13.6 μg/L
	p-Dichlorobenzene	7.5 μg/L
	Ethylbenzene	2.7 μg/L
	Toluene	4.6 μg/L
	1,1,1-Trichloroethane	0.80 μg/L
	Trichloroethene	0.40 μg/L
	Acenaphthene	1.3 μg/L
	1,4-Dichlorobenzene	7.2 μg/L
	Naphthalene	2.2 μg/L
	2 Methylnphathalene	5.5 μg/L
	Copper	0.030 mg/L
	Lead	0.002 mg/L
	Selenium	0.002 mg/L
	Zinc	0.07 mg/L
	Antimony	0.004 mg/L
	Nickel	0.06 mg/L

Table C.3 SWMU 9 Fire Fighter Training Facility Summary of Groundwater Analyses (Source: Environmental Investigation — April, 1991)		
Monitoring Well	**Constituent Identified Above Detection Limit**	**Concentration**
CNY-FMW-3	Benzene	1.5 µg/L
	Chlorobenzene	7.5 µg/L
	p-Dichlorobenzene	1.1 µg/L
	Toluene	1.7 µg/L
	1,1,1-Trichloroethane	0.6 µg/L
	Copper	0.020 mg/L
	Zinc	0.06 mg/L
	Nickel	0.04 mg/L

Notes:
mg/L = milligrams per liter

Fall 1993

The following qualifiers may appear with results from the samples:

—	—	Indicates compound was analyzed for but not detected.
J	—	Indicates an estimated value.
R	—	Indicates unusable data due to spike recovery not within control limits.
UJ	—	Compound was analyzed but not detected. The value given is an estimated detection limit for that compound.

Table C.4 Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall, 1993)						
Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 02 0' - 1'	SWMU 9 Boring 02 3' - 5'	SWMU 9 Boring 03 0' - 1'	SWMU 9 Boring 04 0' - 1'	SWMU 9 Boring 05 0' - 1'	SWMU 9 Boring 05 3' - 5'
PARAMETER						
***INORGANICS* (units of concentration mg/kg)**						
Aluminum	10000	16000	4600	2100	6500	5800
Antimony	6.0 R	—	5.7 R	5.6 R	5.7 R	7.4 R
Arsenic	—	—	7.4 J	2.1 J	—	—
Barium	42.0	79.0	47.0	15.0	30.0	11.0
Beryllium	—	1.4	0.69	—	0.74	—
Calcium	62000	78000	7400	250000	12000	220000
Chromium	35.0 J	48.0 J	26.0 J	11.0 J	35.0 J	53.0 J
Cobalt	3.0	3.9	7.0	2.9	4.6	—
Copper	18	65	660	13	140	18
Iron	13000	14000	15000	3800	9600	5400
Lead	16 J	23 J	92 J	10 J	170 J	7.1 J
Magnesium	2900	3600	2800	3700	2700	7600
Manganese	140	110	110	220	63	44
Mercury	0.087	0.12	0.057	0.014	0.080	0.068
Nickel	14	13	79	7.0	45	22
Potassium	740 J	960 J	550 J	500 J	790 J	1000 J
Sodium	410	1500	200	780	930	1500
Vanadium	30	41	15	606	22	30
Zinc	62	170	520	27	400	55

Table C.4
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall, 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 02 0' - 1'	SWMU 9 Boring 02 3' - 5'	SWMU 9 Boring 03 0' - 1'	SWMU 9 Boring 04 0' - 1'	SWMU 9 Boring 05 0' - 1'	SWMU 9 Boring 05 3' - 5'
PESTICIDES/PCBS **(units of concentration ug/kg)**						
Heptachlor epoxide	—	—	—	—	360	—
4,4-DDE	—	27	—	—	—	—
4,4-DDD	—	92 J	—	—	—	—
4,4-DDT	—	14 J	—	—	—	—
alpha-Chlordane	—	—	—	—	1.9 J	—
gamma-Chlordane	—	—	—	—	11.0 J	—
Aroclor-1260	—	—	—	—	360	—

Table C.4
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall, 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 02 0' - 1'	SWMU 9 Boring 02 3' - 5'	SWMU 9 Boring 03 0' - 1'	SWMU 9 Boring 04 0' - 1'	SWMU 9 Boring 05 0' - 1'	SWMU 9 Boring 05 3' - 5'
SEMIVOLATILES **(units of concentration ug/kg)**						
Acenaphthene	—	—	210 J	—	—	—
Anthracene	—	—	430 J	—	—	—
Benzo(a)anthracene	—	—	1500 J	—	—	—
Benzo(a)pyrene	—	—	1400 J	—	38 J	—
Benzo(b)fluoranthene	56 J	—	2100 J	66 J	—	—
Benzo(g,h,i)perylene	—	—	760 J	—	—	—
Benzo(k)fluoranthene	—	—	690 J	—	—	—
bis(2-Ethylhexyl)phthalate	—	—	2500 J	—	—	—
Butylbenzylphthalate	—	—	1500 J	—	71 J	—
Carbazole	—	—	230 J	—	—	—
Chrysene	—	—	1500 J	—	39 J	—
Dibenzofuran	—	—	130 J	—	—	—
Fluoranthene	—	—	2700 J	69 J	—	—
Fluorene	—	—	220 J	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	890 J	—	—	—
2-Methylnaphthalene	—	—	67 J	—	—	—
Naphthalene	—	—	76 J	—	—	—
Phenanthrene	—	—	1700 J	59 J	32 J	—
Pyrene	73 J	72 J	3800 J	110 J	110 J	—
VOLATILES **(units of concentration ug/kg)**						
Acetone	—	—	160 J	—	—	—
Chlorobenzene	31 J	—	15 J	13 J	12 J	—
Methylene chloride	—	—	—	—	—	23
Tetrachloroethene	—	—	—	—	31	—
Xylenes (total)	—	—	5.7 J	—	—	—

Table C.4 (Continued)
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 06 0' - 1'	SWMU 9 Boring 07 0' - 1'	SWMU 9 Boring 08 0' - 1'	SWMU 9 Boring 12 0' - 1'	SWMU 9 Boring 13 0' - 1'
PARAMETER					
INORGANICS **(units of concentration mg/kg)**					
Aluminum	4000	5200	7300	2800	2500
Antimony	5.7 R	5.7 R	—	—	—
Arsenic	9.1 J	3.8 J	4.9 J	2.5	2.7
Barium	79	45	28	14	11
Beryllium	0.84	—	—	—	—
Cadmium	—	2.1	0.68	—	—
Calcium	11000	55000	38000	200	462
Chromium	19 J	51 J	27 J	7.1	5.3
Cobalt	4.9	4.6	2.6	—	—
Copper	570	230	25	180	12
Cyanide, total	—	—	1.3 R	1.1 R	1.1 R
Iron	12000	9200	8200	1500	1300
Lead	110 J	170 J	34 J	120 J	9.5 J
Magnesium	530	1700	2200	130	140
Manganese	61	110	81	4.3	4.8
Mercury	0.14	0.15	0.056 J	0.15 J	0.016 J
Nickel	27	43	16	—	—
Potassium	460 J	380 J	480	150	130
Sodium	97	260	1300	—	—
Vanadium	38	12	43	4.5	4.7
Zinc	270	210	57 J	8.5 J	7.7 J

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)					
Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 06 0' - 1'	SWMU 9 Boring 07 0' - 1'	SWMU 9 Boring 08 0' - 1'	SWMU 9 Boring 12 0' - 1'	SWMU 9 Boring 13 0' - 1'
PESTICIDES/PCBS **(units of concentration μg/kg)**					
4,4-DDD	—	12 J	—	—	—
4,4-DDE	5.0 J	10 J	—	—	—
alpha-Chlordane	—	—	14 J	—	—
gamma-Chlordane	—	8.3 J	18 J	—	—
Dieldrin	4.8	—	—	—	—
Endrin aldehyde	—	15 J	—	—	—
Aroclor-1260	230 J	—	97 J	—	—

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)					
Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 06 0' - 1'	SWMU 9 Boring 07 0' - 1'	SWMU 9 Boring 08 0' - 1'	SWMU 9 Boring 12 0' - 1'	SWMU 9 Boring 13 0' - 1'
SEMIVOLATILES **(units of concentration μg/kg)**					
Acenaphthene	—	2700	—	—	—
Anthracene	—	3400	—	—	—
Benzo(a)anthracene	—	5500	—	—	—
Benzo(a)pyrene	58 J	5100	34 J	—	—
Benzo(b)fluoranthene	100 J	8300	59 J	—	—
Benzo(g,h,i)perylene	—	—	18 J	—	—
Benzo(k)fluoranthene	—	2600	—	—	—
bis(2-Ethylhexyl)phthalate	120 J	3700	—	—	—
Butylbenzylphthalate	—	—	—	78 J	—
Carbazole	—	2800	—	—	—
Chrysene	110 J	6100	36 J	—	60 J
Di-n-butylphthalate	—	—	—	240 J	200 J
Dibenz(a,h)anthracene	—	470 J	—	—	—
Dibenzofuran	—	1800 J	—	—	—
Fluoranthene	270 J	16000	53 J	80 J	110 J
Fluorene	—	3200	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—	—
2-Methylnaphthalene	—	790 J	—	—	—
Naphthalene	—	820 J	—	—	—
Phenanthrene	91 J	16000	31 J	—	—
Pyrene	290 J	16000	54 J	65 J	83 J
VOLATILES **(units of concentration μg/kg)**					
Acetone	—	—	—	—	—
Chlorobenzene	—	—	18 J	—	—
Ethylbenzene	—	5.7	—	—	—
Xylenes (total)	—	11	—	—	—

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)						
Site Sample Type Sample Number Sample Interval	SWMU 9 Boring 14 0' - 1'	SWMU 9 Boring 15 0' - 1'	SWMU 9 Boring 16 0' - 1'	SWMU 9 Sediment 01 0' - 6'	SWMU 9 Sediment 02 0' - 6'	SWMU 9 Sediment 03 0' - 6'
PARAMETER						
INORGANICS **(units of concentration mg/kg)**						
Aluminum	2000	3700	2900	9100	6000	12000
Antimony	—	—	—	11 R	12 R	11 R
Arsenic	9.4	—	3.8	17	5.6	7.7
Barium	17	11	18	16	14	30
Calcium	230	150	700	12000	19000	18000
Chromium	18	5.8	8.4	32	320	422
Cobalt	—	—	—	4.4	3.3	5.1
Copper	650	65	45	15	49	120
Cyanide	1.1 R	1.1 R	1.1 R	2.1 R	2.3 R	2.3 R
Iron	6900	1300	2600	21000	11000	17000
Lead	74 J	4.3 J	390 J	41	80	120
Magnesium	190	150	160	5400	7800	7300
Manganese	40	4.7	7.5	160	91	150
Mercury	0.014 J	00116 J	0.19 J	0.027	0.16	0.2
Nickel	23	—	—	—	31	37
Potassium	290	170	170	2800	1200	1500
Sodium	—	—	—	8600	9500	8500
Thallium	—	—	—	—	—	2.3
Vanadium	8.7	7.3	7.2	23	34	34
Zinc	47 J	10 J	19 J	43	220	380
PESTICIDES/PCBS **(units of concentration μg/kg)**						
gamma-Chlordane	—	—	—	—	—	7.5 J

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)						
Site **Sample Type** **Sample Number** **Sample Interval**	**SWMU 9** **Boring** **14** **0' - 1'**	**SWMU 9** **Boring** **15** **0' - 1'**	**SWMU 9** **Boring** **16** **0' - 1'**	**SWMU 9** **Sediment** **01** **0' - 6'**	**SWMU 9** **Sediment** **02** **0' - 6'**	**SWMU 9** **Sediment** **03** **0' - 6'**
SEMIVOLATILES **(units of concentration µg/kg)**						
Acenaphthene	150 J	—	—	—	—	—
Acenaphthalene	—	—	—	—	—	1200 J
Anthracene	210 J	—	—	—	39 J	1500 J
Benzo(a)anthracene	380 J	—	52 J	—	—	13000
Benzo(a)pyrene	180 J	—	—	—	—	8900
Benzo(b)fluoranthene	420	—	70 J	—	240 J	18000
Benzo(g,h,i)perylene	87 J	—	—	—	—	3900
Benzo(k)fluoranthene	170 J	—	—	—	—	7300
bis(2-Ethylhexyl)phthalate	65 J	—	—	—	230 J	—
Carbazole	100 J	—	—	—	—	540 J
Chrysene	590	—	79 J	—	—	22000
Dibenz(a,h)anthracene	—	—	—	—	—	1200 J
Dibenzofuran	150 J	—	—	—	—	—
Fluoranthene	1600	50 J	230 J	—	260 J	38000
Fluorene	180 J	—	—	—	—	—
Indeno(1,2,3-cd)pyrene	100 J	—	—	—	—	5000
Naphthalene	200 J	—	—	—	—	—
Phenanthrene	970	—	97 J	—	97 J	1000 J
Pyrene	1200	36 J	160 J	—	360 J	32000
VOLATILES **(units of concentration µg/kg)**						
Acetone	—	—	—	110	—	59 J
Carbon disulfide	—	—	—	43	—	16
Chlorobenzene	—	—	—	—	—	14
Tetrachloroethene	—	—	—	13	—	—

Table C.4 (Continued)
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 01 3-5'	SWMU 9 Trench 02 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 04 3-5'	SWMU 9 Trench 05 3-5'
PARAMETER						
INORGANICS **(units of concentration mg/kg)**						
Aluminum	2800	5060	6530	4490	9040	4400
Antimony	5.9 UJ	5.5 UJ	9.4 J	5.6 UJ	7.2 UJ	5.8 UJ
Arsenic	2.8	2.6 J	4.6	2.8	8.9	1.3
Barium	23.2	30.9	25.1	13.6	19.5	8.2
Cadmium	0.60	—	1.1	—	2.2	—
Calcium	861	3090	54300	8970	11200	2900
Chromium	24.0	14.7	36.8	7.9	26.8	16.6
Cobalt	4.2	2.1	2.2	1.7	4.4	1.8
Copper	67.8	112	314	21.5	16.6	160
Iron	5190	7970	8940	2970	21000	2490
Lead	51.7 J	147 J	417 J	38.4 J	24.5 J	18.6 J
Magnesium	191 J	307 J	2520 J	259 J	2050 J	252 J
Manganese	23.2	23.4	58.7	21.5	791	14.8
Mercury	0.16	0.24	0.12	0.09	0.18	0.08
Nickel	10.9	12.5	17.1	5.7	9.3	67.7
Potassium	200	503	581	159	907	141
Selenium	1.2 UJ	2.2 UJ	1.3 UJ	1.1 UJ	2.9 UJ	1.2 UJ
Sodium	—	74.5	290	—	324	—
Thallium	1.2 UJ	1.1 UJ	1.3 UJ	1.1 UJ	1.4 UJ	1.2 UJ
Vanadium	7.0	15.7	18.5	7.1	35.5	5.9
Zinc	224 J	216 J	213 J	124 J	69.7 J	80.6 J

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)						
Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 01 3-5'	SWMU 9 Trench 02 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 04 3-5'	SWMU 9 Trench 05 3-5'
PESTICIDES/PCBS **(units of concentration μg/kg)**						
Endrin ketone	—	—	—	—	12	—
alpha-Chlordane	4.6	—	—	2.5	—	—
gamma-Chlordane	9.7	14	—	5.0	—	—
Aroclor-1242	360	—	6700	—	270	—
Aroclor-1254	220	740	—	—	380	2500
Aroclor-1260	—	—	1300	—	—	—

Table C.4 (Continued)
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 01 3-5'	SWMU 9 Trench 02 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 03 3-5'	SWMU 9 Trench 04 3-5'	SWMU 9 Trench 05 3-5'
SEMIVOLATILES **(units of concentration μg/kg)**						
Acenaphthene	—	—	120 J	—	—	—
Acenaphthylene	—	—	120 J	—	—	—
Anthracene	840	—	850	—	—	—
Benzo(a)anthracene	350 J	—	—	—	—	—
Benzo(a)pyrene	220 J	30 J	—	—	—	53 J
Benzo(b)fluoranthene	310 J	—	—	35 J	—	74 J
Benzo(g,h,i)perylene	120 J	—	—	—	—	—
Benzo(k)fluoranthene	90 J	—	—	—	—	—
bis(2-Ethylhexyl)phthalate	27000 J	180 J	1100	—	170 J	250 J
Butylbenzylphthalate	810	45 J	100 J	—	—	—
Carbazole	—	—	—	—	—	—
Chrysene	2200	46 J	—	—	—	64 J
Dibenzofuran	47 J	—	100 J	—	—	—
1,4-Dichlorobenzene	—	—	94 J	—	—	—
Di-n-butylphthalate	120 J	—	72 J	—	—	51 J
Fluoranthene	240 J	70 J	290 J	61 J	—	200 J
Fluorene	99 J	—	—	—	—	—
Indeno(1,2,3-cd)pyrene	120 J	—	—	—	—	—
2-Methylnaphthalene	96 J	—	120 J	—	—	—
3-Methylphenol/4-Methylphenol(m&p - cresol)	—	—	100 J	—	—	—
Naphthalene	—	—	220 J	—	—	—
Phenanthrene	200 J	30 J	—	91 J	51 J	110 J
Pyrene	5600 J	75 J	370 J	49 J	—	150 J

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall 1993)						
Site **Sample Type** **Sample Number** **Sample Interval**	**SWMU 9** **Trench** **01** **3-5'**	**SWMU 9** **Trench** **02** **3-5'**	**SWMU 9** **Trench** **03** **3-5'**	**SWMU 9** **Trench** **03** **3-5'**	**SWMU 9** **Trench** **04** **3-5'**	**SWMU 9** **Trench** **05** **3-5'**
***VOLATILES* (units of concentration $\mu g/kg$)**						
Acetone	110	16	110	65	680	130
Benzene	—	—	—	—	23 J	—
2-Butanone (MEK)	38	—	—	—	53 J	2 J
Chlorobenzene	—	—	—	—	—	—
4-Methyl-2-pentanone (MIBK)	1 J	—	—	—	—	—
1,1,1-Trichloroethane	1 J	—	3 J	—	—	—

Table C.4 (Continued)
Charleston Naval Shipyard
Soil and Sediment Analytical Results (Fall, 1993)

Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 06 0A	SWMU 9 Trench 07 0B	SWMU 9 Trench 08 0A	SWMU 9 Trench 09 0A	SWMU 9 Trench 10 0A	SWMU 9 Trench 11 01
PARAMETER						
***INORGANICS* (units of concentration mg/kg)**						
Aluminum	3730	2160	8320	4910	5000	1530
Antimony	26.9 J	5.8 UJ	6.9 UJ	5.6 UJ	5.9 UJ	5.3 UJ
Arsenic	4.7	1.6	5.6	12.4	7.4	1.6
Barium	47.9	9.2	69.0	45.0	23.6	9.0
Beryllium	—	—	2.1	0.87	—	—
Cadmium	1.1	—	0.74	1.1	0.79	—
Calcium	15800	240	129000	46200	69700	7000 J
Chromium	27.7	6.1	59.5	29.5	23.5	10.9
Cobalt	4.2	—	12.8	6.7	4.1	1.9
Copper	276	7.5	460	339	178	529
Iron	6040	2150	14900	10200	8430	5020
Lead	203 J	2.6 J	349 J	106 J	131 J	75.2
Magnesium	791 J	119 J	5530 J	1530 J	2660 J	227 J
Manganese	21.3	4.3	154	70.0	121	40.3
Mercury	0.19 J	0.01 J	0.24 J	0.15 J	0.27 J	—
Nickel	8.6	5.9	131	40.8	34.5	16.9
Potassium	329	144	1070	509	556	197
Selenium	1.2 UJ	1.2 UJ	2.8 UJ	5.6 UJ	2.4 UJ	1.1 UJ
Sodium	91.6	—	1090	400	310	—
Thallium	1.2 UJ	—	—	1.1 UJ	1.2 UJ	5.9 UJ
Vanadium	12.6	7.0	35.4	50.3	22.8	3.0
Zinc	282 J	16.9 J	1430 J	383 J	272 J	303 J

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall, 1993)						
Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 06 0A	SWMU 9 Trench 07 0B	SWMU 9 Trench 08 0A	SWMU 9 Trench 09 0A	SWMU 9 Trench 10 0A	SWMU 9 Trench 11 01
***PESTICIDES/PCBS* (units of concentration µg/kg)**						
Aldrin	3.9	—	—	—	—	—
4,4'-DDD	8.8	—	—	5.9	21	0.77 J
4,4'-DDE	—	—	9.8	6.0	18	0.67 J
4,4'-DDT	—	—	—	—	—	5.9
Endrin ketone	—	—	—	—	—	—
Heptaclor epoxide	—	—	—	—	—	0.43 J
alpha-Chlordane	—	—	—	—	8.1	—
gamma-Chlordane	—	—	—	—	28	0.47
Aroclor-1016	—	44	—	—	—	—
Aroclor-1242	400	—	—	—	—	—
Aroclor-1254	140	—	—	—	—	—
Aroclor-1260	—	—	46	920	580	—

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall, 1993)						
Site Sample Type Sample Number Sample Interval	SWMU 9 Trench 06 0A	SWMU 9 Trench 07 0B	SWMU 9 Trench 08 0A	SWMU 9 Trench 09 0A	SWMU 9 Trench 10 0A	SWMU 9 Trench 11 01
SEMIVOLATILES **(units of concentration µg/kg)**						
Acenaphthene	—	—	—	—	—	—
Acenaphthylene	—	—	—	—	—	—
Anthracene	—	—	—	39 J	170 J	—
Benzo(a)anthracene	—	—	46 J	130 J	460 J	—
Benzo(a)pyrene	39 J	—	—	83 J	430 J	—
Benzo(b)fluoranthene	67 J	—	52 J	160 J	820 J	—
Benzo(g,h,i)perylene	—	—	—	—	—	—
Benzo(k)fluoranthene	—	—	—	—	250 J	—
bis(2-Ethylhexyl)phthalate	650	130 J	100 J	350 J	—	180 J
Butylbenzylphthalate	—	—	—	160 J	—	—
Carbazole	—	—	—	—	—	—
Chrysene	77 J	—	61 J	150 J	560 J	—
Dibenzofuran	—	—	—	—	—	—
1,4-Dichlorobenzene	38 J	—	—	—	—	—
Di-n-butylphthalate	—	—	—	—	—	—
Di-n-octylphthalate	160 J	—	—	—	—	90 J
3-Methylphenol/4-Methylphenol (m&p - cresol)	42 J	—	91 J	—	—	—
Fluoranthene	250 J	—	110 J	290 J	990 J	—
Fluorene	—	—	—	38 J	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—	52 J
Naphthalene	—	—	—	—	—	—
Phenanthrene	120 J	—	—	220 J	610 J	—
Pyrene	170 J	—	96 J	290 J	- 1100 J	—

Table C.4 (Continued) Charleston Naval Shipyard Soil and Sediment Analytical Results (Fall, 1993)						
Site **Sample Type** **Sample Number** **Sample Interval**	**SWMU 9** **Trench** **06** **0A**	**SWMU 9** **Trench** **07** **0B**	**SWMU 9** **Trench** **08** **0A**	**SWMU 9** **Trench** **09** **0A**	**SWMU 9** **Trench** **10** **0A**	**SWMU 9** **Trench** **11** **01**
VOLATILES **(units of concentration μg/kg)**						
Acetone	48	36	76	47	71	—
2-Butanone (MEK)	—	—	—	—	—	—
4-Methyl-2-pentanone (MIBK)	—	—	—	—	—	—
Tetrachloroethene	—	—	—	—	—	0.9 J
1,1,1-Trichloroethane	1 J	—	2 J	—	2 J	1 J

Table C.5
Charleston Naval Shipyard
Groundwater Analytical Results

Site Sample Type Sample Number Sample Date	SWMU 9 water CNSY-09-01 11-10-93	SWMU 9 water CNSY-09-02 11-09-93	SWMU 9 water CNSY-09-03 11-09-93	SWMU 9 water CNSY-09-04 11-10-93	SWMU 9 water CNSY-09-05 11-09-93	SWMU 9 water CNSY-09-06 11-15-93
PARAMETER						
INORGANICS **(units of concentration μg/l)**						
Aluminum	—	—	—	—	—	350
Arsenic	—	—	12	—	—	—
Barium	180	24	590	170	45	42
Calcium	16000	270000	25000	410000	91000	11000
Cyanide	10 R	—	—	10 R	—	—
Iron	150	14000	140	490	8500	—
Lead	6.8	—	—	—	—	—
Magnesium	6700	78000	20000	550000	98000	3200
Manganese	18	1600	12	230	110	51
Mercury	0.20 R	—	0.64	0.20 R	—	—
Potassium	63000	35000	68000	160000	43000	1600
Sodium	650000	420000	560000	5200000	1200000	3200
Thallium	50 R	—	—	200 R	—	—
Zinc	23	—	—	—	—	56

Table C.5
Charleston Naval Shipyard
Groundwater Analytical Results

Site Sample Type Sample Number Sample Date	SWMU 9 water CNSY-09-01 11-10-93	SWMU 9 water CNSY-09-02 11-09-93	SWMU 9 water CNSY-09-03 11-09-93	SWMU 9 water CNSY-09-04 11-10-93	SWMU 9 water CNSY-09-05 11-09-93	SWMU 9 water CNSY-09-06 11-15-93
SEMIVOLATILES **(units of concentration μg/l)**						
Anthracene	—	—	0.48 J	—	—	—
bis(2-Ethylhexyl)phthalate	—	—	—	—	3.2 J	—
Carbazole	—	—	2.2 J	—	—	—
4-Chloro-3-methylphenol	—	—	3.8 J	—	—	—
2,4-Dimethylphenol	48	—	18	—	—	—
2-Methylnaphthalene	—	—	9.6 J	—	—	—
2-Methylphenol	—	—	3.6 J	—	—	—
3-Methylphenol/4-Methylphenol	3.0 J	—	17	—	—	—
Naphthalene	3.9 J	—	8.3 J	—	—	—
Phenanthrene	—	—	1.3 J	—	—	—
VOLATILES **(units of concentration μg/l)**						
Ethylbenzene	140	—	—	—	—	—
Xylenes (total)	430	—	12	—	—	—

Table C.5 (Continued) Charleston Naval Shipyard Groundwater Analytical Results					
Site Sample Type Sample Number Sample Date	SWMU 9 water CNSY-09-07 11-10-93	SWMU 9 water CNSY-09-08 11-09-93	SWMU 9 water CNSY-09-09 11-09-93	SWMU 9 water CNSY-09-10 11-09-93	SWMU 9 water CNSY-09-11 11-09-93
PARAMETER					
INORGANICS **(units of concentration $\mu g/l$)**					
Aluminum	—	—	630	—	—
Arsenic	—	14	15	—	29
Barium	410	83	84	520	39
Calcium	650000	220000	82000	120000	120000
Chromium	12	—	—	—	—
Cyanide	10 R	—	—	—	—
Iron	48000	19000	13000	37000	25000
Lead	—	—	18	—	—
Magnesium	300000	130000	26000	240000	45000
Manganese	500	1700	260	610	430
Mercury	0.20 R	—	—	—	—
Potassium	110000	36000	29000	83000	29000
Sodium	2500000	1400000	370000	1900000	350000
Thallium	200 R	—	—	—	—
Zinc	—	—	32	—	—

Table C.5 (Continued)
Charleston Naval Shipyard
Groundwater Analytical Results

Site Sample Type Sample Number Sample Date	SWMU 9 water CNSY-09-07 11-10-93	SWMU 9 water CNSY-09-08 11-09-93	SWMU 9 water CNSY-09-09 11-09-93	SWMU 9 water CNSY-09-10 11-09-93	SWMU 9 water CNSY-09-11 11-09-93
SEMIVOLATILES **(units of concentration μg/l)**					
Acenaphthene	—	—	16	3.6 J	—
Anthracene	—	—	1.6 J	—	—
bis(2-Chloroethyl)ether	250 J	—	—	—	—
Carbazole	—	—	23	—	—
2-Chlorophenol	—	—	—	9.9 J	—
Dibenzofuran	—	—	3.9 J	—	—
1,3-Dichlorobenzene	—	—	—	2.7 J	—
1,4-Dichlorobenzene	—	—	—	11	—
2,4-Dimethylphenol	2600	—	—	—	—
Fluoranthene	—	—	3.2 J	—	—
Fluorene	—	—	6.9 J	2.2 J	—
2-Methylnaphthalene	—	—	8.4 J	8.5 J	—
2-Methylphenol	1100	—	—	—	—
3-Methylphenol/4-Methylphenol	7400	—	—	—	—
Naphthalene	—	—	—	4.4 J	—
Phenanthrene	—	—	9.6 J	2.3 J	—
Phenol	660 J	—	—	—	—
Pyrene	—	—	2 J	—	—

Table C.5 (Continued) Charleston Naval Shipyard Groundwater Analytical Results					
Site Sample Type Sample Number Sample Date	SWMU 9 water CNSY-09-07 11-10-93	SWMU 9 water CNSY-09-08 11-09-93	SWMU 9 water CNSY-09-09 11-09-93	SWMU 9 water CNSY-09-10 11-09-93	SWMU 9 water CNSY-09-11 11-09-93
VOLATILES **(units of concentration μg/l)**					
Benzene		—	—	190 J	—
Chlorobenzene		—	—	1200	—

Table C.6
SWMU 14 Chemical Disposal Area
Summary of Trace Metal and Organic Data in Monitoring Wells
(Source: Environmental Investigation — July 1981 and February, 1982)

Site **Sample Type** **Sample Number**	**SWMU 14** **Well** **CD-1**	**SWMU 14** **Well** **CD-2**	**SWMU 14** **Well** **CD-3**	**SWMU 14** **Well** **CD-4**	**SWMU 14** **Well** **CD-5**
PARAMETER					
Inorganics Detected (July 1981) mg/L unless otherwise noted					
Iron (μg/L)	200	400	46	130	1200
Magnesium	800	820	260	280	280
Sodium	5500	6300	2200	2500	2800
Volatile Organics Detected: July 1981 (February 1982) μg/L unless otherwise noted					
Methylene Chloride	0.58 28	0.32 2000	— 7.5	— 1800	— 1500
Chloroform	— —	— —	— 1.5	— —	— —
Chlorobenzene	— —	— —	0.14 —	— —	10.68 —
Parameters for Secondary Drinking Water Standards: July 1981, mg/L unless otherwise noted					
Chlorine (g/L)	7.3	6.6	0.2	1.9	2.7
Floride	0.46	0.57	0.13	0.71	0.69
NO_3	<0.01	0.02	0.23	<0.01	<0.01
SO_4	26	<1	4	400	61
pH	6.85	6.85	7.45	7.30	7.30
Total Organic Carbon	110	110	63	190	170

APPENDIX D

WELL INVENTORY
AND
CONSTRUCTION DETAILS
ZONE H

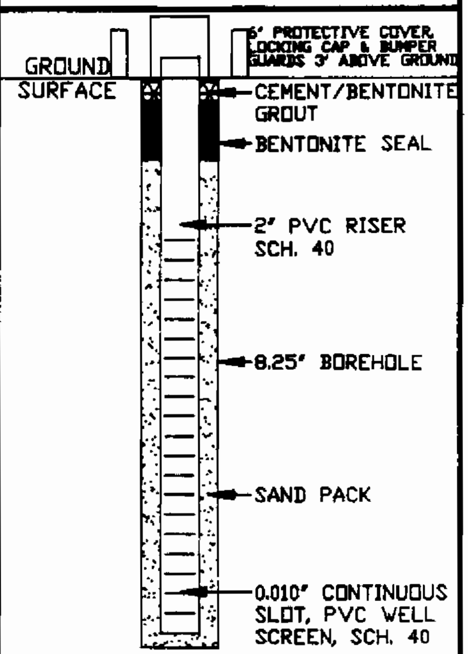
EnSafe Wells

CNSY-09-01 through CNSY-09-11

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
	SS	20	6–6 7–40	SC	BROWN CLAYEY SAND; SATURATED
5					
	SS	8	10–6 6–3	ML	LIGHT BROWN SANDY SILT WITH SOME CLAY; SATURATED
10					
	SS	25		SM	BROWN FINE SAND; MINOR SILT; STRONG ODOR; SATURATED
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

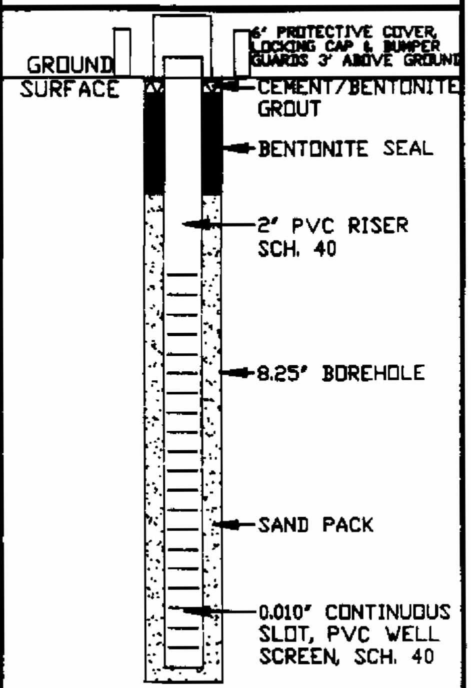
CNSY–09–01
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY91

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
	HA	100			
	SS	100	8–6 6–8	CL CL	3–3.5' BROWN SANDY CLAY; DRY TO MOIST 3.5–4.5' GRAY CLAY 4.5–5' BLACK SILTY CLAY; FEW WOOD PIECES; WET
5					
	SS	100		ML SM ML	8–9' BROWN/BLACK SILT 9–9.5' LIGHT BROWN SILT, FINE SAND; SATURATED 9.5–10' BROWN SANDY SILT; SATURATED
10					
	SS	100		ML	13–15' BROWN/BLACK CLAYEY SILT; LOCAL LIGHT BROWN FINE SAND STRINGERS; SATURATED
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

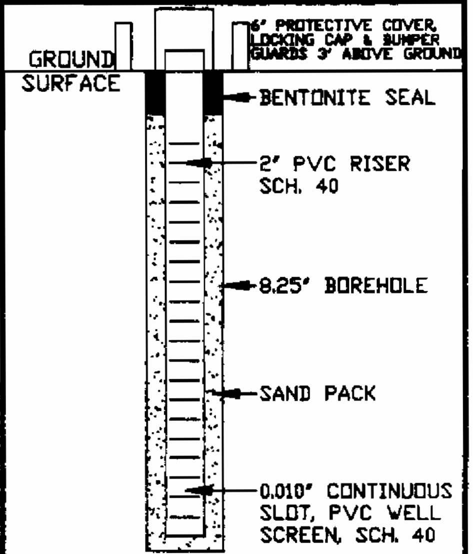
CNSY–09–02
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY92

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – BLACK GRAVEL AND GRIT
	HA	100			
	SS	0			COULD NOT DRIVE SPOON PAST 3 FT.
5					
	SS	50		ML	8–9' BLACK SANDY SILT; RUBBER AND WOOD DEBRIS
10					
					METAL SPRINGS AND SHAVINGS ON AUGER HEAD WHEN RETRIEVED FROM HOLE
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

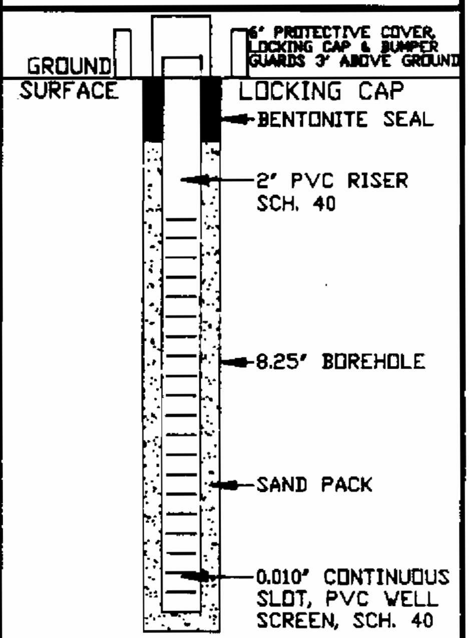
CNSY–09–03
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY93

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – CONCRETE AND METAL DEBRIS AROUND HOLE
	TR	100			
	SS	25		GM	GRAY/BLACK SILTY, SANDY, GRAVEL; SATURATED; REFUSAL AT 3.5 FT.
5					
	SS	100	1–1 1–3	CL	BLACK SILTY CLAY; GRASS AND LEAVES; SATURATED
10					
	SS	100	2–1 1–2	CL	SAME AS ABOVE
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

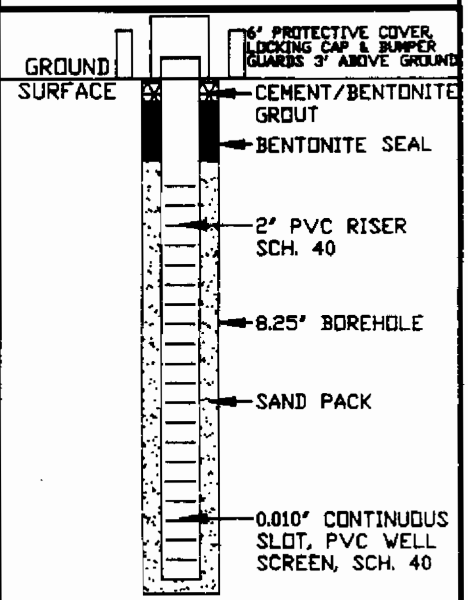
CNSY–09–04
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY94

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – GRASSY
	HA	100			
	HA	100		SM	3–4' LIGHT BROWN SILTY FINE SAND; VERY WET
5					
	SS	50	10–5 5–7	SC	8–9' GRAY CLAYEY FINE SAND; SATURATED
10					
	SS	100	1–1 1–1	SC ML	13–14' GRAY/BROWN CLAYEY SAND 14–15' BLACK CLAYEY SILT; SATURATED
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

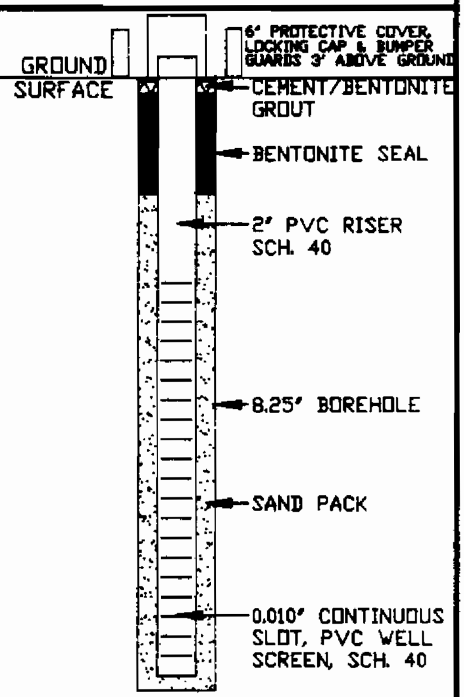
CNSY–09–05
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY95

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – FLY ASH
	TR	100			
	SS	30	>20		FLY ASH IN BOTTOM OF SPOON; ENCOUNTERED SATURATED MATERIAL JUST BELOW FLY ASH
5					
	SS	25	8–10 14–20		GRAVEL, PLASTIC, CERAMIC, BLACK SAND; STRONG OILY ODOR; SATURATED
10					
					WATER ON SPOON HAS OILY SHEEN
	SS	0			
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

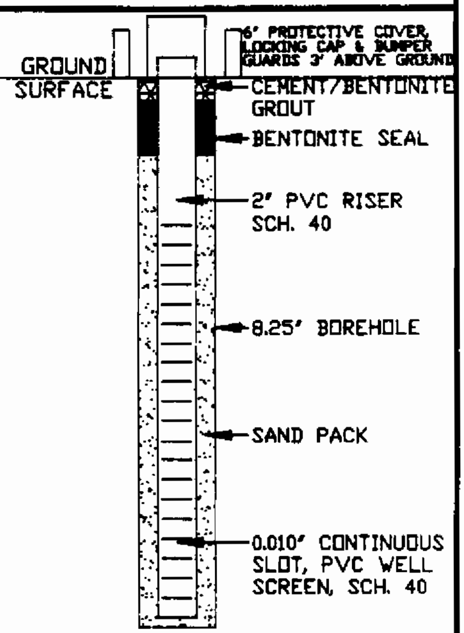
CNSY–09–06
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY96

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
	HA	100			
	SS	30			SPOON REFUSAL AFTER 6 IN.; BOTTOM OF SPOON CONTAINED BLACK SAND; SATURATED NEAR AUGER REFUSAL AT 5 FT. TRASH BELOW 5 FT.
5					
	SS	50	30-8 8-12	SM	BROWN/BLACK SILTY SAND; SOME CLAY; PLASTIC SHAVINGS IN BOTTOM OF SPOON
10					
	SS	50	8-1 1-1	CL	BLACK/BROWN SILTY CLAY; SOME GRASS STEMS; SATURATED
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

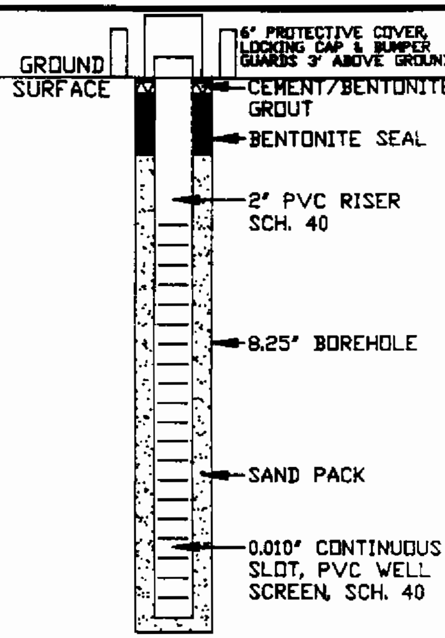
CNSY-09-07
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY97

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – GRASSY, SWAMPY
	HA	100		SC	DARK GRAY SLIGHTLY CLAYEY FINE SAND; MOIST 2 FT. – CUTTINGS BECOME SATURATED
	SS	100		SP CL	3–4' BROWN FINE SAND 4–5' GRAY CLAY; MINOR FINE SAND/SILT – MOIST TO SATURATED
5					
	SS	60		CL/SC	8–9.2' GRAY/GREEN SANDY CLAY/ CLAYEY SAND; MIXED ZONES OF FINE TO MEDIUM GRAY SAND WITH GREEN CLAY (VERY PLASTIC AND COHESIVE)
10					
	SS	12		CL/SC	SIMILAR TO ABOVE
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

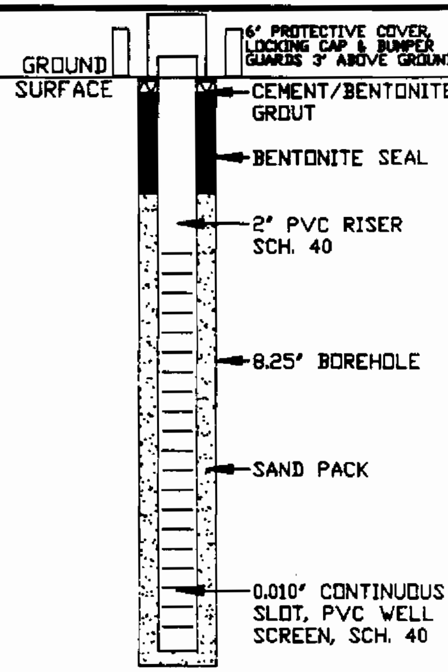
CNSY–09–08
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY98

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – SLIGHTLY GRASSY BROWN CLAYEY SAND
					FILL MATERIAL TO APPROX. 5 FT.
5				ML	5 FT. – CUTTINGS (BLACK CLAYEY SILT) MOIST AND BALLING
	SS	4	18–8 10–12		
10					
					CUTTINGS SAME AS ABOVE TO A DEPTH OF 15 FT.
	SS	0			
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

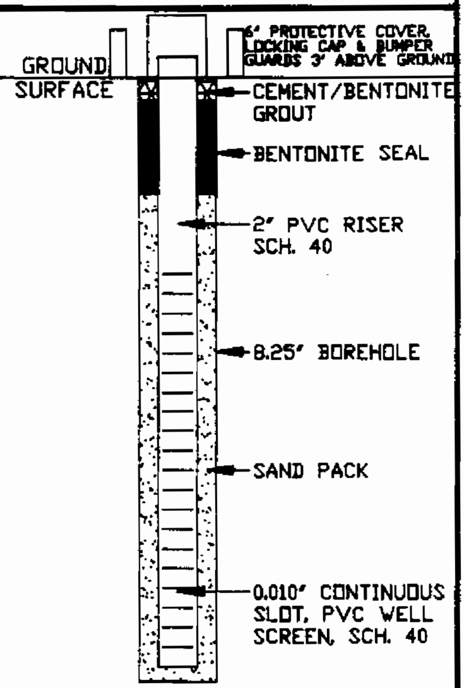
CNSY–09–09
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNSY99

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					SURFACE – SLIGHTLY GRASSY GRAY/BROWN FINE SAND; DRY; LOOSE
					FILL MATERIAL (GRAY, SLIGHTLY CLAYEY FINE SAND) TO APPROX. 7'
5					
					7 FT. – DIFFICULT DRILLING (MAJOR OBSTRUCTION)
	SS	20	30–23 15–10		(SPOON MOSTLY LIQUID CUTTINGS) DARK GRAY SAND/SILT/CLAY MIXTURE; ROOTS; SATURATED
10					
	SS	12	12–8 4–3		SAME AS ABOVE; MORE SANDY; SOME PLASTIC REFUSE MATERIAL
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

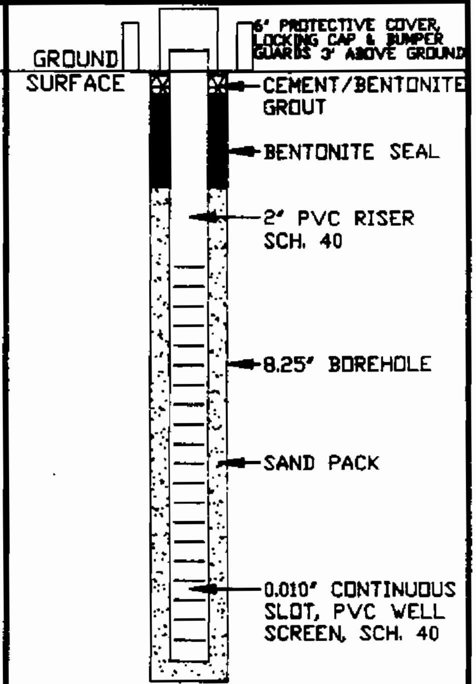
CNSY–09–10
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNS910

DEPTH (FEET)	SAMPLE TYPE	% RECOVERY	BLOWS/FT.	USCS SYMBOL	DESCRIPTION OF SUBSURFACE MATERIALS
					FILL (BROWN FINE SAND) TO APPROX. 5 FT.
5					5 FT. – CUTTINGS BECOME DARK GRAY, MOIST AND MORE CLAYEY
	SS	100	1–1 2–4	CL	DARK GRAY CLAY WITH FINE SAND (MID–SPOON MORE SANDY); SOMEWHAT PLASTIC; MOIST
10					
	SS	4	10–12 10–13	CL	SAME AS ABOVE; SATURATED
15					
20					
25					
30					
35					

SS – SPLIT SPOON
HA – HAND AUGER
TR – TROWEL
PD – POST HOLE DIGGER
BA – BUCKET AUGER

WELL CONSTRUCTION DETAILS



FINAL RFI
ZONE H WORKPLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

CNSY–09–11
MONITORING WELL
CHARLESTON NAVAL SHIP YARD
CHARLESTON, SC

DWG DATE: 10/07/94 | DWG NAME: 29CNS911

Rust

CSY-1313-1, CSY-1313-2

S&ME Wells

CSY-FMW-2 and CSY-FMW-4

Table D.1 Monitoring Well Inventory Zone H						
Well Designation	**Location**	**Contractor**	**Visual Confirmation**	**Diameter (in)**	**Depth (ft)**	**Date**
CNSY-09-01	Landfill, SW	EnSafe	Yes	2	13	9/24/93
CNSY-09-02	South of Building 650	EnSafe	Yes	2	14	9/27/93
CNSY-09-03	Landfill, SW Center	EnSafe	Yes	2	11	9/27/93
CNSY-09-04	Landfill, S.	EnSafe	Yes	2	13	9/28/93
CNSY-09-05	Landfill, E. of Holland Street	EnSafe	Yes	2	12	9/28/93
CNSY-09-06	South of Building 903	EnSafe	Yes	2	15	9/29/93
CNSY-09-07	East of Plate Street Near Building 903	EnSafe	Yes	2	13	9/29/93
CNSY-09-08	E. of Holland Street Near Building 661	EnSafe	Yes	2	13	10/4/93
CNSY-09-09	Landfill S. of Building 673	EnSafe	Yes	2	14	10/4/93
CNSY-09-10	Landfill, Center	EnSafe	Yes	2	15	10/5/93
CNSY-09-11	Landfill, NE	EnSafe	Yes	2	14	10/5/93
LF-1	Landfill, South of Building 661	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-2	Landfill, S.	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-3	Landfill, S.	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-4	Landfill, SW	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-5	Landfill, West of East Tern Lane	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-7	Landfill, West in PW Storage	Geraghty and Miller	No	Unk.	Unk.	Unk.
LF-9	Landfill, East of Holland St.	Geraghty and Miller	No	Unk.	Unk.	Unk.
SLF-1	Landfill, SW.	Geraghty and Miller	No	Unk.	Unk.	Unk.
SLF-2	Landfill, S. of Building 661	Geraghty and Miller	No	Unk.	Unk.	Unk.
DLF-1	Landfill, SW.	Geraghty and Miller	No	Unk.	Unk.	Unk.
CD-1	East of Building 677	Geraghty and Miller	No	Unk.	Unk.	Unk.
CD-2	East of Building 677	Geraghty and Miller	No	Unk.	Unk.	Unk.

Table D.1 Monitoring Well Inventory Zone H						
Well Designation	Location	Contractor	Visual Confirmation	Diameter (in)	Depth (ft)	Date
CD-3	East of Building 677	Geraghty and Miller	No	Unk.	Unk.	Unk.
CD-4	Subsurface Chem. Disp. Area East of Building 675	Geraghty and Miller	No	Unk.	Unk.	Unk.
CD-5	Subsurface Chem. Disp. Area East of Building 675	Geraghty and Miller	No	Unk.	Unk.	Unk.
CSY-FMW-1	Landfill, South Center	S&ME	No	2	7.5	9/11/91
CSY-FMW-2	Landfill, SW. Center	S&ME	Yes	2	7.5	9/11/91
CSY-FMW-3	Landfill, SW. Center	S&ME	No	2	5.5	9/11/91
CSY-FMW-4	Landfill, West of Center	S&ME	Yes	2	7.5	9/11/91
Observation Tube	Building 661 in Tank Basin	Unk.	Yes	Unk.	Unk.	Unk.
CSY-1313-1	Building 1313, West Side	Rust	Yes	2	20	9/29/90
CSY-1313-2	Building 1313, West Side	Rust	Yes	2	20	9/29/90

APPENDIX E

TREATMENT ALTERNATIVES

Note: Alternatives presented here are for preliminary evaluation only. If undertaken, a Corrective Measures Study will further evaluate these treatment alternatives.

Table E.1 Treatment Alternatives For Groundwater/Leachate SWMU 9, SWMU 14, and Associated Sites				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Vertical barrier	Slurry wall	Trench around site or hot spot is excavated and filled with bentonite slurry.	Organic/inorganic water chemistry[d] Soil type Soil moisture Particle size distribution Porosity Hydraulic conductivity (saturated and unsaturated) Relative permeability Clay content Soil sorptive capacity Cation exchange capacity Organic carbon content Soil pH Depth to groundwater Groundwater velocity and direction Depth to aquitard (Pilot - Compatibility testing with slurry wall material)
	Groundwater collection	Vertical extraction wells	Vertical wells are used to extract contaminated groundwater.	Use of aquifer Depth to water table Direction of flow Rate of flow Hydraulic conductivity (vertical and horizontal) Effective porosity Aquifer type Hydraulic gradient Identification of recharge and discharge areas Identification of aquifer boundaries Aquitard characteristics (Pilot - slug test)
	Leachate collection	Subsurface drains	System of perforated pipe laid in trenches onsite to collect contaminated groundwater.	Use of aquifer Depth to water table Direction of flow Rate of flow Hydraulic conductivity (vertical and horizontal) Effective porosity Aquifer type Hydraulic gradient Identification of recharge and discharge areas Identification of aquifer boundaries Aquitard characteristics (Pilot - slug test)

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of treatments for contaminated groundwater and leachate	Chemical treatment	Ion exchange	Ion exchange is the process of exchanging selected dissolved ionic contaminants with a set of substitute ions. Ion exchangers are primarily used for recovery of dilute solutions of metals or to soften water by removing calcium and manganese.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total organic carbon (TOC) Total suspended solids Zinc
		Oxidation	Oxidation is a chemical reaction in which one or more electrons are transferred from the chemical being oxidized to an oxidizing agent. Chemical oxidation include destruction of cyanide transformation of organics to biodegradable forms, or detoxification of organics and inorganics.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total organic carbon (TOC) Total suspended solids Zinc (Pilot - reagent consumption, optimal pH, and reaction time)

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Chemical treatment	Metal precipitation	Precipitation is a chemical unit process in which soluble metallic ions are removed from solution by conversion to an insoluble form. Precipitation is commonly used to treat heavy metals, phosphorus, and hardness.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total organic carbon (TOC) Total Suspended Solids Zinc (Pilot - chemical dosage, contact time, mixing rate, optimal pH, and sludge handling)
		pH adjustment	Neutralizing agents are added to adjust pH.	Indicator parameters Bicarbonate Calcium Chloride Iron Magnesium Manganese pH Potassium Sodium Sulfate Total Suspended Solids (Pilot - titration curve)

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Biological treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Metals, dissolved Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Total solids Specific conductance Sulfate Sulfide Suspended solids Temperature Volatile suspended solids
	Biological treatment	Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Metals, dissolved Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Total solids Specific conductance Sulfate Sulfide Suspended solids Volatile suspended solids

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Physical treatment	Adsorption (granular activated carbon)	Adsorption is a physical separation process in which organic and inorganic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
		Air Stripping	Stripping refers to the removal of relatively volatile components from wastewater by passage of air, steam, or other gas through the contaminated liquid. Stripping is effective in removing ammonia, chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Chemical oxygen demand Hardness Iron Manganese Metals, dissolved Oil and grease pH

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Physical treatment	Sedimentation	Sedimentation is a physical process that removes suspended solids from a liquid matrix by gravitational settling.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
		Filtration	Filtration is a physical process used to remove suspended solids from wastewater and is generally proceded by chemical precipitation and neutralization.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Disposal	POTW	A chemical, physical, or biological wastewater treatment plant designed and constructed to treat municipal domestic wastewater.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
		RCRA TSDF	The process of chemical, physically, or biologically treating the wastewater in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids

Table E.1
Treatment Alternatives For Groundwater/Leachate
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Disposal	Land application	The process of applying wastewater directly on the land for or to infiltration into the soil.	Depth to water table Total phosphorous Chloride Ammonia Nitrate Alkalinity pH Sodium Total dissolved solids Soil type hydraulic conductivity application rate
		Injection	The process of hydraulically placing wastewater into the aquifer using either vertical or horizontal wells.	Depth to water table Total phosphorous Chloride Ammonia Nitrate Alkalinity pH Sodium Total dissolved solids Total organic carbon Soil type hydraulic conductivity application rate (2.5 gallons/ft^2/day or 5/square root of slowest percolation rate.

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and PCBs

Table E.2
Treatment Alternatives For Hot Spots, Soil, Waste Materials, and Cap
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Surface Water Controls	Erosion and runon/runoff controls	System of vegetation and site grading for preventing soil erosion and stormwater runon/runoff.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Phosphorus Suspended solids
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size TCLP
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen Methane Chemical oxygen Demand

Table E.2
Treatment Alternatives For Hot Spots, Soil, Waste Materials, and Cap
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
		Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Methane Chemical oxygen Demand
	Physical Treatment	Solidification/ fixation	Solidification is a physical process in which organic and inorganic materials are bound to the surface of another.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Suspended Solids Bulk Density Grain size analysis Atterberg limits Cone index Unconfined Compressive strength Temperature pH
		Vacuum Extraction	Vacuum extraction refers to the removal of relatively volatile components from soil or waste by passage of air, steam, or other gas through the contaminated matrix. Stripping is effective in removing chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Moisture content Air Permeability Temperature pH Depth to groundwater

Table E.2
Treatment Alternatives For Hot Spots, Soil, Waste Materials, and Cap
SWMU 9, SWMU 14, and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Physical Treatment	Solvent Extraction	Solvent extraction is a physical separation process in which organic and inorganic materials are removed from the surface of a solid matrix to a liquid matrix.	Organic/inorganic water chemistry[d] Total Organic Carbon Total Recoverable Hydrocarbons Moisture content Soil Texture Permeability Bulk Density Grain size analysis Clay Content Temperature pH Chemical oxygen Demand Cation Exchange Capacity Depth to groundwater TCLP
	Disposal	Consolidation	This is the process of consolidating the waste, soil, and other debris in a properly designed and constructed landfill.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Depth to Groundwater TCLP
		RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

a USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991
b 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction
c USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.
d VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and PCBs

Table E.3
Treatment Alternatives For Soil Gas
SWMU 9, SWMU 14 and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for subsurface gas	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Vent	Vertical Horizontal	Vertical or horizontal wells are used to vent gases.	Moisture content Air Permeability Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
	Physical Treatment	Carbon Absorption	Adsorption is a physical separation process in which organic and inorganic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.	Organic/inorganic water chemistry (VOA and SVOA w/TICs, Pesticides, and PCBs) Moisture content Temperature Total Organic Carbon
		Vacuum Extraction	Vacuum extraction refers to the removal of relatively volatile components from soil or waste by passage of air, steam, or other gas through the contaminated matrix. Stripping is effective in removing chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Moisture content Air Permeability Temperature pH Depth to groundwater

Table E.3
Treatment Alternatives For Soil Gas
SWMU 9, SWMU 14 and Associated Sites

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and PCBs

Table E.4
Treatment Alternatives
SWMU 19

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Excavation	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

a USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991
b 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction
c USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.
d VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and PCBs

Table E.5
Treatment Alternatives
SWMU 20

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Excavation	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and PCBs

Table E.6
Treatment Alternatives
AOC 649, AOC 650, AOC 651, SWMU 121

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Surface Water Controls	Erosion and runon/runoff controls	System of vegetation and site grading for preventing soil erosion and stormwater runon/runoff.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Phosphorus Suspended solids
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size TCLP
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen Methane Chemical oxygen Demand

Table E.6 Treatment Alternatives AOC 649, AOC 650, AOC 651, SWMU 121				
Data Quality Objective Elements	**Remedial Technology**[a]	**Process Option**[b,c]	**Description**	**Data Quality Needs**
	Biological Treatment	Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Methane Chemical oxygen Demand
	Physical Treatment	Solidification/ fixation	Solidification is a physical process in which organic and inorganic materials are bound to the surface of another.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Suspended Solids Bulk Density Grain size analysis Atterberg limits Cone index Unconfined Compressive strength Temperature pH
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Physical Treatment	Solvent Extraction	Solvent extraction is a physical separation process in which organic and inorganic materials are removed from the surface of a solid matrix to a liquid matrix.	Organic/inorganic water chemistry[d] Total Organic Carbon Total Recoverable Hydrocarbons Moisture content Soil Texture Permeability Bulk Density Grain size analysis Clay Content Temperature pH Chemical oxygen Demand Cation Exchange Capacity Depth to groundwater TCLP
	Disposal	Consolidation	This is the process of consolidating the waste, soil, and other debris in a properly designed and constructed landfill.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Depth to groundwater TCLP

Table E.6 Treatment Alternatives AOC 649, AOC 650, AOC 651, SWMU 121				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

Table E.7
Treatment Alternatives For Groundwater/Leachate
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Vertical Barrier	Slurry Wall	Trench around site or hot spot is excavated and filled with bentonite slurry.	Organic/inorganic water chemistry (VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCBs and TPH) Soil type Soil moisture Particle size distribution Porosity Hydraulic conductivity (saturated and unsaturated) Relative permeability Clay content Soil sorptive capacity Cation exchange capacity Organic carbon content Soil pH Depth to groundwater Groundwater velocity and direction Depth to aquitard (Pilot - Compatibility testing with slurry wall material)
	Groundwater Collection	Vertical Extraction Wells	Vertical wells are used to extract contaminated groundwater.	Use of aquifer Depth to water table Direction of flow Rate of flow Hydraulic conductivity (vertical and horizontal) Effective porosity Aquifer type Hydraulic gradient Identification of recharge and discharge areas Identification of aquifer boundaries Aquitard characteristics (Pilot - slug test)
	Leachate Collection	Subsurface Drains	System of perforated pipe laid in trenches onsite to collect contaminated groundwater.	Use of aquifer Depth to water table Direction of flow Rate of flow Hydraulic conductivity (vertical and horizontal) Effective porosity Aquifer type Hydraulic gradient Identification of recharge and discharge areas Identification of aquifer boundaries Aquitard characteristics (Pilot - slug test)

Table E.7 Treatment Alternatives For Groundwater/Leachate SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of treatments for contaminated groundwater and leachate	Chemical Treatment	Ion Exchange	Ion exchange is the process of exchanging selected dissolved ionic contaminants with a set of substitute ions. Ion exchangers are primarily used for recovery of dilute solutions of metals or to soften water by removing calcium and manganese.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total Organic Carbon (TOC) Total Suspended Solids Zinc
		Oxidation	Oxidation is a chemical reaction in which one or more electrons are transferred from the chemical being oxidized to an oxidizing agent. Chemical oxidation include destruction of cyanide; transformation of organics to biodegradable forms, or detoxification of organics and inorganics.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total Organic Carbon (TOC) Total Suspended Solids Zinc (Pilot - reagent consumption, optimal pH, and reaction time)

Table E.7 Treatment Alternatives For Groundwater/Leachate SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Chemical Treatment	Metal Precipitation	Precipitation is a chemical unit process in which soluble metallic ions are removed from solution by conversion to an insoluble form. Precipitation is commonly used to treat heavy metals, phosphorus, and hardness.	Organic/inorganic water chemistry[d] Indicator parameters Bicarbonate Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Copper Iron Magnesium Manganese Nickel Oil and grease pH Potassium Sodium Sulfate Total Organic Carbon (TOC) Total Suspended Solids Zinc (Pilot - chemical dosage, contact time, mixing rate, optimal pH, and sludge handling)
		pH Adjustment	Neutralizing agents are added to adjust pH.	Indicator parameters Bicarbonate Calcium Chloride Iron Magnesium Manganese pH Potassium Sodium Sulfate Total Suspended Solids (Pilot - titration curve)

Table E.7 Treatment Alternatives For Groundwater/Leachate SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Metals, dissolved Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Total solids Specific conductance Sulfate Sulfide Suspended solids Temperature Volatile suspended solids
		Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Metals, dissolved Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Total solids Specific conductance Sulfate Sulfide Suspended solids Volatile suspended solids

Table E.7
Treatment Alternatives For Groundwater/Leachate
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Physical Treatment	Adsorption (Granular Activated Carbon)	Adsorption is a physical separation process in which organic and inorganic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
		Air Stripping	Stripping refers to the removal of relatively volatile components from wastewater by passage of air, steam, or other gas through the contaminated liquid. Stripping is effective in removing ammonia, chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Chemical oxygen demand Hardness Iron Manganese Metals, dissolved Oil and grease pH

Table E.7
Treatment Alternatives For Groundwater/Leachate
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Physical Treatment	Sedimentation	Sedimentation is a physical process that removes suspended solids from a liquid matrix by gravitational settling.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
	Physical Treatment	Filtration	Filtration is a physical process used to remove suspended solids from wastewater and is generally proceeded by chemical precipitation and neutralization.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids

Table E.7
Treatment Alternatives For Groundwater/Leachate
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Disposal	POTW	A chemical, physical, or biological wastewater treatment plant designed and constructed to treat municipal domestic wastewater.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids
	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the wastewater in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry (VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCB, and TPH) Indicator parameters Acidity-alkalinity Biochemical oxygen demand Calcium Chemical oxygen demand Chloride Dissolved oxygen Hardness Iron Metals, dissolved Manganese Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Oil and grease Organic carbon pH Phosphorus Sulfate Sulfide Suspended solids

Table E.7 Treatment Alternatives For Groundwater/Leachate SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Disposal	Land Application	The process of applying wastewater directly on the land to infiltration into the soil.	Depth to water table Total phosphorous Chloride Ammonia Nitrate Alkalinity pH Sodium Total dissolved solids soil type hydraulic conductivity application rate
		Injection	The process of hydraulically placing wastewater into the aquifer using either vertical or horizontal wells.	Depth to water table Total phosphorous Chloride Ammonia Nitrate Alkalinity pH Sodium Total dissolved solids Total organic carbon soil type hydraulic conductivity application rate (2.5 gallons/ft^2/day or 5/square root of slowest percolation rate.

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCBs and TPH

Table E.8
Treatment Alternatives for Hot Spots, Soils, Waste Materials and Cap
SWMU 13 SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Surface Water Controls	Erosion and runon/runoff controls	System of vegetation and site grading for preventing soil erosion and stormwater runon/runoff.	Organic/inorganic water chemistry[d] Indicator parameters Acidity-alkalinity Nitrogen, ammonia Nitrogen, kjeldahl Nitrogen, nitrate-nitrite Phosphorus Suspended solids
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size TCLP
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total Phosphorus Depth to groundwater Dissolved oxygen Methane Chemical oxygen Demand

Table E.8 Treatment Alternatives for Hot Spots, Soils, Waste Materials and Cap SWMU 13 SWMU 17 and AOCs 653, 662, 663, 667				
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**	**Data Quality Needs**
		Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Methane Chemical oxygen Demand
	Physical Treatment	Solidification/ fixation	Solidification is a physical process in which organic and inorganic materials are bound to the surface of another.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Suspended Solids Bulk Density Grain size analysis Atterberg limits Cone index Unconfined Compressive strength Temperature pH
	Physical Treatement	Vacuum Extraction	Vacuum extraction refers to the removal of relatively volatile components from soil or waste by passage of air, steam, or other gas through the contaminated matrix. Stripping is effective in removing chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Moisture content Air Permeability Temperature pH Depth to groundwater

Table E.8
Treatment Alternatives for Hot Spots, Soils, Waste Materials and Cap
SWMU 13 SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants		Solvent Extraction	Solvent extraction is a physical separation process in which organic and inorganic materials are removed from the surface of a solid matrix to a liquid matrix.	Organic/inorganic water chemistry[d] Total Organic Carbon Moisture content Soil Texture Permeability Bulk Density Grain size analysis Clay Content Temperature pH Chemical oxygen Demand Cation Exchange Capacity Depth to groundwater TCLP
	Disposal	Consolidation	This is the process of consolidating the waste, soil, and other debris in a properly designed and constructed landfill.	Organic/inorganic water chemistry[d] Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Depth to groundwater TCLP
	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991
[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction
[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.
[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCBs and TPH

Table E.9
Treatment Alternatives for Soil Gas
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls for subsurface gas	Cap	Native Soil Single Barrier Double Barrier	This is the process of placing a physical horizontal barrier across the site.	Moisture content Permeability In-Situ density Atterberg limits Grain size analysis Porosity Depth
	Vent	Vertical Horizontal	Vertical or horizontal wells are used to vent gases.	Moisture content Air Permeability Atterberg limits Grain size analysis Porosity Depth
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry[d] Moisture content Particle size BTU content TCLP
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size TCLP
	Physical Treatment	Carbon Absorption	Adsorption is a physical separation process in which organic and inorganic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.	Organic/inorganic water chemistry[d] Moisture content Temperature Total Organic Carbon
	Physical Treatment	Vacuum Extraction	Vacuum extraction refers to the removal of relatively volatile components from soil or waste by passage of air, steam, or other gas through the contaminated matrix. Stripping is effective in removing chlorinated solvents, monoaromatics, and other VOCs.	Organic/inorganic water chemistry[d] Moisture content Air Permeability Temperature pH Depth to groundwater

Table E.9
Treatment Alternatives for Soil Gas
SWMU 13, SWMU 17 and AOCs 653, 662, 663, 667

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

a USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991
b 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction
c USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.
d VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCBs and TPH

Table E.10 Treatment Alternatives AOC 658				
Data Quality Objective Elements	**Remedial Technology**[a]	**Process Option**[b,c]	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Vent	Pressure release	Either place cylinder in an enclosed system to vent or place enclosed vent system over the cylinder, then mechanically vent the cylinder.	Cylinder location
	Excavation	Dipup	This is the process of physically removing the hot spot, soil, or waste from site.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Suspended Solids Bulk Density Grain size analysis Atterberg limits pH
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Organic/inorganic water chemistry [d] Moisture content Particle size BTU content TCLP
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics and inorganics from a solid matrix.	Organic/inorganic water chemistry[d] Moisture content Particle size TCLP
	Physical Treatment	Carbon Absorption	Absorption is the physical separation process in which organic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.	Organic/inorganic water chemistry[d] Moisture content Soil Texture Suspended Solids Bulk Density Grain size analysis Atterberg limits Cone index Unconfined Compressive Strength Temperature pH

Table E.10 Treatment Alternatives AOC 658				
Data Quality Objective Elements	**Remedial Technology**[a]	**Process Option**[b,c]	**Description**	**Data Quality Needs**
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Organic/inorganic water chemistry (VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, and, PCBs) Moisture content Soil Texture Temperature pH Soil microorganisms Total nitrogen Total phosphorus Depth to groundwater Dissolved oxygen TCLP

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

[d] VOA and SVOA w/TICs, Metals, Cyanide, Pesticides, PCBs and TPH

Table E.11 Treatment Alternatives for Groundwater/Leachate AOC 655 and AOC 656			
Data Quality Objective Elements	**Remedial Technology[a]**	**Process Option[b,c]**	**Description**
To evaluate the feasibility and implementability of controls for contaminated groundwater and leachate	Groundwater Collection	Vertical Extraction Wells	Vertical wells are used to extract contaminated groundwater.
	Leachate Collection	Subsurface Drains	System of perforated pipe laid in trenches onsite to collect contaminated groundwater.
To evaluate the feasibility and implementability of treatments for contaminated groundwater and leachate	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.
		Anaerobic	Anaerobic is the use of non-oxygen-utilizing micro-organisms to biodegrade contaminants.
	Physical Treatment	Adsorption (Granular Activated Carbon)	Adsorption is a physical separation process in which organic and inorganic materials are removed by sorption or the attraction and accumulation of one substance on the surface of another.
		Air Stripping	Stripping refers to the removal of relatively volatile components from wastewater by passage of air, steam, or other gas through the contaminated liquid. Stripping is effective in removing ammonia, chlorinated solvents, monoaromatics, and other VOCs.
		Sedimentation	Sedimentation is a physical process that removes suspended solids from a liquid matrix by gravitational settling.
		Filtration	Filtration is a physical process used to remove suspended solids from wastewater and is generally proceeded by chemical precipitation and neutralization.
		POTW	A chemical, physical, or biological wastewater treatment plant designed and constructed to treat municipal domestic wastewater.
	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the wastewater in an offsite permitted commercial hazardous waste facility.
		Land Application	The process of applying wastewater directly on the land to infiltration into the soil.

Table E.11
Treatment Alternatives for Groundwater/Leachate
AOC 655 and AOC 656

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description
To evaluate the feasibility and implementability of treatments for contaminated groundwater and leachate (cont'd)	Disposal	Injection	The process of hydraulically placing wastewater into the aquifer using either vertical or horizontal wells

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

Table E.12
Treatment Alternatives for Hot Spots, Soils, Waste Materials and CAP
AOC 655 and AOC 656

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.
	Surface Water Controls	Erosion and runon/runoff controls	System of vegetation and site grading for preventing soil erosion and storm water runon/runoff.
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic using high temperature.
		Thermal Desorption	Thermal desorption is the process of using low temperature to volatilize organics.
	Biological Treatment	Aerobic	Aerobic is the use of oxygen-utilizing micro-organisms to biodegrade contaminants.
	Physical Treatment	Solidification/ fixation	Solidification is a physical process in which organic materials are bound to the surface of another.
	Disposal	Consolidation	This is the process of consolidating the waste, soil, and other debris in a properly designed and constructed landfill.
		RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.

a USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991

b 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction

c USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

Table E-13
Treatment Alternatives For
UXO Site AOC 503, 661, and 665

Data Quality Objective Elements	Remedial Technology[a]	Process Option[b,c]	Description	Data Quality Needs
To evaluate the feasibility and implementability of controls to prevent contact or runoff	Excavation	Dig up	This is the process of physically removing the hot spot, soil, or waste from the site.	Refer to Table E-2.
To evaluate the feasibility and implementability of treatments for contaminated soil and contaminants	Thermal Treatment	Thermal Destruction	Thermal destruction is the process of oxidizing organic and inorganics using high temperature.	Refer to Table E-2.
	Physical Treatment	Solidification/ fixation	Solidification is a physical process in which organic and inorganic materials are bound to the surface of another.	Refer to Table E-2.
		Detonation	Detonation refers to setting off a controled explosion in order to get a desired chain reaction.	Currently not known. This will likely be the responsibility of Navy EOD personnel.
		Solvent Extraction	Solvent extraction is a physical separation process in which organic and inorganic materials are removed from the surface of a solid matrix to a liquid matrix.	Refer to Table E-2.
	Disposal	RCRA TSDF	The process of chemical, physically, or biologically treating the contaminant, soil, and other debris in an offsite permitted commercial hazardous waste facility.	Refer to Table E-2.

[a] USEPA *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, EPA/540/P-91/001, Office of Solid Waste and Emergency Response Directive 9355.3-11, February 1991
[b] 40 Code of Federal Regulations (CFR) 268 Land Disposal Restriction
[c] USEPA *CERCLA Site Discharges to POTWs Treatability Manual*, EPA/540/2-90/007, Office of Solid Waste and Emergency Response, August 1990.

APPENDIX F

RADIATION PROTECTION PROGRAM

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1.0 INTRODUCTION

The EnSafe/Allen & Hoshall (E/A&H) Radiation Protection Program was developed to provide a means for occupational and environmental radiation protection for E/A&H workers who may encounter radioactive materials while working at the Naval Base Charleston (NAVBASE) in Charleston, S.C. The development of this program has been initiated to conform with federal radiation protection guidance and regulations, best industry practices, and the "as low as reasonably achievable" (ALARA) concept. ALARA is the fundamental radiation protection standard designed to protect individuals from exposure to ionizing radiation, given the a-priori assumption that any level of exposure to ionizing radiation, including background, may have some risk of producing biological effect on the human body.

The potential presence of radioactive materials at NAVBASE result from past operational activities at the base, such as production during the naval nuclear propulsion program, as well as the geographical location which has been found to be rich in naturally occurring radioactive material (NORM).

2.0 PURPOSE

This document establishes a Radiation Protection Program for E/A&H/Allen & Hoshall (Ensafe) at NAVBASE in order to ensure that exposures to employees from ionizing radiation and releases of source, byproduct, and naturally occurring radioactive materials (NORM) and other radioactive materials to the environment are maintained ALARA.

3.0 APPLICABILITY

This program applies to all E/A&H employees or contractors while conducting field work at NAVBASE including, but not limited to walkover investigations, drilling, well development, soil sampling, water sampling, and trenching.

4.0 POLICY

Reasonable efforts shall be made to maintain radiation exposures and releases of radioactive materials ALARA, taking into account all relevant considerations including the state of technology as well as social and economic factors.

5.0 REFERENCES

- Title 10, Part 20, Code of Federal Regulations (CFR), *Standards for Protection Against Radiation*.

- Title 29, Part 1910, CFR, *Occupational Safety and Health Administration, Ionizing Radiation*.

- NCRP Report No. 39, *Basic Radiation Protection Criteria*, 15 January, 1979.

- International Commission on Radiological Units and Measurement (ICRU) Report 10A, 1962, *Radiation Quantities and Units*.

6.0 RESPONSIBILITIES

The **Safety Director** shall be ultimately responsible for ensuring compliance with this procedure by all group personnel.

The **Radiation Safety Officer** shall be responsible for ensuring that all personnel are informed about the radiation protection program and are adequately trained in radiation protection practices and procedures.

Each employee of E/A&H shall be responsible for following the procedures outlined in this instruction, to report to his/her supervisor, or the radiation safety officer, any observed violation of these procedures, and to suggest, when noted, modifications that will improve work practices and lower individual and group doses.

7.0 DEFINITIONS

Annual Limit on Intake (ALI). The quantity of a single radionuclide which, if inhaled or ingested in one year, would irradiate a person represented by reference man (ICRP Publication 23) to the limiting value for control of the workplace.

Area Terms

- Controlled Area. Any area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials.

- Radiological Area. Any area within a controlled area where an individual can receive a dose equivalent greater than 5 mrem in 1 hour at 30 cm from the radiation source or any surface through which the radiation penetrates, or where airborne radioactive concentrations greater than 1/10 of the derived air concentrations are present (or are likely to be), or where surface contamination levels greater than those specified in Appendix F-1 of this Program are present.

- Derived Air Concentration (DAC). Quantity obtained by dividing the ALI for any given radionuclide by the volume of air breathed by an average worker during a working year ($2400 m^3$).

As Low As Reasonably Achievable (ALARA)

An operating philosophy and approach to radiation protection designed to control or manage exposures (both individual and collective to the workforce and general public) to as low as technological, economic, practical, and public policy considerations permit. As used in 10 Code of Federal Regulations (CFR) 20, ALARA is not a dose limit but a process, which has the objective of maintaining dose levels as far below applicable limits as reasonably achievable.

Dose Terms

- **Absorbed Dose (D)**. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is express in units of rad.

- **Annual Dose Equivalent**. The dose equivalent received in a year. Annual dose equivalent is expressed in units of Rem.

- **Annual Effective Dose Equivalent**. The effective dose equivalent received in a year. The annual effective dose equivalent is expressed in units of Rem.

- **Collective Dose Equivalent**. The sum of the dose equivalent of all individuals in an exposed population. Collective dose equivalent is expressed in units of person-Rem.

- **Collective Effective Dose Equivalent**. The sum of the effective dose equivalents of all individuals in an exposed population. Collective effective dose equivalent is expressed in units of person-Rem.

- **Committed Dose Equivalent**. The calculated dose equivalent projected to be received by a tissue or organ over a 50-year period after an intake of radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of Rem.

- **Committed Effective Dose Equivalent.($H_{E,50}$)**. The sum of the committed dose equivalents to various tissues in the body multiplied by its weighing factor. It does not include contributions from external dose. Committed effective dose equivalent is expressed in units of Rem.

- **Cumulative Annual Effective Dose Equivalent**. The sum of the annual effective dose equivalents recorded for an individual for each year of employment.

- **Dose Equivalent (H)**. The product of absorbed dose (D) in rads in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent (H) is expressed in units of Rem. $H = QDN$.

- **Effective Dose Equivalent (H_E)**. The sum over specified tissues of the products of the dose equivalent in a tissue (H_t) and the weighing factor (W_t) for that tissue, i.e., $H_E = W_t H_t$. The effective dose equivalent is expressed in units of Rem.

- **Shallow, Deep and Lens of Eye Dose Equivalent**. The dose equivalent at the respective depths of 0.007 cm, 1.0 cm, and 0.3 cm in tissue.

- **Weighing Factor (W_t)**. Is used in the calculation of annual and committed effective dose equivalent to equate the risk arising from the irradiation of tissue T to the total risk when the whole body is uniformly irradiated. The weighing factors as defined in ICRP Publication 26 and NCRP Report 91 are:

Organs or Tissues	Weighing Factor
Gonads	0.25
Breasts	0.15
Red Bone Marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	0.03[1]

Note:

[1] "Remainder" means the five other organs or tissue with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, upper large intestine or lower large intestine). The weighing factor for each Remainder organ or tissue is 0.06. The extremities, skin and lens of the eyes are excluded from the "Remainder" organs or tissue for assessment of effective dose equivalent.

Extremity. Extremity includes hands and arms below the elbow or feet and legs below the knee.

Ionizing Radiation means any or all of the following: alpha particles, beta particle, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other atomic and sub-atomic particles but not sound or radio waves, visible infrared or ultraviolet light.

Monitoring. Actions intended to detect and evaluate radiological conditions.

Non-Stochastic Effects. Effects such as the opacity of the lens of the eye for which the severity of the effect varies with the doses and for which a threshold may exist.

NORM. Naturally occurring radioactive materials of the Uranium 238 and Thorium 232 decay chains found in nature and which emit ionizing radiation spontaneously.

Occupational Worker. An individual who is either a E/A&H or E/A&H contractor employee; an employee of a subcontractor to a E/A&H contractor; or an individual who visits to perform work for or in conjunction with E/A&H or utilizes E/A&H facilities.

Quality Factor (Q). A modifying factor that is employed to derive dose equivalent from absorbed dose.

Radiation Worker. An occupational worker whose job assignment requires work on, with, or in the proximity of radiation producing machines or radioactive materials, and/or who has the potential of being routinely exposed above 100 mrem per year, which is the sum of the annual effective dose equivalent from irradiation and the committed effective dose equivalent from internal irradiation.

Source Material means (1) uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of one percent (0.05%) or more of (i) uranium, (ii) thorium or (iii) any combination thereof.

Stochastic Effects. Malignant and hereditary disease for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

The Exposure (X) is the term reserved for the quantitative assessment of ionizing electromagnetic radiation fields. The exposure at a given place is a measure of the radiation based on its potential ability to produced ionization in air. The special unit of exposure is the Roentgen (R).

The Rad is a measure of dose of any ionizing radiation to body tissues in terms of energy absorbed per unit mass of tissue. One rad is the dose corresponding to the absorption to 100 ergs per gram of tissue.

The Rem is a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of one rad of 250 KeV x-ray.

The Roentgen is defined as the measure of exposure equivalent to the capture of a charge of 2.58×10^{-4} Coulombs/Kg of dry air at standard temperature and pressure.

Working Level (WL) is defined as any combination of radon daughters in one liter of air which will result in the ultimate emission of 1.3×10^{5} million electron volts of potential alpha energy.

Working Level Month (WLM) is defined as the exposure received by a worker breathing air at one working level concentration for 170 hours.

8.0 RADIATION SAFETY OFFICER

A Radiation Safety Officer (RSO) will be designated to safely control all aspects of occupational radiation protection at E/A&H.

Duties and Functions

The Radiation Safety Officer is responsible for the establishment of safe working conditions according to current standards and for compliance with all pertinent federal, state and local regulations. The RSO has the authority as well as the responsibility, to investigate and advise on all work in matters of radiation protection. The RSO may designate Alternate Radiation Safety Officer(s) (ARSO), as necessary to fulfill duties and responsibilities. The specific duties of the RSO and ARSO include:

- Establishing, controlling, reviewing, and updating operating procedures to ensure conformance with applicable federal, state and corporate guidance.

- Providing technical assistance in the planning and execution of operations involving radiation safety considerations, in accordance with this guideline.

- Instructing personnel on proper radiation protection practices, safe working practices (noting the special case of the fertile female), and proper procedures in the event of an emergency.

- Enforcing operational procedures that ensure radiation exposures are held As Low As Reasonably Achievable (ALARA).

- Ensuring proper use of radiation survey instruments and personnel monitoring devices and corresponding recordkeeping requirements.

- Investigating known or suspected cases of excessive or abnormal exposures to ionizing radiation to determine causal factors and to take appropriate steps to prevent reoccurrence.

- Supervising and/or conducting radiation and contamination surveys and maintaining records of surveys and sampling, to include summaries of corrective measures recommended, initiated, and/or instituted or completed.

- Ensuring that suitable caution labels, signs, tapes, ropes, etc. are in place when required by federal state or local regulations or are indicated by safe practice.

Qualifications

Radiation Safety Officers and Alternate Radiation Safety Officers should be chosen from individuals who have received training in radiation protection. Training is to be commensurate with the RSO and ARSO assignment and in accordance with federal, state and local regulations.

9.0 PERMISSIBLE DOSE LIMITS

The following dose limits (see Tables 1, 2 and 3) for occupational exposure to ionizing radiation are prescribed by 10 CFR 20. These dose limits are consistent with the recommendations of the International Commission of Radiological Protection and shall be considered the maximum allowable for all exposures, except for emergency conditions.

Table 1
Radiation Exposure Limits External plus Internal Radiation

	Occupationally Exposed Radiation Workers	Employees (i.e. Other Employees)	General Public
Annual Effective Dose Equivalent to:	Rem	Rem	Rem
Stochastic Effects	5.000	0.100	0.100

Table 1
Radiation Exposure Limits External plus Internal Radiation

	Occupationally Exposed Radiation Workers	Employees (i.e. Other Employees)	General Public
Non-Stochastic Effects	50.00		
Skin of Whole Body	50.00		
Extremities, Hands, Forearms, Feet and Ankles	50.00		
Other Organs not Mentioned	50.00		
Lens of Eye	15.00		
Unborn Child: Entire Period of Gestation	0.5		

Table 2
Airborne Radiation (Derived Air Concentration [uCi/cc])(*)

	Occupational Exposure	Other Employees	Public
222 Radon(**)	3×10^{-8}	1×10^{-10}	2×10^{-11}
226 Radium in Air	3×10^{-10}	9×10^{-13}	9×10^{-13}
232 Thorium in Air	5×10^{-13}	4×10^{-15}	4×10^{-15}
Natural Uranium in Air	0.2 mg/m^3***		
Natural Uranium in Air	2×10^{-11}	9×10^{-14}	9×10^{-14}

Table 3
Annual Limits of Intake (uCi)(*)

Radium 226	2.0 0.6 0.7	Ingestion Inhalation Ingestion

Table 3 **Annual Limits of Intake (uCi)(*)**		
Thorium 232	0.7 0.001	Ingestion Inhalation
Natural Uranium	10.0 1.0	Ingestion Inhalation

Notes:
(*) Other isotopes are listed in 10 CFR 20.
(**) In equilibrium with its daughter products.
(***) ACGIH/OSHA PEL for Chemical Effects for Soluble Forms.

The hazards of radiation exposure during pregnancy shall be explained prior to employing fertile women in a potential radiation environment. Exposure of occupational pregnant females shall be less that 500 mrem (0.5Rem) for the duration of the pregnancy.

Minors, defined as persons under 18 years of age, will not be employed for positions where the actual or projected dose equivalent received will exceed 100 mrem averaged over one year.

10.0 PROCEDURE FOR RADIATION MEASUREMENT

General Site Screening

- All surveys will be made using recently calibrated meters capable of measuring uR levels of exposure and gross beta-gamma radiation. Recent calibration implies calibration on at least an annual basis.

- The unit of measurement for exposure rate is uR/hr. The unit of measurement for gross beta-gamma measurements (contamination screening) is counts per minute (cpm).

- Prior to initiating work or entry into unevaluated site areas, both general area exposure rate and beta-gamma measurements shall be taken. This may be accomplished while traversing a site, such as during site walkovers, or in the immediate vicinity of a planned work area, such as a drilling location.

- Exposure rate and gross beta-gamma measurements shall be taken independently at approximately 3 feet above ground level. Additional gross beta-gamma radiation measurements shall be taken at ground level if contamination in the area is suspected or if a significant increase (2X) over background is sustained using either instrument during screening conducted at the height of 3-foot. Higher gross beta-gamma readings at ground level are indicative of the presence of contamination. Similar readings at ground level and 3 feet are indicative of a radioactive source in the area or airborne radioactivity.

- All measurements and readings should be recorded on a radiological control survey record form (Appendix F-2) coupled with a site map of the respective work locations. This map need not be to scale but should present an accurate enough description that the location of a measurement can be accurately reproduced.

- Special rules and radiological control procedures are specified in Sections 12.0 and 13.0. This information coupled with the flow charts in Appendix F-3 provide guidance as to appropriate measures to be taken if action levels specified in Section 11.0 are exceeded.

Contamination Surveys

- Contamination surveys should be performed for the purpose of classifying equipment or areas for restricted or unrestricted use as defined in Section 13.0.

- Surveys will be made using recently calibrated meters capable of measuring alpha and beta-gamma surface contamination. Recent calibration implies calibration on at least an annual basis.

Note: Alpha surveys are required only when alpha contamination is known or suspected or when releasing equipment or areas potentially contaminated with alpha emitters. Alpha surveys should be made with a zinc sulfide (ZnS) or equivalent detector to determine the presence of external alpha contamination. Due to the low alpha background, readings in excess of a few cpm are indicative of surface contamination. A high alpha background with a ZnS detector (>1-2 cpm) is indicative of a light leak in the detector and should be repaired.

- The unit of measurement for contamination is cpm.

- All direct contamination measurements should be made as close to, but not in contact with (within 1/8-inch) the suspected contaminated surface or equipment. Probe movement across large surfaces should be no more than 1 inch per second to obtain accurate measurements.

- Beta-Gamma measurements should be taken with a survey meter coupled with a GM pancake probe or equivalent. The instrument background should be subtracted from all readings to obtain net count rate. Statistical count rate fluctuations are normal. Positive indication of contamination is generally noted by an increase in count rate of more than four times the square root of the background (i.e. for background count rate of 50 cpm, approximately 80 cpm would be the meter reading required to be sure there was actual contamination present at 30 cpm net). Audible indicators should be used to rapidly detect qualitative changes in radiation levels prior to making analog scale readings.
- Net count rates (after subtracting background) should be converted to appropriate units of $dpm/100cm^2$ prior to comparison with the contamination limits specified in Appendix F-1. (See Footnote 2 of Appendix F-1.) The basic equation for determining

surface activity in units of the guidelines (dpm/100 cm^2) using a direct static measurement is as follows:

$$SA = \frac{Net\,CPM}{E\ x\ (A/100)}$$

where:

SA	=	Surface activity in dpm/100 cm^2
cpm	=	Gross counts minus background counts per minute
E	=	detection efficiency (default value is 10% efficient)
A	=	probe active area (typically 16 cm^2)

- All positive direct contamination measurements should be followed by dry smear samples of 100 cm^2 to determine the removable fraction.

- Dry smear samples should be taken at representative locations with 4.25 cm diameter (or equivalent) filter papers (Whatman #1). The smear samples should be obtained by applying moderate pressure with the tips of the first two fingers to the back of the filter paper and wiping the surface over an area of approximately 100 cm^2.

- Smear samples should be analyzed for gross alpha and gross beta/gamma activity by utilizing an internal low background proportional counter or a scaler with either a zinc sulfide [ZnS(Ag)] crystal to evaluate alpha activity or a G-M tube and tray to measure beta-gamma activity. Since the smear is taken over 100 cm^2 area, the "A/100" scaling term in the equation above can be neglected when determining dpm/100 cm^2.

- All measurements and readings should be recorded on a radiological control survey record form (Appendix F-2) coupled with a site map of the respective work locations. This map need not be to scale but should present an accurate enough description that the location of a measurement can be accurately reproduced.

- Special rules and radiological control procedures are specified in Sections 12.0 and 13.0. This information coupled with the flow charts in Appendix F-3 provide guidance as to appropriate measures to be taken if action levels specified in Section 11.0 are exceeded.

Radiation Exposure Survey

- Surveys will be made using recently calibrated meters capable of measuring low level external exposure rates. Recent calibration implies calibration on at least an annual basis..

- The unit of measurement for exposure monitoring is microroentgen per hour (uR/hr).

- Radiation exposure surveys for employees should be conducted independently of contamination surveys. Positive contamination measurements should always be followed by radiation exposure surveys.

- Estimates of exposure rates in the work area should be made with a recently calibrated ion chamber or survey meter coupled with an energy compensated GM probe, sodium iodide detector, or equivalent instrument. Measurements should be made along work routes, at work positions and at representative locations at least 30 cm from the surface of the radioactive materials source.

- Exposure measurement will be made at the height of the reproductive organs or about 3 feet from the ground.

- All measurements and readings should be recorded on a radiological control survey record form (Appendix F-2) coupled with a site map of the respective work locations. This map need not be to scale but should present an accurate enough description that the location of a measurement can be accurately reproduced.

- Special rules and radiological control procedures are specified in Sections 12.0 and 13.0. This information coupled with the flow charts in Appendix F-3 provide guidance as to appropriate measures to be taken if action levels specified in Section 11.0 are exceeded.

Personnel Monitoring/Frisking

- When working in area were radiation has been detected, personnel shall be frisked for contamination each time an they exit an actual or potentially contaminated area or has been working with radioactive material.

- Surveys shall be made using recently calibrated meters capable of measuring alpha and beta-gamma surface contamination. Recent calibration implies calibration on at least an annual basis.

  Note: Alpha surveys are required only when alpha contamination is known or suspected.

- The unit of measurement for contamination is cpm.

- All direct contamination measurements should be made as close to, but not in contact with (within 1/4-inch) the individual. Probe movement should be no more than 1 inch per second to obtain accurate measurements. Personnel frisking measurements should be taken with a survey meter coupled with a GM pancake probe or equivalent. The instrument background should be subtracted from all readings to obtain net count rate
- Monitor the hands first, then the top of head, shoulders, torso, legs and feet. Time taken should be approximately 1 minute. To monitor the bottoms of the feet, have the individual lean against a wall for balance while he/she lifts 1 foot at a time.

- Statistical count rate fluctuations are normal. Positive indication of contamination is generally noted by an increase in count rate of more than four times the square root of the background (i.e. for background count rate of 50 cpm, approximately 80 cpm would be the meter reading required to be sure there was actual contamination present at 30 cpm net). Audible indicators should be used to rapidly detect qualitative changes in radiation levels prior to making analog scale readings.

- Contamination on an individual is generally limited to hands or feet and can be eliminated by removal of gloves or shoe coverings or by washing the affected area with soap and water. Special rules and radiological control procedures are specified in Sections 12.0 and 13.0. This information coupled with the flow charts in Appendix F-3 provide guidance as to appropriate measures to be taken if action levels specified in Section 11.0 are exceeded.

Ambient Air Sampling

Ambient air samples will be collected and analyzed when airborne radioactivity exceeds the Action Level (see Section X Action Level, airborne radioactivity). In addition, air samples may be collected at the discretion of the Project Health and Safety Officer.

- Surveys will be made using recently calibrated air samplers and counting devices. Recent calibration implies calibration on at least an annual basis. An approved counting laboratory may be used for analytical assessment of filters in leu of internal counting.

- Ambient air monitoring is to be performed in strategic locations to detect and evaluate, in terms of limits established in this program, levels of airborne radioactive materials at work locations that exhibit the presence of radioactive materials.

- Air sampling should be performed through use of a combination of methods including area samples at representative locations and personal air samplers worn by the worker.

- All air samplers should utilize a flow pump to sample a specific volume of air which is routed through a high efficiency particulate filter, for a specified time interval.

- Air monitors utilized should be chosen so as to be capable of measuring one DAC when averaged over 8 hours (8 DAC Hours).

- All measurements and readings should be recorded on a radiological control survey record form (Appendix F-2) coupled with a site map of the respective work locations. This map need not be to scale but should present an accurate enough description that the location of a measurement can be accurately reproduced.

11.0 ACTION LEVELS

Gross beta-gamma Activity and Contamination

- Corrective and/or Preventative Actions should be considered to control radiation exposure, contamination, and/or the release of radioactive materials to the environment when using a Pancake GM detector or equivalent, readings at surfaces or off equipment equal or exceed the contamination limits specified in Appendix F-1.
  - Beta-gamma activity: Using a ratemeter coupled with a 16 cm^2 pancake probe, a net count rate of approximately 150 cpm is about equal to 5000 dpm/100cm^2.
  - Alpha activity: Using a ratemeter coupled with a 75 cm^2 zinc sulfide probe, a net count rate of approximately 500 cpm is about equal to 1,000 dpm/100 cm^2.

- Special rules and radiological control procedures are specified in Sections 12.0 and 13.0. This information coupled with the flow charts in Appendix F-3 provide guidance as to appropriate measures to be taken if action levels specified in Section 11.0 are exceeded.

Exposure Rate

- Corrective, preventative and/or additional monitoring actions should be considered to control radiation exposure if ambient readings taken with a calibrated uR meter exceed 50 uR/hr.

- The use of time, distance, and shielding concepts shall be employed to reduce exposure rates and exposures to levels ALARA..

- Though not required except as provided in section XV., the use of dosimetry should be considered for exposure rates above 50 uR/hr in work locations.

- Radiation areas are defined and radiation area signs are required to be posted when the exposure rate may exceed 5,000 uR/hr at 30 cm from a source or equipment surface. (10 CFR 20).

- The action level flowchart presented in Appendix F-3 provides guidance as to appropriate measures to be taken when exposure action levels are exceeded.

Airborne Radioactivity

- Ambient air monitoring shall be implemented in occupied areas with the potential to exceed 10 percent of any derived air concentration in Tables 1, 2 and 3, and in 10 CFR 20.

- Airborne Radioactivity Areas are defined and posted when the levels of airborne radioisotopes exceed ten percent of the derived air concentrations of 10 CFR 20.

Radioactive Materials Presence

- Radioactive Materials Areas are defined and posted when the quantity of radioactivity present in an area exceeds the limits set forth in Appendix F-2 to 10 CFR 20. (100uCi for U_{nat}).

- Radioactive materials signs or labels will be posted on contaminated equipment, radiation waste storage drums, etc. Signs and labels will be in accordance with ANSI N 12.1-1971 and ANSI, N 2.1-1971.

Other

- Monitoring should be initiated when the presence of radioactivity is suspected.

- An area where dosimetry is required shall be classified as a Controlled Area.

12.0 RULES FOR HANDLING CONTAMINATED MATERIALS OR FREQUENTING CONTAMINATED AREAS

An area where contaminated materials are handled, packaged, and stored, or where contamination is present shall be considered Controlled Area for purposes of radiation protection, and should be defined by the placement of signs reading "Caution, Radioactive Materials," or other appropriately worded signs.

Employees engaged in frequenting contaminated areas shall be provided with appropriate personal dosimetry, as necessary in compliance with federal, state and local regulation.

Areas where contaminated materials are handled, packaged or stored or where contamination is present shall be periodically surveyed to determine external exposure rates, fixed and removable contamination levels, and air concentrations. The frequency of radiation surveys should be such that the exposure of workers can be accurately predicted in order that they may be placed at minimum risk.

Employees and contractors handling potentially contaminated materials or frequenting areas where contamination is present shall:

- Receive training and instruction, consistent with the potential hazard encountered as specified in Section 17.0 of this program and 10 CFR 20, 29 CFR 1910 and applicable state regulations.

- Be prohibited from eating, drinking, smoking, chewing (tobacco) or engaging in other ingestion activities while at work within the restricted area and from engaging in such activities outside the controlled area until they have been deemed to be free of radiological contamination by survey.
- Be provided an area away from the contaminated material where they can thoroughly wash their hands and faces before engaging in ingestion activities or leaving work.

- Be specifically instructed to keep their hands away from their face and mouth while at work or when wearing protective gloves or other equipment.

- Be trained in the use of and have available appropriate working calibrated survey meters.

- Be instructed to work in such a fashion as to minimize the production of dust. Where possible, loose materials shall be wetted before handling or other dust control techniques shall be employed (i.e. HEPA-filtered vacuum and ventilation).

- Be instructed to take maximum advantage of process and engineering controls or to ensure that appropriate ventilation is used where available and/or necessary.

- Be instructed to work in such a manner that spilled material can be easily collected. The use of catch pans, floor covers, catch basins, etc., shall be maximized.

- Be provided and required to wear the following items of protective equipment:
  - Safety Glasses with straps to hold glasses in place
  - Face Shield (if splashing is possible)
  - Impermeable Apron and/or Disposable Coveralls (depending on the nature of potential contact with the radioactive material).
  - Gloves, impermeable or cotton as appropriate for the material handled. (The selection of glove type shall be consistent with the ability of the matrix carrying the radioactive material to penetrate the skin and its chemical toxicity. The use of the glove for radioactive material protection is to provide a stopping media with good personal hygiene providing the final line of defense).
  - Respirator selection shall be consistent with the airborne concentrations of matrix material and radioactive materials present. Respiratory protection is required only when concentrations of radioactive materials cannot be held down, through use of process and engineering controls, to levels below the DAC. Respirator usage is optional for concentrations below the DAC, however, the ALARA principle will still apply for work which does not require respiratory protection.

- Respirator fit and usage shall be in compliance with the E/A&H Corporate Respiratory Protection Program and 10 CFR 20.1703.
- Items of protective equipment shall be cleaned and disinfected at the frequency required in the E/A&H Corporation Respiratory Protection Program.

- Contaminated materials that are no longer needed shall be classified as Low Level Radioactive Waste (LLRW).
  - Low Level Radioactive Waste shall be collected in centralized posted locations and secured from unauthorized access and handling. Low Level Radioactive Waste may be stored in approved Type A containers. The container of choice shall be a plastic lined 55-gallon drum with a locking cover.

- Contaminated materials shall be disposed of by transfer to a cognizant Navy authority. Disposal shall be in accordance with DOD, federal, and state regulations and requirements or, following decontamination as uncontaminated scrap or excess equipment.

13.0 CONTROL PROCEDURES FOR CONTAMINATED EQUIPMENT AND AREAS

Contaminated material and/or areas will be handled, moved, transported or frequented in such a way as to prevent the escape of loose radioactive material to the environment.

Materials and areas will be placed into one of the two following categories:

Restricted Use

- Equipment — Equipment with total fixed and removable surface contamination greater than the levels listed in Appendix F-1, shall be classified for Restricted use. Equipment classed in this category shall not be removed until it has been decontaminated or identified as radioactive waste (unless it is being moved to a decontamination site). Equipment may be moved providing it is labeled, exterior surfaces are free of visible loose material and all openings are plugged to prevent loss of material, etc. Material falling into this category will be tagged to indicate its category. All movement and transportation shall be in accordance with State and DOT regulations.

- Areas — Areas with total fixed and removable surface contamination greater than the levels listed in Appendix F-1, shall be classified for restricted use and shall be controlled from a radiation protection standpoint by following the rules listed in section XI. above

Unrestricted Use

- Unrestricted Use means that equipment and areas can be used, moved or frequented without limitations. Material and areas in this category will either be cleaned or be free of all visible loose materials. Clean is interpreted to mean that accessible surface contamination levels are less than those specified in Appendix F-1. Material and areas that fall into this category may be moved, used, or frequented without restriction.
- Records of surveys demonstrating radiological cleanliness shall be maintained for all items or areas released for unrestricted use.

Out of service Restricted Use materials that cannot be cleaned to meet the Unrestricted Use criteria shall be tagged and stored. These materials shall then be moved to a centralized, secure, approved location. All material movements shall comply with the State and DOT requirements. Records will be maintained to document the following:

- Date of transfer.
- Items transferred.

- Receiving person or agency.
- License/authorization if required to receive material.
- Ultimate destination/disposal site.

The posting of signs shall be in accordance with 10 CFR 20, 29 CFR 1910.9, and applicable state codes.

14.0 DECONTAMINATION OPERATIONS

Personnel working in a contaminated area or with equipment contaminated with radioactive material, in addition to complying with the previous section and any applicable E/A&H procedure, shall:

- At the end of each work day/shift, employees should be provided with sink and/or shower and shall be encouraged to wash thoroughly. Work clothing and protective equipment should be monitored for contamination as workers exit the work area (exclusion zone). Contaminated clothing and equipment shall be cleaned or collected for disposal with the radioactive waste.
- All employees shall be monitored for radioactive contamination and shall be "clean" prior to leaving work.

- Care shall be taken to collect all material removed and all liquids used in cleaning operations. Material so removed will be consolidated in a central location, protected from environmental hazard, and disposed of in an environmentally safe fashion. All disposal procedures shall be approved by the responsible regulatory authority.

15.0 WASTE DISPOSAL

There are currently no authorized methods approved by the U.S. Nuclear Regulatory Commission or the U.S. Environmental Protection Agency for on-site disposal of radioactive materials, including technologically altered naturally occurring radioactive materials.

Radioactive waste including contaminated equipment exceeding the limits in Appendix F-1 shall be disposed of by the Navy in accordance with DOD, federal and state regulations and requirements.

16.0 DOSIMETRY

Personnel Monitoring

- External beta-gamma Dosimetry
  - An approved personnel dosimetric device for employees of E/A&H is the film badge or TLD badge should radiation monitoring be required.
  - All individuals whose potential exposure of the whole body or body parts to ionizing radiation can exceed 10 percent of the limits set forth in Tables 1, 2 and 3 (Section 9.0) shall be provided an appropriate personnel dosimetric device.
- Internal Dosimetry
  - All employees who work in areas where air, surface, or airborne contamination are present, and where the workers could receive 500 mrem annual effective dose equivalents from all intakes of radionuclides from occupational sources, or if any organ or tissue dose equivalent could exceed 5,000 mrem annual dose equivalent, may be monitored using internal dose evaluation programs such as urine bioassay. A monthly bioassay program is optional for all other personnel.

Required Records

- Records of exposure to ionizing radiation will be maintained utilizing forms acceptable to federal, state, and local regulators. These forms shall contain the following information:

  — Name

  — Date of Birth

  — Age in Years

  — Social Security, Employee Number or other appropriate identification Number

  — Place of Employment

  — Occupation

  — Period of Exposure

  — External Exposure

  Beta or Skin Dose for Reporting Period

  Whole Body Dose for Reporting Period

  Cumulative Whole Body and Cumulative Skin Dose

  Extremely Dose (if appropriate) for Reporting Period and Cumulative

  — Internal Exposure

  Whole Body Count

  Urine Specimen

  Other

  — Remarks

  Radionuclide

  Organs at risk

  Bioassay technique

Bioassay result

— The annual effective dose equivalent of an individual shall be determined by summing the annual effective dose equivalents from internally deposited radionuclides and from external exposure to ionizing radiation.

Access to Exposure Records

- The record of exposure to ionizing radiation should be considered confidential. Distribution should be limited to the employee and to those individuals responsible for the health, safety and well-being of the employee.

17.0 INSTRUCTION TO WORKERS

Field staff shall be informed of the presence of radioactive materials; shall be instructed in precautions and procedures used to minimize exposure, and instructed in the purposes and functions of protective devices employed. The extent of these instructions shall be commensurate with potential radiological hazard.

All potentially exposed E/A&H employees and contractors shall receive an orientation in radiation safety within 1 month of their initial assignment to and prior to potential exposure to radiation. Retraining shall be provided when there are significant changes to radiation protection policies and procedures which affect general plant employees and should be provided every 2 years. Generic training (not specific to a facility) in all or some of the topics listed below may be waived provided; (1) this training has been received at another facility utilizing radioactive materials; (2) there is provision of proof-of-training in the form of a certification document containing the individual's name, date of training, and specific topics covered; and (3) an appropriate official has certified the training of the individual. The level of training is to be commensurate with the employee's job assignment with the initial orientation including, but not limited to:

- The risk of low-level occupational radiation exposure, including cancer and genetic effects

- The risk of prenatal radiation exposure

- Basic radiation protection concepts:
    - Regulatory and company radiation protection policies and procedures
    - Employee and management responsibilities for radiation safety
    - Emergency procedures
    - Dose-equivalent limits
    - Mode of exposure (internal external)
    - Dose-equivalent determinations
    - Basic protective measures (time, distance, shielding)
    - Specific procedures for maintaining exposure as low as is reasonably achievable
    - Radiation survey instrumentation (calibration and limitations)
    - Radiation monitoring programs and procedures
    - Contamination control, including protective clothing and equipment and workplace design
    - Personnel decontamination
    - Emergency procedures
    - Responsibilities of employees and management

18.0 EMERGENCY RESPONSE

Purpose

This outline provides emergency action guidance for determining appropriate actions for the rescue and recovery of persons and the protection of health and property in the event of an emergency which could involve radioactive material or radiation sources at NAVBASE. The emergency response flowchart in Appendix F-3 provides additional guidance for handling emergencies involving radioactive materials or radiation sources.

General Considerations

- Controlling exposure to radiation during rescue and recovery actions is extremely complex. Multiple hazards and alternate methods are to be taken into account; and prompt, sound judgment and flexibility of action are crucial to the success of any emergency action. The risk of injury to those persons involved in the rescue and recovery activities should be minimized, to the extent practical. However, the control of radiation exposures should be consistent with the immediate objectives of saving a human life, and/or protection of health and property.

- To avoid unnecessarily restricting action, a rigid upper limit of exposure for lifesaving action is not specified; rather, judgment should guide proposed actions involving further radiation exposure. The evaluation should consider risk versus benefit, i.e., weighing the risks of radiation insults, actual or potential, against the benefits (social, economic, etc.) to be gained. Essential elements in risk determinations include potential exposure, biological consequences related to the exposure, and the number of people involved.

- Any rescue action that might involve substantial personal risk from exposure to ionizing radiation should be performed by volunteers. When feasible, volunteers should be evaluated with respect to age and previous exposure history. Each emergency worker should be advised of the known or anticipated hazards prior to participation by the person onsite having the emergency action responsibility.

- Whenever an emergency response is initiated, the E/A&H Radiation Safety Officer (RSO) or his designee shall monitor for the presence of radiation prior to any rescue or recovery mission, during such operations, and following to ensure control of contamination.

- Whenever contamination levels from radioactive material exceed those of Appendix F-1, a full set of Personal Protective Equipment (PPE) to include, at a minimum, Tyvek suit, hood, booties, and gloves shall be worn. These PPE requirements may be waived by the On-Scene Commander if the emergency conditions warrant.

- In any emergency response, the RSO shall report to the On-Scene Commander what radiological hazard(s) exist and recommend incorporating ALARA techniques and the use of PPE to minimize personnel exposure and to minimize contamination potential.

19.0 POSTING OF WORK PROCEDURES

A copy of this procedure, or a letter stating where the employee may review these procedures will be prominently posted within E/A&H work locations where it can be easily seen by all employees.

In addition, the name of the radiation safety officer and his phone number shall be similarly posted with an invitation to ask questions, make suggestions or to report violations of these procedures.

APPENDIX F-1

ACCEPTABLE SURFACE CONTAMINATION LIMITS

Surface Radioactivity Guidelines

Nuclide[1/]	Average[2/3/6/]	Maximum[2/4/6/]	Removable[2/5/6/]
U-nat, U-235, U-238 and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm α/100 cm^2	300 dpm α/100 cm^2	20 dpm α/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000 dpm α/100 cm^2	3,000 dpm α/100 cm^2	200 dpm α/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 dpm β-γ/100 cm^2	15,000 dpm β-γ 100/cm^2	1,000 dpm β-γ 100/cm^2

Notes:

1/ Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and beta-gamma emitting nuclides should apply independently.

2/ As used in this table, dis/min (disintegration's per minute) means the rate of emission by radioactive material as determined by correcting the cpm observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

3/ Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

4/ The maximum contamination level applies to an area of not more than 100 cm^2.

5/ The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

6/ The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

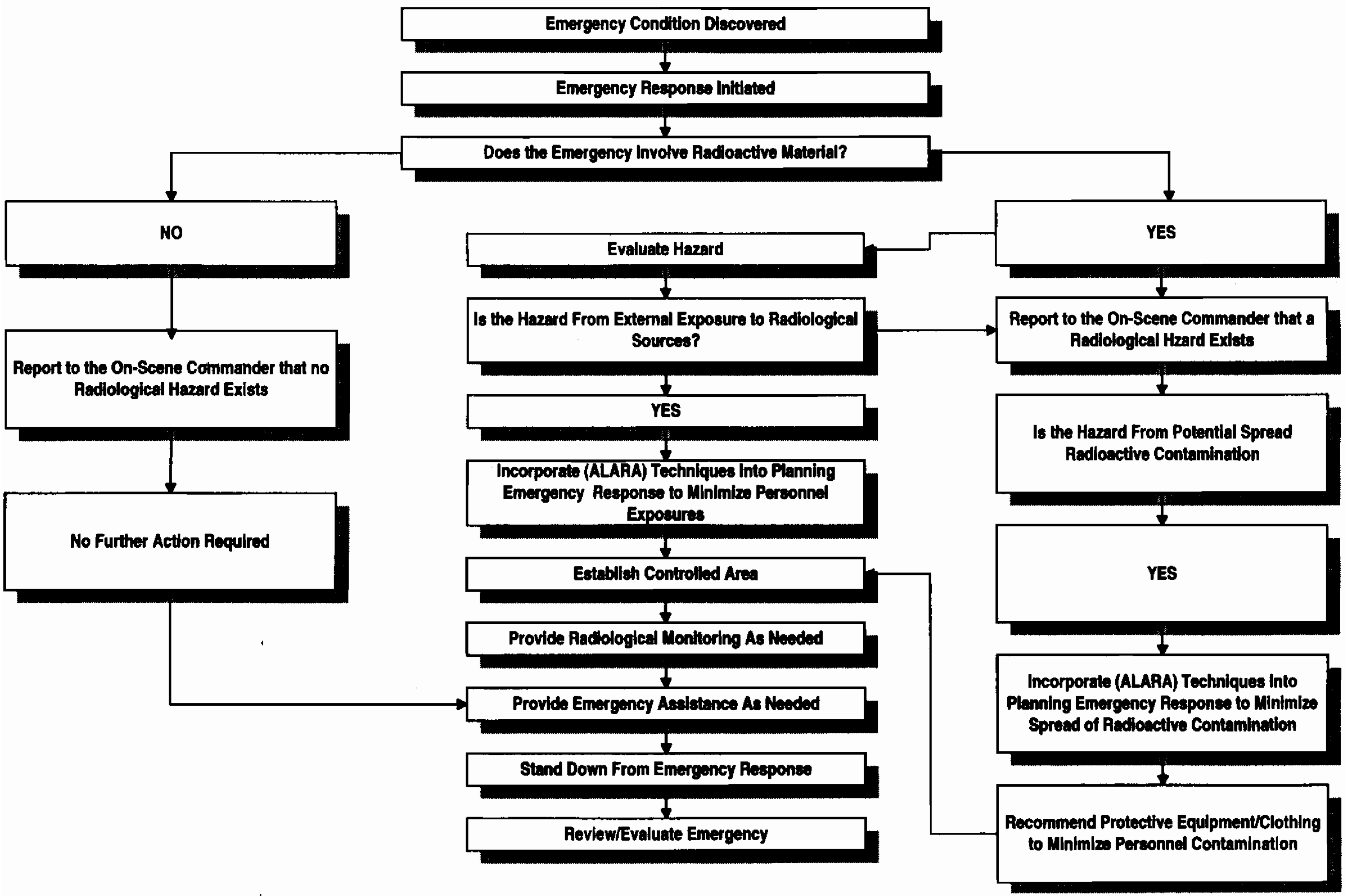
APPENDIX F-2

SAMPLE RADIOLOGICAL SURVEY FORM

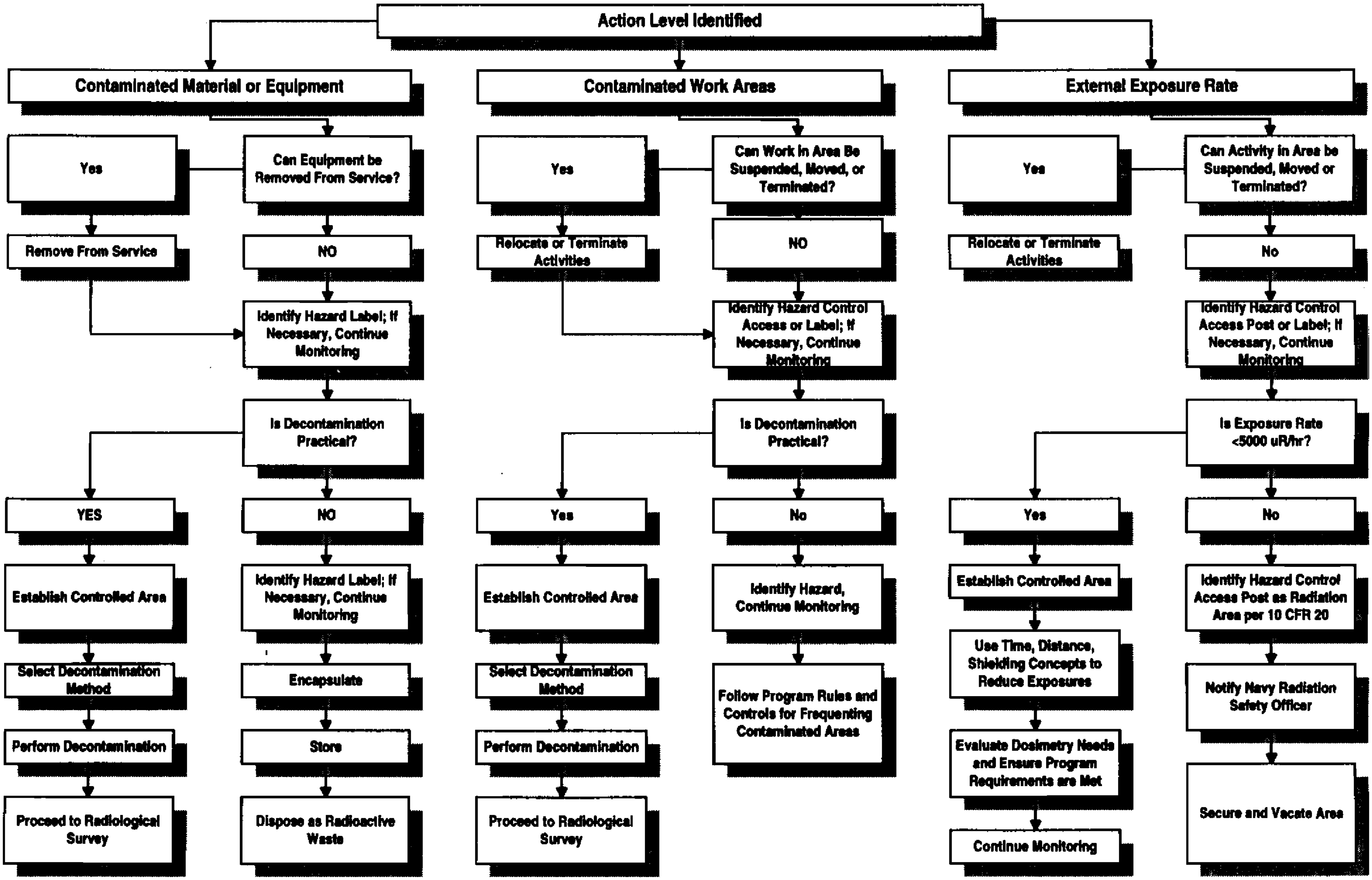
APPENDIX F-3

RADIOLOGICAL SURVEY, ACTION LEVEL AND EMERGENCY RESPONSE FLOW CHARTS

RADIATION PROTECTION EMERGENCY RESPONSE FLOWCHART



ACTION LEVEL FLOWCHART



APPENDIX G

FOCUSED FIELD INVESTIGATION STUDY

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FOCUSED FIELD INVESTIGATION STRATEGY
STATE DEPARTMENT COMPLEX
NAVAL BASE CHARLESTON, SC

1.0 PURPOSE

Identify the human health risk(s), if any, associated with the presence of gaseous phase contaminants of potential concern (COPCs) in indoor air at buildings where internal accumulation is a possibility as a result of soil gas migration from external sources.

2.0 BACKGROUND AND RECENT DEVELOPMENTS

Congressional passage of House Rule 3116 authorized the 01 January 1994 transfer of the Fleet and Mine Warfare Training Center building complex at NAVBASE to the US Department of State. The complex (Buildings 643, 645, 646/646A, 647 and 649) is bounded by Dyess Ave., Proteus St., Bainbridge Ave. and Holland St. Prior to occupation of the transferred buildings by the US State Department, a limited scope "focused" investigation is planned to evaluate the potential for impact on human health as a result of contaminants which may be emanating from SWMUs and AOCs in the vicinity of the building complex. The location of the buildings and the general surrounding area appears on Figure 1.

Current Investigations

NAVBASE is currently the subject of a RCRA Facility Investigation. The Fleet Mine and Warfare Training Center is located within the boundaries of investigation for Zone H. All sampling, analysis, data evaluation, and data reporting will be conducted in accordance with the five volume *Final Comprehensive RFI Work Plan* dated August 30, 1994 which was prepared specifically for the NAVBASE Charleston RFI. The Solid Waste Management Units (SWMU) and areas of concern (AOC) that are located in the vicinity of the building complex being transferred to the State Department are listed in Appendix A.

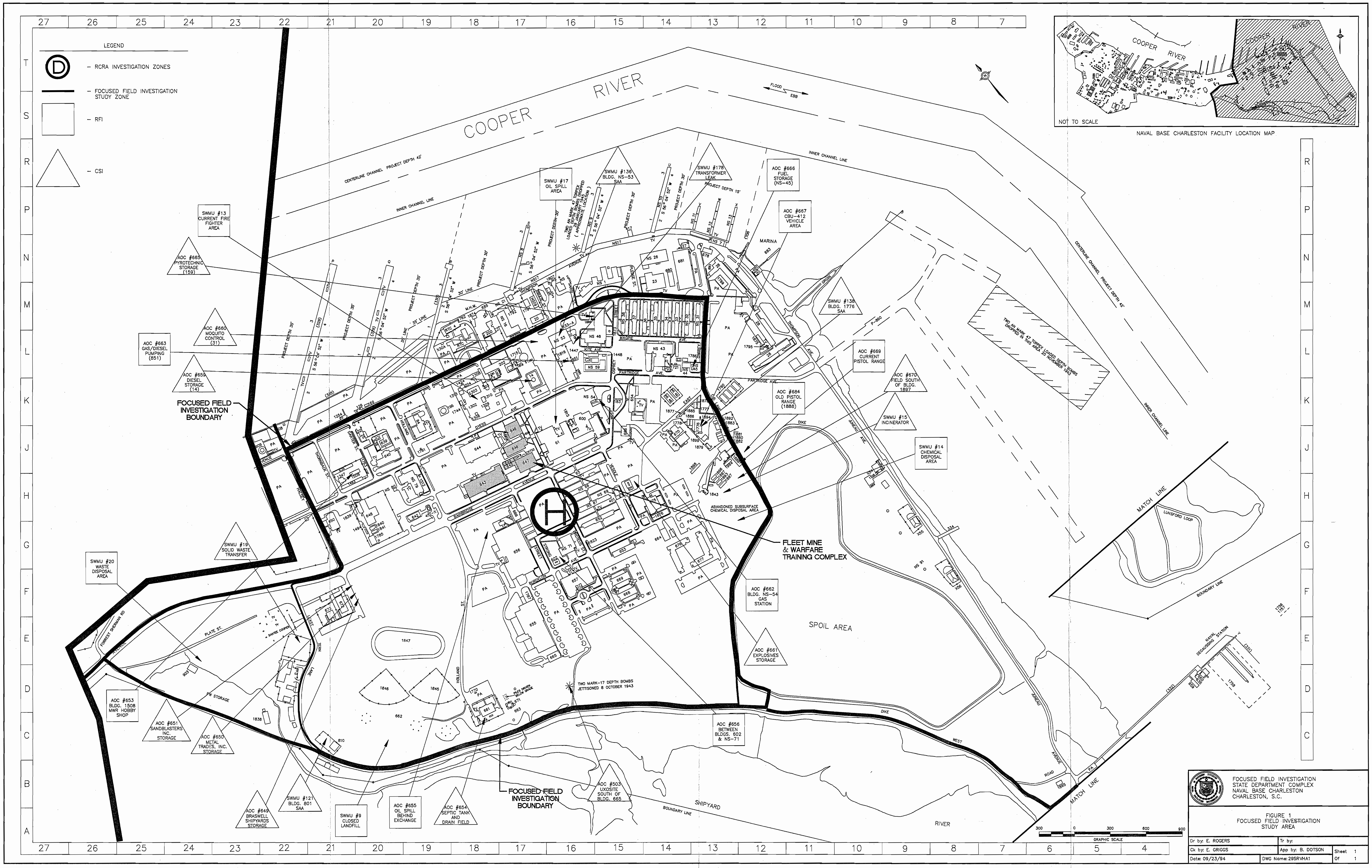


FIGURE 1
FOCUSED FIELD INVESTIGATION
STUDY AREA

Geotechnical Setting

The general geologic setting of NAVBASE is described in Chapter 1.0 of the *Final Comprehensive Sampling and Analysis Plan, August 30, 1994* prepared for the RFI. In that document, the text describes how some areas are known to be filled with material dredged from the Cooper River overlying the natural organic detritus associated with coastal lowlands. The buildings listed above have all been constructed on fill material. Visual evidence indicates that land subsidence occurs under buildings supported by pile foundations. This differential settlement has caused construction joints to open.

Hydrogeologic Setting

The preliminary results of the RFI elements in the vicinity of the State Department Complex indicate a groundwater high exists near the intersection of Bainbridge Avenue and Least Tern Lane. Figure 2 presents the preliminary piezometric surface contours. Preliminary data suggests short-term fluctuations in piezometric surface elevations of 0.02-0.29 feet in wells at the southern end of NAVBASE. In the immediate vicinity of the Fleet Mine and Warfare building complex data indicates piezometric surface fluctuations are less than 0.06 feet. Such short-term fluctuations are normally attributed to tidal fluctuations in the adjacent surface waters (Cooper River and Shipyard Creek). Fluctuations in piezometric surface and groundwater flow direction are frequently suspected of providing a mechanism for contaminant migration in groundwater and vadose zone gases.

3.0 INVESTIGATIVE STRATEGY

The generic term "Focused Field Investigation" or "FFI" was created to refer to the scope described below and has no regulatory meaning. The FFI will be used as a mechanism to expediently answer the question posed by the previously stated purpose. The data will be presented initially in a stand alone technical memo; however, since the scope of

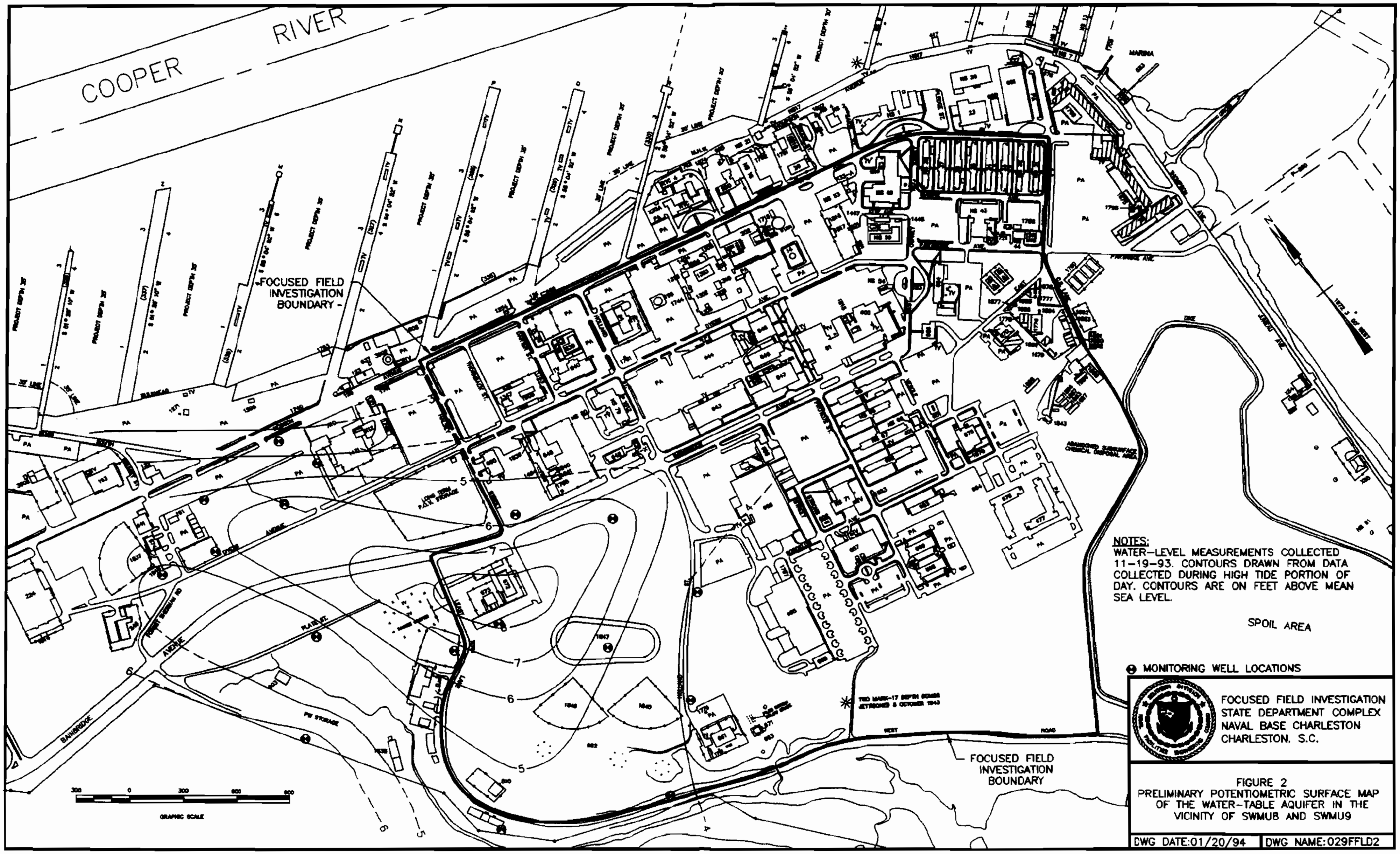


FIGURE 2
PRELIMINARY POTENTIOMETRIC SURFACE MAP OF THE WATER-TABLE AQUIFER IN THE VICINITY OF SWMU8 AND SWMU9

work is within the realm of the RFI process, the data generated will eventually be incorporated into the RFI for Zone H. The goals of the FFI are as follows:

- Identify the presence/absence of indoor air contaminants.
- Determine whether the source is internal or external.
- Evaluate human health risk or absence of risk associated with exposure to airborne parameters originating from external sources.

In as much as the reports of gas emissions and adverse health affects are associated with the Base Exchange, the investigation will initially encompass an area including the Base Exchange and extending at least one block North beyond the State Department building complex, generally bounded, clockwise, by Hobson Ave./Osprey St./C B Ln./northwest dike of the Spoil Area/West Rd./Least Tern Ln./Bainbridge Ave./Halsey St./Hobson Ave. Figure 1 outlines the study area.

The following paragraphs outline the focused investigation elements necessary to achieve the goals of the FFI. Some elements of the survey were completed during an initial phase of field activities conducted in February and March 1994. Previously collected data is also summarized in the appropriate sections below.

3.1 Building Surveys

Separated joints or cracks in floor slabs could constitute migration pathways for soil gases to enter occupied spaces; therefore, each building within the study area was visually examined. Floor plans, acquired during the Base Realignment and Closure (BRAC) environmental baseline survey (EBS), were used to guide the surveys (expansion/construction joint locations) and to record the results. The buildings were inspected for floor separations, unsealed utility penetrations, and land subsidence under the buildings. During the initial phase, floor separations were used as sampling points for the evaluation of sub-floor emission sources and work space air quality.

As a result of the building surveys, the following structures were recommended for air quality sampling: Building 36 (Barracks), Building NS84 (Naval Security Group Activity), Building 202 (Fleet and Mine Warfare Instruction), Building 640 (Steamers-CPO Club), Building 643 (Fleet and Mine Warfare Training Building), Building 644 (Bowling Center), Building 645 (Fleet and Mine Warfare Engine Overhaul Facility), Building 656 (Exchange), and Building 657 (Sports Bar).

3.2 Air Quality Study

The proposed air sampling strategy is designed to maximize the likelihood of detecting airborne volatile and semi-volatile organic contaminants inside and underneath buildings identified during the surveys. Data from the previous phase of air sampling detected some anthropogenic compounds inside the buildings listed in the previous section. The data generated is summarized in Tables 1 through 8 below. A source for the compounds detected was not conclusively identified; therefore, an additional phase of sampling will be conducted in conjunction with the Zone H RFI. During the initial phase, Building 36 was being painted and therefore, was not samples. Samples will be collected during this phase.

Data from the sampling efforts will be used to evaluate human health risks and determine whether COPCs, if identified, are emanating from an internal or external source. If the data suggests that an external source is present, source location and characterization will be conducted under the scope of the Zone H RFI. Key components are as follows:

3.2.1 Sample Methodology — Air samples will be collected into evacuated stainless steel SUMMA canisters, sealed and shipped to a commercial laboratory for analysis. Vacuum flow regulators will be used to control the sampling period (these regulators can be set to collect an integrated composite sample over a prescribed period). Sampling procedures will adhere to the guidelines specified Section 8.3 of the *Final Comprehensive Sampling and Analysis Plan.*

Table 1
Building 643 Results

			Results ($\mu g/m^3$)		
Date	**Location**	**Sample No.**	**Methylene Chloride**	**Freon**	**Comments**
Feb. 10-11	Room 19	6430210-01GL	763	6	Small quantity of chemicals stored in this room including paints, trichloroethylene, oils, lubricants and sealants
Feb. 11-12	Room 19	6430211-01GL	27	ND	
Feb. 12-13	Room 19	6430212-02GL	33	ND	
Feb. 10	Room 19	6430210-02BZ	151	7	Small quantity of chemicals stored in this room including paints, trichloroethylene, oils, lubricants and sealants
Feb. 11	Room 19	6430211-01BZ	18	7	
Feb. 12	Room 19	6430212-01BZ	14	6	
Feb. 10-11	Middle of Mines Bay Room	6430210-03BZ	92	9	Very minor cracking in this room; discontinued sampling at this location

Table 2
Building 202 Results

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Dichloro-benzene	Freon	Other	Comments
Feb. 14-15	Expansion joint, in hallway across from Room 117	2020214-01GL	112	17	2/14[1]	Yes	9 $\mu g/m^3$ toluene
Feb. 15-16		2020215-04GL	57	ND	ND	ND	duplicate sample
Feb. 15-16		2020215-04GL	7	ND	ND	ND	duplicate sample
Feb. 15-16		2020216-04GL	17	ND	19	ND	
Feb. 14-15	Room 117	2020214-03GL	15	ND	2/67	ND	
Feb. 15-16	Room 117	2020215-03GL	10	ND	3/74	ND	
Feb. 16-17	Room 117	2020216-03GL	24	ND	2/54	ND	
Feb. 14	Expansion joint, hallway ASW wing	2020214-02BZ	10	11	6	ND	
Feb. 15		2020215-02BZ	ND	ND	ND	ND	
Feb. 16		2020216-02BZ	14	ND	9	ND	

1 2/14 represents two Freon compounds detected with a combined total of 14 $\mu g/m^3$

Table 3
Building 645 Results

			Results ($\mu g/m^3$)		
Date	**Location**	**Sample No.**	**Methylene Chloride**	**Other**	**Comments**
Feb. 14-15	Room 105	6450214-01GL	71	ND	Diesel engine running in next room for approximately 2 hours
Feb. 15-16	Room 105	6450215-01GL	12	ND	
Feb. 16-17	Room 105	6450216-01GL	ND	ND	
Feb. 16-17	Room 105	6450216-01GL	9	ND	duplicate
Feb. 14	Room 104	6450214-03BZ	21	ND	Diesel engine running in next room for approximately 2 hours
Feb. 15	Room 104	6450215-02BZ	22	ND	
Feb. 16	Room 104	6450216-02BZ	21	ND	

Notes:
ND Means not detected.

Table 4
Building NS 84 Results

			Results ($\mu g/m^3$)		
Date	**Location**	**Sample No.**	**Methylene Chloride**	**Freon**	**Comments**
Feb. 17-18	Hallway by file cabinets, near men's room	NS840217-02GL	ND	ND	
Feb. 18-21		NS840218-02GL	6	ND	
Feb. 21-22		NS840222-01GL	V	V	
Feb. 17		NS840217-02BZ	44	ND	
Feb. 18		NS840218-01BZ	13	ND	
Feb. 22		NS840222-02BZ	ND	ND	
Feb. 22-23		NS840222-02GL	ND	ND	Duplicate Sample

Note:
V = sample voided; SUMMA canister lost vacuum, sample not analyzed

Table 5
Building 644 Results

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Trimethyl-benzene	Freon	Comments
Feb. 17-18	Between alleys 24 and 25	6440217-01GL	14	ND	ND	
Feb. 18-19		6440218-01GL	11	ND	ND	
Feb. 18-19		6440218-01GL	18	ND	ND	duplicate sample
Feb. 22-23		6440222-01GL	ND	ND	ND	
Feb. 17	Between alleys 24 and 25	6440217-02BZ	32	14	17	
Feb. 18		6440218-02BZ	37	2/26	15	
Feb. 22		6440222-02BZ	ND	2/20	23	

Table 6
Building 656 Results

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Toluene	Other	Comments
Feb. 23-24	Center of warehouse along crack	6560223-01GL	ND	ND	ND	
Feb. 24-25		6560224-01GL	ND	ND	ND	
Feb. 25-26		6560225-01GL	ND	ND	ND	
Feb. 23-24	Warehouse along crack, approx. 30 feet from entrance to store area	6560223-02GL	ND	16	ND	
Feb. 24-25		6560224-02GL	6	ND	ND	
Feb. 25-26		6560225-02GL	ND	ND	ND	
Feb. 23-24	Store area, uniforms, dressing room	6560223-05GL	ND	8	ND	
Feb. 24-25		6560224-05GL	8	ND	ND	
Feb. 25-26		6560225-05GL	6	7	ND	
Feb. 23-24	same as 6560223-01GL	6560223-06GL	ND	ND	ND	duplicate sample
Feb. 24	same as 6560224-03BZ	6560224-06BZ	V	V	V	duplicate sample
Feb. 25	same as 65602402-GL	656022-06GL	6	ND	ND	duplicate sample

Table 6
Building 656 Results

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Toluene	Other	Comments
Feb. 23	Store area, uniforms, dressing room	6560223-04BZ	ND	7	ND	
Feb. 24		6560224-04BZ	13	ND	ND	
Feb. 25		6560225-04BZ	ND	10	ND	
Feb. 23	Exchange Bldg. near bicycles and sporting goods	6560223-03BZ	ND	8	ND	
Feb. 24		6560224-03BZ	12	6	ND	
Feb. 25		6560225-03BZ	9	7	ND	
Feb. 23	Warehouse along crack, approx. 30′ from entrance to store area	6560223-07BZ	ND	36	Yes	8 $\mu g/m^3$ trichloroethylene
Feb. 24		6560224-07BZ	7	13	Yes	3 peaks each less than 5 $\mu g/m^3$
Feb. 25		6560225-07BZ	8	ND		

Note:
V = sample voided; SUMMA canister lost vacuum, sample not analyzed.
ND = Non-Detect

Table 7
Building 657 Results

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Toluene	Other
Feb. 23-24	Middle of dance floor	6570223-01GL	ND	ND	ND
Feb. 24-25		6570224-01GL	9	ND	ND
Feb. 25-26		6570225-01GL	ND	ND	ND
Feb. 23		6570223-02BZ	ND	ND	ND
Feb. 24		6570224-02BZ	ND	ND	ND
Feb. 25		6570225-02BZ	ND	ND	ND

Table 8
Control Samples

Date	Location	Sample No.	Results ($\mu g/m^3$) Methylene Chloride	Other
Feb. 23	Outside by Building 12A	12A0223-01BZ	ND	ND
Feb. 24		12A0224-01BZ	ND	ND
Feb. 25		12A0225-01BZ	ND	ND

3.2.2 Sample Period and Frequency — During the previous sampling event, samples were collected over a 24 hour time period. This sampling strategy was designed primarily because of the unknown influence of the tidal cycle on groundwater fluctuations. Since the tidal influence study has indicated the influence is minimal, an 8 hour sampling period is now proposed to emulate conditions during a typical daily work shift. Samples will be collected daily for 3 consecutive days to assess short term variability in air quality. One ambient air sample per day will be collected to establish background conditions. Duplicate samples will be collected at a frequency of 1 per every 10 air samples collected.

3.2.3 Sample Location — Air samples will be collected at three principal locations:

a) Floor separations/penetrations — with the objective of quantifying any sources of airborne contaminants at the potential points of entry within the buildings.

b) The breathing zone in the most frequently/densely occupied areas of the buildings — to assess human exposures to airborne contaminants.

c) Void space between ground surface and building sub-floor. Sampling will be conducted at points immediately ~~below the~~ floor separations/penetrations to provide the most representative evaluation of an external source for COPCs. This sampling is based on the presumption that gases trapped under a structure would tend to accumulate in "dead air" pockets under the floor. underlying voids to prevent the necessity of a potential confined space entry by sampling personnel.

Baseline air quality will be established by ambient air sampling outside Building 656.

3.2.4 Sample Analysis and Sensitivity — Samples from both phases either were or will be analyzed using EPA Compendium Method TO-14; *The determination of Volatile Organics in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatographic Analysis*, having quantitation limits of 10 $\mu g/m^3$ or less for volatile compounds.

Note: These methods are also sensitive enough to likely detect airborne chemicals associated with retail products routinely present in the building, such as, scented soaps and toiletry items, cleaning products, skin care products, adhesive, felt markers and paints.

3.3 Soil-Gas Survey

Although the soil gas and geophysical survey completed in 1993 at the old landfill, SWMU #9, showed only isolated responses central to the landfill, a supplemental passive soil gas survey (Appendix B contains a map depicting the results) was conducted to further investigate the potential for contaminant migration and possible impact in the building area complex. Sample collection was performed in accordance with Section 8.3 of the *Final Comprehensive Sampling and Analysis Plan*. A grid pattern was established to define potential volatile and semivolatile contamination in the complex, as well as assess possible migration and/or dispersion pathways. The following section briefly describe the passive soil gas methodology and results. This information will be described in greater detail in the technical memo which will be produced at the completion of the air sampling.

3.3.1 Soil-Gas Sample Collectors

Installation — The PETREX sample collectors used consisted of a glass sample tube containing two or three ferromagnetic collector wires, coated with activated charcoal, serves as an adsorbent for volatile and semivolatile compounds. All glassware was cleaned in accordance with OSWER Directive 9240.0-05A, December, 1992, "Specifications and Guidance for Contaminant-Free Sample Containers", as applicable. Sample collectors were placed in the bottom of a narrow borehole dug with a hand auger or shovel approximately 18 inches in depth. (Boreholes for sample locations on asphalt were dug slightly deeper to avoid possible false semivolatile readings.)

Following the installation of the sample collectors, the borehole was plugged with aluminum foil above the sampling device to create a void to trap the soil vapors. To protect the sampler, the remainder of the borehole was filled with native material and a marker flag or stake placed next to the borehole. The sample collectors were left in for 3 to 5 days to adsorb soil gases over multiple tidal events. When sample collectors were removed from the ground, boreholes are filled to ground surface with excavation spoils or clean fill and an asphalt patch where necessary.

Analysis — Once a sample from a sample collector at each designated sampling location was collected, the tube was sealed and shipped to a commercial laboratory for analysis. One of the wires from each sampler was analyzed by Thermal Desorption/Mass Spectrometry. For quality assurance purposes, the second wire in 5 percent of the samples was analyzed by Thermal Desorption-Gas Chromotography/Mass Spectrometry. Compound identification was based on molecular weight, compound fragmentation, and isotope distribution. The mass spectral signature was compared to a large library of mass spectra of commonly used chemical mixtures such as gasolines, diesels, industrial oils, solvents, plastics, etc. to assist in both compound and mixture identification. Sample results are reported in ion counts since the sampling method does not include a unit of volume.

3.3.2 Soil-Gas Survey Results — Passive soil gas data results are predominantly qualitative information to be used as a guide in selecting optimum soil and groundwater sampling areas. The results are semi-quantitative in the sense that higher ion responses for a given compound are representative of higher concentrations in the subsurface given that geologic conditions are relatively consistent. Due to chemical differences between compounds including their ability to adsorb and desorb from the activated charcoal it is invalid to compare ion counts between compounds. Factors which may influence the passive soil gas results and need to be considered when interpreting the data include the presence of ground and surface water, microbiotic activity in soil, and ground cover - both natural and synthetic.

Areas where relatively high soil-gas responses were detected are listed as follows.

- Along the west and south sides of Building 656 (an oil spill has been reported in this area).
- Between Buildings 644 and 643 (oil and BTEX results were especially high in this area).
- Between Buildings 644 and 643 at the eastern end of the open area.
- In the vicinity of sample locations 4 and 5 at Building 645.
- The northeast corner of Building 640 in the vicinity of the front door.
- The west end of Building 640 in the vicinity of the loading dock.
- The north side of Building 84.
- The northwest corner of Building 202.
- The east side of Building 656 in the vicinity of the automatic teller machine.

3.4 Tidal Influence Study

Fluctuations in the piezometric surface over a relatively short time period may act as a mechanism to "flush" soil gas from the vadose zone. Continuous water level recorders were installed in several monitoring wells in the vicinity SWMU 9 to record the piezometric surface fluctuations over a 72-hour period (12 tidal cycles). The wells selected were located at various distances from the shoreline. Graphs depicting fluctuations in groundwater elevations versus time were generated and used to predict potential groundwater fluctuations under the buildings. These graphs will be presented in the FFI technical memo. The water level data was monitored and recorded in accordance with Section 10.6.3 of the *Final Comprehensive Sampling and Analysis Plan*.

The groundwater level monitoring investigation identified the general relationship between tidal fluctuations and groundwater levels within the area between Shipyard Creek and Cooper River. Water level fluctuations attributable to tides were minimal across the area investigated and are not expected to provide a force capable of pushing vapor-phase contamination through cracks and floor partings into buildings. Total fluctuation due to tides only exceeded 0.10 foot in one of the wells monitored. The well demonstrating the most fluctuation was approximately 150 feet from Shipyard Creek and directly adjacent to an area daily inundated by the tide. The minimal fluctuations in groundwater levels would not play a significant role in directing contaminants transported by groundwater in any direction other than that determined by the natural groundwater flow gradient.

4.0 BASELINE RISK ASSESSMENT

The potential for human health risks associated with COPCs emanating from sources **external** to the buildings will be evaluated based on the data collected during the FFI. The risk assessment will conform to the *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, USEPA/540/1-89/002, December 1989 (RAGS)* and the *Comprehensive Baseline Risk Assessment Work Plan* prepared for the NAVBASE RFI. The scope of the risk assessment within the FFI will be limited evaluating current risks posed to workers and building visitors. The Navy recognizes that with the impending base closure future uses of buildings may change; however, the intent of the FFI is to assess immediate concerns. The baseline risk assessment to be performed for the entire Zone H will address potential future use scenarios.

5.0 COMMUNITY RELATIONS PROGRAM

The Public Affairs Officers (PAOs) of SOUTHDIV and Naval Base Charleston will continuously monitor the progress of the focused investigation and its results. Should the results justify public notification, or should media representatives make inquiries regarding the investigation, the PAOs will produce appropriate press releases, fact sheets, etc.. The community relations stepped approach is outlined below.

- Before field work began, information sessions were held and fact sheets provided to workers in the area of field investigations/elected officials/RAB/media reps. Publicized information source at the Naval Base and location of the information repository which was established in 1993.

- Provide updates throughout the field investigation, using the Installation Restoration Community Relations Plan as a guide. These updates will be in the form of media releases, fact sheets, paid advertisements, and community meetings. These updates will communicate to the public information on the progress of the field investigation, safety plans, results of tests, risk assessment and future actions.

- Copies of fact sheets, media releases, or other information released about the field investigation will be provided to EPA Region IV and SCDHEC simultaneously.

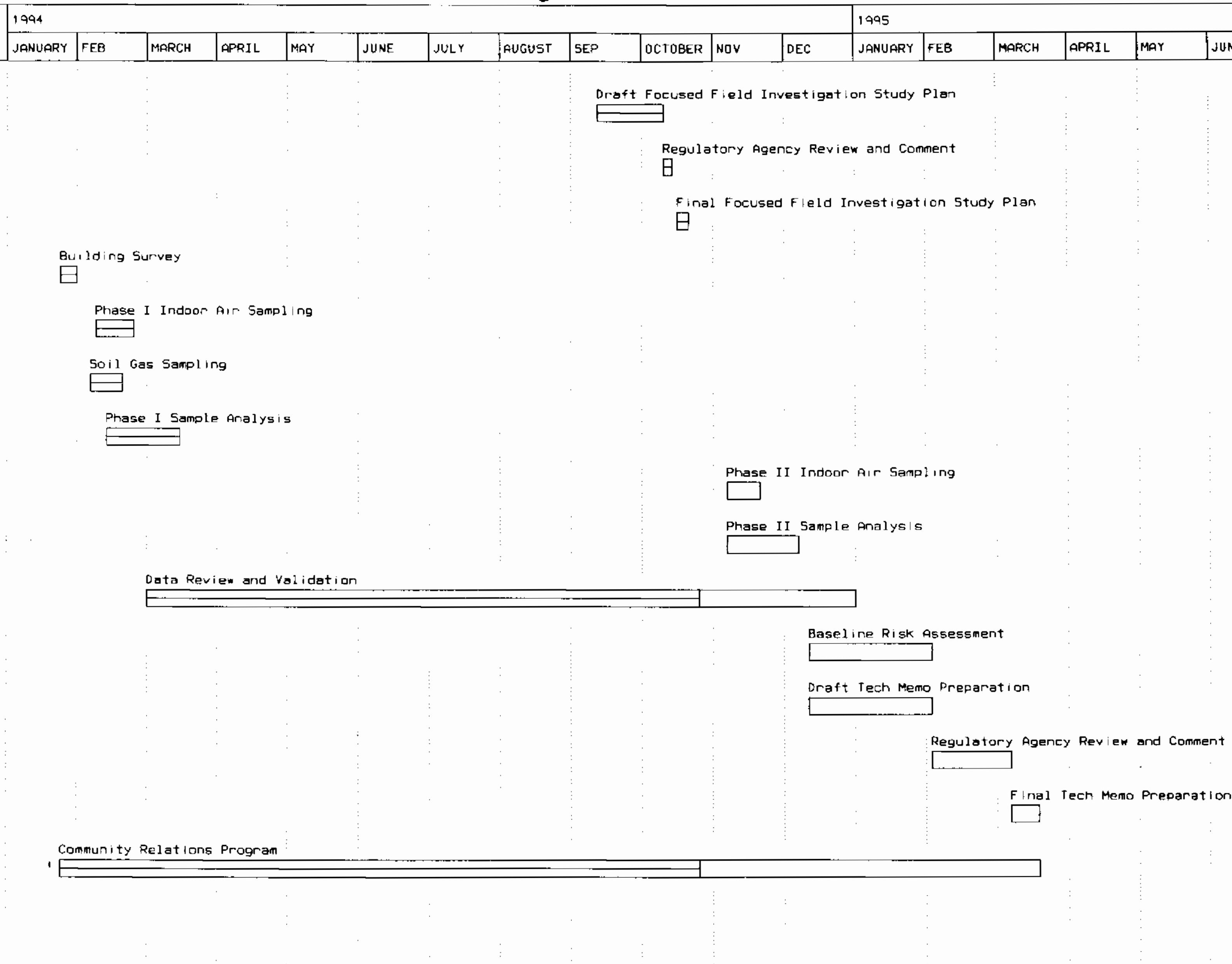
- Allow opportunities for public input during investigation to address concerns on a more frequent basis.

6.0 SCHEDULE

Figure 3 presents a preliminary schedule for the Focused Field Investigation. The Risk Assessment produced from the Focused Field Investigation will exclusively address the State Department building complex. This interim deliverable will be incorporated into the Baseline Risk Assessment at the completion of the Zone H RFI.

Figure 3 Focused Field Investigation Schedule

EARLY START	EARLY FINISH	ORIG DUR	Activity
13SEP94A	10OCT94A	11	Draft Focused Field Investigation Study Plan
11OCT94A	14OCT94A	4	Regulatory Agency Review and Comment
17OCT94A	21OCT94A	5	Final Focused Field Investigation Study Plan
25JAN94A	01FEB94A	8	Building Survey
10FEB94A	26FEB94A	17	Phase I Indoor Air Sampling
07FEB94A	21FEB94A	15	Soil Gas Sampling
15FEB94A	15MAR94A	29	Phase I Sample Analysis
07NOV94E	21NOV94E	15	Phase II Indoor Air Sampling
08NOV94E	07DEC94E	30	Phase II Sample Analysis
02MAR94A	01JAN95E	285	Data Review and Validation
12DEC94E	03FEB95E	54	Baseline Risk Assessment
12DEC94E	03FEB95E	54	Draft Tech Memo Preparation
04FEB95E	07MAR95E	32	Regulatory Agency Review and Comment
08MAR95E	18MAR95E	11	Final Tech Memo Preparation
25JAN94A	18MAR95E	418	Community Relations Program



DESC

PROGRESS

Focused Field Investigation Schedule
State Department Complex
Naval Base Charleston, SC

RUN DATE 27OCT94
START DATE 25JAN94
DATA DATE 27OCT94
FINISH DATE 18MAR95

U.S. Navy SOUTHDIVNAVFACENGCOM
N62467-89-D-0318

SURETRAK
FFI-CHARLESTON

ACETONE

LEGEND

- Not Detected
- 1 - 10,000 Ion Counts
- 10,001 - 100,000 Ion Counts
- 100,001 - 1,000,000 Ion Counts
- Greater than 1,000,000 Ion Counts
- Sampler Broken

Figure 10

Distribution of ACETONE

Note: Shape and size of polygons determined by location of and distance to adjacent data points and building shape.

Draft Focused Field Investigation Report
Passive Soil-Gas Investigation Conducted February, 1994

Naval Base Charleston
Charleston, S.C.

APPENDIX H

MATERIAL SAFETY DATA SHEETS

Individual MSDS shall be included in the field copies of the Health and Safety Plan.

APPENDIX I

DIRECTIONS TO EMERGENCY MEDICAL FACILITIES

DIRECTIONS TO THE CHARLESTON NAVAL HOSPITAL

The nearest hospital to the site is the Charleston Naval Hospital. this hospital should be used for all life threatening medical emergencies. For other medical services please use Baker Hospital.

Nearest Hospital	
Charleston Naval Hospital **McMillan Road** **Charleston, South Carolina**	
Emergency Room Telephone Number:	(803) 743-7011
General Information Number:	(803 743-7000

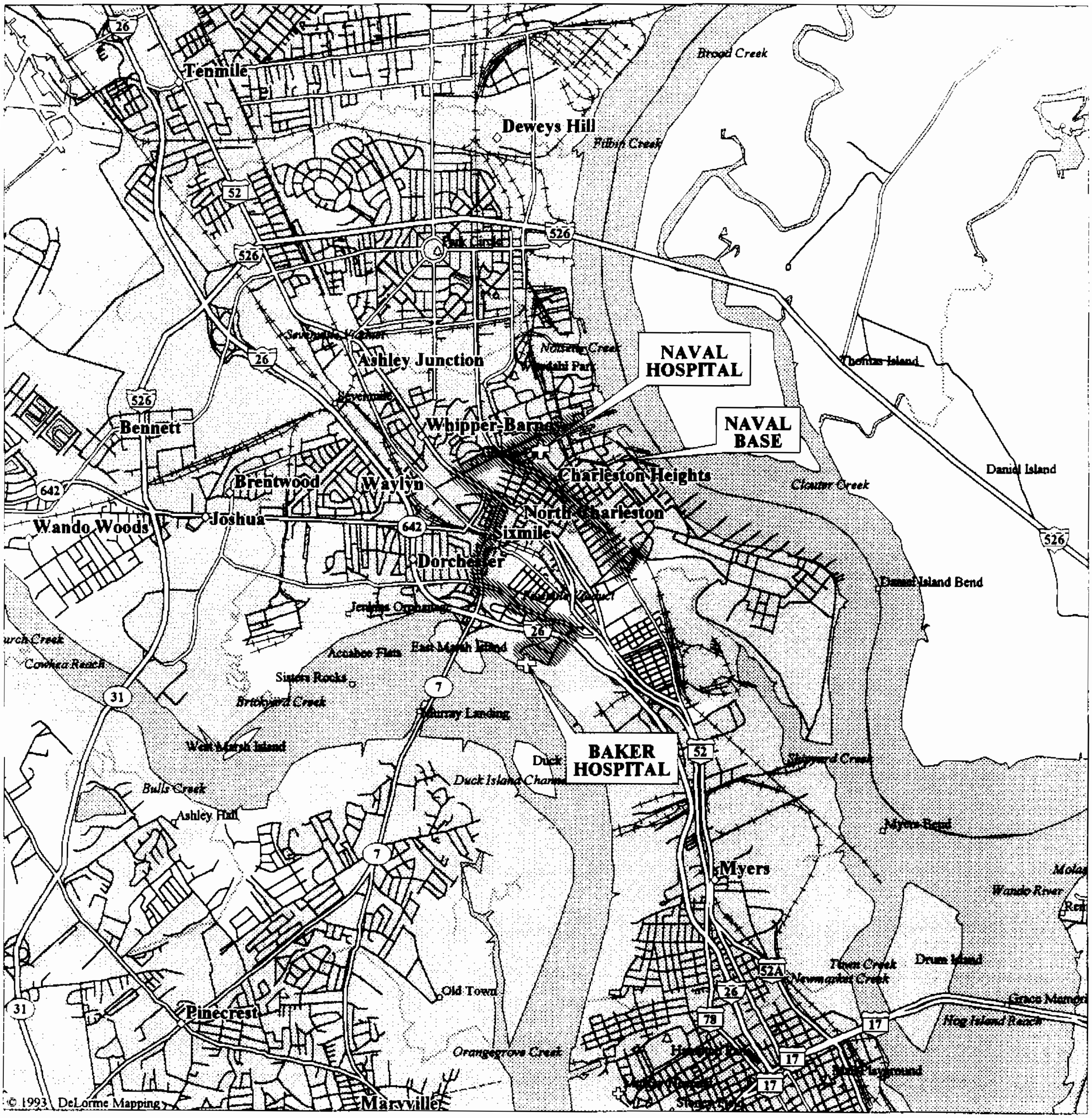
Directions to Charleston Naval Hospital From Main Gate of the Charleston Naval Shipyard:

1) Refer to Figure 6-X, Map to the Charleston Naval Hospital.

2) Exit naval base via the Main Gate (McMillan Gate).

3) Proceed west, toward Rivers Road.

4) At the intersection of McMillan and Rivers, the hospital is on the left.
   - Hospital entrance is just before the intersection.
   - Hospital is approximately 1/2-mile from the Main Gate.



LEGEND

	Population Center		Street, Road		Airfield
	State Route		Hwy Ramps		Land Mass
	Geo Feature		Street, Road		Open Water
	Town, Small City		Major Street/Road		
	Hospital		State Route		
	Park		Interstate Highway		
	Interstate, Turnpike		US Highway		
	US Highway		Railroad		
	County Boundary		River		

Mag 13.00
Fri Jun 24 18:37:09 1994

Scale 1:62,500 (at center)

1 Miles

2 KM

APPENDIX J

HEALTH AND SAFETY PLAN FORMS

PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN

INSTRUCTIONS: This form is to be completed by each person working on the project site and returned to: EnSafe/Allen & Hoshall, Memphis, Tennessee.

Job No: 0029 - 00104

Contract No: N62467-89-D-0318

Project: Zone H - Naval Base Charleston

I have read and understand the contents of the above plan and agree to perform my work in accordance with it.

____

Signed

____

Print Name

____

Company

____

Date

EMPLOYEE EXPOSURE HISTORY FORM

Employee: ______________________________

Job Name: ______________________________

Date(s) From/To: ______________________________

Hours Onsite: ______________________________

Contaminants (Suspected/Reported):

____

____

____

____

____

____

____

(See Attached Laboratory Analysis)

PLAN FEEDBACK FORM

Problems with plan requirements:

Unexpected situations encountered:

Recommendations for revisions:

ACCIDENT REPORT FORM

SUPERVISOR'S REPORT OF ACCIDENT	DO NOT USE FOR MOTOR VEHICLE OR AIRCRAFT ACCIDENTS	
TO	FROM TELEPHONE (Include area code)	
NAME OF INJURED OR ILL WORKER AND COMPANY		
WORKER'S SOCIAL SECURITY NUMBER		
DATE OF ACCIDENT	TIME OF ACCIDENT	EXACT LOCATION OF ACCIDENT
NARRATIVE DESCRIPTION OF ACCIDENT		
NATURE OF ILLNESS OR INJURY AND PART OF BODY INVOLVED		LOST TIME YES ☐ NO ☐
PROBABLE DISABILITY (Check one) FATAL ☐ LOST WORK DAY WITH ____DAYS AWAY FROM WORK LOST WORK DAY WITH ____DAYS OF RESTRICTED ACTIVITY NO LOST WORK DAY ☐ FIRST-AID ONLY ☐		
CORRECTIVE ACTION RECOMMENDED (By whom and by when)		
NAME OF SUPERVISOR	TITLE	
SIGNATURE	DATE	