FINAL COMPREHENSIVE CORRECTIVE MEASURES STUDY PROJECT MANAGEMENT PLAN CNC CHARLESTON SC
6/25/1997
ENSAFE/ ALLEN AND HOSHALL

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RESPONSE TO COMMENTS FOR DRAFT COMPREHENSIVE CORRECTIVE MEASURES STUDY PROJECT MANAGEMENT PLAN AND WORK PLANS DATED JANUARY 31, 1997

NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
CTO-029

CONTRACT NUMBER: N62467-89-D-0318

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

Prepared by:

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(901) 383-9115

June 25, 1997

of the alternatives, this section should describe the final steps for the selection of a remedy that will be implemented at a site or group of sites.

The Navy may recommend a preferred alternative (s) with supporting rationale and justification, in the Corrective Measures Study (CMS) Report.

After all considered alternatives have gone through the evaluation process, using a "weighted criteria value," and have been ranked, then the decision process starts and the final preferred remedy or group of remedies is selected by the implementing agency SCDHEC.

The selected alternative(s) will be proposed in the Statement of Basis that should go through a public comment period. Public comment may influence changes to the selected corrective measure(s). Additionally, the public may request a public meeting where additional comments may be received and considered. A Final Decision and Response to Comments will be developed by SCDHEC to document the selection of the corrective measure(s).

Response 8:

Section 4.5, Remedy Selection, has been added to the document in response to this comment. Section 4.5 describes the selection process, public involvement, and SCDHEC's leading role in final remedy defense and selection.

Comment 9:

Section 5.0, Treatability Study Procedures. This section indicates that first the need for a treatability test should be established before conducting one. Within this basic principle on page 5-1 should be added as the fist bullet that the first step is to evaluate if the existing site data is enough and the uncertainties are acceptable to select a remedial alternative. If the answer is "no", then we can evaluate available treatability data from literature and other sources.

The second and third bullets are more related to specific site/data available information. These two bullets evaluate data needs related to specific site/contaminant characteristics. Thus, these two bullets could be grouped under one bullet that analyzes "data needs"that comes into play once it has been determined that the existing site data and available outside data is not sufficient to choose a remedial alternative and therefore a treatability study is needed.

All the identified data needs should provide enough support for the selection of a remedial alternative. If the treatability study is done in support of not fully understood technologies then the data requirements will be broader.

Response 9:

Concur. The first step in determining the need for treatability testing will be to ascertain if available site data and current uncertainties are acceptable to the selection of a remedial alternative. Section 5.0, Treatability Study Procedures, has been revised to reflect this requested change. The third bullet, previously the second bullet, has been revised and the fourth bullet, previously the third bullet, has been deleted.

Comment 10:

In Section 5.0, the " Treatability Approach" subsection lists several tasks needed in order to complete a total cycle in the treatability study approach. Once the need for a treatability study has been established, then the first step should be to define the Scope and Objectives of the treatability study. These Scope and Objectives should be based on identified data needs and the technologies to be tested. According to this section the first step should be to define Data Quality Objectives (DQOs). This should be the second step, after Scope and Objectives are defined.

Response 10:

DQOs typically comprise scope and objectives of the ensuing effort. Therefore, the meaning was implied by E/A&H. Also, within Sections 5.2 and 5.3, bullet statements are made, designating "test objectives" as being a significant portion of the Treatability Study Work Plan. However, to clarify the intent of the document, a revision was completed on this subsection, which states that the scope and objective are to be defined at the onset of the treatability study.

Comment 11:

Section 5.3, Preparing the Work Plan, describes some of the subjects that should be included in the preparation of a treatability study work plan. The Department believes that a section of the work plan should explain the management of residuals and wastes from bench or pilot studies.

Depending on the type of test to be performed, the amount of residues/wastes could be considerable.

Response 11:

The document has been revised to include a bullet indicating "management of residuals," when required. In addition, it should be noted that Section 2.7, Investigation-Derived Waste, of the comprehensive CMS Work Plan states that all investigation-derived wastes will be handled and disposed of in accordance with Section 5.15 of the SOP QAM and Section 16 of the Final Comprehensive RFI Sampling and Analysis Plan.

Comment 12:

Section 5.6, Analyzing and Interpreting the Data. This section explains that the first goal of data analysis is to determine the quality of data collected. To achieve this goal, a discussion related to the uncertainty of the data analysis should also be included. This issue should be discussed by comparing the initial uncertainty on the data, before the tests was performed, with the remaining uncertainty of the data collected after the test is performed. This section should also discuss, what remains uncertain after the test and what uncertainties were overcome with the additional data obtained from the treatability study.

Response 12:

This section of the document has been revised to reflect the concerns of this comment. The revision states that as a general perspective, the level of process or treatability uncertainty will be presented and discussed initially in the Work Plan prior to the start of treatability efforts. The goal of the treatability study is to eliminate, or at least to reduce the level of, the uncertainty. Upon completion of the treatability effort, the CMS report will state whether any uncertainty remains, and its subsequent adverse impact, if any, to the project.

Comment 13:

Section 6.1, Project Work Elements. This section describes a series of tasks that will be accomplished throughout the CMS process. Task # 11 "Field Work", is subdivided in four additional tasks. The first of these additional tasks reads "perform no-further-action (NFA) evaluation via electronic realistic risk assessment."

It is not clear what this tasks proposes to do. The objective of this task should be explained. Additionally, if a CMS Work Plan has been approved (task 9), it would seem reasonable that at least one remedial alternative will be considered or evaluated for a site or group of sites. It is unclear how at this point in the CMS process, a NFA evaluation could be considered based on a "electronic realistic risk assessment." Please provide an explanation of how all these elements relate.

This comment also includes task # 12, which seems to be related or depending on task # 11. Comment 2 should also be considered as part of this comment.

Response 13:

The tasks listed in Section 6.1, Project Work Elements, have been substantially revised (eg, the work elements list has been restructured and shortened). References to NFA and electronic risk assessments are no longer applicable and therefore have been deleted from the PMP.

Comment 14:

For Volume I, there are some typographical errors:

Page 6-1, Section 6.1, second paragraph, the words "for completion" are repeated twice in the same sentence.

Page 6-6, "Project Team" paragraph, the misspelled names of the SCDHEC representatives really are: Ms. Ann Ragan, Mr. Johnny Tapia.

Response 14

The sentence containing "for completion" twice was corrected. The spelling of Ms. Ann Ragan's and Mr. Johnny Tapia's names were corrected.

Comprehensive CMS Work Plan (Volume II)

Comment 15:

Section 3.0, Quality Assurance/Quality Control Plan. On page 3-1 of this section, there is a paragraph labeled as "Applicable Regulations," which mentions that CFR 40 (260-280) applies. It should be mentioned that the South Carolina Hazardous Waste Management Regulations (SCHWMR R.61-79) also apply, with its latest edition dated December 27, 1996.

Response 15:

The document has been revised to note the applicability of SCHWR R.61-79 dated December 27, 1996.

Comment 16:

Section 4.2, Data Deliverables. This section states that data deliverables elements identified in the Comprehensive RFI Work Plan apply. This is true, however additional elements could be identified during the CMS, due to the introduction of new studies such as bench scale or pilot studies. This section should account for these new elements that are likely to appear during development of the Corrective Measures Study.

Response 16:

The document has been revised to reflect this comment. Additional CMS-specific data deliverable elements, such as those generated as a result of treatability studies or additional soil/ground water sampling, apply.

Comment 17:

Section 4.0 makes reference to the "Engineer in Charge" (EIC). Up to this point in the Work Plan, from the project management stand point, it has not been identified or defined the roll of the Engineer in Charge. This should be clarified.

Response 17:

The EIC is Mr. Matthew A. Hunt of the Southern Division Naval Facilities Engineering Command. Mr. Hunt's role as EIC is described in Section 6.3, Project Management Responsibilities, of the PMP (eg, Volume I). The position description states that Mr. Hunt is responsible for the technical and financial management of Installation Restoration Program activities at Charleston Naval Base. It further states that the EIC prepares the project statement of work; manages the project scope, schedule, and budget; and provides technical review and approval of all deliverables. Section 4.0 of the comprehensive CMS Work Plan was revised to clarify this point.

Comment 18:

It is understood that Section 5.0 of Volume II tries to introduce and provide general information for a basic understanding of how laboratory tests, bench scale tests and pilot study tests, in relation to certain technologies, will be performed at Charleston Naval Base. Some of these descriptions provide very specific technical information, as operating parameters, etc., that should be presented instead, as part of the appropriate work plan when specific test/technology are chosen.

This is a Comprehensive Work Plan, where all general procedures are described. Some technologies proposed for testing go in deep detail with specific values of parameters and volumes of materials. This approach shows inconsistency on the way this section of the work plan is written. The Navy should revise this section to provide a more consistent approach, meaning a similar level of detail in the description of the tests/technologies considered to be applicable at the Charleston Naval Complex.

Response 18:

It was the intent of E/A&H to write, in a general sense, the treatability section of the Work Plan. However, the description of certain treatability processes required a greater level of detail than initially anticipated. This increased level of detail was added to ensure that the Project Team was aware of potential treatability challenges and requirements facing the Charleston Naval Base corrective measures effort.

However, it is reasonable to expect that site-specific treatability studies will include additional and site-specific information beyond what is presently listed. An additional paragraph was added to Section 5.0 that outlined the typical approach to a Treatability Study Work Plan. A key aspect of the Treatability Study Work Plan is its flexibility. The Work Plan must provide allowances and therefore flexibility for unforeseen site conditions and alterations of subsequent treatment options.

Comment 19:

Section 6.4, Authorized Personnel, and Section 6.5, Emergency Information, should be updated. The name of the site contact has changed in the last few months. This update includes pages 6-30, 6-31 and 6.32.

Response 19:

Both of these sections have been updated to reflect personnel who are currently assigned to the posted positions.

Comment 20:

Typographical error on page 6-3, first paragraph. The word is augering instead of auguring.

Response 20:

Correction applied.

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

5090/11
Code 1877
26 June 1997

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

Subj: SUBMITTAL OF FINAL COMPREHENSIVE CORRECTIVE MEASURES STUDY WORK PLAN

Dear Mr. Litton:

The purpose of this letter is to submit the Final Comprehensive Corrective Measures Study Work Plan for Naval Base Charleston. The Work Plan is submitted to fulfill the requirements of condition I.F of the RCRA Part B permit issued to the Navy by the South Carolina Department of Health and Environmental Control and U.S. Environmental Protection Agency.

Comments made by the Department and the EPA on the initial submittal have been addressed and included in this submittal. The Response to Comments is also included and was reviewed with Department and EPA representatives during the Project Team meeting of June 11 and 12, 1997, in order to ensure the comments were adequately addressed. We request that the Department and the EPA review the report and provide comment or approval as appropriate. If you should have any questions, please contact Billy Drawdy or Matthew Hunt at (803) 743-9985 and (803) 820-5525 respectively.

Sincerely,

P. M. ROSE
LCDR, U.S. Navy
Caretaker Site Officer
by direction

Encl: Final Comprehensive Corrective Measures Study Work Plan, dated 25 June 1997

Copy to:
SCDHEC (Bergstrand, Tapia)
USEPA (Bassett)
SOUTHNAVFACENGCOM (Hunt, Batten)
CSO Naval Base Charleston (Drawdy, Fontenot)
SPORTENVDETCHASN (Dearhart)

VOLUME I

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

FINAL COMPREHENSIVE CORRECTIVE MEASURES STUDY PROJECT MANAGEMENT PLAN

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

SOUTHDIV CONTRACT NUMBER: N62467-89-D-0318

Prepared by:

ENSAFE/ALLEN & HOSHALL
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June 25, 1997

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY CHARLESTON NAVAL WEAPONS STATION CHARLESTON, SOUTH CAROLINA CTO-0115

FINAL COMPREHENSIVE CORRECTIVE MEASURES STUDY PROJECT MANAGEMENT PLAN

Prepared for:

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

SOUTHDIV Contract Number:
N62467-89-D-0318

Prepared by:

EnSafe/Allen & Hoshall
5720 Summer Trees Drive, Suite 8
Memphis, Tennessee 38134
(901) 383-9115

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

Date	6/24/97
Signature	[signature], P.G.
Name:	Todd Haverkost
Title:	Task Order Manager

June 25, 1997

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ACRONYM LIST

ACGIH	American Conference of Governmental Industrial Hygienists
AL	Action Level
AOC	Area of Concern
APEG	Alkaline Polyethylene Glycol
AST	Above Ground Storage Tank
ASTM	American Society of Testing and Materials
BCP	BRAC Cleanup Plan
BCT	BRAC Cleanup Team
BEQ	Bachelor Enlisted Quarters
BNA	Business and National Affairs
BOD	Biological Oxygen Demand
BRAC	Base Realignment and Closure
BTU	British Thermal Unit
CAMU	Corrective Action Management Unit
CAMP	Corrective Action Management Plan
cc	Cubic Centimeter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
CH_4	Methane
CHASP	Comprehensive Health and Safety Plan
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Procedures
CM	Corrective Measures
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CNSY	Charleston Naval Shipyard
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COC	Contaminant of Concern
COD	Chemical Oxygen Demand
COLIWASA	Composite Liquid Waste Sampler
COPC	Contaminant of Potential Concern
CRP	Community Relations Plan
CRZ	Contaminant Reduction Zone
CSAP	Comprehensive Sampling and Analysis Plan
CSI	Confirmatory Sampling Investigation
CSV	Chlorinated Semivolatiles
CV	Chlorinated Volatiles
°C	Degree Centigrade

DANC	Decontaminating Agent Noncorrosive
DMP	Data Management Plan
DNAPL	Dense Non-aqueous Phase Liquid
DO	Dissolved Oxygen
DOD	Department of Defense
DRMO	Defense Reutilization and Marketing Office
DQO	Data Quality Objective
E/A&H	EnSafe/Allen & Hoshall
EBS	Environmental Baseline Survey
E_h	Redox Potential
EIC	Engineer in Charge
ENR	Engineering News Record
EOD	Explosive Ordnance Detachment
EPA	Environmental Protection Agency
ESDLOPQCM	USEPA Environmental Services Division *Laboratory Operations and Quality Control Manual* (1990)
$(ev)_3$	Ionization Potential
EZ	Exclusion Zone
°F	Degree Fahrenheit
FIA	Flame Ionization Analyzer
FID	Flame Ionization Detector
FISC	Fleet Industrial Supply Center
ft^2	Square Feet
GC	Gas Chromatograph
GIS	Geographic Information System
gm	Gram
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCL	Hydrochloric Acid
HASP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendment
IDLH	Immediately Dangerous to Life and Health
IDW	Investigation-Derived Waste
IM	Interim Measure
IR	Installation Restoration
KPEG	Potassium Polyethylene Glycol
L	Liter
LDR	Land Disposal Restriction
LEL	Lower Explosion Limit
LFG	Landfill Gas
LTTD	Low Temperature Thermal Desorption

M&S	Marshall & Stevens
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MD	Maryland
mil	One-thousands of an Inch
ml	Milliter
mg/L	Milligram per Liter
mg/m^3	Milligram per Cubic Meter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
MSW	Municipal Solid Waste
N/A	Not Applicable
NaOH	Sodium Hydroxide
NAVBASE	Naval Base Charleston
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substances Contingency Plan
NCR	NEESA Contract Representative
NCSD	North Charleston Sewer District
NCSV	Non-chlorinated Semivolatile
NCV	Non-chlorinated Volatile
NEESA	Naval Energy and Environmental Support Activity
NFA	No Further Action
NFESC	Naval Facilities Engineering Support Center
NIOSH	National Institute for Occupational Safety and Health
NMOC	Non-methane Organic Compound
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRRC	Naval Reserve Readiness Center
NTU	Nephelometric Turbidity Unit
O_2	Oxygen
OB/OD	Open Burn/Open Detonation
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenyl
PEL	Permissible Exposure Limit
pH	Hydrogen Ion Measurement
PAH	Polyaromatic Hydrocarbons
PHSO	Project Health and Safety Officer

PID	Photoionization Detector
PMO	Project Management Office
PMP	Project Management Plan
POL	Petroleum, Oil, and Lubricants
Poly	Polyethylene
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
ppm	Parts per Million
PRG	Preliminary Remedial Goal
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAP	Quality Assurance Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAB	Restoration Advisory Board
RAC	Response Action Contractor
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
redox	Oxidation/Reduction Potential
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RGO	Remedial Goal Option
R_I	Radius of Influence
rpm	Revolutions per Minute
RTC	Response to Comments
SAP	Sampling and Analysis Plan
SAR	Supplied Air Respirator
SCBA	Self-contained Breathing Apparatus
SCD	South Carolina Department
SCDHEC	South Carolina Department of Health and Environmental Control
SDIV	Southern Division Naval Facilities Engineering Command
SESE	Shipboard Electronic Systems Evaluation
SHSO	Site Health and Safety Officer
SIOH	Supervision, Inspection and Overhead
SOP QAM	USEPA Environmental Services Division *Standard Operations and Quality Assurance Manual* (1996)
SOUTHNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SOW	Statement of Work
S/S	Stabilization and Solidification
SSL	Soil Screening-Level
STEL	Short Term Exposure Limit
SVE	Soil Vapor Extraction
SVOC	Semivolatile

SW-846	USEPA *Test Methods for Evaluating Solid Waste*, 3rd. Ed. (1986)
SWMU	Solid Waste Management Unit
SZ	Support Zone
TBA	To Be Announced
TCLP	Toxicity Characteristic Leaching Procedure
TDC	Thermal Conductivity
TDS	Total Dissolved Solids
TGNMO	Total Gaseous Non-Methane Organic
TIC	Target Indicator Compounds
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TSDF	Treatment, Storage and Disposal Facility
TPH	Total Petroleum Hydrocarbon
TSP	Treatability Study Plan
TSS	Total Suspended Solids
TU	Temporary Unit
UCL	Upper Confidence Limit
USCS	Unified Soil Classification Scheme
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet
UXO	Unexploded Ordnance
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This project management plan (PMP) describes the documents required to satisfy Condition IV.E. and the Hazardous and Solid Waste Amendments (HSWA) portion of the RCRA Part B Permit (EPA SCD 170 022 560) and discusses overall corrective measures technology identification, screening, and evaluation. It builds on the existing RCRA (Resource Conservation and Recovery Act) Facility Investigation Final Comprehensive Project Management Plan.

Compliance with the RCRA permit is regulated by both South Carolina Department of Health and Environmental Control (SCDHEC) and the U.S. Environmental Protection Agency (USEPA).

This plan has been prepared for the Naval Base Charleston (NAVBASE) as part of the Department of Defense Installation Restoration (IR) Program and as a result of the Base Realignment and Closure (BRAC) Act. This Corrective Measures Study (CMS) effort includes the area known as the Charleston Naval Shipyard and other tenant commands on NAVBASE. This plan will refer to the entire facility as NAVBASE.

The CMS is part of the RCRA Corrective Action Program which follows the RFA/RFI (RCRA Facility Assessment/RCRA Facility Investigation) process. Corrective Measures Implementation follows the CMS. This plan addresses the general procedures to be followed during the CMS at NAVBASE.

1.1 Purpose of CMS

The CMS is intended to identify, screen, and evaluate/rank potential remedial options for a given site or a group of sites. The CMS' ultimate objective is to rank a list of viable remedial options. There is no maximum or minimum number of remedial options the list may contain.

Viable remedial options will be evaluated and ranked primarily upon their ability to adequately protect human health and the environment, while complying with all applicable regulatory concerns and standards. To achieve this objective, the CMS will consider the following criteria during the evaluation process:

Primary Criteria

- Protection of Human Health and the Environment
- Attainment of Media Cleanup Standards
- Source Control
- Compliance with Applicable Standards for Managing Wastes

Secondary Criteria

- Long-Term Reliability and Effectiveness
- Reduction of the Toxicity, Mobility, or Volume of Wastes
- Short-Term Effectiveness
- Implementability
- Cost

These criteria, as well as the process used to identify, develop, and evaluate potential remedial alternatives, will be discussed later in this plan. The purpose and methodology for ranking alternatives will also be discussed in subsequent sections.

1.2 RCRA Permit Issues

RFI activities at NAVBASE are currently regulated through the RCRA Part B permit issued by the SCDHEC under authority of the USEPA. This permit expired on June 5, 1995; a renewal application has been filed with the state and the issuance of a new permit is expected soon, pending public comments.

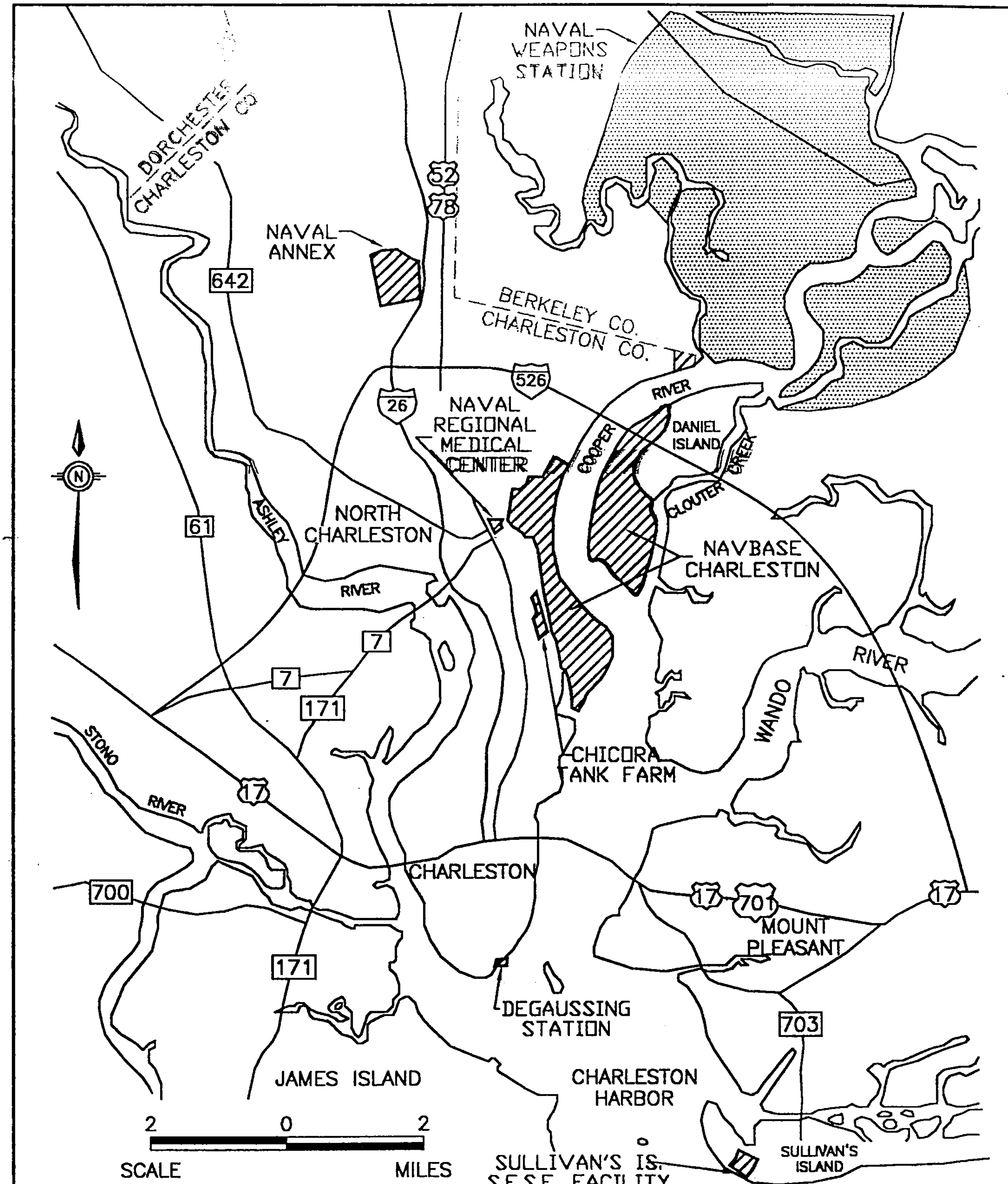
An initial RCRA Facility Assessment was completed in August 1987 to meet the requirements of the 1984 HSWA and the 1976 RCRA. This RFA, conducted by Ebasco Environmental Services, addressed 24 solid waste management units (SWMUs). Six additional SWMUs were added during 1990, one during 1991, and three during 1993, for a total of 34 SWMUs.

As a result of BRAC activities at NAVBASE and the RCRA Corrective Action Program, an additional 155 SWMUs and 203 areas of concern (AOC) were identified in 1994 by the SCDHEC and the USEPA. Of all the SWMUs and AOCs identified at NAVBASE, 194 SWMUs and 205 AOCs are being considered in the RCRA Corrective Action Program.

USEPA Region IV's definitions of a SWMU and AOC are assumed. These definitions were presented in the Comprehensive RFI PMP.

For management of the corrective action process, NAVBASE was divided into 12 study zones. Figure 1-1, Location Map, Naval Base Charleston, Charleston, South Carolina, presents NAVBASE in respect to greater Charleston and Figure 1-2, Investigative Zones Map, Naval Base Charleston, Charleston, South Carolina, shows the location of the 12 investigative zones (A through L) designated at NAVBASE.

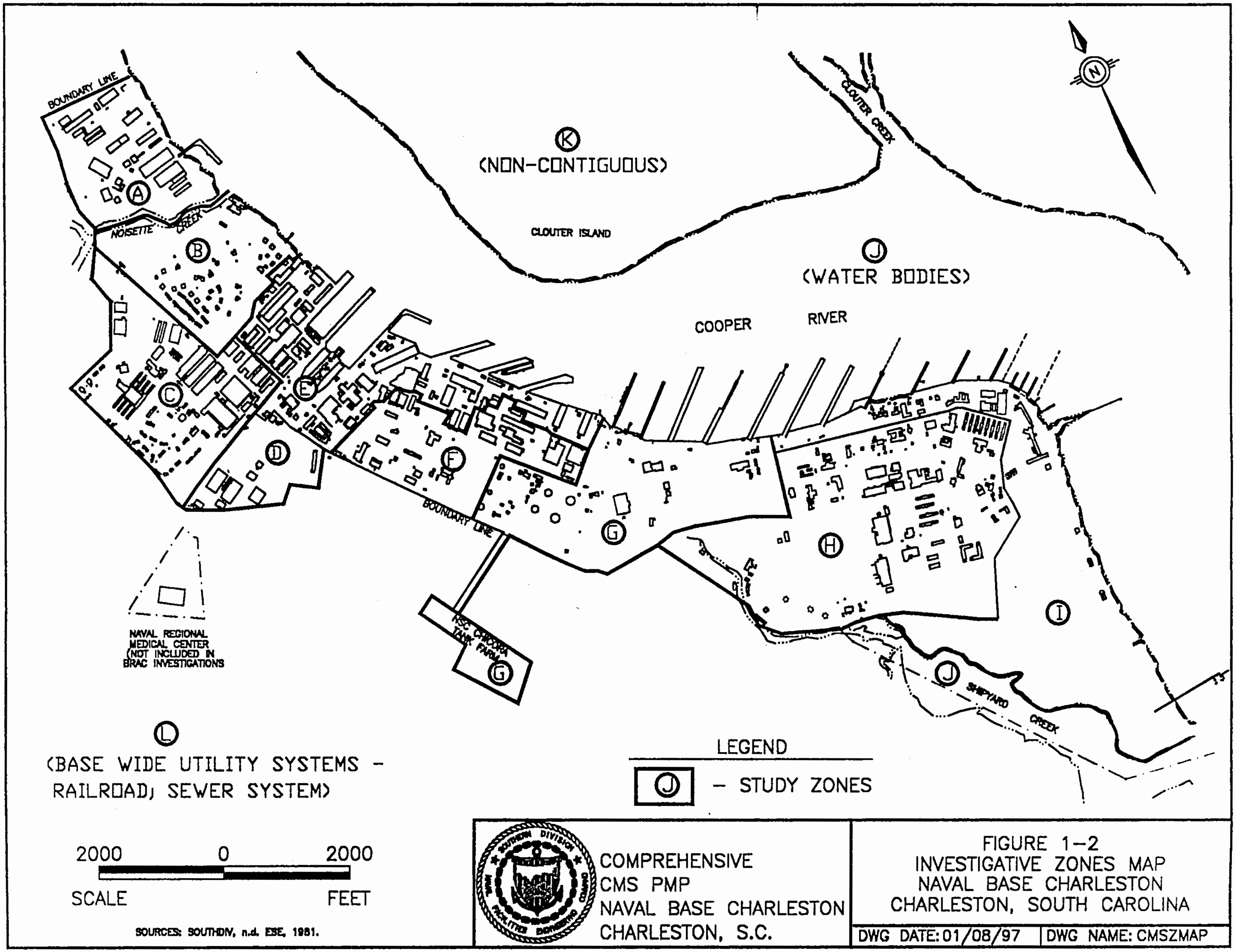
The site's RCRA Part B Permit specifies that SCDHEC and USEPA will review RFI documents and notify NAVBASE if further investigations, CMS, or corrective action are needed. Specific permitting considerations, including necessary changes to the NAVBASE permit, are discussed in later sections of this plan.



COMPREHENSIVE
CMS PMP PLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1–1
LOCATION MAP
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

DWG DATE: 1/08/97 | DWG NAME: 29AREA



COMPREHENSIVE CMS PMP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1-2
INVESTIGATIVE ZONES MAP
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

DWG DATE: 01/08/97 | DWG NAME: CMSZMAP

1.3 Voluntary Acceleration of Cleanup Program

To facilitate BRAC activities at NAVBASE, a Navy Environmental Detachment was developed from former NAVBASE civilian employees. The NAVBASE Environmental Detachment, an official detachment of the U.S. Navy Supervisor of Shipbuilding, Conversion and Repair, Portsmouth, Virginia, has been involved with voluntary cleanup efforts throughout NAVBASE. These efforts have been referred to by the Project Team as Interim Measure (IM) studies and actions.

Table 1-1, Voluntary Cleanup Activities Conducted by Environmental Detachment, lists sites where voluntary cleanup actions have occurred or are pending as of the writing of this document. The table briefly describes the Environmental Detachment's completed or proposed scopes of work (SOW) for voluntary cleanup sites. EnSafe/Allen & Hoshall (E/A&H) will consider the results of these voluntary cleanup actions during the CMS process and the subsequent development of remedial options, if provided.

The CMS is expected to present the general methodology for transition to corrective measures implementation (CMI). The CMS will also focus on the remedial timeframe, permitting, and regulatory concerns for each alternative.

Typically, RCRA permit modifications are required prior to commencement of certain types of corrective actions that are usually defined by the lead agency (eg, SCDHEC). Voluntary cleanup activities by the Environmental Detachment are presently underway at Charleston Naval Base. These cleanup activities are not being completed through the customary RCRA process. Upon completion of the CMS, supporting documentation will be presented and a request for a permit modification will be made to the lead agency. The permit modification is required subsequent to remedy selection and prior to remedy implementation.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
SWMU 5 AOC 605 AOC 621	E	No	Remove lead-contaminated soil by excavating approximately top 12 inches of soil at hot spots with concentrations in excess of 1300 PPM.	Field work is being conducted and soil is being excavated.
SWMU 7 SWMU 6 AOC 635	G	No	Demolish Building 3902; demolish and remove PCB-contaminated slab from Building 3902 Site in Public Works Storage Area. Excavate and remove PCB and pesticide-contaminated soil hot spots to depth of 1 foot.	Field work has been completed and currently awaiting analysis of samples to determine if additional soil removal required.
SWMU 8	G	No	Excavate petroleum-contaminated soil to approximately 5 feet deep. Possible installation of free product recovery system after completion of excavation.	Excavation started (pavement/ROC removal as of 11/27/96).
SWMU 9	H	No	Conduct topographical survey of landfill area and conduct geophysical survey (trenching) in N and NE portion of landfill to determine extent of landfill boundary.	In planning stage, scope of work has yet to be fully defined..
SWMU 13	H	Yes	Ship's force fire fighting training area.	Site has been accepted by SCDHEC for transfer to UST program for remediation as a petroleum release.
SWMU 14	H	No	Locate magnetic anomalies. Excavate anomalies and remove any chemical drums found.	Field work in progress and approx. 80% of mapped anomaly areas have been excavated. Have located several drums, yet mostly inert debris material.
SWMU 19	H	No	Any ensuing cleanup activities for SWMU 19 will be incorporated as part of SWMU 9 remedial actions.	On hold until SWMU 9 completes the CMS process.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
Building 44 (SWMU 25)	E	No	Demolish Building 44 Annex.	Demolition completed. Additional soil samples are being taken to determine if additional soil removal is required from area where annex portion of building was removed.
SWMU 38	A	No	Miscellaneous storage yard north of Building 1605; pesticides.	Field work underway. Soils being excavated.
SWMU 42	A	No	Former asphalt plant northwest of Building 1803.	Field work underway. Soils being excavated.
SWMU 44	C	No	Remove loose coal from storage yard; excavate mixed coal/soil to maximum depth of 5 feet in limited areas.	Site work and report completed.
SWMU 54 SWMU 21	E	No	Remove remaining abrasive blast residue, including surface soil containing blast media (approximately 12 inches).	Site work and report completed.
Building 9 Foundry (SWMU 83)	E	No	Remove all sources/spills of oil, PCBs, Dipropylene Glycol, lead dust, and friable asbestos from interior of Building 9 Foundry.	Site work and report completed.
SWMU 109	F	No	Remove loose abrasive blast media from paved areas under blast media hoppers. Scrape top layer of soil containing blast media from area beside hoppers.	Canceled.
SWMU 121	H	No	Any ensuing cleanup activities for SWMU 121 will be incorporated as part of SWMU 9 remedial actions.	On hold until SWMU 9 completes the CMS process.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
SWMU 138	H	No	Satellite accumulation area at Building 1776.	Not accepted into the UST program. Status is pending.
SWMU 159	H	No	Excavate selected areas of petroleum-contaminated soil to approximately 2 feet deep.	Field work and report completed.
AOC 500	J	No	UXO site between piers S and T	Evaluating subcontractor proposals and coordinating subsequent field work.
AOC 501	J	No	UXO site in Cooper River east of Buildings X54 and X55.	Awaiting proposal from UXB International.
AOC 502	J	No	UXO site between Piers G and H	Awaiting proposal from UXB International.
AOC 503	H	No	UXO site south of Building 665. Clear land for magnetometer survey by Navy EOD from Indian Head, MD. If UXO is found, Indian Head will excavate and remove.	Land cleared as of 12/6/96; Indian Head EOD has performed site check.
UST NH21-1 (AOC 510)	C	Yes	Remove underground heating oil storage tank at geotechnical laboratory, Building NH21 (AOC 510).	UST removed.
UST 1279B (AOC 569)	E	Yes	Remove 3,000-gallon regulated underground unleaded gasoline storage tank at site of former service station between Buildings 25 and 30.	UST removed prior to shipyard closure.
AOC 574	E	No	Excavate and remove petroleum-contaminated soil 15'x20'x3' deep at location of removed Building 9 fuel tank (AST 9C).	Field work completed and report expected August 1997.
AST 9C (AOC 574)	E	Yes	Remove 3,700-gallon above ground fuel oil storage tank.	AST removed.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
UST 1346 (AOC 609)	F	Yes	Remove 650-gallon regulated underground waste oil storage tank at service station Building 1346 (AOC 609).	UST removed.
UST 148 (AOC 623)	G	Yes	Remove 15'x20'x10'' concrete underground fuel oil holding tank (AOC 623).	UST removed.
AOC 626	G	No	Excavate and remove 200 linear feet of 18-inch diameter fuel piping and accompanying petroleum-contaminated soil from fuel farm area; install free product recovery system.	Field work completed. Passive collection system installed and pumping of product as necessary. Report completed.
AOC 636	G	No	This site has recently been determined to be used for storage only and therefore is no longer classified as a UXO site.	Not slated for voluntary cleanup.
UST NS53 UST NS53B (AOC 664, SWMU 178)	H	Yes	Remove 3,000-gallon underground heating oil storage tank NS53; remove 800-gallon underground diesel storage tank NS53B. Tanks are near transfer valve X33A (AOC 664).	UST removals in progress as of 12/4/96.
AOC 653	H	No	Excavate selected areas of petroleum-contaminated soil approximately 5 feet deep.	Field work has been completed. Report is in draft form.
UST 656 (AOC 655)	H	Yes	Remove 5,800-gallon underground heating oil storage tank located at/near site of oil spill (AOC 655) on west side of Building 656.	UST removal.
AOC 659	H	Yes	Diesel Storage at Building 14.	Site in process of transfer to UST program for remediation as a petroleum release.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
UST 851A UST 851B (AOC 663)	H	Yes	Remove 500-gallon regulated underground unleaded gasoline storage tank 851A; remove 500-gallon regulated underground diesel storage tank 851B. Tanks serve pumping station Building 851 (AOC 663).	USTs removed.
UST NS45-TNK-1 (AOC 666)	H	Yes	Remove 25,000-gallon underground fuel oil storage tank NS45 (AOC 666).	UST removed.
AOC 667	H	No	CBU-412 Vehicle Maintenance Area at Building 1776.	Not accepted into UST program. Status is pending.
AOC 670	H	No	Excavate and remove soil contaminated with heavy metals and BEQs from former skeet ranges; possibly remove lead shot from site to prevent ingestion by waterfowl.	Research/work scope reparation.
UST NS4-TNK-1 (AOC 675)	I	Yes	Remove 25,000-gallon underground fuel oil storage tank NS4 (AOC 675).	UST removed.
UST NS2A (AOC 677)	I	Yes	Remove 560-gallon underground waste oil storage tank at Building NS2 (AOC 677).	UST removed.
AOC 681	I	No	Site has been removed from list for consideration of voluntary cleanup.	Site has been turned over to Caretaker Site Office as a possible maintenance issue.
AOC 684	I	No	Excavate and remove soil contaminated with heavy metals, PCBs, and BEQs from former outdoor pistol range.	Work scope preparation.

Table 1-1
Voluntary Cleanup Activities Conducted by Environmental Detachment

SWMU/AOC	Zone	UST Program	Scope of Work/Comments	Status
AST 1708 (AOC 686)	I	Yes	Remove 2,000-gallon aboveground heating oil storage tank at high explosive storage Building X54 (AOC 686).	AST removal.
AOC 690	I	No	Remove trash and construction debris from West Road and Lunsford Loop.	IM complete.
AOC 693	K	No	Potential UXO site on Clouter Island.	No longer being considered for voluntary cleanup.
AOC 694	K	No	Potential UXO site on Clouter Island.	No longer being considered for voluntary cleanup.
AOC 699	L (E)	No	Clean sediment from piping and catch basins for storm drain outfalls 30, 35, and 36, possibly also 22, 23, and 27.	Cost negotiations in progress.
AOC 707	I	No	Excavate selected areas of petroleum-contaminated soil approximately 2 feet deep at diesel spill adjacent to Building 1795 near Building 28.	Field work completed.
AOC 708	I	No	Excavate selected areas of petroleum-contaminated soil approximately 2 feet deep at petroleum release near Buildings NS669 and NS 669.	Field work completed.

Notes:

PPM	Parts per million	IM	Interim measure
SOUTHDIV	Southern Division Naval Facilities Engineering Command	SCDHEC	South Carolina Department of Health and Environmental Control
USEPA	United States Environmental Protection Agency	UXO	Unexploded ordnance
EOD	Explosive Ordnance Division	UST	Underground storage tank
AST	Aboveground storage tank	PCB	Polychlorinated biphenyl
BEQ	Bachelor Enlisted Quarters		

2.0 TECHNICAL APPROACH

This section outlines the technical requirements of the RCRA corrective measures process, which begins with the RFA and proceeds through the RFI and the CMS eventually to the CMI (Corrective Measures Implementation) activity. Figure 2-1, Corrective Action Flow Chart, summarizes the sequence of events and illustrates how various stages of the process are interrelated.

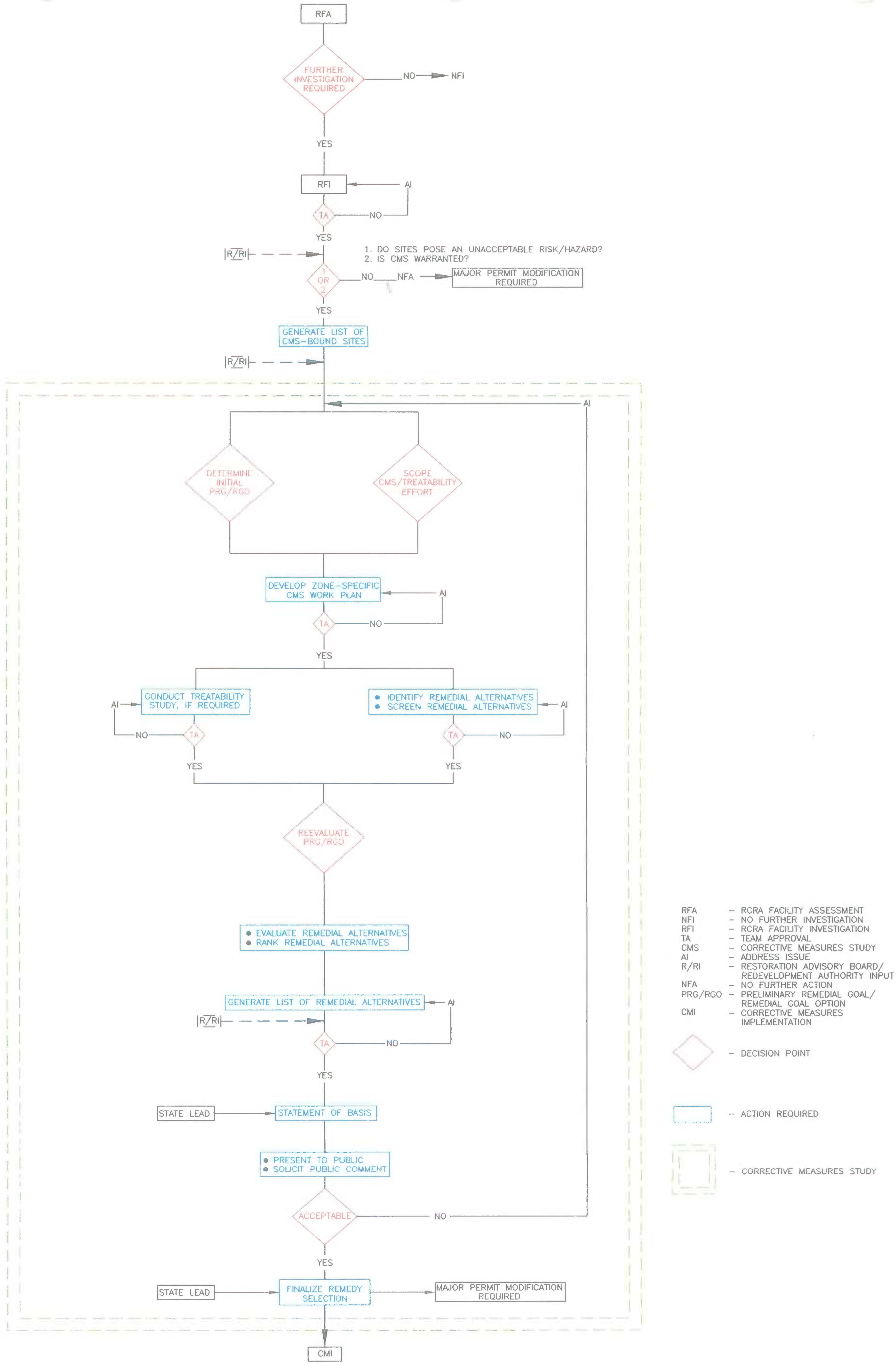
The evaluation of technologies that apply to sites requiring remediation necessitates the development of work plans for data collection and evaluation. Specifically for the NAVBASE CMS, comprehensive and zone-specific CMS work plans are being developed. The purpose and general content of each is discussed below.

2.1 Comprehensive Work Plan

The comprehensive CMS work plan adopts the final comprehensive RFI work plan, adding only the information specifically relating to the comprehensive CMS work plan not previously provided. Specifically, it adopts the following final comprehensive RFI work plan elements: project management plan, sampling and analysis plan, data management plan, baseline risk assessment plan, and health and safety plan. In addition to supplements to these plans, the comprehensive CMS work plan includes a treatability study plan that outlines the general technical approach for conducting a treatability study.

2.2 Zone-Specific Work Plans

To effectively coordinate corrective measures, NAVBASE has been subdivided into discrete zones for RFI investigation and potential transfer to both federal and nonfederal entities. The RFI has been conducted using these specific zones. Therefore, the CMS will be conducted on a zone-specific basis except where contamination extends across zone boundaries.



COMPREHENSIVE CMS
PROJECT MANAGEMENT
AND WORK PLANS
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2–1
CORRECTIVE ACTION
FLOW CHART

DWG DATE: 06/20/97 | DWG NAME: 29CRAFCT

Zone-specific CMS work plans will identify the specific sites recommended for the CMS, summarize historical information, identify contaminants of concern and their associated residential and industrial human health risk, ecological risk, and background contaminant concentrations, and identify remedial goal objectives, future land use, and data gaps. They will also outline the sampling plan (e.g., number and location of soil borings, monitoring wells, soil-gas detection points, air monitoring stations), outline any treatability studies and any modeling programs to be used, and identify a list of initially screened alternatives. Identifying these plan elements will essentially define the CMS objectives.

The zone-specific CMS work plans will include a basic outline of the subsequent CMS report. This outline will support CMS work plan generation efforts and will show how the development of the work plan influences the final report.

Corrective measures technologies for a given zone will consider the findings of other zones to ensure that data collected along zone boundaries are complementary and that the technology's maximum efficiency is considered. Additionally, ongoing efforts of the Navy's underground storage tank remedial program and voluntary cleanup activities will be considered when conducting the CMS.

The following describes the administrative steps that will be taken to develop zone-specific CMS work plans.

2.2.1 Defining the Zone-Specific CMS Work Plans

The process will begin with a review of specific site characteristics, conditions, and contaminant distribution and a review of the preliminary remedial goals (PRGs) such as applicable media cleanup standards, background concentrations, and an assessment of risk to human health and the environment. Existing data quality will be reviewed relative to its appropriateness to the CMS.

A list of remedial alternatives will be prepared and (if necessary) the appropriate bench-scale or pilot-scale treatability studies will be planned. A treatability SOW will be prepared when a treatability study is required. The SOW will be submitted to the Navy for approval and funding.

The list of reasonable or likely remedial alternatives will be presented to the project team in a project scoping meeting. The purpose of the scoping meeting will be to: (1) identify site-specific data quality objectives, (2) discuss additional field work required for implementation of the remedial action, and (3) select a final list of remedial alternatives for each site.

To focus the project scoping meeting and to expedite alternative screening and data quality objectives (DQOs) development; a comprehensive CMS work plan (Volume II) has been prepared detailing methods and procedures most likely to be used during the CMS process. The purpose of this plan is to provide methodology and procedures that the project team can agree upon so they will not have to be repeated in zone-specific work plans. The comprehensive CMS work plan will be the basis from which zone-specific plans will be expanded from.

Zone-specific draft CMS work plans will present the remedial alternatives for each site and the approach for completing the evaluation of remedial alternatives. The work plans will be submitted to the project team for review. Regulatory comments will be addressed by the Navy and E/A&H, followed by an approval meeting with the project team before preparation and submittal of the final zone-specific CMS work plans.

2.2.2 Field Work

Negotiations for additional field work such as treatability studies will be required. Once a contract from the Navy is received, treatability study plans will be implemented. Upon approval of zone-specific work plans by the project team, field crews will be mobilized and sampling and treatability tasks will be performed. Sampling and analysis methods and procedures are summarized in the comprehensive CMS work plan. Treatability procedures and data needs for likely treatability studies are also summarized in the comprehensive CMS work plan.

Treatability studies will be performed in-house, by equipment vendors, or sub-contracted in accordance with the approach presented in this plan. Laboratory services will be sub-contracted and modeling will be performed by E/A&H engineers and geologists or subcontractors, and/or the U.S. Geological Survey.

Intermediate progress meetings will be held with the project team to discuss the findings and progress of field work and in-house modeling and alternative evaluation. Once field work is completed, a meeting will be held with the project team to discuss the results of field work and review data.

2.2.3 Report Preparation

Before draft CMS report preparation, E/A&H engineers, geologists, and scientists will evaluate field data and perform additional modeling and evaluation, as needed. The draft CMS report will present the findings of the field work and provide decision makers with an evaluation of remedial alternatives in accordance with the nine criteria discussed in Section 1 of this report. The project team will hold a presubmittal meeting to ensure that the evaluation presentation meets their needs and objectives. Additional meetings will be held as needed during the report review and report preparation process before submittal of the final CMS report to the Navy, SCDHEC, and the USEPA.

2.3 General Approach to CMS

The following discusses general approaches to be used during the CMS process for data collection, identifying target media cleanup goals, statistical applications to corrective measures evaluation, modeling, and cost estimating. These approaches are fundamental to a CMS.

2.3.1 Data Collection

Defining the nature of potential contaminants or chemicals of potential concern (COPC) was the initial step in the RFI data collection process. This step depends largely on the quality (as defined by data quality objectives) of the data available and collected, and was accomplished by collecting a minimal number of highly biased samples following DQO Level III and IV protocols and procedures. In addition to establishing initial measures of concentrations of COPCs present, the data will be used in the CMS process to define PRGs and to evaluate corrective measures technologies. Additional data may be necessary to fill data gaps, define quantities, volume, mass, or to evaluate the effectiveness or feasibility of a technology.

Data quality objectives are qualitative and quantitative statements which specify the data requirements to support decisions during remedial response activities. The amount and quality of data required to support selection of corrective measures alternatives varies by site. It may not be possible to identify all data needs during the initial scoping activities. Additional data needs may become more clearly defined as initial data are obtained and evaluated. By conducting laboratory, bench, field, and pilot studies, data can be collected and evaluated sequentially, with a refinement or redefinition of data needs at the completion of each study. Applying the DQO process to a phased investigation improves the usability of the data and the cost effectiveness of the investigation.

The ultimate goal of a Corrective Measures Study is to select cost-effective corrective measures alternatives which mitigate threats to public health, welfare, and the environment and protects them. Corrective measures studies entail development, screening, and evaluation of alternatives. CMS objectives are to develop and evaluate alternatives with respect to protection of public health and environment, compliance with applicable requirements (i.e., maximum contaminant level), and to reduce contaminant mobility and/or toxicity. To ensure that adequate and sufficient data are collected to perform the CMS, site managers will continually coordinate the evaluation and re-evaluation of data collected during the RCRA Facility Investigation.

Developing data quality objectives begins during project scoping and ends with the development of a sampling and analysis plan for each project phase. As additional details regarding the site are identified, decisions are refined, allowing for further specification of data needs and design of the data collection program.

The usefulness of data collected during the RFI will be evaluated relative to the corrective measures alternative evaluation. The data will be reviewed to assess if they are adequate to describe the current site conditions. Current site conditions will be assessed by field observation to determine if site conditions have changed. The age, analytical method, method detection limits, and quality assurance and quality control (QA/QC) procedures and documentation will be reviewed, along with sampling objectives, approach, methods, preservation, and holding times. Based on data review, a site model will be developed, in which source, pathway, and receptors are defined.

Computer models may be used in assessing the data and remedial needs of sites. Groundwater, air quality, fate and transport, surface water, sediment and transport, and geostatistical models may be used during the CMS. The following levels of analysis may be used: simple graphical techniques, analytical solution techniques, and numerical solution techniques. For most smaller sites, simple graphical techniques and analytical solutions will generally suffice. Numerical models are typically used when the site is large with complex stratigraphy, and has contamination in multiple layers with variable media parameters.

Table 2-1 lists the RFI DQO objective with its corresponding CMS activity.

Table 2-1
General CMS Objectives

Objective	CMS Activity
Determine presence or absence of contaminants	Evaluate applicability of no-action alternative for source areas/pathways
Determine types of contaminants	Evaluate environmental/public health threat; identify applicable remedial technologies
Determine quantities (concentrations) of contaminants	Evaluate costs to achieve applicable or relevant and appropriate standards
Determine mechanisms of contaminant release to pathways	Evaluate effectiveness of containment/remedial technologies
Determine direction of pathway(s) of transport	Identify most effective points in pathway to control transport of contaminants
Determine boundaries of source(s) and pathways	Evaluate costs to achieve relevant/applicable standards; identify applicable remedial technologies
Determine environmental/public health factors	Evaluate applicable standards or risk; identify applicable remedial technologies
Determine source/pathway contaminant characteristics with respect to mitigation (bench studies)	Evaluate treatment schemes

The probability of making an incorrect remedial decision is related to the quantity and quality of data available. Data quantity and quality are independent variables which must be considered jointly during the CMS process. Increasing the quantity of data may not significantly reduce the probability of making an incorrect decision. Increasing the quality of data may not add significantly to the body of knowledge to be used in making a decision. The DQO process provides a systematic way to evaluate the probability associated with making an incorrect decision and to determine the uncertainty associated with decisions.

Data are used to evaluate various remedial technologies. Engineering data are collected in support of remedial alternative evaluation and to develop cost estimates. This may involve performing bench-scale or pilot-scale studies to determine if a particular process or material may be effective in mitigating site contamination.

In collecting additional data, the following information or analyses are considered during the DQO process:

- List of candidate remedial actions.
- Method by which the initial alternatives will be screened, including effectiveness criteria, implementability criteria, and cost criteria.
- Detailed effectiveness screening will examine whether alternatives protect public health and the environment, meet promulgated standards, reduce toxicity, mobility, or volume, and provide acceptable reliability.
- Detailed implementability screening will examine the technical feasibility, availability, and administrative feasibility of each alternative.
- Detailed cost screening will examine the capital, operation and maintenance (O&M), and replacement cost, as well as the present worth of the alternatives.
- Both the short- and long-term effects of the screening factors must be assessed and the alternatives must be compared to identify their relative strengths and weaknesses.

Consideration of data quality begins with the identification of data uses and types. Important factors in defining quality include:

- Appropriate analytical level
- Contaminants of concern
- Level of concern
- Required detection limit
- Critical samples

Appropriate analytical levels account for those factors which critically affect data quality where little or no information is available such as: sample variability, sample container cleanliness, effect of different sample collection and analytical preparation techniques, changes due to temperature and pressure, etc. Appropriate analytical levels are used to group data and assumed critical effects. Level II, III, and IV are often used in evaluating alternatives. Some physical property type analyses will fall within the Level V and "other" categories. Level II field analyses use sophisticated portable analytical instruments. Level III analyses are performed in offsite laboratories which may not use validation or documentation procedures required under Level IV. Level IV are analyses performed in offsite laboratories following rigorous QA/QC protocols and documentation. Level V analyses have non-standard methods and are performed in offsite laboratories which may not use validation or documentation procedures required under Level IV.

Contaminants of concern may be limited to one single contaminant detected at a site or they may be one of many contaminants detected at a site. Where more than one contaminant is detected at a site, it is not feasible or desirable to specify levels of concern for each contaminant. Indicator chemicals, which are used as contaminants of concern, are the most toxic, mobile, persistent, or frequently occurring contaminants detected. The process of selecting indicator contaminants is described in the *Superfund Public Health Evaluation Manual*, USEPA 1995.

Levels of concern specify the concentration above which some action may need to be taken. Determining levels of concern is a site-specific activity. The decision makers and data users will meet to determine the appropriate action-level range for the site. Levels may be appropriate action level ranges as cited by a regulation or law. These action levels do not consider simultaneous exposure from multiple routes and may also be based on concentrations, duration, or frequencies of exposure that differ from those at a specific site. Standards and criteria used as levels of concern must meet site- and media-specific conditions.

The level of concern selected directly affects data quality requirements. If a level of concern is a maximum concentration level in parts per million, it will not be necessary to use analytical techniques with practical quantitation limits in the ten parts per billion for evaluation of alternatives. The level of detection should be appropriate.

Critical samples are those for which valid data must be obtained such as an upgradient well in a groundwater study. A background soil sample is another example. Critical samples are vital to the decision-making process.

The data quality objectives requirements for the type and amount of data must consider the fact that feasibility studies estimate alternative cost to within +50% and -30% of actual cost. If the cost of removal or treatment is strictly proportional to the volume of material, sufficient data must be obtained to determine the volume of material within +50% and -30%. However, due to uncertainty in capital costs and the efficiency of the treatment or removal procedure, it is necessary to determine volumes as accurately as possible.

Cost is a consideration in evaluating sampling and analysis options. Sample costs must be considered in the cost of corrective measures alternatives implementation. If the site is small and the cost for obtaining a quantity of data to ensure a high degree of certainty about the site conditions is a significant percentage of the cost to remove or treat the site, then the decision may be to spend the money on remediation.

Other indicators of data quality are precision, accuracy, representativeness, completeness, and comparability (PARCC), which are defined by the end use. Precision measures the reproducibility of measurements under a given set of conditions. Accuracy measures the bias in a measurement system. Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Completeness is the percentage of measurements made which are judged to be valid. Comparability, a qualitative parameter, expresses the confidence with which one data set can be compared to another. Data users must keep the level of concern and the data's end use in mind when reviewing precision and accuracy. In some cases, even data with poor precision and/or accuracy may be useful.

2.3.2 Development of Target Media Cleanup Goals

Preliminary remedial goals, site-specific goals for corrective measures, are based on human health and environment criteria, information gathered during the RFI, USEPA guidance, and applicable federal and state statutes. PRGs will be developed for each SWMU/AOC or group of SWMUs/AOCs where current data justifies conducting a CMS.

PRGs are typically based on promulgated standards such as maximum contaminant levels (MCLs) and surface water quality standards; and relevant nonpromulgated requirements such as EPA's Risk Based Concentrations (RBC) and EPA's Soils Screening-Levels (SSL) for soil where there is a single contaminant. Sites with multiple contaminants (including naturally occurring contaminants) and multiple pathways should not use media-specific criteria such as PRGs because they become less protective under these circumstances. Therefore PRGs need to be adjusted using background concentrations and risk-based concentrations to account for these site-specific circumstances. Since there are several naturally occurring inorganics and organics in the soil and groundwater (much of the base is comprised of dredge spoils), background concentrations will be considered when establishing PRGs. Human health and ecological risk-based concentrations, estimated in accordance with USEPA risk assessment guidance, will also be considered when establishing PRGs.

The USEPA guidance document *RCRA Corrective Action Plan* (USEPA, 1994) outlines issues to be considered in developing corrective action objectives for groundwater, soil, surface water, sediment, and air.

Risk Assessment and Background

Evaluating baseline risk and determining background concentration methodology and rationale were discussed in detail in the comprehensive RFI work plan, Volume III. USEPA methodology is used in evaluating human health and the ecological baseline risk. Background concentrations are being assessed using a variable grid-based sampling scheme. PRGs for COPCs and contaminants of concern were assessed in the RFI. Based on the estimated risk or hazard, SWMUs and AOCs are recommended for a CMS. However, the process of risk assessment does not end here. Remedial goal options (RGOs) will be developed where attainment of PRGs are demonstrated to be technically impractical from an engineering perspective or where other circumstances prohibit achieving the initial goals. In such cases, the RGOs will be selected in consultation with USEPA, SCDHEC, and the Navy.

During the CMS process, risk assessment methods will be applied to assess the effectiveness of potential cleanup options as they relate to protection of human health and the environment. Protectiveness can be achieved through use of engineering controls (e.g. barriers), institutional controls (e.g. deed restrictions) and/or removal and elimination of the contaminants.

Before specific cleanup technologies are considered, the remedial ground rules will be established by evaluating actual exposed population(s), exposure conditions, site activities, exposure pathways, and current exposure point concentrations. Risk and/or hazard goals established by the risk managers will be re-evaluated.

Prior to proceeding to the CMS phase, it must be established that current site conditions are not sufficiently protective of human health and the environment. If risk and hazard goals are not exceeded under current circumstances, a no further action conclusion may be warranted. Conversely, a CMS is required if risk/hazard goals are exceeded.

Risk assessment methods are used to evaluate the reductions in risk/hazard corresponding to implementation of various engineering alternatives. These reductions vary as a function of the efficiency or effectiveness of the selected remedy. The corrective measures risk assessment evaluates alternatives with respect to their attainment or nonattainment with applicable risk/hazard goals, standards and/or background levels.

Many of the SWMUs and AOCs investigated at the NAVBASE had no confirmed releases of hazardous waste or the release caused only limited impacts. In these instances, only a few samples (soil, groundwater, etc.) were necessary to delineate the contamination. Often, risk and hazard projections were made based upon maximum concentrations in accordance with risk assessment protocol, and are driven by individual sample results. For these relatively uncomplicated sites, the efficacy of the remedial alternative can be tested by reducing maximum contaminant concentrations relative to the capabilities of the technology. For instance, capping could effectively preclude direct exposure to impacted soil, resulting in no excess risk/hazard (100% reduction). Alternatively, in situ bioremediation might reduce petroleum-based contaminant concentrations by 50%.

Generally, these sites can be addressed using spreadsheets and/or calculators. Treatment volumes can be estimated for a variety of remedial options with little effort. A limited number of SWMUs and AOCs at NAVBASE have widespread and diverse contamination over a significant area. At these sites, potential exposure, and thus risk/hazard, is affected by results from a large number of sample locations. As a result, engineering estimates of volume or mass of impacted media that must be remediated (and the degree to which they must be remediated) can become rather complex. This complication has been traditionally overcome by establishing remedial standards solely on the basis of fixed point concentrations rather than overall risk/hazard reduction. The following section describes the approach which will be used to scope and evaluate cleanup for various engineering alternatives during the CMS.

The Use of GIS in the Risk Assessment Process

Results from evaluations of human health risks associated with environmental contamination are traditionally presented non-spatially. Because of the expense associated with sampling and analysis, samples of environmental contaminants are often taken from relatively few spatial locations such as test wells. Moreover, in many cases, the environmental gradient of contamination is known to be anisotropic due to directional forces such as groundwater flow or wind. To avoid presenting misleading information, non-spatial tabular reporting of single values, such as increased incidence of human cancer, has become the widely accepted convention for communication of human health risk results.

A Geographic Information System (GIS) will be used to recover the spatial component of risk without extrapolating beyond the known data. Thiessen polygons will be the technique employed to define these areas. The sizes and shapes of each Thiessen polygon were determined by the proximity and location of adjacent sample points. Thiessen polygons define individual areas of influence around each point in such a way that the polygon boundaries are equidistant from neighboring points, and each location within a polygon is closer to its contained point than to any other point. The Thiessen polygons are not necessarily representative of the true spatial extent of an area where sample points are widely spaced, a factor considered when using this method.

Ultimately, it is necessary to interpolate contaminant data which are infrequently detected in space and time for full evaluation of human risks. Spatial interpolation techniques make assumptions, and may therefore be misleading, incomplete, or incorrect. To encapsulate human health risk into a single value in a table may be at least as incomplete or misleading, since the spatial relationships among contaminant values are not retained. Presenting an interpolated contaminant layer, together with bar and pie chart symbols placed at actual sample locations, distinguishes between measured and derived concentration values and provides a means of qualitatively evaluating uncertainty. Such a presentation also communicates the spatial weighting of the sampling design.

2.3.3 Statistical Applications to Corrective Measures Evaluation

Because the corrective measures to be evaluated in the CMS are potential responses to contamination described and analyzed in the RFI reports for the individual NAVBASE investigatory zones, statistical approaches used in the RFIs are relevant to the CMS. These approaches will be discussed briefly under three general groupings: analytical questions, site characterization, and background characterization.

As explained in *DQOs for Remedial Response Activities, Development Process* (March 1987; EPA/540/G-87/003), analytical error can be summarized in terms of accuracy and precision. Statistical procedures to ensure the accuracy and precision of sampling data are detailed in the comprehensive RFI work plan, the comprehensive sampling and analysis plan, and in equivalent documents for individual zones. In general, accuracy was determined from spiked samples, while precision was evaluated using duplicates or splits.

NAVBASE sites have been characterized using specified and approved methods. As appropriate to the investigative phase of a project, environmental media samples collected for the RFI were based on judgment (biased) rather than random. Because they were not random samples, the appropriate number of samples necessary to characterize a site could not be determined using statistical guidelines such as those presented in USEPA's SW-846 field manual. Instead, the appropriate number of samples for each site was based on the analytical results of the first sampling round relative to the respective RBCs and background levels of the chemicals detected, combined with knowledge of past site activities, and the data quality objectives established at the start of the project. Where first-round sample results were insufficient to properly characterize a site, additional samples were collected and analyzed.

Estimates of the mean concentrations of site contaminants are built into the methodology of the human health component of baseline risk assessments, which largely determined the CMS status of the sites. Risk and hazard to humans are calculated using the 95% upper confidence limit (UCL) for the mean as a conservative estimate of the actual mean concentration of each COPC, leading to conservative assessment of risk. To the extent that baseline risk assessment results are included in the development of target media cleanup goals, this conservative statistical approach will be incorporated into the resulting goals.

Background concentrations of inorganic chemicals in soil and groundwater were characterized separately for each zone during the RFIs. For background delineation, systematic random samples were collected on random-start grids. The largest background data sets for soils were collected in the first zone investigated, Zone H. Smaller data sets were collected on somewhat wider and less extensive grid spacings in subsequent zones. A similar procedure was followed for groundwater samples, although Zones E and I had larger data sets than Zone H. Site sample concentrations were statistically compared to background concentrations for each chemical, medium, and depth as groups (using the Wilcoxon rank sum test) and for individual samples (using parametric or nonparametric upper tolerance limits), as explained in the RFI reports. Chemicals with concentrations not demonstrably higher than background were eliminated as COPCs.

In addition to the statistical methods employed in the RFIs, simple statistics will be used in various stages of the CMS. Means, standard deviations, and UCLs will be calculated as needed in the screening and evaluation process for corrective measures and corrective measures alternatives.

2.3.4 Modeling

This section primarily discusses groundwater flow models, though the modeling process and many of the general comments apply to other types of environmental models.

The following American Society for Testing and Materials (ASTM) standards have been established for groundwater modeling, and will be followed when applicable:

- D 5447-93: Application of a Ground-Water Flow Model to a Site-Specific Problem.
- D 5490-93: Comparing Ground-Water Flow Model Simulations to Site-Specific Information.
- D 5609-93: Defining Boundary Conditions in Ground-Water Flow Modeling.
- D 5611-94: Conducting a Sensitivity Analysis for a Ground-Water Flow Model Application.

Description of the Models

Environmental models are typically either numerical or analytical. Generally, numerical models can be used for more complex simulations, and can incorporate heterogeneities, varying physical and chemical conditions over the site, and differing boundary conditions. Analytical models are simpler calculations for homogenous site conditions.

Simulations using numerical models generally take much longer than those using analytical models, and are therefore much more expensive.

E/A&H own the rights to use the following models anticipated to be incorporated in the evaluation process of the CMS:

Groundwater

Analytical Models	Numerical Models	Particle Track
CAPZONE	MODFLOW	GWPATH
	FLOWPATH	MODPATH

Aquifer Analysis	Saturated Fate and Transport
AQTESOLVE	PRINCE
Aquifer Test for windows	SOLUTE
Specific Capacity	Tguess
Qovers	MT3D (numerical model)

Soil

Unsaturated Fate and Transport	Others
D-Leach	HELP
Chem-Flow	MultiMed

Air

<u>**Models**</u>

ISCST

ISCLT

SCREEN

Modeling Process

The following is a overview of the modeling process which will be used on all modeling efforts. It closely follows the guidelines set out in ASTM D 5447-93. The sequential stages are outlined below:

- **Establish Study Objectives:** The study objectives determine the purpose of the modeling, and hence, the level of accuracy and detail provided by the model. These will be established before modeling.

- **Develop Conceptual Model:** The conceptual model is derived from geologic and hydrogeologic data. It describes the characteristics and dynamics of the geohydrologic system, and includes the geologic and hydrologic framework, physical and chemical processes, hydraulic properties, and sources and sinks. A conceptual model, which will be developed before modeling, is the most important phase of the whole modeling process. The conceptual model partly determines the complexity which will be incorporated into the computer model, and may affect the selection of the model.

- **Select Model:** Groundwater flow models vary greatly in size and capability. The selection of the model to be used on an individual project depends on the complexity of the system, objectives of the modeling and the modeling budget, and the experience of the modeler with a particular model.

- **Construct the Model:** When the conceptual model and objectives are established and the computer model is selected, the model will be constructed. Model construction is the process of transforming the conceptual model into a mathematical model. For example, the fundamental components of a groundwater flow model include model area dimensions, time and space, boundary and initial conditions, and aquifer hydraulic properties.

- **Calibrate the Model and Perform Sensitivity Analysis:** After construction, the model will be calibrated. For a groundwater flow model, calibration is achieved by adjusting hydraulic parameters, boundary conditions and initial conditions within reasonable ranges to match the observed and simulated potentials or other calibration targets.

- **Perform Sensitivity Analysis:** A sensitivity analysis is performed to identify the model inputs having the most influence on model calibration and predictions and to help determine the uncertainty of the simulation. Sensitivity analysis is a quantitative method of determining the effect of parameter variation on model results to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses, and boundary conditions. The sensitivity analysis is performed during the model calibration and predictive analysis.

- **Make Predictive Simulations:** After model calibration, predictive simulations will be made.

- **Document Modeling Study — Modeling Report:** As stated in ASTM Standard D5447, the model report will communicate the study findings, document the procedures and assumptions inherent in the study, and provide detailed information for review. It will be a complete document allowing reviewers to formulate their own opinion as to the credibility of the model.

An exception to this process is the model being developed by the U.S. Geological Survey (USGS), which is described below.

USGS Groundwater Model

The USGS Water Resources Division is developing a groundwater flow model for NAVBASE. This steady-state model, based on the MODFLOW model concept by McDonald and Harbough, 1988, covers approximately seven square miles and is centered at the base. The modeling cells are tightly gridded across the base and are being developed on 70-foot gridded squares.

The model is being developed to answer questions about our current understanding of the hydrogeologic conceptual model that has been based on field observations and hydrogeologic data obtained during the RFI process.

In addition, the model should aid in determining the following:

- The importance of the marsh clay layer in preventing potential downward contaminant migration to lower flow zones.

- The direction (flow paths) and rate of movement of potential contaminants (via a particle tracking system known as MODPATH developed by Pollack, 1994).

- The total volume of groundwater that moves through a given area/zone of the base.

- The total volume of water that enters nearby surface drainage features such as the Cooper River, Noisette and Shipyard Creeks, marshes, tributaries, and potentially leaky underground storm drains.

- The effects of various proposed remedial designs (such as pumping, slurry walls, capping, intrinsic bioremediation, and others) on groundwater flow at the impacted site.

The model could also be used as a platform for solute transport simulations. For example, if intrinsic bioremediation was considered as a remedial alternative for the site, a solute transport analysis would be required. Often, a solute transport model is used to help determine whether dissolved contaminants will migrate to downgradient receptors at concentrations that exceed regulatory limits. To run a solute model, arrays of groundwater velocity vectors are needed and can be provide by the MODFLOW model being developed for NAVBASE.

2.3.5 Cost Estimating

There are several approaches to cost estimating. This section presents the approach to be used when evaluating cost of corrective measure technologies.

Costing Sources:

- Means Building Construction Data.
- *The Environmental Restoration Unit Cost Book.*
- *Mil-HDBK-1010A Cost Engineering: Policy and Procedures.*
- Industry Quotes.
- Other Sources as Applicable.

Costs will be evaluated to a present worth value by using a combination of *USEPA's Remedial Action Costing Procedures*, EPA/600/8-87/049, October 1987, *USEPA's Superfund Cashout User's Manual*, PB94-141678, September 1992, and *Engineering Economic Analysis* by Donald G. Newman. A present worth analysis makes it possible to compare remedial alternatives on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. Therefore, for cost comparison only, it is advantageous to seek the remedial alternative with the lowest present worth. An inflation rate of 1.22%, based on the Chemical Engineering Plant cost index for years 1989 through 1995 and a prime interest rate of 8.25%, is assumed for base calculations yet will be further refined during each zone-specific CMS process. The present worth cost will be estimated from midyear and an increase in the discount rate would decrease the present worth of the alternative.

The cost elements for each remedial alternative will be summarized in the cost analysis section of the CMS report. In accordance with USEPA guidelines, the cost estimates provided for each alternative will reflect actual costs with an accuracy of -30 to +50%. Most costs will be discounted over 30 years. Indirect costs will include an overhead labor rate of 45% with an additional 15% administration fee on all direct cost. A 10% profit will be added to all labor and material. A 5% to 15% contingency on all labor and material will be assumed. A 6% design fee will be used.

As an aid to the U.S. Navy cost estimating methodology, the CMS cost estimates will also be presented as follows: cost of the primary facility, cost of the supporting facility, subtotal, contingency cost, total contract cost, supervision/inspection/overhead (SIOH) at 6%, total request, total request rounded, and equipment provided from other appropriations.

Cost sensitivity will be addressed for remedial technologies that have a high potential for a wide range of costs due to certain site- and/or technology-specific conditions. As an example, a site may be a candidate for soil vapor extraction (SVE) treatment. It is understood that the effectiveness of SVE is highly dependent on many factors of which permeability is dominant. Therefore, the cost for this technology is highly dependent on, or very sensitive to, soil permeability at the subject site. This sensitivity information will be useful in determining relative costs, or potential costs, for a proposed treatment alternative.

2.4 Orientation Meeting

Before performing any field activities, personnel will attend an orientation meeting summarizing general and site-specific requirements for sampling, testing, and documentation at NAVBASE. General topics to be discussed will include the base location, the locations of the site office trailer, subject site, decontamination areas within the base, and the comprehensive health and safety plan.

Sampling requirements to be discussed will include general sampling protocol, use of proper sampling devices, the sample numbering system, quality assurance/quality control sampling requirements, sample packaging, sample quantities, treatability testing, and investigation-derived wastes. Documentation requirements to be discussed will include the use of field forms, field logbooks, and documentation of photographs. The checklist of these requirements and an acceptance form is provided in the comprehensive RFI work plan.

3.0 ZONE BACKGROUND INFORMATION

To manage the environmental assessment and investigation of Charleston Naval Base, the facility was divided into 12 investigative zones. The boundaries of the zones were based on numerous factors, including the grouping of comparable surface activities that result in potentially comparable environmental impacts.

As an example, the entire shipyard and its repair facilities were designated as Zone E. Likewise, the base golf course and senior military officers' housing area were designated Zone B. The 12 zones are briefly described below:

Zone A Background Information

Zone A is at the extreme northern portion of the main base, and includes all base areas north of Noisette Creek. Though the DRMO (Defense and Reutilization and Marketing Office) and a printing operation were located in Zone A, the area is mainly one of storage and warehouse type operations. This zone contains eight SWMUs and two AOCs.

Field work, to include post-year (initial year) quarterly groundwater monitoring, has been completed for Zone A.

Zone B Background Information

Zone B comprises the base golf course and the senior military officers' housing area. One AOC is in this zone, which has no SWMUs.

Field work, to include post-year quarterly groundwater monitoring, has been completed for Zone B. This zone has been designated by the Project Team as a "no further action" site and therefore will not be considered in the CMS process.

Zone C Background Information

Zone C comprises administrative areas, additional housing areas, warehouses, and the base coal pile, which has been the focus of a voluntary cleanup effort by the Environmental Detachment. This zone contains 6 SWMUs and 17 AOCs.

Field work, to include post-year quarterly groundwater monitoring, has been completed for Zone C.

Zone D Background Information

This zone consists of property and facilities between Reynolds Avenue and McMillan Avenue. It contains primarily paved parking areas and warehouses. Zone D contains three SWMUs and one AOC.

Field work, to include post-year quarterly groundwater monitoring, is presently ongoing for Zone D.

Zone E Background Information

Zone E, which is on the waterfront, includes the shipyard industrial areas and dry docks. As a result of the RFA, 101 SWMUs and 83 AOCs were identified within this zone. However, a combined total of 77 SWMUs and AOCs, some grouped together due to proximity, form the final total of 49 sites, which were eventually investigated during the RFI process.

Field work, to include post-year quarterly groundwater monitoring, is presently ongoing for Zone E.

Zone F Background Information

This zone, in the central portion of the base, includes the area between Hobson Street, Carolina Street, the eastern base boundary, Wood Street and 11th Street. Facilities within this zone include the former public works area. Zone F contains 14 SWMUs and 16 AOCs.

Field work, to include post-year quarterly groundwater monitoring, is presently ongoing for Zone F.

Zone G Background Information

Zone G, also in the central portion of the base, includes the FISC (Fleet Industrial Supply Center) petroleum facilities, as well as the Chicora Tank Farm, approximately one-half mile east of the base. Since the Chicora Tank Farm is connected to the base via pipeline easements, it is included in Zone G, which contains 16 SWMUs and 26 AOCs.

Field work, to include post-year quarterly groundwater monitoring, is presently ongoing for Zone G.

Zone H Background Information

Zone H is in the southern portion of the peninsula formed by Shipyard Creek and the Cooper River. It is bounded by Hobson Avenue to the north; Shipyard Creek to the south; Osprey Street, South Carolina Lane, and the spoils area to the east; and property boundaries to the west. The zone has 26 SWMUs and 23 AOCs.

The zone's western portion is the area of a former landfill active from the 1930s until 1973. The landfill contained domestic, construction and industrial type waste. Various support activities, including a chemical disposal area, recycling areas, material transfer stations, storage areas, maintenance areas and hobby shops, are in the zone. The fire-fighting training facility (SWMU 13) is at the northern boundary of Zone H. The *Draft RCRA Facility Assessment*

Report identified numerous potential POL spill areas and the *Final RCRA Facility Investigation Report* identified polychlorinated biphenyl (PCB) contamination at SWMU 17, which is in Zone H.

Field work, including post-year quarterly groundwater monitoring, has been completed for Zone H.

Zone I Background Information

This zone comprises the remainder of the southern end of the base. It includes the waterfront property from Halsey Street to the southern tip of the base and it is located on a peninsula formed by the Cooper River and Shipyard Creek. Zone I includes land that was formed from past dredge spoils. This zone contains 8 SWMUs and 20 AOCs.

Field work, to include post-year quarterly groundwater monitoring, has been completed for Zone I.

Zone J Background Information

Zone J includes nearby water bodies such as creeks, wetlands, and the Cooper River. Five AOCs are in this zone, with which no SWMUs are associated.

Field work is presently ongoing for Zone J.

Zone K Background Information

This zone is made up of additional noncontiguous properties (the Shipboard Electronic Systems Evaluation Facility on Sullivan's Island, the Naval Station Annex, Clouter Island, and the downtown degaussing facility). This zone contains nine SWMUs and six AOCs.

The Naval Regional Medical Center and Clouter Island are not being excessed, and therefore, they are not included in the BRAC process. The SWMUs/AOCs on Clouter Island will be addressed in the RFI. The Naval Short Stay facility, downtown degaussing facility, and Sullivan's Island are leased and therefore are not included in the BRAC process.

Field work, to include post-year quarterly groundwater monitoring, is presently ongoing for Zone K.

Zone L Background Information

This zone makes up the sanitary sewer system (SWMU 37) excluding domestic sources, the storm water sewer system (AOC 699), and the railroad system (AOC 504). At least a portion of one or more of the Zone L components is in the boundaries of the remaining 10 investigative zones within the contiguous naval base property. Zone L was created to evaluate each system (sanitary sewer, storm water sewer and railroad system) in its entirety at one time rather than conduct a piece-meal investigation of each as the individual zones were investigated.

Field work is presently ongoing for Zone L.

4.0 INVESTIGATING AND EVALUATING POTENTIAL REMEDIES

As previously stated, the CMS portion of the RCRA corrective action process is designed to identify and evaluate remedial alternatives for releases that have been detected at a facility. The scope and requirements of a CMS are to be balanced with the expeditious initiation of remedies and rapid restoration of contaminated media, both major goals of the RCRA corrective action process.

The study of evaluating environmentally protective remedies may be relatively straightforward at some SWMUs or AOCs, and may not require extensive evaluation of numerous remedial alternatives. The CMS will be tailored to fit the complexity and scope of the remedial situation presented at each SWMU or AOC. For example, if the environmental problems at a SWMU or AOC are limited to a small area of soils with low-level contamination, the CMS may be limited to a single remedial approach (such as dig and haul) known to be effective for such types of contaminants in soil. The general approach for alternative evaluation is the identification and screening of alternatives through goal development, technology identification and evaluation, and the assembly and ranking of final alternatives.

For sites with very extensive or highly complex environmental problems, it is likely that an assessment of several alternative remedial technologies or approaches will be needed. Sites with large volumes of concentrated wastes and contaminated soil may require several treatment technologies to achieve varying degrees of effectiveness (such as reduction of toxicity or volume), in conjunction with different types of containment systems for residuals. A given contaminant problem may have several different practicable approaches which offer varying degrees of long-term reliability.

The use of innovative treatment technologies may be viable and would require an extensive analysis for effectiveness. For example, at SWMU 9, a former military landfill, it is obvious that the source control element of the CMS should be focused on containment, while contaminated media remediation may require more extensive study such as aquifer testing, soil-gas vent testing, infiltration/leachate generation testing, and groundwater and contaminant modeling.

4.1 Site Grouping Criteria

To simplify and expedite the CMS process, sites will be grouped by common criteria such as:

- Common disposal/release mechanisms
- Similar contaminants
- Comparable concentrations and/or risk-derived remediation levels
- Common impacted matrix
- Common hydrogeologic characteristics
- Physical proximity to one another
- Economies of scale

As an example of this grouping concept, consider three pesticide contaminated sites within a zone that has recently been through the RFI process. Assume the contamination is limited to soil only. Similar contaminants and common impacted matrix could link these three sites to one another for the purpose of the CMS process. This assumed site grouping could possibly enter into the CMS process as a single entity.

The end result of the CMS would be a list of potential remedial options available for this group. The result would have probably been the same if the sites individually entered the CMS process, though it would have required substantially more resources and time.

Another important additional advantage of seeking commonalities between sites exists. As sites are investigated and defined in the RFI process, it will be possible to associate some of these sites with current groups that have previously been through the CMS process. The required CMS effort for the newly grouped site should be minor, and preferably nonexistent.

4.2 Identification, Screening, and Development of Corrective Measure Technologies

Engineering practice and experience will be used to identify which of the corrective action technologies appear most suited for each SWMU or AOC. During the development of the RFI work plans, assumptions were made concerning the type of contaminants potentially released and media impacted at each SWMU or AOC. Corrective measures technologies were listed and data quality objectives were defined to develop a reliable database for use in assessing appropriate corrective measures technology, if a release were detected. This initial list of corrective measures technologies included presumptive remedies. These remedies are technologies that USEPA believes will be the most appropriate remedy for a specified type of site, based upon its past experience. Presumptive remedies were included for military and municipal landfills, contaminated groundwater, PCB sites, and wood-treating and coal-gas sites.

This list of initial corrective measures technologies has been carried throughout the RFI process and is presented in each zone-specific RFI report. However, to ensure adequacy of the CMS process, each site will be thoroughly screened during the CMS for appropriate technologies.

The initial steps in assembling corrective measures technology alternatives is the review of the RFI results, corrective action objectives, and identification of technologies applicable to corrective measures of each SWMU/AOC or group of SWMUs/AOCs. Corrective measures technologies will be selected based on site-, waste- and technology-specific characteristics using current literature, vendor information, USEPA's treatability databases, technology databases, guidance documents and handbooks, and experience in developing alternatives for similar sites and releases.

4.2.1 Identification and Screening of Corrective Measure Technologies

The initial step in identifying corrective measures technologies is to group site-specific characteristics into impacted media types, soil/sediment/sludge, groundwater/surface water, and air. The second step is to group similar contaminant types, volatiles, semivolatiles, fuels, inorganics, and explosives. Thirdly, elements of reliability, cleanup time, cost, and operation and maintenance need to be considered, as well as advantages and disadvantages. The fourth step is to screen technologies using these general parameters.

Table A-1 of Appendix A presents a screening matrix of treatment technologies which is presented in *Remedial Technologies Screening Matrix and Reference Guide*, Second Edition, prepared by the Department of Defense Environmental Technology Transfer Committee, October 1994 and other USEPA guidance documents and handbooks, as well as E/A&H experience. Table A-2 describes each technology listed in Table A-1. Tables A-3, A-4, A-5, and A-6 list each technology's advantages and disadvantages and states whether the technology is retained or eliminated from further evaluation. A technology retained may not necessarily be applicable to a site and may be eliminated and a technology eliminated may be retained later for a particular site.

The list of alternatives retained is only for the purpose of establishing a minimum list of alternatives for which the comprehensive CMS work plan is to be written. Zone-specific CMS work plans may contain other technologies not present in the tables.

4.2.2 Development of Corrective Measure Alternatives

Based on engineering practice and experience, specific corrective measures technologies are assembled into specific alternatives that may meet the corrective action objectives for all media. Each alternative may consist of an individual technology or a combination of technologies used in sequence (i.e., treatment train). Depending upon site-specific situations, different alternatives may be considered for separate areas of the facility. To further assist in the development of corrective measures alternatives, contaminants present have been grouped into one or more of the following categories:

- Chlorinated volatiles such as trichloroethene, tetrachloroethene, vinyl chloride, 1,1,1-Trichloroethane, and chlorobenzene.

- Nonchlorinated volatiles such as benzene, toluene, xylenes, and 2-butanone.

- Chlorinated semivolatiles such as 1,2-dichlorobenzene, 2-chlorophenol, and pentachlorophenol.

- Nonchlorinated semivolatiles such as phenol, naphthalene, anthracene, and benzo(k)fluoranthene.

- Pesticides/herbicides such as alpha-Chlordane and 4,4'-DDT.

- Polychlorinated biphenyls such as Aroclor 1254 and Aroclor 1260.

- Dioxins.

- Inorganic compounds such as arsenic, cadmium, chromium, copper, and lead.

- Petroleum, oils and lubricants (POLs) such as total petroleum hydrocarbons (TPH), heating oil, jet fuel, motor gasoline, and diesel.

- Explosives such as TNT, Cyclotrimethylenetrinitramine, gunpowder, etc.

Using these contaminant groupings and the identified technologies, a list of likely corrective measure technologies is developed. Table 4-1 lists removal, containment, and disposal technologies retained for further evaluation; Table 4-2 lists contaminant-grouping specific technologies retained for further evaluation. Section 4.4 describes how these technologies will be fully evaluated.

Explosive wastes are not included because the Department of Defense is managing those types of wastes including radioactive wastes.

4.3 Evaluation of Corrective Measures Alternatives

Each alternative proposed (including when only one alternative is proposed) will be evaluated according to five standards reflecting the major technical components of remedies, including cleanup of releases, source control, and management of wastes generated by remedial activities. The specific standards are provided below:

- Protection of human health and the environment.
- Attainment of media cleanup standards set by the implementing agency.
- Control of the source of releases so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment.
- Compliance with any applicable standards for management of wastes.
- Other factors.

Table 4-1
Removal/Containment/Disposal Options

Action	Soil	Groundwater/ Leachate	Sediment	Surface Water	Air
Removal	Excavation	Groundwater extraction Leachate collection	Dredging	Diversion Pumping	N/A
Containment	Institutional controls Capping Storm water controls Long-term monitoring Intrinsic (natural) bioremediation/attenuation	Slurry wall Gradient controls Long-term monitoring Intrinsic (natural) bioremediation/attenuation	Berms/diversion Storm water controls	Diversion	N/A
Disposal	Landfill	POTW NPDES discharge Land application	Landfill	POTW NPDES discharge	Discharge via air permit

Notes:
POTW — Publicly Owned Treatment Works
NPDES — National Pollutant Discharge Elimination System
N/A — Not Applicable

Table 4-2
Treatment Technology Options

Contaminant Type	Soil	Groundwater/ Leachate	Sediment	Air
Chlorinated volatiles	Soil washing Incineration Thermal desorption Soil-vapor extraction (SVE) Steam extraction Bioremediation	Oxidation Bioremediation Adsorption Air stripping	Same as soil	Oxidation Adsorption
Nonchlorinated volatiles	Soil washing Incineration Thermal desorption SVE Solvent extraction Bioremediation Steam extraction	Oxidation Bioremediation Adsorption Air stripping	Same as soil	Adsorption Oxidation
Chlorinated semivolatiles	Soil washing Bioremediation Solvent extraction Incineration Thermal desorption Solidification/stabilization Vitrification	Oxidation Bioremediation Adsorption Air stripping	Same as soil	Adsorption Oxidation

Table 4-2
Treatment Technology Options

Contaminant Type	Soil	Groundwater/ Leachate	Sediment	Air
Nonchlorinated semivolatiles	Soil washing Incineration Thermal desorption Solvent extraction Bioremediation Solidification/stabilization Vitrification	Oxidation Bioremediation Adsorption	Same as soil	Oxidation Adsorption
Pesticides/ Herbicides	Solidification/stabilization Soil washing Dehalogenation Bioremediation Incineration Thermal desorption Vitrification	Oxidation Bioremediation Adsorption	Same as soil	Oxidation
PCBs	Solidification/stabilization Soil washing Solvent extraction Dehalogenation Incineration Thermal desorption Vitrification	Oxidation	Solvent extraction Dehalogenation Vitrification Solidification/stabilization	Oxidation

Table 4-2
Treatment Technology Options

Contaminant Type	Soil	Groundwater/ Leachate	Sediment	Air
Dioxins	Incineration Thermal desorption Dehalogenation Vitrification Solidification/stabilization	Oxidation	Dehalogenation	Oxidation
Inorganics	Solidification/stabilization Soil washing Vitrification	Ion exchange Precipitation Adsorption Sedimentation Filtration	Same as soil	Filtration Scrubbers Adsorption
TPH	Bioremediation SVE Thermal desorption Solvent extraction	Oxidation Bioremediation Air stripping	Same as soil	Oxidation

These standards are detailed in the following sections. Volume II, *Comprehensive Corrective Measures Study Work Plan* provides a comprehensive sampling and analysis plan and quality assurance and quality control plan for conducting a CMS.

4.3.1 Protection of Human Health and the Environment

Corrective action remedies must be protective of human health and the environment. The degree of protection afforded by each alternative will be discussed in this section.

Remedies may also include measures that are needed to be protective of human health and the environment, although they are not directly related to media cleanup, source control, or management of wastes. For example, access controls and deed restrictions may be implemented to prevent contact with contaminated media while intrinsic remediation or attenuation processes are monitored or augmented. This section will discuss any short-term remedies implemented to meet this standard.

4.3.2 Attainment of Media Cleanup Standards Set by the Implementing Agency

Each alternative will be evaluated as to whether the potential remedy will achieve the PRGs. This evaluation will include an estimate of the time necessary for each alternative to meet these standards. RGOs may be established where PRGs can not be attained.

4.3.3 Control of the Sources of Releases

As part of the CMS report, source control measures will be evaluated to determine if they are necessary to control or eliminate further releases that may threaten human health or the environment. If a source control measure is proposed, the report will discuss the technology to be implemented for the given site conditions and the reliability of the selected technology. In addition, technical limitations and, if required, multiple mechanism control methodology (eg, the use of more than one method to affect source control), also will be discussed.

Source control measures will be considered when it is necessary to stop further environmental degradation by controlling or eliminating further releases that may threaten human health or the environment. Without source control measures, some efforts to clean up releases may be ineffective or (at best) will essentially involve a perpetual cleanup. In these cases, an effective source control program may be essential to ensure the long-term effectiveness and protectiveness of the corrective action program.

Source control measures may include all protective remedies to control the source. Such remedies may include partial waste removal, capping, slurry walls, in situ treatments and/or stabilization, and consolidation.

4.3.4 Compliance with Any Applicable Standards for Management of Wastes

For each alternative, the report will discuss how the specific waste management activities will maintain compliance with all applicable state or federal regulations, such as closure requirements, land disposal restrictions, etc.

4.3.5 Other Factors

Five general factors will be considered as appropriate in selecting/approving a remedy that meets the standards listed above. These factors combine technical measures and management controls to address the environmental problems at the facility. The five general decision factors include:

- Long-term reliability and effectiveness
- Reduction in the toxicity, mobility, or volume of wastes
- Short-term effectiveness
- Implementability
- Cost

Long-Term Reliability and Effectiveness

The CMS will evaluate whether the technology or a combination of technologies has been used effectively under analogous site conditions, whether failure of any one technology in the alternative would have an immediate impact on receptors, and whether the alternative would have the flexibility to deal with uncontrollable changes onsite.

This criterion will assess the proposed useful life of the overall alternative and its component technologies. Useful life is defined as the length of time the level of effectiveness can be maintained. Typically, most corrective measures technologies deteriorate with time. Deterioration can often be slowed through proper system operation and maintenance, but the technology may eventually require replacement to maintain effectiveness. The CMS will consider these issues.

Reduction in the Toxicity, Mobility, or Volume of Wastes

This criterion will be used to assess the degree to which each alternative reduces the toxicity, mobility, or volume of wastes. In general, preferred remedies employ treatment and can eliminate (or substantially reduce) the potential for contaminated media to cause future environmental releases or other risks to human health and the environment. Estimates of how much the corrective measures alternatives will reduce the waste toxicity, mobility, or volume may help in assessing this criterion.

In some situations, reduction in toxicity, mobility, or volume may not be practical or even desirable. For example, large municipal-type landfills or unexploded munitions may be extremely dangerous to handle. In these situations, the short-term risks of treatment outweigh the potential long-term benefits.

Short-Term Effectiveness

The short-term effectiveness of each alternative will be assessed, including: the potential for fire, explosion, and exposure to hazardous substances; as well as threats associated with treatment, excavation, transportation, and redisposal or containment of waste material. This criterion is important in densely populated areas and where waste characteristics are such that risks to workers or to the environment are high and special protective measures are needed.

Implementability

The implementability of each alternative will be evaluated to assess any potential impacts on the time required to implement a given remedy. Information to consider for implementability includes:

- The administrative activities needed to implement the corrective measures alternative (eg, permits, rights of way, offsite approvals) and the length of time these activities will take.

- The criteria for construction, time for implementation, and time for beneficial results.

- The availability of adequate offsite treatment, storage capacity, disposal services, needed technical services, and materials.

- The availability of prospective technologies for each corrective measures alternative.

Cost

The CMS will consider the relative cost for each remedy. This criterion is especially useful when several technologies offer the same degree of protection to human health and the environment but vary widely in cost. The accuracy of cost estimating increases as the project moves forward from the conceptual/feasibility-type phase to an actual design, fabrication, and start-up phase. Therefore, cost estimates to be calculated in the actual CMS should be viewed as guidance and not as definitive fact in the ensuing decision-making process.

Cost estimates are generally subdivided into:

- **Direct Capital Costs** — Remedial action construction, equipment, land/site development, building and services, relocation of population and disposal costs.

- **Indirect Capital Costs** — Engineering expenses, supervision/inspection/overhead, and monitoring and testing.

- **Contingency Allowances** — Varies.

- **Other Indirect Expenses** — Legal fees, license/permit costs, and start-up/shake-down.

- **Operation and Maintenance Cost** — Operating labor, maintenance material and labor, auxiliary materials and labor, purchased services, administration, insurance/taxes/licenses, maintenance reserve and contingency costs, and other costs.

4.4 Ranking the Corrective Measure Alternatives

Once corrective measures have been discussed for each site or group of sites using each applicable scenario (residential and/or BRAC-specified future use and/or third yet to specified reuse), alternatives under each will be ranked by desirability. By establishing a ranking system, an unbiased systematic and quantitative process is produced.

The ranking system will apply a weighing factor selected by the project team and BRAC Cleanup Team (BCT), with input from the Restoration Advisory Board (RAB), to determine the importance of each corrective measure criterion. The weighing factors will be developed by the project team and BCT during the CMS process. The numbers 1 though 9 will be assigned to the previously discussed nine evaluation criteria, with the number 9 assigned to the criterion considered the most important by the project team and BCT in selecting a corrective measure alternative. The remaining criterion will likewise be assigned appropriate numbers in descending significance (i.e., number 1 would be assigned to the criteria considered the least important by the project team and BCT).

Each corrective measures alternative will then be assessed according to its ability to meet the nine criteria. Corrective measures alternatives that meet and far exceed the requirements of a specific criteria will receive a "meets criteria" value of 4. Those that do not meet the requirements of a specific criteria will receive a "meets criteria" value of 1. Numbers 2 and 3 are assigned to corrective measures alternatives that fit between the two extremes of what could be considered solid success or solid failure (in respect to meeting a certain criteria).

A "weighted criteria value" is calculated for each of the nine criteria per alternative by multiplying the "criteria weighing factor" by the "meets criteria value." A quantitative comparison of the alternatives is then made by comparing the sum of the "weighted criteria values." The alternatives are ranked based on the sum of their "weighted criteria values." Those alternatives with the highest total being most preferable, and the lowest total being least preferable.

Table 4-3 shows the format of the ranking system. The example presented in this table considers a hypothetical site which has contaminated soil with relatively high (10 to 1,000 parts per million) concentrations of polyaromatic hydrocarbons (PAHs). Three alternatives were developed: excavation and disposal in a permitted landfill, excavation and thermal treatment, and capping in-situ.

Table 4-3
Comparison and Ranking of Alternatives

		Alternative 1			Alternative 2			Alternative 3		
Objective & Criteria	**Weighing Factor**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**
Protection of human health and the environment		Protective of human health and community	3		Protective of human health and community	3		Protective of human health and community	3	
Attainment of media cleanup standards		Excavates soil above cleanup goals	3		Excavates soil above cleanup goals	3		No	1	
Control the sources of releases		Eliminates source material above cleanup goals	3		Eliminates source material above cleanup goals	3		Controls sources of releases through containment, reduction in leachate	3	
Compliance with any applicable standards for management of wastes		Must comply with LDRs, USDOT regulations	3		Must comply with LDRs, air emissions regulations	3		Must comply with RCRA cap requirements, monitoring	3	

Table 4-3
Comparison and Ranking of Alternatives

		Alternative 1			Alternative 2			Alternative 3		
Objective & Criteria	**Weighing Factor**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**
Other Factors										
Long-term reliability and effectiveness		Effective over the long term	3		Effective over the long term	3		Effective with regular maintenance activities.	3	
Reduction in toxicity, mobility, and volume		Does not reduce toxicity, mobility, or volume	1		Reduces toxicity, mobility, and volume through treatment	4		Does not reduce toxicity, mobility, or volume	1	
Short term effectiveness		Minimal exposure to site workers during excavation	3		Minimal exposure to site workers during excavation and treatment	3		Minimal exposure to site workers during excavation	4	
Implementability		Easily implemented, common approach to contaminated soil	4		Requires mobile treatment unit mobilization; may be time inefficient	2		Easily implemented, common approach to contaminated soil	3	

Table 4-3
Comparison and Ranking of Alternatives

		Alternative 1			Alternative 2			Alternative 3		
Objective & Criteria	**Weighing Factor**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**	**Description**	**Meets Criteria**	**Weighted Criteria Value**
Cost		Present worth cost = $193,000	3		Present worth cost = $354,000	1		Present worth cost = $8,000	4	
Totals										

Notes:
"Meets Criteria" ranking values are based on the following scale.
4 — Meets and far exceeds criteria/objectives
3 — Slightly exceeds criteria/objectives
2 — Meets only minimally the criteria/objectives
1 — Does not meet criteria/objectives

Weighing Factors will be determined by NAVBASE
LDRs — Land Disposal Restrictions
USDOT — U.S. Department of Transportation

The purpose of this example is to show the format and nature of the comparisons in the discussed tabular form. This table can be used by the project team and BCT to recommend a corrective measures alternative for a specific site or group of sites. The table can also be presented to the public during the public participation period of the CMS portion of the RCRA corrective action process.

4.5 Remedy Selection

Upon completion of the previously described "comparison and ranking" table, and with supporting rationale as presented in the CMS report, the Navy may recommend a preferred alternative or combination of alternatives. However, the implementing agency, SCDHEC, retains the lead role in final remedy selection.

The selected remedy(ies) is then proposed to the public through a Statement of Basis administrative process. The Statement of Basis will include supporting information from the CMS on why a certain remedy was selected.

Written public comment may influence and require that changes be made to the selected corrective measure. Additionally, the public may request a public meeting where additional comments, verbal and written, may be received and considered. A final decision and response to comments will be developed by the SCDHEC to document the selection of the remedy(ies).

5.0 TREATABILITY STUDY PROCEDURES

Treatability studies are often required as part of a CMS. Treatability testing may be conducted to determine if a particular remedial alternative is viable for given site conditions or to determine removal efficiencies or operating parameters for a full-scale system, among other reasons. Treatability tests may vary in scale from laboratory-, bench- to full-scale pilot testing. Tests may be conducted during the CMS, if the data are to be used in selecting alternatives, or during CMI, when specific design parameters are needed.

Before conducting a treatability test, the following criteria will be evaluated to determine the need for treatability testing:

- Are existing site data sufficient and are uncertainties acceptable enough for selection of a remedial alternative?

- Are treatability data available from other sources (literature, vendors, operational treatment plants)?

- Will site- and contaminant-specific conditions significantly impact the treatment efficiencies?

If the answers to these questions indicate a lack of supporting information (a negative response to the first two questions) or a doubt about potential treatment capability (a positive response to the third question), treatability studies should be conducted. A treatability study scope defining the objectives and requirements of the testing should be developed once the need for testing is indicated.

This section describes the approach that will be followed to effectively perform and evaluate treatability studies. The approach entails the following tasks.

Treatability Approach

- Defining the scope and objective of a treatability study
- Establishing data quality objectives (DQOs)
- Selecting a contracting mechanism and issuing the work assignment
- Preparing the work plan
- Complying with regulatory requirements
- Executing the study
- Analyzing and interpreting data
- Reporting the results

5.1 Establishing Data Quality Objectives

The quality of treatability testing data required depends upon the decisions to be made from these data. For simple laboratory screening tests used to decide whether a treatment process is applicable and should be studied further, limited data quality is required. Data collected from bench-scale and pilot-scale studies generally determine whether cleanup criteria and discharge limits can be met; therefore, these studies will require more rigorous data quality because decisions made from their results have more far-reaching implications.

5.2 Selecting a Contracting Mechanism and Issuing the Work Assignment

Once a decision has been made to conduct a treatability study and the scope of the project has been defined, a contractor or technology vendor who has the technical capabilities and experience to perform the work will be identified. Obtaining treatability services from contractors will adhere to all CLEAN contracting procedures.

A work assignment is a contractual document which briefly outlines the SOW to be performed and serves as documentation during contracting procedures. It gives the rationale for conducting the study, identifies the wastestream and technology to be tested, and specifies the level of testing required. The work assignment may include information such as:

Work Assignment Requirements

- Background
- Test objectives
- Approach
- Reporting requirements
- Schedule
- Level of effort

This information may be incorporated into the contracting documents, or submitted as an addendum/attachment. The sole purpose of this information is to inform the vendor of the nature and extent of the treatability test. More information can be provided in the treatability study work plan, as discussed below. A copy of the work assignment should remain on file in the event that further contracting is required.

5.3 Preparing the Work Plan

Carefully planned treatability studies are necessary to ensure that the data generated are useful for evaluating the validity or performance of a technology. To achieve this end, a work plan will be developed detailing the scope, requirements, and objectives of the treatability study, as well as test methods and end use of the test data. Although the work plan may be organized in different ways, the following subjects should be included.

Work Plan Requirements

- Project description
- Remedial technology description
- Test objectives
- Equipment and materials
- Sampling and analysis
- Management of residuals

- Testing procedures
- Data analysis and interpretation
- Health and safety
- Community relations
- Schedule
- Project organization
- QA/QC
- Data validation
- Reporting requirements

The purpose of the work plan is to ensure that all parties involved — the U.S. Navy, CLEAN contractors, subcontractors, and regulators — understand who will be performing the tests, where and when the tests will be performed, why the tests will be performed, how they will be performed and to what performance standards (DQOs). End objectives and reporting requirements will be clarified.

The treatability work plan will be prepared by E/A&H, possibly in conjunction with a subcontractor or vendor. It typically consists of a sampling and analysis plan, quality assurance plan (QAP), and health and safety plan. Where possible, the comprehensive CMS work plan and zone-specific CMS work plan will be used.

Once the work plan is completed, it will be submitted to state and federal agencies for approval.

5.4 Complying with Regulatory Requirements

This section briefly discusses issues that will be considered to ensure that the treatability testing complies with applicable local, state, and federal regulatory requirements. The section also discusses the differences between requirements for bench-scale and pilot-scale testing. Bench-scale testing will typically be exempt from environmental regulations because of the small volumes of waste generated. Pilot-scale testing typically is more complex.

Although pilot-scale treatability testing is usually small-scale and affects relatively small volumes of soil, groundwater, and air, these activities will adhere to appropriate regulatory requirements for permitting for several facets of treatability testing, and the appropriate disposal of waste generated during the treatability processes.

Before performing a pilot-scale treatability test, it will be approved by the appropriate agency either through permitting and/or work plan approval. For sites falling under state voluntary cleanup programs and UST sites, agency approval is generally required before field activities may begin. For RCRA sites, the treatability testing may require permitting (RCRA Part B).

Pilot-scale treatability testing may require groundwater discharge, air emissions, sewer-use agreements with the local publicly owned treatment works (POTW), and well installation permits. It is important that the permitting process begin as early in the planning stages as possible to avoid delays in the activities schedule due to regulatory permit review and issuance processes. Permits may be necessary to discharge treated groundwater to nearby surface water bodies, or for surface discharges or aquifer injection. Additionally, communication with the local POTW should start early if discharge to the local sewer system is anticipated. This type of discharge may require a sewer use agreement or order of approval from the POTW, which can be a lengthy process. Other permits may be required to install extraction wells and discharge air emissions to the atmosphere from treated or untreated off-gas.

In most instances, pilot-scale treatability studies produce waste material that must be handled and discarded in accordance with the appropriate regulatory requirements. Waste that may be produced during treatability testing includes soil cuttings, groundwater, spent granular activated carbon, and partially treated waste. Depending on the status of the site (RCRA or CERCLA) and the constituent concentrations of the waste material, it may require disposal into a solid, hazardous, or special waste landfill; incineration and disposal; treatment at an offsite water treatment plant; and onsite storage, disposal, or treatment. Regardless of the means of disposal, it must comply with state and federal regulations.

CMS managers are aware of disposal, permitting, and treatment requirements and the regulations governing those activities.

5.5 Executing the Study

Execution of the treatability study begins after work plan approval. The steps of the test include: (1) collecting a sample of the wastestream or contaminated media for characterization, (2) conducting the test, and (3) collecting and analyzing samples of the treated waste and residuals.

Wastestream/Contaminated Media Characterization

Characterization samples should be collected from the same material that will be used in the treatability study. Characterization is necessary to determine the chemical, physical, and/or biological properties exhibited by the wastestream or contaminated media so that the results of the treatability study and initial waste characterization can be compared. The waste characterization sample should represent average or worst-case conditions to yield a conservatively designed treatability test.

Treatability Testing

The treatability study will adhere to the testing procedures presented in the approved work plan. Detailed laboratory or field notes should be kept to indicate sample designations, sample times, sample locations, and changes in operating parameters (e.g., flow rates, chemical doses, retention times). The treatability testing notes will be a record of all testing data necessary to determine the applicability of performing the remedial technology at the subject site and will provide the information needed to prepare the treatability study report.

Sampling and Analysis

Samples collected during treatability testing may include influent and effluent water samples, air samples, untreated and treated soil samples, or process residuals. These samples will be collected in accordance with the approved work plan, which specifies the location, frequency, and analytical methods required.

5.6 Analyzing and Interpreting the Data

Upon completion of a treatability study, the data will be summarized and evaluated to determine whether the technology applies to the subject site. In addition, a determination will be made as to whether the level of uncertainty for a potential treatment technology has decreased adequately enough to render a decision or statement about its viability at the subject site. Treatability studies are designed to produce objective results (eg, treatability efficiencies) that decrease process uncertainty.

The first goal of data analysis is to determine the quality of the data collected. The data will be checked to assess precision, accuracy, and completeness using procedures performed in accordance with the QA/QC and data validation requirements presented in the comprehensive CMS work plan and the approved work plan. If the QA/QC objectives for the data have not been met, the project manager and the project team will determine the usefulness of the data and the corrective actions required.

Second, the data will be used to assess the applicability of the technology for treatment of media at the subject site. If the test was at bench-scale, it is necessary to determine whether further study is warranted at the pilot-scale level. The applicability of the technology should be based on an analysis of the technology's effectiveness, economics, efficiency, and regulatory compliance, as specified in the work plan.

5.7 Reporting the Results

The final step in conducting a treatability study is reporting the test results. The formality of the report may be different, depending on the site's regulatory status. For example, sites falling under state voluntary cleanup may not require the depth of reporting detail that a RCRA site would require. Although reporting requirements may differ, the treatability study report will be complete and accurate because decisions about full-scale treatment alternatives can be based on treatability results. Additionally, if results are presented clearly and concisely, the agency review can be completed more efficiently and usually faster.

In cases where the technology is being tested at several levels (e.g., bench-scale tests are performed first, and if results are promising, pilot-scale work is performed), it may not be necessary to prepare a formal report for each test. However, a final report encompassing the entire study may be developed after all testing is complete.

At a minimum, the treatability report should present:

- An introduction to the site and remedial technology being assessed.
- Treatability study objectives, design, procedures, equipment, sampling data, QA/QC, treatment processes, and deviations from the work plan.
- Data analysis and interpretations from the wastestream and treatability study results.
- Conclusions and recommendations.

5.8 Technologies that Typically Require Treatability Testing

Table 5-1 Treatability Testing Matrix, Corrective Measures Study — Naval Base Charleston, Charleston, South Carolina, indicates those technologies (e.g., remedial alternatives) that typically require some form of treatability study prior to assessing their effectiveness. The table also presents data needs, objectives, technology description, and whether the testing would be completed in-house, or by a vendor or subcontractor.

As previously discussed, a treatability test is completed to determine the suitability of a specific technology to accomplish certain cleanup goals and objectives.

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Adsorption	Air	Modeling	Contaminant concentrations, flow rate, pressure, temperature, emission standards	Vendor	To size adsorption equipment	None required, established technology
	Groundwater	Modeling	Contaminant concentrations, flow rate, discharge limit	Vendor	To size adsorption equipment	None required, established technology
Air Stripping	Groundwater	Modeling	Groundwater extraction flow rate, volatile organic compound (VOC) contaminant concentrations, inorganic constituent concentrations, treatment standards	Vendor	To size air stripping equipment	None required, established technology
Bioremediation	Groundwater	Bench-scale Treatability	Contaminant/water solubility, oxidation rate, microorganisms, water and air temperature, nutrient content (nitrogen, phosphorous), hydrogeologic data, total organic carbon (TOC), biological oxygen demand (BOD), chemical oxygen demand (COD).	In-house	To determine the potential for bioremediation through monitoring of microbial growth and the reduction of contaminant concentrations	Augmentation and simulation of bioremediation by controlling and monitoring microorganisms and nutrients (nitrogen, phosphorous, organic content)
Bioremediation	Soil	Pilot-scale Treatability	Contaminant/water solubility, sorption coefficient, hydrolysis rate, oxidation rate, organic content, texture, water-holding capacity, microorganisms, soil and air temperature, nutrient content (nitrogen, phosphorous), rainfall data.	In-house	To determine the potential for bioremediation through monitoring microbial growth and the reduction of contaminant concentrations	Augmentation and simulation of bioremediation by controlling and monitoring microorganisms and nutrients (nitrogen, phosphorous, organic content)

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Coagulation / Flocculation	Groundwater	Bench-scale Treatability	Inorganics concentrations, total suspended solids (TSS), pH, oil and grease, treatment standards	In-house	To determine the optimum chemical doses for effective coagulation/flocculation of inorganic constituents	Trial and error of coagulants/flocculants and their doses to determine the most effective regime for the reduction of inorganic constituent concentrations and to quantify sludge production.
Dehalogenation	Soil	Pilot-scale Treatability	Water content, alkaline metals content, humic acid content, organic halides, treatment standard	In-house	To determine the oxidation reduction potential of a particular soil for degradation of contaminants using reducing agent and catalyst	PCB contaminated soil will be mixed with sodium hydroxide and catalysts then heated to dehalogenate and partially volatilize the contaminant. Another technology uses an alkaline polyethylene glycol as the reagent. Ultraviolet light is used in another technology with reagents.
Filtration	Groundwater	Bench-scale Treatability	Contaminant concentrations, TSS, total and dissolved inorganic constituent concentrations, filter mesh size, treatment standard	In-house	Calculate removal efficiency by comparing pre- and post-filter contaminant concentrations	Collect representative sample of groundwater. Mix sample and analyze a portion of the sample for contaminants of concern. Pass the remaining portion of the sample through filter mesh being evaluated and analyze filtrate for the same contaminants of concern. Compare results to meet objectives.
Incineration	Soil	Pilot-scale Treatability	Contaminant concentrations, treatment standards, emissions standards	Sub-contractor	To determine removal efficiencies and verify compliance with applicable emission standards	Incinerate a relatively large sample (truck load or roll-off box) of representative soil using an onsite or offsite incineration unit similar to the unit proposed for full-scale operation. Monitor emission concentrations to ensure compliance and compare pre- and post-incineration contaminant concentrations.

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Ion-exchange	Groundwater	Bench-scale Treatability	Inorganics concentrations, TSS, pH, treatment standard.	In-house or sub-contracted	To determine whether effective reduction of inorganics in groundwater can be achieved using various ion exchange resins	Collect a representative sample of groundwater and filter to remove TSS. Pass the water through various ion (cationic or ionic) exchange beds equipped with various ion exchange resins. Compare pre- and post-treatment contaminant concentrations to determine the most effective resin for inorganics removal.
Natural Attenuation	Groundwater	Bench-scale Treatability	Contaminant concentrations, aquifer transmissivity and conductivity, type of aquifer, aquifer formation, potential for dense non-aqueous phase liquid (DNAPL), treatment standard, risk to human health and the environment, contaminant/water solubility, hydrolysis rate, oxidation rate, water temperature, TOC, BOD, COD, microorganisms, nutrient content, historical analytical data	In-house	To assess the potential for degradation of contaminants through natural processes such as oxidation, biodegradation, and dilution	Collect representative sample of groundwater. Monitor contaminant concentrations over time while groundwater is placed in a laboratory-controlled environment similar to site conditions.

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Natural Attenuation	Soil	Bench-scale Treatability	Contaminant concentrations, water table elevation, contaminant/water solubility, sorption coefficient, hydrolysis rate, oxidation rate, organic content, microorganisms, soil temperature, nutrient content, risk to human health and the environment, treatment standard, historical analytical data	In-house	To assess the potential for degradation of contaminants through natural processes such as oxidation and biodegradation	Collect representative sample of soil. Monitor contaminant concentrations over time while soil is placed in a laboratory-controlled environment similar to site conditions.
Oxidation	Air	Modeling	Contaminant concentrations and type, flow rate, pressure, temperature, emission standards	Vendor	To assess the effectiveness of contaminant destruction with ultraviolet light and catalysts	None required when using established catalysts. Data from previous studies is available to demonstrate whether a particular contaminant will be destroyed through oxidation using specific catalysts
	Groundwater	Bench-scale Treatability	Contaminant concentrations and type, flow rate, inorganic constituent concentrations, treatment standard	Vendor	To assess the effectiveness of contaminant destruction with UV light and catalysts	
Scrubbers	Air	Modeling	Contaminant concentrations, flow rate, pressure, temperature, emission standards	Vendor	To assess the effectiveness of contaminant containment	None required, established technology
Solidification/ Stabilization	Soil	Pilot-scale or Bench-scale Treatability	Particle size, Atterberg limits, moisture content, inorganic concentrations, sulfate concentrations, organic content, density, permeability, leachability, pH	Sub-contractor	To determine whether successful stabilization of the material is possible through measurements of leachability	Stabilize a sample of the material and compare pre- and post-stabilization contaminant concentrations to a leaching procedure.

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Soil-Vapor Extraction	Soil	Pilot-scale Treatability	Soil lithology, soil type, soil permeability, depth to water table, humic and fulvic acid concentrations, vertical and horizontal extent of contamination, anomalies in soil media (utilities, tanks, etc.), treatment standard, emission standards	Sub-contractor or In-house	To determine whether a soil media allows effective extraction of air through its pore space to promote the removal of vapor-phase contaminants	Install pilot-test extraction wells and monitoring points. Apply a vacuum to the extraction wells to induce air flow through the soil media. Monitor pressure, temperature, vapor-phase contaminant concentrations, and flow rates at extraction wells, monitoring points, and the blower discharge. Based on data, determine the air permeability of the soil media and determine whether effective removal of contaminants is possible.
Soil Washing	Soil	Pilot-scale Treatability	Soil type, soil moisture content, soil permeability, TOC, pH, contaminant solubility, partition coefficient, washing fluid type and compatibility, treatment standard	Sub-contractor or In-house	To assess the effective transfer of contaminants from soil to water by passing and mixing water through a batch of soil	In a contained system, pass water through a batch of soil and compare contaminant concentrations in soil and water before and after washing. If effective, the washing solution (water) will require treatment prior to disposal. (Generally for inorganic contaminants)
Solvent Extraction	Soil	Pilot-scale Treatability	Particle size, pH, partitioning coefficient, organic content, toxicity leaching procedure (TCLP) analysis, moisture content, inorganic concentrations, VOC concentrations, soil type, treatment standard	Sub-contractor	To assess the effectiveness of a surfactant to reduce contaminant concentrations in soil by mixing the surfactant through a batch of soil	In a contained system, mix applicable surfactants into a batch of soil and extract the surfactant from the soil. Compare contaminant concentrations in soil and surfactant before and after extraction. (Used for contaminants not soluble in water.)

Table 5-1
Treatability Testing Matrix
Corrective Measures Study - Naval Base Charleston, Charleston, South Carolina

Technology	Media	Action Required	Data Needs (prior to test)	Sub-contractor, Vendor, or In-house	Objectives	Treatability Description
Steam Extraction	Soil	Pilot-scale Treatability	Particle size, partitioning coefficient, organic content, contaminant concentrations, treatment and emission standards	In-house	To assess the reduction of contaminant concentrations in soil through the use of steam extraction	Excavate and stockpile contaminated soil and inject and extract steam. Monitor pressure, temperature, vapor-phase contaminant concentrations. Compare contaminant concentrations in soil before and after steam extraction.
Thermal Desorption	Soil	Pilot-scale Treatability	Contaminant concentrations, moisture content, soil type, treatment standards, emission standards	Sub-contractor	To determine contaminant removal efficiencies and verify compliance with applicable emission standards	Collect a relatively large batch of representative soil, screen the soil to remove large objects, place soil in a closed unit with a reducing atmosphere (nitrogen, natural gas, etc.), heat soil to destroy contaminants, and use bag filters to contain off-gases. Compare pre- and post-treated contaminant concentrations in soil to calculate removal efficiencies and monitor off-gas to ensure effective containment of off-gas.
Vitrification	Soil	Pilot-scale Treatability	Contaminant concentrations and type, soil type, moisture content, treatment standards, grain-size distribution, emission standards, water table elevation	Sub-contractor	To determine the effective destruction of organics and immobilization of inorganics in soil or sludges through vitrification	Pass electrical current through representative batch of soil or sludge to perform pilot-scale vitrification. Inspect material for complete vitrification. Inhibitors may be void space, rubble, or combustible organics in excess of 5-10% by weight. Compare pre- and post-vitrification samples for contaminants of concern with a leaching procedure.

6.0 PROJECT MANAGEMENT

This section outlines the proposed project management plan for the CMS to be conducted at NAVBASE, including project work elements, schedule, and project management responsibilities. The main goal of this effort is to achieve compliance with the HSWA portion of the Part B permit for operating a hazardous waste storage and transfer facility.

Corrective measures will be evaluated on three scales: individual sites, zone-wide, and base-wide. Base-wide corrective measures may be considered as additional data are gathered in other zones. As previously discussed, grouping of sites may be based on common factors (physical proximity of sites, common hydrogeologic conditions, similar contaminants, etc). Zone- and base-wide applications refer to this grouping concept.

6.1 Project Work Elements

The CMS will begin with a review of the site's characteristics, nature and extent of contamination, identification of corrective action objectives, and corrective measures alternatives. Based on the review of these data, a treatability study will be implemented (if needed) and an in-depth analysis of alternatives will be conducted to rank the most appropriate and cost-effective corrective measures for each site or site grouping.

The CMS can be broken into several proposed project work elements or tasks. Each proposed project work task may consist of additional sub-tasks that are not listed and that may be zone-specific. The proposed project work tasks, anticipated deliverables, and estimated time-frames for completion are described in the following list and time line presentation. The time frames presented have been estimated for a typical investigative zone at NAVBASE. Complex investigative zones (eg, those zones that are technically complex and/or containing a significant number of SWMUs and AOC that warrant a CMS) can be expected to take longer than indicated by the time line. Likewise, less complex zones will probably take less time than indicated by the time line.

The general nature of these project work elements were previously presented in Figure 2-1, Corrective Action Flow Chart.

Proposed Project Word Tasks

Task 1	Direct Sites into CMS Process or Designate as NFA
Task 2	Start Permit Modifications, as Required — Navy Lead
Task 3	Determine Initial PRG/RGO and scope CMS/treatability effort, as required.
Task 4	Develop Zone-Specific CMS Work Plans and Treatability Study Plans, as Required
Task 5	Plan(s) Review, Response to Comments and Final Approval
Task 6	Initiate CMS Effort
Task 7	Reevaluate PRG/RGO
Task 8	Identify and Screen Alternatives
Task 9	Team Approval
Task 10	Evaluate and Rank Alternatives
Task 11	Team Approval
Task 12	Statement of Basis and Public Participation — State Lead
Task 13	Permit Modifications, as Required — Navy Lead
Task 14	Finalized Remedy Selection

6.2 Project Schedule

This section provides a schedule for completing the above-mentioned tasks. Appendix C of the HSWA portion of the Part B permit contains a facility submission or compliance schedule based on task versus duration for completing the RFI/CMS. In accordance with HSWA permit Condition II.G.1, a Corrective Action Management Plan (CAMP) was prepared and submitted to the USEPA and SCDHEC.

The CAMP outlined a proposed schedule for completing the RFI and CMS implementation. The following schedule, Figure 6-1, Time Line Schedule, is a proposed schedule based on the aforementioned tasks for a typical CMS at a typical zone. This time line is intended to remain flexible throughout the CMS process.

6.3 Project Management Responsibilities

NAVBASE

NAVBASE has officially been closed since April of 1996. Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) is the Officer-in-Charge of the Caretaker Site Office and is responsible for ensuring that conditions of the RCRA Part B permit are satisfied and complied with.

SOUTHNAVFACENGCOM

SOUTHNAVFACENGCOM's Engineer-in-Charge (EIC), Mr. Matthew A. Hunt, is responsible for the technical and financial management of IR Program activities at Charleston Naval Base. He prepares the project statement of work; manages the project scope, schedule, and budget; and provides technical review and approval of all deliverables. Mr. Hunt will be responsible for approving changes in the IR scope of work.

EnSafe/Allen & Hoshall

As the Project Management Office (PMO), E/A&H is under contract to SOUTHNAVFACENGCOM to administer, plan and implement the CMS at Charleston Naval Base.

TIME LINE SCHEDULE

MONTHS: 1 2 3 4 5 6 7 8 9 10 11 12

ACTIVITY	DUR.	
TASK 01	XX	Direct Sites into CMS Process or Designate as NFA
TASK 02	XX	Start Permit Modifications, as Required – Navy Lead
TASK 03	30	Determine Initial PRG/RGO
TASK 04	60	Develop Zone–Specific CMS Work Plans and Treatability Study Plans, as Required
TASK 05	45	Plan(s) Review, Response to Comments and Final Approval
TASK 06	XX	Initiate CMS Effort
TASK 07	15	Reevaluate PRG/RGO
TASK 08	45	Identify and Screen Alternatives
TASK 09	7	Team Approval
TASK 10	60	Evaluate and Rank Alternatives
TASK 11	7	Team Approval
TASK 12	60	Statement of Basis and Public Participation – State Lead
TASK 13	unknown	Permit Modifications, as Required – Navy Lead
TASK 14	XX	Finalized Remedy Selection

NOTE
1. CALENDAR DAYS PRESENTED.
2. HOLIDAYS, VACATIONS, ETC. NOT INCLUDED.
3. TYPICAL CMS PROCESS PRESENTED; DOES NOT INCLUDE EXTENSIVE TREATABILITY TESTING TIME FRAME.

COMPREHENSIVE CMS PROJECT MANAGEMENT AND WORK PLANS
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 6–1
TIME LINE SCHEDULE

DWG DATE:06/20/97 | DWG NAME:29ZNFG1A

The following individuals will be involved in this effort:

- Principal-in-Charge — Mr. Jim Speakman, Ph.D., P.E.
- Task Order Manager — Mr. Todd Haverkost, P.G.
- Site Supervisor — TBA
- Comprehensive CMS Project Manager — Mr. Larry Bowers, P.E.
- Zone-Specific CMS Project Engineers — TBA engineering staff
- Zone-Specific CMS field support staff — TBA field support staff
- Site Health and Safety Officer — Mr. Tim McCord
- Project Health and Safety Officer — Mr. John Borowski, C.I.H.

BRAC Cleanup Team (BCT)

The NAVBASE BCT is composed of two Navy BRAC Environmental Coordinators representing the Department of Defense, a representative from the USEPA Region IV, and a representative from SCDHEC. The BCT is responsible for conducting periodic program review and for attaining consensus on decisions with federal and state regulators. This team is primarily involved in issues involving property transfer at the former naval base.

Project Team

The project team was formed after the formation of the BCT and it is made up of three Navy representatives (Mr. Matthew Hunt, Mr. Daryle Fontenot, and Mr. Reece Batten), one USEPA Region IV member (Mr. Jay Bassett), three SCDHEC representatives (Ms. Ann Ragan, Mr. Paul Bergstrand, and Mr. Johnny Tapia), two Environmental Detachment members (Mr. Bobby Dearhart and Mr. Kevin Tunstall), and two E/A&H representatives (Mr. Todd Haverkost and Mr. Dave Backus). This team is primarily involved in direct issues pertaining to the ongoing environmental assessment, investigation, and cleanup at NAVBASE.

7.0 COMMUNITY INVOLVEMENT

Though the RCRA corrective action process typically does not require a community participation program for facilities that are experiencing RCRA-regulated assessment, investigation, and/or cleanup, it has been policy of the U.S. Navy for NAVBASE to emulate a public involvement plan comparable to what would be expected under CERCLA-mandated assessment and remediation projects.

7.1 Community Relations Plan

In response to Navy guidance, E/A&H was tasked with developing a Community Relations Plan (CRP) that details community involvement and strategy for the entire RCRA Corrective Action Process (CAP). The CRP has been implemented to encourage open communication among NAVBASE; federal, state, and local regulatory agencies; interested community groups; and, individual community residents regarding environmental activities that are subsequent to NAVBASE remediation and closure. Community involvement has been encouraged from the beginning of the CAP (i.e., RFA) and will continue through the end of the CAP (i.e., CMI).

7.2 Benefits

Community involvement and input results in many benefits. In particular, the RAB, as described in the CRP, provides a forum where applicable project information is presented to the community, and public input is actively solicited and acted upon. The implementation of any program has a greater chance for success where the community has taken an active role in the full program from start-up to alternative solution selection and implementation. It is vital to have community support during the period of solution implementation.

7.3 Public Interaction

As mentioned in previous sections of this work plan, the final product of the CMS will include a list of the ranked cleanup alternative(s) as well as the recommended alternative. The CRP requires that this list be presented to the local community through a public notice published in the newspaper, and at a public hearing. Written responses will be accepted from the public during a comment period that typically ranges from 30 to 45 days long. E/A&H, in coordination with the BCT, will produce written responses to comments received during this period. Changes to the proposed cleanup alternative(s) may be made after consideration of public comments.

In addition to the public notice, hearing, and comment period, monthly RAB meetings, which are open to the public, will act as a forum for citizen education, involvement, and input throughout the entire CMS process. Fact sheets and other educational material reporting CMS findings will be published if community interest is expressed.

8.0 REFERENCES

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9.0 SIGNATORY REQUIREMENT

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

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

________________________ Date 7/1/97

Officer in Charge, Caretaker Site Office
Charleston Naval Base
Southern Division Naval Facilities Engineering Command

APPENDIX A
TECHNOLOGY SCREENING TABLES

Table A-1
Additional Treatment Technologies Screening Matrix

Technology	A	B	C	D	E	F	G	H	I	J	K	L	M
Soil, Sediment, and Sludge													
Biodegradation	Full	■	None	No	■	■	■	Δ	■	Δ	Δ	○	2
Bioventing	Full	■	None	No	■	■	■	Δ	□	■	○	■	1
White Rot Fungus	Pilot	Δ	None	No	Δ	Δ	Δ	Δ	■	Δ	Δ	○	2
Pneumatic Fracturing (enhancement)	Pilot	Δ	None	Yes	○	○	○	○	○	■	NA	■	1
Soil Flushing	Pilot	■	Liquid	No	■	○	○	■	Δ	○	Δ	□	2
Soil Vapor Extraction (in situ)	Full	■	Liquid	No	■	○	■	Δ	Δ	■	○	■	2
In Situ Solidification/Stabilization	Full	■	Solid	No	Δ	○	Δ	■	Δ	■	■	■	3
Thermally Enhanced SVE	Full	○	Liquid	No	○	■	○	Δ	Δ	○	■	○	4
In Situ Vitrification	Pilot	Δ	Liquid	No	○	○	○	■	Δ	Δ	■	Δ	4
Composting	Full	■	None	No	■	○	■	Δ	■	■	○	■	1
Controlled Solid Phase Bio. Treatment	Full	■	None	No	■	○	■	Δ	■	■	○	■	1
Landfarming	Full	■	None	No	■	○	■	Δ	○	■	Δ	■	1
Slurry Phase Bio. Treatment	Full	○	None	No	■	○	■	Δ	■	○	○	○	4
Chemical Reduction/Oxidation	Full	■	Solid	Yes	○	○	○	■	Δ	■	■	○	1
Dehalogenation	Full	Δ	Vapor	No	○	■	Δ	Δ	Δ	□	□	□	5
Dehalogenation (Glycolate)	Full	○	Liquid	No	○	■	Δ	Δ	Δ	Δ	Δ	Δ	4
Soil Washing	Full	○	Solid, Liquid	Yes	○	■	■	■	■	○	■	○	4
Solid Vapor Extraction (ex situ)	Full	■	Liquid	No	■	○	○	Δ	Δ	■	○	■	1
Ex Situ Solidification/Stabilization	Full	■	Solid	No	Δ	○	Δ	■	Δ	■	■	■	3

Notes:

A = Development Status
B = Availability
C = Residuals Produced
D = Treatment Train
E = Volatile Organic Compounds
F = Semivolatile Organic Compounds
UV = Ultraviolet

G = Fuels
H = Inorganics
I = Explosives
J = System Reliability/Maintainability
K = Cleanup Time
L = Overall Cost
POTW = Public Owned Treatment Works

M = Cost Driver
1 = Neither
2 = Operations & Maintenance
3 = Capital
4 = Both
NPDES = National Pollutant Discharge Elimination System

5 = Inadequate Data
■ = Better
○ = Average
Δ = Worse
□ = Inadequate Data
NA = Not Applicable

This table is based on EnSafe/Allen & Hoshall experience, U.S. Environmental Protection Agency's *Remediation Technology Screening Matrix and Reference Guide*, EPA/542/B-94/013 October 1994 and other guides, handbooks, and documents.

Table A-1
Additional Treatment Technologies Screening Matrix

Technology	A	B	C	D	E	F	G	H	I	J	K	L	M
Solvent Extraction (chemical extraction)	Full	○	Liquid	Yes	○	■	○	Δ	■	○	Δ	Δ	4
High-temperature Thermal Desorption	Full	■	Liquid	Yes	○	■	○	Δ	Δ	○	■	○	4
Hot Gas Decontamination	Pilot	○	None	No	Δ	Δ	Δ	Δ	■	■	■	■	4
Incineration	Full	■	Liquid Solid	No	○	■	■	Δ	■	○	■	Δ	4
Low-temperature Thermal Desorption	Full	■	Liquid	Yes	■	○	■	Δ	■	○	■	■	4
Open Burn/Open Detonation	Full	■	Solid	No	Δ	Δ	Δ	Δ	■	■	■	■	4
Pyrolysis	Full	Δ	Liquid Solid	No	○	■	○	Δ	□	□	■	Δ	4
Ex Situ Vitrification	Full	○	Liquid	No	○	○	○	■	Δ	○	○	Δ	4
Excavation, Retrieval, and Offsite Disposal	NA	■	NA	No	○	○	○	○	○	■	■	Δ	1
Natural Attenuation	NA	■	None	No	■	■	■	Δ	Δ	■	Δ	■	1
No Action	Full	■	All	No	○	○	○	○	○	Δ	Δ	Δ	1
Filter Press	Full	■	Liquid	No	Δ	Δ	Δ	■	Δ	■	○	■	4
Groundwater, Surface Water, and Leachate													
Cometabolic Treatment	Pilot	Δ	None	No	■	■	○	Δ	○	Δ	○	○	2
Nitrate Enhancement	Pilot	Δ	None	No	■	■	■	Δ	○	○	○	■	1
Oxygen Enhancement with Air Sparging	Full	■	None	No	■	■	■	Δ	○	■	○	■	1
Oxygen Enhancement with H_2O_2	Full	■	None	No	■	■	■	Δ	○	Δ	○	○	2
Air Sparging	Full	■	Vapor	Yes	■	Δ	■	Δ	Δ	■	■	■	1

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Technology	A	B	C	D	E	F	G	H	I	J	K	L	M
Directional Wells (enhancement)	Full	Δ	NA	Yes	○	○	○	○	○	○	■	□	1
Dual-phase Extraction	Full	■	Liquid Vapor	Yes	■	Δ	■	Δ	Δ	○	○	○	2
Free-product Recovery	Full	■	Liquid	No	Δ	■	■	Δ	Δ	○	■	■	1
Hot Water or Steam Flushing/Stripping	Pilot	○	Liquid Vapor	Yes	○	■	■	Δ	Δ	Δ	■	○	3
Hydrofracturing (enhancement)	Pilot	□	None	Yes	○	○	○	○	○	■	■	○	1
Passive Treatment Walls	Pilot	Δ	Solid	No	■	■	○	■	■	□	Δ	□	3
Slurry Walls (containment only)	Full	■	NA	NA	○	○	○	○	○	■	■	■	3
Vacuum Vapor Extraction	Pilot	Δ	Liquid Vapor	No	■	○	■	□	Δ	■	○	○	3
Bioreactors	Full	■	Solid	No	■	■	■	Δ	○	○	NA	■	3
Air Stripping	Full	■	Liquid Vapor	No	■	○	○	Δ	Δ	■	NA	■	2
Filtration	Full	■	Solid	Yes	Δ	Δ	Δ	■	○	■	■	■	1
Ion Exchange	Full	■	Solid	Yes	Δ	Δ	Δ	■	Δ	■	○	■	1
Liquid-phase Carbon Adsorption	Full	■	Solid	No	■	■	○	○	■	■	NA	Δ	2
Precipitation	Full	■	Solid	Yes	Δ	Δ	Δ	■	□	■	○	■	1
UV Oxidation	Full	■	None	No	■	■	■	Δ	■	Δ	NA	○	4
Natural Attenuation	NA	■	None	No	■	■	■	Δ	Δ	■	Δ	■	1
No Action	Full	■	All	No	○	○	○	○	○	Δ	Δ	Δ	1
pH Adjustment	Full	■	Solid	No	Δ	○	Δ	■	○	■	■	■	1
Reverse Osmosis	Full	○	Liquid Solid	No	Δ	Δ	■	■	■	■	○	Δ	4

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Wet Air Oxidation	Full	○	Solid	No	■	■	○	○	○	○	■	○	4
UV Reduction	Full	○	None	Yes	■	■	○	○	○	○	○	○	1
Sedimentation	Full	■	Liquid Solid	No	Δ	Δ	Δ	■	Δ	■	○	■	2
Oil/Water Separation	Full	■	Liquid Solid	No	■	■	■	Δ	Δ	■	■	■	2
Dissolved Air Flotation	Full	■	Liquid Solid	No	■	■	■	Δ	Δ	■	■	○	4
Resin Adsorption	Full	○	Liquid Solid	No	○	○	Δ	○	○	○	○	○	4
Land Application	Full	○	Liquid Solid	No	○	○	○	■	Δ	○	Δ	○	2
Aquatic Plant Systems	Full	Δ	Liquid Solid	No	Δ	○	Δ	■	■	○	Δ	■	2
Natural Wetlands	Full	■	None	Yes	○	■	Δ	■	■	Δ	Δ	■	2
Air Emissions/Offgas Treatment													
Biofiltration	Full	○	None	NA	■	○	■	Δ	○	Δ	NA	○	1
High-energy Corona	Pilot	Δ	None	NA	■	■	■	○	Δ	Δ	NA	○	5
Membrane Separation	Pilot	Δ	None	NA	■	○	○	Δ	○	Δ	NA	○	5
Oxidation	Full	■	None	NA	■	■	■	Δ	○	■	NA	■	1
Vapor-phase Carbon Adsorption	Full	■	Solid	NA	■	■	■	○	■	■	NA	■	1
No Action	Full	■	All	No	○	○	○	○	○	Δ	Δ	Δ	1
Flare	Full	■	None	Yes	■	○	○	Δ	Δ	■	■	■	3
Condensers	Full	■	Liquid	No	■	■	■	Δ	○	○	○	○	4
Absorbers	Full	■	Liquid	Yes	■	○	○	Δ	○	○	○	○	4

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Table A-1
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Technology	A	B	C	D	E	F	G	H	I	J	K	L	M
Filter Fabric	Full	■	Solid	No	Δ	Δ	Δ	○	Δ	○	○	○	4
Electrostatic Precipitators	Full	○	Solid	No	Δ	Δ	Δ	■	Δ	■	○	○	3
Wet Scrubbers	Full	○	Liquid Solid	Yes	○	Δ	Δ	■	Δ	○	○	○	4
Dust Suppressants	Full	■	None	Yes	Δ	○	Δ	■	Δ	■	Δ	■	2
Removal, Containment, and Disposal Options													
Groundwater Extraction	Full	■	Liquid	No	■	■	■	■	■	■	○	■	2
Leachate Collection	Full	■	Liquid	No	■	■	■	■	■	○	○	○	2
POTW	Full	■	Liquid	No	■	■	■	■	■	■	■	■	2
NPDES Discharge	Full	■	Liquid	No	■	■	■	■	■	○	○	■	2
Reinjection	Full	■	Liquid	No	■	■	■	■	■	○	○	○	2
Surface Controls	Full	■	Solid	No	Δ	○	Δ	○	○	○	Δ	○	2
Capping	Full	■	Solid	No	Δ	○	Δ	○	○	■	Δ	Δ	2
Landfill	Full	■	Solid	No	Δ	○	Δ	■	○	■	Δ	Δ	4
Storm Water Controls	Full	■	Liquid Solid	No	Δ	○	Δ	■	○	■	Δ	Δ	2
Dredging	Full	■	Liquid Solid	No	Δ	○	○	■	○	■	■	Δ	2
Clean, Inspect, and Repair Sewer Lines	Full	■	Liquid Solid	No	Δ	○	○	○	Δ	○	○	○	2
Long-term Monitoring	Full	■	All	No	Δ	Δ	Δ	Δ	Δ	○	Δ	■	2
Institutional Controls	Full	■	All	No	Δ	Δ	Δ	Δ	Δ	○	Δ	■	2
Intrinsic	Full	■	All	No	Δ	Δ	Δ	Δ	Δ	Δ	Δ	■	2

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Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
SOIL, SEDIMENT, AND SLUDGE	
In Situ Biological Treatment	
Biodegradation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soil to enhance in situ biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from subsurface materials.
Bioventing	Oxygen is delivered to contaminated unsaturated soil by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.
White Rot Fungus	White rot fungus has been reported to degrade a wide variety of organopollutants by using their lignin-degrading or wood-rotting enzyme system. Two different treatment configurations have been tested for white rot fungus, in situ and bioreactor.
In Situ Physical/Chemical Treatment	
Pneumatic Fracturing	Pressurized air is injected beneath the surface to develop cracks in low-permeability and over-consolidated sediments, opening new passageways (i.e., effective permeability) that increase the effectiveness of many in situ processes and enhance extraction efficiencies.
Soil Flushing	Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and treated.
Soil Vapor Extraction	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to diffuse through soil to extraction wells. The process includes a system for handling offgasses. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction.
Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
In Situ Thermal Treatment	
Thermally Enhanced Soil Vapor Extraction	Steam/hot air injection or electric/radio frequency heating is used to increase volatilization and mobility of vapor phase contaminants to facilitate extraction. The process includes a system for handling offgases.
Vitrification	Electrodes for applying electricity are used to melt contaminated soil and sludge, producing a glass and crystalline structure with very low leaching characteristics.
Ex Situ Biological Treatment (assuming excavation)	
Composting	Contaminated soil is excavated and mixed with bulking agents and organic amendments such as wood chips, animal and vegetative wastes, which enhance the porosity and organic content of the mixture to be decomposed.
Controlled Soil-phase Biological Treatment	Excavated soil are mixed with soil amendments and placed in above ground enclosures. Processes include prepared treatment beds, biotreatment cells, soil piles, and composting.
Landfarming	Contaminated soil is applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste and to aid natural biodegradation processes.
Slurry-Phase Biological Treatment	An aqueous slurry is created by combining soil or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.
Ex Situ Physical/Chemical Treatment (assuming excavation)	
Chemical Reduction/ Oxidation	Reduction/oxidation chemically converts hazardous contaminants to nonhazardous or less-toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.
Base Catalyzed Decomposition Dehalogenation	Contaminated soil is screened, processed with a crusher and pug mill, and mixed with NaOH and catalysts. The mixture is heated in a rotary reactor to dehalogenate and partially volatilize the contaminants.
Glycolate Dehalogenation	An alkaline polyethylene glycol (APEG) reagent is used to dehalogenate the halogenated aromatic compounds in a batch reactor. Potassium polyethylene glycol (KPEG) is the most common APEG reagent. Contaminated soil and the reagent are mixed and heated in a treatment vessel. In the APEG process, the reaction causes the polyethylene glycol to replace halogen molecules and render the compound nonhazardous. For example, the reaction between chlorinated organics and KPEG replaces a chlorine molecule and reduces toxicity.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Soil Washing	Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system based on particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.
Soil Vapor Extraction	A vacuum is applied to a network of aboveground perforated piping passing through the excavated material to facilitate volatilization of organics from the excavated media. The process includes a system for handling offgases.
Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).
Solvent Extraction	Waste and solvent are mixed in an extractor, dissolving the organic contaminant into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated for treatment and future use.
Ex Situ Thermal Treatment (assuming excavation)	
High-Temperature Thermal Desorption	Wastes are heated to 315-538°C (600-1,000°F) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.
Hot Gas Decontamination	The process raises the temperature of the contaminated equipment or material for a specified period of time. The gas effluent from the material is treated in an afterburner system to destroy all volatilized contaminants.
Incineration	High temperatures, 87-1,204°C (1,600-2,200°F), are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.
Low-Temperature Thermal Desorption	Wastes are heated to 93-315°C (200-600°F) to volatilize water or organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.
Open Burn/Open Detonation (OB/OD)	In OB operations, explosives or munitions are destroyed by self-sustained combustion, which is ignited by an external source, such as flame, heat, or a detonatable wave (that does not result in a detonation). In OD operations, detonatable explosives and munitions are destroyed by a detonation, which is initiated by detonating a disposal charge.
Pyrolysis	Chemical decomposition is included in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.
Vitrification	Contaminated soil and sludge are melted at high temperature to form a glass and crystalline structure with very low leaching characteristics.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Other Treatment	
Excavation and Offsite Disposal	Contaminated material is removed and transported to permitted offsite treatment and disposal facilities. Pretreatment may be required.
Natural Attenuation	Natural subsurface processes — dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials — are allowed to reduce contaminant concentrations to acceptable levels.
No Action	No action is taken.
Filter Press	Contaminated soil, sediment, and sludge are dewatered by slinging, squeezing, or sucking. The objective is to reduce moisture content and increase solids content.
GROUNDWATER, SURFACE WATER, AND LEACHATE	
In Situ Biological Treatment	
Cometabolic Processes	This emerging application involves the injection of water containing dissolved methane and oxygen into groundwater to enhance methanotrophic biological degradation.
Nitrate Enhancement	Nitrate is circulated throughout groundwater contamination zones as an alternative electron acceptor for biological oxidation of organic contaminants by microbes.
Oxygen Enhancement with Air Sparging	Air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes.
Oxygen Enhancement with Hydrogen Peroxide	A dilute solution of hydrogen peroxide is circulated throughout a contaminated groundwater zone to increase the oxygen content of groundwater and enhance the rate of aerobic biodegradation of organic contaminants by microbes.
In Situ Physical/Chemical Treatment	
Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization. Vaporization components rise to the unsaturated zone, where they are removed by vacuum extraction and then treated, if required.
Directional Wells (enhancement)	Drilling techniques are used to position wells horizontally, or at an angle, in order to reach contaminants not accessible via direct vertical drilling.
Dual-phase Extraction	A high-vacuum system is applied to simultaneously remove liquid and gas from low-permeability or heterogeneous formations.
Free-product Recovery	Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (e.g., pumping) or a passive collection system.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Hot Water or Steam Flushing/Stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporization components rise to the unsaturated zone where they are removed by vacuum extraction and then treated.
Hydrofracturing (enhancement)	Pressurized water is injected through wells to crack low-permeability, over consolidated sediments. Cracks are filled with porous media that serve as avenues for bioremediation or to improve effective hydraulic conductivity.
Passive Treatment Walls	These barriers allow the passage of water while prohibiting the movement of contaminants by employing such agents as chelators (liquids selected for their specificity for a given metal), sorbents, microbes, and others.
Slurry Walls	These subsurface barriers consist of vertically excavated trenches filled with slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and retard groundwater flow.
Vacuum Vapor Extraction	Air is injected into a well, lifting contaminated groundwater in the well and promoting additional groundwater flow to the well. Once inside the well, some of the volatile organics in the contaminated groundwater are transferred from the water to air bubbles, which rise and are collected at the top of the well by vapor extraction.
Ex Situ Biological Treatment (assuming pumping)	
Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin. In attached systems, such as rotating biological contactors and trickling filters, microorganisms are established on an inert support matrix.
Ex Situ Physical/Chemical (assuming pumping)	
Air Stripping	Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.
Filtration	Filtration isolates solid particles by running a fluid stream through a porous medium. The driving force is either gravity or a pressure differential across the filtration medium.
Ion Exchange	Ion exchange removes ions from the aqueous phase by exchange with innocuous ions on the exchange medium.
Liquid-phase Carbon Adsorption	Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Precipitation	This process transforms dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. The process usually uses pH adjustment, addition of chemical precipitant, and flocculation.
UV Oxidation	Ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows to the treatment cell. An ozone destruction unit may be needed to treat offgases from the treatment tank.
Other Treatment	
Natural Attenuation	Natural subsurface processes — such as dilution, volatilization, biodegradation, absorption, and chemical reactions with subsurface materials — are allowed to reduce contaminant concentrations to acceptable levels.
No Action	No action is taken.
pH Adjustment	Acids or bases are added to change the hydrogen ion concentration of a mixture.
Reverse Osmosis	Removes organic compounds from water mixtures using membrane processes. Process will remove organics with a molecular weight greater than 200.
Wet Air Oxidation	Destroys organic compounds in aqueous solutions by inducing oxidation and hydrolytic reactions at high temperature and pressure.
UV Reduction	Chemically reduces organics in water mixtures through simultaneous application of UV light and a proprietary liquid or adsorbent solid catalyst.
Sedimentation	The physical separation of particles from water mixtures by gravity.
Oil/Water Separation	The physical separation of aqueous-phase liquids from water mixtures by gravity or density differences.
Dissolved Air Flotation	Compressed air is released into a waste water which is then released to the atmosphere causing particles and oils to separate from a water mixture and float where they can be recovered.
Resin Adsorption	Contaminants are transferred from the dissolved state to the surface of the resin. The resin can be regenerated by removing the contaminants with steam or solvent.
Land Application	Dilute solution of contaminants is applied to the land surface by spraying or flooding. Inorganic contaminants will attenuate to the soil by cation exchange or precipitation. Organic contaminants may biodegrade.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Aquatic Plant Systems	Water plants are grown in diluted contaminated waters. Once plants get to mature size, they can be harvested and properly disposed of. Aquatic plants may uptake contaminants and either use them as energy or attenuate them.
Natural Wetlands	Either natural wetlands or man-made wetlands are ecological systems of native plants, insects, and animals which thrive in low marshy areas. Contaminants are either attenuated or used as energy by the plants and soil in these systems.
Oxidation/Reduction	The process involve with the transfer of electrons from one species to another.
AIR EMISSIONS/OFFGAS TREATMENT	
Biofiltration	Vapor-phase organic contaminants are pumped through a soil bed and sorb to the soil surface, where they are degraded by microorganisms in the soil.
High-energy Corona	This processes uses high-voltage electricity to destroy volatiles at room temperature.
Membrane Separation	This organic vapor/air separation technology involves the preferential transport of organic vapors through a nonporous gas separation membrane (a diffusion process analogous to putting hot oil on a piece of waxed paper).
Oxidation	Organic contaminants are destroyed in a high temperature 1,000°C (1,832°F) combustor.
Vapor-phase Carbon Adsorption	Offgases are pumped through a series of canisters or columns containing activated carbon to which organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.
Flares	Landfill gases are pumped through a flame, where they are ignited.
Condensers	Gases and vapors are pumped through a chamber where they come into contact with plates or coils which are cooler, thus condensing the gases or vapors.
Adsorbers	Resins are used to separate contaminants from air or vapor streams. This technology is similar to vapor-phase carbon adsorption.
Filter Fabrics	Fabric filters are used to trap contaminant-laden particles from air streams. Fabrics come in different mesh sizes.
Electrostatic Precipitators	Electric current or charge is used to trap particles of opposite charge. This is more effective with particles of relative small sizes.
Wet Scrubber	Water or solvent droplets capture contaminants and particles from air streams. The water or solvent contaminated solution can then be treated.
Dust Suppressants	Fluids including water are applied to soil, sediment, or sludge surfaces to prevent fine particles from becoming airborne.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Removal, Containment, Disposal Options	
Groundwater Extraction	Pumps are used to remove groundwater. This process dewaters an aquifer or removes water at a specific yield.
Leachate Collection	A system of trenches, pipes, or other conveyances which are used to intercept a groundwater and/or surface water and contaminants mixture resulting from a particular site.
POTW	A public owned treatment works (POTWs), like North Charleston sewage treatment facility, treats domestic and industrial waste.
NPDES Discharge	A National Pollutant Discharge Elimination System (NPDES) permit is used to control the discharge of pollutants to waters of the states and United States.
Land Application	Wastewaters applied to surface soil for the purpose of evaporation or infiltration. Land application is considered to be a nondischarge under NPDES permitting.
Reinjection	The aquifer is recharged by pumping or leaching wastewaters back into the aquifer using wells or subsurface drains.
Surface Controls	These measures are designed to reduce or prevent direct contact with contaminated surface soil and to reduce the spread of contaminants by volatilization, tracking, tidal action, or wind.
Capping	Capping is an engineering control in which an area of contamination is covered to reduce surface infiltration and direct contact with the contaminants.
Landfill	A landfill is an engineering control where contaminants are placed in or on the ground and covered. A landfill may have liners on the bottom, sides, and top. A landfill may be used to contain contaminants or encapsulate them.
Storm Water Controls	These are best management practices to control the release of storm water and to control and reduces erosion and sedimentation.
Dredging	This is the process of using hydraulic pumps or draglines to remove soil, sediment, and sludge from water bodies.
Clean, Inspect, and Repair Sewer Lines	Storm, sanitary, and industrial sewer lines convey contaminants and water mixtures to treatment facilities or disposal points. Contaminants may be trapped and accumulate in the lines or lines may become damaged causing them to either exfiltrate or infiltrate contaminants. Lines can be cleaned using a number of methods including but not limited to pressure washing, pigging, brushing, etc. Inspection can be made by visual or sounding. Repairs can be accomplished by slip lining, grouting, or replacement.

Table A-2
Definition of Matrix Treatment Technologies

Technology	Description
Long-term Monitoring	This is the process of sampling and analyzing impacted environmental media over a period of years.
Institutional Controls	These are controls like deed restrictions, posting signs, erecting fences and other barriers which may restrict use or access to a contaminated area.
Intrinsic	This is the process of using natural attenuation to contain contaminants with other technologies to enhance attenuative process, such as precipitation, ion exchange, bioremediation, reduction, oxidation, dilution, etc.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
No Action	• No cost would be incurred other than monitoring.	• Does not reduce exposure potential for human or environmental receptors. • Would not reduce mobility, toxicity, or volume of contaminants	Retained	May not be protective of human health or the environment.
Biodegradation (in situ)	• Treatment would reduce volume, toxicity, and mobility of contaminants present. • Polynuclear aromatics and organic aromatics are amenable to biological treatment. • No air emissions or secondary wastestreams are produced.	• Bench-scale treatability studies would be required. • Soil matrix may prohibit contaminant-microorganism contact. • High concentrations of heavy metals or inorganic salts may be toxic to microorganisms. • Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain.	Retained	Potentially applicable to contaminants of concern.
Bioventing (in situ)	• Demonstrated at pilot-scale for treating hydrocarbons in soil. • Reduces toxicity and volume of organics. • No secondary waste streams. • Not subject to Resource Conservation and Recovery Act (RCRA) land disposal restrictions.	• Significant time and expense for laboratory degradation studies and field demonstrations. • Injected air may mobilize volatiles in the vadose zone. • Strict operating controls are required to maintain optimal biodegration environment.	Retained	Capable of treating organics. May be used with soil vapor extraction.
White Rot Fungus (in situ)	• Treatment would reduce volume, toxicity, and mobility of conventional explosives in soil. • Contaminants are degraded to nontoxic compounds. • No air emissions or secondary wastestreams are produced.	• Bench-scale treatability studies would be required. • Soil matrix may prohibit contaminant-microorganism contact. • High concentrations of heavy metals or inorganic salts may be toxic to microorganisms. • Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain.	Eliminated	Potentially applicable to explosive contaminants of concern.
Pneumatic Fracturing (in situ)	• Applicable to silts, clays, shale, and bedrock. • Creates fractures in vadose zone for soil venting.	• May open new pathways for contaminant to spread.	Eliminated	Shallow groundwater table limits its use.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Soil Flushing (in situ)	• Can be used in conjunction with groundwater treatment. • Effective for removal of organics from permeable soil. • Not subject to RCRA land disposal restrictions. • Full-scale units are available.	• Difficulty in treating complex waste mixtures. • Potential for uncontrolled migration of contaminants to groundwater. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction.	Eliminated	Not effective for fine-grained clay fractions and complex wastes.
Soil Vapor Extraction (in situ)	• Reduces mobility, toxicity, and volume of contaminants if vapors are collected and treated. • Effective for extraction of volatiles from unsaturated zone. • Demonstrated capability for extracting up to 2,000 pounds of volatiles per day. • Extraction equipment and experienced vendors are readily available.	• Dispersion of vapors could result in localized concentrations of contaminants near the wellhead. • Contaminants with low vapor pressure cannot be effectively removed. • Extensive soil, air, and groundwater monitoring required, including soil borings. • Treatment of metals remaining in soil potentially required. • Not effective for treating soil with a high moisture content, like those at Charleston.	Retained	Capable of treating organic contaminants. May be used with air sparging or bioventing.
Solidification/ Stabilization (in situ)	• Technology has been demonstrated at pilot scale for metals. • Reduces mobility of metals. • Not subject to RCRA land disposal restrictions.	• High concentrations of organics may interfere with the setting agent. • Reagent and waste ratios are difficult to control. • Volume of contaminated media increases. • Verification of treatment can be difficult.	Retained	May be effective in reducing mobility of metals.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Thermally Enhanced Soil Vapor Extraction (in situ)	• Reduces mobility, toxicity, and volume of contaminants if vapors are collected and treated. • Effective for extraction of volatiles and semivolatiles from unsaturated zone. • After application bioremediation may be used to treat residuals. • Extraction and hot air/steam injection equipment is readily available.	• Performance depends on maximum temperature achieved. • Tight soil structure or high moisture content may decrease air permeability. • Not effective in the saturated zone. • Dispersion of vapors could result in localized concentrations of contaminants near the wellhead. • Contaminants with low vapor pressure cannot be effectively removed. • Extensive soil, air, and groundwater monitoring required, including soil borings. • Treatment of metals remaining in soil potentially required.	Eliminated	May be capable of treating SVOCs.
Vitrification (in situ)	• Reduces mobility, toxicity, and volume of organics and mobility of heavy metals. • Process has been tested on a broad range of volatiles and semivolatiles including dioxins, and most metals. • Not subject to RCRA land disposal restrictions.	• Treatability studies will be required. • Heating may cause contaminant migration. • Solidified soil may hinder future site use. • Processing contaminants below the water table may require some recharge. • This technology is very expensive to implement.	Retained	Energy requirements would be large.
Composting (ex situ)	• Widely used technology for organic wastes and does not require specialized operating personnel. • Minimal operating cost. • No secondary wastestream generated. • Operating equipment readily available. • Treated soil can be used for backfilling. • Very cost-effective method of treatment.	• Treatability studies may be necessary for site-specific wastes. • Release of volatiles release may be uncontrolled. • Heavy metals are not treated.	Retained	Capable of treating site contaminants.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Biological Treatment (ex situ)	• Treatment would reduce volume, toxicity, and mobility of contaminants present. • Polynuclear aromatics (PAHs), organic aromatics, chlorinated organics, and PCBs are amenable to biological treatment.	• Bench-scale treatability studies would be required. • Soil matrix may prohibit contaminant-microorganism contact. • High concentrations of heavy metals or inorganic salts may be toxic to microorganisms. • Air emissions may be produced during phasing.	Eliminated	May be difficult with the type of soil onsite.
Landfarming (ex situ)	• Treatment would reduce volume, toxicity, and mobility of contaminants present. • PAHs and organic aromatics, are amenable to biological treatment. • Farming equipment and experienced vendors are readily available.	• Bench-scale treatability studies would be required. • Soil matrix may prohibit contaminant-microorganism contact. • High concentrations of heavy metals or inorganic salts may be toxic to microorganisms. • Air emissions may be produced.	Retained	Potentially applicable to contaminants of concern.
Slurry-phase Biological Treatment (ex situ)	• Treatment would reduce volume, toxicity, and mobility of contaminants present. • PAHs, organic aromatics, chlorinated organics, and polychlorinated biphenyls (PCBs) are amenable to biological treatment. • Favored for heterogenous soil, low-permeability soil, and where groundwater capture is difficult.	• Bench-scale treatability studies would be required. • Sizing of materials can be difficult and expensive. • Dewatering soil fines after treatment can be expensive. • Wastewater will require treatment.	Eliminated	May be difficult and expensive to implement.
Chemical Reduction/ Oxidation (ex situ)	• Treatment would reduce toxicity, and mobility of contaminants. • Reduces or oxidizes inorganics. • Proven full-scale technology.	• Incomplete oxidation or formation of intermediate may occur. • Not cost-effective for high concentrations. • Oil and grease should be minimized.	Retained	Capable of treating inorganics present in the soil.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Dehalogenation (ex situ)	• Treatment would reduce toxicity and mobility of contaminants. • Contaminants are decomposed. • Treats halogenated semivolatiles and pesticides.	• High clay and moisture content increase treatment cost. • Alkaline metals, humic content, and total organic halides affect processing time and cost. • Requires sludge, water, and air treatment systems.	Retained	Technology requires material handling and process residuals treatment.
Dehalogenation (glycolate) (ex situ)	• Treatment would reduce toxicity and mobility of contaminants. • Treats halogenated semivolatiles and pesticides. • One of few processes for treating PCBs other than incineration.	• Bench-scale treatability studies would be required. • Alkaline metals, humic content, and total organic halides affect processing time and cost. • Requires sludge, water, and air treatment systems. • Not cost-effective for large volumes.	Retained	Capable of treating PCBs in the soil onsite.
Soil Washing (ex situ)	• Demonstrated at full-scale for removal of metals from soil. • Wide application to varied waste groups. • Mobile units are available.	• Potential difficulty in removing washing solution from soil. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fractions. • Not effective for treating complex wastes (i.e., volatiles, semivolatiles, pesticides, and inorganics).	Retained	May be used for treating coarse-grained soil with either SVOCs, fuels, or inorganics.
Soil Vapor Extraction (ex situ)	• Reduces mobility, toxicity, and volume of contaminants if vapors are collected and treated. • Effective for extraction of volatiles from soil piles. • Extraction equipment and experienced vendors are readily available.	• Air emissions may occur during excavation and material handling. • High humic content or fine-grained soil inhibits volatilization. • Residuals and air emissions require treatment. • A large space is required.	Retained	Capable of treating organic compounds.
Solidification/ Stabilization (ex situ)	• Technology has been demonstrated at pilot scale for metals. • Reduces mobility of metals. • Not subject to RCRA land disposal restrictions.	• High concentrations of organics may interfere with the setting agent. • Reagent and waste ratios are difficult to control. • Volume of contaminated media increases. • Long-term effectiveness not demonstrated.	Retained	Effective in binding metals.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Solvent Extraction (ex situ)	• Extracts contaminants from soil so they may be treated using best demonstrated available technologies. • Effective in treating sludge, sediment, and soil with PCBs, semivolatiles, halogenated solvents, and fuels.	• Traces of extracting solvent remain in soil. • Solvent extraction is least effective on very high molecular weight organics. • Extraction is difficult on fine-grained soil and soil with high moisture content.	Retained	Capable of treating site contaminants but limited to coarse-grained soil.
High-temperature Thermal Desorption (ex situ)	• Used for volatilizing organics and in combination with incineration, solidification/stabilization, or dechlorination for complex mixtures. • Targets semivolatiles, PAHs, PCBs, and pesticides with varying degrees of effectiveness.	• Fine-grained soil impact applicability and cost. • Dewatering may be required. • Treatability testing is needed.	Retained	Capable of treating semivolatile orgaincs.
Hot Gas Decontamination (ex situ)	• Technology is used for treating explosive-contaminated material.	• Cost is higher than open burning. • Flash chamber must be properly designed.	Retained	Explosives have not been detected in site soil.
Incineration (ex situ)	• Destruction and removal efficiencies are greater than 99.99 %, thus reducing volume of contaminants. • Technology is reliable and has been demonstrated for treating organics at full scale. • Widely used for treatment of organics wastes. • Mobile units area available.	• Treatment of volatile metals (e.g., lead) collected by air pollution control equipment potentially required. • Treatment of inorganics remaining in soil potentially required. • Incineration of RCRA waste would require trial burns to receive permits to operate.	Retained for offsite	This technology will be retained for offsite treatment.
Low-temperature Thermal Desorption (Ex situ)	• A physical separation process to volatilize water and organic contaminants. • A proven full-scale technology. • Afterburner can destruct contaminants to 95%. • Treated soil may support biological activity.	• Will not treat metals. • Dewatering may be needed. • Specific feed size and material handling may impact applicability or cost. • Secondary wastestream may require further treatment.	Retained	Capable of treating organics.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Open Burn/Open Detonation (ex situ)	• Used to destroy explosives, pyrotechnics, propellants and munitions. • A proven full-scale technology.	• Large space required. • Emissions are difficult to capture. • Requires good weather.	Retained	Capable of treating explosives or munitions.
Pyrolysis (ex situ)	• Chemical decomposition of organic material in absence of oxygen.	• Emerging technology. • Secondary wastestream requires further treatment. • Specific feed size and material handling may impact applicability and cost. • Requires moisture content of <1%. • Will not treat metals.	Retained	Not cost-effective for site soil.
Vitrification (ex situ)	• Encapsulates inorganic contaminants, which reduces mobility. • Destructs organics.	• Organic offgases need to be controlled. • Metals may volatilize and require offgas system. • Use or disposal of slag is required.	Retained	Not cost-effective for site soil. Very high energy user.
Excavation, Retrieval, and Offsite Disposal	• Equipment is readily available. • Disposal facilities are readily available. • Quickly removes contaminants from the site and places them on another site where they may be contained, treated, or destroyed.	• Generates fugitive emissions. • Transportation through populated areas may affect community acceptability.	Retained	May be a cost-effective technology.
Natural Attenuation	• Natural process of reducing toxicity and mobility of contaminants. • Is acceptable for nonhalogenated volatiles, semivolatiles, and fuels.	• Intermediate degradation products may be more mobile and more toxic than the original contaminant. • Contaminants may migrate before they degrade. • Site may have to be fenced and not reused until contaminant concentrations are reduced.	Retained	Cost for modeling contamination degradation rates may be justified.

Table A-3
Screening of Corrective Measure Technologies for Soil, Sediment, and Sludge

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Filter Press	• Demonstrated technology for dewatering sludges. • Several equipment choices exist, centrifuge, belt filter press, vacuum filter press, plate filter press, and sand beds which are available off-the-shelf. • Reduces volume and moisture content of sludge to be handled, treated, or disposed of.	• Sludge and residual water may require further treatment. • Does not reduce toxicity of contaminants.	Retained	Technology is used with other technologies.

Table A-4
Screening of Corrective Measure Technologies
for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
No Action	• Least costly	• May not be protect human health and environment.	Retained	May not be protective.
Cometabolic Treatment	• Uses secondary substrate transformation for primary substrate oxidation. • Degrade volatiles and semi-volatiles.	• Pilot study required. • Not demonstrated on a practical scale. • Heterogeneous subsurface is difficult to treat.	Eliminated	Not demonstrated technology.
Nitrate Enhancement	• Enhances anaerobic biodegradation of nonhalogenated volatiles, semivolatiles, and fuels. • Uses naturally occurring microbes.	• Technology is not proven effective. • Heterogeneous subsurface is difficult to treat. • Nitrate has a maximum contaminant level of 10 parts per million. • Nitrates are prohibited from being injected.	Eliminated	Nitrates are prohibited from being injected.
Oxygen Enhancement with Air Sparging	• Injected air may volatilize contaminants from the saturated zone to the vadose zone. • Effective for volatiles when used in conjunction with soil vapor extraction. • Can enhance naturally occurring microbes. • Primarily designed to treat nonhalogenated volatiles, semivolatiles, and fuels.	• Treatability studies may be required to determine proper dispersion rates and well spacing. • Extensive soil, air, and groundwater monitoring required. • Clay layers may reduce effectiveness.	Retained	Would provide effective treatment if combined with soil vapor extraction.
Oxygen Enhancement with H_2O_2	• Uses hydrogen peroxide to enhance aerobic biodegradation of naturally occurring microbes. • Treats volatiles, semivolatiles, and fuels.	• Difficult to circulate solution through a heterogeneous subsurface. • High iron content may rapidly reduce concentration of hydrogen peroxide. • Biofouling wells will retard input of nutrients. • Recovered groundwater may be treated prior to being reinjected.	Eliminated	Limited aquifer could become further limited with this technology.

Table A-4
Screening of Corrective Measure Technologies for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Air Sparging	• Not subject to RCRA land disposal restrictions. • Injected air may volatilize contaminants from the saturated zone to the vadose zone. • Effective for volatiles when used in conjunction with soil vapor extraction. • Can enhance naturally occurring microbes. • Primarily designed to treat nonhalogenated volatiles, semivolatiles, and fuels.	• Treatability studies may be required to determine proper dispersion rates and well spacing. • Extensive soil, air, and groundwater monitoring required. • Clay layers may reduce effectiveness.	Retained	Would provide effective treatment if combined with soil vapor extraction.
Directional Wells (enhancement)	• A horizontal or angle well to enhance other in situ technologies. • Vendors are readily available.	• Well failure due to collapse or installation. • Costly. • Limited to depths of less than 50 feet.	Retained	May be a technology to use beneath buildings or other surface structures.
Dual-phase Extraction	• A high-vacuum system to remove liquid and vapor from low-permeability or heterogeneous zones. • Equipment is readily available. • Recovers volatiles and fuels.	• Site geology and contaminant distribution may limit effectiveness. • May require a high-yielding aquifer. • Requires treatment of recovered water and vapor or gas.	Retained	May be used as a pump and treat system.
Free-product Recovery	• Removes liquid-phase organics for further treatment or reuse. • Is a full-scale technology. • Primary for the recovery of semivolatiles and fuels.	• Site geology and aquifer yield may limit the technology's application and effectiveness. • Technology is used for containment.	Retained	Acceptable technology for containment.
Hot Water or Steam Flushing/Stripping	• Vaporize volatile and semivolatile contaminants. • Technology is applicable to shallow and deep contaminated areas.	• Site geology and aquifer yield may limit the technology's application and effectiveness. • Other technologies are more cost-effective.	Eliminated	Technology is not readily available for full scale.
Hydrofracturing (enhancement)	• Can be used on fine-grained soil. • Enhances other in situ technologies.	• Provides potential pathways for mobility of contaminants.	Eliminated	Technology is not likely to be used.

Table A-4
Screening of Corrective Measure Technologies for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Passive Treatment Wells	• Can be a relatively inexpensive treatment system for groundwater passing through it. • Equipment is readily available for shallow installation. • May be applied to volatiles, semivolatiles, and inorganics.	• May lose their reactive capacity over time. • Requires consistent pH control. • Biological activity may limit barrier permeability.	Retained	May apply to chlorinated organics.
Slurry Walls (containment only)	• May reduce mobility of contaminants. • Is a full-scale technology. • Divert groundwater from drinking water intakes.	• Containment would not reduce the toxicity or volume of contaminants. • Walls may degrade or deteriorate over time. • Are limited to depths of 50 feet or less.	Retained	May apply to contain leachate or groundwater.
Vacuum Vapor Extraction	• Technology may be used for halogenated volatiles, semivolatiles, and fuels. • Contaminants are stripped from groundwater within the well. • Groundwater is not brought to the surface.	• Technology is pilot scale. • Shallow aquifers may limit process effectiveness.	Eliminated	Technology is still being developed.
Bioreactors	• Treatment would reduce volume, toxicity, and mobility of contaminants. • Polynuclear aromatics and organic aromatics are amenable to biological treatment. • Aerobic reactors may be suspended or attached growth types.	• Bench-scale treatability studies would be required. • Residuals will require treatment and disposal. • High contaminant concentration may be toxic to microbes. • Low ambient temperatures impact biodegradation rates.	Retained	Potentially applicable to contaminants of concern.
Air Stripping	• Treatment would reduce the volume of contaminants in groundwater. • Proven and reliable treatment technology for organics.	• Offgasses may require collection, treatment, and disposal. • Pretreatment may be need for inorganics to prevent fouling. • Treatment is not effective for low volatile contaminants. • Posttreatment may be required to meet wastewater discharge requirements.	Retained	Capable of treating VOCs in groundwater.

Table A-4
Screening of Corrective Measure Technologies
for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Filtration	• Effectively treats metals and oils. • Is used as a pretreatment or posttreatment process.	• Requires treatability studies. • Expended filters require disposal. • High suspended solids can clog filter.	Retained	Capable of pretreating metals.
Ion Exchange	• Effectively treats metals. • Demonstrated technology. • Experienced vendors available. • Effective as a polishing step in metal treatment.	• Does not reduce toxicity or volume. • Requires a treatability study. • Wastewater requires additional treatment and disposal.	Retained	Potentially effective for treating metals.
Liquid-phase Carbon Adsorption	• Treatment effectively removes semivolatiles and explosive contaminants. • Technology is reliable and has been demonstrated. • Can be used for liquid or vapor-phase contaminants. • Equipment and vendors are readily available.	• Suspended solids may clog the carbon bed if not removed. • Spent carbon has to be treated or disposed. • Metals can foul the system. • Cost are high as a primary treatment.	Retained	Capable of treating organics in the groundwater.
Precipitation	• Metal concentrations can be reduced to low parts per million. • Mobile units are readily available. • Treatment is well demonstrated.	• Produces sludge requiring further treatment and disposal which may be more toxic. • Relatively long detention times required. • Solids separation is required.	Retained	Capable of treating metals.
Ultraviolet Oxidation	• Destructs organic contaminants. • No air emissions or sludge are produced. • Effective for aromatics and chlorinated aliphatic. • Several vendors are available.	• Suspended solids may limit treatment. • Treatability study required. • Costs are higher than other technologies. • Groundwater will require pretreatment.	Retained	Capable of treating organics with pretreatment.
Natural Attenuation	• Natural process of reducing toxicity and mobility of contaminants. • Is acceptable for nonhalogenated volatiles, semivolatiles, and fuels.	• Intermediate degradation products may be more mobile and more toxic than the original contaminant. • Contaminants may migrate before they degrade. • Site may have to be fenced and not reused until contaminant concentrations are reduced.	Retained	Potentially applicable to site conditions and contaminants.

Table A-4
Screening of Corrective Measure Technologies for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
pH Adjustment	• Reduces the toxicity or mobility of contaminants. • Effective for inorganics and biological process. • Equipment and vendors are readily available.	• Bench-study needed. • May raise a wastewater temperature or create hydrogen gas. • Chemical can attack treatment vessel materials. • Increase total dissolved solids. • Can produce toxic gases.	Retained	Potentially applicable to site contaminants as secondary or primary treatment.
Reverse Osmosis	• Applicable at near-neutral pHs. • Demonstrated to work well on inorganics and nitrate removal. • Developed for separation of oil/water emulsions.	• Treatability studies would be required. • Works on oily wastestreams. • Requires pretreatment • High cost to operate and maintain.	Eliminated	Not applicable for dilute solutions in groundwater.
Wet Air Oxidation	• Technology achieve 80% efficiency oxidation of organics. • Treatment would reduce volume of contaminants.	• This technology is costly. • Mobile units are not available.	Retained	Technology may be applicable to polychlorinated biphenyl mixture with groundwater.
Ultraviolet Reduction	• Treatment destructs organics into carbon dioxide and water or nontoxic intermediates. • No air emissions or sludge.	• Reliability has not been demonstrated. • Treatability studies are needed. • Pretreatment is required.	Retained.	Technology reliability has not been demonstrated but may apply.
Sedimentation	• Treatment is based on Stoke's Law, particle size, and gravity. • Technology is reliable and demonstrated. • Technology will not reduce toxicity. • Technology can be used with many other technologies.	• Technology is limited to particle size, flow rate, and depth of flow. • Technology is limited to inorganics attached to soil particles or floc. • Technology is limited on emulsions.	Retained	Technology is reliable and demonstrated.

Table A-4
Screening of Corrective Measure Technologies
for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Oil/Water Separation	• Treatment is based on Stoke's Law, particle size, and gravity. • Technology is reliable and demonstrated. • Technology will not reduce toxicity. • Technology can be used with many other technologies. • Technology is readily available.	• Technology is limited to organics or soil particles and nonwater soluble light and dense product. • Technology is limited on emulsions. • Ten parts per million and less oil will pass through without treatment.	Retained	Demonstrated technology.
Dissolved Air Flotation	• Technology is reliable and demonstrated for recovering product from emulsions. • Technology is available. • Technology concentrates sludges and oils.	• Bench-scale study may be needed. • Air emissions will need to be collected and treated.	Retained	Technology is reliable and demonstrated.
Resin Adsorption	• Treatment would reduce the volume of contaminants. • Removes organics and metals. • Capable of treating high flows.	• Process concentrates contaminants within the resin, requiring further treatment and disposal. • Reliability of this technology has not been demonstrated. • Treatability testing would be required.	Eliminated	Reliability has not been demonstrated.
Land Application	• Proven treatment for waters containing organics and metals. • Reduces some of the organics by biodegradation.	• Requires a large land area. • Requires permeable soil. • Applies contaminants to surface soil. • Air emissions. • Requires groundwater extensive monitoring.	Eliminated	Technology requires a large land area.
Aquatic Plant System	• Uses lined pond on which plants grow. • Treats some organics and inorganics. • A natural biological degradation and sorption process. • Used as a secondary treatment.	• Long retention times. • Requires an area where mosquitoes and odor can be tolerated. • Plant harvest and wastewater would require further treatment or disposal.	Eliminated	Technology requires long retention time.

Table A-4
Screening of Corrective Measure Technologies for Groundwater, Surface Water, and Leachate

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Natural Wetlands	• Uses native plants to uptake contaminants. • Used as a secondary treatment. • Provides a habitat for wildlife. • Acceptable technology for waste water.	• Long retention times and flow critical. • Requires an area where mosquitoes and odor can be tolerated. • Natural wetland require permitting.	Retained	Natural wetlands are present onsite.
Oxidation/Reduction	• Treatment would reduce toxicity, and mobility of contaminants present. • Reduces or oxidizes inorganics. • Proven full-scale technology.	• Incomplete oxidation or formation of intermediate may occur. • Not cost-effective for high concentrations. • Oil and grease should be minimized.	Retained	Applicable to inorganic contaminants.

Table A-5
Screening of Corrective Measure Technologies
for Air Emissions/Offgas

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
No Action	• Allows for natural dispersion. • May not require a permit.	• May not protective of human health and environment.	Retained	May not be protective.
Biofiltration	• Vapor-phase organics are degraded by microorganisms in packed media. • Offgas is carbon dioxide. • Reduces volume, toxicity and mobility of contaminant. • Halogenated volatiles can be treated.	• Rate of influent air is constrained by the size of biofilter. • Fugitive fungi may be a problem. • Low temperatures may slow or stop effectiveness.	Retained	Technology may apply to site contaminants and treatment of other technology offgas.
High-energy Corona	• Destroys volatiles at room temperature. • Used to treat volatiles and semivolatiles.	• Not a demonstrated full-scale technology.	Eliminated	Not a proven demonstrated technology.
Membrane Separation	• Process uses a condenser and a spiral-wound membrane to remove volatile organics. • Technology has shown a 95% removal efficiency.	• Technology is not reliable and has not been demonstrated full scale.	Eliminated	Not a proven demonstrated technology.
Oxidation	• Catalytic oxidation can destruct volatiles and semivolatiles including some halogenated volatiles. • About 50% of heat produced is recovered. • Several commercially catalysts are available.	• Sulfur or halogenated compounds require special catalysts and additional flue gas scrubber. • Influent gas concentrations must be <25% of the lower explosive limit. • Chlorinated hydrocarbons and heavy metals may poison the catalyst.	Retained	Applicable as a secondary technology to other technologies.
Vapor-phase Carbon Adsorption	• A readily available technology which can be provided by many vendors. • Carbon can be regenerated.	• Does not reduce the toxicity of contaminant. • Further treatment of the contaminant is required.	Retained	Proven technology.
Flare	• A readily available technology for landfill gas. • Proven and demonstrated technology for landfill gas.	• Nonmethane gas generate acids which requires the effluent air stream to be further treated. • Requires another fuel source.	Eliminated	Oxidation can be applied where a flare can.

Table A-5
Screening of Corrective Measure Technologies for Air Emissions/Offgas

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Condensers	• Surface condensers produce relatively small volume of wastewater. • Recovered condensate may be recycled. • Proven technology.	• Pretreatment is needed for dehumidification.	Retained	Applies as a secondary technology to other technologies.
Absorbers	• Proven technology with readily available equipment and vendors. • Removes volatiles and semivolatiles from air or gas stream.	• Not suited for gas streams with appreciable amounts of particles. • Absorbents do not work well for multicontaminants. • Absorbent and wastewater will require further treatment.	Eliminated	Vapor-phase carbon adsorption can be used in place of this technology.
Filter Fabric	• Several filter fabrics are available. • Has a particle efficiency of 99% down to 0.3 microns particle size.	• Gaseous contaminants are not affected. • An explosion can occur.	Retained	Technology may be required as part of a material handling system.
Electostatic Precipitators	• Highly effective, efficiencies exceeding 99%. • Low power requirement. • Low maintenance requirements. • Some acids and tar mists are effectively collected. • Equipment and vendors are readily available.	• High capital cost. • Large space requirement. • Gaseous contaminants are not affected.	Retained	Technology is a secondary treatment technology.
Wet Scrubber	• Can remove particles from a gas stream. • Liquid can be used to remove volatilized contaminants from the gas stream.	• Particles and wastewater will require further treatment and disposal. • Does not reduce the toxicity of contaminants.	Retained	Technology is a secondary treatment technology.
Dust Suppressants	• Several dust suppressants are on the market, including water. • Reduces the mobility of a contaminant, particularly an inorganic contaminant by being windborne or by vehicular traffic.	• May mask the contaminant.	Retained	Applicable technology to sites being excavated.

Table A-6
Screening of Corrective Measure Technologies for Removal, Containment, and Disposal Options

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Groundwater Extraction	• High design flexibility. • Construction costs may be lower than groundwater barriers. • Good reliability when properly monitored.	• May not adequately drain fine-grained silty soil. • High operation and maintenance cost.	Retained	A reliable technology.
Leachate Collection	• Operation costs are inexpensive. • Provides a means of collecting leachate without the use of impervious liners. • Technology is reliable provided there is continuous monitoring.	• Not suited for fine-grained silty soil. • Technology requires monitoring.	Retained	Technology may be applicable.
Public Owned Treatment Works	• May be used as primary or secondary treatment. • Low capital costs. • Can be used as point source discharge.	• May require pretreatment. • Requires monitoring.	Retained	Technology is applicable to the disposal of treated groundwater and leachate.
National Pollutant Discharge Elimination System Discharge	• Allows the discharge of large volumes of treated waste-water to be disposed in surrounding surface waters. • Discharge is regulated by the treatment system operator.	• Requires a permit and public notice. • Requires continuous monitoring.	Retained	Technology applies to storm water discharges and treated wastewater discharges.
Land Application	• Applies wastewater to surface for evaporation and infiltration. • May assist in attenuating organics and inorganics. • May assist in flushing contaminants in the subsurface soil.	• Requires a permit and public notice. • Requires continuous monitoring. • Not suited for fined-grained soil with high moisture content.	Retained	Technology may be used with other technologies.
Reinjection	• Alters hydraulic gradient of groundwater for containment and flushing. • Allows groundwater removal without complete dewatering. • May be used to deliver nutrient and oxygen to the subsurface.	• May require a permit and public notice. • Requires continuous monitoring. • Not suited for fine-grained soil.	Retained	Technology may be applicable with other technologies.

Table A-6
Screening of Corrective Measure Technologies for Removal, Containment, and Disposal Options

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Surface Controls	• Stabilizes surface soil from runoff and infiltration and collects or traps sediments. • Proven and reliable technologies. • Equipment and vendors are readily available.	• Surface seals may crack and plastic and rubber liners are subject to tearing and degradation by sunlight. • Grading may require soils from offsite. • Improperly installed dikes and berms may increase seepage. • Berms, ditches, and levees will require maintenance.	Retained	Technology is reliable.
Capping	• Reduces direct contact with contaminants. • Reduces leachate production by limiting infiltration. • Contains contaminants.	• Does not reduce toxicity nor volume of contaminants.	Retained	Technology is good at containing the contaminants and removing the potential for direct contact with contaminant.
Landfill	• Contains contaminants. • Reduces direct contact with contaminants. • Reduces leachate production by limiting infiltration. • Consolidates contaminants into one management unit.	• Requires proper engineering controls and long-term monitoring. • Does not reduce toxicity nor volume of contaminants. • May transfer contaminants to on offsite areas without treatment. • Resource Conservation and Recovery Act (RCRA) land disposal restrictions apply.	Retained	Technology may be cost-effective.
Storm Water Controls	• Sediment basins, traps, check dams, pipes, and ditches are available technology for storm water controls. • Required technology for sites over 5 acres. • Diverts storm water from being in contact with contaminants.	• Requires maintenance. • May only apply to a portion of the storm water.	Retained	Technology may be required.
Dredging	• Equipment and vendors are readily available. • Applicable to large areas. • Efficient removal of solids and water mixtures.	• Necessity of locating spoil management facilities. • Necessitates high-volume handling of solids and water mixtures. • Mobilization may be costly.	Retained	Technology may apply to sediments in the surface water bodies.

Table A-6
Screening of Corrective Measure Technologies for Removal, Containment, and Disposal Options

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Clean, Inspect, and Repair Sewer Lines	• A number of in situ cleaning, inspecting, and repairing technologies are reliable and cost-effective. • Reduces contaminant migration pathway. • Improve the quality of the line and reduces potential for failure.	• May disrupt sewer use. • Will not reduce infiltration/exfiltration.	Retained	Technology is retained for the site sewer and storm sewer lines.
Long-term Monitoring	• Provides a measure of contaminant migration. • It may use existing groundwater monitoring wells.	• Does not reduce the toxicity, volume, or mobility of a contaminant. • May be regulatory binding. • High operations and maintenance (O&M) cost.	Retained	May be applicable with other technologies.
Institutional Controls	• Provides for limited exposure to contaminants. • Allows properties to continue to be used for existing purpose without significant cleanup. • Provides governmental control over the use of property.	• Does not reduce contaminant toxicity, volume, or mobility. • Restricts use of land.	Retained	May be applicable with other technologies.
Intrinsic	• Relies on natural attenuation processes. • Little capital cost.	• Does not reduce the toxicity, volume, or mobility of a contaminant. • High O&M cost.	Retained	May apply to residues.