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TETRA TECH NUS

Comprehensive Long-term Environmental Action Navy

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Feasibility Study
for
Site 4 – Golf Course Landfill

Naval Construction Battalion Center Gulfport
Gulfport, Mississippi

Contract Task Order 0068

November 2009

NAS Jacksonville
Jacksonville, Florida 32212-0030

TETRA TECH NUS, Inc.

FEASIBILITY STUDY
FOR
SITE 4 – GOLF COURSE LANDFILL

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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This document, which describes the Feasibility Study for Site 4, *Golf Course Landfill,* at Naval Construction Battalion Center (NCBC) Gulfport, Mississippi, was reviewed by a registered professional engineer. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document was prepared for Site 4 at NCBC Gulfport, Mississippi and should not be construed to apply to any other site.

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TABLE OF CONTENTS

SECTION **PAGE**

PROFESSIONAL CERTIFICATION iii
EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1
1.1 CERCLA FS PROCESS 1-1
1.2 PURPOSE 1-3
1.3 ENVIRONMENTAL CONDITIONS 1-5
1.4 SITE DESCRIPTION 1-5
1.5 WASTE DISPOSAL AREA 1-5
1.6 SOIL ASSESSMENT 1-6
1.7 GROUNDWATER ASSESSMENT 1-7
1.8 SURFACE WATER AND SEDIMENT ASSESSMENT 1-7
1.9 CHEMICALS OF CONCERN 1-9
1.10 CONCLUSIONS 1-11
1.11 REPORT ORGANIZATION 1-11

2.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS 2-1
2.1 REMEDIAL ACTION OBJECTIVES 2-1
2.1.1 ARARs and TBC Criteria 2-1
2.1.2 Constituents and Media of Concern 2-3
2.1.3 Preliminary Remediation Goals 2-4
2.1.4 Statement of RAOs 2-5
2.2 GENERAL RESPONSE ACTIONS 2-6
2.3 ESTIMATED VOLUMES OF CONTAMINATED MEDIA 2-6

3.0 SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF PRESUMPTIVE REMEDY COMPONENTS AND ALTERNATIVES 3-1
3.1 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS 3-2
3.2 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS 3-3
3.2.1 No Action 3-3
3.2.2 Land Use Controls 3-3
3.2.3 Monitoring 3-4
3.2.4 Containment 3-4
3.3 SELECTION OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS 3-9
3.4 DEVELOPMENT OF ALTERNATIVES 3-10
3.4.1 Alternative 1: No Action 3-10
3.4.2 Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management 3-10

4.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 4-1
4.1 INTRODUCTION 4-1
4.1.1 Evaluation Criteria 4-1
4.1.2 Relative Importance of Criteria 4-5
4.1.3 Selection of Remedy 4-5
4.2 ASSEMBLY OF REMEDIAL ALTERNATIVES 4-6
4.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 4-6
4.3.1 Alternative 1: No Action 4-6
4.3.2 Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management and Monitoring 4-8

TABLE OF CONTENTS (CONTINUED)

SECTION **PAGE**

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES 5-1
5.1 COMPARISON OF REMEDIAL ALTERNATIVES BY CRITERIA 5-1
5.1.1 Overall Protection of Human Health and the Environment 5-1
5.1.2 Compliance with ARARs and TBCs 5-1
5.1.3 Long-Term Effectiveness and Permanence 5-2
5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment 5-2
5.1.5 Short-Term Effectiveness 5-2
5.1.6 Implementability 5-2
5.1.7 Cost 5-3
5.2 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES 5-3

REFERENCES R-1

APPENDICES

A PRESUMPTIVE REMEDY INFORMATION/DETERMINATION
B COSTS
C TREATABILITY STUDY MEMORANDUM
D COVER ASSESSMENT
E REMEDIAL SITE CONCEPTUAL EXPOSURE MODEL
F REGULATORY REVIEW COMMENTS

TABLES

NUMBER

1-1 Chemicals of Concern From Chemicals of Potential Concern
1-2 Chemicals of Concern From Ecological Chemicals of Potential Concern
2-1 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria
2-2 Chemicals of Concern by Media with Appropriate PRGs
5-1 Comparative Analysis of Remedial Alternatives

FIGURES

NUMBER

1-1 Vicinity Map
1-2 Location Map
1-3 Magnetometer Results
1-4 EM-61 Results
1-5 Vinyl Chloride in Groundwater and Selected Monitoring Well Results
2-1 Potentiometric Surface – September 2007
3-1 Alternative 2

ACRONYMS

ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or relevant and appropriate requirement
ARD	Anaerobic reductive dechlorination
bls	Below land surface
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chemical of concern
COPC	Chemical of potential concern
CTO	Contract Task Order
CVOC	Chlorinated volatile organic compound
DCA	Dichloroethane
DCE	Dichloroethene
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
DPT	Direct push technology
ESV	Ecological Screening Value
FS	Feasibility Study
GRA	General Response Action
HHRA	Human health risk assessment
HI	Hazard index
HO	Herbicide Orange
HpCDD	Heptachlorodibenzo-p-dioxin
HQ	Hazard quotient
IAS	Initial Assessment Study
IR	Installation Restoration
LUC	Land use control
MCL	Maximum contaminant level
MDEQ	Mississippi Department of Environmental Quality
mg/kg	Milligrams per kilogram
N/A	Not applicable or not available
NAVFAC SE	Naval Facilities Engineering Command, Southeast

ACRONYMS (Continued)

NCBC	Naval Construction Battalion Center
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
ng/kg	Nanograms per kilogram
NPW	Net present worth
OCDD	Octachlorodibenzo-p-dioxin
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
pg/L	Picograms per liter
PPE	Personal protection equipment
PRG	Preliminary remediation goal
RAO	Remedial action objective
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SCEM	Site conceptual exposure model
SLERA	Screening Level Ecological Risk Assessment
SVOC	Semivolatile organic compound
TBC	To be considered
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	Trichloroethene
TEQ	Toxicity equivalency quotient
TRG	Target remediation goal
TtNUS	Tetra Tech NUS, Inc.
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

The purpose of this Feasibility Study (FS) is to develop and evaluate alternatives for the remedial action for Site 4 – Golf Course Landfill at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-04-D-0055, Contract Task Order (CTO) 0068.

This FS describes the basis for and the evaluation of remedial alternatives for Site 4.

SITE DESCRIPTION AND HISTORY

Site 4 is an approximately 4 acre former landfill located in the northwestern section of NCBC Gulfport. The landfill area is located northeast of the intersection of 7th Street and Canal No. 1 and is adjacent to the driving range at the Pine Bayou Golf Course. The northwestern boundary of the landfill is adjacent to Canal No. 1.

The Site 4 landfill was operated from 1966 until 1972 and was the only operating landfill on the base at that time. Waste material was disposed in trenches, burned daily, and then the trenches were backfilled. Most, if not all, of the solid waste and some of the liquid and chemical waste generated at the base were disposed at Site 4 during the period of landfill operation [Naval Energy and Environmental Support Activity (NEESA), 1985]. As much as 200,000 gallons of waste liquids were disposed at the site including fuels, oils, solvents (methyl ethyl ketone, toluene, and xylene), paints, and paint thinners. In addition, 16,000 tons of solid waste were disposed at the landfill. Building and infrastructure debris were also disposed at the site following Hurricane Camille in 1969.

Canal No. 1 at Site 4 is approximately 30 feet wide and approximately 4 feet deep. Storm water run-off from the areas surrounding Site 4, primarily the southwestern portions of the base, flows into various tributary ditches which feed into Canal No. 1. Surface water in Canal No. 1 flows to the north and eventually leaves the NCBC Gulfport at the outfall located at 28th Street.

SUMMARY OF REMEDIAL INVESTIGATION

The overall purpose of the Remedial Investigation (RI) was to address potential risks associated with Site 4 and to develop and evaluate options for the remediation of contaminated soil at Site 4, following

presumptive remedy guidance as described by the United States Environmental Protection Agency (USEPA).

The data from the geophysical survey were used to identify disposal cell locations. The analytical results from the sampling efforts were screened against the appropriate Mississippi Department of Environmental Quality (MDEQ) Tier 1 (unrestricted) target remediation goals (TRGs) for human health and the USEPA Region 4 Biological Technical Assistance Group (BTAG) ecological receptor screening concentration values.

NATURE AND EXTENT OF CONTAMINATION

In soil, arsenic and dibenzo(a,h)anthracene were detected at concentrations greater than MDEQ Tier 1 unrestricted TRGs. Volatile organic compounds (VOCs), other semivolatile organic compounds (SVOCs), and several pesticides were detected, but at concentrations less than Tier 1 unrestricted TRGs.

In groundwater, iron, antimony, trichloroethene (TCE), cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and vinyl chloride were detected at concentrations greater than MDEQ Tier 1 TRGs. Several SVOCs were detected at concentrations less than Tier 1 TRGs.

In surface water, several VOCs, dioxins, and metals were detected, but all concentrations were less than MDEQ Tier 1 groundwater TRGs. In sediment, arsenic, benzo(a)pyrene, several polynuclear aromatic hydrocarbons (PAHs), and dioxin toxicity equivalency quotient (TEQ) were detected at concentrations greater than Tier 1 unrestricted TRGs.

As determined in the RI Report (TtNUS, 2009), arsenic, dioxins/furans, benzo(a)anthracene, dibenzo(a,h)anthracene, vinyl chloride, TCE, iron, manganese, cis-1,2-DCE, trans-1,2-DCE, Aroclor-1260, 4,4'- dichlorodiphenyldichloroethane (DDD), 4,4'-dichlorodiphenyltrichloroethane (DDT), and lead were retained as chemicals of concern (COCs). As explained in Section 2.1.2, Site 4 subsurface soil, sediments, surface water, and groundwater have been retained as media of concern. Remedial alternatives, as detailed in presumptive remedy guidance, were developed to address COCs.

PRESUMPTIVE REMEDY

The nature and extent of the materials disposed at Site 4 result in site conditions that meet the requirements to pursue the presumptive remedy strategy.

The Application of the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) Municipal Landfill Presumptive Remedy to Military Landfills (USEPA, 1996) guidance document identifies

the waste characteristics of military landfills that allow the application of the presumptive remedy. The guidance document states that appropriate characteristics include:

- Risks are low-level except for "hot spots." The results of sampling were generally less than TRG screening levels except for the groundwater plume and the organic rich muck in the canal.

- Treatment of wastes is usually impractical due to the volume and heterogeneity of the waste. The landfill area is large, over 3 acres, and a variety of wastes were reported to have been disposed.

- Waste types include household, commercial, non-hazardous sludge, and industrial waste solids. The Initial Assessment Study (IAS) (NEESA, 1985) reports that 16,000 tons of non-hazardous solids and debris were disposed in cells across the site.

- Lesser quantities of hazardous wastes are present as compared to municipal wastes. The hotspots at the site represent a very small volume of the total waste.

- Land application units, surface impoundments, injection wells, and waste piles are not included. There is neither reported history, nor any visual evidence of these units at Site 4.

The guidance further states it is anticipated that military landfills will have industrial solid waste, paints (and paint thinners), pesticides, transformer oils, and other solvents in relatively low proportion to the volume of municipal wastes – including construction debris, commercial/household type garbage, and yard wastes. The types of waste that would exclude a military site from presumptive remedy consideration include chemical warfare agents, munitions, and other explosives.

Based on the site investigation results, Site 4 has the acceptable characteristics necessary to continue with the presumptive remedy.

BASELINE RISK EVALUATION

A baseline risk evaluation was conducted as part of the RI for both human health and ecological receptors and the results are summarized below.

The following analytes were identified in the Human Health Risk Assessment (HHRA) as COCs:

- Subsurface soil – benzo(a)anthracene, dibenzo(a,h)anthracene
- Groundwater – cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, dioxins/furans, iron, manganese
- Surface Water – dioxins/furans
- Sediment – benzo(a)anthracene, dibenzo(a,h)anthracene, dioxins/furans

Based on an evaluation of site-specific data with respect to USEPA Region 4 ecological screening criteria, Aroclor-1260, lead, DDT, DDD, and dioxins/furans were retained as COCs for ecological receptors in sediments. Additionally, lead was retained as a COC for ecological receptors in surface water. Potential ecological risks from other contaminants had hazard indices (HIs) that were less than 1.0 and only detected in isolated locations.

Ecological risk resulting from exposure to surface soil was not evaluated because of the planned final cover for Site 4, based on presumptive remedy guidance.

REMEDIAL ACTION OBJECTIVES

The Remedial Action Objectives (RAOs) identified in this section are based on the COCs retained for Site 4 and consist of the following:

RAO 1: Prevent direct contact with landfill contents; therefore, eliminating unacceptable human exposure scenarios for soils.

RAO 2: Minimize infiltration and resulting contaminant leaching of PAHs and dioxins/furans to groundwater.

RAO 3: Prevent human exposure to contaminated groundwater and monitor groundwater quality beyond the site boundary.

RAO 4: Prevent direct exposure routes for human and ecological receptors to the COCs in surface water and sediments.

SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIATION TECHNOLOGIES, AND PROCESS OPTIONS

General Response Actions (GRAs) and associated technologies and processes were screened for effectiveness, implementability, and cost. Technologies that were determined to be ineffective or not consistent with the presumptive remedy were eliminated from further consideration. The following GRAs, remediation technologies, and process options were retained to develop soil, sediment, surface water, and groundwater remedial alternatives for Site 4:

- No Action
- Limited Action
- Containment
- Removal

- Surface Water and Sediment Protection
- Groundwater Treatment
- Disposal
- Landfill Gas Control

DEVELOPMENT OF REMEDIAL ALTERNATIVES

Since the waste characteristics of Site 4 are consistent with a presumptive remedy landfill site, the remedial alternatives developed were based on historical patterns of remedy selection to increase consistency and streamline the remedial action process.

- Alternative 1: No Action
- Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, Land Use Controls (LUCs), Groundwater Monitoring, and Landfill Gas Management and Monitoring.

DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were analyzed in detail using the nine criteria provided in the USEPA's National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and CERCLA.

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were compared to each other using the same nine criteria that were used for detailed analysis. The following is a summary of these comparisons:

Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment because contaminants would remain at concentrations in soil in excess of their TRGs and exposure to the contaminants would not be prevented.

Alternative 2 would provide the greatest level of protection because contaminated sediment from Canal No. 1 would be removed and the landfill would receive a final cover, eliminating direct exposure to the soil and landfill contents and reducing the percolation of rain water through the landfill material and into the groundwater. Also, the groundwater would be monitored, and the landfill gas would be vented. LUCs would prevent exposure to groundwater, prevent residential site uses, establish procedures for excavation, and limit landfill gas accumulation by controlling the design of nearby structures.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific applicable or relevant and appropriate requirements (ARARs). Action-specific ARARs or requirements to be considered (TBC) would not apply. Alternative 2 would comply with chemical- and action-specific ARARs and TBCs.

There are no location-specific ARARs identified for Site 4.

Long-Term Effectiveness and Permanence

Alternative 1 would not have a long-term effectiveness and permanence because no contaminant removal or reduction would occur.

Alternative 2 would be an effective long-term and permanent remedy. Under this alternative, contaminated sediment would be removed, the final cover would limit infiltration and prevent direct exposure to contaminated soil and the landfill contents, groundwater and landfill gas would be monitored, and landfill gas would be vented. LUCs would provide a mechanism to maintain the cap and erosion control measures.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not achieve any reduction of toxicity, mobility, or volume of contaminated media.

Alternative 2 does not include treatment, so there would be no reduction of toxicity, mobility, or volume of contaminants through treatment.

Short-term Effectiveness

Because no action would occur, implementation of Alternative 1 would not pose any risks to on-site workers or result in short-term adverse impact to the local community and the environment. Alternative 1 would never achieve the RAOs and, although some PRG might eventually be achieved through natural attenuation in the very long term, monitoring would not be in place to verify this condition.

Alternative 2 would have some short-term effectiveness concerns. Exposure of workers to contamination during remediation activities would be minimized by implementing engineering controls (e.g., dust suppression) and complying with site-specific health and safety procedures, including the use of appropriate personal protection equipment (PPE). Alternative 2 would not result in a significant destruction of ecological habitat. The RAOs would be achieved upon completion of remedial activities.

Implementability

Alternative 1 would be simple to implement because no action would be required.

Alternative 2 would be easy to implement because resources, equipment, and materials are readily available to perform the sediment excavation, capping, groundwater and landfill gas monitoring, and the venting of the landfill gas.

Administratively, Alternative 2 would require the development and implementation of LUCs, performance of long-term monitoring, site inspection, and maintenance, and 5-year site reviews.

Cost

The capital and operation and maintenance (O&M) costs and net present worth (NPW) of the remedial alternatives were estimated to be as follows:

Alternative	Capital Cost	NPW of O&M	NPW
1	0	0	0
2	$1,938,000	$467,000 (30 years)	$2,405,000 (30 years)

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates.

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS), under Comprehensive Long-Term Environmental Action Navy (CLEAN) IV Contract Number N62467-04-D-0055 to Naval Facilities Engineering Command Southeast (NAVFAC SE), is conducting this Feasibility Study (FS) to address Site 4 - Golf Course Landfill at Naval Construction Battalion Center (NCBC) Gulfport located in Gulfport, Mississippi (Figure 1-1). This FS report includes the development, screening, and evaluation of potential remedial alternatives addressing affected soil and groundwater at Site 4.

This FS follows United States Environmental Protection Agency (USEPA) guidance and regulations regarding cleanup of past activities as outlined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) and by Executive Order 12580. References made to CERCLA in this report should be interpreted as CERCLA, as amended by SARA; National Oil and Hazardous Substance Pollution Contingency Plan (NCP) [40 Code of Federal Regulations (CFR) Part 300]; and Remedial Investigation/FS (RI/FS) Guidance (USEPA, 1988). Also, the presumptive remedy for CERCLA military landfills with municipal landfill waste characteristics as given by USEPA under Directive No. 9355.0-49FS Presumptive Remedy for CERCLA Municipal Landfill Sites (USEPA, 1993a) and Directive No. 9355.0-67FS Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (USEPA, 1996) was determined to be appropriate for this site.

Additionally, Site 4 is currently under the Navy's Installation Restoration (IR) Program which was designed to identify, assess, characterize, and abate or control contaminant migration resulting from past operations at naval installations while complying with local and federal requirements.

1.1 CERCLA FS PROCESS

The presumptive remedy for military landfills with municipal-type landfill wastes, which are being addressed under CERCLA as given in the USEPA directives, will be followed. Using the presumptive remedy eliminates the need for the initial identification and screening of alternatives during the FS, since this is accomplished by the directives mentioned above. The presumptive remedy for landfills such as Site 4 is containment, based on the historical review of completed remedial actions at similar sites by the USEPA.

The development of remedial alternatives for CERCLA sites consists of developing preliminary remediation goals (PRGs) and areas and volumes of contamination, and then identifying applicable technologies and developing those technologies into remedial alternatives to meet the PRGs.

Therefore, the first step in this FS process is to develop remedial action objectives (RAOs) specifying the contaminants, media of interest, and exposure pathways leading to development of the PRGs. The PRGs are developed based on chemical-specific applicable or relevant and appropriate requirements (ARARs), and when available, site-specific risk-based factors or other available information. For this site, based on discussions between the Navy, Mississippi Department of Environmental Quality (MDEQ), and the USEPA, it was agreed that human health related PRGs for the project would be based on the State of Mississippi target remediation goals (TRGs) and ecological related PRGs would be based on USEPA Region 4 Ecological Screening Values (ESVs). As a result, TRGs and USEPA Region 4 ESVs will serve as the basis for remedial action.

Chemicals of concern (COCs) as identified in the RI are those chemicals with average concentrations exceeding the PRGs and background. Once the PRGs and COCs have been determined, the areas and volumes of contamination requiring remedial action are determined.

Once RAOs/PRGs are identified, general response actions (GRAs) for each medium of interest are developed. GRAs typically fall into the following categories: no action, containment, excavation, extraction, treatment, disposal, or other actions, singular or in combination, taken to satisfy the RAOs for the site.

The next step in the FS process is to develop remedial action alternatives based on the presumptive remedy components for landfills and site-specific criteria. Those technologies that satisfy the site specific criteria are then described and analyzed in detail using the CERCLA evaluation criteria described in the NCP, including the nine criteria listed below:

<u>Threshold Criteria</u>

1) Overall protection of human health and the environment
2) Compliance with ARARs

<u>Balancing Criteria</u>

3) Long-term effectiveness and permanence
4) Reduction of toxicity, mobility, or volume of contaminants through treatment
5) Short-term effectiveness
6) Implementability
7) Cost

Alternatives are evaluated against two additional factors (Modifying Criteria) after state and community participation:

Modifying Criteria

8) State acceptance
9) Community acceptance

These criteria are described further in Section 4.1.1.

The results of the detailed analyses are summarized and compared in a comparative analysis. The alternatives are compared against each other using the CERCLA evaluation criteria.

These criteria are used because SARA requires them to be considered during remedy selection. Modifying criteria, including state and community acceptance, are also evaluated. State acceptance is evaluated when the state reviews and comments on the draft FS report, and a Proposed Plan is then prepared in consideration of the state's comments. Community acceptance is evaluated based on comments received on the Proposed Plan during a public comment period. This evaluation is described in a responsiveness summary and will be included in the Decision Document.

Upon completion of the FS report, the Proposed Plan will be developed. The Proposed Plan will identify the preferred remedial alternative for Site 4. This document will be written in community-friendly language and will be made available for public comment. Following receipt of all public comments, responses to these comments will be developed in a responsiveness summary included with the Decision Document. The Decision Document will document the chosen alternative for the site and will include the responsiveness summary as an appendix. Once the Decision Document is signed, the chosen remedial alternative will be implemented.

The entire FS process provides the technical information and analyses forming the basis for the selection of the remedy, and the subsequent Proposed Plan which provides all the necessary information for the Decision Document.

1.2 PURPOSE

The goal of this FS for Site 4 at NCBC Gulfport is to develop remedial alternatives addressing real or potential threats to human health and/or the environment resulting from contaminated media due to the historic use of the landfill. For brevity, general information presented in the RI report will not be repeated in this FS report.

As a review, the RI serves as the mechanism for collecting data to identify the nature and extent of contamination. It also analyzes the migration pathway characteristics for conducting a baseline risk assessment and for collecting physical measurements and analytical data necessary for the remedial

alternative evaluation in the FS. The RI report for Site 4 at NCBC Gulfport provides the following information:

- Site description and a summary of previous investigations at Site 4
- A summary of the field investigation methods used during the RI and a summary of prior investigations
- A site-specific data quality assessment
- The identification of chemicals of potential concern (COPCs) for the site
- An assessment of the extent, magnitude, and impact of contamination at the site
- A qualitative and quantitative assessment of risks to human health and the environment

The FS uses the results of the RI and the information presented in the human health risk assessment (HHRA) and the Screening Level Ecological Risk Assessment (SLERA) to identify RAOs and PRGs. RAOs are then used to develop, screen, and evaluate potential remedial alternatives to meet the objectives.

USEPA has published specific guidance detailing presumptive remedies for those sites that are military landfills with contents similar to municipal landfills. Therefore, a presumptive remedy will be recommended, and the alternatives have been limited to a few specific areas. Using the presumptive remedy eliminates the need for initial identification and screening during the FS since this is accomplished by USEPA directives Presumptive Remedy for CERCLA Municipal Landfill Sites (USEPA, 1993a) and Application of CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (USEPA, 1996).

The following criteria were considered in identifying the appropriate remedial actions for Site 4:

- RAOs: RAOs are developed to specify the contaminants, media of interest, exposure pathways, and remedial action goals.

- Presumptive Remedy: Technologies applicable for addressing contaminated media in landfills are identified and screened.

- Detailed Analysis: Selected remedial alternatives are described and evaluated using seven of the nine criteria outlined in the NCP.

- Comparative Analysis: Remedial alternatives are compared against each other using threshold and primary balancing criteria.

1.3 ENVIRONMENTAL CONDITIONS

NCBC Gulfport is located in the northwestern part of Gulfport, Mississippi, in the southeastern part of Harrison County, approximately 2 miles north of the Gulf of Mexico. Nine sites at NCBC Gulfport, including Site 4, were identified in the Initial Assessment Study (IAS) as potential threats to human health or the environment (NEESA, 1985). Contamination was first reported from the area designated as Site 4 during the Surface Water and Sediment Dioxin Delineation Study conducted in 1995 (ABB-ES, 1997). Figure 1-2 presents the base layout and the location of Site 4 at NCBC Gulfport. Analytical results from the groundwater samples collected from shallow monitoring wells installed at Site 4 for the 1995 investigation identified dioxins and vinyl chloride. Dioxins were also reported in a seep sample collected from the bank of Canal No. 1.

1.4 SITE DESCRIPTION

Site 4 is an approximately 4 acre former landfill located in the northwestern section of NCBC Gulfport. The landfill area is located northeast of the intersection of 7th Street and Canal No. 1 and is adjacent to the driving range at the Pine Bayou Golf Course (Figure 1-2). The northwestern boundary of the landfill is adjacent to Canal No. 1. The southern portion of the site is covered by the greens of the 9th and 18th holes of the golf course.

The Site 4 landfill was operated from 1966 until 1972 and was the only operating landfill on the base at that time. Waste material was disposed in trenches, burned daily, and then the trenches were backfilled. Most, if not all, of the solid waste and some of the liquid and chemical waste generated at the base were disposed at Site 4 during the period of landfill operation (NEESA, 1985). As much as 200,000 gallons of waste liquids may have been disposed at the site including fuels, oils, solvents (methyl ethyl ketone, toluene, and xylene), paints, and paint thinners. In addition, 16,000 tons of solid waste were disposed at the landfill, and building and infrastructure debris were disposed at the site following Hurricane Camille in 1969.

Canal No. 1 at Site 4 is approximately 30 feet wide and approximately 4 feet deep. Storm water run-off from the areas surrounding Site 4 flows into various small tributary ditches that feed into Canal No. 1, which collects the run-off from other parts of the base. Surface water in Canal No. 1 flows to the north and eventually leaves the NCBC Gulfport at the outfall located at 28th Street.

1.5 WASTE DISPOSAL AREA

At Site 4, the waste disposal boundary was established by evaluating the results of the magnetometer and EM-61 surveys. Both the EM-61 and magnetometer surveys indicate a roughly rectangular landfill comprised of many smaller disposal cells or trenches approximately 800 feet (northeast-southwest) by

200 feet (northwest-southeast) (see Figures 1-3 and 1-4). The landfill area as defined by the geophysical survey is approximately 3.7 acres.

Within the landfill area, both geophysical methods detected significantly more buried material in the southwestern portion of the site. The source of the chlorinated volatile organic compound (CVOC) plume has also been identified in the southwestern portion of the site.

The higher level responses on the EM-61 in several areas were influenced by the steel reinforcement in the golf cart paths. Examples are the northeastern portion of the landfill as indicated by the linear northwest-southeast trending anomalies and the western boundary with a linear east-west anomaly.

As discussed in the RI, visual observations of the drilling spoils at 45 locations further aided the definition of the waste disposal area. Those observations noted a variety of land-filled debris, including wire, wood, household-type garbage, and construction debris. In addition, these observations confirmed that the geophysical survey was an effective method in accurately determining the waste disposal boundaries of the landfill. Some of the material and the soil matrix showed indications of burning. These findings are consistent with the reported disposal activities at Site 4 and are consistent with the types of wastes allowed under a presumptive remedy.

1.6 SOIL ASSESSMENT

The release of contaminants at Site 4 probably resulted from landfill operations. The detections of CVOCs and metals at Site 4 support the reported disposal of these materials at the site.

Arsenic was detected in 9 of the 10 soil samples at concentrations greater than the Tier 1 unrestricted TRG. Two of these locations had arsenic concentrations greater than the restricted TRG. However, the detected concentrations of arsenic at Site 4 are typical for coastal plain soils in Mississippi, as reported by the "Arsenic Concentrations in Selected Soils and Parent Materials in Mississippi" (Pettry and Switzer, 2001). Other metals and cyanide were detected at concentrations less than the Tier 1 unrestricted TRGs.

Volatile organic compound (VOC) concentrations in the soil samples were less than the Tier 1 unrestricted TRGs. Dibenzo(a,h)anthracene was detected in one soil sample at a concentration greater than the unrestricted TRG, but less than the restricted TRG. Concentrations of other semivolatile organic compounds (SVOCs) in the soil samples were less than the Tier 1 unrestricted TRGs.

Several pesticides were detected in Site 4 soil samples at concentrations less than the Tier 1 unrestricted TRGs. Concentrations of polychlorinated biphenyls (PCBs) and organophosphorus pesticides were less than standard laboratory detection limits.

Herbicide concentrations in the soil samples were less than standard laboratory detection limits.

Dioxins were detected in both of the soil samples submitted for dioxin analysis. The octachlorodibenzo-p-dioxin (OCDD) and 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD) congeners were at concentrations one or two orders of magnitude greater than the tetrachlorodibenzo-p-dioxin (TCDD) concentration. The dioxin toxicity equivalency quotients (TEQs) calculated from the Site 4 soil samples were less than the Tier 1 unrestricted TRG for TCDD.

1.7 GROUNDWATER ASSESSMENT

The metals, iron, and antimony were detected at concentrations greater than TRGs. Iron was detected in four direct push technology (DPT) groundwater samples and three monitoring well groundwater samples at concentrations greater than the TRG. Antimony was detected in one monitoring well sample at a concentration greater than the TRG.

A dissolved CVOC plume was delineated in the southern part of Site 4 (see Figure 1-5). Concentrations of vinyl chloride, cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and trichloroethene (TCE) in groundwater exceeded the Tier 1 TRGs. The plume has an area of approximately 60,000 square feet. Comparison of analytical data from shallow and deep well pairs indicates that the CVOC plume is limited to the uppermost sand zone of the shallow surficial aquifer, to a depth of approximately 24 feet, and has not migrated vertically. The CVOC plume has migrated to the northwestern side of Canal No. 1, indicating that the canal is not a hydraulic barrier. Data suggest that the phenomena known as DCE stall has occurred in the dissolved CVOC plume at Site 4. DCE stall in groundwater systems results when insufficient electron acceptors or substrates or adverse environmental conditions prevent further biological reductive dechlorination of CVOCs. Under these conditions, additional reductive dechlorination would require amendment of existing site conditions within the area of the plume to complete the degradation process.

Detected SVOCs and cyanide concentrations in monitoring well samples were less than Tier 1 TRGs. Herbicides, pesticides, and PCB concentrations in the groundwater samples were less than standard laboratory detection limits.

1.8 SURFACE WATER AND SEDIMENT ASSESSMENT

Arsenic was detected in the eight sediment samples at concentrations greater than the Tier 1 unrestricted TRG. Five of these locations had arsenic concentrations greater than the restricted TRG. The detected concentrations of arsenic at Site 4 are typical for coastal plain soils in Mississippi. Other metals and cyanide were detected at concentrations less than the Tier 1 unrestricted TRGs.

Detected concentrations of VOCs, dioxins, cyanide, and metals in the surface water samples were less than the Tier 1 TRGs for groundwater. Concentrations of SVOCs, pesticides, PCBs, and herbicides in the surface water samples were less than standard laboratory detection limits.

Detected concentrations of VOCs, pesticides, PCBs, and cyanide in the sediment samples were less than the Tier 1 unrestricted TRGs. Concentrations of herbicides were less than standard laboratory detection limits.

Benzo(a)pyrene was detected in one sediment sample at a concentration greater than the Tier 1 restricted TRG and in two sediment samples at concentrations greater than the Tier 1 unrestricted TRG, but less than the Tier 1 restricted TRG. Dibenzo(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene were also detected in one sediment sample at concentrations greater than the unrestricted TRG, but less than the Tier 1 restricted TRG. Concentrations of other SVOCs detected in sediment samples from Site 4 were less than screening criteria.

OCDD, octachlorodibenzofuran, and 1,2,3,4,6,7,8-HpCDD were detected in one surface water sample. TCDD was not detected in this sample, and the TEQ was less than the Tier 1 TRG for TCDD. Concentrations of other dioxins in the surface water samples were less than standard laboratory detection limits.

TCDD was detected in all three of the sediment samples. The dioxin TEQ for two sediment samples was greater than the unrestricted TRG and less than the restricted TRG. The lack of corresponding Herbicide Orange (HO) ingredients [herbicides 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)] suggests a source for the TCDD that is not HO. The significant volume of treated railroad ties and other lumber used to construct the nearby golf course bridges may provide the source. Furthermore, the physical properties of dioxins and furans result in tight binding to soil particles making it unlikely that a landfill to sediment pathway is the sole (or even primary) source for the reported concentrations.

The concentrations and frequency of detection for non-volatile constituents were generally greater than adjacent results in the groundwater at Site 4. This relationship suggests that seeps along the bank of the landfill cannot be the sole source for these contaminants. Other likely sources include:

- Large amounts of treated lumber in the golf course bridges upstream of the Site.
- Several large parking lots and equipment training areas upstream of the Site.
- Golf course maintenance activities.

One additional consideration is the nature of the muck currently lining Canal No.1. This highly organic material is very effective at binding and trapping organic compounds such as pesticides, SVOCs, and dioxins. Removal of this muck will effectively remove these contaminants.

The results of the surface water and sampling study support the overall presumptive remedial strategy of containment and the specific response action objectives of removing sediment and lining for Canal No. 1 to minimize infiltration at Site 4.

1.9 CHEMICALS OF CONCERN

In general, a constituent is selected as a COPC and retained for further quantitative risk evaluation in the HHRA if the maximum concentration in a sampled medium is greater than a conservative screening value(s). It should be noted that the conservative screening values used are the MDEQ Tier 1 TRG unrestricted screening values and USEPA maximum contaminant levels (MCLs), per the RI Report (TtNUS, 2009). Contaminants eliminated from further evaluation in the HHRA are assumed to present minimal risks to potential human receptors.

Per Table 1-1, COPCs that showed human risks having a hazard index (HI) greater than 1 or a carcinogenic risk greater than 1×10^{-6} were selected as COCs, as follows:

- Subsurface soil – benzo(a)anthracene, dibenzo(a,h)anthracene
- Groundwater – cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, dioxins/furans, iron, manganese
- Surface Water – dioxins/furans
- Sediment – benzo(a)anthracene, dibenzo(a,h)anthracene, dioxins/furans

Arsenic was excluded as a COC because concentrations are consistent with regional background levels. No other chemicals were excluded from the risk assessment on the basis of background concentrations because site-specific background data are not available for NCBC Gulfport.

Also, five COPCs (see Table 1-2) were retained as COCs based on the results of the SLERA. The contaminants are screened against the PRGs to determine the COPCs. The COCs are those constituents that were determined to be COPCs with concentrations greater than criteria after being evaluated running a Food Chain Hazard Quotient Assessment on representative species under a conservative scenario. The screening criteria used for SLERA are the PRGs for Ecological Endpoints (USEPA, 1997). Therefore, the COCs due to ecological concerns are:

- Surface Water – lead
- Sediment – Aroclor-1260, lead, 4,4'-DDT, 4,4'-DDD, dioxins/furans

Note that conservative assumptions are used in the SLERA. They are re-evaluated, and factors that affect potential exposures such as quality and size of the habitat, and actual use of the site by modeled receptors, are considered. In summary, the overall level of ecological risk associated with the cited contamination in Canal No. 1 is considered to be minimal.

As discussed in this section, one of the primary objectives of the investigative program was to evaluate the nature and extent of the materials disposed at Site 4 and to determine if the resulting site conditions meet the requirements to continue to pursue the current presumptive remedy strategy.

The CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (USEPA, 1996) identifies the waste characteristics of military landfills that allow the application of the presumptive remedy. The guidance states that appropriate characteristics include:

- Risks are low-level except for "hot spots." The results of sampling were generally less than Tier 1 TRG screening levels except for the groundwater plume and the organic rich muck in the canal.

- Treatment of wastes is usually impractical due to the volume and heterogeneity of the waste. The landfill area is large, over 3 acres, and a variety of wastes were reported to have been disposed.

- Waste types include household, commercial, non-hazardous sludge, and industrial waste solids. The IAS reports that 16,000 tons of non-hazardous solids and debris were disposed in the cells across the site.

- Lesser quantities of hazardous wastes are present as compared to municipal wastes. The hotspots at the site represent a very small volume of the total waste.

- Land application units, surface impoundments, injection wells, and waste piles are not included. There is no reported history or any visual evidence of these types of units at Site 4.

The guidance further states that, it is anticipated that military landfills will have industrial solid waste, paints (and paint thinners), pesticides, transformer oils, and other solvents in relatively low proportion to the volume of municipal wastes – including construction debris, commercial/household type garbage, and yard wastes. The types of waste that would exclude a military site from presumptive remedy consideration include chemical warfare agents, munitions, and other explosives.

Also, the guidance states that the presumptive remedy relates primarily to containment of landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that is causing saturation of the landfill mass may be implemented as part of the presumptive remedy (USEPA, 1993a).

Based on the site investigation results, Site 4 has the acceptable characteristics necessary to continue with the presumptive remedy.

1.10 CONCLUSIONS

Based on the historical information, site investigation results, and presumptive remedy guidance, Site 4 has the acceptable characteristics necessary to continue with the presumptive remedy strategy. However, the CVOC groundwater plume will require additional non-presumptive remedial action in order to address the potentially unacceptable risk at the site.

1.11 REPORT ORGANIZATION

This FS report is organized into five sections. Section 1.0 presents the purpose, site description, and regulatory setting; Section 2.0 presents the development of the RAOs, PRGs, and areas and volumes of contamination; Section 3.0 identifies and screens the alternatives; Section 4.0 presents the detailed analysis of the alternatives; and Section 5.0 presents the comparative analysis for the remedial alternatives at Site 4.

This FS report also includes five appendices (A through E). Presumptive remedy guidance document are included in Appendix A, and Remedial Alternative Cost Estimates are presented in detail in Appendix B. Copies of the Treatability Study Memorandum and Cover Assessment Data are included in Appendices C and D, respectively. The Remedial Site Conceptual Exposure Model (SCEM) is included in Appendix E.

TABLE 1-1

CHEMICALS OF CONCERN FROM CHEMICALS OF POTENTIAL CONCERN
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

CHEMICAL OF POTENTIAL CONCERN	UNITS	MAXIMUM DETECTED CONCENTRATION	MEDIA	COC	REASON
Benzo(a)anthracene	mg/kg	0.76	subsurface soil	yes	cancer risk > 1 x 10^{-6}
		1.6	sediment	yes	
Dibenzo(a,h)anthracene	mg/kg	0.21	subsurface soil	yes	cancer risk > 1 x 10^{-6}
		0.54	sediment	yes	
Aluminum	mg/kg	7,680	subsurface soil	no	HI < 1
		18,600	sediment	no	
Arsenic	mg/kg	7.6	subsurface soil	no	Concentrations found at the site are within regional background concentrations.
	µg/L	11.4	groundwater	no	
	µg/L	6.8	surface water	no	
	mg/kg	5.7	sediment	no	
Iron	mg/kg	10,300	subsurface soil	no	HI < 1
	µg/L	69,700	groundwater	yes	HI > 1
	µg/L	5,180	surface water	no	HI < 1
	mg/kg	13,000	sediment	no	HI < 1
Vanadium	mg/kg	19.8	subsurface soil	no	HI < 1
	µg/L	18.1	groundwater	no	HI < 1
	mg/kg	27.5	sediment	no	HI < 1
1,2-DCA	µg/L	0.2	groundwater	no	HI < 1
cis-1,2-DCE	µg/L	280	groundwater	yes	HI > 1
trans-1,2-DCE	µg/L	190	groundwater	yes	HI > 1
Benzene	µg/L	0.4	groundwater	no	HI < 1
TCE	µg/L	20.4	groundwater	yes	HI > 1

TABLE 1-1

CHEMICALS OF CONCERN FROM CHEMICALS OF POTENTIAL CONCERN
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

CHEMICAL OF POTENTIAL CONCERN	UNITS	MAXIMUM DETECTED CONCENTRATION	MEDIA	COC	REASON
Vinyl chloride	µg/L	172	groundwater	yes	cancer risk > 1 x 10^{-6}
Dioxins/furans	pg/L	10	groundwater	yes	cancer risk > 1 x 10^{-6}
	pg/L	4.9	surface water	yes	
	ng/kg	30.5	sediment	yes	
Dibenzofuran	µg/L	7	groundwater	no	HI < 1
Aluminum	µg/L	8,690	groundwater	no	HI < 1
Antimony	µg/L	26.3	groundwater	no	HI < 1
Barium	µg/L	1,620	groundwater	no	HI < 1
Chromium	µg/L	11.8	groundwater	no	HI < 1
Manganese	µg/L	465	groundwater	yes	HI > 1
		205	surface water	no	HI < 1
PCE	µg/L	3	surface water	no	HI < 1
Benzo(a)pyrene	mg/kg	1.8	sediment	no	HI < 1
Benzo(b)fluoranthene	mg/kg	2.5	sediment	no	HI < 1
Indeno(1,2,3-cd)pyrene	mg/kg	0.98	sediment	no	HI < 1
Aroclor-1260	mg/kg	0.24	sediment	no	HI < 1
Thallium	mg/kg	0.76	sediment	no	HI < 1

HI = Hazard index.
DCA = Dichloroethane.
DCE = Dichloroethene.
TCE = Trichloroethene.
PCE = Tetrachlorethene.
COC = Chemical of concern.

mg/kg = Milligrams per kilogram.
ng/kg = Nanograms per kilogram.
pg/L = Picograms per liter.
µg/L = Micrograms per liter.

TABLE 1-2

CHEMICALS OF CONCERN FROM ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

CHEMICAL	CONCENTRATION USED FOR SCREENING	UNITS	HQ	MEDIA	COC
2-Butanone	0.062	mg/kg	n/a	sediment	no
Acetone	0.34	mg/kg	n/a	sediment	no
	11	µg/L	n/a	surface water	no
Carbon disulfide	0.008	mg/kg	n/a	sediment	no
Chloroethane	0.002	mg/kg	n/a	sediment	no
Cyclohexane	0.0008	mg/kg	n/a	sediment	no
Methyl cyclohexane	0.008	mg/kg	n/a	sediment	no
Methyl tert-butyl ether	0.002	mg/kg	n/a	sediment	no
cis-1,2-dichloroethene	0.018	mg/kg	n/a	sediment	no
Total-1,2-dichloroethene	0.002	mg/kg	n/a	sediment	no
Toluene	0.002	mg/kg	n/a	sediment	no
Trichloroethene	0.001	mg/kg	n/a	sediment	no
Trichlorofluoromethane	0.006	mg/kg	n/a	sediment	no
Vinyl chloride	0.044	mg/kg	n/a	sediment	no
Benzaldehyde	0.43	mg/kg	n/a	sediment	no
Benzo(a)anthracene	1.6	mg/kg	4.85	sediment	no
Benzo(a)pyrene	1.8	mg/kg	5.45	sediment	no
Benzo(b)fluoranthene	2.5	mg/kg	n/a	sediment	no
Benzo(g,h,i)perylene	1	mg/kg	n/a	sediment	no
Benzo(k)fluoranthene	1.5	mg/kg	n/a	sediment	no
Bis(2-ethylhexyl)phthalate	0.61	mg/kg	3.35	sediment	no
Carbazole	0.11	mg/kg	n/a	sediment	no
Chrysene	1.8	mg/kg	5.45	sediment	no
Dibenzo(a,h)anthracene	0.54	mg/kg	1.64	sediment	no
Dibenzofuran	0.092	mg/kg	n/a	sediment	no
Fluoranthene	1.2	mg/kg	3.64	sediment	no
Indeno(1,2,3-cd)pyrene	0.98	mg/kg	n/a	sediment	no
Phenanthrene	0.8	mg/kg	2.42	sediment	no
Pyrene	2	mg/kg	6.06	sediment	no
4,4'-DDD	0.012	mg/kg	4	sediment	yes
4,4'-DDT	0.005	mg/kg	1.67	sediment	yes
Alpha-chlordane	0.0051	mg/kg	3	sediment	no
Gamma-chlordane	0.37	mg/kg	217.65	sediment	no
Aroclor-1260	0.24	mg/kg	7.27	sediment	yes
2,3,7,8-TCDD TEQ	30.487	ng/kg	12.19	sediment	yes
Aluminum	18,600	mg/kg	n/a	sediment	no
Barium	54.1	mg/kg	n/a	sediment	no
	51.7	µg/L	n/a	surface water	no
Beryllium	0.21	mg/kg	n/a	sediment	no
Cobalt	2.4	mg/kg	n/a	sediment	no
Lead	43.4	mg/kg	1.44	sediment	yes
	3.2	µg/L	2.1	surface water	yes

TABLE 1-2

CHEMICALS OF CONCERN FROM ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

CHEMICAL	CONCENTRATION USED FOR SCREENING	UNITS	HQ	MEDIA	COC
Manganese	38	mg/kg	n/a	sediment	no
	205	µg/L	n/a	surface water	no
Selenium	0.78	mg/kg	n/a	sediment	no
Thallium	0.76	mg/kg	n/a	sediment	no
Vanadium	27.5	mg/kg	n/a	sediment	no
Cyanide	0.37	mg/kg	n/a	sediment	no
	6.4	µg/L	1.2	surface water	no
Iron	5,180	µg/L	5.2	surface water	no

mg/kg = Milligrams per kilogram.
ng/kg = nanograms per kilogram.
µg/L = Micrograms per liter.
DDD = Dichlorodiphenyldichloroethane.
DDT = Dichlorodiphenyltrichloroethane.
TCDD = Tetrachlorodibenzo-p-dioxin.
TEQ = Toxicity equivalency quotient.
HQ = Hazard quotient.
COC = Chemical of concern.
n/a = Not applicable.

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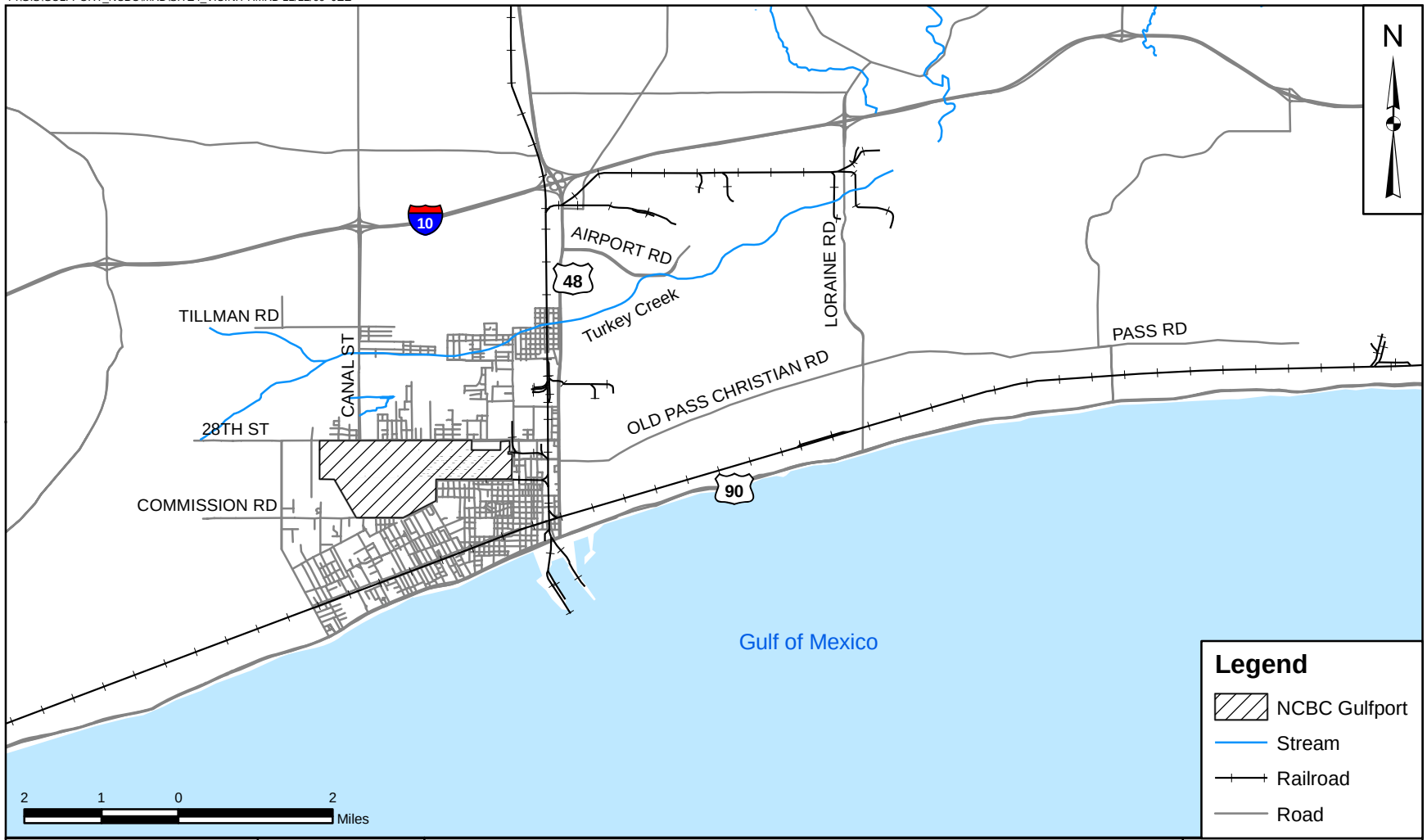

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CHECKED BY J. LOGAN	DATE 11/10/09		APPROVED BY ___ DATE ___
COST SCHEDULE AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 1-1 / REV 0

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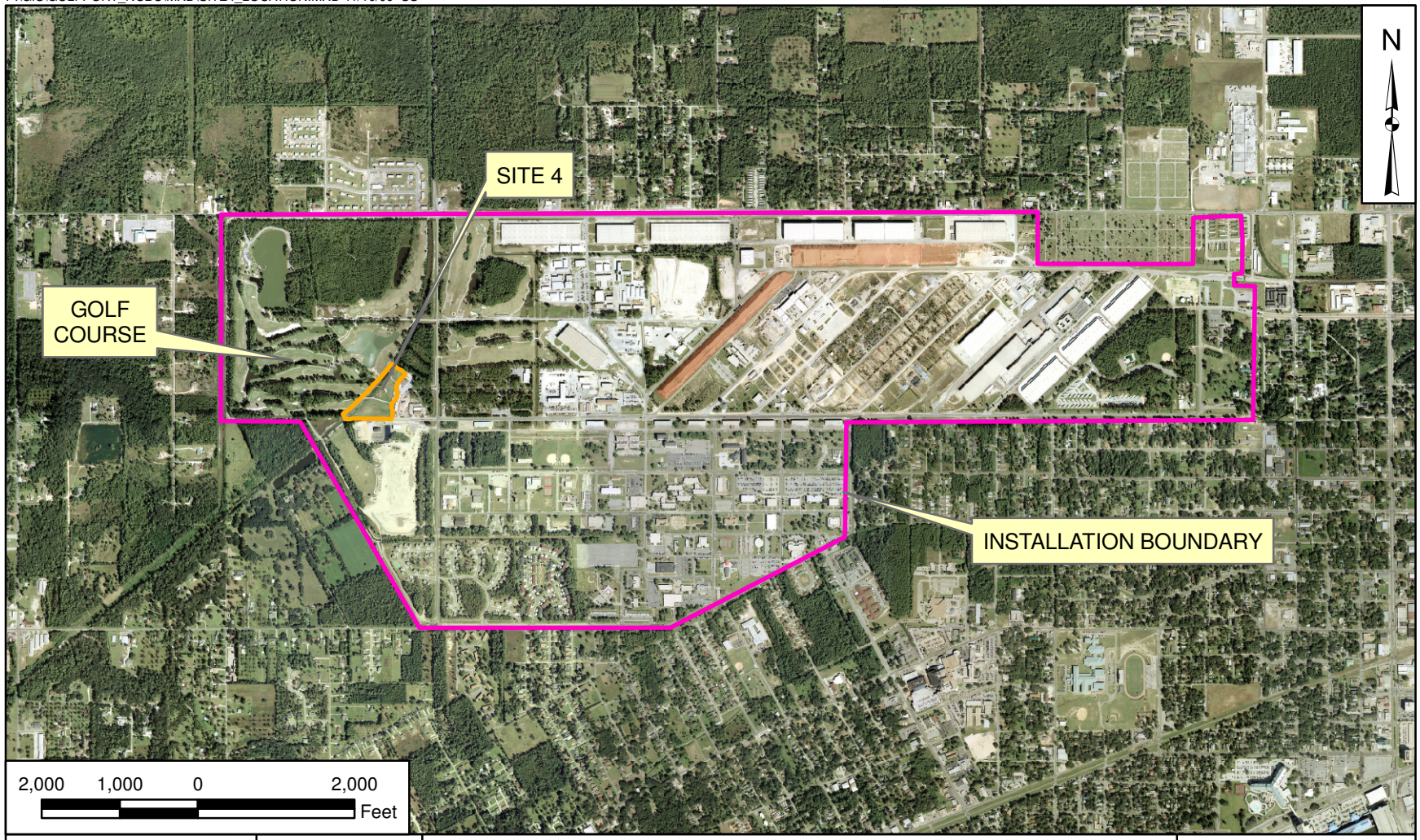

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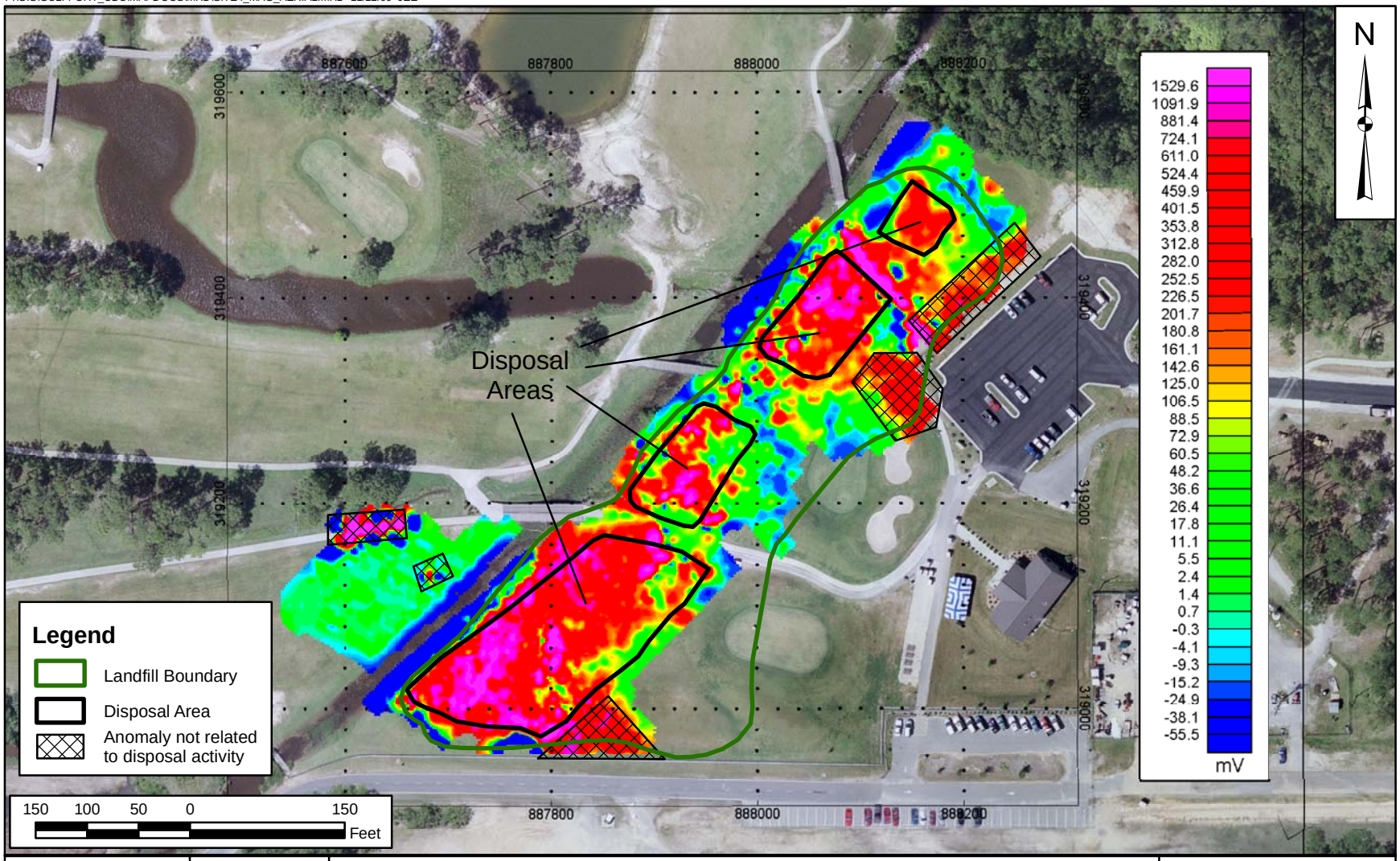

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CHECKED BY J. LOGAN	DATE 11/12/09		APPROVED BY ___ DATE ___
COST/SCHED AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 1-3 / REV 0

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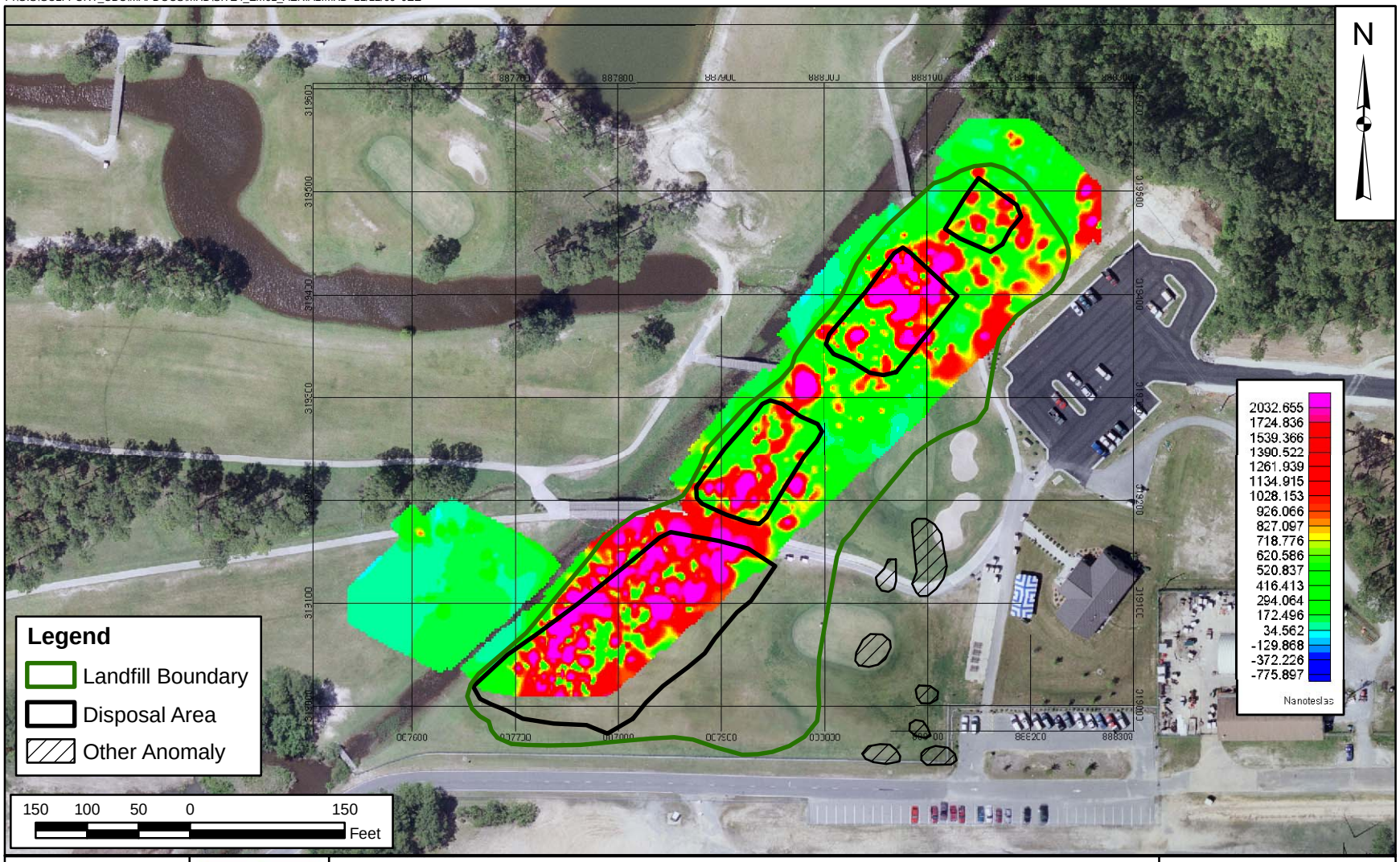

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COST/SCHED AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 1-4 / REV 0

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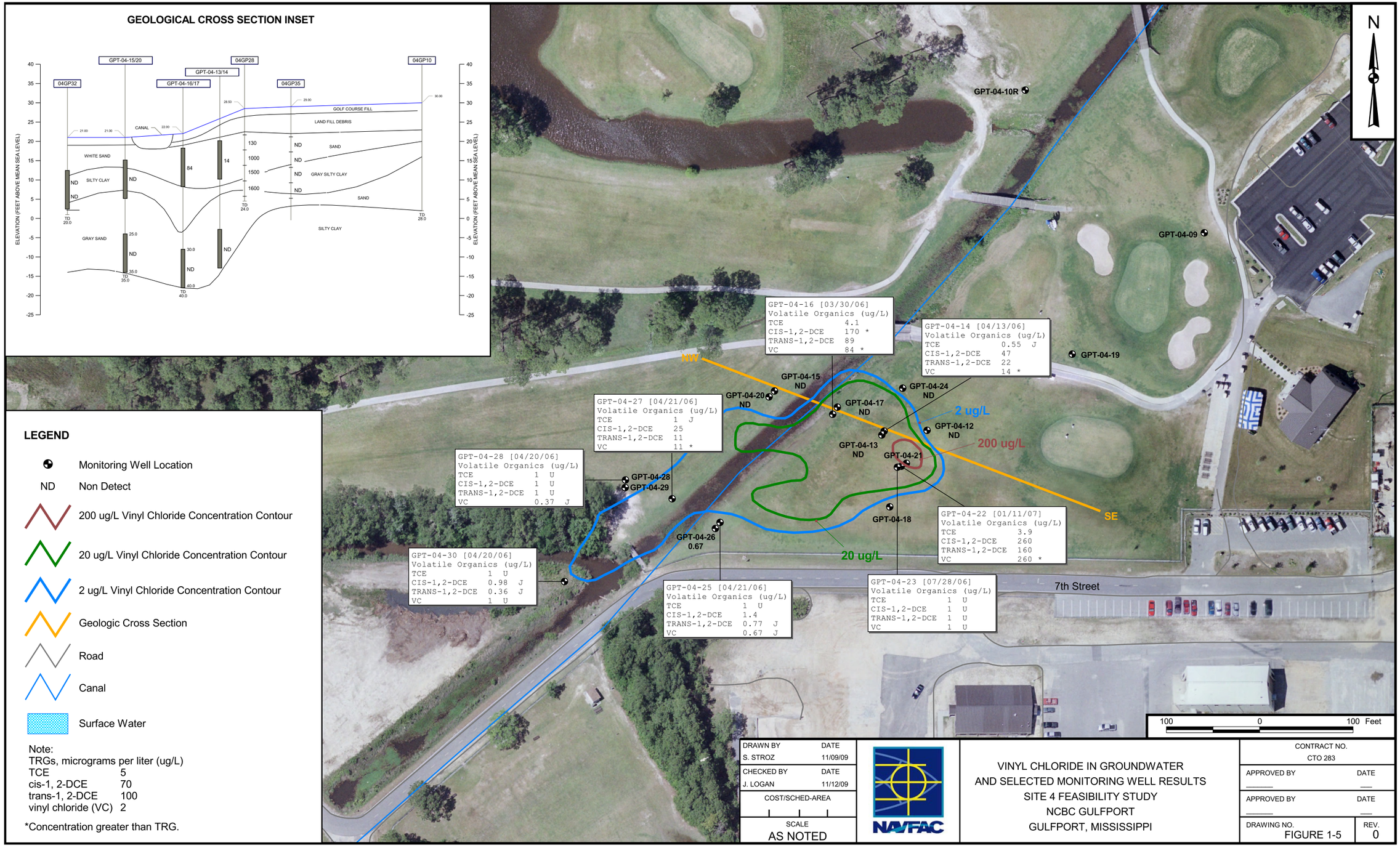

2.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

The objectives and goals for the remedial action at Site 4 provide the basis for selecting RAOs and identifying presumptive remedy technologies to address unacceptable exposure scenarios that may be encountered at Site 4.

USEPA established source containment as the presumptive remedy for municipal landfill sites regulated under CERCLA in September of 1993. The presumptive remedy for this site would be containment via a low permeability cover and lining Canal No. 1 to prevent groundwater from entering surface waters.

This section presents the development of RAOs. As part of this development, regulatory requirements, or ARARs and requirements to be considered (TBCs), are identified. Next, the media of concern are identified based on COCs selected for Site 4. Preliminary action levels or PRGs for each medium of concern are then identified. Taking into consideration this information, RAOs are then defined.

This section also presents GRAs for contaminated media at Site 4. GRAs are categories of actions that could be implemented to satisfy or address a component of the RAOs for the site. Lastly, this section provides an estimate of the volumes of contaminated media to be addressed at Site 4.

Containment is the presumptive remedy for military landfills with municipal landfill waste characteristics. Application of the presumptive remedy approach has been discussed, and data collected during the RI process support its use toward the alternatives development for Site 4 landfill. As described in the specific guidance, use of the presumptive remedy eliminates the need of the initial identification and screening of alternatives during the FS because USEPA has found that certain technologies are appropriately eliminated on the basis of effectiveness, feasibility, or cost.

2.1 REMEDIAL ACTION OBJECTIVES

2.1.1 ARARs and TBC Criteria

ARARs for this FS are the federal and state environmental requirements used to define the appropriate extent of site cleanup, to identity sensitive land areas or land uses, to develop remedial alternatives, and to direct site remediation. The CERCLA and the NCP require remedial actions to comply with state ARARs when they are more stringent than federal ARARs.

The NCP defines two ARAR components: (1) applicable requirements and (2) relevant and appropriate requirements. Applicable requirements are those cleanup standards, standards of control, and other

substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws specifically addressing a hazardous substance, pollutant, contaminant, remedial action, or other circumstance found at a CERCLA site. Applicable state standards are only those (1) identified by the state in a timely manner, (2) consistently enforced, and (3) more stringent than federal requirements.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements under federal and state environmental and facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, or remedial action, address situations sufficiently similar to those encountered at the CERCLA site so their use is well-suited to the particular site. Only those state standards (1) identified in a timely manner and (2) more stringent than federal requirements may be relevant and appropriate.

"Applicability" is a legal determination of jurisdiction of existing statutes and regulations, whereas "relevant and appropriate" is a site-specific determination of the appropriateness of existing statutes and regulations. Therefore, relevant and appropriate requirements allow flexibility not provided by applicable requirements in the final determination of cleanup levels. After a requirement is identified as an ARAR, the selected remedy must comply with or be waived from compliance with the ARAR, even if the ARAR is not required to assure protectiveness. Applicable requirements apply to both on- and off-site remedial actions.

TBC guidance criteria are federal and state non-promulgated advisories or guidance that are not legally binding and do not have the status of potential ARARs. However, if there are no specific ARARs for a chemical or site condition, or if ARARs are not deemed sufficiently protective, then guidance or advisory criteria should be identified and used to ensure the protection of human health and the environment.

Under the description of ARARs set forth in the NCP and the SARA, state and federal ARARs are categorized as follows:

- Chemical-specific: Controlling the extent of site remediation with regard to specific contaminants and pollutants.

- Location-specific: Governing site features such as wetlands, floodplains, and sensitive ecosystems (including features of historical significance).

- Action-specific: Pertaining to the proposed site remedies and governing the implementation of the selected site remedy.

During the detailed analysis of remedial alternatives presented in Section 4.0, each alternative will be analyzed to determine its compliance with ARARs. Chemical- and action-specific ARARs for Site 4 are presented in Table 2-1. There are no location-specific ARARs.

2.1.2 Constituents and Media of Concern

As determined in the RI (TtNUS, 2009), dioxins/furans, benzo(a)anthracene, dibenzo(a,h)anthracene, vinyl chloride, TCE, iron, manganese, cis-1,2-DCE, trans-1,2-DCE, Aroclor-1260, 4,4'-DDD, 4,4'-DDT, and lead were retained as COCs (see Table 2-2). As explained in the following paragraphs, Site 4 subsurface soil, sediments, surface water, and groundwater have been retained as the media of concern. Remedial alternatives, as detailed in presumptive remedy guidance, were developed to address COCs.

Sediment is retained as a medium of concern because of the detection of polynuclear aromatic hydrocarbons (PAHs) and dioxins/furans. Benzo(a)anthracene was detected with concentrations ranging from 0.043 to 1.6 milligrams per kilogram (mg/kg) in half of the samples, dibenzo(a)anthracene was found in only one sample at a concentration of 0.54 mg/kg. Two samples were analyzed for dioxins and dioxins were found in both of the samples at 3.9 and 30.5 micrograms per kilogram (µg/kg). Also, for ecological concerns, the following contaminants were retained as COCs in sediment: 4-4'-DDD, 4-4'-DDT, Aroclor-1260, and lead.

Surface water is also retained as a medium of concern. Dioxins/furans were detected in one Site 4 surface water sample at a concentration of 4.9 picograms per liter (pg/L). Lead is retained as a COC because of ecological concerns from a concentration of 3.2 micrograms per liter (µg/L) detected in one sample. However, remedial alternatives were not developed to directly address impacts to surface water. Instead, it is assumed that remedial actions to address soil and sediment will indirectly address dioxins/furans and lead impacts to surface water.

Groundwater is retained as a medium of concern and should be addressed separately. The Treatability Study Memorandum (TtNUS, 2007) evaluated five different remedial technologies to address CVOCs in groundwater. A copy of this memorandum is included in Appendix C. The groundwater investigated at Site 4 was encountered in the shallow subsurface, typically within 15 to 22 feet below land surface (bls). The surficial aquifer consists of silty fine sand and is unconfined. The surficial aquifer extends to approximately 45 feet bls at Site 4 and is separated from the primary drinking water aquifer by a much more plastic gray silty/sandy clay layer. Water levels in monitoring wells screened at a similar depth were used to construct a potentiometric surface map, as shown on Figure 2-1.

The CVOCs retained as COCs in groundwater are cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride. Cis-1,2-DCE was detected in 12 samples ranging from 0.2 to 280 µg/L, trans-1,2-DCE was detected in 10 samples at concentrations ranging from 7.0 to 190 µg/L, TCE was detected in 8 samples with detections from 0.8 to 20.4 µg/L, and vinyl chloride was detected in 14 of 38 samples at concentrations ranging from 0.2 to 172 µg/L. Also, dioxins/furans were detected in 3 of 13 samples at concentrations ranging from 2.1 to 10 pg/L. Inorganics were detected as follows; arsenic was detected in four of 23 samples at concentrations from 3.3 to 11.4 µg/L, iron was detected in 22 of 23 samples at concentrations ranging from 370 to 69,700 µg/L, and manganese was detected at concentrations ranging from 35.1 to 465 µg/L.

Subsurface soils were retained as a medium of concern due to the detections of PAHs and dioxins/furans. Benzo(a)anthracene and dibenzo(a)anthracene were detected in 1 of 10 samples at concentrations of 0.76 and 0.21 mg/kg, respectively.

2.1.3 Preliminary Remediation Goals

Based on discussions between the Navy, MDEQ, and USEPA, it was agreed that the State of Mississippi would be the regulatory lead agency at Site 4 and that PRGs for the project would be based on the State of Mississippi TRGs. As a result, the MDEQ TRG will serve as the basis for remedial action.

Per Mississippi Code Section 49-35-21, TRGs are based on either (1) a $1x10^{-6}$ target incremental cancer risk level for each carcinogenic chemical, (2) an HI not to exceed 1.0 for each systemic toxicant, or (3) constituent TRG concentrations established through federal/state programs (e.g., the Safe Drinking Water Act). The State of Mississippi lists TRGs for both restricted (industrial) and unrestricted (residential) land use. Because of Site 4's proximity to the golf course, unrestricted (residential) TRGs are deemed appropriate for remedial consideration. The State of Mississippi unrestricted TRGs for COCs in groundwater and soil are provided in Table 2-2.

As part of the CERCLA process, PRGs are periodically revised because of new guidance requirements and promulgated or updated ARARs. Final remediation goals will not be formally established until the approval of the Decision Document.

As stated previously, for this site the PRGs are MDEQ Tier 1 TRG unrestricted screening values and USEPA MCLs. For SLERA, the ecological screening values from the Supplemental Guidance to RAGS: USEPA Region 4 Bulletins Ecological Risk Assessments were used as the PRGs for ecological receptors.

2.1.4 Statement of RAOs

RAOs are the medium-specific goals established to protect human health and the environment (USEPA, 1988). USEPA's documents Presumptive Remedy for CERCLA Municipal Landfill Sites (1993) guidance and Applications of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (1996) list typical primary components of the presumptive remedy:

- Preventing direct contact with landfill contents.
- Minimizing infiltration and resulting contaminant leaching to groundwater.
- Controlling surface water run-off and erosion.
- Collecting and treating contaminated groundwater and leachate to contain the contaminant plume and prevent further migration from source area.
- Controlling and treating landfill gas.

Also, the above guidance lists the following non-presumptive remedy components:

- Remediating groundwater
- Remediating contaminated surface water and sediments
- Remediating contaminated wetland areas

Taking the referenced documents in consideration and evaluating the information from previous investigations and COCs retained, the RAOs for Site 4 consist of the following:

RAO 1: Prevent direct contact with landfill contents; therefore, eliminating unacceptable human exposure scenarios for soil.

RAO 2: Minimize infiltration and resulting contaminant leaching of PAHs and dioxins/furans to groundwater.

RAO 3: Prevent human exposure to contaminated groundwater and monitor groundwater quality beyond the site boundary.

RAO 4: Prevent direct exposure routes for human and ecological receptors to the COCs in surface water and sediments.

2.2 GENERAL RESPONSE ACTIONS

GRAs describe categories of actions that could be implemented to satisfy or address a component of the RAOs for the site. Remedial alternatives will be developed using one or more GRAs to meet the RAOs. These remedial alternatives will be capable of achieving the RAOs for each contaminated medium at the site. General GRAs may include no action, containment, excavation, extraction, disposal treatment, institutional controls, monitoring, or a combination of these. Based on the RAOs, the following GRAs will be considered for soil, sediment, surface water, and groundwater at Site 4:

- No Action
- Limited Action
- Containment
- Removal
- Surface Water and Sediment Protection
- Groundwater Treatment
- Disposal
- Landfill Gas Control

2.3 ESTIMATED VOLUMES OF CONTAMINATED MEDIA

Approximate values for soil capping, sediment removal, and canal lining are presented below. Taking in consideration the data from the RI Report (TtNUS, 2009), the volume to be capped is approximately 71,000 cubic yards (with a surface area of approximately 145,000 square feet). The quantity of sediment to be removed is approximately 1,400 cubic yards (with a surface area of approximately 38,000 square feet).

TABLE 2-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

NAME AND REGULATORY CITATION	DESCRIPTION	CONSIDERATION IN THE REMEDIAL ACTION PROCESS	TYPE
FEDERAL			
USEPA Region 3 RBC Table	Provides risk-based concentrations for screening of soil.	TBC. These guidelines aid in the screening of chemicals in soil.	Chemical-specific
USEPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment	Provides risk-based concentrations for screening contaminated media for ecological receptors.	TBC. These levels serve as guidelines for the Ecological Risk Assessment.	Chemical-specific
National Emissions Standards for Hazardous Air Pollutants (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous air pollutants.	Relevant and appropriate. Remedial action (e.g., soil excavation) may result in release of hazardous air pollutants.	Action-specific
RCRA Treatment, Storage, and Disposal of Hazardous Waste (40 CFR 262-266)	Regulates the treatment, storage, and disposal of hazardous waste.	Relevant and appropriate. Hazardous waste generated by site remediation must meet RCRA generator and treatment, storage, or disposal requirements.	Action-specific
STATE			
MDEQ TRGs (Mississippi Code Section 49-35-21)	Default screening levels. Human Health risk-based cleanup goals for soil and groundwater.	Applicable. These regulations apply to all remedial actions in the State of Mississippi.	Chemical-specific
MDEQ Risk Evaluation Procedures for Voluntary Cleanup and Redevelopment	Risk-based procedures and rationale for site evaluation and remediation.	TBC. These regulations apply to all Voluntary Cleanup and Brownfield actions in the State of Mississippi.	Action-specific
MDEQ Office of Pollution Control Hazardous Waste Management Regulations	Adopts by reference specific sections of the federal Hazardous Waste regulations.	Relevant and Appropriate. These regulations may apply if material is removed from the base.	Action-specific

TABLE 2-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

NAME AND REGULATORY CITATION	DESCRIPTION	CONSIDERATION IN THE REMEDIAL ACTION PROCESS	TYPE
STATE (CONTINUED)			
Mississippi Commission on Environmental Quality Regulation SW-2, 2005. Non-hazardous Solid Waste Management Regulations & Criteria, April, 2005.	Landfill closure regulations	Relevant and Appropriate. These regulations apply because the current soil cover does not meet the permeability requirements for landfill closures.	Action-specific

CAA = Clean Air Act.
CFR = Code of Federal Regulations.
MDEQ = Mississippi Department of Environmental Quality.
RBC = Risk-Based Concentration.
RCRA = Resource Conservation and Recovery Act.
TBC = To be considered.
TRG = Target Remediation Goal.

TABLE 2-2

CHEMICALS OF CONCERN BY MEDIA WITH APPROPRIATE PRGs
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

MEDIA	COC	MDEQ (TIER 1 TRG UNRESTRICTED)	MDEQ (TIER 1 TRG RESTRICTED)	BTAG REGION 4
Groundwater	Iron	**11,000 µg/L**	-	-
	cis-1,2-DCE	**70 µg/L**	-	-
	trans-1,2-DCE	**100 µg/L**	-	-
	TCE	**5 µg/L**	-	-
	Vinyl chloride	**2 µg/L**	-	-
	Dioxins/furans	**3.0×10^{-5} ug/L**	-	-
	Manganese	**730 ug/L**	-	-
Subsurface Soil	Benzo(a)anthracene	**0.875 mg/kg**	7.84 mg/kg	-
	Dibenzo(a,h)anthracene	**0.0875 mg/kg**	0.784 mg/kg	-
Surface Water	Dioxins/furans	**3.0×10^{-5} ug/L**	-	-
	Lead*	150 ug/L	-	**1.32 µg/L**
Sediment	Benzo(a)anthracene	**0.875 mg/kg**	7.84 mg/kg	-
	Dioxins/furans	**4.26×10^{-6} mg/kg**	3.82×10^{-5} mg/kg	-
	Dibenzo(a,h)anthracene	**0.0875 ng/kg**	0.784 mg/kg	-
	Aroclor -1260*	1 mg/kg	10 mg/kg	**33 mg/kg**
	4,4'-DDD*	2.66 mg/kg	23.8 mg/kg	**3.3 mg/kg**
	4,4'-DDT*	1.88 mg/kg	16.8 mg/kg	**3.3 mg/kg**
	Lead*	400 mg/kg	1700 mg/kg	**30.2 mg/kg**

* The numbers in bold are the corresponding cleanup goal. These chemicals are COCs only because of the ecological assessment; therefore, PRGs for Ecological Endpoints (1987) were used for PRGs.
Bolded value indicates selected PRG.
µg/L = Micrograms per liter.
ng/kg = Nanograms per kilogram.
mg/kg = Milligrams per kilogram.
DCE = Dichloroethene.
TCE = Trichloroethene
DDD = Dichlorodiphenyldichloroethane.
DDT = Dichlorodiphenyltrichloroethane.
COC = Chemical of concern.
PRG = Preliminary remediation goal.
MDEQ = Mississippi Department of Environmental Quality.
TRG = Target remediation goal.
BTAG = Biological Technical Assistance Group.
- = No criterion.

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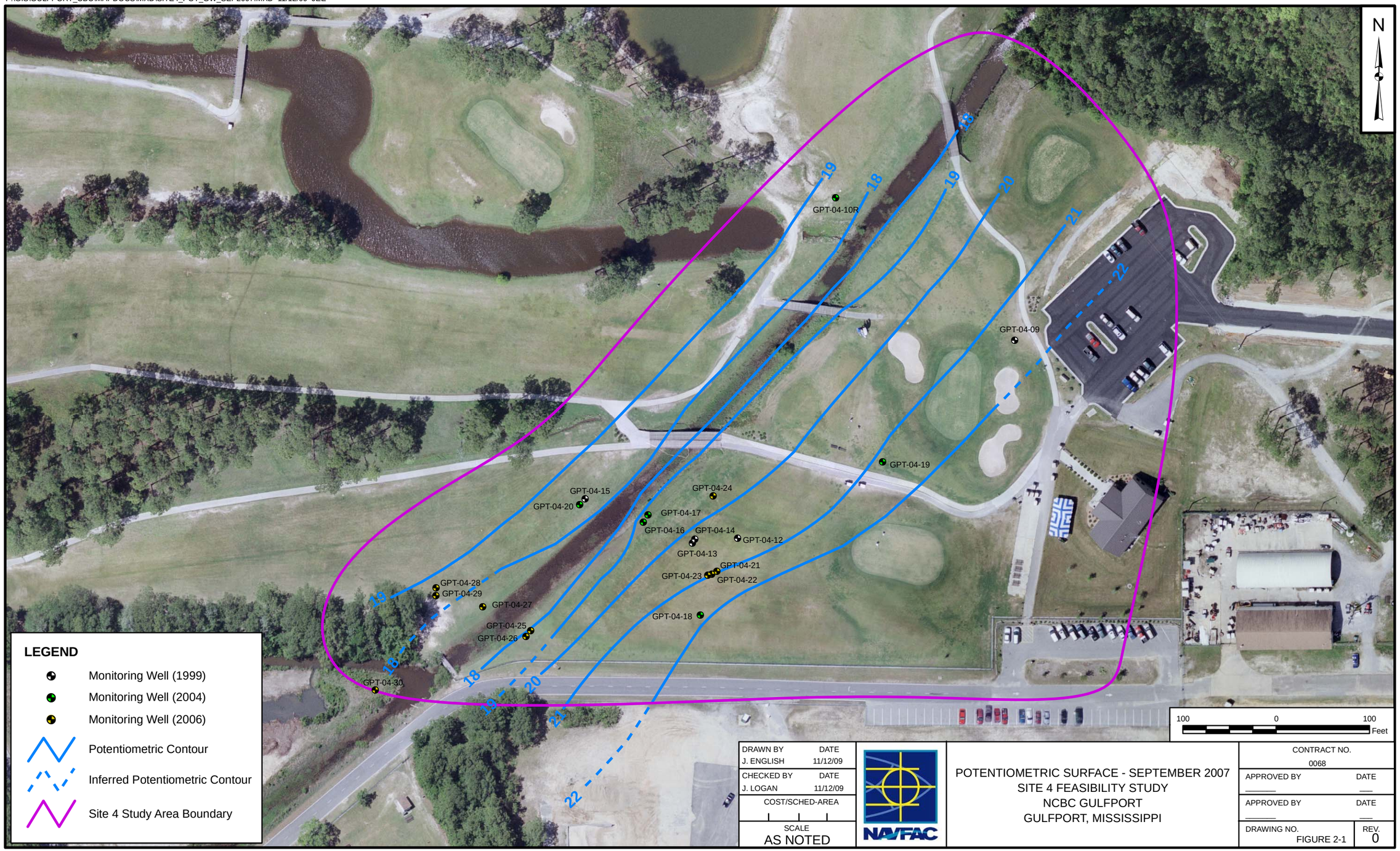


DRAWN BY J. ENGLISH	DATE 11/12/09	POTENTIOMETRIC SURFACE - SEPTEMBER 2007 SITE 4 FEASIBILITY STUDY NCBC GULFPORT GULFPORT, MISSISSIPPI	CONTRACT NO. 0068
CHECKED BY J. LOGAN	DATE 11/12/09		APPROVED BY ____ DATE ____
COST/SCHED-AREA			APPROVED BY ____ DATE ____
SCALE AS NOTED			DRAWING NO. FIGURE 2-1 / REV. 0

3.0 SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF PRESUMPTIVE REMEDY COMPONENTS AND ALTERNATIVES

This section identifies, screens, and evaluates the potential technologies and process options that may be applicable to assemble remedial alternatives for Site 4 at NCBC Gulfport. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that will be used for developing remedial alternatives. Given the applicability of the presumptive remedy approach to Site 4, containment is the recommended remedy, with appropriate modifications as necessary to address the remaining RAOs described in Section 2.1.4.

The basis for remediation technology identification and screening was presented in Section 2.0 with a series of discussions that included the following:

- Identification of ARARs
- Development of RAOs
- Identification of GRAs
  - No Action
  - Limited Action
  - Containment
  - Surface water and sediment protection
  - Groundwater treatment
  - Disposal
  - Landfill gas control

Remedial technology screening is performed in this section with the completion of the following analytical steps:

- Identification and screening of remedial technologies and process options
- Evaluation and selection of representative process options

The selection of remediation technologies and process options for initial screening is based on the Guidance for Conducting RI/FS under CERCLA (USEPA, 1988). The screening is first conducted at a preliminary level to focus on relevant remediation technologies and process options, and then the screening is conducted at a more detailed level based on the evaluation criteria. Finally, process options are selected to represent the remediation technologies that have passed the entire evaluation and screening process.

The USEPA has developed a response action or "presumptive remedy" for CERCLA municipal landfills which should also be applied to all appropriate military landfills (USEPA, 1996). As discussed, the conditions at Site 4 meet the presumptive remedy guidelines so there is no need for conducting an initial identification and screening of alternative technologies for the landfill. Technologies for the sediment, surface water, and groundwater were screened.

Presumptive remedy components include landfill cap, landfill gas collection, and land use controls (LUCs) to supplement engineering controls. Each of these components will be evaluated with the RAOs to determine those applicable for the site-specific conditions. Remedial action alternatives will be established based on the applicable technology types.

3.1 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens remediation technologies and process options at a preliminary stage based on implementation with respect to site conditions and COCs. The following table summarizes the preliminary screening of technologies and process options. It presents the GRAs, identifies the technologies and process options. The following are the technologies and process options that were retained for detailed screening:

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	LUCs	Legal restrictions on land use
		Maintenance of existing cover
	Monitoring	Sampling and analysis of groundwater
		Landfill gas monitoring
Containment	Cap/Cover	Soil cover system
		Cap system
Removal	Excavation	Excavation of sediment
Surface Water and Sediment Protection	Capping of bank and erosion control	Capping canal bank
		Riprap lining of canal bank
Groundwater Treatment	Chemical oxidation	Chemical oxidation
	Anaerobic Reduction Dechlorination	Biostimulation
		Biostimulation and bioaugmentation
Disposal	Landfill	On-site consolidation
Landfill Gas Control	Landfill gas collection, treatment, and monitoring	Landfill gas venting
		Landfill gas to energy

3.2 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

3.2.1 No Action

No action consists of maintaining the status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants.

Effectiveness

The No Action alternative would not be effective in meeting the RAOs for the site. No Action would not be effective in evaluating either potential contaminant reduction through natural attenuation or potential contaminant migration off site since no monitoring would be performed.

Implementability

There would be no implementability concerns since no actions would be implemented.

Cost

Because no remedial actions are conducted under this alternative, there are no costs associated with this alternative.

Conclusion

No action is retained for comparison to other options.

3.2.2 Land Use Controls

LUCs would consist of preparing and implementing a Land Use Control Remedial Design document that would prohibit current site users from being exposed to contaminants and deed restrictions to prevent the site from being used in the future for residential purposes. LUCs would also be used to implement long-term requirements such as inspection and maintenance of a cap/cover, monitoring, and reporting.

Effectiveness

Restricting site access and future uses of the site would prevent direct exposure of both human and ecological receptors to waste and groundwater.

Implementability

LUCs would be readily implementable. Legal requirements for property transfer would need to be met in the event of base closure. Site controls would be easy to formulate and implement. Resources are readily available for the implementation of LUCs.

Cost

Costs of LUCs would be low compared to active remedial measures.

Conclusion

LUCs are retained in combination with other process options for the development of remedial alternatives.

3.2.3 Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from the site to evaluate trends in concentrations and check for potential migration. Monitoring may be considered when contaminated media are left in place without treatment. Monitoring would also include measuring the level of methane in landfill gas beneath the landfill cover and in the vicinity of the landfill.

Effectiveness

Monitoring would not, by itself, remediate the CVOC concentrations in groundwater. However, monitoring would be an effective tool to evaluate potential migration and/or attenuation of contaminants and to determine the direction of future actions.

Implementability

A long-term monitoring program could be readily implemented. Sampling is a routine activity that can be performed by qualified and trained personnel. Environmental consulting firms that offer sampling and laboratory services are readily available.

Cost

Capital and operation and maintenance (O&M) costs of monitoring would be low.

Conclusion

Monitoring is retained in combination with other process options for the development of remedial alternatives.

3.2.4 Containment

3.2.4.1 Cap/Cover

Because the current landfill cover does not meet State of Mississippi Landfill Cover Requirements (see Cover Assessment in Appendix D), slope and grading work must be done, and cover materials need to be added to the landfill to meet the regulatory requirements. This work must satisfy Mississippi Air Quality

Regulations, Storm Water Management, and Non-Hazardous Solid Waste Management Regulations and Criteria.

Covering would consist of providing a barrier to prevent direct exposure to contaminated soil and landfill material, and minimize potential off-site migration of contaminated soil via erosion. Capping would consist of providing a barrier to prevent direct exposure to contaminated soil and landfill material, reduce percolation of precipitation through the waste, and minimize potential off-site migration of contaminated soil via erosion.

Effectiveness

Caps and soil covers as physical barriers can be effective in reducing risk associated with human and ecological exposure to contaminated soil and landfill material beneath the cap or cover. Caps can be effective in reducing the infiltration of rainfall/surface water run-off into the landfill material beneath the cover, which in turn reduces vertical contaminant migration.

Implementability

Capping and soil covering are common remedial alternative and would be fully implementable. Materials are readily available from several vendors, and the materials are commonly used. It is anticipated that borrow sources can be identified relatively close to the base. The main concern with the implementation of the cap would be its maintenance under the influence of natural (e.g., storms and burrowing animals) and human interferences (e.g., development). Proper engineering and continued O&M would minimize the impacts of natural interferences. Because the site is under federal control, human interferences could also be minimized.

Cost

Costs associated with landfill caps/covers are moderate, depending on the materials and labor involved in placement. O&M costs for caps are typically low to moderate.

Conclusion

Capping is retained for development as an alternative. The cap system would be designed to meet MDEQ SW-2 requirements. Soil cover would not have a significant effect on reducing percolation through the waste. This technology meets the requirements of the presumptive remedy for landfills.

3.2.4.2 Removal

A variety of equipment such as front-end loaders, hydraulic excavators, backhoes, and other mechanical equipment could be used to excavate the sediment from the canal. The type of equipment selected must take into consideration several factors, such as the type of material to be removed, the load-bearing

capacity of the ground surrounding the removal area, the depth and areal extent of removal, and the required rate of removal.

The logistics of excavation must take into account the available space for operating the equipment, loading and unloading of the excavated material, location of the site, etc. After sediment removal is completed, the location may be filled and graded with clean fill material.

Because saturated sediment is difficult to handle, sediment traps would be installed at either end of a segment of the canal to be excavated so that the water flow can be diverted around the segment. After the free water has drained from the sediment, the sediment would be excavated. This process would be repeated along the length of the canal until the limits of the excavation have been reached.

Effectiveness

Excavation is a well-proven and effective method of removing sediment. Properly designed excavation plan would remove the contaminated sediment, and the remaining sediment would not pose an unacceptable risk to human health or the environment. However, excavation does not reduce contaminant toxicity or mobility.

Implementability

Excavation of contaminated sediment would be implementable. Excavation equipment is readily available from multiple vendors. This technology is well proven and established in the construction/remediation industry. During excavation, site-specific health and safety procedures and Occupational Safety and Health Administration (OSHA) regulations would be complied with to ensure that the exposure of the workers to COCs is minimized. Based on previous analytical results, it is unlikely that the sediment would be a hazardous waste.

Cost

Cost of excavation on a unit volume basis would be low.

Conclusion

Excavation of sediment is retained in combination with other process options.

3.2.4.3 Surface Water and Sediment Protection

Surface water and sediment protection would consist of lining portions of the canal to reduce groundwater migration into the canal and prevent erosion of the landfill into the canal.

Effectiveness

Lining the bank of the canal by extending the cap down the bank of the landfill side of the canal would be effective in reducing groundwater migration and would be effective in preventing direct contact with contaminated soil. Riprap would prevent erosion of the cap and landfill material. The lining and riprap would need to be inspected and maintained/repaired to ensure its effectiveness over time.

Implementability

Extending the landfill cap down the canal bank and placing riprap would be easy to implement, and the resources, materials, and services required to implement this technology are readily available.

Cost

Capital and O&M costs for surface water and sediment protection would be moderate.

Conclusion

Surface water and sediment protection is retained in combination with other process options for the development of remedial alternatives.

3.2.4.4 Groundwater Treatment

According to the Treatability Study Memorandum (TtNUS, 2007, see Appendix C), various technologies were evaluated for treatment the CVOC groundwater plume. Chemical oxidation, enhanced aerobic biodegradation, enhanced anaerobic reductive dechlorination (ARD) via biostimulation (addition of substrate), ARD via biostimulation and bioaugmentation (addition of suitable microbiota), and cometabolic biodegradation were evaluated to address the CVOC plume in Site 4 during the Treatability Study. Based on the characteristics of the site, such as a naturally reducing environment and significant amount of organic carbon, the ARD via biostimulation and bioaugmentation (addition of suitable microbiota) was chosen as most likely to succeed.

The Treatability Study Memorandum (TtNUS, 2007) concluded that enhanced ARD can be an effective remedial approach for Site 4. The enhanced ARD via bioaugmentation and biostimulation removed a significant mass of CVOCs from the groundwater during the treatability study. Only low concentrations of COCs remain in the groundwater.

Effectiveness

Groundwater treatment would be effective in treating the CVOC plume. The groundwater would be analyzed to verify the treatment, and, if needed, treatment would be repeated to ensure its effectiveness over time. The Treatability Study verified the effectiveness of the process.

Implementability

Groundwater treatment would be easy to implement; and the resources, materials, and services required to implement this technology are readily available.

Cost

Capital and O&M costs for groundwater treatment would be moderate to high.

Conclusion

Groundwater treatment is eliminated because of the low concentrations remaining in the groundwater following the source area treatment that was performed for during the treatability study.

3.2.4.5 On-Site Consolidation

On-site consolidation would consist of placing the excavated sediment on the landfill prior to capping.

Effectiveness

Consolidation would not of itself remove the COCs or reduce their toxicity. Nonetheless, consolidation (with capping) is a well-established and proven technology that would be effective in preventing direct exposure to contaminated sediment and preventing off-site migration of contaminants in the sediment.

Implementability

Consolidation would be relatively easy to implement. Materials and services required to implement this technology are readily available and would be performed during the sediment excavation. Because the landfill is adjacent to the canal, transportation requirements for the sediment to the consolidation area would be low, and there would be no off-site impacts. Risk of worker exposure to contaminated sediment during consolidation would be adequately mitigated by wearing of appropriate personal protection equipment (PPE) and by compliance with OSHA regulations and site-specific health and safety procedures.

Cost

The cost of on-site consolidation would be low.

Conclusion

On-site consolidation is retained in combination with other process options.

3.2.4.6 Landfill Gas Control

A landfill gas survey was conducted as part of the RI to determine if the final cover would need to include a landfill gas venting system. The evaluation included the field measurement of vadose zone gas from five locations at Site 4.

The sampling results showed sufficient methane concentrations to warrant landfill gas control. Landfill gas is typically vented and can be discharged to the atmosphere, treated (e.g, with activated carbon), or used to generate power. However, because of the relatively small size of the landfill and the age of the landfill, a sufficient quantity of methane is not likely to be generated to be burned in a flare or to be used as fuel in an internal combustion engine.

Effectiveness

Landfill gas collection and venting would be effective in preventing the accumulation of explosive landfill gas in on-site and nearby structures. The landfill gas collection and venting system would need to be maintained/repaired and monitored to ensure its effectiveness over time.

Implementability

Landfill gas collection and venting would be easy to implement and the resources, materials, and services required to implement this technology are readily available. The collection and venting system would be included as part of the cap design.

Cost

Capital and O&M costs for landfill gas collection and venting would be low to moderate.

Conclusion

Landfill gas collection and venting is retained in combination with other process options for the development of remedial alternatives.

3.3 SELECTION OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

The following technologies and process options are retained to develop remedial alternatives:

- No Action
- LUCs
- Capping
- Removal: Sediment Excavation
- Surface Water and Sediment Protection: Capping Canal Bank and Erosion Control

- Groundwater Monitoring
- Disposal: On-Site Consolidation of Excavated Sediment
- Landfill Gas Control: Venting and Monitoring

3.4 DEVELOPMENT OF ALTERNATIVES

Alternatives have been developed based on an assembly of the technologies selected under each of the GRAs. The assembly of alternatives follows the assembly of GRAs discussed in Section 2.0. Alternatives are developed to provide an appropriate range of options. Sufficient information is included to adequately evaluate and compare alternatives and to determine the most appropriate alternative. Alternatives are based on USEPA's presumptive remedy guidance to remediate military landfills with municipal landfill characteristics under CERCLA. Also, since the presumptive remedy for this landfill includes capping with landfill gas management, only two alternatives will be analyzed during the following phases of this FS. With the information from the Treatability Study Memorandum, and after discussing the options with regulatory agencies, the two alternatives to be evaluated are no action and a comprehensive action, which includes all the processes retained and the presumptive remedy. The following discusses the assembly of alternatives.

3.4.1 Alternative 1: No Action

The No Action alternative is used as the baseline to use for comparison with other alternatives.

3.4.2 Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management

As shown in Figure 3-1, this alternative consists of various technologies and remedial actions. Institutional controls would consist of restricting access to soil, sediments, groundwater, and surface water with unacceptable risk. LUCs would be developed and implemented to prevent residential development, withdrawal of groundwater, or excavation. Periodic inspections would be required to ensure that the integrity of the cap has not been compromised and to determine whether maintenance to the surface protection is required. Approximately 145,000 square feet would be capped. The cap would consist of three layers (from top to bottom): an erosion layer of topsoil, a low permeability layer, and a gas venting layer. Prior to placing the cap, the site will be graded to promote drainage.

The low permeability layer (MDEQ Regulation SW-2 “infiltration layer”) would consist of 18 inches of soil with a maximum hydraulic conductivity of 1×10^{-5} centimeters per second or a layer with an equivalent hydraulic conductivity installed to minimize the infiltration of rainwater into the landfill. The infiltration layer would minimize the amount of infiltration that would come into contact with the underlying waste. This

action would result in reduced infiltration through the waste and into the groundwater, which would reduce the transport of contaminants from the waste to groundwater.

Beneath the infiltration layer would be a gas venting layer consisting of a granular material, a geocomposite, or a heavy needle-punched nonwoven geotextile that would collect landfill gas. Below the gas venting layer would be a 6-inch layer of common fill (or select waste) that would protect the overlying layer(s) from puncture. Landfill gas will be collected and vented.

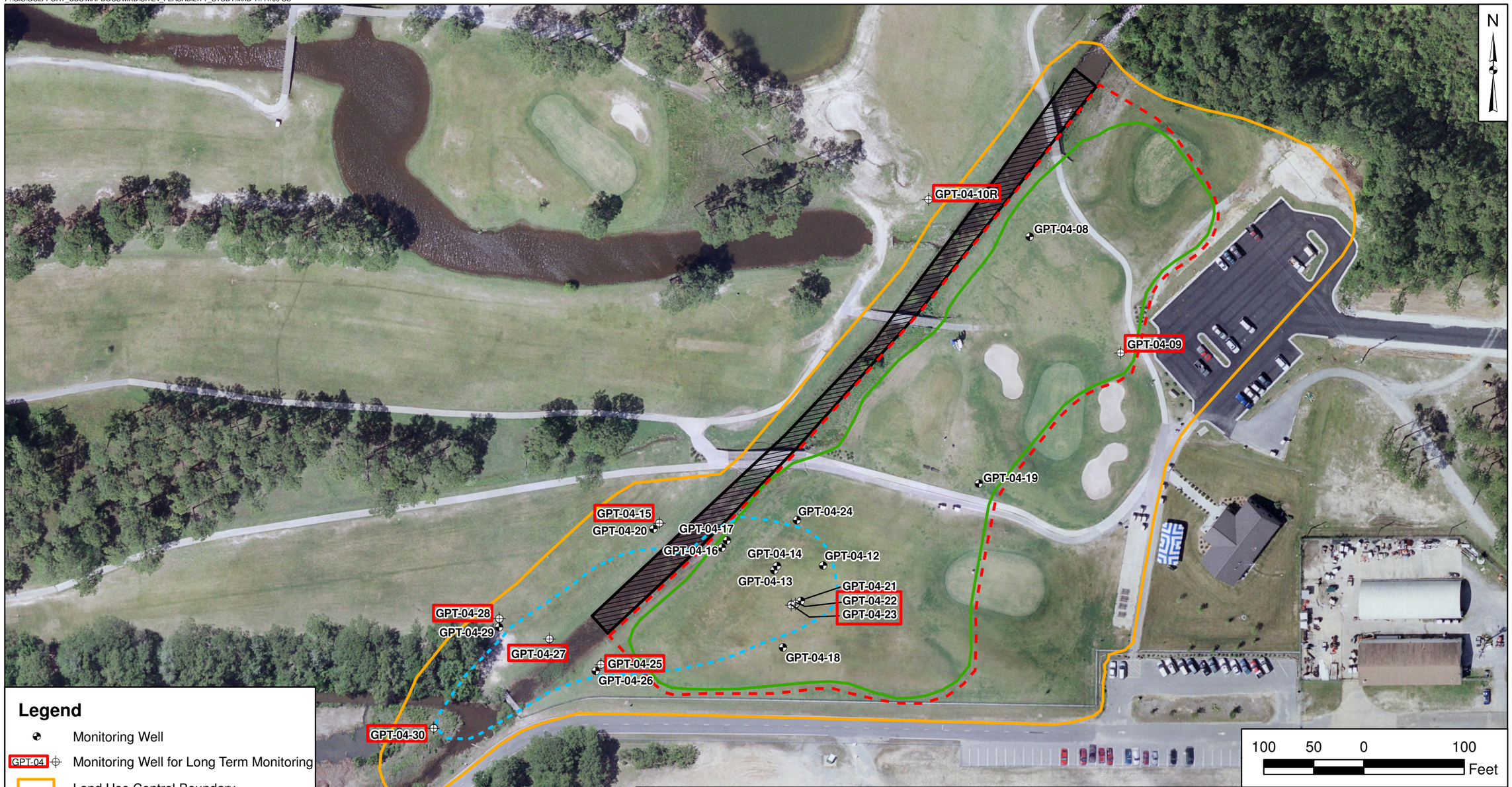
Overlying the infiltration layer would be a topsoil layer (MDEQ Regulation SW-2 “erosion layer”). A 6-inch layer of topsoil would be placed to provide the necessary slope to meet MDEQ requirements. Grading and final site layout would support existing conditions of the golf course.

To prevent erosion of waste and contaminated soil and to reduce the flow of groundwater into the surface water, the landfill cap would extend down the canal bank along the site and be covered with riprap. Prior to capping, the bottom sediment (i.e., highly organic muck) would be dredged and consolidated on site beneath the low permeability cap. The bottom of the canal would be dredged to an average depth of 2.5 feet over a length of approximately 700 feet. The estimated volume of sediment is 1,400 cubic yards. The canal side slope along the landfill would be graded to provide an even surface and to maintain the existing canal cross-section after the placement of the riprap. The length of the canal to be lined is approximately 700 linear feet. Based on data collected during the RI, it is assumed that the excavated material would be characterized as non-hazardous waste.

Landfill gas would be managed by preventing the accumulation of methane gas below the cap. Specific details of the venting system would be identified in the design phase. A gas monitoring program, including vents and probes between the landfill and nearby structures, would also be developed in the design phase.

Because a significant mass of contaminants were removed from the groundwater during the treatability study, no additional treatment is required. Groundwater monitoring would consist of groundwater sample collection and analysis of nine monitoring wells on a quarterly basis for the first year, semi-annually for the next 2 years, and annually thereafter. Samples will be analyzed for VOCs, dioxins/furans, and metals. Wells would be selected to monitor the existing plume and the downgradient side of the landfill.

P:\GIS\GULFPORT_CBC\MAPDOCS\MXD\SITE4_FEASABILITY_STUDY.MXD 11/11/09 SS



Legend

- Monitoring Well
- GPT-04 Monitoring Well for Long Term Monitoring
- Land Use Control Boundary
- Groundwater Plume
- Landfill Boundary
- Landfill Cap Limit
- Sediment Removal Area

DRAWN BY T. WHEATON	DATE 11/06/09
CHECKED BY J. LOGAN	DATE 11/11/09
COST/SCHEDULE-AREA	
SCALE AS NOTED	

NAVFAC

ALTERNATIVE 2
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NUMBER CTO 0068	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
FIGURE NO. FIGURE 3-1	REV 0

4.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

As described in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988), the detailed analysis of alternatives consists of the evaluation and presentation of relevant information needed to allow the selection of a site remedy. In this section, the remedial technologies retained from the presumptive remedy alternatives and components selected in Section 3.0 are assembled into multiple remedial alternatives. The following sections contain descriptions of these alternatives and provide a detailed analysis of these alternatives in accordance with the CERCLA evaluation criteria.

4.1 INTRODUCTION

This section presents an evaluation of each remedial alternative with respect to the nine criteria of the NCP of 40 CFR Part 300, as revised in 1990. The criteria as required by the NCP and the relative importance of these criteria are described in the following subsections.

4.1.1 Evaluation Criteria

In accordance with the NCP (40 CFR 300.430), the following nine criteria are used for the evaluation of remedial alternatives:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

4.1.1.1 Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and the environment, in both the short and long term, from unacceptable risks posed by hazardous substances or contaminants present at the site. For this purpose, alternatives should eliminate, reduce, or control exposure to levels of contaminants exceeding remediation goals. Overall protection draws on the assessments of other

evaluation criteria, especially compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness.

4.1.1.2 Compliance with ARARs

Alternatives must be assessed to determine whether they attain ARARs under federal and state environmental or facility siting regulations. If one or more regulations that are applicable cannot be complied with, a waiver must be invoked by the appropriate regulatory body for the alternative to be considered acceptable. Grounds for invoking a waiver would depend on the following circumstances:

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limit through use of another method or approach.
- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.
- For CERCLA-financed response actions only, an alternative that attains the ARARs, will not provide a balance between the need for protection of human health and the environment at the site and the availability of CERCLA funds to respond to other sites that may present a threat to human health and the environment.

4.1.1.3 Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered as appropriate include the following:

- Magnitude of Residual Risk - Residual risk is posed by untreated waste or treatment residuals at the conclusion of remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and Reliability of Controls - Controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste must be shown to be reliable. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the potential need to replace technical components of an alternative such as a cap, slurry wall, or treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

4.1.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

- The treatment or recycling processes the alternative employs and the materials that they will treat.
- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.
- The degree of expected reduction in toxicity, mobility, or volume of waste due to treatment or recycling and the specification of which reductions are occurring.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that will remain following treatment considering the persistence, toxicity, mobility, and propensity to bioaccumulate of hazardous substances and their constituents.
- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

4.1.1.5 Short-Term Effectiveness

The short-term impacts of the alternative shall be assessed considering the following:

- Short-term risks that might be posed to the community during implementation.
- Potential impacts on workers during the remedial action and the effectiveness and reliability of protective measures.

- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.
- Time until protection is achieved.

4.1.1.6 Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.
- Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies.
- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists and provisions to ensure necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

4.1.1.7 Cost

Capital costs shall include both direct and indirect costs. Annual O&M costs shall be provided. A net present value of the capital and O&M costs shall also be provided. Typically, the cost estimate accuracy range is plus 50 percent to minus 30 percent.

4.1.1.8 State Acceptance

The state's concerns that must be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives.
- State comments on ARARs or the proposed use of waivers.

The state (MDEQ) was provided with the Draft FS for their review and comment. The state's concerns will be evaluated and addressed. These concerns will be incorporated and discussed, to the extent possible, in the Proposed Plan to be issued for public comment.

4.1.1.9 Community Acceptance

This assessment consists of responses from the community to the Proposed Plan. This assessment includes determining which components of the alternative interested people in the community support, have reservations about, or oppose. This assessment can be done after comments on the Proposed Plan are received from the public.

4.1.2 Relative Importance of Criteria

Among the nine criteria, the threshold criteria are considered to be the following:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied for an alternative to be eligible for selection.

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria and are used to weigh the relative merits of alternatives:

- Long-Term Effectiveness and Permanence
- Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

The remaining two criteria - State Acceptance and Community Acceptance - are considered to be modifying criteria that must be considered during remedy selection. State acceptance will be addressed at the Final FS. The last criteria, community acceptance, cannot be completely evaluated until the Proposed Plan has been discussed in a public meeting. Therefore, this section addresses only seven of the nine criteria for each alternative.

4.1.3 Selection of Remedy

The selection of a remedy is a two-step process. The first step consists of identification of a preferred alternative and presentation of the alternative in a Proposed Plan to the community for review and comment. The preferred alternative must meet the following criteria:

- Protection of Human Health and the Environment.
- Compliance with ARARs Unless a Waiver is Justified.
- Cost Effectiveness in Protecting Human Health and the Environment and in Complying with ARARs.
- Utilization of Permanent Solutions and Alternate Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable.

The second step consists of the review of the public comments and the determination, in consultation with MDEQ, as to whether or not the preferred alternative continues to be the most appropriate remedial action for the site.

4.2 ASSEMBLY OF REMEDIAL ALTERNATIVES

Based on the technology screening presented in Section 3.0, and taking into consideration the presumptive remedy guidance, the following two remedial alternatives were developed.

- Alternative 1: No Action
- Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management and Monitoring.

Alternative 1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative 2 was formulated and analyzed to evaluate active remediation. Descriptions and detailed analyses of these alternatives are presented in the following sections.

4.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.3.1 Alternative 1: No Action

4.3.1.1 Description

The no action alternative maintains the site as is. This alternative does not address site contamination and is only retained to provide a baseline for comparison to other alternatives. There would be no reduction in toxicity, mobility, or volume of the COCs other than what might result from natural dispersion, dilution, and other attenuating factors. Existing monitoring programs and institutional controls would be discontinued, and the site would be available for unrestricted use.

4.3.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment. Under the current land-use scenario (industrial/military), the potential for human contact with contaminated soil and landfill material would remain. The primary exposure route would be through construction activities because controls would not be in place to prevent unauthorized digging activities from occurring. If unauthorized digging occurred, construction workers could be exposed to contaminated material primarily through dermal contact and to a lesser extent through ingestion of soil. Additionally, this alternative would not be protective of potential future residents because soil could erode over time and humans could be exposed to elevated contaminant concentrations found in deeper soil. Moreover, these exposed soils could migrate canal and drainage system via erosion.

Concentrations of COCs in soil are expected to migrate into the groundwater at Site 4 if no active remedy is put in place. As a result, this alternative would not be protective of humans who would consume or come into contact with Site 4 groundwater in the future.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce contaminant concentrations. There are no location-specific ARARs identified for Site 4. Action-specific ARARs or TBCs are not applicable because no action would be taken.

Long-Term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence because soil with contaminants with concentrations greater than MDEQ unrestricted TRGs would remain on site. Since there would be no institutional controls to control land use, the potential would exist for human exposure to COCs (primarily construction workers). Because there would be no monitoring, potential migration would not be detected. Although concentrations might eventually decrease to acceptable levels through natural attenuation over the very long term, monitoring would not be in place to verify this condition.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce toxicity, mobility, or volume of COCs through treatment because no treatment would occur. Some reduction of toxicity and volume might occur through natural dispersion, dilution, or other attenuation processes in the very long term, but no monitoring would be performed to verify this condition.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative 1 would not pose any risks to on-site workers or result in short-term adverse impact to the local community and the environment. Alternative 1 would never achieve the RAOs and, although some PRG might eventually be achieved through natural attenuation in the very long term, monitoring would not be in place to verify this condition.

Implementability

Because no action would occur, Alternative 1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability are not applicable. Implementability of administrative measures is not applicable because no such measures would be taken.

Cost

There would be no costs associated with the no action alternative.

4.3.2 Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management and Monitoring

4.3.2.1 Description

Alternative 2 consists of the following components: (1) waste containment, (2) sediment removal and on-site consolidation, (3) canal lining, (4) LUCs, (5) groundwater monitoring, and (6) landfill gas management and monitoring.

Component 1: Waste Containment

Waste containment with a landfill cap, that satisfies current MDEQ requirements would be installed at Site 4. The landfill capping will:

- Prevent direct contact with COC contaminated media
- Reduce direct infiltration
- Reduce leaching to groundwater
- Prevent transport due to erosion

Component 2: Sediment Removal and On-Site Consolidation

Sediment will be excavated from Canal No. 1 and consolidated on Site 4 beneath the cap.

Component 3: Canal Lining

The cap described in component 1 will be extended into Canal No. 1 in order to reduce the flow of groundwater into surface water.

Component 4: LUCs

LUCs would be developed and implemented to prevent residential development, prohibit groundwater consumption on Site 4, establish procedures for excavation, and control the design of structures on or near the landfill to prevent the accumulation of landfill gas. Periodic inspections would be required to ensure that the integrity of the surface protection has not been compromised and to determine whether maintenance of the surface protection is required.

Component 5: Groundwater Monitoring

The current concentration of CVOCs along the western (downgradient) landfill cap boundary are less than treatment standards, but should be monitored over time to ensure that the source area treatment performed during the treatability study remains an effective control. The samples will also be analyzed for dioxins/furans and metals because of the presence of these COCs in monitoring wells within the waste area.

Component 6: Landfill Gas Management and Monitoring

Landfill gas would be controlled by preventing the accumulation of methane gas below the cap. Specific details would be identified in the design phase. The methane concentration in the gas will be routinely sampled and analyzed. Methane would be measured at landfill vents and from probes located between the landfill and nearby structures.

4.3.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health and the environment.

Removal of contaminated sediment from Canal No. 1 would eliminate risk of exposure to human and ecological receptors. Capping the landfill will prevent direct contact with contaminated media. Groundwater monitoring will confirm that contaminants are not migrating. These remedial activities would also protect human health and the environment by reducing the potential for future migration of contaminants. Also, capping the landfill would prevent further transport and possible human exposure. LUCs would prevent exposure by prohibiting groundwater use, preventing unrestricted site uses (for example, residential uses), establish procedures for excavation, and control the design of structures to prevent the accumulation of landfill gas.

Compliance with ARARs and TBCs

Alternative 2 would comply with chemical- and action-specific ARARs and TBCs. There are no location-specific ARARs identified for Site 4.

Long-Term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness and permanence. Excavation of sediment from Canal No. 1, surface/waste protection with a landfill cap, and landfill gas venting are technologies that would offer effective and permanent solutions to prevent exposure to contaminants at the site. Removal of sediment from Canal No. 1 would effectively minimize the adverse impact from contaminated media on human health and the environment. Furthermore, the capping and lining of the Canal No. 1 would reduce direct infiltration and reduce the flow of groundwater to surface water. LUCs would provide a mechanism to maintain the cap and erosion controls on the canal bank.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although exposure to contaminants would be limited by capping and LUCs, there is no reduction of toxicity, mobility, or volume through treatment in Alternative 2.

Short-term Effectiveness

Alternative 2 would have some short-term effectiveness concerns. Exposure of workers to contamination during remediation activities would be minimized by implementing engineering controls (e.g., dust suppression) and complying with site-specific health and safety procedures, including the use of appropriate PPE. Alternative 2 would not result in a significant destruction of ecological habitat. The RAOs would be achieved upon completion of remedial activities.

Implementability

Alternative 2 would be readily implemented.

Implementation of excavation of contaminated sediment, capping the landfill and canal bank, groundwater and landfill gas monitoring, and landfill gas control could readily be accomplished. The resources, equipment, and materials required to implement these activities are readily available.

Administratively, implementation and enforcement of excavation notification and excavated sediment testing requirements would be relatively simple to implement. Also, because the current landfill cover does not meet MDEQ Regulation SW-2 requirements, additional slope and grading work must be done, and cover materials need to be added to the landfill to meet the regulatory requirements. This work must satisfy Mississippi Air Quality Regulations, storm water management, and non-hazardous solid waste management regulations and criteria. These administrative procedures, while constituting a significant effort, could readily

be accomplished. Long-term groundwater and landfill gas monitoring, site inspection, and maintenance could be easily implemented. Five-year reviews would be required because contaminated media will remain on site.

Cost

The estimated costs for Alternative 2 are:

- Capital cost: $1,938,000
- NPW of O&M cost: $467,000
- NPW: $2,405,000

A detailed breakdown of the cost estimate for this alternative is provided in Appendix B.

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the analyses that were presented for each of the remedial alternatives in Section 4.0. The criteria for comparison are identical to those used for the detailed analysis of individual alternatives.

5.1 COMPARISON OF REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal/On-Site Consolidation, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management and Monitoring.

5.1.1 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment because contaminants would remain at concentrations in excess of the PRGs in subsurface soil, groundwater, surface water and sediments. Exposure to these contaminants would not be prevented. Also, under this alternative, no monitoring would occur; therefore, no warning would be provided if concentrations of contaminants were to migrate through the canal or groundwater.

Alternative 2 would provide the highest level of protection because contaminated sediments would be removed from the canal and consolidated on-site beneath the low permeability cap. Groundwater and landfill gas would be monitored and the landfill would be properly capped to prevent exposure to contaminants and landfill material. LUCs would prevent exposure by prohibiting groundwater use, preventing unrestricted site uses (for example, residential uses), establish procedures for excavation, and control the design of structures to prevent the accumulation of landfill gas.

5.1.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs. Action-specific ARARs or TBCs would not apply. Alternative 2 would comply with chemical- and action-specific ARARs and TBCs. There are no location-specific ARARs identified for Site 4.

5.1.3 Long-Term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because no contaminant removal or reduction would occur. Because there would be no site controls to restrict access to Site 4, the potential would also exist for direct exposure to contaminated media. Because there would be no monitoring, potential migration of contaminants would remain undetected.

Alternative 2 would be the most long-term effective and permanent remedy. Under this alternative, contaminated sediments would be removed from the canal. The landfill would be capped, the canal bank would be capped, and groundwater would be monitored. LUCs would provide a mechanism to maintain the cap and erosion controls on the canal bank. These actions would eliminate threats to human and ecological health effectively and permanently.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not achieve any reduction of toxicity, mobility, or volume of contaminated media through treatment. This alternative might eventually achieve reduction of contaminant toxicity and volume through natural attenuation; however, this reduction would neither be verified or quantified.

Alternative 2 would not achieve any reduction of toxicity, mobility, or volume of contaminated media through treatment.

5.1.5 Short-Term Effectiveness

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment because no remedial activities would be performed. Alternative 1 would never achieve the RAOs, and although the groundwater PRGs might eventually be attained through natural attenuation processes in the very long term, this occurrence would not be verified.

Implementation of Alternative 2 would result in the possibility of exposing construction workers to contamination during remedial activities. However, the risk of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression) and compliance with proper site-specific health and safety procedures. Alternative 2 would be expected to achieve RAOs immediately upon completion of all remedial activities.

5.1.6 Implementability

Alternative 1 would be extremely simple to implement because no action would occur.

Alternative 2 would be easy to implement because resources, equipment, and materials are readily available to perform the excavation, capping, groundwater and landfill gas monitoring, and landfill gas control. Site controls, long-term monitoring, inspection, and maintenance, and 5-year reviews would be required because contaminated media will remain on site.

5.1.7 Cost

The capital and O&M costs and NPW of the alternatives are summarized as follows:

Alternative	Capital	NPW of O&M		NPW	
1	0	0		0	
2	$1,938,000	$467,000	(30 Year)	$2,405,000	(30 Year)

Detailed cost estimates are provided in Appendix B.

5.2 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Table 5-1 summarizes the comparative analysis of the two remedial alternatives.

TABLE 5-1

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SITE 4 FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

Criterion	Alternative 1: No Action	Alternative 2: Comprehensive Action
Overall Protection of Human Health and the Environment	The No Action alternative provides a baseline against other alternatives. This alternative would involve no treatment, engineering measures, or institutional actions. If implemented, this action would not be protective of human health or the environment.	Capping of landfill and removal of contaminated sediment would eliminate potential exposure to COCs. Capping of the landfill will prevent migration of contaminants via erosion and prevent percolation of rain from leaching contaminants from landfill material to groundwater. LUCs would prevent exposure to contaminants in the groundwater.
Compliance with ARARs and TBC	The No Action alternative does not trigger any ARAR. However, it does not comply with federal and state ARARs that require cleanup of contaminated sites.	Would meet the threshold criteria for compliance with ARARs.
Long-Term Effectiveness and Permanence	This alternative would not be effective in the long term.	This alternative should be effective for the long term in protecting human health and the environment by keeping contaminant migration pathways from being completed. LUCs would provide for routine inspection, maintenance, and monitoring.
Reduction of Toxicity, Mobility, or Volume through Treatment	This alternative would not reduce toxicity, mobility, or volume of contaminated media through treatment.	This alternative would not reduce toxicity, mobility, or volume of contaminated media through treatment.
Short-Term Effectiveness	This alternative would not entail any remedial activities that would impact the community, workers, or the environment during implementation.	Risk to workers would be limited to those normally associated with construction and groundwater and landfill gas monitoring activities. This risk would be mitigated through the development and implementation of a project-specific health and safety plan.
Implementability	This alternative could be readily implemented because it would not involve remediation activities.	The technology needed for this alternative would be readily available, easily implemented, and reliable.
Cost	There would be no cost with this alternative.	Capital cost: $1,938,000 NPW of O&M cost: $467,000 NPW: $2,405,000

ARAR = Applicable or relevant and appropriate requirement.
COC = Chemical of concern.
LUC = Land use control.
TBC = To be considered.
FS = Feasibility Study.
NPW = Net present worth.
O&M = Operation and maintenance.

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APPENDIX A

PRESUMPTIVE REMEDY INFORMATION/DETERMINATION

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response
Directive No.9355.0-67FS
EPA/540/F-96/020
PB96-963314
December 1996

EPA

Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills

Federal Facilities Restoration and Reuse Office
Mail Code 5101

Quick Reference Fact Sheet

Presumptive remedies are preferred technologies for common categories of sites based on historical patterns of remedy selection and the U.S. Environmental Protection Agency's (EPA's) scientific and engineering evaluation of performance data on technology implementation. By streamlining site investigation and accelerating the remedy selection process, presumptive remedies are expected to ensure the consistent selection of remedial actions and reduce the cost and time required to clean up similar sites. Presumptive remedies are expected to be used at all appropriate sites. Site-specific circumstances dictate whether a presumptive remedy is appropriate at a given site.

EPA established source containment as the presumptive remedy for municipal landfill sites regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in September of 1993 (see the directive *Presumptive Remedy for CERCLA Municipal Landfill Sites*). The municipal landfill presumptive remedy should also be applied to all appropriate military landfills. This directive highlights a step-by-step approach to determining when a specific military landfill is an appropriate site for application of the containment presumptive remedy. It identifies the characteristics of municipal landfills that are relevant to the applicability of the presumptive remedy, addresses characteristics specific to military landfills, outlines an approach to determining whether the presumptive remedy applies to a given military landfill, and discusses administrative record documentation requirements.

PURPOSE

This directive provides guidance on applying the containment presumptive remedy to military landfills. Specifically, this guidance:

- Describes the relevant characteristics of municipal landfills for applicability of the presumptive remedy;
- Presents the characteristics specific to military installations that affect application of the presumptive remedy;
- Provides a decision framework to determine applicability of the presumptive remedy to military landfills; and
- Provides relevant contacts/specialists in military wastes, case histories, administrative record documentation requirements, and references.

BACKGROUND

Municipal landfills are those facilities in which a combination of household, commercial and, to a lesser extent, industrial wastes have been co-disposed. The presumptive remedy for municipal landfills – source containment – is described in detail in the directive *Presumptive Remedy for CERCLA Municipal Landfill Sites*. Highlight 1 outlines the components of the containment presumptive remedy. Highlight 2 lists the characteristics of municipal landfills that are compatible with the presumptive remedy of containment.

Highlight 1

Components of the Containment Presumptive Remedy

- Landfill cap
- Source area groundwater control to contain plume
- Leachate collection and treatment
- Landfill gas collection and treatment
- Institutional controls to supplement engineering controls

Highlight 2

Appropriate Municipal Landfill Characteristics for Applicability of the Presumptive Remedy

- Risks are low-level, except for "hot spots"
- Treatment of wastes is usually impractical due to the volume and heterogeneity of waste
- Waste types include household, commercial, nonhazardous sludge, and industrial solid wastes
- Lesser quantities of hazardous wastes are present as compared to municipal wastes
- Land application units, surface impoundments, injection wells, and waste piles are not included

The presumptive remedy process involves streamlining of the remedial investigation/feasibility study (RI/FS) or, for non-time-critical removals, an Engineering Evaluation/Cost Analysis (EE/CA) by:

- Relying on existing data to the extent possible rather than characterizing landfill contents (limited or no landfill source investigation unless there is information indicating a need to investigate hot spots);
- Conducting a streamlined risk assessment; and
- Developing a focused feasibility study that analyzes only alternatives consisting of appropriate components of the presumptive remedy and, as required by the National Contingency Plan, the no action alternative.

Several directives, including *Presumptive Remedy for CERCLA Municipal Landfill Sites, Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, and *Streamlining the RI/FS for CERCLA Municipal Landfill Sites,* provide a complete discussion of these streamlining principles.

USE OF THIS GUIDANCE

EPA anticipates that the containment presumptive remedy will be applicable to a significant number of landfills found at military facilities. Although waste types may differ between municipal and military landfills, these differences do not preclude use of source containment as the primary remedy at appropriate military landfills.

Additionally, EPA continues to seek greater consistency among cleanup programs, especially in the process of selecting response actions for sites regulated under CERCLA and corrective measures for facilities regulated under the Resource Conservation and Recovery Act (RCRA). In general, even though the Agency's presumptive remedy guidances were developed for CERCLA sites, they should also be used at RCRA Corrective Action sites to focus RCRA Facility Investigations, simplify evaluation of remedial alternatives in the Corrective Measures Study, and influence remedy selection in the Statement of Basis. For more information, refer to the *RCRA Corrective Action Plan*, the proposed *Subpart S regulations,* and the *RCRA Corrective Action Advance Notice of Proposed Rulemaking.*

CHARACTERISTICS OF MILITARY LANDFILLS

The size of the landfill and the presence, proportion, distribution, and nature of wastes are fundamental to the application of the containment presumptive remedy to military landfills.

An examination of 31 Records of Decisions (RODs) that document the remedial decisions for 51 landfills at military installations revealed that no action was chosen for 10 landfills and remedial actions were chosen at 41 landfills (see Appendix). Of these 41 landfills, containment was selected at 23 (56 percent). For the remaining 18 landfills where other remedies were selected, institutional controls only were selected at three landfills, excavation and on-site consolidation were selected at four landfills, and excavation and off-site disposal were selected for 11 landfills.

The military landfills examined in the 51 RODs mentioned above ranged in size from 100 square feet to 150 acres and contained a wide variety of waste types. Of the 41 landfills for which remedial actions were chosen, 14 (34 percent) were one acre or less in size; containment was not selected for any of these landfills. Containment was chosen at 23 (85 percent) of the 27 landfills that were greater than one acre in size. This information suggests that the size of the landfill area is an important factor in determining the use of source containment at military landfills.

The wastes most frequently deposited at these military landfills were municipal-type wastes: household, commercial (e.g., hospital wastes, grease, construction debris), and industrial (e.g., process wastes, solvents, paints) wastes. Containment was the remedy selected at the majority of these sites. Military-specific wastes (e.g., munitions) were found at only 5 of the 51 landfills (10 percent).

Highlight 3 lists typical municipal and military wastes, including:

(1) Wastes that are common to both municipal landfills and military landfills;

(2) Wastes that are usually specific to military bases but that do not necessarily pose higher risks than other industrial wastes commonly found in municipal landfills (i.e., low-hazard military-specific wastes), depending on the volume and heterogeneity of the wastes; and

(3) High-hazard military wastes that, because of their unique characteristics, would require special consideration (i.e., high-hazard military-specific wastes).

The proportion and distribution of hazardous wastes in a landfill are important considerations. Generally, municipal landfills produce low-level threats with occasional hot spots. Similarly, most military landfills present only low-level threats with pockets of some high-hazard waste. However, some military facilities (e.g., weapons fabrication or testing, shipbuilding, major aircraft or equipment repair depots) have a high level of industrial activity compared to overall site activities. In these cases, there may be a higher proportion and wider distribution of industrial (i.e., potentially hazardous) wastes present than at other less industrialized facilities.

PRACTICAL CONSIDERATIONS

Sensitive Environments

Site-specific conditions may limit the use of the containment presumptive remedy at military landfills. For example, the presence of high water tables, wetlands and other sensitive environments, and the possible destruction or alteration of existing habitats as a result of a particular remedial action could all be important factors in the selection of the remedy.

Land Use

Reasonably anticipated future land use is also an important consideration at all sites. However, at military bases undergoing base closure procedures, where expeditiously converting property to civilian use is one of the primary goals, land use may receive heightened attention. Thus, at bases that are closing, it is particularly important for reuse planning to proceed concurrently with environmental investigation and restoration activities. The local reuse group is responsible for developing the preferred reuse alternatives. The Base Realignment and Closure Team should work closely with the reuse group to integrate reuse planning into the cleanup process, where practicable (see the *Land Use in CERCLA Remedy Selection* directive).

Highlight 3
Examples of Municipal-Type and Military-Specific Wastes

Municipal-Type Wastes

Municipal landfills contain predominantly nonhazardous materials. However, industrial solid waste and even some household refuse (e.g., pesticides, paints, and solvents) can possess hazardous components. Further, hazardous wastes are found in most municipal landfills as a result of past disposal practices.

Predominant Constituents

Household refuse, garbage, and debris
Commercial refuse, garbage, and debris
Construction debris
Yard wastes

Found In Low Proportion

Asbestos
Batteries
Hospital wastes
Industrial solid waste(s)
Paints and paint thinner
Pesticides
Transformer oils
Other solvents

Military-Specific Wastes

The majority of military landfills contain primarily nonhazardous wastes. The materials listed in this column are rarely predominant constituents of military landfills.

Low-Hazard Military-Specific Wastes

These types of wastes are specific to military bases but generally are no more hazardous than some wastes found in municipal landfills.

Low-level radioactive wastes
Decontamination kits
Munitions hardware

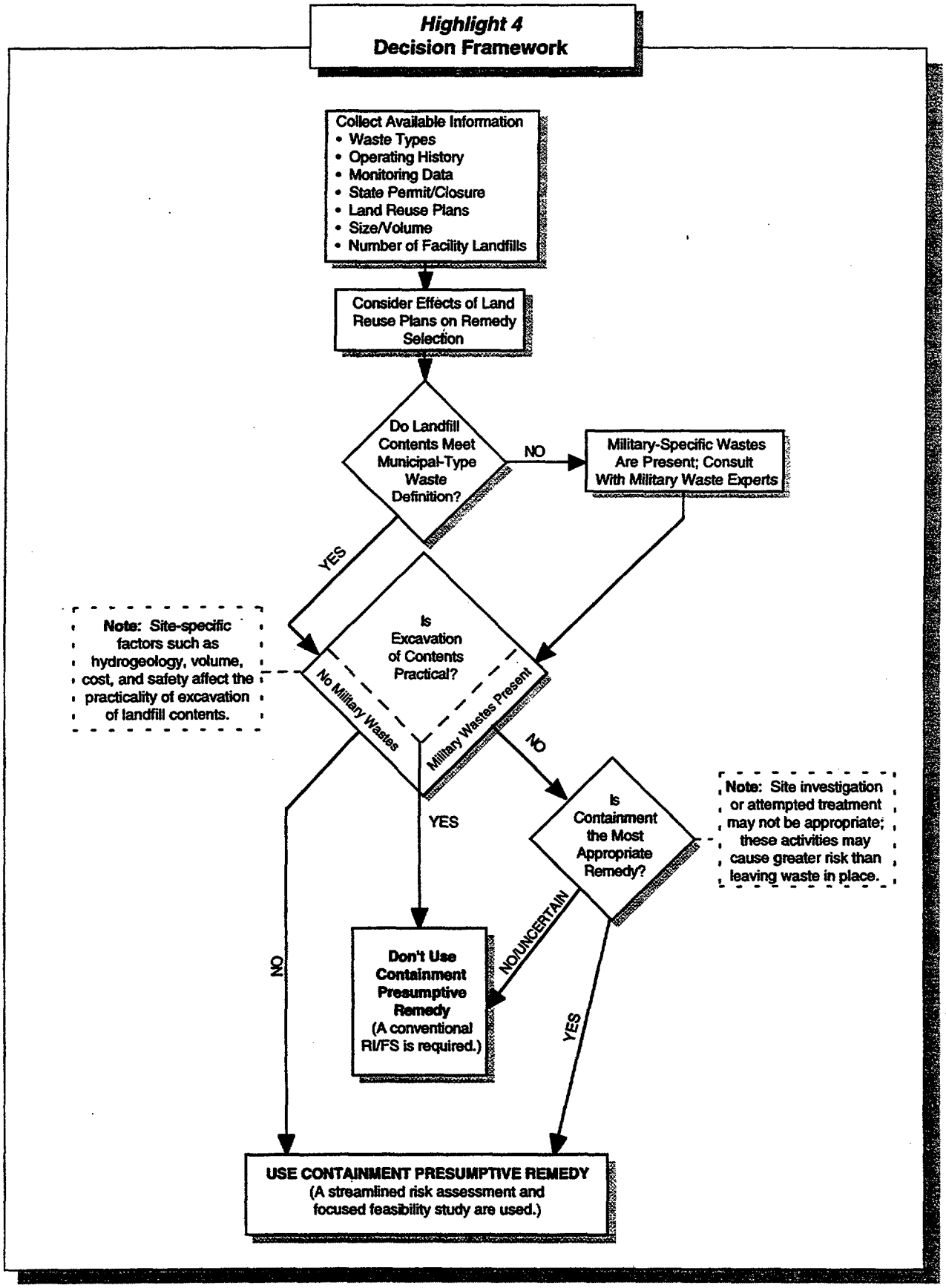
High-Hazard Military-Specific Wastes

These wastes are extremely hazardous and may possess unique safety, risk, and toxicity characteristics. Special consideration and expertise are required to address these wastes.

Military Munitions

Chemical warfare agents
(e.g., mustard gas, tear agents)
Chemical warfare agent training kits
Artillery, small arms, bombs
Other military chemicals
(e.g., demolition charges, pyrotechnics, propellants)
Smoke grenades

Highlight 4
Decision Framework



DECISION FRAMEWORK TO EVALUATE APPLICABILITY OF THE PRESUMPTIVE REMEDY TO MILITARY LANDFILLS

This Section and Highlight 4 describe the steps involved in determining whether the containment presumptive remedy applies to a specific military landfill.

1. What Information Should Be Collected? Determine the sources, types, and volumes of landfill wastes using historical records, state files, closure plans, available sampling data, etc. This information should be sufficient to determine whether source containment is the appropriate remedy for the landfill. If adequate data do not exist, it may be necessary to collect additional sampling or monitoring data. The installation point of contact (environmental coordinator, base civil engineer, or public works office) should be contacted to obtain records of disposal practices. Current and former employees are also good sources of information.

2. How May Land Reuse Plans Affect Remedy Selection? For smaller landfills (generally less than two acres), land reuse plans may influence the decision on the practicality of excavation and consolidation or treatment of landfill contents. Excavation is a remedial alternative that is fundamentally incompatible with the presumptive remedy of source containment.

3. Do Landfill Contents Meet Municipal Landfill-Type Waste Definition? To determine whether a specific military landfill is appropriate for application of the containment presumptive remedy, compare the characteristics of the wastes to the information in Highlights 2 and 3.

4. Are Military-Specific Wastes Present? Military wastes, especially high-hazard military wastes, may possess unique safety, risk, and toxicity characteristics. Highlight 3 presents examples of these types of materials. If historical records or sampling data indicate that these wastes may have been disposed at the site, special consideration should be given to their handling and remediation. Caution is warranted because site investigation or attempted treatment of these contaminants may pose safety issues for site workers and the community. Some high-hazard military-specific wastes could be considered to present low-level risk, depending on the location, volume, and concentration of these materials relative to environmental receptors. Consult specialists in military wastes (see Highlight 5) when determining whether military-specific wastes at a site fall into either the low-hazard or the high-hazard military-specific waste category found in Highlight 3.

Highlight 5
Specialists in Military Wastes

The installation point of contact will notify the major military command's specialists in military wastes (Explosive Ordnance Disposal Team) for assistance with regard to safety and disposal issues related to any type of military items.

Army chemical warfare agents specialists:

- Project Manager, Non-Stockpile Chemical Materiel, Aberdeen Proving Ground, Maryland 21010-5401, (410) 671-1083.

Navy ordnance related items specialists:

- The Navy Ordnance Environmental Support Office, Naval Surface Warfare Center, Indian Head, Maryland 20460-5035, (301) 743-4534/ 4906/4450.

Navy low-level radioactive wastes specialists:

- The Naval Sea Systems Command Detachment, Radiological Affairs Support Office, Yorktown, Virginia 23691-0260, (804) 887-4692.

Air Force ordnance specialists:

- The Air Force Civil Engineering Support Agency, Contingency Support Division, Tyndall AFB, Florida 32403-5319, (904) 283-6410.

Responsibilities for response are clearly spelled out in the regulation *Interservice Responsibilities For Explosive Ordnance Disposal.*

5. Is Excavation of Contents Practical? The volume of landfill contents, types of wastes, hydrogeology, and safety must be considered when assessing the practicality of excavation and consolidation or treatment of wastes. Consideration of excavation must balance the long-term benefits of lower operation and maintenance costs and unrestricted land use with the initial high capital construction costs and potential risks associated with excavation. Although no set excavation volume limit exists, landfills with a content of more than 100,000 cubic yards (approximately two acres, 30 feet deep) would normally not be considered for excavation. If military wastes are present, especially high-hazard military wastes such as ordnance, safety considerations may be very important in determining the practicality of excavation.

If excavation of the landfill contents is being considered as an alternative, the presumptive remedy should not be used. Therefore, a standard RI/FS would be required to adequately analyze and select the appropriate remedial actions.

6. Can the Presumptive Remedy Be Used? The site manager will make the initial decision of whether a particular military landfill site is suitable for the presumptive remedy or whether a more comprehensive RI/FS is required. This determination must be made before the RI/FS is initiated. This decision will depend on whether the site is a potential candidate for excavation, and if not, whether the nature of contamination is such that a streamlined risk evaluation can be conducted.* A site generally is eligible for a streamlined risk evaluation if groundwater contaminant concentrations clearly exceed chemical-specific standards or the Agency's level of risk or if other conditions exist that provide a justification for action (e.g., direct contact with landfill contents due to unstable slopes). If these conditions do not exist, a quantitative risk assessment that addresses all exposure pathways will be necessary to determine whether action is needed. Before work on the RI/FS workplan is initiated, the community and state should be notified that a presumptive remedy is being considered for the site. It is important for all stakeholders to understand completely how the presumptive remedy process varies from the usual clean-up process, and the benefits of using the presumptive remedy process.

TREATING "HOT SPOTS"

The presumptive remedy also allows for the treatment of hot spots containing military-specific (or other) waste. While the analysis, *Feasibility Study Analysis for CERCLA Municipal Landfill Sites,* that justified the selection of source containment as the presumptive remedy for municipal landfill sites did not specifically take into account high-hazard military wastes, the high-hazard materials present in some military landfills may be compared to the hazardous wastes at municipal landfills and could potentially be treated as hot spots. For further information and case studies on treatment of hot spots, see the *Presumptive Remedy for CERCLA Municipal Landfill Sites* directive.

CASE HISTORIES

The case histories below illustrate how use of the municipal landfill presumptive remedy at military landfills follows the decision framework in Highlight 4.

* See *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, which states that if MCLs or non-zero MCLGs are exceeded [a response] action generally is warranted.

The decision to use the presumptive remedy can be made for one landfill or as a part of a site-wide strategy (as in the Loring Air Force Base example below), depending on factors such as the nature of the wastes, size of the landfill, land reuse potential, and public acceptance.

The following case histories present examples of where the containment presumptive remedy was or was not applied, based on site-specific conditions.

Disposal of Municipal-Type Wastes

The **Naval Reactor Facility (NRF)** site in Idaho Falls, Idaho, was established in 1949 as a testing site for the nuclear propulsion program. The three landfill units at the site received solid wastes similar to municipal landfills. These wastes included petroleum and paint products, construction debris, and cafeteria wastes. Historical records do not indicate that any radioactive wastes were disposed of in these landfill units. The selected remedy for the landfills at the site included the installation of a 24-inch native soil cover designed to incorporate erosion control measures to reduce the effects from rain and wind. The remedy also provided for maintenance of the landfill covers, including subsidence correction and erosion control. Monitoring of the landfills will include sampling of soil gas to assess the effectiveness of the cover and sampling of the groundwater to ensure that the remedy remains protective. Institutional controls will also be implemented to prevent direct exposure to the landfill. The NRF site is an example of where the streamlining principles of the presumptive remedy process, including a streamlined risk assessment and a focused feasibility study, were successfully employed.

Co-Disposal of High-Hazard Wastes

At the **Massachusetts Military Reservation**, in Cape Cod, Massachusetts, anecdotal information indicated that munitions had been disposed of at an unidentified location in a landfill that primarily contained municipal-type waste. Ground penetrating radar was utilized to determine if there were any discrete disposal areas containing potential hot spots at this site and found none. Because the munitions waste was not in a known discrete and accessible area, it could not be treated as a hot spot. Consequently, without excavating or treating the munitions waste as a hot spot, the authorities decided to cap the landfill. In this case, the streamlining principles of the presumptive remedy process were applied. For example, site investigation was limited and treatment options were not considered.

Land Reuse Considerations

At **Loring Air Force Base**, a closing base in Limestone, Maine, base landfills 2 and 3 (9 and 17 acres, respectively) consisted primarily of municipal and flightline wastes. The selected remedy for these landfills included a multi-layer cap, passive venting system, and institutional controls. The RODs for the landfills, signed in September 1994, required placing a RCRA Subtitle C cap on the landfills. To construct the RCRA cap, the designers estimated that 400,000 to 600,000 cyds of material would have to be placed on the landfills prior to construction of the cap to ensure proper drainage and slopes.

At Loring, the streamlining principles of the containment remedy, a focused feasibility study, and a streamlined risk assessment were applied for landfills 2 and 3. Additionally, the RODs signed for these landfills specified that excavated material from other parts of the base would be used at the landfills to meet subgrade design specifications. To date, more than 500,000 cyds of contaminated soils have been excavated and used as subgrade for the landfills (after demonstrating compliance with RCRA Land Disposal Restrictions). In addition to cost savings realized by providing subgrade, other benefits have been realized, such as limiting the number of parcels requiring deed restrictions and minimizing locations requiring operation and maintenance. At this base, the landfill consolidation efforts resulted in an estimated total cost savings of $12–20 million while incorporating future land use considerations into the decision process.

The Brunswick Naval Air Station in Brunswick, Maine, contained several landfill sites. One of the first RODs signed, for Sites 1 and 3, called for construction of a 12-acre RCRA Subtitle C cap and a slurry wall, as well as for groundwater extraction and treatment. Subsequently, during the remedy selection process for Site 8, the public objected to containment as the proposed remedy for this relatively small (0.6 acre) site on the grounds that should the base eventually close, containment would create several useless parcels of land. After public comment, the Navy reconsidered, proposing instead to excavate Site 8 and consolidate the removed materials (which consisted of construction debris and soil contaminated with nonhazardous levels of polycyclic aromatic hydrocarbons) as part of the necessary subgrade fill for the landfill cap to be constructed at Sites 1 and 3. In this case, land reuse considerations preempted the selection of a containment remedy.

PRESUMPTIVE REMEDY ADMINISTRATIVE RECORD DOCUMENTATION REQUIREMENTS

As stated earlier, it must be determined whether the military landfill in question contains military-specific wastes, as described in Highlight 3. This should be followed by a determination of whether anything about these wastes would make the engineering controls specified in the presumptive remedy for municipal landfills less suitable at that site. These determinations must be documented in the administrative record, which supports the final decision. This information, in turn, will assist the public in understanding the evaluation of the site as a candidate for use of the presumptive remedy and the advantage it provides. For further reference, the administrative record requirements for all Superfund sites including military landfills are explained in the *Final Guidance on Administrative Records for Selecting CERCLA Response Actions.*

The administrative record must contain the following generic and site-specific information, which documents the selection or non-selection of the containment presumptive remedy.

Generic Information

A. **Generic Documents.** These documents should be placed in the docket for each federal facility site where the containment presumptive remedy is selected. Each EPA Regional Office has copies of the following presumptive remedy documents:

- *Presumptive Remedy: Policy and Procedures*
- *Presumptive Remedy for CERCLA Municipal Landfill Sites*
- *Application of the Municipal Landfill Presumptive Remedy to Military Landfills*
- *Feasibility Study Analysis for CERCLA Municipal Landfill Sites*

B. **Notice Regarding Backup File.** The docket should include a notice specifying the location of and times when public access is available to the generic file of backup materials used in developing the *Feasibility Study Analysis for CERCLA Municipal Landfill Sites*. This file contains background materials such as technical references and portions of the feasibility studies used in the generic study. Each EPA Regional Office has a copy of this file.

Site-specific Information

Focused FS or EE/CA. Military-specific wastes need to be addressed in site-specific analyses when determining the applicability of the containment presumptive remedy to military landfills. High-hazard military-specific waste materials (e.g., military munitions) require special consideration when applying the presumptive remedy.

As noted on pages 1 and 2 of this directive, the presumptive remedy approach allows you to streamline and focus the FS or EE/CA by eliminating the technology screening step from the feasibility study process. EPA has already conducted this step on a generic basis in the *Feasibility Study Analysis for CERCLA Municipal Landfill Sites*. Thus, the FS analyzes only alternatives comprised of components of the containment remedy identified in Highlight 1. In addition, the focused FS or EE/CA should include a site-specific explanation of how the application of the presumptive remedy satisfies the National Contingency Plan's three site-specific remedy selection criteria (i.e., compliance with state applicable or relevant and appropriate requirements, state acceptance, and community acceptance).

CONCLUSION

This directive provides guidance for the use of the containment presumptive remedy at appropriate military landfills. The remedies selected at numerous military installations indicate that source containment is applicable to a significant number of military landfills. These landfills need not be identical to municipal landfills in all regards. Key factors determining whether the containment presumptive remedy should be applied to a specific military landfill include the size of the landfill; volume and the type of landfill contents; future land use of the area; and the presence, proportion, and distribution of military-specific wastes.

REFERENCES

California Base Closure Environmental Committee, *Integrating Land Use and Cleanup Planning at Closing Bases*, December 1994.

Federal Register, 1996. Volume 61, No. 85, May 1, 1996; *Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities, Advance Notice of Proposed Rulemaking.*

Federal Register, 1990. Volume 55, No. 145, July 27, 1990; 40 CFR Parts 264, 265, 270 and 271; *Corrective Action for Solid Waste Management Units at Hazardous Waste Facilities; Proposed* (proposed Subpart S regulations).

U.S. Environmental Protection Agency, OSWER Directive 93557-04, *Land Use in the CERCLA Remedy Selection*, May 25, 1995.

U.S. Environmental Protection Agency, OSWER Directive 9356.0-03, EPA/540/R-94/081, *Feasibility Study Analysis for CERCLA Municipal Landfill Sites*, August 1994.

U.S. Environmental Protection Agency, OSWER Directive 9902.3-2A, EPA/520/R-94/004, *RCRA Corrective Action Plan*, May 1994.

U.S. Environmental Protection Agency, OSWER Directive 9355.0-49FS, *Presumptive Remedy for CERCLA Municipal Landfill Sites*, September 1993.

U.S. Environmental Protection Agency, OSWER Directive 9355.0-47FS, EPA/540/F-93/047, *Presumptive Remedy: Policy and Procedures*, September, 1993.

U.S. Environmental Protection Agency, OSWER Publication 9380.3-06FS, *Guide to Principal Threat and Low Level Threat Wastes*, November 1991.

U.S. Environmental Protection Agency, OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, April 22, 1991.

U.S. Environmental Protection Agency, OERR, EPA/540/P-91/001, *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, February 1991.

U.S. Environmental Protection Agency, OSWER Directive 9833.3A.1, *Final Guidance on Administrative Records for Selecting CERCLA Response Actions*, December 3, 1990.

U.S. Environmental Protection Agency, OSWER Directive 9355.3-11FS, *Streamlining the RI/FS for CERCLA Municipal Landfill Sites*, September 1990.

U.S. Department of Navy, *Interservice Responsibilities for Explosive Ordnance Disposal* OPNAVINST 8027.1G (also known as MCO 8027.1D, AR 75-14; or AFR 32-3002), February 14, 1992.

NOTICE

The policies set out in this document are intended solely as guidance to the EPA personnel; they are not final EPA actions and do not constitute rulemaking. These policies are not intended, nor can they be relied upon, to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided in this document, or to act at variance with the guidance, based on an analysis of specific site circumstances. EPA also reserves the right to change this guidance at any time without public notice.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Brunswick NAS, Sites 1 and 3 (OU1), ME, Region 1 6/16/92	Site 1, 8.5 acres; Site 3, 1.5 acres. Sites are in close proximity and not easily distinguishable; the combined volume of Sites 1 and 3 is 300,000 cy	Household refuse, waste oil, solvents, pesticides, paints, isopropyl alcohol	Metals, VOCs, PAHs, PCBs, pesticides	**Remedy:** Capping (permanent, low-permeability, RCRA Subtitle C cap), of 12 acres with a slurry wall and pump and treat ground water within cap and slurry wall.
Brunswick NAS, Sites 5 and 6 (OU3), ME, Region 1 8/31/93	Site 5, 0.25 acres, 12 cy	Asbestos-covered pipes	Asbestos	**Remedy:** Excavation, containerization, and transport to landfill Sites 1 and 3 for use as fill under cap.
Brunswick NAS, Sites 5 and 6 (OU3), ME, Region 1 8/31/93	Site 6, 1.0 acre, 8,800 - 18,700 cy	Construction debris, and aircraft parts, asbestos pipes	Asbestos	**Remedy:** Excavation, containerization, and transport to Sites 1 and 3 landfill for use as fill under cap.
Brunswick NAS, Site 8 (OU4), ME, Region 1 8/31/93	Site 8, 0.6 acres, 5,600 - 14,000 cy	Rubble, debris, trash, and possibly solvents	Metals, pesticides, PCBs[1]	**Remedy:** Excavation, containerization, and transport to landfill Sites 1 and 3 for use as fill under cap.
Loring AFB, Landfills 2 and 3 (OU2), ME, Region 1 9/30/94	Landfill 2, 9 acres	Domestic waste, construction debris, flightline wastes, sewage sludge and oil-filled switches	PCBs, VOCs, SVOCs, metals, DDT[1]	**Remedy:** Capping (low-permeability cover system which meets RCRA Subtitle C and Maine hazardous waste landfill cap requirements), passive gas venting system and controls, and institutional controls.
Loring AFB, Landfills 2 and 3 (OU2), ME, Region 1 9/30/94	Landfill 3, 17 acres	Waste oil/fuels, solvents, paints, thinners, and hydraulic fluids	VOCs, SVOCs, DDT, PCBs, metals[1]	**Remedy:** Capping (low-permeability cover system which meets RCRA Subtitle C and Maine hazardous waste landfill cap requirements), passive gas venting system and controls, and institutional controls.

[1] Contaminants of Potential Concern

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Newport Naval Education and Training Center, McAllister Point Landfill, RI, Region 1 9/27/93	McAllister Point Landfill, 11.5 acres	Domestic refuse, spent acids, paints, solvents, waste oils, and PCB-contaminated transformer oil	VOCs, PAHs, PCBs, pesticides, phenols, metals	**Remedy:** Capping (RCRA Subtitle C, multi-layer cap), landfill gas management, surface controls, and institutional controls.
Otis Air National Guard, Camp Edwards, Massachusetts Military Reservation, MA, Region 1 1/14/93	Landfill Number 1 (LF-1), 100 acres	General refuse, fuel tank sludge, herbicides, blank ammunition, paints, paint thinners, batteries, DDT, hospital wastes, sewage sludge, coal ash, possibly live ordnance	VOCs, SVOCs, inorganics	**Remedy:** Capping (composite-low-permeability cover system), institutional controls, soil cover inspection, and ground water monitoring.
Pease AFB (OU1), NH, Region 1 9/27/93	LF-5, 23 acres	Domestic and industrial wastes, waste oils and solvents, and industrial wastewater treatment plant sludge	VOCs, PAHs, arsenic and other metals	**Remedy:** Excavation, dewatering and consolidation and regrading of waste under a composite-barrier type cap, institutional controls, and extraction and treatment of ground water with discharge to base wastewater treatment facility.
Fort Dix Landfill Site, NJ, Region 2 9/24/91	Main area, 126 acres	Domestic waste, paints and paint thinners, demolition debris, ash, and solvents	VOCs, metals	**Remedy:** Capping 50-acre portion (New Jersey Administrative Code 7:26 closure plan for hazardous waste), installing gas venting system and an air monitoring system, ground water, surface water, and air monitoring, and institutional controls.
Naval Air Engineering Center (OU3), NJ, Region 2 9/16/91	Site 26, 1500 sq. ft., volume not reported	Oil, roofing materials, building debris	No contamination was detected	**Remedy:** Source: No action.
Naval Air Engineering Center (OU3), NJ, Region 2 9/16/91	Site 27, 6.4 acres	Scrap steel cable	No contamination was detected	**Remedy:** Source: No action.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Naval Air Engineering Center (OU17), NJ, Region 2 9/26/94	Site 29, 20 acres	Construction debris, metal, asbestos, solvents, other miscellaneous wastes	VOCs, SVOCs, metals	**Remedy:** Source: No action.
Plattsburgh AFB, LF-022, NY, Region 2 9/30/92	LF-022, approx. 13.7 acres, approx. 524,000 cy	Household refuse	Metals, pesticides	**Remedy:** Capping (NY State requirements for solid waste landfills, 12 inch soil cap), and institutional controls.
Plattsburgh AFB, LF-023, NY, Region 2 9/30/92	LF-023, approx. 9 acres, approx. 406,000 cy	Household refuse, debris, car parts	Metals, VOCs, SVOCs, PCB, pesticides	**Remedy:** Capping (NY State requirements for solid waste landfills, low permeability cap), and institutional controls.
U.S. Army Aberdeen Proving Grounds (OU 1), MD, Region 3 6/30/92	Michaelsville Landfill, 20 acres, greater than 100,000 cy	Household refuse, limited quantities of industrial waste, burned sludges, pesticide containers, paint, asbestos shingles, solvents, waste motor oils, grease, PCB transformer oils, possible pesticides	Metals, pesticides, VOCs, PCBs, PAHs	**Remedy:** Capping (multi-layer cap in accordance with MDE requirements for sanitary landfills, using a geosynthetic membrane, 0-2 feet compacted earth material), surface water controls, and gas venting system.
Marine Corps Base, Camp Lejeune (OU1), NC, Region 4 9/15/94	Site 24, 100 acres, volume not reported	Fly ash, cinders, solvents, used paint stripping compounds, sewage sludge, spiractor sludge, construction debris	Pesticides, metals, SVOCs, PCBs	**Remedy:** Source: No action.
Robins AFB (OU1), GA, Region 4 6/25/91	Main area (Landfill No. 4), 45 acres, greater than 100,000 cy	Household refuse, industrial waste	VOCs, metals	**Remedy:** Capping (to maintain a minimum 2-foot cover over the waste materials), renovation of current soil cover including clearing, filling, regrading, adding soil and clay cover material and seeding to maintain a minimum 2-foot cover over the waste material.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Twin Cities AFB Reserve, MN, Region 5 3/31/92	Main area, approx. 2 acres, volume not reported	Household refuse, small amounts of industrial; *some burned waste*	VOCs, metals	**Remedy:** Source: Institutional controls, natural attenuation, ground water and surface water monitoring.
Wright-Patterson AFB, (Source Control Operable Unit) OH, Region 5 7/15/93	LF-8, 11 acres, 187,300 cy	General refuse and hazardous materials	PAHs, pesticides, PCBs, VOCs, metals, inorganics	**Remedy:** Capping (low-permeability clay cap that complies with Ohio EPA regulations for sanitary landfills which meet or exceed RCRA Subtitle D requirements), institutional controls, ground water treatment and monitoring.
Wright-Patterson AFB, (Source Control Operable Unit) OH, Region 5 7/15/93	LF-10, 8 acres, 171,600 cy	General refuse and hazardous materials	PAHs, pesticides, PCBs, VOCs, metals, inorganics	**Remedy:** Capping (low-permeability clay cap that complies with Ohio EPA regulations for sanitary landfills which meet or exceed RCRA Subtitle D requirements), institutional controls, ground water treatment and monitoring.
Hill AFB (OU4), UT, Region 8 6/14/94	Landfill 1, 3.5 acres, 140,000 cy	Burned solid waste, small amounts of waste oils and solvents (from vehicle maintenance facility).	VOCs (TCE)	**Remedy:** Capping (clay or multi-media cap), pumping, treating, and discharging ground water to POTW, treating contaminated surface water, soil vapor extraction, implementing institutional controls and access restrictions.
Defense Depot, Ogden (OU1), UT, Region 8 6/26/92	Plain City Canal Backfill Area, 4,000 cy	Electrical wire, glass, ash, charcoal, asphalt, wood, concrete, plastic and metal fragments	Metals, PCBs, dioxins, furans, VOCs	**Remedy:** Excavation, sorting, and off-site disposal in a RCRA permitted facility.
Defense Depot, Ogden (OU3), UT, Region 8 9/28/92	Burial Site 3-A: Chemical Warfare Agent Identification Kit Burial Area, 100 cy	Vials of chemical surety agents, broken glass	Metals, chemical warfare agents	**Remedy:** Excavation, sorting, and off-site disposal in a RCRA permitted facility.
Defense Depot, Ogden (OU3), UT, Region 8 9/28/92	Burial Site 3-A: Riot Control and Smoke Grenade Burial Area, 90 cy	Unfused grenades and grenade fragments, as well as riot control grenades	No contaminants identified	**Remedy:** Excavation, sorting, and off-site disposal in a RCRA permitted facility.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Defense Depot, Ogden (OU3), UT, Region 8 9/28/92	Burial Site 3-A: Compressed Gas Cylinder Reburial Area	Two compressed gas cylinders and four smaller steel tanks removed from the Chemical Warfare Agent Identification Kit and Riot Control and Smoke Grenade burial areas	Unknown, possible chemical warfare agents	**Remedy:** Excavation of compressed gas cylinders and disposal by a commercial operator.
Defense Depot, Ogden (OU3), UT, Region 8 9/28/92	Burial Site 3-A: Miscellaneous Items Burial Area, 230 cy	Chemical Warfare Agent Identification Kits containing no CWAs, World War II gas mask canisters, paint, broken glass, wooden boxes, and pieces of iron	No contaminants identified	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted hazardous waste landfill.
Defense Depot, Ogden (OU3), UT, Region 8 9/28/92	Water Purification Tablet Burial Area, 110 cy	Bottles containing halazone water purification tablets	No contaminants identified	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted industrial waste landfill.
Defense Depot, Ogden (OU4), UT, Region 8 9/28/92	4-A, 7500, sq. ft., 3000 cy	Wood, crating materials, paper, greases, debris, medical waste, oils, some burned waste	Pesticides, VOCs, PCBs	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted hazardous waste landfill.
Defense Depot, Ogden (OU4), UT, Region 8 9/28/92	4-B, (inside 4-E), less than 7,500, sq. ft.	Fluorescent tubes	No contaminants identified	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted landfill.
Defense Depot, Ogden (OU4), UT, Region 8 9/28/92	4-C, 6,000 sq. ft	Food products, sanitary landfill waste	Pesticides, VOCs, PCBs	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted landfill.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Defense Depot, Ogden (OU4), UT, Region 8 9/28/92	4-D, 2,000 sq. ft.	Methyl bromide cylinders, halazone tablets (jars)	Possibly methyl bromide	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted industrial landfill.
Defense Depot, Ogden (OU4), UT, Region 8 9/28/92	4-E, 7,500 sq. ft., volume not reported	Oils, spent solvents, industrial waste	PCBs, VOCs, pesticides	**Remedy:** Excavation and transportation for off-site disposal in a RCRA permitted hazardous landfill.
Rocky Mountain Arsenal, Shell Section 36 Trenches (OU23), CO, Region 8 5/3/90	Shell Trench Area, 8 acres	Rags, plastic and metal cans, glass jars, piping, pipe fittings, insulation, refuse, insulation, liquid and solid wastes generated from the manufacture of pesticides	VOCs, SVOCs, pesticides[2]	**Remedy:** Capping (physical barrier with a soil and vegetative cover).
Fort Ord Landfills (OU2), CA, Region 9 8/23/94	Landfills, 150 acres	Household and commercial refuse, dried sewage sludge, construction debris, small amounts of chemical waste including paint, oil, pesticides, and epoxy adhesive, electrical equipment	VOCs	**Remedy:** Capping (California Code of Regulations for non-hazardous waste), institutional controls, extraction, treatment, and recharge of ground water.
Riverbank Army Ammunition Plant Site, CA, Region 9 3/24/94	Landfill, 4.5 acres	Paper, oils, greases, solvents, hospital wastes, construction debris, and industrial sludges	Metals	**Remedy:** Capping (a multi-layer cap as specified in Dispute Resolution Agreement), pump and treat ground water, discharge treated water to on-site ponds.

[2] Contaminants identified as emanating from the trenches but not contaminants of concern

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Williams AFB (OU1), AZ, Region 9 5/18/94	Landfill LF-04, 90 acres, 59,000 cy	Dried sewage sludge, domestic trash and garbage, wood, metal, brush, construction debris, some solvents and chemicals	Soil, pesticides, SVOCs, inorganics, including beryllium, lead, zinc	**Remedy:** Capping (a permeable cap with a 24 inch soil cover), stormwater runoff controls, institutional actions, and soil and ground water monitoring.
Williams AFB (OU1), AZ, Region 9 5/18/94	Pesticide Burial Area (DP-13), 0.4 acre	Pesticides	Pesticides, VOCs, metals	**Remedy:** Source: No action.
Williams AFB (OU1), AZ, Region 9 5/18/94	Radioactive Instrumentation Burial Area (RW-11), 100 sq. ft.	Cement; radioactive instruments	Radium (background levels)	**Remedy:** Source: No action.
Elmendorf AFB (OU1), AK, Region 10 9/29/94	LF05, 17 acres	General refuse, scrap metal, used chemicals and other scrap material	VOCs, PCBs, metals, PAHs	**Remedy:** Source: No action.
Elmendorf AFB (OU1), AK, Region 10 9/29/94	LF07, 35 acres	Base generated refuse, scrap metal, construction rubble, drums of asphalt, empty pesticide containers, small amounts of shop wastes, and asbestos wastes	VOCs, PCBs, metals, PAHs	**Remedy:** Source: No action.
Elmendorf AFB (OU1), AK, Region 10 9/29/94	LF13, 2 acres	Empty drums, metal piping, drums of asphalt, and small quantities of quicklime	VOCs, PCBs, metals, PAHs	**Remedy:** Source: No action.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Elmendorf AFB (OU1), AK, Region 10 9/29/94	LF59, 2 landfills (.5 acres each)	General refuse and construction debris, and tar seep	VOCs, PCBs, metals, PAHs	**Remedy:** Source: No action.
Fairchild AFB (OU1), WA, Region 10 2/13/93	Southwest area, 12.6 acres, 407,300 cy	Coal ash, solvents, dry cleaning filters, paints, thinners, possibly electrical transformers.	VOCs	**Remedy:** Capping (low-permeability cap designed to meet the closure requirements of Washington State's Minimum Functional Standards for Solid Waste handling and of federal RCRA Subtitle D), SVE/ treatment system, extracting contaminated ground water and treating by air stripping and granular activated carbon, disposal off-site, monitoring off-site water supply wells.
Fairchild AFB (OU1), WA, Region 10 2/13/93	Northeast area, 6 acres, 291,000 cy	Coal ash, solvents, dry cleaning filters, paints, thinners, possibly electrical transformers.	VOCs	**Remedy:** Capping (low-permeability cap designed to meet the closure requirements of Washington State's Minimum Functional Standards for Solid Waste handling and of federal RCRA Subtitle D), SVE/ treatment system, extracting contaminated ground water and treating by air stripping and granular activated carbon, disposal off-site, monitoring off-site water supply wells.
Fort Lewis Military Reservation, Landfill 4 and the Solvent Refined Coal Pilot Plant, WA, Region 10 9/24/93	LF4, 52 acres	Domestic and light industrial solid waste (no landfill records were maintained).	VOCs, metals	**Remedy:** Source: Institutional controls, treat ground water and soil using SVE and air sparging system.
Naval Air Station, Whidbey Island, Ault Field (OU1), WA, Region 10 12/20/93	Area 6 Landfill, 40 acres. Within Area 6 there are 2 distinct areas where wastes were disposed.	Household waste, construction debris, and yard waste	VOCs	**Remedy:** Capping (low-permeability cap to meet Washington State Minimum Functional Standards for non-hazardous closure), air stripping ground water, ground water monitoring, and institutional controls.
Naval Air Station, Whidbey Island, Ault Field (OU2), WA, Region 10 12/20/93	Area 2, 13 acres; Area 3, 1.5 acres. Both treated together due to close proximity.	Solid waste from the base, industrial wastes, and construction and demolition debris	Metals, PAHs	**Remedy:** Source: Institutional controls, ground water monitoring.

ROD / Site Name, State, Region, ROD Sign Date	Disposal Area, Size, Volume of Waste	Type of Waste Deposited	Contaminants of Concern	Remedy
Naval Reactor Facility, ID, Region 10 9/27/94	Landfill Unit 8-05-1, (350 ft. by 450 ft. by 4-25 ft.)	Construction debris, small quantities of paints, solvents, cafeteria wastes, and petroleum products	Metals, VOCs	**Remedy:** Capping (24-inch native soil cover), institutional controls.
Naval Reactor Facility, ID, Region 10 9/27/94	Landfill Unit 8-05-51, (450 ft. by 100 -175 ft. by 10-15 ft.)	Construction debris, small quantities of paints, solvents, cafeteria wastes, and petroleum products	Metals, VOCs	**Remedy:** Capping (24-inch native soil cover), institutional controls.
Naval Reactor Facility, ID, Region 10 9/27/94	Landfill Unit 8-06-53, (900 ft. by 1200 ft. by 7- 10 ft.)	Construction debris, small quantities of paints, solvents, cafeteria wastes, and petroleum products	Metals, VOCs	**Remedy:** Capping (24-inch native soil cover), institutional controls.

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EPA

Presumptive Remedies: Policy and Procedures

Office of Emergency and Remedial Response
Hazardous Site Control Division 5203G

Quick Reference Fact Sheet

Since Superfund's inception in 1980, the remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, types of disposal practices, or how environmental media are affected. Based on information acquired from evaluating and cleaning up these sites, Superfund is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these sites. The presumptive remedy approach is one tool of acceleration within the **Superfund Accelerated Cleanup Model (SACM).**

The objective of the presumptive remedies initiative is to use the program's past experience to streamline site investigations and speed up selection of cleanup actions. Overtime presumptive remedies are expected to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites. Presumptive remedies are expected to be used at all appropriate sites except under unusual site-specific circumstances. EPA plans to develop a series of directives on presumptive remedies for various types of sites.

This directive serves as an overall guide to the presumptive remedies initiative and its effect on site cleanup. Through a question and answer format, it explains, in general terms, ways in which presumptive remedies will streamline or change the remedial and removal processes from the conventional processes and how certain Superfund policies will be affected by the initiative. This directive also unites the series of directives, due to come out over the next year, on presumptive remedies for specific site types (e.g., Volatile Organic Compounds (VOCs), wood treaters, ground water). This general directive, together with the site type-specific directives, will provide readers with a comprehensive knowledge of the procedural as well as policy considerations of the presumptive remedies initiative. The directive is designed for use by staff involved in managing site cleanups (e.g., Remedial Project Managers (RPMs), On-Scene Coordinators (OSCs), Site Assessment Managers (SAMs)). Site managers in other programs, such as RCRA Corrective Action, the Underground Storage Tank program, State Project Managers, or private sector parties, may also use this directive, as appropriate.

Provided below are several common questions and answers regarding general issues associated with presumptive remedies.

Q1. What Are Presumptive Remedies and How Should They Be Used?

A. Presumptive Remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. EPA has evaluated technologies that have been consistently selected at past sites using the remedy selection criteria set out in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP); reviewed currently available performance data on the application of these technologies; and has determined that a particular remedy, or set of remedies, is **presumptively** the most appropriate for addressing specific types of sites.

Presumptive remedies are expected to be used at all appropriate sites. The approaches described in each presumptive remedies directive are designed to accommodate a wide range of site-specific circumstances. In some cases, multiple technologies are included (e.g., VOCs); in others, various

components of the presumptive remedy are optional, depending on site situation (e.g., municipal landfills). Further, these directives recognize that at some sites, there may be unusual circumstances (such as complex contaminant mixtures, soil conditions, or extraordinary State and community concerns) that may require the site manager to look beyond the presumptive remedies for additional (perhaps more innovative) technologies or remedial approaches.

These tools will help site managers to focus data collection efforts during site investigations (e.g., remedial investigations, removal site evaluation) and significantly reduce the technology evaluation phase (e.g., Engineering Evaluation/Cost Analysis (EE/CA) and/or Feasibility Studies (FS)) for certain categories of sites. The specific impacts on the various stages of the remedy selection process are highlighted in questions 7 and 8 of this guidance. It is advised that presumptive remedies be used with the assistance of the expert teams[1] for the various categories of sites.

Q2. Why Should Presumptive Remedies Be Used?

Presumptive remedies are expected to have several benefits. Limiting the number of technologies considered should promote focused data collection, resulting in streamlined site assessments and accelerated remedy selection decisions which achieve time and cost savings. Additional time savings could be realized during the remedial design since early knowledge of the remedy may allow technology-specific data to be collected upfront during the remedial investigation. Presumptive remedies will also produce the added benefit of promoting consistency in remedy selection, and improving the predictability of the remedy selection process for communities and potentially responsible parties (PRPs).

Presumptive remedies may be used as part of a wide variety of response actions. These actions include non-time-critical removal and early remedial actions, actions at sites with different leads (e.g., Fund-lead, State-lead, PRP-lead), actions addressing one or more contaminated media, actions with several operable unitss, and actions involving treatment trains.

Q3. Can Presumptive Remedies be Implemented Within the Existing NCP Process?

Yes. The presumptive remedy approach is consistent with all of the requirements of the NCP, and in particular the site management principle of streamlining (see section 300.430(a)(1)(ii)(C)). The presumptive remedy approach simply consolidates what have become the common, expected results of site-specific decision making at Superfund sites over the past decade. The various presumptive remedies directives and supporting documentation (e.g., "Feasibility Study Analysis for CERCLA Sites with Volatile Organic Compounds in Soils") provide the basis for an administrative record which justifies consideration of a very limited number of cleanup options. These materials summarize the findings of EPA's research and analysis, and the reasons that were found for generally considering certain technologies more or less appropriate.

The availability of presumptive remedies does not preclude a Region from expanding the FS (either on its own initiative or at the suggestion of outside parties) to consider other technologies under unusual site-specific circumstances. The site type directives will define the kind of circumstances (e.g., soil conditions, heterogeneous and complicated contamination mixtures, field tests demonstrating significant advantages of alternate or innovative technologies, etc.) that may make presumptive remedies less clearly suited for particular sites. Most of these directives also provide references to additional technologies if the presumptive remedies are found not to apply at a particular site.

Q4. How Did the Presumptive Remedies Initiative Evolve?

A. The general concept of presumptive remedies was first proposed in 1990 during the Superfund 90-Day Study and subsequently in 1991 during the 30-Day Study as a method of accelerating the remedial process. These management studies were efforts to generate options for accelerating the overall Superfund clean-up process. The presumptive remedies initiative is also consistent with, and supports, a larger program initiative known as the Superfund Accelerated Cleanup

[1] It is envisioned that for most categories of sites, teams of experts (technical, legal, policy, etc.) who have developed the presumptive remedies guidance and Regional site managers conducting field demonstrations, will be available to assist site managers in implementing presumptive remedies on a site-specific basis.

Table 1
Current Presumptive Remedies and Contacts

Site Type/Schedule	Presumptive Remedy(ies)	Anticipated Products	EPA Contact
General Policy and Procedures (9/93)	NA	*Presumptive Remedies: Policy and Procedures*	Shahid Mahmud Headquarters, HSCD (703) 603-8789
Volatile Organic Compounds (VOCs) in Soils (9/93)	Soil Vapor Extraction, Thermal Desorption, Incineration	*Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with VOCs in Soils*	Shahid Mahmud Headquarters, HSCD (703) 603-8789
Wood Treaters (6/94)	For Organics - Incineration, Bioremediation, Dechlorination For Inorganics - Immobilization	*Presumptive Remedy: Wood Treating Sites* *Technology Selection Guide for Wood Treater Sites (5/93)*	Lisa Boynton Headquarters, ERD (703) 603-9052 Harry Allen Emergency Response Division (908) 321-6747
Municipal Landfills (9/93)	Containment (could include capping, leachate collection and treatment, LF gas treatment, institutional controls, etc.)	*Presumptive Remedy for CERCLA Municipal Landfill Sites*	Andrea McLaughlin Headquarters, HSCD (703) 603-8793
Contaminated Ground Water (1/94)	Pump and Treat (Will specify preferred treatment technologies & describe overall approach)	*TBD*	Ken Lovelace Headquarters, HSCD (703) 603-8787
Region 7 Pilots - PCB Sites, Coal Gas Sites, Grain Storage Sites (6/94)	TBD	*TBD*	Diana Engeman Region 7 (913) 551-7746

KEY:
TBD - To Be Determined
NA - Not Applicable

Model (SACM). SACM incorporates theexperience gained from past Superfund actions into an integrated approach to site cleanup aimed at getting response action decisions made and implemented more quidkly. The presumptive remedies initiative is one mechanism for accomplishing the broad sreamlining goal set fort by SACM. The presemptive remedies initiative was also identifies as one of the Adminsitrative Improvements to Superfund in June of 1993.

Q5. What Other Presumptive Remedy Initiatives are Underway or Planned?

A. There are a variety of presumptive remedy activities currently planned or underway. Table 1 lists the site types with the anticipated schedule of associated presumptive remedy products that are currently underway along with the Headquarters and Regional contacts. There are four site types for which presumptive remedies are being developed in EPA Headquarters: VOCs, wood treaters, municipal landfills, and contaminated ground-water sites. Concurrently, Region 7 is preparing presumptive remedy guidances for PCB, coal gasification, and grain storage sites.

Q6. How Will Presumptive Remedies Affect the Remedy Secection Process?

A. Presumptive remedies are anticipated to affect se3veral phases of the ccurrent remedy selection process. A diagram depicting the generic impacts on the overall process is provded in Table 2.

Data collection during the initial site assessment(Preliminary Assessment/Site Inspection (PA/SI)

Table 2
Generic Effect of Presumptive Remedies

	Phases of Cleanup Process	Effect on Cleanup Process
SITE ASSESSMENT	PA/SI or Removal Site Evaluation	X
	Scoping • Collect and analyze existing data	○
	• Identify initial project/OUs and remedial action objectives	■
	• Identify range of likely alternatives	■
	• Identify potential ARARs	○
	• Identify initial DQOs	○
	• Prepare project plans	■
	Remedial Investigation • Conduct field investigation	X(1)
	• Define nature and extent of contamination	○(1)
	• Identify ARARs	○
	• Conduct baseline risk assessment	○(1)
FEASIBILITY STUDY OR EE/CA	Remedy Selection • Identify potential treatment technologies and containment/disposal requirements	●
	• Screen technologies	●
	• Assemble technologies into alternatives	●
	• Screen alternatives as necessary to reduce number subject to detailed analysis	●
	• Further refine alternatives as necessary	■
	• Analyze alternatives against the nine criteria and each other	■
	Proposed Plan	■
	Record of Decision	■
	Remedial Design	■

○ = not impacted ■ = Streamlined
X = Focused ● = Eliminated
(1) Streamlined for Municipal Landfills

or Removal Site Evaluation) can be used to help define the specific site typw and to determine whether presumptive remedies may be potentially applicable.

Assuming the site warrants further attention (i.e., it is listed on the National Priorities List (NPL) or determined by the Regional Decision Team (RDT) to be an NPL-caliber site or to merit a removal action), further confirmation of the site type should take place as either an RI/FS or EE/CA is scoped to determine whether the site is a potential candidate for presumptive remedies. For a detailed discussion of how to make this determination, refer to the appropriate site type-specific directive. If it is determined that a site falls into a certain category, the presumptive remedies associated with that site type should be included in the list of likely remedial alternatives (e.g., no action, presumptive remedies, etc.) For the site. Other aspects of scoping that may be affected by presumptive remedies are the designation of appropriate operable units (OUS) and identification of data needed to support the evaluation and selection of a presumptive remedy.

Presumptive remedies are expected to help focus data collection efforts. Specifically, initial data collection would focus on confirming the site type. If the site is of the typw for which presumptive remedies have been developed, the streamlined steps for site characterization outlined in the site type-specific directive for the particular site type should be followed. These steps outline data collection to determine the extent of contamination and to support selection of the presumptive remedy and Remedial Design (RD).

Presumptive remedies will streamline the FS and the alternatives analysis in the EE/CA more than any other phase of the remedy selection process. In most cases, after a site is confirmed as being a type for which presumptive remedies exist, a focused FS or EE/CA which eliminates the technology identification and screening step would be prepared. The study would limit its consideration to the no action alternative and the presumptive remedy technologies. This is possible because EPA has conducted an analysis of potentially available technologies for most of the presumptive remedies site categories and has determined that certain technologies are routinely and appropriately screened out either on the basis of effectiveness, implementability, or excessive cost (NCP Section 300.430 (e)(3) and (7)), or have not been selected under the nine criteria analysis identified in NCP Section 300.430 (e) (9). This detailed analysis will serve to substitute for the development and screening of alternatives phases of the FS (and will allow the

remaining alternatives to be limited to variations of the presumptive remedy). The site-specific directive and supporting documentation (e.g., "Feasibility Study Analysis for CERCLA Municipal Landfill Sites") along with this directive then can be placed in the administrative record for the site to support the elimination of the screening step identified in section 300.430 (e) (1) of the NCP. Further supporting materials can be provided by Headquarters (e.g., FS reports included in the analysis, technical reports), as needed. The specific presumptive remedy directives address the process of eliminating the alternatives development and screening step of the RI/FS or EE/CA in further detail. The directives also provide generic discussion of a partial nine criteria analysis (excluding state ARARs and community and state acceptance) and may help streamline the detailed analysis of alternatives within the FS and EE/CA reports. However, the user is cautioned that the criteria are discussed on a general basis and the nine criteria analysis should be supplemented to reflect the site-specific conditions.

The Proposed Plan (PP) and subsequent ROD would be similarly streamlined by focusing only on the presumptive remedy(ies). The remedial design (RD) may be streamlined since some RD data will likely have been collected previously during the site assessment and RI.

Q?. How Will Presumptive Remedies Affect the Removal Process?

A. Non-time critical removal actions are anticipated to be used more often to accomplish early actions at Superfund sites under SACM. The presumptive remedies approach will focus the data collection during the removal site evaluation and reduce the number of technologies identified and analyzed in the EE/CA. Presumptive remedies are not expected to have an impact on emergency and time-critical actions under the removal program.

Q8. What are the Implications of Presumptive Remedies for Innovative Technologies?

The NCP in section 300.430 (a) (1) (iii) (E) states that "EPA expects to consider using innovative technology when such technology offers the potential for comparable or superior treatment performance and implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies." The use of the presumptive remedies may tend to reduce the frequency of the full evaluation of innovative technologies. However, as indicated previously, the presumptive remedies provide a tool for streamlining the remedy selection process. They do not preclude the consideration of innovative technologies should the technologies be demonstrated to be as effective or superior to the presumptive remedies. Innovative technologies may be evaluated and recommended in addition to the presumptive remedies where these criteria are met.

EPA encourages review of the latest Innovative Technologies Semi-Annual Reports or Engineering Bulletins for the up-to-date information on the potential effectiveness and applicability of various innovative technologies. Site managers are strongly encouraged to involve the site-type expert team (see Question 13) to determine whether unusual circumstances exist to consider a non-presumptive remedy based on site-specific conditions and/or community, state, and PRP concerns, or the availability of a potentially promising innovative technology.

Q9. How Will Presumptive Remedies Affect Risk Assessments?

A. Generally, the role of baseline risk assessments under the presumptive remedy approach would be unaffected with Municipal Landfill sites being a notable exception. It is anticipated that risk assessments would still be needed on a site-specific basis to assist site managers in determining the need for a response action. EPA managers have indicated the value of the risk assessment in communicating with states, PRPs, and local communities about the nature and extent of health and environmental threats. Therefore, it is recommended that the current risk assessment process be continued on an individual site basis except for Municipal Landfills. The site manager should refer to the EPA Directive entitled "Presumptive Remedy for CERCLA Municipal Landfill Sites," Directive No. 9355.0-49FS to identify streamlining opportunities at Municipal Landfill sites.

Guidance on developing risk-based preliminary remediation goals (PRGs) would be unaffected under this initiative. These goals are needed for individual sites especially in the absence of ARARs to assist in determining which remedial options

will result in medium-specific chemical concentrations that are protective of human health. For example, there may be several candidate presumptive remedies identified in the site-type directives. But it is the extent and degree of contamination across a given site that will determine whether a technology, which is predicted to reduce a chemical's concentration to some specified level, will be adequate by itself to produce protective concentrations following remedial action. For some sites or site locations, because of the magnitude of contamination or co-occurrence of contaminants, it may be necessary to assemble several technologies into a treatment train to adequately reduce levels of all chemicals of concern in a medium to protective levels. In other cases, it may be necessary to evaluate the use of institutional and/or engineering controls on an area following remediation to ensure protection during subsequent land use. In other words, it is not reasonable to assume that because a specific technology resulted in "protection" at one site, it will result in protective levels at all sites. A determination that the selected remedy will result in protection of human health and the environment must be made for each site. Both ARARs and risk-based PRGs are important tools in this exercise.

Generally, presumptive remedy directives will specify those technologies that have been determined to achieve levels protective of human health and the environment under a variety of site conditions. However, because all sites differ to some extent, especially in their relation to surrounding communities and sensitive ecosystems, a determination must still be made on a site-specific basis as to how a given remedy design is expected to achieve "protectiveness" during remedy construction and following remedial action. Overall protection of human health and the environment is one of two threshold considerations (the other being compliance with ARARs) that must be met in order for an alternative to be eligible for selection as the remedy for a given site.

Q10. What if Outside Parties such as PRPs or the Community Want Other Alternatives Considered?

A. The identification of a presumptive remedy does not relieve EPA of the obligation to propose the remedy for public comment, or to respond to comments suggesting that other alternatives should have been considered. In some cases, the information in the site-type directive and supporting documentation may be sufficient to address such comments; in others, additional analysis may be required to assess the relative merits of an alternative technology proposed by a commenter.

To reduce the risk of delay due to the need to respond to such comments, it is generally desirable to publicize the planned use of presumptive remedies early on, and give States, communities, PRPs, and others an early opportunity to express any concerns they may have about focusing the FS or EE/CA in this way. The agency may then decide whether to include additional alternatives in the FS or EE/CA so that those concerns can be addressed before the remedy is proposed.

In general, it is expected that the directive and supporting documents will provide substantial justification for preferring the presumptive remedy over alternative technologies. Therefore, the submission of comments advocating other approaches does not necessarily require broadening of the FS or EE/CA, or conducting additional analysis after the plan has been proposed. Whether additional documentation is required will depend upon how substantial or persuasive the comments are (e.g., whether a comment identifies unusual site circumstances that seriously call into question the applicability of the presumptive remedy). The Region will have to assess this by evaluating each comment on its own merits.

It should be noted that even if the FS is broadened to consider alternatives other than the presumptive remedy, much of the benefit of the presumptive remedy approach can still be achieved. In such cases, it is not necessary to address the full array of possible technologies, rather only the presumptive remedy and the specific alternative(s) that genuinely warrant detailed study. Therefore, the FS can still be narrowed and data gathering can still be focused.

Q11. How do State ARARs Affect the Use of Presumptive Remedies?

A. Any remedy, including presumptive remedies, must be selected in accordance with Section 121(d)(2)(A)(ii) of the Comprehensive Environmental Response, Compensation and Liability Act

(CERCLA), which specifies that selected remedial actions comply with promulgated standards under Federal and more stringent State environmental laws (i.e., State ARARs). At this time it is difficult to predict situations where presumptive remedies will not comply with State ARARs, and such issues must necessarily be addressed on a site-specific basis. However, as the presumptive remedies have been widely selected, they are likely to be capable of meeting State ARARs.

Q12. What Are the Implications of Presumptive Remedies on Community, PRP, and State Relations?

A. It will generally be desirable to notify the community, State, and PRP(s) as early in the clean-up process as possible that presumptive remedies are being considered for the site. This notification can take the form of a fact sheet, a notice in the newspaper, and/or a public meeting in which the site manager (with assistance from the expert team, as desired) explains the rationale for taking such actions and distributes the appropriate directives of the site type in question. Additionally, the site manager should explain the potential benefits associated with the use of presumptive remedies such as time and cost savings, and consistency. Early discussions about the rationale for presumptive remedies should help instill confidence in both the technologies and remedy selection processes.

Q13. How Will EPA Communicate Progress on Current Presumptive Remedies, Newly Developed Presumptive Remedies, and Future Issues Related to Presumptive Remedies?

A. Information about presumptive remedies will be communicated in several ways. First, it is anticipated that an orientation will be provided to communicate the key elements of presumptive remedies to Regional site managers as appropriate. This may be followed by periodic meetings with expert teams, if necessary, to scope out the applications of presumptive remedies on a site-specific basis. The expert team may also be used to convey any new developments on technology or policies and procedures for general or specific applications. A quarterly conference call is also anticipated between site managers and the expert teams to allow for the exchange of ideas and to identify and resolve technical issues. Technology selection directives, SACM Bulletins, and Q&A directives will be published periodically to disseminate information on presumptive remedies and related issues as they arise. Finally, the presumptive remedies directives on the various site categories will be updated every several years to reflect new technology development and up-to-date performance data, as appropriate.

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Solid Waste and
Emergency Response

Directive No. 9355.0-49FS
EPA 540-F-93-035
PB 93-963339
September 1993

Presumptive Remedy for CERCLA Municipal Landfill Sites

Office of Emergency and Remedial Response
Hazardous Site Control Division 5203G

Quick Reference Fact Sheet

Since Superfund's inception in 1980, the remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, types of disposal practices, or how environmental media are affected. Based on information acquired from evaluating and cleaning up these sites, the Superfund program is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these types of sites. The presumptive remedy approach is one tool of acceleration within the **Superfund Accelerated Cleanup Model (SACM).**

Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedies initiative is to use the program's past experience to streamline site investigation and speed up selection of cleanup actions. Over time presumptive remedies are expected to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites. Presumptive remedies are expected to be used at all appropriate sites except under unusual site-specific circumstances.

This directive establishes **containment** as the presumptive remedy for CERCLA municipal landfills. The framework for the presumptive remedy for these sites is presented in a streamlining manual entitled *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites,* February 1991 (OSWER Directive 9355. 3-11). This directive highlights and emphasizes the importance of certain streamlining principles related to the scoping (planning) stages of the remedial investigation/feasibility study (RI/FS) that were identified in the manual. The directive also provides clarification of and additional guidance in the following areas: (1) the level of detail appropriate for risk assessment of source areas at municipal landfills and (2) the characterization of hot spots.

BACKGROUND

Superfund has conducted pilot projects at four municipal landfill sites[1] on the National Priorities List (NPL) to evaluate the effectiveness of the manual *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites* (hereafter referred to as "the manual") as a streamlining tool and as the framework for the municipal landfill presumptive remedy. Consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (or NCP), EPA's expectation was that containment technologies generally would be appropriate for municipal landfill waste because the volume and heterogeneity of the waste generally make treatment impracticable. The results of the pilots support this expectation and demonstrate that the manual is an effective tool for streamlining the RI/FS process for municipal landfills.

Since the manual's development, the expectation to contain wastes at municipal landfills has evolved into a presumptive remedy for these sites.[2] Implementation of the streamlining principles outlined in the manual at the four pilot sites helped to highlight issues requiring further clarification, such as the degree to which risk assessments can be streamlined for source areas and the characterization and remediation of hot spots. The pilots also demonstrated the value of focusing streamlining efforts at the scoping stage, recognizing that the biggest savings in time and money can be realized if streamlining is incorporated at the beginning of the RI/FS process. Accordingly, this directive addresses those issues identified during the pilots and highlights streamlining opportunities to be considered during the scoping component of the RI/FS.

[1] Municipal landfill sites typically contain a combination of principally municipal and to a lesser extent hazardous wastes.

[2] See EPA Publication 9203.1-02I, SACM Bulletins, *Presumptive Remedies for Municipal Landfill Sites,* April 1992, Vol. 1, No. 1, and February 1993, Vol. 2, No. 1, and SACM Bulletin *Presumptive Remedies,* August 1992, Vol. 1, No. 3.

Finally, while the primary focus of the municipal landfill manual is on streamlining the RI/FS, Superfund's goal under SACM is to accelerate the entire clean-up process. Other guidance issued under the municipal landfill presumptive remedy initiative identifies design data that may be collected during the RI/FS to streamline the overall response process for these sites (see Publication No. 9355.3-18FS, *Presumptive Remedies:* CERCLA *Landfill Caps Data Collection Guide,* to be published in October 1993).

CONTAINMENT AS A PRESUMPTIVE REMEDY

Section 300.430(a)(iii)(B) of the NCP contains the expectation that engineering controls, such as containment, will be used for waste that poses a relatively low long-term threat where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment of the waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in CERCLA landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. Because treatment usually is impracticable, EPA generally considers containment to be the appropriate response action, or the "presumptive remedy," for the source areas of municipal landfill sites.

The presumptive remedy for CERCLA municipal landfill sites relates primarily to containment of the landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected ground water at the perimeter of the landfill, and/or upgradient ground-water that is causing saturation of the landfill mass may be implemented as part of the presumptive remedy.

The presumptive remedy does not address exposure pathways outside the source area (landfill), nor does it include the long-term ground-water response action. Additional RI/FS activities, including a risk assessment, will need to be performed, as appropriate, to address those exposure pathways outside the source area. It is expected that RI/FS activities addressing exposure pathways outside the source generally will reconducted concurrently with the streamlined RI/FS for the landfill source presumptive remedy. A response action for exposure pathways outside the source (if any) may be selected together with the presumptive remedy (thereby developing a comprehensive site response), or as an operable unit separate from the presumptive remedy.

Highlight 1 identifies the components of the presumptive remedy. Response actions selected for individual sites will include only those components that are necessary, based on site-specific conditions.

Highlight 1: Components of the Presumptive Remedy: Source Containment

- Landfill cap;
- Source area ground-water control to contain plume;
- Leachate collection and treatment;
- Landfill gas collection and treatment; and/or
- Institutional controls to supplement engineering controls.

The EPA (or State) site manager will make the initial decision of whether a particular municipal landfill site is suitable for the presumptive remedy or whether a more comprehensive RI/FS is required. Generally, this determination will depend on whether the site is suitable for a streamlined risk evaluation, as described on page 4. The community, state, and potentially responsible parties (PRPs) should be notified that a presumptive remedy is being considered for the site before work on the RI/FS work plan is initiated. The notification may take the form of a fact sheet, a notoice in a local newspaper, and/or a public meeting.

Use of the presumptive remedy eliminates the need for the initial identification and screening of alternatives during the feasibility study (FS). Section 300.430(e)(1) of the NCP states that, "... the lead agency shall include art alternatives screening step, when needed, (emphasis added) to select a reasonable number of alternatives for detailed analysis."

EPA conducted an analysis of potentially available technologies for municipal landfills and found that certain technologies are routinely and appropriately screened out on the basis of effectiveness, feasibility, or cost (NCP Section 300.430(e)(7)). (See Appendix A to this directive and "Feasibility Study Analysis for CERCLA Municipal Landfills," September 1993 available at EPA Headquarters and Regional Offices.) Based on this analysis, the universe of alternatives that will be analyzed in detail may be limited to the components of the containment remedy identified in Highlight 1, unless site-specific conditions dictate otherwise or alternatives are considered that were not addressed in the FS analysis. The FS analysis document, together with this directive, must be included in the administrative record for each municipal landfill presumptive remedy site to support elimination of the initial identification and screening of site-specific alternatives. Further detailed and comprehensive

supporting materials (e.g., FS reports included in analysis, technical reports) can be provided by Headquarters, as needed.

While the universe of alternatives to address the landfill source will be limited to those components identified in Highlight 1, potential alternatives that may exist for each component or combinations of components may be evaluated in the detailed analysis. For example, one component of the presumptive remedy is source area ground-water control. If appropriate, this component may be accomplished in a number of ways, including pump and treat, slurry walls, etc. These potential alternatives may then be combined with other components of the presumptive remedy to develop a range of containment alternatives suitable for site-specific conditions. Response alternatives must then be evaluated in detail against the nine criteria identified in Section 300.430(e)(g) of the NCP. The detailed analysis will identify site-specific ARARs and develop costs on the basis of the particular size and volume of the landfill.

EARLY ACTION AT MUNICIPAL LANDFILLS

EPA has identifies the presumptive remedy site categories as good candidates for early action under SACM. At municipal landfills, the upfront knowledge that the source area will be contained may facilitate such early actions as installation of a landfill cap or a ground-water containment system. Depending on the circumstances, early actions may be accomplished using either removal authority (e.g., non-time-critical removal actions) or remedial authority. In some cases, it may be appropriate for an Engineering Evaluation/Cost Analysis to replace part or all of the RI/FS if the source control component will be a non-time-critical removal action. Some factors may affect whether a specific response action would be better accomplished as a removal or remedial action including the size of the action, the associated state cost share, and/ or the scope of O&M. A discussion of these factors is contained in *Early Action and Long-term Action Under SACM - Interim Guidance*, Publication No. 9203.1-05I, December 1992.

SCOPING A STREAMLINED RI/FS UNDER THE PRESUMPTIVE REMEDY FRAMEWORK

The goal of an RI/FS is to provide the information necessary to: (1) adequately characterize the site; (2) define site dynamics; (3) define risks; and (4) develop the response action. As discussed in the following sections, the process for achieving each of these goals can be streamlined for CERCLA municipal landfill sites because of the upfront presumption that landfill contents will be contained. The strategy for streamlining each of these areas should be developed early (i.e., during the scoping phase of the RI/FS).

1. Characterizing the Site

The use of existing data is especially important in conducting a streamlined RI/FS for municipal landfills. Characterization of a landfill's contents is not necessary or appropriate for selecting a response action for these sites except in limited cases; rather, existing data are used to determine whether the containment presumption is appropriate. Subsequent sampling efforts should focus on characterizing areas where contaminant migration is suspected, such as leachate discharge areas or areas where surface water runoff has caused erosion. It is important to note that the decision to characterize hot spots should also be based on existing information, such as reliable anecdotal information, documentation, and/or physical evidence (see page 6).

In those limited cases where no information is available for a site, it may not be advisable to initiate use of the presumptive remedy until some data are collected. For example, if there is extensive migration of contaminants from a site located in an area with several sources, it will be necessary to have some information about the landfill source in order to make an association between on-site and off-site contamination.

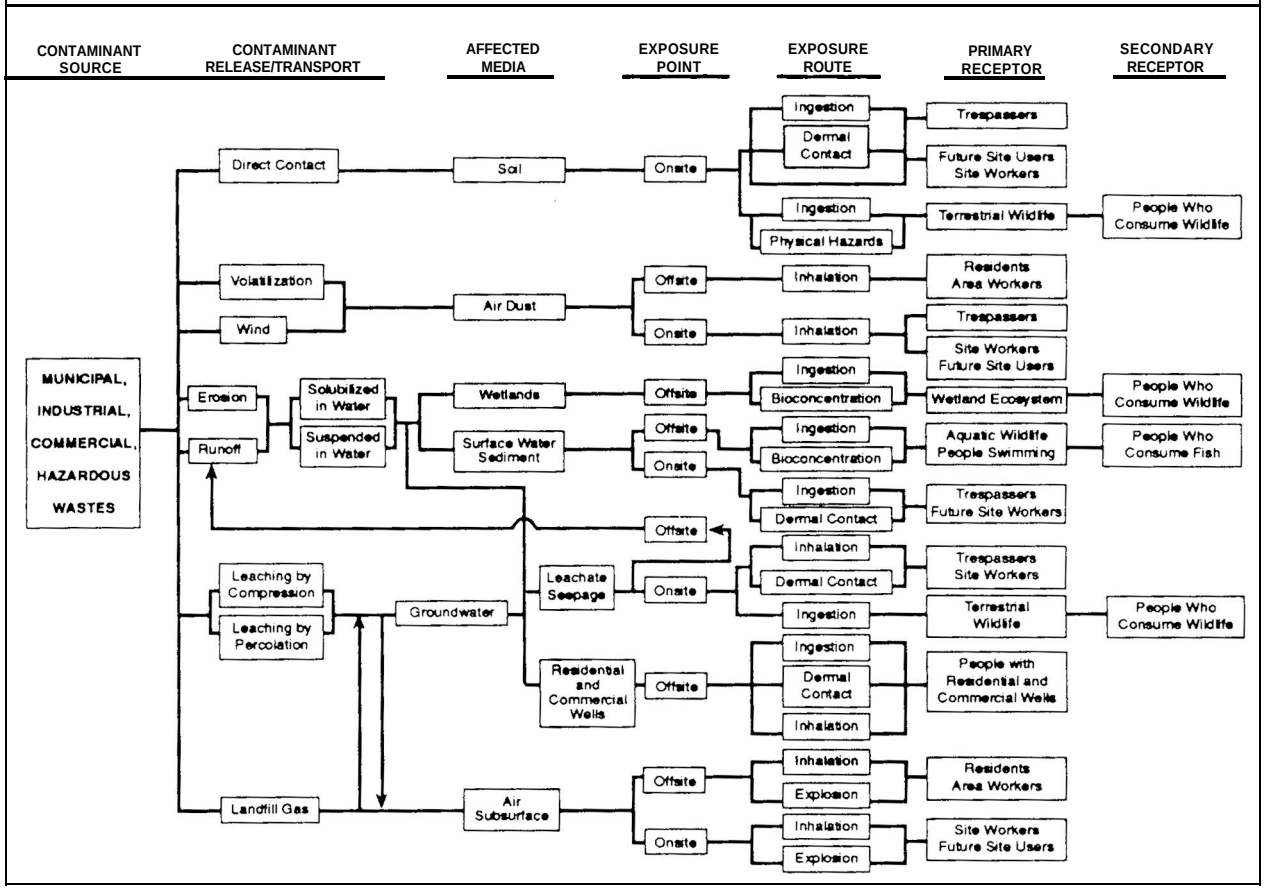
Sources of information of particular interest during scoping include records of previous ownership, state files, closure plans, etc., which may help to determine types and sources of hazardous materials present. In addition, a site visit is appropriate for several reasons, including the verification of existing data, the identification of existing site remediation systems, and to visually characterize wastes (e.g., leachate seeps). Specific information to be collected is provided in Sections 2.1 through 2.4 of the municipal landfill manual.

2. Defining Site Dynamics

The collected data are used to develop a conceptual site model, which is the key component of a streamlined RI/FS. The conceptual site model is an effective tool for defining the site dynamics, streamlining the risk evaluation, and developing the response action. Highlight 2 presents a generic conceptual site model for municipal landfill. The model is developed before any RI field activities are conducted, and its purpose is to aid in understanding and describing the site and to present hypotheses regarding:

- The suspected sources and types of contaminants present;
- Contaminant release and transport mechanisms;

Highlight 2: Generic Conceptual Site Model



- Rate of contaminant release and transport (where possible);
- Affected media;
- Known and potential routes of migration; and
- Known and potential human and environmental receptors.

After the data are evaluated and a site visit is completed, the contaminant release and transport mechanisms relevant to the site should be determined. The key element in developing the conceptual site model is to identify those aspects of the model that require more information to make a decision about response measures. Because containment of the landfill's contents is the presumed response action, the conceptual site model will be of most use in identifying areas beyond the landfill source itself that will require further study, thereby focusing site characterization away from the source area and on areas of potential contaminant migration (e.g., ground water or contaminated sediments).

3. Defining Risks

The municipal landfill manual states that a streamlined or limited baseline risk assessment will be sufficient to initiate response action on the most obvious problems at a municipal landfill (e.g., ground water, leachate, landfill contents, and landfill gas). One method for establishing risk using a streamlined approach is to compare contaminant concentration levels (if available) to standards that are potential chemical-specific applicable or relevant and appropriate requirements (ARARs) for the action. The manual states that where established standards for one or more contaminants in a given medium are clearly exceeded, remedial action generally is warranted.[3]

It is important to note, however, that based on site-specific conditions, an active response is not required if ground-water contaminant concentrations exceed chemical-specific standards but the site risk is within the Agency's acceptable risk range (10^{-4} to 10^{-6}). For example, if it is determined that the release of

[3] See also OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions,* April 22, 1991, which states that if MCLs or non-zero MCLGs are exceeded, [a response] action generally is warranted.

contaminants from a particular landfill is declining, and concentrations of one or more ground-water contaminants are at or barely exceed chemical-specific standards, the Agency may decide not to implement an active response. Such a decision might be based on the understanding that the landfill is no longer acting as a source of ground-water contamination, and that the landfill does not present an unacceptable risk from any other exposure pathway.

A site generally will not be eligible for a streamlined risk evaluation if ground-water contaminant concentrations do not clearly exceed chemical-specific standards or the Agency's accepted level of risk, or other conditions do not exist that provide a clear justification for action (e.g., direct contact with landfill contents resulting from unstable slopes). Under these circumstances, a quantitative risk assessment that addresses all exposure pathways will be necessary to determine whether action is needed.

Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern, not just those that triggered the remedial action. As described in the following sections, the conceptual site model is an effective tool for identifying those pathways and illustrating that they have been addressed by the containment remedy.

Streamlined Risk Evaluation Of The Landfill Source

Experience from the presumptive remedy pilots supports the usefulness of a streamlined risk evaluation to initiate an early response action under certain circumstances. As a matter of policy, for the source area of municipal landfills, a quantitative risk assessment that considers all chemicals, their potential additive effects, etc., is not necessary to establish a basis for action if ground-water data are available to demonstrate that contaminants clearly exceed established standards or if other conditions exist that provide a clear justification for action.

A quantitative risk assessment also is not necessary to evaluate whether the containment remedy addresses all pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways can be identified using the conceptual site model and compared to the pathways addressed by the containment presumptive remedy. Highlight 3 illustrates that the containment remedy addresses all exposure pathways associated with the source at municipal landfill sites.

Finally, a quantitative risk assessment is not required to determine clean-up levels because the type of cap will be determined by closure ARARs, and ground water that is extracted as a component of the presumptive remedy will be required to meet discharge limits, or other standards for its disposal. Calculation of clean-up levels for ground-water contamination that has migrated away from the source will not be accomplished under the presumptive remedy, since such contamination will require a conventional investigation and a risk assessment.

Highlight 3: Source Contaminant Exposure Pathways Addressed by Presumptive Remedy

1. Direct contact with soil and/or debris prevented by landfill cap;
2. Exposure to contaminated ground water within the landfill area prevented by ground-water control;
3. Exposure to contaminated leachate prevented by leachate collection and treatment; and
4. Exposure to landfill gas addressed by gas collection and treatment, as appropriate.

Streamlining the risk assessment of the source area eliminates the need for sampling and analysis to support the calculation of current or potential future risk associated with direct contact. It is important to note that because the continued effectiveness of the containment remedy depends on the integrity of the containment system, it is likely that institutional controls will be necessary to restrict future activities at a CERCLA municipal landfill after construction of the cap and associated systems. EPA has thus determined that it is not appropriate or necessary to estimate the risk associated with future residential use of the landfill source, as such use would be incompatible with the need to maintain the integrity of the containment system. (Long-term waste management areas, such as municipal landfills, may be appropriate, however, for recreational or other limited uses on a site-specific basis.) The availability and efficacy of institutional controls should be evaluated in the FS. Decision documents should include measures such as institutional controls to ensure the continued integrity of such containment systems whenever possible.

Areas of Contaminant Migration

Almost every municipal landfill site has some characteristic that may require additional study, such as leachate discharge to a wetland or significant surface water run-off caused by drainage problems. These migration pathways, as well as ground-water contamination that has migrated away from the source, generally will require characterization and a more comprehensive risk assessment to determine whether action is warranted beyond the source area and, if so, the type of action that is appropriate.

While future residential use of the landfill source area itself is not considered appropriate, the land adjacent to

landfills is frequently used for residential purposes. Therefore, based on site-specific circumstances, it may be appropriate to consider future residential use for ground water and other exposure pathways when assessing risk from areas of **contaminant migration.**

4. Developing the Response Action

As a first step in developing containment alternatives, response action objectives should be developed on the basis of the pathways identified for action in the conceptual site model. Typically, the primary response action objectives for municipal landfill sites include:

Presumptive Remedy

- Preventing direct contact with landfill contents;
- Minimizing infiltration and resulting contaminant leaching to ground water;
- Controlling surface water runoff and erosion;
- Collecting and treating contaminated ground water and leachate to contain the contaminant plume and prevent further migration from source area; and
- Controlling and treating landfill gas.

Non-Presumptive Remedy

- Remediating ground water;
- Remediating contaminated surface water and sediments; and
- Remediating contaminated wetland areas.

As discussed in Section 3, "Defining Risks," the containment presumptive remedy accomplishes all but the last three of these objectives by addressing all pathways associated with the source. Therefore, the focus of the RI/FS can be shifted to characterizing the media addressed in the last three objectives (contaminated ground water, surface water and sediments, and wetland areas) and on collecting data to support design of the containment remedy.

Treatment of Hot Spots

The decision to characterize and/or treat hot spots is a site-specific judgement that should be based on the consideration of a standard set of factors. Highlight 4 lists questions that should be answered before making the decision to characterize and/or treat hot spots. The overriding question is whether the combination of the waste's physical and chemical characteristics and volume is such that the integrity of the new containment system will be threatened if the waste is left in place. This question should be answered on the basis of what is known about a site (e.g., from operating records or other reliable information). An answer in the affirmative to all of the questions listed in Highlight 4 would indicate that it is likely that the integrity of the containment system would be threatened, or that excavation and treatment of hot spots would be practicable, and that a significant reduction in risk at the site would occur as a result of treating hot spots. EPA expects that few CERCLA municipal landfills will fall into this category; rather, based on the Agency's experience, the majority of sites are expected to be suitable for containment only, based on the heterogeneity of the waste, the lack of reliable information concerning disposal history, and the problems associated with excavating through refuse.

The volume of industrial and/or hazardous waste co-disposed with municipal waste at CERCLA municipal landfills varies from site to site, as does the amount of information available concerning disposal history. It is impossible to fully characterize, excavate, and/or treat the source area of municipal landfills, so uncertainty about the landfill contents is expected. Uncertainty by itself does not call into question the containment approach. However, containment remedies must be designed to take into account the possibility that hot spots are present in addition to those that have been identified and characterized. The presumptive remedy must be relied upon to contain landfill contents and prevent migration of comtaminants. This is accomplished by a combination of measures, such as a landfill cap combined with a leachate collection system. Monitoring will further ensure the continued effectiveness of the remedy.

The following examples illustrate site-specific decision making and show how these factors affect the decision whether to characterize and/or treat hot spots.

Examples of Site-Specific Decision Making Concerning Hot Spot Characterization/ Treatment

Site A

There is anecdotal information that approximately 200 drums of hazardous waste were disposed of at this 70-acre former municipal landfill, but their location and contents are unknown. The remedy includes a landfill cap and ground-water and landfill gas treatment.

A search for and characterization of hot spots is not supported at Site A based on the questions listed in

Highlight 4: Characterization of Hot Spots

If all of the following questions can be answered in the affirmative, it is likely that characterization and/or treatment of hot spots is warranted:

1. Does evidence exist to indicate the presence and approximate location of waste?
2. Is the hot spot known to be principal threat waste?*
3. Is the waste in a discrete, accessible part of the landfill?
4. Is the hot spot known to be large enough that its remediation will reduce the threat posed by the overall site but small enough that it is reasonable to consider removal (e.g., 100,000 cubic yards or less)?

*See *A Guide to Principal Threat and Low Level Threat Wastes,* November 1991, Superfund Publication No. 9380.3-06FS.

Highlight 4: (1) no reliable information exists to indicate the location of the waste; (2) the determination of whether the waste is principal threat waste cannot be made since the physical/chemical characteristics of the wastes are unknown; (3) since the location of the waste is unknown, the determination of whether the waste is in a discrete accessible location cannot be made; (4) in this ease, the presence of 200 drums in a 70-acre landfill is not considered to significantly affect the threat posed by the overall site. Rather, the containment system will include measures to ensure its continued effectiveness (e.g., monitoring and/or leachate collection) given the uncertainty associated with the landfill contents and suspected drums.

Site B

Approximately 35,000 drums, many containing hazardous wastes, were disposed of in two drum disposal units at this privately owned 80-acre inactive landfill, which was licensed to receive general refuse. The site is divided into two operable units. The remedy for Operable Unit 1 (OU 1) is incineration of drummed wastes in the two drum disposal units. The remedy for OU 2 consists of treatment of contaminated ground water and leachate and containment of treatment residuals (from OU 1) and remaining landfill contents, including passive gas collection and flaring.

Treatment of landfill contents is supported at Site B because all of the questions in Highlight 4 can be answered in the affirmative: (1) existing evidence from previous investigations and sampling conducted by the state (prior to the RI) indicated the presence and approximate location of wastes; (2) the wastes were considered principal threat wastes because they were liquids and (based on sampling) were believed to contain contaminants of concern; (3) the waste is located in discrete accessible parts of the landfill; and (4) the waste volume is large enough that its remediation will significantly reduce the threat posed by the overall site.

CLOSURE REQUIREMENTS

Subtitle D

In the absence of Federal Subtitle D closure regulations, State Subtitle D closure requirements generally have governed CERCLA response actions at municipal landfills as applicable or relevant and appropriate requirements (ARARs). New Federal Subtitle D closure and post-closure care regulations will be in effect on October 9, 1993 (56 FR 50978 and 40 CFR 258).[4] State closure requirements that are ARARs and that are more stringent than the Federal requirements must be attained or waived.

The new Federal regulations contain requirements related to construction and maintenance of the final cover, and leachate collection, ground-water monitoring, and gas monitoring systems. The final cover regulations will be applicable requirements for landfills that received household waste after October 9,1991. EPA expects that the final cover requirements will be applicable to few, if any, CERCLA municipal landfills, since the receipt of household wastes ceased at most CERCLA landfills before October 1991. Rather, the substantive requirements of the new Subtitle D regulations generally will be considered relevant and approptiate requirements for CERCLA response actions that occur after the effective date.

Subtitle C

RCRA Subtitle C closure requirements may be applicable or relevant and appropriate in certain circumstances. RCRA Subtitle C is applicable if the landfill received waste that is a listed or characteristic waste under RCRA, and:

1. The waste was disposed of after November 19,1980 (effective date of RCRA), or

[4] An extension of the effective date has been proposed but not finalized at this time.

2. The new response action constitutes disposal under RCRA (i.e., disposal back into the original landfill).[5]

The decision about whether a Subtitle C closure requirement is relevant and appropriate is based on a variety of factors, including the nature of the waste and its hazardous properties, the date on which it was disposed, and the nature of the requirement itself. For more information on RCRA Subtitle C closure requirements, see *RCRA ARARs:Focus on Closure Requirements,* Directive No. 9234.2-04FS, October 1989.

[5]Note that disposal of only small quantity hazardous waste and household hazardous waste does not make Subtitle C applicable.

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APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES

This Appendix summarizes the analysis that EPA conducted of feasibility study (FS) and Record of Decision (ROD) data from CERCLA municipal landfill sites which led to the establishment of containment as the presumptive remedy for these sites. The objective of the study was to identify those technologies that are consistently included in the remedies selected, those that are consistently screened out, and to identify the basis for their elimination. Results of this analysis support the decision to eliminate the initial technology identification and screening steps on a site-specific basis for this site type. The technical review found that certain technologies are appropriately screened out based on effectiveness, implementability, or excessive costs.

The methodology for this analysis entailed reviewing the technology identification and screening components of the remedy selection process for a representative sample of municipal landfill sites. The number of times each technology was either screened out or selected in each remedy was compiled. A detailed discussion of the methodology used is provided below.

METHODOLOGY

Identification of Sites for Feasibility Study Analysis

Of the 230 municipal landfill sites on the NPL, 149 sites have had a remedy selected for at least one operable unit. Of the 149 sites, 30 were selected for this study on a random basis, or slightly greater than 20 percent. The sites range in size from 8.5 acres to over 200 acres and are located primarily in Regions 1,2,3, and 5. This geographical distribution approximates the distribution of municipal landfills on the NPL.

Technology Secrrning and Remedial Alternative Analysis

The FS analysis involved a review of the technology identification and screening phase, including any pre-screening steps, followed by a review of the detailed analysis and comparative analysis phases. Information derived from each review was documented on site-specific data collection forms, which are available for evaluation as part of the Administrative Record for this presumptive remedy directive. The review focused on the landfill source contamination only; ground-water technologies and alternatives were not included in the analysis.

For the screening phase, the full range of technologies considered was listed on the data collection forms, along with the key reasons given for eliminating technologies from further consideration. These reasons were categorized according to the screening criteria: cost, effectiveness, or implementability. The frequency with which specific reasons were given for eliminating a technology from further consideration was then tallied and compiled into a screening phase summary table.

For the detailed analysis and comparative analysis, information on the relative performance of each technology/alternative with respect to the seven NCP criteria was documented on the site-specific data collection forms. The advantages and disadvantages associated with each clean-up option were highlighted. In some cases, a technology was combined with one or more technologies into one or more alternatives. The disadvantages of a technology/alternative were then compiled into a detailed analysis/comparative analysis summary table, under the assumption that these disadvantages contributed to non-selection. All summary tables are available for review as part of the Administrative Record.

APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES (continued)

RESULTS

The information from the technology screening and remedial alternative analyses is provided in Table 1. It demonstrates that containment (the presumptive remedy), was chosen as a component of the selected remedy at all thirty of the sites analyzed. No other technologies or treatments were consistently selected as a remedy or retained for consideration in a remedial alternative. However, at eight of the thirty sites, there were circumstances where technologies were included in the selected remedy to address a site-specific concern, such as principal threat wastes. These technologies are included in the column entitled "Tech. Not Primary Component of Alternative"[1] in Table 1 and include incineration at two sites, waste removal and off-site disposal at two sites, soil vapor extraction at two sites, and bioreclamation at one site.

Leachate collection and gas collection systems were also tracked as part of the detailed analysis and comparison of remedial alternatives. These types of systems generally were not considered as remediation technologies during the screening phases. At fifteen sites, leachate collection was selected as part of the overall containment remedy. At seventeen sites, gas collection systems were selected as part of the overall containment remedy.

This analysis supports the decision to eliminate the initial technology identification and screening step for municipal landfill sites. On a site-specific basis, consideration of remediation technologies may be retained as needed.

[1] This column title is used for record-keeping purposes only and is not meant to imply that these treatment technologies are not considered important components of the selected remedies.

TABLE 1• SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS[1]

TECHNOLOGY[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3: Cost	Effectiveness	Implement.	# RODs Tech. Selected	# RODs Tech. Not Selected	Protect.	#RODs Where Criterion Contributed to Non-selection: ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Multi-layer Cap	28	25	3	0	2	2	0	18	7	1	0	0	1	3	5	3	---	---
Clay Cap	16	8	8	0	1	8	0	4	4	2	2	1	2	1	0	1	---	---
Asphalt Cap	17	0	17	0	2	14	5	0	0	0	0	0	0	0	0	0	---	---
Concrete Cap	17	0	17	0	3	14	5	0	0	0	0	0	0	0	0	0	---	---
Soil Cover	16	7	5	4	0	5	1	5	2	1	0	0	0	0	0	0	---	---
Synthetic Cap	13	3	10	0	0	10	1	2	1	1	1	1	1	1	1	1	---	---
Chemical Seal	5	0	5	0	0	4	0	0	0	0	0	0	0	0	0	0	---	---
Slurry Wall	22	5	14	3	2	8	6	2	3	3	2	2	1	2	0	2	---	---
Grout Curtain	18	0	18	0	3	15	9	0	0	0	0	0	0	0	0	0	---	---
Sheet Piling	17	1	16	0	0	13	5	0	1	0	0	0	0	0	0	0	---	---
Grout Injection	8	0	8	0	0	8	2	0	0	0	0	0	0	0	0	0	---	---
Block Displacement	5	0	5	0	0	3	3	0	0	0	0	0	0	0	0	0	---	---
Bottom Sealing	5	0	5	0	0	3	4	0	0	0	0	0	0	0	0	0	---	---

TABLE 1• SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS[1]

TECHNOLOGY[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3: Cost	Effectiveness	Implement.	# RODs Tech. Selected	# RODs Tech. Not Selected	Protect	#RODs Where Criterion Contributed to Non-selection: ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Vibrating Beam	5	0	5	0	0	3	3	0	0	0	0	0	0	0	0	0	---	---
Liners	2	0	2	0	0	1	2	0	0	0	0	0	0	0	0	0	---	---
Offsite Nonhazardous Landfill	3	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	---	---
Offsite RCRA Landfill	17	0	13	4	8	3	12	0	0	0	0	0	0	0	0	0	---	---
Offsite Landfill (unspecified)	9	1	8	0	5	3	5	1	0	0	0	0	0	0	0	0	---	---
Onsite Nonhazardous Landfill	2	0	2	0	1	1	1	0	0	0	0	0	0	0	0	0	---	---
Onsite RCRA Landfill	14	1	11	2	3	2	10	0	1	0	0	0	0	0	0	1	---	---
Onsite Landfill (unspecified)	7	0	6	1	3	3	6	0	0	0	0	0	0	0	0	0	---	---
Bioremediation (unspecified)	13	0	13	0	0	13	1	0	0	0	0	0	0	0	0	0	---	---
Bioremediation Ex-situ	10	0	10	0	0	7	7	0	0	0	0	0	0	0	0	0	---	---
Bioremediation In-situ	15	1	14	0	1	13	7	1	0	0	0	0	0	0	0	0	---	---
Dechlorinization/ APEG	6	0	5	1	1	4	2	0	0	0	0	0	0	0	0	0	---	---
Oxidation/ Reduction	12	0	12	0	1	8	5	0	0	0	0	0	0	0	0	0	---	---

TABLE 1• SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS[1]

TECHNOLOGY[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3: Cost	Effectiveness	Implement.	# RODs Tech. Selected	# RODs Tech. Not Selected	Protect.	#RODs Where Criterion Contributed to Non-selection: ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Neutralization	4	0	3	1	0	2	1	0	0	0	0	0	0	0	0	0	---	---
Thermal Destruction (unspecified)	6	0	6	0	0	3	4	0	0	0	0	0	0	0	0	0	---	---
Offsite Incineration (unspecified)	19	2	14	3	9	5	10	1	1	0	0	0	0	1	1	0	---	---
Onsite Incineration (unspecified)	12	0	8	3	5	5	6	0	1	0	0	0	0	1	1	1	---	---
Fluidized Bed	9	0	9	0	5	6	4	0	0	0	0	0	0	0	0	0	---	---
Infrared	8	0	7	1	6	3	3	0	0	0	0	0	0	0	0	0	---	---
Pyrolysis	5	2	3	1	2	2	1	0	1	0	1	0	0	1	1	1	---	---
Multiple Hearth	4	0	4	0	2	2	1	0	0	0	0	0	0	0	0	0	---	---
Rotary Kiln	10	0	9	1	6	5	4	0	0	0	0	0	0	0	0	0	---	---
Vitrification	21	0	21	0	8	15	11	0	0	0	0	0	0	0	0	0	---	---
Low Temperature Thermal Desorp/ Stripping	13	1	11	1	2	9	3	0	1	0	0	0	0	0	1	0	---	---
In-situ Steam Stripping	5	0	5	0	1	4	2	0	0	0	0	0	0	0	0	0	---	---
Soil Flushing	16	2	14	0	2	9	10	0	0	0	0	0	0	0	0	0	---	---

TABLE 1• SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS[1]

TECHNOLOGY[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3			# RODs Tech. Selected	# RODs Tech. Not Selected	#RODs WHERE CRITERION CONTRIBUTED TO NON-SELECTION							
					Cost	Effectiveness	Implement			Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Soil Washing	12	2	9	1	1	8	6	0	0	0	0	0	0	0	0	0	---	---
Soil Vapor Extraction (SVE)	14	1	11	2	2	9	5	1	0	0	0	0	0	0	0	0	---	---
Fixation	7	1	5	1	0	4	2	2	0	0	0	0	0	0	0	0	---	---
Stabilization/ Solidification	20	0	19	2	1	13	6	0	0	0	0	0	0	0	0	0	---	---
Aeration	7	0	7	0	0	5	3	0	0	0	0	0	0	0	0	0	---	---

[1] The study was conducted on 30 RODs and their corresponding FSs.
[2] This does not include the no-action or institutional control only alternatives. No RODs selected either of these as remedies.
[3] FSs and RODs may contain more than one criterion for screening or non-selection of technology. Also, some FSs did not fully explain the criteria for screening out a technology. Thus, the totals for screening and non-selection criteria are not equal to the number of FSs and RODs considered.
[4] Information on State and community concerns was not included in this analysis because FSs do not contain this information and RODs generally only reference supporting documentation (i.e., State concurrence letter and responsiveness summary).

APPENDIX B

COSTS

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
Site 4
Alternative 2: Landfill Cap, Sediment Removal, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Managemen
Capital Cost

				Unit Cost			Extended Cost				
Item	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Construction/Work Plans	300	hr			$35.00		$0	$0	$10,500	$0	$10,500
2 MOBILIZATION, DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer	6	mo				$375.00	$0	$0	$0	$2,250	$2,250
2.2 Field Office Support	6	mo		$150.00			$0	$900	$0	$0	$900
2.3 Storage Trailer (2)	12	mo				$101.00	$0	$0	$0	$1,212	$1,212
2.4 Utility Connection/Disconnection (phone/electric)	1	ls	$1,500.00				$1,500	$0	$0	$0	$1,500
2.5 Site Utilities	6	mo	$150.00				$900	$0	$0	$0	$900
2.6 Underground Utility Clearances	1	ls	$9,000.00				$9,000	$0	$0	$0	$9,000
2.7 Construction Survey Support	40	day	$935.00				$37,400	$0	$0	$0	$37,400
2.8 Equipment Mobilization/Demobilization	8	ea			$158.00	$384.00	$0	$0	$1,264	$3,072	$4,336
2.9 Site Superintendent	120	day			$355.00		$0	$0	$42,600	$0	$42,600
2.10 Site Health & Safety and QA/QC	120	day			$325.00		$0	$0	$39,000	$0	$39,000
3 DECONTAMINATION											
3.1 Decontamination Services	2	mo		$1,100.00	$2,025.00	$1,400.00	$0	$2,200	$4,050	$2,800	$9,050
3.2 Equipment Decon Pad	1	ls		$3,500.00	$3,000.00	$425.00	$0	$3,500	$3,000	$425	$6,925
3.3 Decon Water	2,000	gal		$0.20			$0	$400	$0	$0	$400
3.4 Decon Water Storage Tank, 6,000 gallon	2	mo				$704.00	$0	$0	$0	$1,408	$1,408
3.5 Clean Water Storage Tank, 4,000 gallon	2	mo				$633.00	$0	$0	$0	$1,266	$1,266
3.6 Disposal of Decon Waste (liquid & solid)	2	mo	$950.00				$1,900	$0	$0	$0	$1,900
4 SITE PREPARATION, EXCAVATION, AND COVER											
4.1 Grading Soil	2,000	cy		$12.00			$0	$24,000	$0	$0	$24,000
4.2 Dozer, 140 hp	10	day			$318.40	$611.40	$0	$0	$3,184	$6,114	$9,298
4.3 Excavator, 2 cy	10	day			$318.40	$994.60	$0	$0	$3,184	$9,946	$13,130
4.4 Compactor, 125 h.p. (2 each)	20	day			$318.40	$565.60	$0	$0	$6,368	$11,312	$17,680
4.5 Site Labor, (3 laborers)	10	day			$690.00		$0	$0	$6,900	$0	$6,900
4.6 Gas Vent Pipes, 6" dia. header PE	700	lf		$2.60			$0	$1,820	$0	$0	$1,820
4.7 Trench for Pipe	2	day				$51.00	$0	$0	$0	$102	$102
4.80 Site Labor, (3 laborers)	2	day			$690.00		$0	$0	$1,380	$0	$1,380
5 SITE RESTORATION											
5.1 Infiltration and Gas Vent Layers, sand	10,800	cy		$24.00			$0	$259,200	$0	$0	$259,200
5.2 Dozer, 140 hp (2 each)	60	day			$318.40	$611.40	$0	$0	$19,104	$36,684	$55,788
5.3 Compactor, 125 h.p. (2 each)	60	day			$318.40	$565.60	$0	$0	$19,104	$33,936	$53,040
5.4 Site Labor, (3 laborers)	30	day			$690.00		$0	$0	$20,700	$0	$20,700
5.5 Geotextile,	16,200	sy		$1.05	$0.18		$0	$17,010	$2,916	$0	$19,926
5.6 Topsoil (loam)	2,700	cy		$24.93			$0	$67,311	$0	$0	$67,311
5.7 Dozer, 140 hp (2 each)	40	day			$318.40	$611.40	$0	$0	$12,736	$24,456	$37,192
5.8 Site Labor, (3 laborers)	20	day			$690.00		$0	$0	$13,800	$0	$13,800
5.9 Sod, Bent Grass	145	msf	$675.00				$97,875	$0	$0	$0	$97,875
5.10 Seeding Disturbed Areas	36	msf	$71.00				$2,556	$0	$0	$0	$2,556
5.11 Irrigation System, 60' dia. coverage	27	ea	$200.00				$5,400	$0	$0	$0	$5,400
5.12 Ditch Dredging, Gradall	10	day			$318.40	$905.80	$0	$0	$3,184	$9,058	$12,242
5.13 Site Labor, (3 laborers)	10	day			$690.00		$0	$0	$6,900	$0	$6,900
5.14 Characterization/Offsite Disposal Soil Testing	6	ea	$543.00	$10.00			$3,258	$60	$0	$0	$3,318
5.15 Ditch Lining, riprap	300	sy		$19.00	$36.00	$14.90	$0	$5,700	$10,800	$4,470	$20,970
6 MONITORING WELLS											
6.1 Driller Mob/Demob (Abandonment)	1	ls	$500.00				$500	$0	$0	$0	$500
6.2 Well Abandonment	350	feet	$10.00				$3,500	$0	$0	$0	$3,500
6.3 Removal/Disposal of Casings	14	each	$100.00				$1,400	$0	$0	$0	$1,400
6.4 Driller Mob/Demob (Install Replacement Wells)	1	ls	$500.00				$500	$0	$0	$0	$500
6.5 Well Installation (MWs and LF Gas Wells)	190	feet	$80.00				$15,200	$0	$0	$0	$15,200
6.6 Protective Casing	13	each	$250.00				$3,250	$0	$0	$0	$3,250
6.7 IDW Disposal (Non-hazardous)	13	drum	$185.00				$2,405	$0	$0	$0	$2,405

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
Site 4
Alternative 2: Landfill Cap, Sediment Removal, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Managemen
Capital Cost

				Unit Cost			Extended Cost				
Item	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Subtotal
7 POST CONSTRUCTION COST											
7.1 Contractor Completion Report	150	hr			$35.00		$0	$0	$5,250	$0	$5,250
7.2 Remedial Action Closeout Report	200	hr			$35.00		$0	$0	$7,000	$0	$7,000
7.3 Prepare LUC Document	150	hr			$35.00		$0	$0	$5,250	$0	$5,250
7.4 LUC Survey Support	2	day	$935.00				$1,870	$0	$0	$0	$1,870
Subtotal							$188,414	$382,101	$248,174	$148,511	$967,200
Local Area Adjustments							100.0%	100.9%	86.3%	86.3%	
Subtotal							$188,414	$385,540	$214,174	$128,165	$916,293
Overhead on Labor Cost @ 30%									$64,252		$64,252
G & A on Labor Cost @ 10%									$21,417		$21,417
G & A on Material Cost @ 10%								$38,554			$38,554
G & A on Equipment Cost @ 10%										$12,816	$12,816
G & A on Subcontract Cost @ 10%							$18,841				$18,841
Tax on Materials and Equipment Cost @ 7%								$26,988		$8,972	$35,959
Total Direct Cost							$207,255	$451,082	$299,844	$149,953	$1,108,134
Indirects on Total Direct Cost @ 25%											$276,558
Profit on Total Direct Cost @ 10%											$110,813
Subtotal											$1,495,506
Health & Safety Monitoring @ 2%											$29,910
Total Field Cost											$1,525,416
Contingency on Total Field Costs @ 20%											$305,083
Engineering on Total Field Cost @ 7%											$106,779
TOTAL CAPITAL COST											**$1,937,278**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
Site 4
Alternative 2: Landfill Cap, Sediment Removal, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management
Annual Cost

Item	Item Cost year 1	Item Cost years 2 to 3	Item Cost years 4 to 30	Item Cost every 5 years	Notes
Site Inspection & Report	$3,150	$3,150	$3,150		Visit to inspect site once a year for LUC RD
Sampling	$28,960	$14,480	$7,240		Labor and supplies to collect samples from wells using a crew of two.
Analysis/Water	$47,600	$23,800	$11,900		Analyze groundwater samples from 8 wells for CVOCs, dioxins/furans, & metals in years 1 through 30. Collect samples 4 times a year in year 1, 2 times a year in years 2 and 3, and once a year for years 4 through 30.
Report	$6,000	$3,000	$1,500		Document sampling & results
Five Year Review				$17,000	
Subtotal	$85,710	$44,430	$23,790	$17,000	
Contingency @ 10%	$8,571	$4,443	$2,379	$1,700	
TOTAL	$94,281	$48,873	$26,169	$18,700	

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
Site 4
Alternative 2: Landfill Cap, Sediment Removal, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$1,937,278		$1,937,278	1.000	$1,937,278
1		$94,281	$94,281	0.935	$88,153
2		$48,873	$48,873	0.873	$42,666
3		$48,873	$48,873	0.816	$39,880
4		$26,169	$26,169	0.763	$19,967
5		$44,869	$44,869	0.713	$31,992
6		$26,169	$26,169	0.666	$17,429
7		$26,169	$26,169	0.623	$16,303
8		$26,169	$26,169	0.582	$15,230
9		$26,169	$26,169	0.544	$14,236
10		$44,869	$44,869	0.508	$22,793
11		$26,169	$26,169	0.475	$12,430
12		$26,169	$26,169	0.444	$11,619
13		$26,169	$26,169	0.415	$10,860
14		$26,169	$26,169	0.388	$10,154
15		$44,869	$44,869	0.362	$16,243
16		$26,169	$26,169	0.339	$8,871
17		$26,169	$26,169	0.317	$8,296
18		$26,169	$26,169	0.296	$7,746
19		$26,169	$26,169	0.277	$7,249
20		$44,869	$44,869	0.258	$11,576
21		$26,169	$26,169	0.242	$6,333
22		$26,169	$26,169	0.226	$5,914
23		$26,169	$26,169	0.211	$5,522
24		$26,169	$26,169	0.197	$5,155
25		$44,869	$44,869	0.184	$8,256
26		$26,169	$26,169	0.172	$4,501
27		$26,169	$26,169	0.161	$4,213
28		$26,169	$26,169	0.15	$3,925
29		$26,169	$26,169	0.141	$3,690
30		$44,869	$44,869	0.131	$5,878
				TOTAL PRESENT WORTH	**$2,404,358**

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1813PW0 110 100	
SUBJECT: Site 4 FS			
BASED ON:		DRAWING NUMBER:	
BY: TJR Date: 9/26/07	CHECKED BY: Date:	APPROVED BY:	DATE:

SOIL REMEDIAL ALTERNATIVES

Alternative 2: Comprehensive Action: Landfill Cap, Sediment Removal, Canal Lining, LUCs, Groundwater Monitoring, and Landfill Gas Management

Annual Cost

Cover Inspection & Report (1 person)

Car, 3 days	$300	
Hours	$2,600	(40 hours * $65/hr for field & report)
Misc	$250	
	$3,150	

Cover Maintenance

Assume golf course will maintain cover.

Sampling

Labor & Materials, per round (2 wells per day: 10 wells)

Assume 5 days to sample with 2 people, local

2 people @ $60.00 per hour for 10 hours per day for 5 days =	$6,000
car for 5 days =	$500
report @ $65.00 per hour for 6 hours =	$390
Misc supplies, copying, etc. =	$350
	$7,240

Analytical, per round for 30 years

Collect water samples from wells and analyze for CVOCs, dioxins/furans, & metals

type	cost each	number	total
CVOCs	$75	10	$750
dioxins/furans	$650	10	$6,500
metals	$125	10	$1,250
			$8,500
40% QA/QC & Data Validation			$3,400
			$11,900

Sampling report assume $1,500 per round $1,500

APPENDIX C

TREATABILITY STUDY MEMORANDUM

TETRA TECH NUS, INC.
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Project Number 9666

Commander, Southeast
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Reference: Clean Contract No. N62467-94-D0888
Contract Task Order No. 9666

Subject: Treatability Study (TS) Memorandum for Site 4
Naval Construction Battalion Center, Gulfport, Mississippi

Dear Mr. Art Conrad:

Tetra Tech NUS (TtNUS), under contract to the U. S. Department of the Navy, Naval Facilities Engineering Command Southeast (NAVFAC SE), has prepared this Treatability Study (TS) Memorandum for Site 4 at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. This memorandum was prepared under the Comprehensive Long-term Environmental Action Navy (CLEAN) III, Contract No. N62467-94-D-0888.

Introduction

The objective of the TS at Site 4 was to provide information for the selection of a remedial option for chlorinated volatile organic compounds (CVOCs) in groundwater to compliment the overall cap/cover presumptive remedy for Site 4. A bioaugmentation technology using substrate and microbial culture injection was tested in a small area of the site. Analytical data collected prior to and following the technology application were evaluated to determine how successfully the injected materials were in dechlorinating CVOCs present in groundwater at the site. This report describes the field activities, data collection, laboratory analyses, and data evaluation that were

performed for the TS. Initial information on the TS was provided in the Remedial Investigation (RI) and Treatability Study Work Plan Addendum submitted in November 2005. The following investigation activities provided the data for evaluating conditions at Site 4:

1997/1998	Base wide groundwater study and surface water/sediment study identified CVOC plume
August 2004	RI DPT groundwater sampling
September 2004	RI monitoring well sampling
March 2006	Groundwater delineation - DPT Sampling with mobile laboratory
April 2006	Baseline groundwater and soil sampling
September 2006	Verification groundwater sampling and substrate (sodium lactate) application
October 2006	Injection of Bacterial Culture
January 2007	Performance Monitoring

Site Background

The RI conducted at Site 4 in 2004 investigated a plume of CVOC-contaminated groundwater first detected in 1997. Groundwater samples were collected using direct push technology (DPT) from 25 locations for VOC analysis and groundwater samples were collected for full suite analysis from monitoring wells. CVOCs were detected in groundwater samples at concentrations exceeding risk-based screening criteria. The lithology of the site includes discontinuous clay and sandy clay horizons that may influence vertical distribution of contaminants. Analysis of natural biodegradation indicator parameters (e.g. dissolved oxygen, reduction/oxidation potential, etc.) indicated that reducing conditions were present in site groundwater.

These data suggest that the phenomena known as "DCE/VC stall" has occurred in the dissolved VOC plume at Site 4. A site is considered to be in DCE/VC stall if these compounds are accumulating as concentrations of TCE are reduced. DCE/VC stall may occur when insufficient electron donors or microbes are present, and/or adverse environmental conditions prevent complete biological anaerobic reductive dechlorination (ARD) of VOCs to non-toxic components such as ethene, ethane, carbon dioxide, and water. Despite the fact that DCE/VC stall is occurring at the site, the lack of VOCs in some wells and the relatively high ethane concentrations in the wells sampled provide evidence that complete ARD is also occurring.

Field Activities

Field activities conducted for the TS include:

- Installation of three temporary monitoring points (MPs) in treatment cell area, installed to a depth of 18 feet
- Collection of groundwater and soil samples from the MP locations and groundwater samples from selected monitoring wells to establish baseline conditions
- Technology application - Injection of substrate and microbial culture
- Performance Monitoring

Field activities were conducted in accordance with the site specific Health and Safety Plan and the RI Work Plan (TtNUS, 2004). Detailed descriptions of field procedures are located in the RI Work Plan. Locations that were sampled for the TS and parameters analyzed are summarized in Table 1.

To fill data gaps from the initial RI, additional field sampling activities were conducted in March and April 2006. The activities included advancement of 20 soil borings via DPT and collection of 63 groundwater samples at varying depths in those borings. DPT groundwater samples were analyzed in a mobile laboratory. Data from the field analysis of the samples found the highest VOC concentrations were at the 04GP28 DPT location (Figure 1):

- trichloroethene (TCE) - 120 micrograms per liter (µg/L)
- cis-1,2-dichlorethene (cis-1,2-DCE) - 970 µg/L
- trans-1,2-dichloroethene (trans-1,2-DCE) - 800 µg/L
- vinyl chloride (VC) - 1,600 µg/L

Ten permanent monitoring wells were installed for long term monitoring of the CVOC plume. Three of these wells were installed in the 04GP28 area:

- GPT-04-21 screened from 6 to 16 feet
- GPT-04-22 screened from 19 to 24 feet
- GPT-04-23 screened from 40 to 45 feet

Groundwater samples were collected from each of these locations as well as seven existing monitoring wells and analyzed in a fixed-base laboratory. These data were used to delineate the extent of the CVOC plume and identify the location of the highest CVOC concentrations.

Because the groundwater samples collected at 04GP28 had the highest detected CVOC concentrations, the treatment cell for the TS was moved from between monitoring wells GPT-04-13/GPT-04-14 and GPT-04-16/GPT-04-17, as originally planned, to the area between monitoring wells GPT-04-13/GPT-04-14 and GPT-04-21/GPT-04-22/GPT-04-23 (Figure 1).

MP installation

Three temporary MPs were installed for the TS. Two of the MPs, MP-01 and MP-02, were located downgradient of monitoring well GPT-04-21 (installed at the 04GP28 location) in the general direction of monitoring wells GPT-04-13/GPT-04-14 (Figure 1). The third MP, MP-03, was installed to the west of monitoring wells GPT-04-21/GPT-04-22/GPT-04-23 (Figure 1).

Baseline Sampling

Baseline or pre-treatment sampling for the TS was conducted to determine the existing contaminant concentrations and geochemical conditions. Baseline samples were collected from the three temporary MPs installed in the TS cell area and selected permanent monitoring wells. The baseline sampling analyses are summarized in Table 1. Field sampling data forms and validated laboratory data are included in the Appendix.

Baseline Site Conditions

CVOC concentrations were less than expected in the MP samples. Elevated CVOC concentrations in the TS cell area were limited to GPT-04-22 (screened from 19 to 24 feet):

- TCE 110 µg/L
- cis-1,2-DCE 470 µg/L
- trans-1,2-DCE 310 µg/L
- VC 190 µg/L

Elevated CVOC concentrations were reported in GPT-04-14 and GPT-04-16, located downgradient of the TS area (Table 2). These results indicated that the CVOC contamination was occurring in the deeper part of the shallow aquifer. Analytical results for CVOCs are summarized in Table 2.

Conditions in the aquifer at the site range from slightly reducing to strongly reducing. The oxidation reduction potential (ORP) was negative, ranging from -19 to -132 millivolts (mV). The dissolved oxygen (DO) readings were below 1 milligram per liter (mg/L), with one of the readings below 0.5 mg/L. pH readings ranged from 5.75 to 6.85 in the TS area. Field water quality measurements are summarized in Table 3.

Very low quantities of microbes responsible for degradation of DCE and VC were present in the groundwater at MP-01 and MP-03. Dhc concentrations at those wells were 13.4 and 5.48 cells per milliliter, respectively (Table 4). The functional genes believed to be responsible for reduction of DCE and VC, BAV1 VC R-Dase and VC R-Dase, were present at only very low concentrations, less than 1 cell per milliliter. Laboratory reports for the microbial census are included in the Appendix.

Soil samples from the temporary wells indicate that chlorinated VOCs are not present in the soil in the TS area (Table 5).

Pre-Treatment Verification Sampling

Because the CVOC concentrations in the baseline samples from the three MPs were far lower than anticipated (Table 2), the three shallow MPs were resampled and DPT groundwater samples were collected from locations adjacent to the MPs at a depth of 24 feet before the injection of the sodium lactate substrate. The DPT sample locations are identified as MP-01D, MP-02D, and MP-03D. Analytical results from the verification samples indicated that the CVOC plume did not have the horizontal extent in the TS cell area and was at deeper depths than suggested by the DPT data collected for the RI.

Technology Selection

Using data from the RI and baseline and verification sampling, several remedial technologies were evaluated for the TS, including

- chemical oxidation,
- enhanced aerobic biodegradation,
- enhanced ARD via biostimulation (addition of substrate),
- enhanced ARD via biostimulation and bioaugmentation (addition of suitable microbiota),
- cometabolic biodegradation.

Chemical oxidation, enhanced aerobic biodegradation, and cometabolic biodegradation rely on the presence of an oxidizing environment. At Site 4, the present conditions are naturally reducing. Additionally, there is a significant amount of organic carbon present in the soil and groundwater at the site which would deplete the oxidizer or other aerobic amendment as it was added, thus competing with the aerobic degradation of VOCs. Before these technologies could be effective, the natural reducing conditions would have to be overcome, requiring application of significant quantities of oxidizer or other aerobic amendment, potentially over a series of injection events.

Therefore, technologies were evaluated that would exploit the naturally occurring reducing conditions and enhance the natural ARD occurring at the site. Based on the data, it appeared that natural reduction of TCE was occurring, with the reactions in some portions of the site stalling at DCE and VC. This is a common occurrence at sites where either insufficiently reducing conditions, lack of the proper microbial community, and/or some other condition inhibiting biodegradation (e.g., pH outside of the optimal range, elevated sulfate concentrations, etc.) are present.

Data from the site indicate that while reducing conditions sufficient for ARD of DCE and VC are present in some portions of the site, they may not be present in the area where the highest contaminant concentrations have been observed (the TS area). Therefore, biostimulation, through the addition of a carbon source (substrate) to the subsurface, will be implemented. In this case, a fast acting substrate (lactate) has been chosen over a slow release substrate such as vegetable oil; lactate was chosen to quickly achieve strongly reducing conditions in the TS area and to provide timely information on the success of enhanced ARD.

Another cause of DCE/VC stall can be the lack of the proper microbial community in the subsurface. While several bacterial groups are involved in partial reductive dechlorination (e.g., *Dehalobacter, Desulfuromonas, etc*), *Dehalococcoides* (Dhc) is the key consortia involved in complete reductive dechlorination to ethene. However, the Dhc organism is not ubiquitous and, if present, may be at insufficient quantities for complete ARD. Laboratory data from Site 4 showed that Dhc concentrations in the TS area were orders of magnitude below levels believed to sustain ARD. Further, the Dhc functional genes believed to be responsible for ARD of DCE and VC are not present at sufficient levels. Bioaugmentation is the process of supplementing the existing microbial population with a culture of Dhc. In this case, biostimulation was implemented with bioaugmention to create favorable conditions and continue to provide a food source for the

bacteria for complete, efficient, and rapid ARD, while providing more of the microbes responsible for complete ARD.

Treatment Design and Application

Based on the reducing conditions already present at the site, and the low levels of microbes capable of reducing VC and DCE, ARD via biostimulation and bioaugmentation was chosen as the technology most likely to be successful at Site 4. Specifically, this included injection of fast acting organic substrate (lactate) and microorganisms known to degrade less chlorinated VOCs (e.g., Dhc) into the subsurface. Other conditions that may be contributing to the DCE/VC stall the site include low pH and the presence of competing electron acceptors. The optimal pH for ARD is between 6 and 9. The pH observed at GPT-04-22, located in the TS area, was 5.75. Therefore, sodium bicarbonate was added with the substrate to raise the pH to more optimal conditions.

The substrate application was conducted in September 2006. 220 gallons of 60% sodium lactate solution was mixed with tap water to create a lactate solution of approximately 15 percent (by weight). A total of approximately 650 gallons of water was required to properly dilute the lactate. The solution was mixed in approximately 175-gallon batches. Each batch contained 44 gallons of lactate and 130 gallons of water. Because of the low pH in the TS area, approximately six pounds of sodium bicarbonate was added to each batch of the solution, to raise the pH of the aquifer.

The solution was injected into the aquifer at five locations using DPT (Figure 2). Each 175-gallon batch of solution was injected evenly through the DPT rods from a depth of approximately 24 feet to a depth of approximately eight feet.

The microbial culture was applied in October 2006. The selected Dhc culture was KB-1 dechlorinator provided by SiREM Laboratories. The Dhc culture was added to the aquifer after sufficient time to develop reducing conditions to allow the microbes to propagate, based on field readings (primarily DO and ORP) after addition of the lactate in September (Table 3). The injection of the Dhc culture (in locations at or near the locations of the lactate addition) was done in accordance with the manufacturer's instructions. Field data records of the KB-1 application and photographs of the application equipment are included in the Appendix.

Performance Monitoring

To evaluate the efficacy of the technology chosen for the treatability study, a round of performance monitoring sampling was conducted in January 2007, approximately three months following the injection of the Dhc culture. Baseline samples were collected from the three temporary MPs installed in the TS cell area, using DPT at locations adjacent to the MPs, and selected permanent monitoring wells. The baseline sampling analyses are summarized in Table 1. Field sampling data forms and validated laboratory data are included in the Appendix.

Data Evaluation

The success of the technology application in promoting ARD has been evaluated using two lines of evidence:

- Primary Evidence – Evaluate changes in CVOC concentrations and mass balance that may be attributed to ARD and the concentrations of final break-down products of ARD - dissolved gas (ethene and ethane) and chloride.

- Secondary Evidence– Determine if aquifer geochemical conditions support ARD and if a suitable microbiological consortium is present

Data were compared for locations in the treatment cell MP-01/MP-01D and GPT-04-22, downgradient of the injection area, MP-02/MP-02D and side gradient of the treatment cell, MP-03/MP-03D (CVOC concentrations at this location were less than TRGs). CVOC data from the TS sampling events are shown in Figure 2.

Changes in Contaminant Concentration

The concentrations of CVOCs at each of the sample locations decreased following the application of the substrate and Dhc culture, except for the VC concentration at GPT-04-22, which increased (Table 6). The decreased CVOC concentrations may not necessarily indicate destruction of the CVOCs. Comparison of overall changes of the total CVOC concentration to changes in individual CVOC species can indicate if decreasing concentrations have resulted from dechlorination. Analytical results from MP-01D and GPT-04-22, within the treatment cell, clearly show higher concentrations changes for TCE and lower concentration changes for VC, suggesting ARD in these locations. The increasing VC concentration in GPT-04-22 particularly indicates dechlorination of TCE and DCE, producing VC. The data from MP-02D, located downgradient of

the treatment cell, indicate that each of the chlorinated ethenes decreased equally in concentration, suggesting that the reduced concentrations did not result from dechlorination.

Changes in the contaminant mass balance

Comparison of the ratios of molar concentrations of CVOCs is more indicative of contaminant destruction than comparison of concentration by volume, because dechlorination of CVOCs produces lower molecular weight daughter products (Table 7). Analytical data from MP-01, MP-01D, and GPT-04-22 again generally show decreases in TCE and DCE as part of the total CVOC mass and increases in VC, indicating that the more chlorinated ethenes are being reduced to VC or ethene. By comparison, data from MP-02D show that the molar fractions of the CVOCs do not change as the mass per volume concentrations decrease, indicating that the decrease is not due to ARD.

Changes in concentrations of break-down products

Chloride concentrations almost doubled in the sample locations in the treatment cell (MP-01 and GPT-04-22). Chlorine atoms removed from the CVOCs during dechlorination can increase the chloride concentration in the groundwater. Chloride concentrations increased less significantly at MP-02 and MP-03.

Ethene concentrations increased three orders of magnitude in the treatment cell area. Ethene is the resulting byproduct when all of the chlorine atoms are removed from a chlorinated ethene, e.g., DCE or VC. Therefore, an increase in ethene concentrations can indicate that CVOCs are being dechlorinated. Ethene concentrations outside the treatment cell and ethane concentrations in the samples collected showed little change.

Secondary Lines of Evidence

Evaluation of secondary lines of evidence for ARD helps determine the degree to which the technology application was successful in creating conditions in the subsurface suitable for ARD, including indicators of reductive conditions (DO and ORP), microbial concentrations, volatile fatty acids concentrations, and concentrations of bio-indicator parameters. These data are summarized in Table 8.

ORP in each of the sample locations decreased shortly following the substrate application and have remained at these decreased levels, indicating that an adequate amount of substrate was supplied to maintain highly reducing conditions in the treatment cell area.

DO concentrations in each of the wells and monitoring points showed an increase following the substrate injection (Table 3). This DO increase may have resulted from the use of tap water to dilute the sodium lactate solution. These changes in DO concentration do not correlate with observed increases in methane or the very low ORP measurements, which indicate reducing conditions. DO data measured during the performance monitoring sampling event indicated that DO concentrations in locations outside of the treatment cell, MP-02 and MP-03 had returned to very low levels, while the DO concentrations in the treatment cell area, MP-01 and GPT-04-22 were still elevated.

Hydrogen concentrations in the treatment cell area, MP-01 and GPT-04-22 remained at levels conducive to ARD, greater than 2 nanomoles per liter (nM/L) (Table 8). Hydrogen concentrations decreased in wells outside of the treatment cell compared to the baseline and correspond to a higher redox state more suitable to iron (0.2 to 0.8 nM/L) and sulfate reduction (1 to 4 nM/L).

The microbial census data showed an increase in the population of Dhc in the site groundwater, but an overall decrease in total microbes (Table 5). These changes in microbe abundance can be attributed to the dilution of the existing micro biota and the preferential addition of Dhc in the KB-1 Dechlorinator.

Concentrations of volatile fatty acids were observed to increase, up to five or six orders of magnitude in some cases, at the sample locations inside the treatment cell, suggesting increased microbial metabolic activity (Table 8).

Sulfate concentrations inside the treatment cell area decreased, suggesting that sulfate reduction is not competing with ARD in this area (Table 8). Sulfate concentrations increased outside of treatment area.

Sulfide concentrations increased across the TS area (Table 8), suggesting the sufficiently reducing conditions are present to reduce sulfate.

Dissolved iron concentrations decreased at the sampling locations inside and outside of the treatment cell (Table 8), which is the opposite of what is expected under reducing conditions. The decrease in iron concentrations may be tied to coprecipitation of iron with the increased sulfides.

Nitrate and nitrite concentrations have been at or below detection limits in samples collected at Site 4, indicating that nitrate reduction is not a factor in groundwater geochemistry at the site.

Concentrations of orthophosphate in site groundwater have been low and shown little change, indicating little impact on microbial activity at the site (Table 8).

Summary of Treatability Study

Data collected during the TS indicate that enhanced ARD can be an effective remedial approach for this site as demonstrated by the following:

- The substrate injection appears to have rapidly improved aquifer conditions for ARD
- Application of the Dhc culture has established a higher proportion of Dhc in the subsurface micro biota
- Evidence of ARD was observed in two sampling locations, MP-01/MP-01D and GPT-04-22, where mass balance changes in CVOCs suggest dechlorination is occurring.
- Increased chloride and ethene concentrations as break down products in the treatment cell area also support the occurrence of ARD

A pilot scale test should be considered prior to full scale implementation of this technology at Site 4. To optimize application of Dhc culture, more detailed vertical delineation of the contaminant plume is advised. A source of low DO groundwater water or treated tap water should be secured prior to preparation of the lactate solution. DPT injection appears to be a viable method of substrate and Dhc application. The area of influence of each injection location and injection spacing was suitable to treat groundwater in the treatment cell, however there appears to have been little enhancement of ARD downgradient or sidegradient of the treatment cell.

If you have any questions regarding the information presented in this document, please contact me by phone at (850) 385-9899 or via email at Robert.Fisher@ttnus.com.

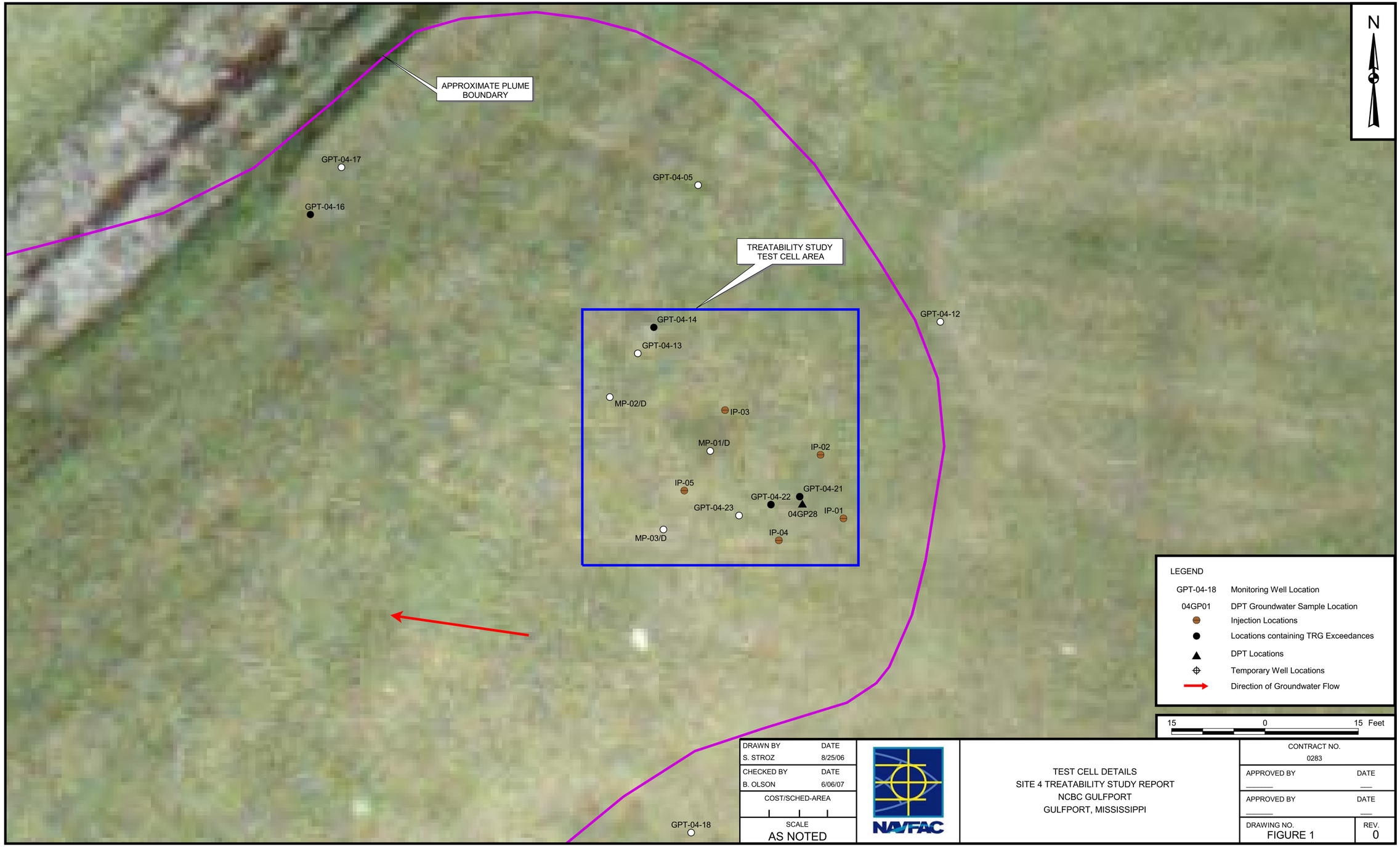
Sincerely,

Robert Fisher
Task Order Manager

Enclosures: 2 copies

CC:
Gordon Crane, NCBC Gulfport (2 copies)
Debbie Humbert (Letter Only)
Mark Perry/File

P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE04.APR UPDATED SITE 4 GROUNDWATER VOC TRG LAYOUT 6/06/07 SS



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SCALE	
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TEST CELL DETAILS
SITE 4 TREATABILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

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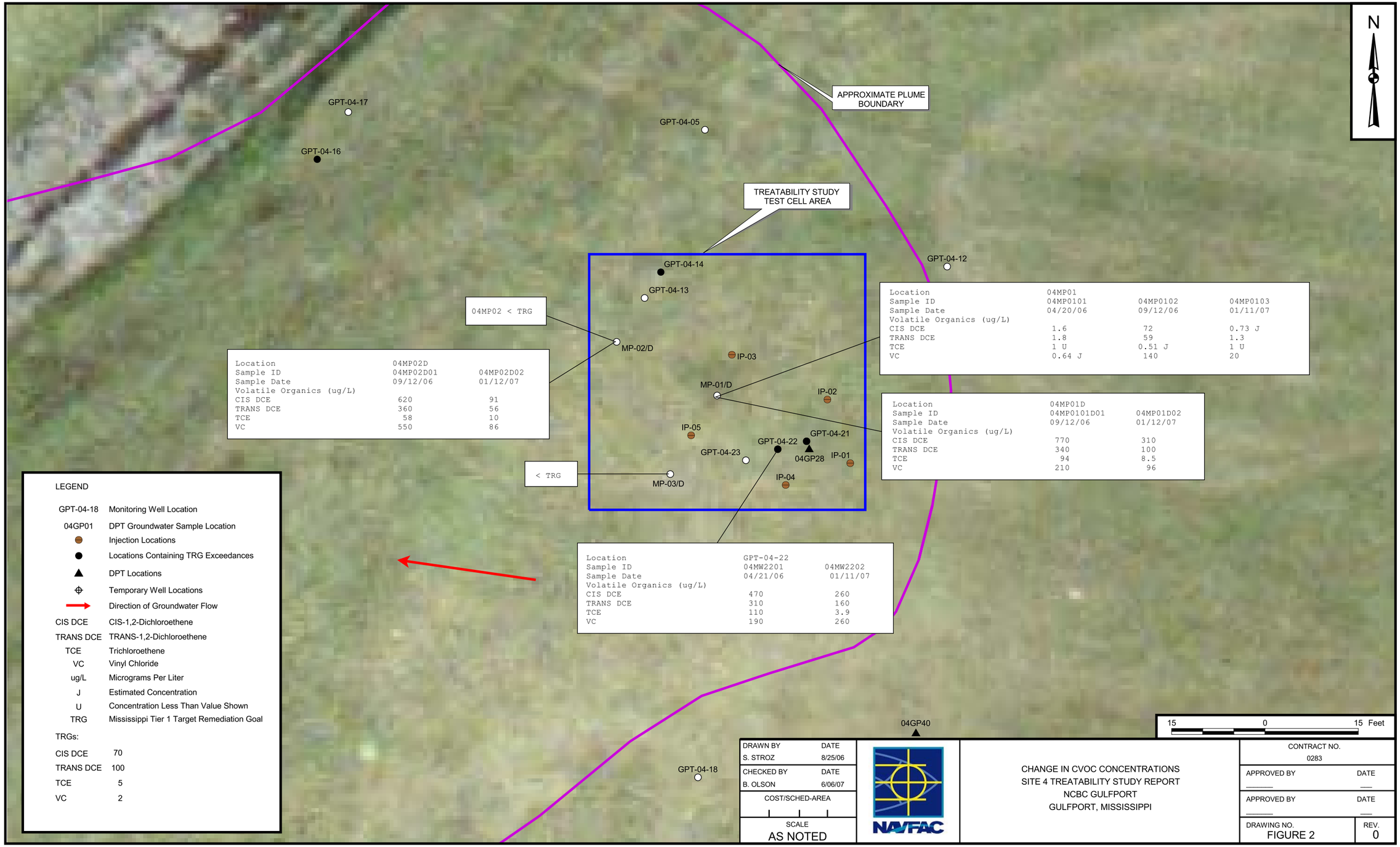
P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE04.APR CHANGES IN CVOC CONCENTRATIONS LAYOUT 6/06/07 SS



Location	04MP02D	
Sample ID	04MP02D01	04MP02D02
Sample Date	09/12/06	01/12/07
Volatile Organics (ug/L)		
CIS DCE	620	91
TRANS DCE	360	56
TCE	58	10
VC	550	86

Location	04MP01		
Sample ID	04MP0101	04MP0102	04MP0103
Sample Date	04/20/06	09/12/06	01/11/07
Volatile Organics (ug/L)			
CIS DCE	1.6	72	0.73 J
TRANS DCE	1.8	59	1.3
TCE	1 U	0.51 J	1 U
VC	0.64 J	140	20

Location	04MP01D	
Sample ID	04MP0101D01	04MP01D02
Sample Date	09/12/06	01/12/07
Volatile Organics (ug/L)		
CIS DCE	770	310
TRANS DCE	340	100
TCE	94	8.5
VC	210	96

Location	GPT-04-22	
Sample ID	04MW2201	04MW2202
Sample Date	04/21/06	01/11/07
Volatile Organics (ug/L)		
CIS DCE	470	260
TRANS DCE	310	160
TCE	110	3.9
VC	190	260

LEGEND

GPT-04-18	Monitoring Well Location
04GP01	DPT Groundwater Sample Location
	Injection Locations
	Locations Containing TRG Exceedances
	DPT Locations
	Temporary Well Locations
	Direction of Groundwater Flow
CIS DCE	CIS-1,2-Dichloroethene
TRANS DCE	TRANS-1,2-Dichloroethene
TCE	Trichloroethene
VC	Vinyl Chloride
ug/L	Micrograms Per Liter
J	Estimated Concentration
U	Concentration Less Than Value Shown
TRG	Mississippi Tier 1 Target Remediation Goal

TRGs:

CIS DCE	70
TRANS DCE	100
TCE	5
VC	2

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COST/SCHED-AREA

SCALE
AS NOTED

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CHANGE IN CVOC CONCENTRATIONS
SITE 4 TREATABILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

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0283

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TABLE 1
SAMPLING AND ANALYSIS SUMMARY
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

Baseline Sampling			Verification Sampling			Performance Monitoring		
March/April 2006			September 12, 2006			January 11, 2007		
Location	**Sample ID**	**Analyses**	**Location**	**Sample ID**	**Analyses**	Location	Sample ID	Analyses
Monitoring Wells								
GPT-04-16	04GW1602	CVOC/NA/Microbial Census						
GPT-04-22	04MW2201	VOC				GPT-04-22	04MW2202	CVOC
Temporary Monitoring Points								
04MP01	04MP0101	CVOC/NA/Microbial Census/Soil	04MP01	04MP0102	CVOC	04MP01	04MP0103	CVOC
04MP02	04MP0201	CVOC/NA/Soil	04MP02	04MP0202	CVOC	04MP02	04MP0203	CVOC/NA/Microbial Census
04MP03	04MP0301	CVOC/NA/Microbial Census/Soil	04MP03	04MP0302	CVOC	04MP03	04MP0303	CVOC/NA/Microbial Census
			DPT Monitoring Points					
			04MP01D	04MP01D01	CVOC	04MP01D	04MP01D02	CVOC
			04MP02D	04MP02D01	CVOC	04MP02D	04MP02D02	CVOC
			04MP03D	04MP03D01	CVOC	04MP03D	04MP03D02	CVOC

Notes:
CVOC Chlorinated Volatile Organic Compounds
NA Natural Attenuation Parameters
Soil Soil samples for CVOC and total organic carbon

TABLE 2
GROUNDWATER CVOC ANALYTICAL SUMMARY
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

MONITORING WELLS

location		GPT-04-13		GPT-04-14		GPT-04-16		GPT-04-17		GPT-04-21	GPT-04-22		GPT-04-23
sample ID		04GW1301	04MW1302	04GW1401	04MW1402	04GW1601	04GW1602	04GW1701	04MW1702	04MW2101	04MW2201	04MW2202	04MW2301
sample date	Mississippi	09/22/04	04/11/06	09/22/04	04/13/06	09/13/04	03/30/06	09/13/04	04/13/06	04/21/06	04/21/06	01/11/07	04/20/06
sample depth - feet	Tier 1	5-15		24-34		4-14		35-40		6-16	19-24		45-50
sample event	TRG	RI Sampling	Baseline	RI Sampling	Baseline	RI Sampling	Baseline	RI Sampling	Baseline	Baseline	Baseline	Perf. Mon.	Baseline
Volatile Organics (ug/L)													
1,1-DICHLOROETHENE	7	5 U	1 U	5 U	1 U	0.6 J	2 U	5 U	1 U	1 U	1.2	2 U	1 U
1,2-DICHLOROETHANE	5	5 U	1 U	5 U	1 U	0.2 J	2 U	5 U	1 U	1 U	0.24 J	2 U	1 U
CIS-1,2-DICHLOROETHENE	70	5 U	1 U	55	47	**280**	**170**	5 U	1 U	5.9	**470**	**260**	1 U
TRANS-1,2-DICHLOROETHENE	100	5 U	1 U	30	22	**190**	89	5 U	1 U	6.4	**310**	**160**	1 U
TETRACHLOROETHENE	5	5 U	1 U	5 U	1 U	5 U	2 U	5 U	1 U	1 U	0.72 J	2 U	1 U
TRICHLOROETHENE	5	5 U	1 U	0.8 J	0.55 J	**8**	4.1	5 U	1 U	1	**110**	3.9	1 U
VINYL CHLORIDE	2	5 U	1 U	**25**	**14**	**150**	**84**	5 U	1 U	**18**	**190**	**260**	1 U

TEMPORARY MONITORING POINTS

location		04MP01			04MP02			04MP03		
sample ID		04MP0101	04MP0102	04MP0103	04MP0201	04MP0202	04MP0203	04MP0301	04MP0302	04MP0303
sample date	Mississippi	04/20/06	09/12/06	01/11/07	04/20/06	09/12/06	01/11/07	04/20/06	09/12/06	01/11/07
sample depth - feet	Tier 1	8-18			8-18			8-18		
sample event	TRG	Baseline	Verification	Perf. Mon.	Baseline	Verification	Perf. Mon.	Baseline	Verification	Perf. Mon.
Volatile Organics (ug/L)										
1,1-DICHLOROETHENE	7	1 U	0.46 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-DICHLOROETHANE	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CIS-1,2-DICHLOROETHENE	70	1.6	**72**	0.73 J	0.37 J	1 U	1 U	1 U	1 U	1 U
TRANS-1,2-DICHLOROETHENE	100	1.8	59	1.3	0.38 J	1 U	1 U	1 U	1 U	1 U
TETRACHLOROETHENE	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TRICHLOROETHENE	5	1 U	0.51 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U
VINYL CHLORIDE	2	0.64 J	**140**	**20**	1 U	1.4	1 U	1 U	1 U	1 U

DPT MONITORING POINTS

location		04MP01D		04MP02D		04MP03D	
sample ID		04MP01D01	04MP01D02	04MP02D01	04MP02D02	04MP03D01	04MP03D02
sample date	Mississippi	09/12/06	01/12/07	09/12/06	01/12/07	09/12/06	01/12/07
sample depth - feet	Tier 1	20-24		20-24		20-24	
sample event	TRG	Verification	Perf. Mon.	Verification	Perf. Mon.	Verification	Perf. Mon.
Volatile Organics (ug/L)							
1,1-DICHLOROETHENE	7	10 U	2 U	10 U	1 U	1 U	1 U
1,2-DICHLOROETHANE	5	10 U	2 U	10 U	1 U	1 U	1 U
CIS-1,2-DICHLOROETHENE	70	**770**	**310**	**620**	**91**	1 U	0.84 J
TRANS-1,2-DICHLOROETHENE	100	**340**	100	**360**	56	1 U	1 U
TETRACHLOROETHENE	5	100	2 U	10 U	1 U	1 U	1 U
TRICHLOROETHENE	5	**94**	**8.5**	**58**	**10**	1 U	1 U
VINYL CHLORIDE	2	**210**	**96**	**550**	**86**	1 U	0.32 J

Notes:

ug/L	micrograms per liter
Perf. Mon.	Performance Monitoring Event
U	Concentration less than value shown
J	Estimated concentration

Concentrations in bold exceed Tier 1 TRG

TABLE 3
FIELD WATER QUALITY DATA
SITE 4 TREATABILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

Sample Location	GPT-04-22			MP-01			MP-02			MP-03		
Sample Date		9/27/2006	1/11/2007		9/27/2006	1/11/2007		9/27/2006	1/11/2007		9/27/2006	1/11/2007
Sample Event	Baseline	Verification	Perf. Mon.	Baseline	Verification	Perf. Mon.	Baseline	Verification	Perf. Mon.	Baseline	Verification	Perf. Mon.
pH	5.75	6.14	5.48	6.56	6.64	5.54	6.83	7.12	6.00	6.85	6.98	5.87
Conductivity (mS/cm)	0.92	1.49	2.56	1.91	6.8	2.86	2.03	1.46	2.37	2.20	1.98	2.72
Temperature (C^o)	22.56	24.46	23.05	21.65	25.85	22.12	21.48	25.74	20.08	22.22	26	21.34
Turbidity (NTU)	2.4	195	8.4	20.5	61.1	9	11.3	17	0.16	6.16	9.5	2.1
Dissolved Oxygen (mg/L)	0.44	2.26	2.08	0.57	2.10	1.11	0.94	2.18	0.00		2.81	0.00
ORP (mV)	-19	-315	-298	-118	-434	-395	-197	-270	-274	-132	-322	-337

Notes:

Perf. Mon.	Performance Monitoring
mS/cm	millisiemens/centimeter
C^o	Degrees celsius
NTU	Nephelometric Turbidity Unit
mg/L	milligrams per liter
ORP	Oxidation-Reduction Potential
mV	millivolts

TABLE 4
MICROBIAL CENSUS RESULTS
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

Location	04MP01		04MP03		GPT-4-16
Sample ID	04MP0101	04MP0103	04MP0301	04MP0303	04GW1602
Depth Range (feet)					
Sample Date	4/20/2006	1/11/2007	4/20/2006	1/11/2007	3/30/2006
Dechlorinating Bacteria (cells/mL)					
Dehalococcoides spp	1.34E+01	**5.35E+01**	5.48E+00	**1.44E+01**	3.52E-01
Desulfuromonas sp	9.88E+01	1.73E+01	9.11E+01	**1.04E+02**	1.2E+00
Dehalobacter spp.	5.5E+03	8.51E+00	1.92E+03	7.89E-01	9.24E+03
Desulfitobacterium sp.	3.1E+04	2.03E+02	7.35E+04	2.1E+03	5.29E+01
Functional Genes (cells/mL)					
BAV1 VC R-Dase	<8.33E-01	<6.25E-01	<4.17E-01	<3.33E-01	<2E-01
TCE R-Dase	<8.33E-01	**3.56E-01 (J)**	<4.17E-01	<3.33E-01	<2E-01
VC R-Dase	<8.33E-01	**2.01E+01**	1.21E-01 (J)	<3.33E-01	<2E-01
Soluble Methane Monooxygenase	2.67E+01	**1.98E+02**	1.19E+01	**1.3E+04**	1.43E+02
Other Genera (cells/mL)					
Geobacter spp.	2.47E+03	<9.38E-01	1.34E+03	<5E-01	3.99E+01
Other Genera (cells/mL)					
Eubacteria	1.29E+06	**2.99E+06**	5.79E+05	**2.63E+06**	1.21E+05
Methanogens	3.11E+04	<1.25E+00	2.71E+04	**3.36E+04**	8.72E+03
Sulfate and Iron Reducing Bacteria	9.86E+03	<9.38E-01	6.91E+03	2.55E+01	4.46E+02
Methanotrophs (total)	2.67E+04	**8.45E+06**	4.29E+04	**2.99E+07**	2.15E+04
Type I MOB	1.37E+04	4.84E+03	1.55E+04	**2.81E+06**	5.E+03
Type II MOB	1.31E+04	**8.45E+06**	2.75E+04	**2.71E+07**	1.65E+04

Notes:
J = estimated value
Values in bold show an increase over baseline sampling results

TABLE 5
SOIL ANALYTICAL RESULTS
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

Sample ID Sample Depth - Feet Sample Date	04MP0101 4-8 04/13/06	04MP0201 4-8 04/13/06	04MP0301 4-8 04/13/06
Volatile Organics (ug/kg)			
1,1-DICHLOROETHENE	5 U	5.6 U	6.6 U
1,2-DICHLOROETHANE	5 U	5.6 U	6.6 U
CARBON TETRACHLORIDE	5 U	5.6 U	6.6 U
CHLOROFORM	5 U	5.6 U	6.6 U
CHLOROMETHANE	0.55 U	0.45 U	0.74 U
CIS-1,2-DICHLOROETHENE	5 U	5.6 U	6.6 U
METHYLENE CHLORIDE	13 U	13 U	17 U
TETRACHLOROETHENE	5 U	5.6 U	6.6 U
TRANS-1,2-DICHLOROETHENE	5 U	5.6 U	6.6 U
TRICHLOROETHENE	5 U	5.6 U	6.6 U
VINYL CHLORIDE	5 U	5.6 U	6.6 U
Miscellaneous Parameters (mg/kg)			
TOTAL ORGANIC CARBON	2700	2600	5000

ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
U - Sample concentration less than value shown

TABLE 6
GROUNDWATER CVOC ANALYTICAL RESULTS
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

	RI SAMPLING	BASELINE SAMPLING	VERIFICATION SAMPLING	PERFORMANCE MONITORING	CONCENTRATION CHANGE
location		04MP01	04MP01	04MP01	
sample ID		04MP0101	04MP0102	04MP0103	
sample date		04/20/06	09/12/06	01/11/07	% decreased
CIS-1,2-DCE		1.6	72	0.73	99
TRANS-1,2-DCE		1.8	59	1.3	98
TCE		1 U	0.51	0.5	2
VINYL CHLORIDE		0.64 J	140	20	86
TOTAL CVOC			272	23	92
location			04MP01D	04MP01D	
sample ID			04MP01D01	04MP01D02	
sample date			09/12/06	01/11/07	% decreased
CIS-1,2-DCE			770	310	60
TRANS-1,2-DCE			340	100	71
TCE			94	8.5	91
VINYL CHLORIDE			210	96	54
TOTAL CVOC			1,414	515	64
location			04MP02D	04MP02D	
sample ID			04MP02D01	04MP02D02	
sample date			09/12/06	01/11/07	% decreased
CIS-1,2-DCE			620	91	85
TRANS-1,2-DCE			360	56	84
TCE			58	10	83
VINYL CHLORIDE			550	86	84
TOTAL CVOC			1,588	243	85
location		GPT-04-22		GPT-04-22	
sample ID		04MW2201		04MW2202	
sample date		04/20/06		1/11/2007	% decreased
CIS-1,2-DCE		470		220	53
TRANS-1,2-DCE		310		130	58
TCE		110		4.6	96
VINYL CHLORIDE		190		260	Increased 37 %
TOTAL CVOC		1,080		615	43
location	GPT-04-14	GPT-04-14			
sample ID	04GW1401	04GW1402			
sample date	09/22/04	04/11/06			% decreased
CIS-1,2-DCE	55	47			15
TRANS-1,2-DCE	30	22			27
TCE	0.8	0.55			31
VINYL CHLORIDE	25	14			44
TOTAL CVOC	111	84			25
location	GPT-04-16	GPT-04-16			
sample ID	04GW1601	04GW1602			
sample date	09/13/04	03/30/06			% decreased
CIS-1,2-DCE	280	170			39
TRANS-1,2-DCE	190	89			53
TCE	8	4.1			49
VINYL CHLORIDE	150	84			44
TOTAL CVOC	628	347			45

DCE - Dichloroethene
TCE - Trichloroethene
Concentrations in ug/L

TABLE 6
GROUNDWATER CVOC ANALYTICAL RESULTS
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CVOC - Chlorinated Volatile Organic Compounds

TABLE 7
CVOC MASS BALANCE
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

location	04MP01	Molar	Molar	04MP01	Molar	Molar	Change in
sample ID	04MP0102	Concentration	Fraction	04MP0103	Concentration	Fraction	Molar Fraction
sample date	09/12/06	(moles/liter)	(per cent)	01/11/07	(moles/liter)	(per cent)	(per cent)
CIS-1,2-DCE (ug/L)	72	7.42651E-07	21	0.73	7.52965E-09	3	-17
TRANS-1,2-DCE (ug/L)	59	6.08561E-07	17	1.3	1.3409E-08	6	-11
TCE (ug/L)	0.51	3.88157E-09	0.1	0.5	5.1573E-09	2	2
VINYL CHLORIDE (ug/L)	140	2.23964E-06	62	20	2.06292E-07	89	26
	Total	3.59474E-06		Total	2.32388E-07		

location	04MP01D	Molar	Molar	04MP01D	Molar	Molar	Change in
sample ID	04MP01D01	Concentration	Fraction	04MP01D02	Concentration	Fraction	Mole Fraction
sample date	09/12/06	(moles/liter)	(per cent)	01/11/07	(moles/liter)	(per cent)	(per cent)
CIS-1,2-DCE (ug/L)	770	7.94224E-06	51	310	3.19752E-06	55	4
TRANS-1,2-DCE (ug/L)	340	3.50696E-06	23	100	1.03146E-06	18	-5
TCE (ug/L)	94	7.15427E-07	5	8.5	6.46929E-08	1	-3
VINYL CHLORIDE (ug/L)	210	3.35946E-06	22	96	1.53575E-06	26	5
	Total	1.55241E-05		Total	5.82943E-06		

location	04MP02D	Molar	Molar	04MP02D	Molar	Molar	Change in
sample ID	04MP02D01	Concentration	Fraction	04MP02D02	Concentration	Fraction	Mole Fraction
sample date	09/12/06	(moles/liter)	(per cent)	01/11/07	(moles/liter)	(per cent)	(per cent)
CIS-1,2-DCE (ug/L)	620	6.39505E-06	33	91	9.38628E-07	32	-1
TRANS-1,2-DCE (ug/L)	360	3.71325E-06	19	56	5.77617E-07	19	0
TCE (ug/L)	58	4.41434E-07	2	10	7.61093E-08	3	0
VINYL CHLORIDE (ug/L)	550	8.79859E-06	45	86	1.37578E-06	46	1
	Total	1.93483E-05		Total	2.96813E-06		

location	GPT-04-22	Molar	Molar	GPT-04-22	Molar	Molar	Change in
sample ID	04MW2201	Concentration	Fraction	04MW2202	Concentration	Fraction	Mole Fraction
sample date	04/20/06	(moles/liter)	(per cent)	1/11/2007	(moles/liter)	(per cent)	(per cent)
CIS-1,2-DCE (ug/L)	470	4.84786E-06	41	220	2.26921E-06	29	-12
TRANS-1,2-DCE (ug/L)	310	3.19752E-06	27	130	1.3409E-06	17	-10
TCE (ug/L)	110	8.37202E-07	7	4.6	3.50103E-08	0.4	-7
VINYL CHLORIDE (ug/L)	190	3.03951E-06	25	260	4.15933E-06	53	28
	Total	1.19221E-05		Total	7.80445E-06		

Mass/Molar Conversion Factor	grams/mole	ug/mole
CIS-1,2-DICHLOROETHENE	96.95	96,950,000
TRANS-1,2-DICHLOROETHENE	96.95	96,950,000
TRICHLOROETHENE	131.39	131,390,000
VINYL CHLORIDE	62.51	62,510,000

TABLE 8
INDICATOR PARAMETERS
SITE 4 TREATABILITY STUDY
NCBC GULFPORT
GULFPORT, MISSISSIPPI

	In TS Cell		Downgradient of TS Cell		Sidegradient of TS Cell		Downgradient Plume Edge	
location	04MP01	GPT-04-22	04MP02		04MP03		GPT-04-16	
sample ID	04MP0101	04MW2202	04MP0201	04MP0203	04MP0301	04MP0303	04GW1601	04GW1602
sample date	04/20/06	01/12/07	04/20/06	01/12/07	04/20/06		9/13/04	03/30/06
sampling event	Baseline	Perf. Mon.	Baseline	Perf. Mon.	Baseline	Perf. Mon.	RI Sampling	Baseline
Inorganics (ug/L)								
IRON	23,200	11,900	1,720	485	9,440	3,610	48,000	38,600
IRON (Filtered)	20,400	6,260	1,200	289	5,120	700		6,890
Miscellaneous Parameters (mg/L)								
CHLORIDE	28.2	41.2	17.3	23.1	17.5	26.9	34	30.1
ORTHOPHOSPHATE-P	0.076	0.01 U	0.059	0.26	0.041	0.12		0.01 U
SULFATE	106	6.8	222	501	348	568	96	69.2
SULFIDE	0.75 U	5.4	1.3	2.1	0.8 J	2.7		0.75 U
TOTAL ORGANIC CARBON	45	520	25	19	35	28	31	31
Volatile Fatty Acids (mg/L)								
ACETIC ACID	0.667	410		0.12	0.125	1.9		0.11
BUTANOIC ACID	0.282	56		0.07 U	0.07 U	0.07 U		0.07 U
HEXANOIC ACID	0.1 U	6.4		0.1 U	0.1 U	0.1 U		0.10 U
LACTIC ACID	0.1 U	10 J		0.24 U	0.1 U	0.1 U		0.10 U
PENTANOIC ACID	0.07 U	42		0.07 U	0.07 U	0.07 U		0.07 U
PROPIONIC ACID	0.07 U	580		0.07 U	0.07 U	0.13		0.07 U
PYRUVIC ACID	0.07 U	7.3		0.07 U	0.07 U	0.07 U		0.07 U
Light Gases (ug/L)								
BUTANE	0.037	0.05 U	0.044	0.13	0.059	0.046		0.017 J
ETHANE	5.8	6.7	0.27	0.3	2.7	2.3	3.4	2.5
ETHENE	0.038	15	0.009 J	0.008 J	0.013	0.01 U	20	14
ISOBUTANE	0.022 J	0.05 U	0.022 J	0.044 J	0.037	0.022 J		0.014 J
METHANE	3,600	12,000	1,600	6,000	1,900	6,300	3,000	1,600
PROPANE	0.38	0.064	0.27	0.36	0.39	0.24		0.22
PROPYLENE	0.022 J	0.25	0.025 U	0.015 J	0.014 J	0.05 U		0.10
HYDROGEN (NM)	3.9	3	2.6	0.68	2.5	1.3	1.1	3.5

ug/L - micrograms per liter
mg/L - milligrams per liter
NM - Nano moles
ug/Perf. Mon. - Performance Monitoring
J - Estimated concentration
U - Sample concentration less tha value shown
Blank cells indicate sample not analyzed for that parameter

APPENDIX D

COVER ASSESSMENT

5492 MOISTURES

MOISTURE CONTENT DETERMINATION

JOB# 07-5492 JOB NAME TERRA TECH

TECHNICIAN jdh DATE 5-22-07

Qu	BORING	DEPTH	CAN#	WET WT	DRY WT.	%W	DESCRIPTION
	J1844		A	51.8	46.3	12.4	04 GT 0101
	J1845		B		48.1	8.0	04 GT 0201
	J1846		C		45.9	13.4	04 GT 0301
	J1847		D		48.1	8.0	04 GT 0401
	J1848		E		47.9	8.5	04 GT 0501
	J1849		F		48.4	7.3	04 GT 0601
	J1856		G		48.5	7.1	05 GT 0101
	J1857		H		48.1	8.0	05 GT 0201
	J1858		I		48.5	7.1	05 GT 0301
							(MOISTURES FROM
							JAR SAMPLES)

G81

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PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 07-5492
LAB ID: J1844
DATE: 05-23-07
TYPE SAMPLE: JAR
LOCATION: DHGT0101
TECHNICIAN: S. Brown
DRY WEIGHT: 265.1

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	5.6	5.6		
#10	3.8	9.4		

WASH OVER ANALYSIS

DRY WEIGHT: 100.2 DS

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	6.4			
#100	64.0			
#200	73.8			

A
X-S
QW

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	24	5	19
	30	28	18	5	13
	60	28	15	5	10
	120	27	15	5	10
	180	26	15	6	9
	1440	28	12	5	7

PHB

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GS2

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 07-5492
LAB ID: TT1645
DATE: 5-23-07
TYPE SAMPLE: JAR
LOCATION: 04GT0201
TECHNICIAN: S. BROWN
DRY WEIGHT: 237.8

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	3.0	3.0		
#10	2.3	5.3		

WASH OVER ANALYSIS

DRY WEIGHT: 100.9 D4

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	2.7			
#100	60.9			
#200	74.0			

*1
21
AB

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	24	5	19
	30		19	5	14
	60		17	5	12
	120		17	5	12
	180		16	5	11
	1440	28	14	5	9

TN

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GS3

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA-TECH
PROJ. NUMBER: 07-5492
LAB ID: 07846
DATE: 05-23-07
TYPE SAMPLE: JAR
LOCATION: 04GT0301
TECHNICIAN: S.BRAD
DRY WEIGHT: 298.2

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	8.1	8.1		
#10	9.9	18.0		

WASH OVER ANALYSIS

DRY WEIGHT: 100.8 C2

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	14.1			
#100	60.9			
#200	70.6			

X-1
2B
E

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	25	5	20
	30	28	17	5	12
	60	28	16	5	11
	120	27	15	5	10
	180	26	15	16	9
	1440	28	13	5	8

PJD

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GS4

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRATECH
PROJ. NUMBER: 07-5492
LAB ID: J1847
DATE: 05-23-07
TYPE SAMPLE: JAR
LOCATION: 04GT0401
TECHNICIAN: S. BROWN
DRY WEIGHT: 309.2

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	3.2	3.2		
#4	1.0	4.2		
#10	10.4	14.6		

WASH OVER ANALYSIS

DRY WEIGHT: 100.2 D1

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	2.4			
#100	13.6			
#200	73.4			

D14
L
MM

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	23	5	18
	30	28	20	5	15
	60	28	18	5	13
	120	27	17	5	12
	180	26	17	6	11
	1440	28	15	5	10

PJP

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615-350-8124

655

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 07-5492
LAB ID: J1848
DATE: 8-23-07
TYPE SAMPLE: JAR
LOCATION: 04GT0501
TECHNICIAN: B. Crouch
DRY WEIGHT: 368.9

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	13.6	13.6		
#10	13.7	27.3		

WASH OVER ANALYSIS

DRY WEIGHT: 100.0 D3

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	9.3			
#100	73.5			
#200	81.0			

AT
D1
C6

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	20	5	15
	30	28	13	5	8
	60	28	12	5	7
	120	27	12	5	7
	180	26	12	6	6
	1440	28	10	5	5

PJH

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656

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 07-52192
LAB ID: J1849
DATE: 5-23-07
TYPE SAMPLE: JAR
LOCATION: 04GT0601
TECHNICIAN: S. BROWN
DRY WEIGHT: 316.8

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	1.8	1.8		
#10	11.7	13.5		

WASH OVER ANALYSIS

DRY WEIGHT: 100.0 C1

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL	
#40	7.6				#6
#100	69.3				C1
#200	78.6				C2

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	20	5	15
	30	28	15	5	10
	60	28	14	5	9
	120	27	14	5	9
	180	26	14	6	8
	1440	28	11	5	6

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GS7

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 07-5492
LAB ID: J1896
DATE: 5-23-07
TYPE SAMPLE: JAR
LOCATION: 05GT0101
TECHNICIAN: S. BROWN
DRY WEIGHT: 379.3

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	19.4	19.4		
1/2"	18.6	38.0		
#4	53.8	91.8		
#10	23.5	115.3		

WASH OVER ANALYSIS

DRY WEIGHT: 100.0 C6

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	31.9			
#100	76.5			
#200	81.1			

D3
D5
M

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	20	5	15
	30	26	15	5	10
	60	28	14	5	9
	120	27	13	5	8
	180	26	13	6	7
	1440	28	11	5	6

PBB

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658

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA-TECH
PROJ. NUMBER: 07-5492
LAB ID: J1857
DATE: 05-23-07
TYPE SAMPLE: JAR
LOCATION: 05GT0201
TECHNICIAN: S. BROWN
DRY WEIGHT: 329.4

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	0	0		
1/2"	0	0		
#4	1.3	1.3		
#10	11.7	13.0		

WASH OVER ANALYSIS

DRY WEIGHT: 100.0 DZ

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	17.0			
#100	70.5			
#200	77.2			

AK
AR
C4

HYDROMETER ANALYSIS

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	21	5	16
	30		17	5	12
	60		15	5	10
	120		12	5	7
	180		12	5	7
	1440	28	11	5	6

PBD

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G59

PARTICLE SIZE ANALYSIS OF SOILS

ASTM D 422

PROJECT: TERRA TECH
PROJ. NUMBER: 075492
LAB ID: J1858
DATE: 5-23-07
TYPE SAMPLE: JAR
LOCATION: 05GT0301
TECHNICIAN: S. BROWN
DRY WEIGHT: 368.2

MECHANICAL ANALYSIS

SIEVE SIZE	INDIVIDUAL WEIGHT	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT PASSING
1"	0	0		
3/4"	15.0	15.0		
1/2"	0	15.0		
#4	25.3	40.3		
#10	37.6	77.6		

WASH OVER ANALYSIS

DRY WEIGHT: 100.0 C3

SIEVE SIZE	CUMMULATIVE WEIGHT	PERCENT RETAINED	PERCENT (-) #10	PERCENT TOTAL
#40	20.5			
#100	75.5			
#200	79.7			

QE
XM
*3

HYDROMETER ANALYSIS

F

TIME OF DAY STARTED	MINUTES SINCE START	TEMP CENT.	HYDROMETER ORIG.	HYDROMETER CORR.	HYDROMETER FINAL
	5	28	18	5	13
	30		13	5	8
	60		12	5	7
	120		11	5	6
	180		11	5	6
	1440	28	9	5	4

PJB

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

P1

DATE 5-24-07

CLIENT ELAB ST1850 PROJ NO. 07-5492

PROJECT TERRATECH FACILITY I.D.

LOCATION OF SAMPLE 04ST0601 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND GR BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.469 , 7.492 , 7.411 = 7.457 MOISTURE 7.3 pcf:

LENGTH: 7.824 , 7.865 , 7.831 = 7.840

WEIGHT: 573.5

MOISTURE	
TARE NO	1850
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.4
WATER	3.4
TARE WEIGHT	1.8
DRY SOIL	46.6
WATER %	7.3

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	1:45	10	15	14.5	9.2			
	2:00	20	25	14.8	10.2			
	2:10	30	35	15.2	12.2			
	2:20	40	45	16.0	13.0			
	2:35	50	55	16.3	13.8			
	2:45	60	65	16.5	14.0	601		
	2:55	70	75	16.9	15.1	/699		B = 98
	3:05	80	85	17.1	15.2			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: 97850

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	9.0	30.4	
	0:10	10s			11.9	27.5	2.9 - 2.9
	0:20	10s			14.3	25.1	2.4 - 2.4
	0:30	10s			16.8	22.6	2.5 - 2.5
	0:40	10s			19.4	20.0	2.6 - 2.6
	0:50	10s			22.1	17.3	2.7 - 2.7
	1:00	10s			24.6	14.8	2.5 - 2.5
	1:10	10s			26.2	12.2	2.6 - 2.6
	1:20	10s			28.8	9.6	2.6 - 2.6

Done

middlecell

P2

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 5-24-07

CLIENT ELAB ST 1851 PROJ NO. 07-5492

PROJECT TERRATECH FACILITY I.D.

LOCATION OF SAMPLE 04 ST 0501 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND DK GR BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.215 / 7.219 / 7.234 = 7.223 MOISTURE 8.5 pcf:

LENGTH: 6.951 / 6.913 / 6.946 = 6.937

WEIGHT: 544.0

MOISTURE	
TARE NO	1851
TARE+WET SOIL	51.8
TARE+DRY SOIL	47.9
WATER	3.9
TARE WEIGHT	1.8
DRY SOIL	46.1
WATER %	8.45

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	12:30	10	15	9.6	10.4			
	12:40	20	25	10.4	12.2			
	1:10	30	35	15.6	13.8			
	2:00	40	45	17.1	15.8			
	2:10	50	55	18.5	17.0			
	2:30	60	65	18.9	17.4	601 /		
	2:45	70	75	19.5	18.0	/	701	B=100
	3:10	80	85	19.7	18.2			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: ST 1851

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
5-25	0:00	83	80	85	10.0	30.2	
	0:10	10s			12.8	27.4	2.8 - 2.8
	0:20	10s			15.5	24.7	2.7 - 2.7
	0:30	10s			18.0	22.2	2.5 - 2.5
	0:40	10s			20.5	19.7	2.5 - 2.5
	0:50	10s			23.0	17.2	2.5 - 2.5
	1:00	10s			25.6	14.6	2.6 - 2.6
	1:10	10s			28.1	12.1	2.5 - 2.5
	1:20	10s			30.7	9.5	2.6 - 2.6

Done

Middle

P3

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 5-23-07

CLIENT ECAB ST 1852 PROJ NO. 07-5492

PROJECT TERRATECH FACILITY I.D.

LOCATION OF SAMPLE 04ST0401 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND DK YEL BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.370 / 7.370 / 7.354 = 7.365 MOISTURE 8.0 pcf:

LENGTH: 5.422 / 5.247 / 5.292 = 5.320

WEIGHT: 428.3

MOISTURE	
TARE NO	1852
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.1
WATER	3.7
TARE WEIGHT	1.8
DRY SOIL	46.3
WATER %	8.0

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	12:30	10	15	6.0	4.2			
	12:40	20	25	7.8	7.3			
	12:45	30	35	8.4	9.1			
	12:50	40	45	9.3	9.5			
	1:00	50	55	12.5	13.1			
	1:05	60	65	13.9	14.2	604		
	1:15	70	75	14.5	14.9	/702		B=98
	1:25	80	85	15.9	16.3			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: 57852

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	2.5	32.6	
	0:20	20s			6.2	28.9	3.7 - 3.7
	0:40	20s			9.9	25.2	3.7 - 3.7
	1:00	20s			13.6	21.5	3.7 - 3.7
	1:20				17.3	17.8	3.7 - 3.7 (1)
	1:40				21.1	13.9	3.8 - 3.9 (2)
	2:00				24.9	10.2	3.8 - 3.7 (3)
	2:20				28.6	6.5	3.7 - 3.7 (4)
	2:40	10s			32.4	2.7	3.8 - 3.7

Done 5

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PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

P4

DATE 5-29-07
CLIENT ELAB ST 1853 PROJ NO. 07-5492
PROJECT TERRA TECH FACILITY I.D.
LOCATION OF SAMPLE 04ST0301 DEPTH
SHELBY TUBE OR REMOLDED
SOIL TYPE & COLOR SAND DK GRAY BROWN ODOR? NO fill?
DESCRIPTION
ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.277 / 7.314 / 7.160 = 7.250 MOISTURE 8.0 pcf:

LENGTH: 6.975 / 7.011 / 7.040 = 7.009

WEIGHT: 531.2

MOISTURE	
TARE NO	1853
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.1
WATER	3.7
TARE WEIGHT	1.8
DRY SOIL	46.3
WATER %	8.0

TOTAL BACKPRESSURE 80
MAX CONSOLID STRESS
MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	1:25	10	15	7.1	6.9			
	1:30	20	25	8.6	7.4			
	1:42	30	35	11.2	10.3			
	1:51	40	45	12.2	12.4			
	2:10	50	55	12.9	12.5			
	2:25	60	65	15.1	14.5	599/601		
	2:35	70	75	15.4	15.0			B=102
	2:45	80	85	16.2	15.4			

UA-5

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: ST 8553

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	10.0	32.4	
	0:05	5s			12.8	29.6	2.8 - 2.8
	0:10	5s			15.6	26.8	2.8 - 2.8
	0:15	5s			18.4	24.0	2.8 - 2.8
	0:20	5s			21.2	21.2	2.8 - 2.8
	0:25	5s			24.0	18.4	2.8 - 2.8
	0:30	5s			26.8	15.6	2.8 - 2.8

Done

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PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

P5

middle COP

DATE 5-23

CLIENT ST 1854 PROJ NO. 07-5492

PROJECT TERRATECH FACILITY I.D.

LOCATION OF SAMPLE 04ST0201 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND DK YEL BR ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.227 , 7.243 , 7.216 = 7.229 MOISTURE 8.0 pcf:

LENGTH: 6.136 , 6.148 , 6.194 = 6.159

WEIGHT: 472.0

MOISTURE	
TARE NO	1854
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.1
WATER	3.7
TARE WEIGHT	1.8
DRY SOIL	46.3
WATER %	8.0

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
		10	15	13.5	12.9			
		20	25	14.0	13.1			
		30	35	14.5	13.3			
		40	45	18.1	14.0			
		50	55	19.9	14.8			
		60	65	21.0	16.1	601		
		70	75	23.4	18.2	/703		B=102
		80	85	24.1	19.1			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D. ST 1854

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00			0	9.8	28.0	
	0:15	15s			11.2	26.6	1.4 - 1.4
	0:30	15s			13.3	24.5	2.1 - 2.1
	0:45	15s			15.2	22.6	1.9 - 1.9
	1:00	15s			16.8	20.9	1.6 - 1.7
	1:15	15s			18.5	19.2	1.7 - 1.7
	1:30	15s			20.2	17.5	1.7 - 1.7
	1:45	15s			21.9	15.8	1.7 - 1.7

DONE

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BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

P6

DATE 5-24-07

CLIENT ELAB ST 1855 PROJ NO. 07-5492

PROJECT TERRA TECH FACILITY I.D.

LOCATION OF SAMPLE 04 ST0101 DEPTH

SHELBY TUBE OR REMOLDED

SOIL TYPE & COLOR DARK BROWN SAND ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.461 , 7.398 , 7.412 = 7.424 MOISTURE 12.4 pcf:

LENGTH: 6.812 , 6.846 , 6.861 = 6.840

WEIGHT: 513.0

MOISTURE	
TARE NO	1855
TARE+WET SOIL	51.8
TARE+DRY SOIL	46.3
WATER	5.5
TARE WEIGHT	1.8
DRY SOIL	44.5
WATER %	12.36

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL cell	PORE METER	CALCULATE B VALUE
5-24	12:00	10	15	2.3	2.8	3.1		
	12:10	20	25	2.6	3.0	4.9		
	12:30	30	35	2.6	7.4	5.8		
	12:40	40	45	2.7	8.1	6.3		
	1:10	50	55	3.2	11.1	7.8		
	2:00	60	65	3.3	11.8	7.9	600/	
	2:30	70	75	3.9	12.2	8.1	/701	B=101
	2:45	80	85	4.3	12.5	8.3		

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D. 5T1855

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	2.5	23.5	
	0:20	20s			5.0	21.0	2.5 - 2.5
	0:40	20s			7.6	18.5	2.6 - 2.5
	1:00	20s			10.2	15.9	2.6 - 2.6
	1:20	20s			12.7	13.4	2.5 - 2.5
	1:40	20s			15.2	10.9	2.5 - 2.5
	2:00	20s			17.8	8.3	2.6 - 2.6

Done

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BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 5-29-07

CLIENT ELAB ST 1859 PROJ NO. 07-5492 P7

PROJECT TERRA TECH FACILITY I.D.

LOCATION OF SAMPLE 05 ST 0101 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND DK YEL BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL.

DIAMETER: 7.376 , 7.383 , 7.352 = 7.370 MOISTURE 7.1 pcf:

LENGTH: 6.534 , 6.558 , 6.637 = 6.576

WEIGHT: 540.4

MOISTURE	
TARE NO	1859
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.5
WATER	3.3
TARE WEIGHT	1.8
DRY SOIL	46.7
WATER %	7.1

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	11:00	10	15	8.5	9.5			
	11:10	20	25	9.0	10.2			
	11:23	30	35	12.3	12.0			
	12:06	40	45	12.9	12.8			
	12:10	50	55	13.2	12.9	502/		
	12:30	60	65	13.7	13.2	/603		B=.107
	12:35	70	75	14.0	14.1			
	12:40	80	85	14.1	14.1			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: ST1859

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES	
	0:00	83	80	85	10.0	39.5		
	0:05	5s			12.8	40.7	2.8 - 2.8	
	0:10	5s			15.8	33.7	3.0 - 3.0	1
	0:15	5s			18.8	30.7	3.0 - 3.0	2
	0:20	5s			21.7	27.7	2.9 - 3.0	3
	0:25	5s			24.7	24.7	3.0 - 3.0	4

Done

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BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 5-25-07

CLIENT ELAB ST 1860 PROJ NO. 07-5492

PROJECT TERRATECH FACILITY I.D.

LOCATION OF SAMPLE 05 ST0201 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND GR BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.146 / 7.241 / 7.215 = 7.201 MOISTURE 8.0 pcf:

LENGTH: 7.420 / 7.454 / 7.461 = 7.445

WEIGHT: 570.0

MOISTURE	
TARE NO	1860
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.1
WATER	3.7
TARE WEIGHT	1.8
DRY SOIL	46.3
WATER %	8.0

TOTAL BACKPRESSURE 80

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	12:00	10	15	7.0	10.3			
	12:10	20	25	7.4	10.7			
	12:20	30	35	14.2	13.3			
	12:30	40	45	17.2	16.1			
	12:40	50	55	18.0	16.5			
	12:45	60	65	18.7	18.5	598		
	12:50	70	75	19.3	19.0	/	697	B=99
	1:00	80	85	20.1	20.0			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: ST 1860

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	10.0	32.3	
	0:10	105			14.0	28.3	4.0-4.0
	0:20	105			18.0	24.3	4.0-4.0
	0:30				22.1	20.2	4.1-4.0
	0:40				26.2	16.2	4.1-4.1
	0:50				30.2	12.1	4.0-4.1
	1:00	105			34.2	8.1	4.0-4.0

Done

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BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 5-23-07

CLIENT ELAB ST 1861 PROJ NO. 07-5492

PROJECT TERRA TECH FACILITY I.D.

LOCATION OF SAMPLE 05ST 0301 DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR SAND DK GRAY BRN ODOR? NO fill?

DESCRIPTION

ANY PEBBLES OR OTHER MATERIALS? SOME GRAVEL

DIAMETER: 7.458 , 7.464 , 7.431 = 7.451 MOISTURE 7.1 pcf:

LENGTH: 6.919 , 6.917 , 6.934 = 6.923

WEIGHT: 605.1

MOISTURE	
TARE NO	1861
TARE+WET SOIL	51.8
TARE+DRY SOIL	48.5
WATER	3.3
TARE WEIGHT	1.8
DRY SOIL	46.7
WATER %	7.1

TOTAL BACKPRESSURE

MAX CONSOLID STRESS

MIN CONS STRESS

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
5-23-07		10	15	4.6	3.2			
		20	25	5.2	3.6			
		30	35	5.9	4.2			
		40	45	6.8	5.8			
		50	55	7.4	7.3			
		60	65	8.2	8.1	604		
		70	75	10.1	10.1	/	703	B=99
		80	85	11.9	11.8			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: S184

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	3.8	29.6	
	0:20	20s			5.8	27.6	2.0 - 2.0
	0:40	20s			7.8	25.6	2.0 - 2.0
	1:00	20s			9.8	23.6	2.0 - 2.0
	1:20	20s			11.8	21.6	2.0 - 2.0
	1:40	20s			13.8	19.6	2.0 - 2.0
	2:00	20s			15.8	17.6	2.0 - 2.0
	2:20	20s			17.8	15.6	2.0 - 2.0

Done

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BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD
NASHVILLE, TN 37209
615-350-8124
e-mail: DATA@BEAVERENGINEERING.COM

DETERMINATION OF PHYSICAL PROPERTIES OF SOILS

PROJECT: **TERRA TECH** DATE: **MAY 31, 2007**

PROJECT #: **07-5492**

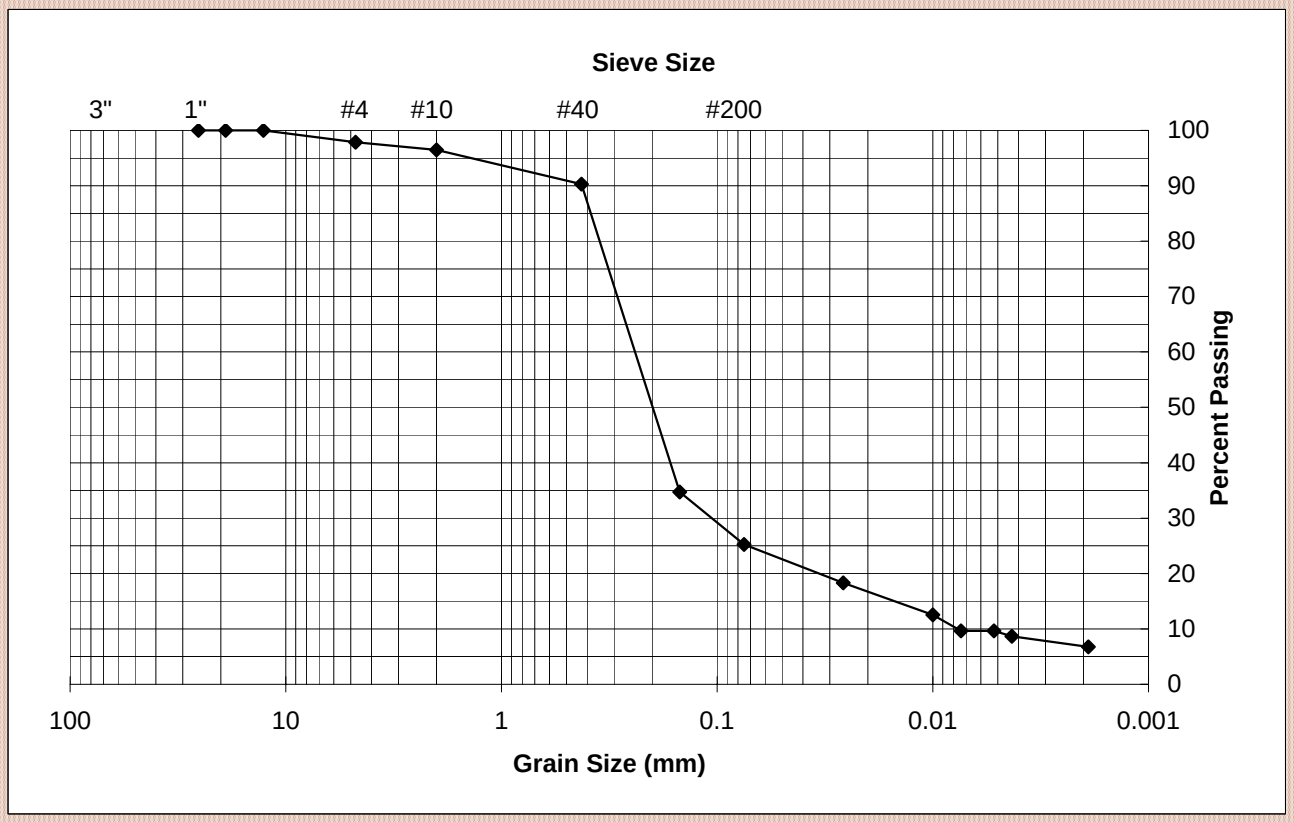
DETERMINATION OF SOIL MOISTURE

ASTM D2216

SAMPLE IDENTIFICATION AND TEST RESULTS

LOCATION	LAB ID	MOISTURE AS % OF OVEN DRIED MASS
04GT0101	J 1844	**12.4** %
04GT0201	J 1845	**8.0** %
04GT0301	J 1846	**13.4** %
04GT0401	J 1847	**8.0** %
04GT0501	J 1848	**8.5** %
04GT0601	J 1849	**7.3** %
05GT0101	J 1856	**7.1** %
05GT0201	J 1857	**8.0** %
05GT0301	J 1858	**7.1** %

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

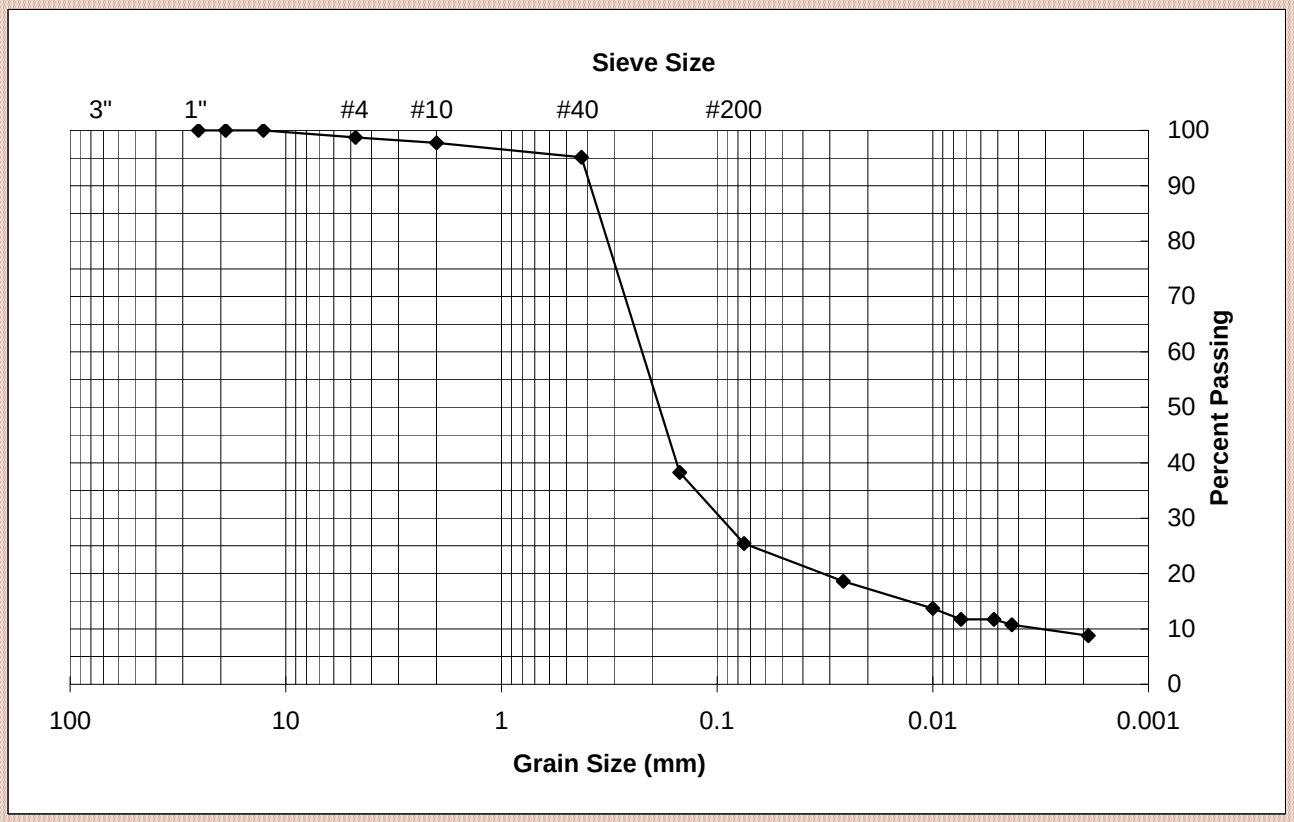
SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0101	100	100	100	98	96	90	35	25	18	13	10	10	9	7
	2%			**73%**				**16%**				**10%**		
LAB ID J 1844	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0201	100	100	100	99	98	95	38	25	19	14	12	12	11	9
	1%			**73%**				**14%**				**12%**		
LAB ID J 1845	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

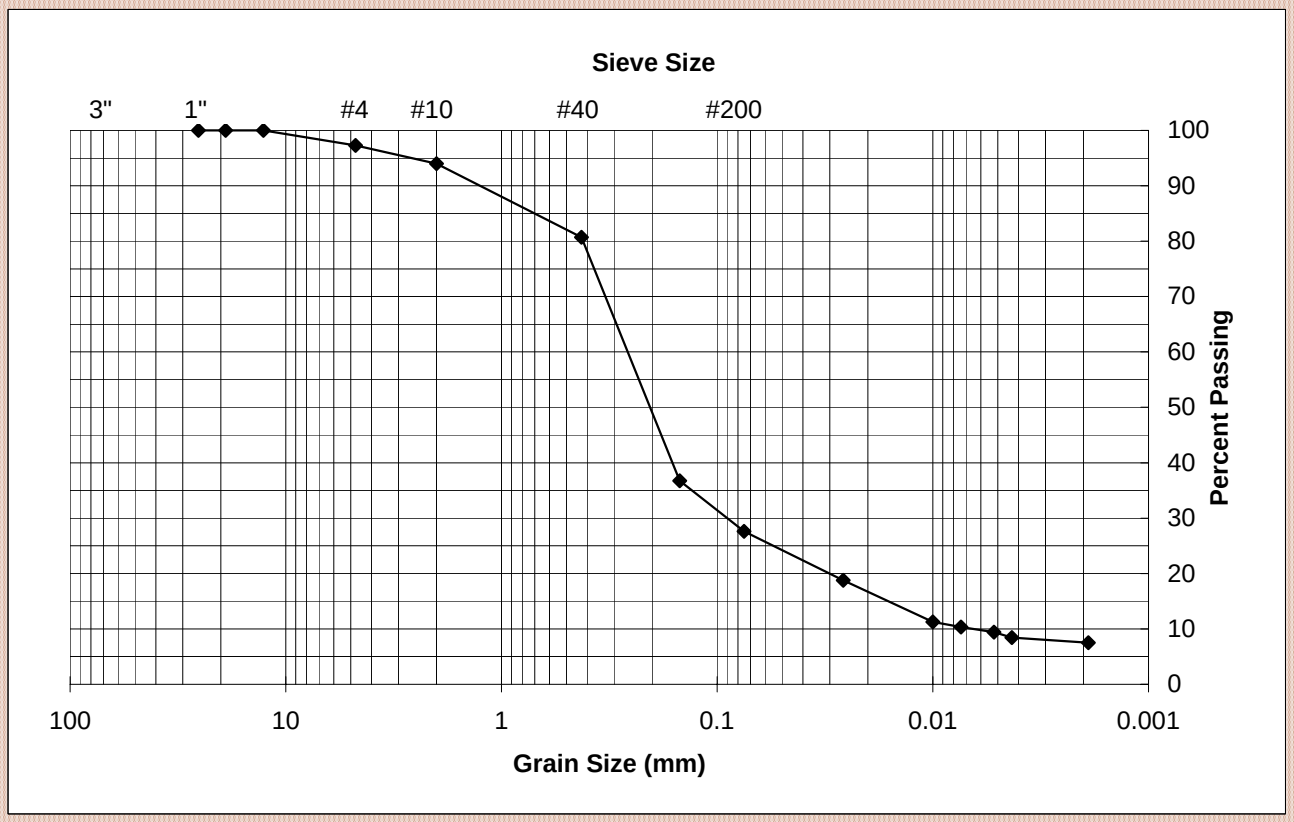
BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0301	100	100	100	97	94	81	37	28	19	11	10	9	8	8
	3%			**70%**				**18%**				**9%**		
LAB ID J 1846	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

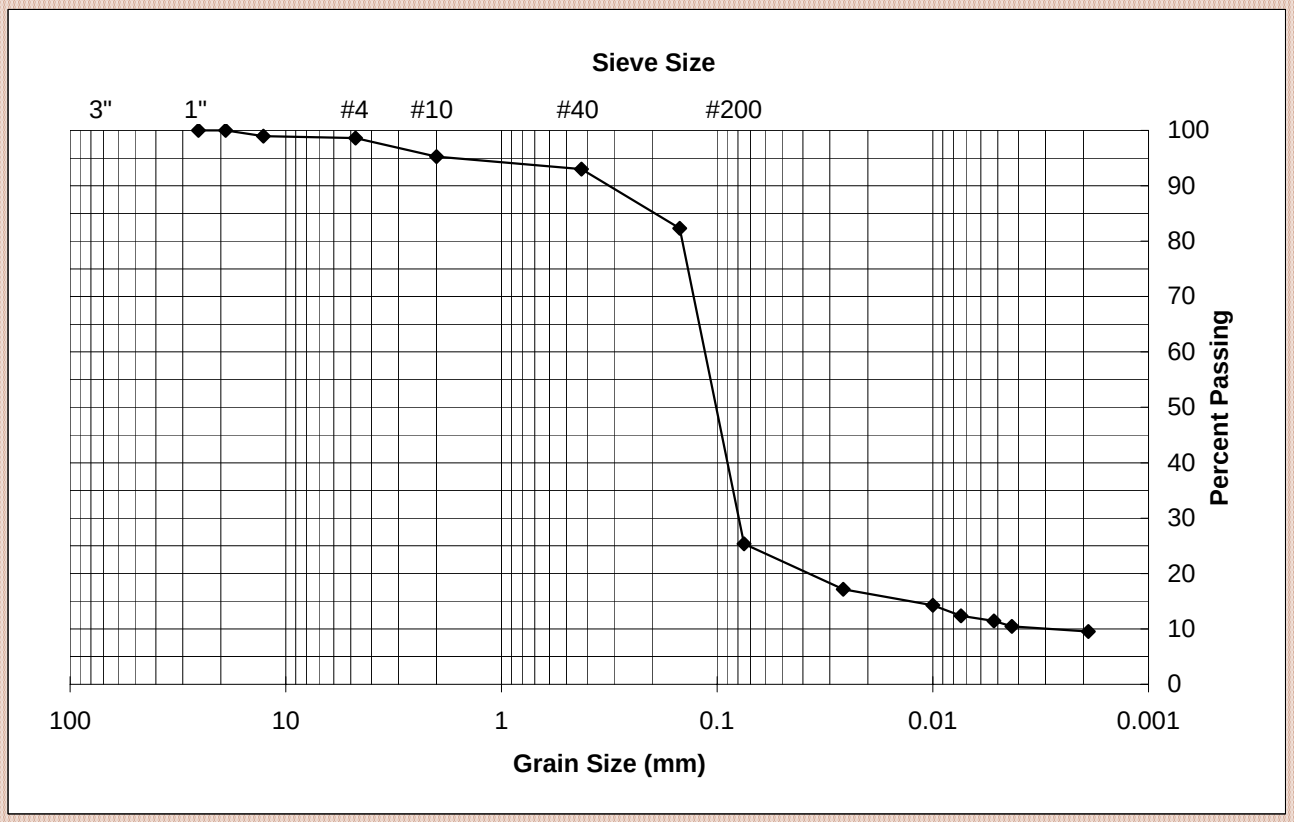
BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0401	100	100	99	99	95	93	82	25	17	14	12	11	10	10
	1%			**73%**				**14%**				**11%**		
LAB ID J 1847	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

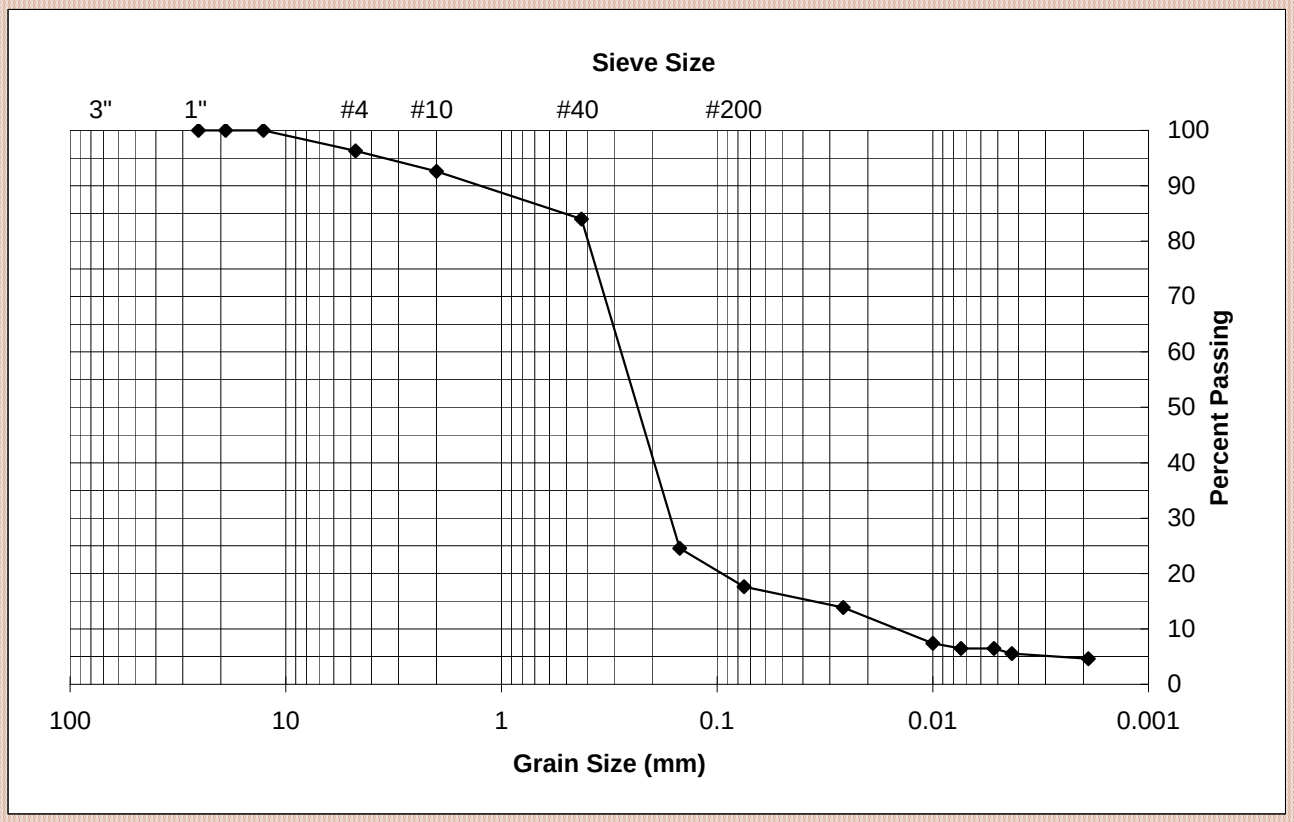
BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0501	100	100	100	96	93	84	25	18	14	7	6	6	6	5
	4%			**79%**				**11%**				**6%**		
LAB ID J 1848	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

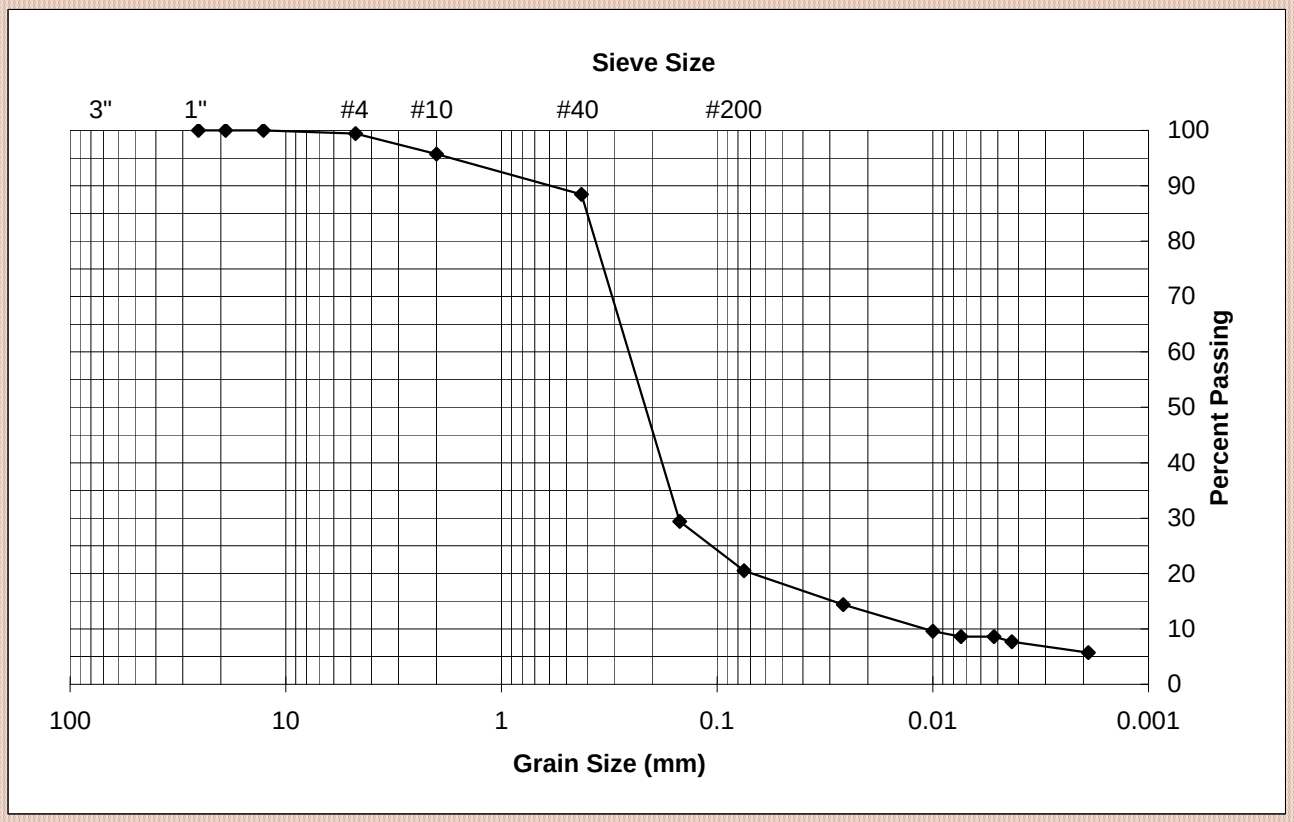
BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
04GT0601	100	100	100	99	96	88	29	20	14	10	9	9	8	6
	1%			**79%**				**12%**				**9%**		
LAB ID J 1849	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

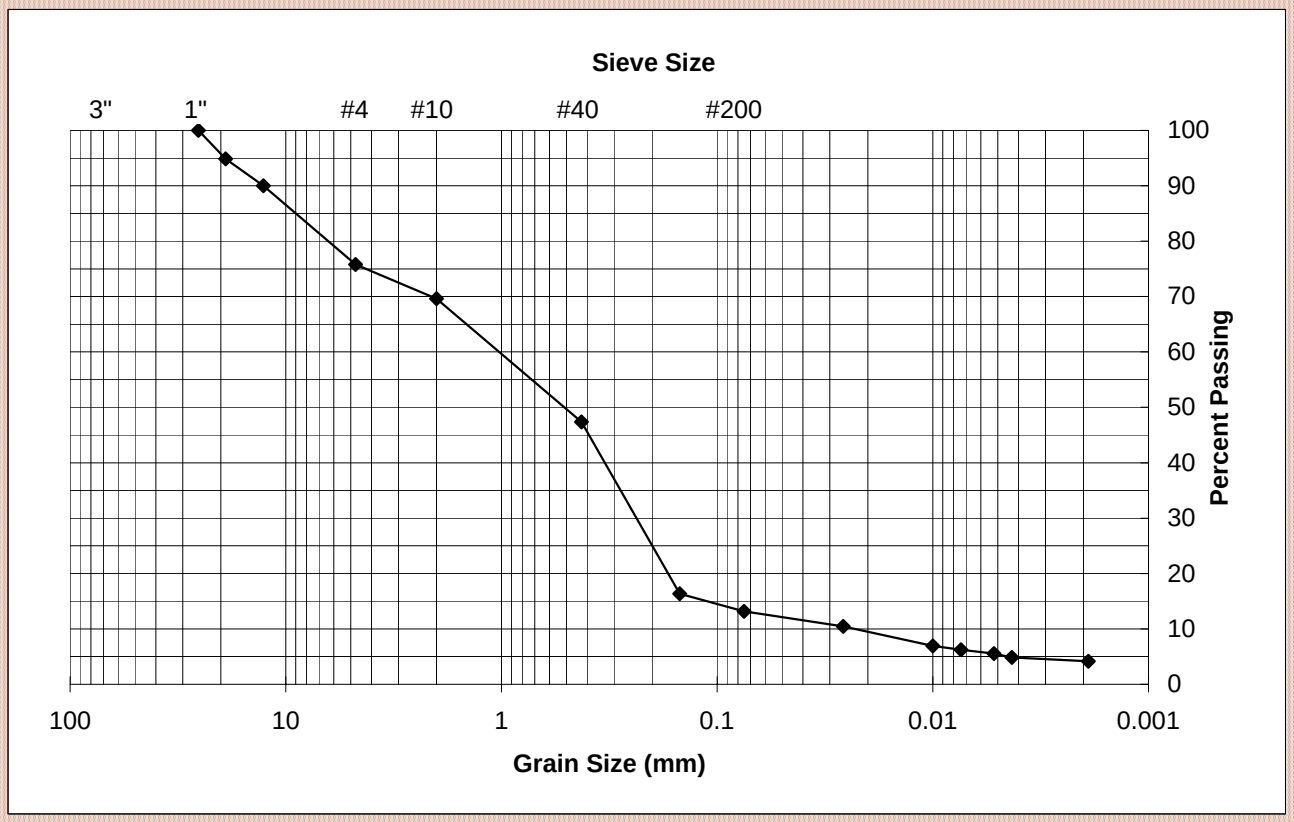
BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

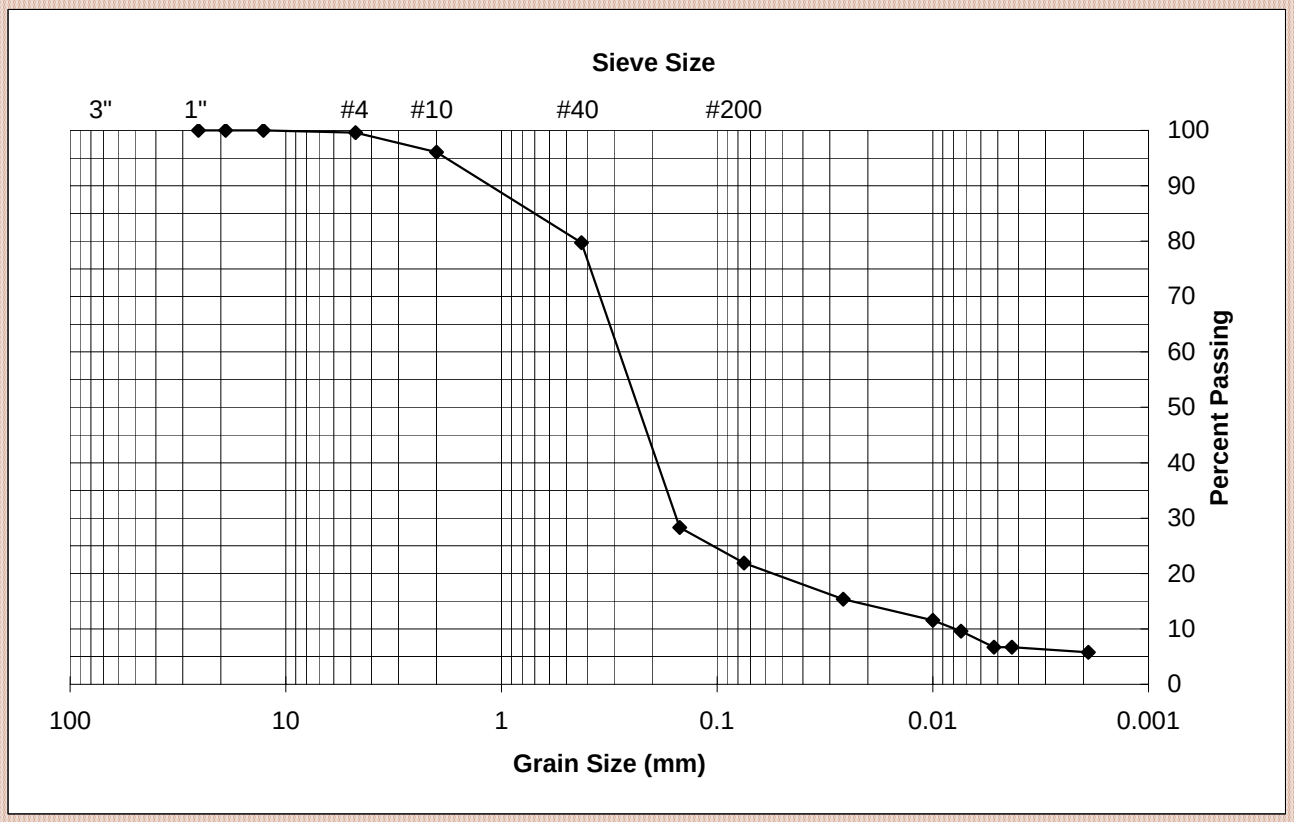
SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
05GT0101	100	95	90	76	70	47	16	13	10	7	6	6	5	4
	24%			**63%**				**8%**				**6%**		
LAB ID J 1856	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

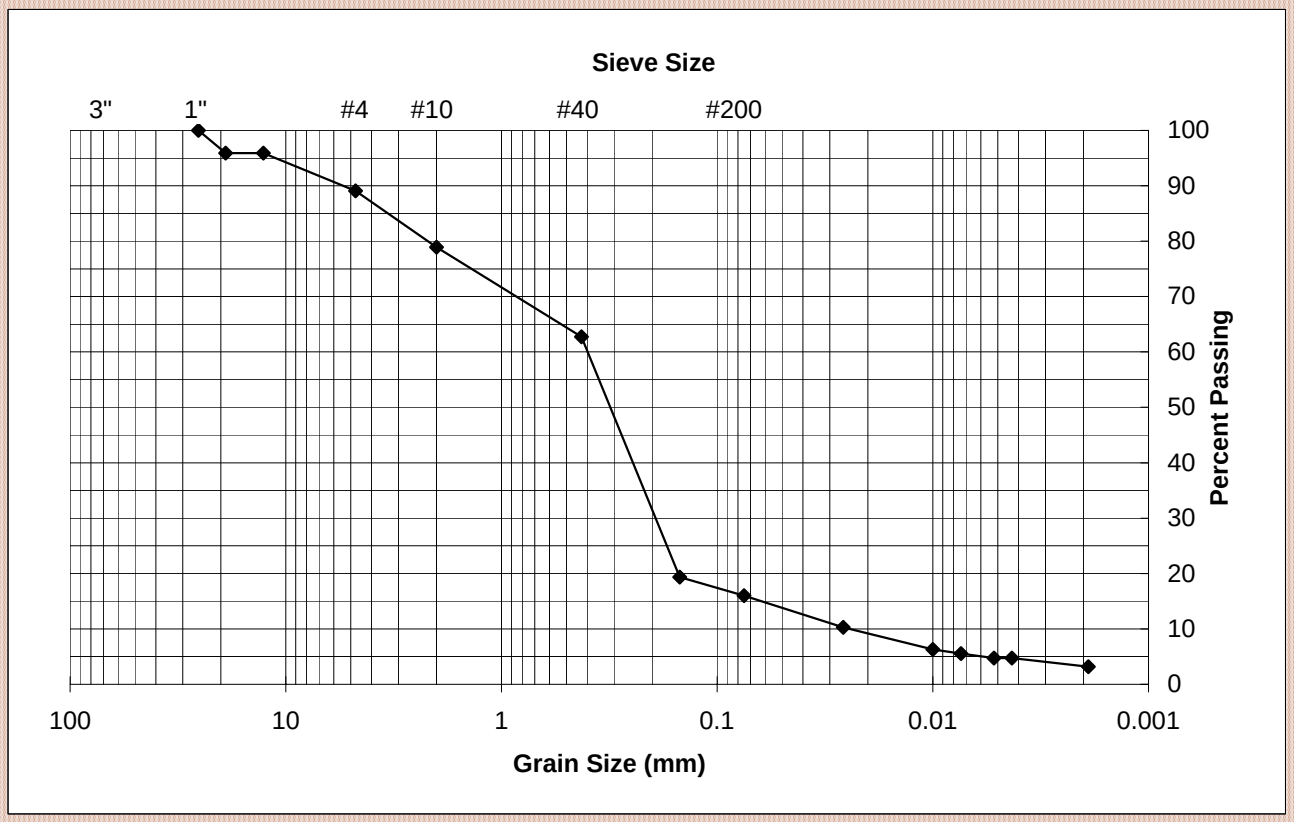
SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
05GT0201	100	100	100	100	96	80	28	22	15	12	10	7	7	6
	0%			**78%**				**15%**				**7%**		
LAB ID J 1857	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

GRAIN SIZE DISTRIBUTION REPORT
ASTM D 422



PERCENT PASSING

SAMPLE ID	Seive Sizes for Mechanical Analysis								Diameters for Hydrometer Analysis (mm)					
	1.0(in)	0.75(in)	0.50(in)	#4	#10	#40	#100	#200	0.026	0.01	0.0074	0.0052	0.0043	0.0019
05GT0301	100	96	96	89	79	63	19	16	10	6	6	5	5	3
	11%			**73%**				**11%**				**5%**		
LAB ID J 1858	**GRAVEL**			**SAND**				**SILT**				**CLAY**		

BEAVER ENGINEERING

PROJECT: **TERRA TECH**

PROJECT NUMBER: **07-5492**

DATE: **MAY 31, 2007**

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0601**		
DESCRIPTION	**SAND, GREYISH BROWN**		
LAB ID	**ST 1850**		
TYPE SAMPLE	**SHELBY TUBE**		
SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	7.9 cm	TEST DATE	5/31/2007
WEIGHT	573.5 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	43.69 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	7.3%	HEAD PRESSURE	83 psi
DENSITY	97.0 pcf	CONSOLIDATION STRESS:	
	1.55 g/cu cm	MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	10	10	10	10
INITIAL READING,influent liquid		19.4	22.1	24.6	26.2
INITIAL READING,effluent liquid		20.0	17.3	14.8	12.2
END READING, influent liquid		22.1	24.6	26.2	28.8
END READING, effluent liquid		17.3	14.8	12.2	9.6
TOTAL CUBIC CENTIMETERS	Q=	2.7	2.5	1.6	2.6
LENGTH OF SAMPLE	L=	7.9	7.9	7.9	7.9
LOSS OF HEAD	H=	208.8	203.6	198.5	194.3
CROSS SECTIONAL AREA	A=	43.69	43.69	43.69	43.69
EQUATION, K = QL/AHT	K=	**2.3E-04**	**2.2E-04**	**1.5E-04**	**2.4E-04**

2.1E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0501**				
DESCRIPTION	**SAND, DARK GREYISH BROWN**				
LAB ID	**ST 1851**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	6.9	cm	TEST DATE	5/31/2007	
WEIGHT	544.0	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	40.99	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	8.5%		HEAD PRESSURE	83	psi
DENSITY	110.1	pcf	CONSOLIDATION STRESS:		
	1.76	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	10	10	10	10
INITIAL READING,influent liquid		18.0	20.5	23.0	25.6
INITIAL READING,effluent liquid		22.2	19.7	17.2	14.6
END READING, influent liquid		20.5	23.0	25.6	28.1
END READING, effluent liquid		19.7	17.2	14.6	12.1
TOTAL CUBIC CENTIMETERS	Q=	2.5	2.5	2.6	2.5
LENGTH OF SAMPLE	L=	6.9	6.9	6.9	6.9
LOSS OF HEAD	H=	212.6	207.6	202.5	197.4
CROSS SECTIONAL AREA	A=	40.99	40.99	40.99	40.99
EQUATION, K = QL/AHT	K=	**2.0E-04**	**2.0E-04**	**2.2E-04**	**2.1E-04**

2.1E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0401**				
DESCRIPTION	**SAND, DARK YELLOWISH BROWN**				
LAB ID	**ST 1852**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	5.3	cm	TEST DATE	5/31/2007	
WEIGHT	428.3	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	42.62	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	8.0%		HEAD PRESSURE	83	psi
DENSITY	109.2	pcf	CONSOLIDATION STRESS:		
	1.75	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	20	20	20	20
INITIAL READING,influent liquid		13.6	17.3	21.1	24.9
INITIAL READING,effluent liquid		21.5	17.8	13.9	10.2
END READING, influent liquid		17.3	21.1	24.9	28.6
END READING, effluent liquid		17.8	13.9	10.2	2.7
TOTAL CUBIC CENTIMETERS	Q=	3.7	3.8	3.8	3.7
LENGTH OF SAMPLE	L=	5.3	5.3	5.3	5.3
LOSS OF HEAD	H=	215.1	207.5	200.0	188.7
CROSS SECTIONAL AREA	A=	42.62	42.62	42.62	42.62
EQUATION, K = QL/AHT	K=	**1.1E-04**	**1.1E-04**	**1.2E-04**	**1.2E-04**

1.2E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0301**				
DESCRIPTION	**SAND, DARK GREYISH BROWN**				
LAB ID	**ST 1853**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	7.0	cm	TEST DATE	5/31/2007	
WEIGHT	531.2	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	41.30	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	8.0%		HEAD PRESSURE	83	psi
DENSITY	106.1	pcf	CONSOLIDATION STRESS:		
	1.70	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	5	5	5	5
INITIAL READING,influent liquid		15.6	18.4	21.2	24.0
INITIAL READING,effluent liquid		26.8	24.0	21.2	18.4
END READING, influent liquid		18.4	21.2	24.0	26.8
END READING, effluent liquid		24.0	21.2	18.4	15.6
TOTAL CUBIC CENTIMETERS	Q=	2.8	2.8	2.8	2.8
LENGTH OF SAMPLE	L=	7.0	7.0	7.0	7.0
LOSS OF HEAD	H=	219.3	213.7	208.1	202.5
CROSS SECTIONAL AREA	A=	41.30	41.30	41.30	41.30
EQUATION, K = QL/AHT	K=	**4.3E-04**	**4.4E-04**	**4.6E-04**	**4.7E-04**

4.5E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0201**				
DESCRIPTION	**SAND, DARK YELLOWISH BROWN**				
LAB ID	**ST 1854**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	6.2	cm	TEST DATE	5/31/2007	
WEIGHT	472.0	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	41.06	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	8.0%		HEAD PRESSURE	83	psi
DENSITY	107.9	pcf	CONSOLIDATION STRESS:		
	1.73	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	15	15	15	15
INITIAL READING,influent liquid		15.2	16.8	18.5	20.2
INITIAL READING,effluent liquid		22.6	20.9	19.2	17.5
END READING, influent liquid		16.8	18.5	20.2	21.9
END READING, effluent liquid		20.9	19.2	17.5	15.8
TOTAL CUBIC CENTIMETERS	Q=	1.6	1.7	1.7	1.7
LENGTH OF SAMPLE	L=	6.2	6.2	6.2	6.2
LOSS OF HEAD	H=	216.6	213.3	209.9	206.5
CROSS SECTIONAL AREA	A=	41.06	41.06	41.06	41.06
EQUATION, K = QL/AHT	K=	**7.4E-05**	**8.0E-05**	**8.1E-05**	**8.2E-05**

7.9E-05 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**04ST0101**				
DESCRIPTION	**SAND, DARK BROWN**				
LAB ID	**ST 1855**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	6.8	cm	TEST DATE	5/31/2007	
WEIGHT	513.0	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	43.30	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	12.4%		HEAD PRESSURE	83	psi
DENSITY	96.2	pcf	CONSOLIDATION STRESS:		
	1.54	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	20	20	20	20
INITIAL READING,influent liquid		7.6	10.2	12.7	15.2
INITIAL READING,effluent liquid		18.5	15.9	13.4	10.9
END READING, influent liquid		10.2	12.7	15.2	17.8
END READING, effluent liquid		15.9	13.4	10.9	8.3
TOTAL CUBIC CENTIMETERS	Q=	2.6	2.5	2.5	2.6
LENGTH OF SAMPLE	L=	6.8	6.8	6.8	6.8
LOSS OF HEAD	H=	219.2	214.1	209.1	204.0
CROSS SECTIONAL AREA	A=	43.30	43.30	43.30	43.30
EQUATION, K = QL/AHT	K=	**9.4E-05**	**9.2E-05**	**9.4E-05**	**1.0E-04**

9.5E-05 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**05ST0101**		
DESCRIPTION	**SAND, DARK YELLOWISH BROWN**		
LAB ID	**ST 1859**		
TYPE SAMPLE	**SHELBY TUBE**		
SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.6 cm	TEST DATE	5/31/2007
WEIGHT	540.4 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	42.68 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	7.1%	HEAD PRESSURE	83 psi
DENSITY	112.2 pcf	CONSOLIDATION STRESS:	
	1.80 g/cu cm	MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	5	5	5	5
INITIAL READING,influent liquid		12.8	15.8	18.8	21.7
INITIAL READING,effluent liquid		36.7	33.7	30.7	27.7
END READING, influent liquid		15.8	18.8	21.7	24.7
END READING, effluent liquid		33.7	30.7	27.7	24.7
TOTAL CUBIC CENTIMETERS	Q=	3.0	3.0	2.9	3.0
LENGTH OF SAMPLE	L=	6.6	6.6	6.6	6.6
LOSS OF HEAD	H=	231.8	225.8	219.8	213.9
CROSS SECTIONAL AREA	A=	42.68	42.68	42.68	42.68
EQUATION, K = QL/AHT	K=	**4.0E-04**	**4.1E-04**	**4.1E-04**	**4.3E-04**

4.1E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**05ST0201**				
DESCRIPTION	**SAND, DARK GREYISH BROWN**				
LAB ID	**ST 1860**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	7.4	cm	TEST DATE	5/31/2007	
WEIGHT	570.0	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	40.74	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	8.0%		HEAD PRESSURE	83	psi
DENSITY	108.6	pcf	CONSOLIDATION STRESS:		
	1.74	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	10	10	10	10
INITIAL READING,influent liquid		18.0	22.1	26.2	30.2
INITIAL READING,effluent liquid		24.3	20.3	16.2	12.1
END READING, influent liquid		22.1	26.2	30.2	34.2
END READING, effluent liquid		20.3	16.2	12.1	8.1
TOTAL CUBIC CENTIMETERS	Q=	4.1	4.1	4.0	4.0
LENGTH OF SAMPLE	L=	7.4	7.4	7.4	7.4
LOSS OF HEAD	H=	213.2	205.0	196.8	188.8
CROSS SECTIONAL AREA	A=	40.74	40.74	40.74	40.74
EQUATION, K = QL/AHT	K=	**3.5E-04**	**3.7E-04**	**3.7E-04**	**3.9E-04**

3.7E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	**ELAB**		
PROJECT	**TERRA TECH**	PROJ. NO.	**07-5492**

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION	**05ST0301**				
DESCRIPTION	**SAND, DARK GREYISH BROWN**				
LAB ID	**ST 1861**				
TYPE SAMPLE	**SHELBY TUBE**				
SAMPLE INFORMATION:			TEST INFORMATION:		
LENGTH	6.9	cm	TEST DATE	5/31/2007	
WEIGHT	605.1	grams	TOTAL BACKPRESSURE	80	psi
CROSS SECTIONAL AREA	43.62	cmsq	CELL PRESSURE	85	psi
MOISTURE OF SAMPLE	7.1%		HEAD PRESSURE	83	psi
DENSITY	116.8	pcf	CONSOLIDATION STRESS:		
	1.87	g/cu cm	MAXIMUM	5	psi
PERMEANT:	WATER		MINIMUM	2	psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	20	20	20	20
INITIAL READING,influent liquid		7.8	9.8	11.8	13.8
INITIAL READING,effluent liquid		25.6	23.6	21.6	19.6
END READING, influent liquid		9.8	11.8	13.8	15.8
END READING, effluent liquid		23.6	21.6	19.6	17.6
TOTAL CUBIC CENTIMETERS	Q=	2.0	2.0	2.0	2.0
LENGTH OF SAMPLE	L=	6.9	6.9	6.9	6.9
LOSS OF HEAD	H=	226.7	222.7	218.7	214.7
CROSS SECTIONAL AREA	A=	43.62	43.62	43.62	43.62
EQUATION, K = QL/AHT	K=	**7.0E-05**	**7.1E-05**	**7.3E-05**	**7.4E-05**

7.2E-05 AVERAGE CENTIMETERS PER SECOND

APPENDIX E

REMEDIAL SITE CONCEPTUAL EXPOSURE MODEL

Worksheet

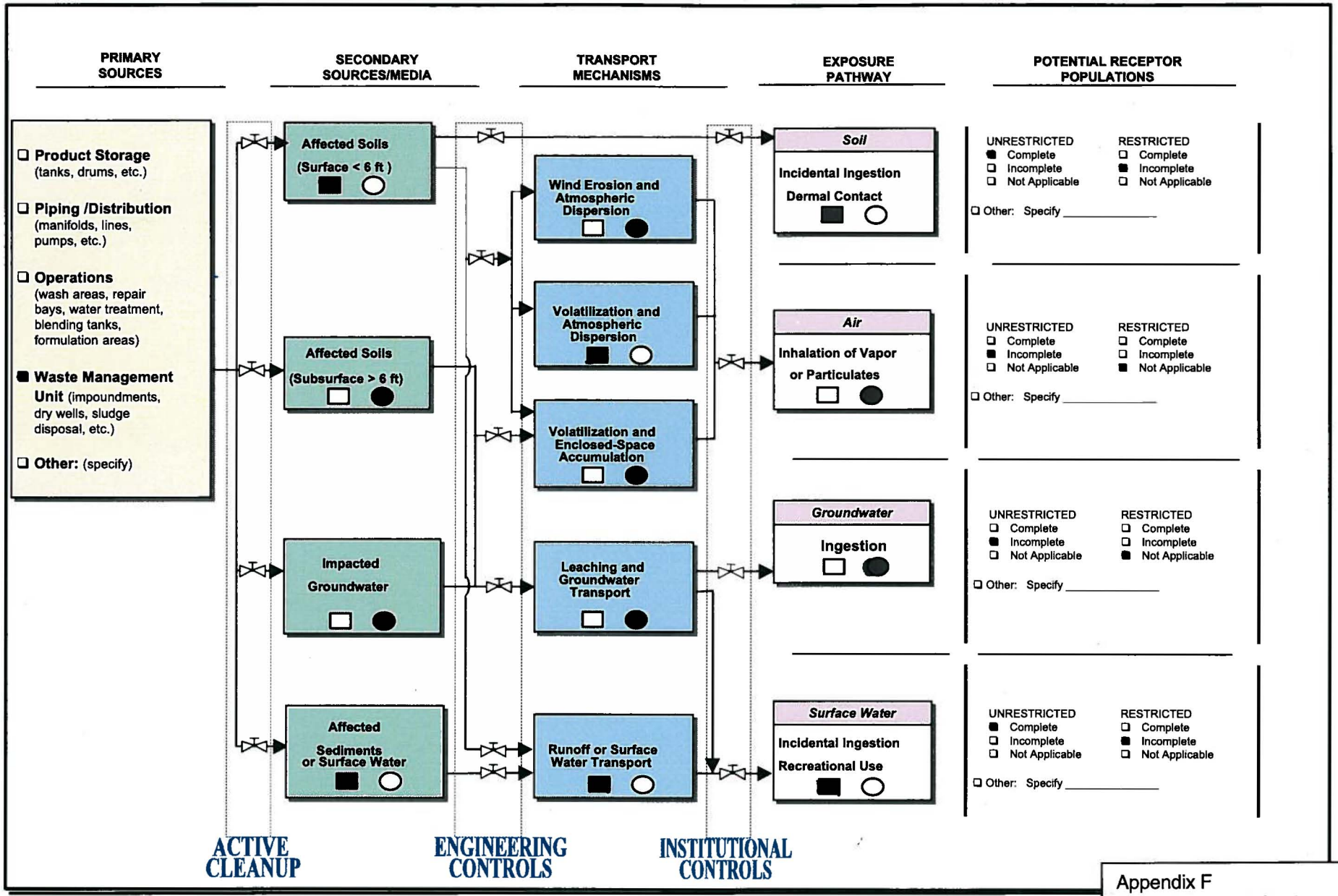
Baseline Site Conceptual Exposure Model (SCEM)

Site Name: Site 4 (Golf Course Landfill)
Site Location: NCBC Gulfport, Mississippi

Completed By: YML
Revision Date: 10/31/2007

☐ Complete
○ Potentially Complete

■ Draft
☐ Final



Appendix F
Site 4 Feasibility Study
NCBC Gulfport, Mississippi

Worksheet

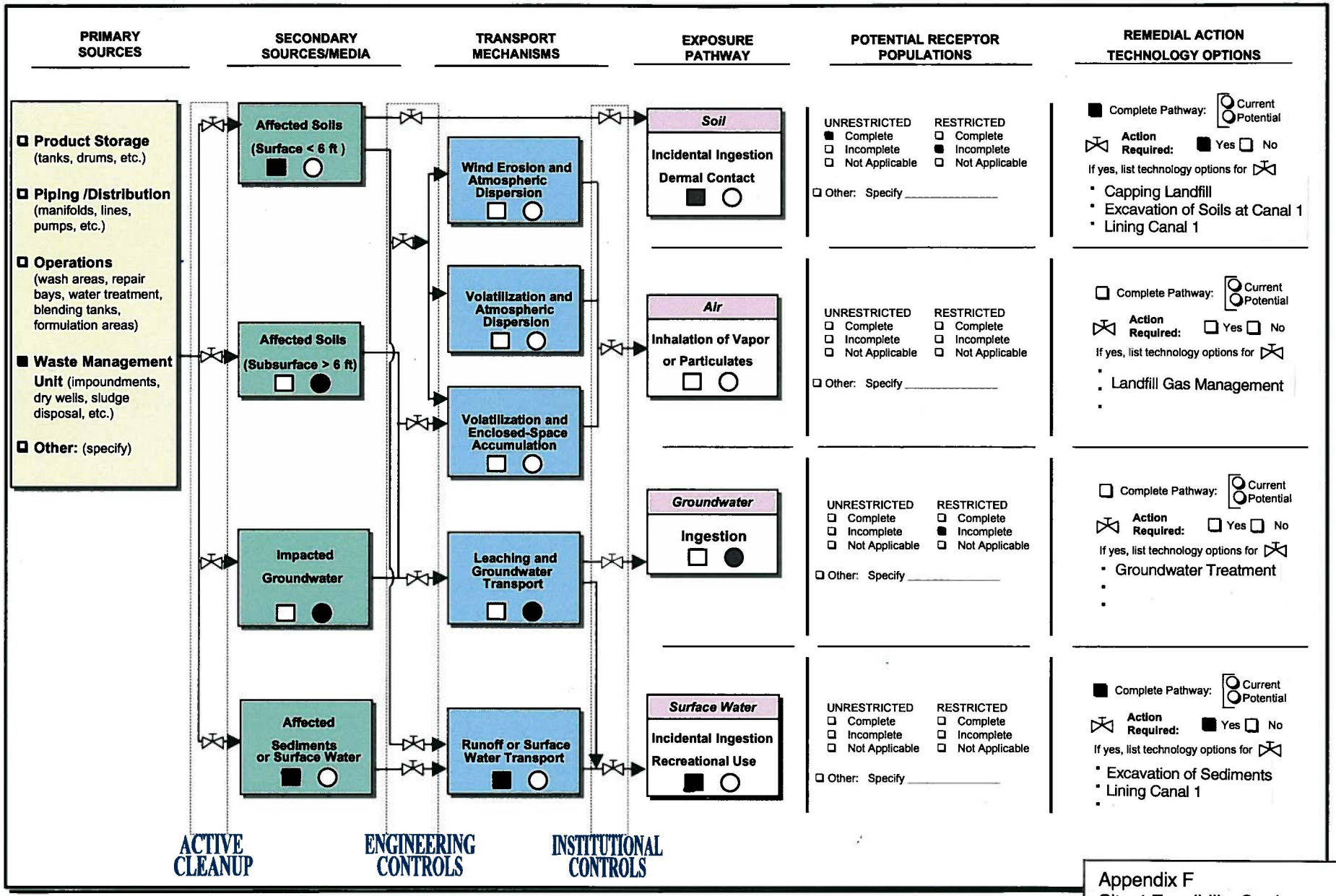
Remedial Site Conceptual Exposure Model (SCEM)

Site Name: Site 4 (Golf Course Landfill)
Site Location: NCBC Gulfport, Mississippi

Completed By: YML
Revision Date: 10/31/2007

☐ Complete
○ Potentially Complete

■ Draft
☐ Final



Appendix F
Site 4 Feasibility Study
NCBC Gulfport, Mississippi

APPENDIX F

REGULATORY REVIEW COMMENTS

STATE OF MISSISSIPPI
HALEY BARBOUR
GOVERNOR
MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY
TRUDY D. FISHER, EXECUTIVE DIRECTOR

18 September 2009

Robert Fisher
NAVFAC SE (OPG6)
PO Box 30, Bldg 903
NAS Jacksonville, FL 32212-0030

Re: Feasibility study for Site 4 (Golf course Landfill), Naval Construction Battalion Center Gulfport, Mississppi, Draft, November 2007.

The Mississippi Office of Pollution Control has reviewed the above referenced Feasibility Study (FS) received on 18 December 2007. The following concerns were noted during document review.

1. Groundwater monitoring is not included in text discussions concerning groundwater treatment technologies (pages 3-6 and 3-7, page 3-10, paragraph 5) or as an element of any of the remedial alternatives discussed in the document. Monitoring is only discussed with reference to soil sampling (page 3-4, paragraph 3). Groundwater monitoring should be included as both a short term and long term program conducted in order to demonstrate the integrity of the selected remedy. The CVOC plume should be contained by the monitoring well network and monitored periodically to insure that further migration does not occur after the proposed treatment technology described on page 3-6 (paragraph 4) is applied. If an alternative remedy is chosen, long term monitoring should still be conducted in order to determine the effectiveness of the selected remedy and to provide an adequate evaluation of the CVOC plume.

2. The text (page 3-8, last paragraph) states that the landfill cover will consist of a geosynthetic material that will be equivalent to an 18 inch thick cover material with a hydraulic conductivity of 1E-5 cm/sec. A geosynthetic cover material will provide a more desirable cap with a permeability of 1E-6 cm/sec. (or less), especially when used in combination with the layered system (including an infiltration zone and topsoil cap) described in the text. The text should state that this cover system will provide a landfill cap with a 1E -6 cm/sec. (or less) vertical hydraulic conductivity rather than the stated 1E-5 cm/sec. That (1 E-6 cm/sec.) value should be repeated when cover material is described elsewhere in the document.

3. A soil cover has been discussed for some abandoned landfills at NCBC Gulfport. Landfill closure (cover) requirements were specified in 40CFR for Subtitle D (non hazardous) landfills that operated after 9 October 1993.Landfill soil cover materials with a maximum hydraulic conductivity of 1E -5 cm/sec. were specified in 40CFR guidance for closing non hazardous (municipal solid waste) landfills that received municipal waste prior to 9 October 1991 if the permeability (vertical hydraulic conductivity) of the liner material was unknown, however this applied only to non hazardous waste landfills. This conceptual model can be applied to abandoned non hazardous waste landfills for selection of a cover material when appropriate. The geosynthetic cover material proposed in the FS would provide a more protective cap for Site 4 and would qualify as an appropriate element of a cover for disposal cells containing hazardous materials. It should be noted that the EPA Presumptive Remedy Guidance referenced in the FS addresses Subtitle C (hazardous waste) landfill closure evaluations (page 7, last paragraph) and provides references that are utilized to determine whether hazardous or non hazardous waste landfill closure criteria are relevant and appropriate (page 8, item 2). Given these considerations and the fact that the waste stream for Site 4 is not definitively documented, OPC concurs that the geosynthetic membrane material (discussed on page 3-8, last paragraph) should be incorporated into the cover system.

4. It should be noted that the FS does not identify the selected remedy. OPC appreciates the opportunity to participate in the development of the remedial design.

Please feel free to contact me if I can be of further assistance.

Sincerely,

Bob Merrill

cc. Bart Reedy, USEPA

RESPONSE TO COMMENTS

Responses to MDEQ comments dated September 18, 2009 for the Feasibility Study for the Site 4 – Golf Course Landfill at NCBC Gulfport dated November, 23, 2007 (Rev. 0).

MDEQ Comment 1:

Groundwater monitoring is not included in text discussions concerning groundwater treatment technologies (pages 3-6 and 3-7, page 3-10, paragraph 5) or as an element of any of the remedial alternatives discussed in the document. Monitoring is only discussed with reference to soil sampling (page 3-4, paragraph 3). Groundwater monitoring should be included as both a short term and long term program conducted in order to demonstrate the integrity of the selected remedy. The CVOC plume should be contained by the monitoring well network and monitored periodically to insure that further migration does not occur after the proposed treatment technology described on page 3 (paragraph 4) is applied. If an alternative remedy is chosen, long term monitoring should still be conducted in order to determine the effectiveness of the selected remedy and to provide an adequate evaluation of the CVOC plume.

Response to MDEQ Comment 1:

Agree. Section 3.2.3 has been revised to delete the reference to soil monitoring, and only refer to groundwater monitoring. The proposed groundwater monitoring component for Alternative 2 is detailed in the last paragraph of Section 3.4.2 and is also described as Component 5 in Section 4.3.2.1.

MDEQ Comment 2:

The text (page 3-8, last paragraph) states that the landfill cover will consist of a geosynthetic material that will be equivalent to an 18 inch thick cover material with a hydraulic conductivity of 1E-5 cm/sec. A geosynthetic cover material will provide a more desirable cap with a permeability of 1E-6 cm/sec. (or less), especially when used in combination with the layered system (including an infiltration zone and topsoil cap) described in the text. The text should state that this cover system will provide a landfill cap with a 1E-6 cm/sec (or less) vertical hydraulic conductivity rather than the stated 1E-5 cm/sec. That (1E-6 cm/sec) value should be repeated when cover material is described elsewhere in the document.

Response to MDEQ Comment 2:

The approach to the cap design has been revised and now includes an infiltration layer of 18 inches of soil with a maximum hydraulic conductivity of 1×10^{-5} cm/sec soil instead of a geosynthetic clay liner (GCL). Therefore, the comment no longer applies. Any other references to the 18 inches of 1×10^{-5} cm/sec soil simply refer to it as the infiltration layer. There are no other references to the hydraulic conductivity value in the text.

MDEQ Comment 3:

A soil cover has been discussed for some abandoned landfills at NCBC Gulfport Landfill closure (cover) requirements were specified in 40 CFR for Subtitle D (non hazardous) landfills that operated after 9 October 1993. Landfill soil cover materials with a maximum hydraulic conductivity of 1E-5 cm/sec were specified in 40 CFR guidance for closing non-hazardous (municipal solid waste) landfills that received municipal waste prior to 9 October 1991 if the permeability (vertical hydraulic conductivity) of the liner material was unknown, however this applied only to non hazardous waste landfills. This conceptual model can be applied to abandoned non-hazardous waste landfills for selection of a cover material when appropriate. The geosynthetic cover material proposed in the FS would provide a more protective cap for Site 4 and would qualify as an appropriate element of a cover for disposal cells containing hazardous materials. It should be noted that the EPA Presumptive

Remedy Guidance referenced in the FS addresses Subtitle C (hazardous waste) landfill closure evaluations (page 7, last paragraph) and provides references that are utilized to determine whether hazardous or non-hazardous waste landfill closure criteria are relevant and appropriate (page 8, item 2). Given these considerations and the fact that the waste stream for Site 4 is not definitively documented, OPC concurs that the geosynthetic membrane material (discussed on page 3-8, last paragraph) should be incorporated into the cover system

Response to MDEQ Comment 3:

Comment is acknowledged. However, as noted in the response to Comment No. 2 above, a geosynthetic membrane or GCL is not being proposed. An 18-inch layer of 1 X 10^{-5} cm/sec soil is being proposed for the cap.

MDEQ Comment 4:

It should be noted that the FS does not identify the selected remedy. OPC appreciates the opportunity to participate in the development of the remedial design.

Response to MDEQ Comment 4:

Comment is acknowledged. MDEQ is always welcomed to comment. The preferred alternative will be presented in the Proposed Plan, and the remedial alternative will be selected after comments from MDEQ and the public are received.