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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 9 (OU 9) SITE 57 AND SITE 58 NAS CECIL FIELD FL

10/2/2002

TETRA TECH NUS INC

Feasibility Study Report
for
Operable Unit 9, Sites 57 and 58

Naval Air Station Cecil Field
Jacksonville, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888

Contract Task Order 0078

October 2002

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FEASIBILITY STUDY REPORT
FOR
OPERABLE UNIT 9, SITES 57 AND 58

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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This document that describes the Feasibility Study Report for Operable Unit 9, Sites 57 and 58, Naval Air Station Cecil Field, Jacksonville, Florida, has been prepared under the direction of a Florida-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.

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CERTIFICATION OF TECHNICAL
DATA CONFORMITY

The Contractor, Tetra Tech NUS, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-94-D-0888 are complete and accurate and comply with all requirements of this contract.

DATE: October , 2002

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TABLE OF CONTENTS

SECTION **PAGE NO.**

CERTIFICATION OF TECHNICAL DATA CONFORMITY iii

LIST OF ACRONYMS AND ABBREVIATIONS ix

EXECUTIVE SUMMARY ES-1
E.1 PURPOSE OF THE REPORT ES-1
E.2 SITES DESCRIPTION AND HISTORY ES-1
E.3 SUMMARY OF THE INVESTIGATIONS FINDINGS ES-1
E.4 REMEDIAL ACTION OBJECTIVES AND CLEANUP GOALS ES-3
E.5 SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIATION TECHNOLOGIES, AND PROCESS OPTIONS ES-4
E.6 DEVELOPMENT OF REMEDIAL ALTERNATIVES ES-5
E.7 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES ES-7
E.8 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES ES-7

1.0 INTRODUCTION 1-1
1.1 SITES DESCRIPTION AND BACKGROUND 1-1
1.1.1 Site 57 1-1
1.1.2 Site 58 1-2
1.2 SITE INVESTIGATIONS 1-3
1.2.1 Site 57 1-3
1.2.2 Site 58 1-5
1.3 SUMMARY OF INVESTIGATIONS FINDINGS 1-7
1.3.1 Nature and Extent of Soil Contamination 1-7
1.3.2 Nature and Extent of Groundwater Contamination 1-7
1.3.3 Human Health Risk Assessment 1-9
1.3.4 Ecological Risk Assessment 1-9
1.4 DOCUMENT ORGANIZATION 1-9

2.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS 2-1
2.1 REMEDIAL ACTION OBJECTIVES 2-1
2.1.1 Statement of Remedial Action Objectives 2-1
2.1.2 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria 2-2
2.1.3 Media of Concern 2-4
2.1.4 Chemicals of Concern for Remediation 2-4
2.2 CLEANUP GOALS 2-5
2.2.1 Site 58 Soil Cleanup Goals 2-5
2.2.2 Site 57 Groundwater Cleanup Goals 2-6
2.2.3 Site 58 Groundwater Cleanup Goals 2-6
2.3 GENERAL RESPONSE ACTIONS (GRAs) AND ACTION-SPECIFIC ARARs 2-7
2.3.1 General Response Actions 2-7
2.3.2 Action-Specific ARARs 2-8
2.4 ESTIMATED VOLUMES OF CONTAMINATED MEDIA 2-8
2.4.1 Estimated Volume of Site 58 Contaminated Soil 2-8
2.4.2 Estimated Volume of Site 57 Contaminated Groundwater 2-8
2.4.3 Estimated Volume of Site 58 Contaminated Groundwater 2-9

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

3.0 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS 3-1
3.1 PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS 3-2
3.2 DETAILED SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS 3-3
3.2.1 No Action 3-3
3.2.2 Limited Action 3-3
3.2.3 Containment 3-5
3.2.4 Removal 3-6
3.2.5 Ex-Situ Treatment 3-7
3.2.6 Disposal 3-10
3.3 SELECTION OF SOIL TECHNOLOGIES AND PROCESS OPTIONS 3-11
3.4 PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS 3-12
3.5 DETAILED SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS 3-12
3.5.1 No Action 3-12
3.5.2 Limited Action 3-13
3.5.3 Removal 3-16
3.5.4 In-Situ Treatment 3-17
3.5.5 Ex-Situ Treatment 3-19
3.5.6 Disposal 3-27
3.6 SELECTION OF REPRESENTATIVE GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS 3-29

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 4-4
4.1.3 Selection of Remedy 4-5
4.2 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES 4-5
4.2.1 Alternative 1: No Action 4-6
4.2.2 Alternative 2: Institutional Controls and Monitoring 4-7
4.2.3 Alternative 3: Excavation and Off-Base Disposal 4-10
4.3 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES 4-13
4.3.1 Alternative 1 - No Action 4-14
4.3.2 Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring 4-16
4.3.3 Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring 4-23
4.3.4 Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring 4-27
4.3.5 Alternative 5: Extraction, On-Site Treatment, and Surface Discharge; Institutional Controls; and Monitoring 4-32

5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES 5-1
5.1 COMPARISON OF SOIL REMEDIAL ALTERNATIVES BY CRITERIA 5-1
5.1.1 Overall Protection of Health and 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 5-3

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

5.1.6 Implementability 5-3
5.1.7 Cost 5-4
5.2 SUMMARY OF COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES 5-4
5.3 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES BY CRITERIA 5-4
5.3.1 Overall Protection of Health and Environment 5-5
5.3.2 Compliance with ARARs and TBCs 5-5
5.3.3 Long-term Effectiveness and Permanence 5-6
5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment 5-6
5.3.5 Short-term Effectiveness 5-7
5.3.6 Implementability 5-8
5.3.7 Cost 5-9
5.4 SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES 5-9

REFERENCES R-1

APPENDICES

A LUCs RISK ANALYSIS
B GROUNDWATER MODELING
C CONCEPTUAL DESIGN CALCULATIONS
D DETAILED COST ESTIMATES

TABLES

NUMBER **PAGE NO.**

1-1 Summary of Site 58 Soil RI Analytical Data 1-11
1-2 Summary of Site 57 Groundwater RI Analytical Data 1-12
1-3 Summary of Site 57 Surface Water RI Analytical Data 1-18
1-4 Summary of Site 58 Groundwater RI Analytical Data 1-19
2-1 Federal Chemical-Specific ARARs 2-11
2-2 State Chemical-Specific ARARs 2-12
2-3 Federal Location-Specific ARARs 2-14
2-4 State Location-Specific ARARs 2-16
2-5 Federal Action-Specific ARARs 2-17
2-6 State Action-Specific ARARs 2-23
3-1 Preliminary Screening of Soil Remediation Technologies and Process Options 3-31
3-2 Preliminary Screening of Groundwater Technologies and Process Options 3-34
5-1 Summary of Comparative Analysis of Soil Remedial Alternatives 5-11
5-2 Summary of Comparative Evaluation of Groundwater Remedial Alternatives 5-13

FIGURES

NUMBER **PAGE NO.**

1-1 Site Location Map, Site 57 1-23
1-2 Site Layout and Monitoring Well Locations, Site 57 1-25
1-3 Site Location Map, Site 58 1-27
1-4 Site Layout and Monitoring Well Locations, Site 58 1-28
1-5 Site 58 Soil RI Analytical Data 1-29
1-6 Site 57 Groundwater VOCs RI Analytical Data 1-31
1-7 Site 57 Groundwater PAHs RI Analytical Data 1-33
1-8 Site 57 Groundwater TRPH RI Analytical Data 1-35
1-9 Site 58 Groundwater VOCs RI Analytical Data 1-37
1-10 Site 58 Groundwater PAHs RI Analytical Data 1-38
1-11 Site 58 Groundwater TRPH RI Analytical Data 1-39
2-1 Extent of Site 58 Soil Contaminated in Excess of Cleanup Goals 2-27
2-2 Extent of Site 57 Petroleum Plume 2-28
2-3 Extent of Site 57 TCE Plume 2-29
2-4 Extent of Site 58 Naphthalene Plume 2-30
4-1 Block Flow Diagram, Soil Alternative 2 4-39
4-2 Block Flow Diagram, Soil Alternative 3 4-41
4-3 Block Flow Diagram, Groundwater Alternative 2 4-43
4-4 Block Flow Diagram, Groundwater Alternative 3 4-45
4-5 Block Flow Diagram, Groundwater Alternative 4 4-47
4-6 Process Flow Diagram, Typical Groundwater AS Treatment System 4-49
4-7 Block Flow Diagram, Groundwater Alternative 5 4-51
4-8 Process Flow Diagram, Typical Groundwater Extraction and On-Site Treatment System 4-53
4-9 Site 57 Groundwater Extraction Wells and Treatment System Location 4-54
4-10 Site 58 Groundwater Extraction Wells and Treatment System Location 4-55

LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	Microgram(s) per kilogram
µg/L	Microgram(s) per liter
ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
AS	Air sparging
AS/VE	Air sparging / vapor extraction
AST	Aboveground storage tank
atm-L/mole	Atmosphere-liter per mole
AWQCs	Ambient Water Quality Criteria (U.S. EPA's)
BCT	BRAC Cleanup Team
bgs	Below ground surface
BOD	Biochemical oxygen demand
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	Cubic feet per minute
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CO_2	Carbon dioxide
COC	Chemical of concern
CSF	Cancer Slope Factor (U.S. EPA's)
CTO	Contract Task Order
CWA	Clean Water Act
DCA	Dichloroethane
DCE	Dichloroethene
DO	Dissolved oxygen
DOT	Department of Transportation (U.S.)
DPT	Direct push technology
EBCT	Empty bed contact time
EBS	Environmental Baseline Survey
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FOTW	Federally owned treatment works

FS	Feasibility Study
ft^2	Square foot or square feet
ft^3	Cubic foot or cubic feet
GAC	Granular activated carbon
GCTL	Groundwater Cleanup Target Levels (FDEP's)
gpm	Gallon(s) per minute
GRA	General Response Action
HASP	Health and Safety Plan
HLA	Harding Lawson Associates
HQ	Hazard Quotient
HRC®	Hydrogen release compound
IBDS	Inorganic Background Data Set
ICR	Incremental cancer risk
IR	Installation Restoration (program)
KAG	Kerosene Analyte Group (FDEP's)
LDRs	Land Disposal Restrictions (U.S. EPA's)
LTTD	Low-temperature thermal desorption
LUC	Land use control
MB-18	Main Base Area 18
MCL	Maximum Contaminant Level (USEPA's)
mg/kg	Milligram(s) per kilogram
mg/L	Milligram(s) per liter
MTBE	Methyltert-butyl ether
NAAQS	National Ambient Air Quality Standards (U.S. EPA's)
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPW	Net present worth
NSPS	New Source Performance Standards (U.S. EPA's)
O&M	Operation and maintenance
ORC®	Oxygen release compound
ORP	Oxydation/Reduction potential
OSHA	Occupational Safety and Health Act
OSWER	Office of Solid Waste and Emergency Response

OU	Operational Unit
PAH	Polynuclear aromatic hydrocarbon
POTW	Publicly owned treatment works
PPE	Personal protection equipment
PRB	Permeable reactive barrier
PRE	Preliminary Risk Evaluation
RAO	Remedial Action Objective
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RfD	Refernce Dose (U.S. EPA's)
RI	Remedial Investigation
ROI	Radius of influence
SAOR	Sampling and Analysis and Outline Report
SAR	Sampling and Analysis Report
SCTL	Soil Cleanup Target Level (FDEP's)
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level (USEPA's)
SOUTHDIVNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SPECAP	Specific capacity (test)
STP	Sewage treatment plant
SVOC	Semivolatile organic compound
SWMU	Solid waste management unit
TBC	To Be Considered (criterion)
TCA	Trichloroethane
TCE	Trichloroethene
TOC	Total organic carbon
TRPH	Total recoverable petroleum hydrocarbons
TSDF	Treatment, storage, disposal facility
TSS	Total suspended solids
TtNUS	Tetra Tech NUS, Inc.
U.S. EPA	United States Environmental Protection Agency
UIC	Underground Injection Control
USFWS	United States Fish and Wildlife Service
UST	Underground storage tank
UV	Ultraviolet
VOC	Volatile organic compound
yd^3	Cubic yard(s)

EXECUTIVE SUMMARY

E.1 PURPOSE OF THE REPORT

The purpose of this Feasibility Study (FS) Report is to develop and evaluate options for the remediation of contaminated soil and groundwater for Operable Unit (OU) 9, Sites 57 and 58 at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida.

E.2 SITES DESCRIPTION AND HISTORY

Sites 57 and 58 are located in the northwestern portion of the Main Base west of the North-South runway.

Site 57 includes Buildings 293, 817, 824, 824A, 824ALS, 825, 825LS, 841, 846, 852, 870, and 1848, and the adjacent land areas. These buildings were used for aircraft maintenance and/or aircraft and aircraft parts storage. Site 57 also includes the Day Tank 1 area. Day Tank 1 was a 200,000-gallon jet fuel aboveground storage tank (AST) that was removed in 1999 along with 24,000 tons of petroleum contaminated soil. Following this removal action, a biosparge and vapor collection system was installed and started in 2000 and groundwater contamination was monitored for natural attenuation. Although it is physically located within Site 57, the Day Tank 1 area is currently being investigated and remediated as part of the Petroleum Program and will not be evaluated in this FS.

Site 58 includes Buildings 312 and 312LS and the adjacent land areas. Building 312 was a corrosion control facility that housed two paint booths and administrative offices. Structures associated with Building 312 included a hydraulic lift, an aircraft wash rack, an oil-water separator, and a waste oil underground storage tank (UST), that have been removed. Building 312LS is a sanitary sewer lift station that serves Building 312 and used to serve the adjacent wash rack.

Several environmental investigations were performed at Site 57 and 58, starting with an Environmental Baseline Survey (EBS) [ABB Environmental Services, Inc. (ABB-ES), 1994] through a Remedial Investigation (RI) [Tetra Tech NUS, Inc. (TtNUS), 2002]. These investigations showed that the Site 58 soil is contaminated with polynuclear aromatic hydrocarbons (PAHs). These investigations also showed that the Site 57 and 58 groundwater is contaminated with volatile organic compounds (VOCs), PAHs, and total recoverable petroleum hydrocarbons (TRPH).

E.3 SUMMARY OF THE INVESTIGATIONS FINDINGS

Three PAHs [benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene] were detected in soil in one Site 58 sample at concentrations in excess of their respective Soil Cleanup Target Levels (SCTLs)

for direct residential exposure of 1,400, 100, and 100 micrograms per kilogram (μg/kg) as defined by the Florida Department of Environmental Protection (FDEP) (FDEP, 1999a). The source of this contamination appears to be the former aircraft wash rack. Soil contamination is assumed to extend over an area approximately 2,400 square feet (ft^2) in size and to a depth of 2 feet below ground surface (bgs). This estimate represents a worst-case scenario and will be verified by additional sampling prior to remediation.

Four non-chlorinated VOCs, including benzene, ethylbenzene, toluene, and xylenes (BTEX); four chlorinated VOCs, including trichloroethene (TCE), 1,1- and 1,2-dichoroethene (DCE), and 1,1-dichoroethane (DCA); three PAHs, including naphthalene and 1- and 2-methylnaphthalene; and TRPH were detected in the Site 57 groundwater at concentrations greater than the FDEP Groundwater Cleanup Target Levels (GCTLs) (FDEP, 1999a). Two distinct but partially overlapping contaminant plumes have been delineated, including a petroleum plume and a TCE plume. The Site 57 Petroleum Plume, defined as the area of groundwater with benzene concentrations greater than the GCTL of 1.0 microgram per liter (µg/L), extends over an area approximately 137,000 ft^2 in size and to a depth ranging from 25 to 47.5 feet bgs. The Site 57 TCE Plume, defined as the area of groundwater with TCE concentrations greater than the GCTL of 3.0 µg/L, extends over an area approximately 48,000 ft^2 in size and down to a depth of up to 61 feet bgs.

Three chlorinated VOCs [1,1-DCA, 1,1-DCE, and 1,1,1-trichloroethane (TCA)], one PAH (naphthalene), and TRPH were detected in the Site 58 groundwater at concentrations greater than FDEP GCTLs. A contaminant plume, designated as the Site 58 Naphthalene Plume, has been delineated as the area of groundwater with naphthalene concentrations greater than the GCTL of 20 µg/L. The Site 58 Naphthalene Plume extends over an area approximately 15,500 ft^2 in size and to a depth of up to 21 feet bgs.

The Preliminary Risk Evaluation (PRE) performed as part of the RI identified benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene as chemicals of concern (COCs) for the Site 58 soil. The PRE also identified naphthalene and TRPH as COCs for groundwater at both Site 57 and 58. In addition, BTEX, 1,1-DCE, 1,1-DCA, cis-1,2-DCE, TCE, and 1- and 2-methylnaphthalene were identified as Site 57 groundwater COCs.

The ecological risk assessment performed as part of the RI established that Sites 57 and 58 consist primarily of buildings and parking lots that provide an ecological habitat of marginal quality and can be of little use to terrestrial wildlife. Therefore, the RI concluded that Sites 57 and 58 does not present a significant ecological risk.

E.4 REMEDIAL ACTION OBJECTIVES AND CLEANUP GOALS

The Remedial Action Objectives (RAOs) identified for Sites 57 and 58 are as follows:

- Prevent unacceptable risk from exposure to Site 58 soil with concentrations of PAHs greater than the FDEP SCTLs for residential exposure.
- Prevent unacceptable risk from exposure to Site 57 groundwater with concentrations of chlorinated VOCs, BTEX, PAHs, and TRPH greater than the FDEP GCTLs.
- Prevent unacceptable risk from exposure to Site 58 groundwater with concentrations of naphthalene and TRPH greater than the FDEP GCTLs.
- Restore groundwater quality at Sites 57 and 58.

The cleanup goals for the Site 58 soil are as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[1]
PAHS (µg/kg)				
Benzo(a)anthracene	1 / 3	1,433	CEF-B312-SD001	1,400
Benzo(a)pyrene	2 / 3	78.3 J – 1,569	CEF-B312-SD001	100
Dibenzo(a,h)anthracene	1 / 3	172	CEF-B312-SD001	100

NOTES:
1 FDEP SCTL (FDEP, 1999a)

The cleanup goals for the Site 57 groundwater are as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[1]
VOCs (µg/L)				
Benzene	11 / 41	0.87 – 248	CEF-824A-4S	1
cis-1,2-DCE	5 / 39	0.94 - 825	CEF-293-19	70
1,1-DCA	7 / 41	1.1 – 97.2	CEF-824A-14S	70
1,1-DCE	2 / 41	5 – 33.8	CEF-824A-8S	7
Ethylbenzene	11 / 41	1 - 150	CEF-293-11	30
Toluene	7 / 41	1 - 63	CEF-293-11	40
TCE	4 / 41	1 - 43	CEF-293-19	3
Xylenes	12 / 41	1.9 - 560	CEF-293-11	20

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[(1)]
PAHs (µg/l)				
1-Methylnaphthalene	13 / 41	1.2 - 160	CEF-824A-11S	20
2-Methylnaphthalene	12 / 41	1.6 - 184	CEF-824A-11S	20
Naphthalene	15 / 41	1.2 - 396	CEF-824A-11S	20
TRPH (µg/l)				
TRPH	21 / 41	203 – 14,300	CEF-824A-11S	5,000

NOTES:
1 FDEP GCTL (FDEP, 1999a)

The cleanup goals for Site 58 groundwater are as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[(1)]
VOCs (µg/l)				
1,1-DCA	10/18	1.0 - 421	CEF-B312-08S	70
1,1-DCE	2/18	1.6 - 130	CEF-B312-08S	7
1,1,1-TCA	1/18	841	CEF-B312-08S	200
PAHs (µg/l)				
Naphthalene	9 / 18	1.3 - 156	CEF-B312-01S	20
TRPH µg/l)				
TRPH	9 / 18	587 - 9,000	CEF-B312-01S	5,000

NOTES:
(1) FDEP GCTL (FDEP, 1999a)

E.5 SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIATION TECHNOLOGIES, AND PROCESS OPTIONS

General Response Actions (GRAs) and the remediation technologies and process options associated to these GRAs were screened for effectiveness, implementability, and cost. Remediation technologies that were determined to be ineffective or too difficult to implement were eliminated from further consideration.

The following technologies and process options were retained for Site 58 soil:

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Limited Action	Institutional Controls	Fencing, Posting, and Land Use Controls (LUCs)
	Monitoring	Sampling and Analysis
Removal	Excavation	Excavation
Disposal	Off-Base Disposal	Solid Waste Disposal Facility

The following GRAs, remediation technologies, and process options were retained to develop groundwater remedial alternatives for Sites 57 and 58:

General Response Action	Remediation Technology	Process Options
No Action	None	Not Applicable
Limited Action	Monitoring	Sampling and Analysis
	Institutional Controls	Groundwater Use Restrictions
	Natural Attenuation	Dispersion, Dilution, and Biodegradation
Removal	Groundwater Extraction	Extraction Wells
In-situ Treatment	Biological	Enhanced Biodegradation
	Physical	Air Sparging (AS) Treatment
Ex-situ Treatment	Physical	Filtration
		Air Stripping
		Liquid-phase Granular Activated Carbon (GAC) Adsorption
Discharge/Disposal	Onsite Surface Discharge	Direct Discharge

E.6 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based upon the results of the screening of remediation technologies, the following remedial alternatives were assembled for Site 58 soil:

- **Soil Alternative 1: No Action.** No action would be taken. Retained as a baseline for comparison with other alternatives.

- **Soil Alternative 2: Institutional Controls and Monitoring.** Institutional controls would consist to maintain, and if necessary to upgrade, the fence around the Site 58 drainage ditch area and to post warning signs on that fence. Institutional controls would also consist of implementing Land Use Controls (LUCs) to prevent future residential development. Annual site inspections would be performed to verify implementation of the institutional controls. Monitoring would consist of long-term soil and groundwater sampling and analysis to evaluate any changes in soil COC concentrations and detect potential migration of COCs from soil to groundwater.

- **Soil Alternative 3: Excavation and Off-Base Disposal.** This alternative would consist of excavating approximately 180 cubic yards (yd^3) of soil with concentrations of PAHs greater than the FDEP SCTLs for direct residential exposure and backfilling the excavated area with clean soil. The excavated soil would be transported off-base to a permitted treatment, storage, and disposal facility (TSDF) for disposal through landfilling.

Based upon the results of the screening of remediation technologies, the following remedial alternatives were developed for Sites 57 and 58 groundwater:

- **Groundwater Alternative 1: No Action**. No action would be taken. Retained as a baseline for comparison with other alternatives.

- **Groundwater Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring**. Natural attenuation would consist of letting concentrations of groundwater COCs decrease through naturally-occurring processes such as biodegradation, dilution, and dispersion. Institutional controls would consist of preventing the use of groundwater for drinking purposes until the cleanup goals has been met. Annual site inspections would be performed to verify implementation of the institutional controls. Monitoring would consist of regularly collecting and analyzing groundwater samples both from within the contaminant plumes to assess natural attenuation and downgradient of leading edge of the plume to evaluate potential contaminant migration.

- **Groundwater Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring**. In-situ biological treatment would consist of injecting oxygen release compounds (ORC®) and/or hydrogen release compounds (HRC®) in the groundwater to accelerate biodegradation of COCs. ORC® would be used to promote the aerobic biodegradation of the BTEX, PAHs, and TRPH in the Site 57 Petroleum Plume (ORC® System No. 1) and of the naphthalene and TRPH in the Site 58 Naphthalene Plume (ORC® System No. 2). HRC® would be used to promote the anaerobic biodegradation of chlorinated VOCs in the Site 57 TCE Plume (HRC® System). ORC® System No. 1 would consist of an initial injection of 16,500 pounds of ORC® through 138 direct push technology (DPT) injection points. The HRC® System would consist of an initial injection of 19,800 pounds of HRC® through 120 DPT injection points. ORC® System No. 2 would consist of injecting a total of 10,200 pounds of ORC® through 60 DPT injection points. Institutional controls and monitoring would be similar to those of Groundwater Alternative 2.

- **Groundwater Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring**. In-situ AS treatment would consist of injecting air in the groundwater to promote the volatilization of BTEX and chlorinated VOCs and the aerobic biodegradation of BETX, PAHs, and TRPH. There would be one AS system for each of the three contaminant plumes. AS System No. 1 would treat the Site 57 Petroleum Plume and feature 97 sparging wells, one 750 cubic feet per minute (cfm) compressor, and one 300 cfm compressor. AS System No. 2 would treat the Site 57 TCE Plume and feature 19 sparging wells and one 200 cfm compressor. AS System No. 3 would treat the Site 58 Naphthalene Plume and feature 16 sparging wells and one 200 cfm compressor. Institutional controls and monitoring would be similar to those of Groundwater Alternative 2.

- **Groundwater Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring**. This alternative would consist of removing the contaminated groundwater through extraction wells and treating the extracted groundwater in an on-site system prior to discharge to local drainage ditches. Separate extraction and on-site treatment systems would be installed and operated for Sites 57 and 58. The Site 57 system would have a design capacity of 37.5 gallons per minute (gpm) and would feature five extraction wells and an on-site treatment system consisting of equalization, filtration, air stripping, and liquid-phase granular activated carbon (GAC) adsorption. The Site 58 system would have a design capacity of 22.5 gpm and would feature three extraction wells and an on-site treatment system consisting of equalization, filtration, and liquid-phase GAC adsorption. Institutional controls and monitoring would be similar to those for Groundwater Alternative 2.

E.7 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were analyzed in detail using seven of the nine criteria provided in the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). These seven criteria are as follows:

- Overall Protection of Human Health and the Environment,
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBCs) guidance criteria,
- Long-term Effectiveness and Permanence,
- Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment,
- Short-term Effectiveness,
- Implementability, and
- Cost

Two other criteria, State and Community Acceptance were not evaluated in this report. They will be evaluated after regulatory and public comments are available.

E.8 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

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

Site 58 Soil

- **Overall Protection of Human Health and Environment**

Soil Alternative 1 would not be protective of human health and the environment. Under the current industrial land use scenario, unacceptable human health risk could occur from exposure to contaminated soil. Under a potential future residential land use scenario, the human health risk would be further aggravated and an unacceptable ecological risk could also occur. Also, the potential would remain for soil COCs to migrate either offsite or to groundwater and no monitoring would be performed to detect this potential migration. Although Soil Alternative 2 would not actively remove contaminants, it would be protective of human health and the environment because institutional controls would minimize unacceptable risk from exposure to contaminated soil and monitoring would warn of possible migration of soil COCs to groundwater. Soil Alternative 3 would be most protective of human health and the environment because soil contaminated above SCTLs for direct residential exposure would be physically removed from the site and effectively and irreversibly disposed off-base.

- **Compliance with ARARs and TBCs**

Soil Alternative 1 would not comply with chemical- or location-specific ARARs and TBCs. No action-specific ARARs or TBCs would apply to this alternative. Soil Alternative 2 would comply with location- and action-specific ARARs and TBCs and might eventually comply with chemical-specific ARARs and TBCs through natural attenuation, as verified by monitoring. Soil Alternative 3 would comply with the chemical-, location-, and action-specific ARARs and TBCs.

- **Long-term Effectiveness and Permanence**

Soil Alternative 1 would have no long-term effectiveness and permanence because no action would be taken to reduce soil contamination, to control exposure to contaminated soil, or to monitor possible migration of contaminants from soil to groundwater. Soil Alternative 2 would have some long-term effectiveness and permanence because institutional controls would effectively reduce the current risk of exposure to contaminated soil and prevent future residential development and monitoring would effectively measure possible natural attenuation of COCs in soil and detect potential migration of COCs from soil to groundwater. Soil Alternative 3 would have the best long-term effectiveness and permanence because it would permanently remove from the site the soil contaminated above cleanup goals and permanently and irreversibly dispose of the removed soil.

- **Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment**

Soil Alternatives 1 and 2 would not reduce contaminant toxicity, mobility, or volume through treatment. Under these alternatives some reduction of contaminant toxicity and volume might occur through natural attenuation but only Soil Alternative 2 would monitor this reduction. Soil Alternative 3 would reduce contaminant mobility and volume. Under this alternative approximately 180 yd^3 of soil containing approximately 1.2 pounds of COCs would be permanently and irreversibly removed from the site.

- **Short-term Effectiveness**

There would be no short-term effectiveness concerns associated with Soil Alternative 1 because no action would be taken. Soil Alternative 2 would have minimal short-term effectiveness concerns associated with the collection of soil and groundwater samples. These concerns would be effectively addressed by adherence to a site-specific Health and Safety Plan (HASP), including the wearing of the appropriate personal protection equipment (PPE). Soil Alternative 3 would have significant short-term effectiveness concerns because excavation and off-base transportation and disposal would involve greater exposure of workers to contaminated soil. Because of off-base transportation, Soil Alternative 3 would also have the slight possibility to impact the surrounding community. However, the short-term concerns associated with Soil Alternative 3 could be adequately addressed through implementation of proper engineering controls and adherence to applicable Occupational Safety and Health Act (OSHA) regulations and to the site-specific HASP, including the wearing of appropriate PPE.

Soil Alternative 1 would not achieve the soil RAO and, although the soil cleanup goals might eventually be attained through natural attenuation, there would be no means of verifying it. Soil Alternative 2 would achieve the soil RAO immediately upon implementation of institutional controls and monitoring and might eventually attain soil cleanup goals through natural attenuation as verified through monitoring. Soil Alternative 3 would attain the soil RAO and cleanup goals within an estimated 2 months of the start of the removal action.

- **Implementability**

Soil Alternative 1 would be easiest to implement because there would be no activities to implement.

Technically, the institutional controls and monitoring components of Soil Alternative 2 would be very simple to implement. Soil Alternative 3 would be hardest to implement because, although it would not require institutional controls and long-term monitoring, it would involve a closely-coordinated multi-stage operation for the excavation and off-base transportation and disposal of contaminated soil. However,

implementation of this alternative would still be relatively simple and the necessary resources, equipment, and materials are readily available.

Administratively, the institutional controls component of Soil Alternative 2 would be simple to implement. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land use restrictions and monitoring. The administrative implementability of Soil Alternative 3 would be somewhat more difficult than that of Soil Alternative 2 as it would require construction permits, manifesting of the excavated soil for off-base transportation, and acceptance of the excavated soil by the off-base TSDF. However, these requirements could be readily implemented.

- **Cost**

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

Soil Alternatives	Capital	NPW of O&M (years)	NPW (years)
1	$0	$0	$0
2	$20,000	$54,000 (30 Years)	$74,000 (30 Years)
3	$32,000	$0	$32,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. A detailed breakdown of cost estimates is provided in Appendix C.

Sites 57 and 58 Groundwater

- **Overall Protection of Human Health and Environment**

Groundwater Alternative 1 would not be protective of human health and the environment because COCs would remain above cleanup goals, no institutional controls would be implemented to prevent unacceptable risk from ingestion of contaminated groundwater, and no monitoring would be performed to evaluate the progress of natural attenuation or the potential migration of COCs.

Groundwater Alternative 2 would be protective of human health and the environment. Although no active remediation would take place, natural attenuation would dissipate the contaminant plumes, institutional controls would prevent unacceptable exposure to contaminated groundwater, and monitoring would evaluate the progress of natural attenuation and verify that unacceptable migration of contaminants is not taking place.

Groundwater Alternatives 3, 4, and 5 would be slightly more protective of human health and the environment than Groundwater Alternative 2 because, in addition to institutional controls and monitoring, these alternatives would somewhat accelerate removal of COCs, especially at Site 57, through active removal and treatment processes. Although Groundwater Alternatives 3 and 4 would results in fugitive emissions, the rate of these emissions would remain well under the FDEP's allowable de-minimis of 13.75 pounds of VOCs per day and both alternatives would in fact be more protective than Groundwater Alternative 5 because they would achieve complete protection in a significantly shorter time, especially at Site 57.

- **Compliance with ARARs and TBCs**

Groundwater Alternative 1 would not comply with chemical- or location-specific ARARs and TBCs. No action-specific ARARs or TBCs would apply to this alternative. Groundwater Alternatives 2, 3, 4, and 5 would comply with location- and action-specific ARARs and TBCs and, eventually, with chemical-specific ARARs and TBCs as well. It is anticipated that compliance with chemical-specific ARARs and TBCs would first be achieved by Groundwater Alternatives 3 and 4, followed by Groundwater Alternative 5, and then by Groundwater Alternative 2.

- **Long-term Effectiveness and Permanence**

Groundwater Alternative 1 would have no long-term effectiveness and permanence because no action would be taken to reduce contamination, or control exposure to contaminated groundwater, or to monitor the progress of natural attenuation and detect potential migration of contaminants.

Groundwater Alternative 2 would have long-term effectiveness and permanence because natural attenuation has been demonstrated as effective for the removal of the Sites 57 and 58 groundwater COCs. In addition, institutional controls and monitoring would effectively prevent unacceptable exposure to contaminated groundwater until the cleanup goals have been met through natural attenuation.

Groundwater Alternatives 3, 4, and 5 would be more effective than Groundwater Alternative 2, because, in addition to the same institutional controls and monitoring components as Groundwater Alternative 2, they would also include an active treatment component that, compared to natural attenuation, would somewhat accelerate the removal of COCs, especially at Site 57. Groundwater Alternative 4 would be most effective because it would be quickest to meet the cleanup goals and would use a well-proven treatment technology. Groundwater Alternative 3 would be slightly less effective than Groundwater Alternative 4 because, although it would meet the cleanup goals in the same timeframe, its application at Site 57 would use an innovative technology (HRC® injection for removal of chlorinated VOCs) that would require treatability testing. Also at Site 57, there might be some interference between the treatment of

BTEX, PAHs, and TRPH with ORC® and the treatment of chlorinated VOCs with HRC®. Groundwater Alternative 5 would be less effective than either Groundwater Alternatives 3 or 4 because, although it would use an established active remedial approach (pump-and-treat), it would take somewhat more time to meet the cleanup goals and would actually not be significantly quicker than Groundwater Alternative 2.

- **Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment**

Groundwater Alternatives 1 and 2 would not reduce contaminant toxicity, mobility, or volume through treatment. Under these alternatives, contaminant toxicity and volume would be reduced through natural attenuation but only Groundwater Alternative 2 would monitor this reduction.

Groundwater Alternatives 3, 4, and 5 would significantly reduce contaminant toxicity and volume through treatment. The treatment systems of these alternatives would remove an estimated 525 pounds of COCs from the groundwater (504 pounds from Site 57, 21 pounds from Site 58) through their operating life. The contaminant removal achieved by these alternatives would be completely irreversible.

- **Short-term Effectiveness**

There would be no short-term effectiveness concerns and no impact to the surrounding community associated with Groundwater Alternative 1 because no action would be taken.

Groundwater Alternatives 2, 3, 4, and 5 would also not impact the surrounding community but there would be some short-term effectiveness concerns associated with their implementation because of the risk of workers being exposed to contaminated groundwater. The magnitude of this risk would be proportional to the extent of remedial activities, e.g., it would be lowest for Groundwater Alternative 2, higher for Groundwater Alternatives 3 and 4, and highest for Groundwater Alternative 5. However, regardless of its magnitude, the risk of exposure would be properly mitigated through implementation of proper engineering controls, and adherence to applicable OSHA regulations and to the site-specific HASP, including the wearing of appropriate PPE.

Groundwater Alternative 1 would not achieve the groundwater RAOs and, although the groundwater cleanup goals would eventually be attained through natural attenuation, there would be no means of determining when this had occurred. Groundwater Alternatives 2, 3, 4, and 5 would achieve the first two groundwater RAOs immediately upon implementation of institutional controls. Based on the results of experience with similar applications and the modeling presented in Appendix A, it is estimated that the respective timeframes to achieve the third groundwater RAO and the groundwater cleanup goals at Sites 57 and 58 would be 20 years and 3 years for Groundwater Alternative 2, 3 years and 2 years for Groundwater Alternatives 3 and 4, and 14 years and 3 years for Groundwater Alternative 5.

- **Implementability**

Groundwater Alternative 1 would be easiest to implement since there would be no activities to implement.

Technical implementation of the various components of Groundwater Alternatives 2, 3, 4, and 5 would be relatively simple.

The technical implementation of the natural attenuation, institutional controls, and monitoring components of Groundwater Alternative 2 would be very simple. The resources, equipment, and material required for the activities associated with these components are readily available.

The technical implementation of Groundwater Alternatives 3, 4, and 5 would be somewhat more difficult than that of Groundwater Alternative 2 because each of these alternatives would require the installation and O&M of a groundwater treatment system. Of these three alternatives, Groundwater Alternative 3 would be easiest to implement because it would only require the installation of small diameter ORC®/HRC® injection points and the feeding of these chemicals without installation of permanent equipment. Groundwater Alternative 5 would be technically harder to implement than Groundwater Alternative 3 because it would require two groundwater extraction arrays with wells, pumps, and transfer piping, and of two on-site treatment systems featuring multiple process units. Groundwater Alternative 4 would be most technically difficult to implement because it would require three AS systems, each including numerous sparging wells, lengthy interconnecting piping, and one or more compressor systems. However, the resources, equipment, and material necessary to implement any of these three alternatives are readily available.

Administrative implementation of the various components of Groundwater Alternatives 2, 3, 4, and 5 would be relatively simple.

Administrative implementation of the institutional controls component of Groundwater Alternative 2 would be simple because, as part of change of the sites from military to private ownership, appropriate provisions will be incorporated in the property transfer documents to ensure continued enforcement of controls. Administrative implementability of the monitoring component of Groundwater Alternative 2 should also be simple and it would not require the securing of permits.

The administrative implementation of Groundwater Alternatives 3, 4, and 5 would be slightly more difficult than that of Groundwater Alternative 2, because in addition to the same requirements as Groundwater Alternative 2, these three alternatives would also require the securing of permits for the construction of groundwater treatment systems. However, these permits should be relatively easy to obtain.

Groundwater Alternative 5 would also have to meet the substantive requirements of an National Pollutant Discharge Elimination System (NPDES) permit for discharge of treated groundwater to surface water.

- **Cost**

The capital and O&M costs and the NPW of the groundwater remedial alternatives were estimated to be as follows:

Groundwater Alternative	Capital	NPW of O&M (years)	NPW (years)
1	$0	$0	$0
2	$5,000	$519,000 (20 Years)	$52400 (20 Years)
3	$1,265,000	$352,000 (5 Years)	$1,617,000 (5 Years)
4	$1,636,000	$564,000 (5 Years)	$2,200,000 (5 Years)
5	$1,109,000	$1,542,000 (15 Years)	$2,651,000 (15 Years)

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. A detailed breakdown of cost estimates is provided in Appendix D.

1.0 INTRODUCTION

This Feasibility Study (FS) report for Operable Unit (OU) 9, Sites 57 and 58 at the former Naval Air Station (NAS) Cecil Field, Jacksonville, Florida has been prepared by Tetra Tech NUS, Inc. (TtNUS) for Southern Division, Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0078. This FS report describes the formulation and evaluation of remedial alternatives for contaminated soil at Site 58 and groundwater at Sites 57 and 58. The Remedial Investigation (RI) for these sites concluded that no further action is required for soil at Site 57 other than for the soil associated with Day Tank 1 which is being evaluated under the Petroleum Program. (TtNUS, 2002).

The FS was conducted to establish Remedial Action Objectives (RAOs) and Cleanup Goals; screen remedial technologies; and assemble, evaluate, and compare remedial alternatives. This FS focuses on a small area of surface soil contamination detected at Site 58 and on the groundwater contaminant plumes that have been delineated at Sites 57 and 58.

1.1 SITES DESCRIPTION AND BACKGROUND

1.1.1 Site 57

Figure 1-1 provides a site location map for Site 57, and Figure 1-2 provides the site layout and existing monitoring well locations. The Base Realignment and Closure (BRAC) Cleanup Team (BCT) made a decision that the Building 824/824A and Day Tank 1 area groundwater contamination would be investigated in its entirety under the Installation Restoration (IR) program, as governed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Combining the evaluation of this area under one program will expedite the remedial process, prevent duplication of efforts, and provide a comprehensive investigative approach. Previous investigations in the Site 57 area were conducted under the petroleum and CERCLA/IR programs. Site 57 consists of Day Tank 1 area, MB-18 wells, and other wells installed under the BRAC program in the areas of Buildings 293, 846, and 1848. Buildings associated with Site 57 include 824/824A, 293, 817, 824ALS, 825, 825LS, 841, 852, 870, and 1848. Although the Day Tank 1 area is physically located within Site 57, the soil of this area is currently being investigated and remediated as part of the Petroleum Program and thus will not be evaluated in this FS.

Building 824, built in 1957, and Building 824A, annexed in 1988, were used as an electronics maintenance and support facility for jet aircraft. The buildings were used for testing and repair of

electrical equipment including activities such as welding, painting, sandblasting, hydraulics repair, corrosion control, and parts cleaning. Floor drains in various areas of the building reportedly discharged to the sanitary sewer system. Wastewater from parts cleaning activities outside the building reportedly drained into the storm sewer system. Building 293, the Day Tank 1 administrative office building, was constructed in 1955.

Building 817, constructed in 1971, housed diesel-powered generators for use at Building 825, an aircraft hangar, if Main Base power was unavailable. Buildings 824ALS and 825LS are sanitary sewer lift stations that received discharges for over 20 years from Building 824/824A and outside aircraft wash racks, respectively. Building 825 was built in 1966 and was used as an aircraft storage and maintenance area and also used a hazardous waste satellite accumulation point. Building 841, constructed in 1993, was a flammable materials locker used for the storage of hazardous materials and petroleum products. The locker was located on a raised grassy area next to the paved aircraft wash rack between Buildings 824 and 825. Wash water from the rack discharged to storm drains in the pavement and eventually to storm sewers.

Building 846, the ground support equipment storage facility, was constructed in 1974 and was used to temporarily store equipment and materials until they were transferred to Building 1846. Hazardous materials reportedly stored at this facility included hydraulic fluid, jet fuel, compressed gas, epoxy resin, and petroleum naphtha. Buildings 852 and 870, constructed in 1988 and 1980, respectively, were used as hazardous materials storage lockers. Materials stored in these lockers may have included paint, floor adhesive, epoxy resin, polyamide epoxy, aliphatic naphtha, paint thinner, polyurethane coating, hydraulic fluid, and insulating oil. Building 1848 was built in 1985 and was used to store ground support equipment before it was issued for use on the runway [ABB Environmental Services, Inc. (ABB-ES), 1994].

The Day Tank 1 site is the former location of a 200,000-gallon aboveground storage tank (AST) that received jet fuel from the North Fuel Farm and supplied it to high-speed refuelers along the flightline. A retention pond north of the tank received wastewater and drained to the storm sewer system. Numerous spills have been reported over the course of site operations. As previously mentioned, the Day Tank 1 area is currently being investigated and remediated as part of the Petroleum Program and will not be evaluated in this FS.

1.1.2 Site 58

Figure 1-3 provides a site location map for Site 58, and Figure 1-4 provides the site layout and existing monitoring well locations. Previous investigations in this area were conducted under the petroleum program to investigate the aircraft wash rack. Investigations identified that groundwater was

contaminated with chlorinated compounds; therefore, the BCT made a decision that this area would be investigated under the IR program.

Building 312, a corrosion control hangar, was built in 1957 and previously housed administrative offices and two paint booths. Activities conducted in this building included sanding, priming, and corrosion control for jet aircraft and equipment. Associated structures included an abandoned hydraulic lift, an aircraft wash rack, an oil-water separator, and a waste oil underground storage tank (UST). Wastewater from the wash rack appears to have discharged to the storm sewer and sanitary sewer systems. Building 312LS, a sanitary sewer lift station built in 1957, served Building 312 and the wash rack. A small unnumbered building to the northeast of Building 312 was used as a hazardous waste satellite accumulation point (ABB-ES, 1994).

1.2 SITE INVESTIGATIONS

1.2.1 Site 57

The following investigations and studies have been conducted in and around Site 57:

- A contamination assessment conducted in 1996 documented soil and groundwater contamination at the site, and a Remedial Action Plan (RAP) was subsequently developed for the excavation of 20,000 tons of soil and installation of a biosparging/vapor collection groundwater remediation system (ABB-ES, 1997). In November 1999, the AST and approximately 24,000 tons of petroleum-contaminated soil were removed. Startup of the biosparge/vapor collection system was on February 29, 2000.

- As part of the Sampling and Analysis Outline and Report (SAOR) at Main Base Area 18 (MB-18), trichloroethene (TCE) and 1,1-dichloroethane (DCA) were detected in a direct-push technology (DPT) groundwater sample (85Q01301) collected from 13 feet below ground surface (bgs) in a temporary well located southeast of Building 824A [Harding Lawson Associates (HLA), 1999a]. The concentration of TCE detected was greater than the Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level (GCTL). A permanent monitoring well, CEF-824A-01Sa, was installed at this location, and analytical results from the sample identified as 85G01801 showed naphthalene and 2-methylnaphthalene at concentrations in excess of their GCTLs, and 1,1-DCA at a concentration less than its GCTL. TCE was not detected in this sample. This permanent well was re-sampled in May 2000, and analytical data indicated TCE and 2-methylnaphthalene at concentrations in excess of their GCTLs and naphthalene at a concentration less than its GCTL [Tetra Tech NUS, Inc. (TtNUS), 2000].

- Because of the proximity of existing wells installed and sampled as part of the Day Tank 1 investigation to the 824A wells and because of the presence of common groundwater contaminants (petroleum-related and chlorinated), it was decided that a more comprehensive evaluation of groundwater in the area was necessary. Four additional shallow monitoring wells (CEF-824A-02S through CEF-824A-05S) were installed to delineate groundwater contamination detected during the previous sampling and were sampled along with CEF-824A-01Sa in July 2000. In September 2000, an intermediate well (CEF-824A-06I) was installed at the CEF-824A-01Sa location, and a shallow well (CEF-824A-07S) was installed downgradient (southeast) of CEF-824A-01Sa to the north of the storm sewer running east-west through the area (TtNUS, 2000). The intermediate well was installed to investigate potential vertical migration of contamination, and CEF-824A-07S was installed to investigate potential impacts of the storm sewer on contaminant migration. These wells, along with six wells from the Day Tank 1 monitoring program (CEF-293-10, -11, -19, -20, -21, and –22) and CEF-825LS-1S, were sampled in January 2001. In addition, a round of synoptic water level measurements was obtained to investigate groundwater flow conditions.

- A quarterly groundwater monitoring program is ongoing for the biosparging and soil vapor extraction system at Day Tank 1. This program includes sampling of wells CEF-293-4, -9, -13, -20, and -21, and eight vapor extraction wells (VEW-1 through VEW-8) and analysis for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). VEW-1 was not sampled during the quarterly events, and VEW-2 was not sampled during the third quarterly event due to the presence of free product in these wells. VEW-1 has been bailed weekly since October 2000, and as of February 2001, approximately 10 gallons of free product had been recovered. The thickness of free product did not significantly decrease in VEW-1 during this time period. Free product was minimal in VEW-2 after June 2000, and no recovery has been conducted at this well (CH2MHill, 2001).

- A semi-annual groundwater monitoring program for Day Tank 1 was also implemented, which includes collection of samples from wells CEF-293-4, -11, -13, -14, -19, -20, and -21 and analysis for benzene, ethylbenzene, toluene, xylenes (BTEX), methyl tert-butyl ether (MTBE), and polynuclear aromatic hydrocarbons (PAHs).

- A groundwater investigation was performed as part of the RI (TtNUS, 2002). The objective of this investigation was to evaluate the nature and extent of groundwater contaminated with chlorinated VOCs and BTEX in the Building 824A/Day Tank 1 area. Ten new permanent wells, including five shallow, three intermediate, and two deep wells, were installed in the shallow Surficial Aquifer to delineate the horizontal and vertical extent of groundwater contamination. Shallow wells were installed to a depth of 15 feet bgs, intermediate wells were installed to 40 feet bgs, and deep wells were set at the bottom of the surficial sand unit. One round of groundwater level measurements and

sampling were performed in September 2001 on the 10 new wells and 31 existing wells. Two of the new wells and four of the existing wells were re-sampled in December 2001. Samples were analyzed for VOCs, PAHs, and total recoverable petroleum hydrocarbons (TRPH). In addition, samples collected from nine selected wells were analyzed for natural attenuation parameters.

- A free product investigation was performed as part of the RI. The objective of this investigation was to delineate the extent of the area of floating free product previously detected well CEF-293-VEW01. Thirteen temporary wells were installed to a depth of 15 feet bgs using DPT. Depth to groundwater and depth to free product were measured in these wells (TtNUS, 2002).

- As part of the RI, one surface water sample was collected at the discharge of the storm sewer in the area of wells CEF-824A-03S and -07S to investigate the potential impact of infiltration of contaminated groundwater into the storm sewers. Specific capacity (SPECAP) tests were performed in one shallow and one intermediate well to determine the hydrogeological characteristics of the Surficial Aquifer. Also as part of the RI, a soil sample was collected from the 36 to 38 feet bgs interval in well CEF-824A-15I and analyzed for geotechnical characteristics (grain size, porosity, specific gravity, and bulk density).

1.2.2 Site 58

The following investigations and studies have been conducted in and around Site 58:

- As part of field activities associated with the Sampling and Analysis Report (SAR), two groundwater samples, two sediment samples, and one subsurface soil sample were collected (ABB-ES, 1996). Sediment and subsurface soil samples were analyzed for SVOCs, pesticides, and inorganic compounds, and groundwater samples were analyzed for VOCs, SVOCs, and inorganic compounds. Groundwater samples were collected from wells CEF-312-01, located southeast of the wash rack catch basin, and CEF-312-02, located at the northeast corner of Building 312. Sediment samples were collected from a drainage swale south of Building 312 that received discharge from the wash rack. The subsurface soil sample was collected from 2 to 3 feet bgs at a location adjacent to the subsurface hydraulic lift cylinder housing. Naphthalene, aluminum, arsenic, iron, and manganese were detected in unfiltered groundwater samples at concentrations greater than screening criteria. Arsenic was detected in sediment in excess of screening criteria. No analytes were detected in subsurface soil in excess of screening criteria. Based on human health and ecological Preliminary Risk Evaluations (PREs) performed as part of the SAR investigation, it was concluded that concentrations of analytes in groundwater, sediment, and subsurface soil did not pose risks to human health or the environment.

- To investigate previous exccedances of groundwater criteria, monitoring well CEF-312-01 was resampled in 1999 for total and dissolved iron and manganese and naphthalene. Total and dissolved manganese concentrations were less than their FDEP GCTL and NAS Cecil Field Inorganic Background Data Set (IBDS) value (HLA, 1998). Total and dissolved iron concentrations were greater than their GCTL and IBDS value, and the naphthalene concentration was greater than its GCTL. Based on the SAR Addendum issued with these results, it was decided that the groundwater at the site would be evaluated under the petroleum program (TtNUS, 1999).

- The Phase I Groundwater Assessment included the installation and sampling three shallow monitoring wells at the site. CEF-B312-1S was installed west of existing well CEF-312-01, and CEF-B312-02S and CEF-B312-03S were installed northeast and southeast, respectively, of CEF-312-01. Groundwater samples from these wells were analyzed for constituents of the FDEP Kerosene Analytical Group (KAG) including VOCs, PAHs, and lead (FDEP, 1999d). Naphthalene and TRPH concentrations exceeded their GCTLs in the three wells, and the vinyl chloride concentration detected in well CEF-B312-03S exceeded its GCTL.

- The Phase II Groundwater Assessment included installation of five additional shallow wells (CEF-B312-04S, -05S, -06S, -07S, and -08S) and one intermediate well (CEF-B312-01I). Groundwater samples were collected from CEF-312-01 and the nine new and existing Phase I and Phase II wells and analyzed for KAG parameters. Exceedances of GCTLs in Phase II sampling included:

  - CEF-312-01 – Naphthalene
  - CEF-B312-01S – 1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, and TRPH
  - CEF-B312-02S – Naphthalene
  - CEF-B312-03S – Naphthalene, vinyl chloride, and 1,1-dichloroethene (DCE)
  - CEF-B312-06S – Naphthalene
  - CEF-B312-08S – 1-DCE, 1,1-DCA, naphthalene

Based on the results of the Phase I and Phase II Groundwater Assessments, it was decided that groundwater in the Building 312 area would be addressed under the IR program.

- A groundwater investigation was performed as part of the RI. The objective of this investigation was to evaluate the nature and extent of groundwater contaminated with chlorinated compounds, naphthalene, and BTEX in the Building 312 area. A total of seven new permanent wells, including six shallow and one intermediate well, were installed to delineate the horizontal and vertical extent of groundwater contamination. Shallow wells were installed to approximately 15 feet bgs, and the

intermediate well was installed to a depth of 40 feet bgs. One round of groundwater level measurements and sampling was performed in September 2001 on the seven new wells and eleven existing wells. In December 2001, a second round of groundwater level measurements was performed and one well (CEF-B312-08S) was re-sampled. Samples were analyzed for VOCs, PAHs, and TRPH. In addition, samples collected from five selected wells were analyzed for natural attenuation parameters. Three chlorinated VOCs [1,1,1-trichloroethane (1,1,1-TCA), 1,1-DCA, and 1,1-DCE] and xylenes were detected in well CEF-B312-08S at concentrations greater than the GCTLs in the September 2001, but not in December 2001. Naphthalene and TRPH were detected at concentrations greater than GCTLs both in September and December 2001.

- As part of the RI, a SPECAP test was performed in one shallow well to determine the hydrogeological characteristics of the Surficial Aquifer. Three sediment samples were collected from the drainage ditch south of Building 312 to investigate potential migration of contaminants. These samples were analyzed for VOCs, PAHs, and TRPH. Also as part of the RI, a soil sample was collected from the 6 to 8 feet bgs interval in well CEF-B312-10S and analyzed for geotechnical characteristics (grain size, porosity, specific gravity, and bulk density).

1.3 SUMMARY OF INVESTIGATIONS FINDINGS

1.3.1 Nature and Extent of Soil Contamination

Analytical results for soil samples collected at Site 58 are summarized on Table 1-1 and illustrated on Figure 1-5. Although these samples were collected in a drainage ditch and were therefore classified during the RI as sediment samples, this ditch is almost always dry and, for the purpose of this FS, these samples are classified as soil. As indicated by the results of the RI, a small area in the vicinity of sampling location CEF-B312-SD-001 that received discharges from the aircraft wash rack had concentrations of PAHs in excess of the FDEP Soil Cleanup Target Levels (SCTLs) for direct residential exposure (FDEP, 1999a). Samples collected downstream did not have PAH exceedances.

1.3.2 Nature and Extent of Groundwater Contamination

1.3.2.1 Site 57

Analytical results for the groundwater samples collected at Site 57 are summarized on Table 1-2 and illustrated on Figures 1-6 through 1-8. As indicated by these results, a Site 57 Petroleum Plume, defined by benzene concentrations greater than the GCTL of 1.0 microgram per liter (µg/L), extends from the eastern side of Building 846 toward the southeast to the area east of Building 824A. This plume outline also generally encompasses exceedances of toluene, ethylbenzene, xylenes, PAHs, and TRPH. Just east of Building 846, the Site 57 Petroleum Plume is limited to the shallow portion of the Surficial Aquifer,

but extends into the intermediate zone to the west (CEF-824A-12I). The Site 57 Petroleum Plume extends approximately 750 feet to the southeast and has an average width of approximately 225 feet.

A Site 57 TCE Plume, defined by TCE concentrations greater than the GCTL of 3 µg/L, is centered to the east of the Site 57 Petroleum Plume and partially overlaps that plume. The Site 57 TCE Plume reaches down to the intermediate zone of the Surficial Aquifer and, with the exception of the 1,1-DCE exceedance at CEF-824A-08S, the outline of this plume encompasses other chlorinated exceedances at Site 57. The Site 57 TCE Plume extends approximately 250 feet to the southeast and has an average width of approximately 180 feet.

Chlorinated VOCs detected during the RI and in previous investigations in wells to the southeast of the Site 57 TCE Plume (CEF-824A-01Sa, CEF-824A-07S, CEF-824A-08S) do not appear to be associated with that plume as defined by current data. The lack of detections of chlorinated VOCs in wells CEF-293-20, CEF-293-21, and CEF-824A-04S, located between the downgradient edge of the plume and these wells, support this conclusion. Exceedances of GCTLs by chlorinated VOCs are limited to the shallow portion of the Surficial Aquifer in both of these areas. No potential sources of chlorinated VOCs were identified in either area and the presence of that type of contamination is likely a result of past spills, leaks, and/or poor materials handling practices. Solvents were reportedly used and stored in several buildings associated with Site 57.

A surface water sample collected from the storm sewer outfall that receives discharge from Site 57 indicates that surface water quality is not being affected by contaminated groundwater potentially infiltrating into the storm sewer. Surface water analytical data are summarized on Table 1-3.

An area of floating free product, approximately 400 square feet (ft^2) in size, was also delineated during the RI. This area is located east of the Day Tank 1 excavation area and extends beneath Building 846. The suspected source of the free product is a pipeline that transported fuel from Day Tank 1 to the north-south high-speed refueler. The line was capped, but not purged, during Day Tank 1 excavation activities. Because the Navy decided to address this area of floating free product under the ongoing remedial activities for Day Tank 1, it will not be further evaluated in this FS.

1.3.2.2 Site 58

Analytical results for the groundwater samples collected at Site 58 are summarized on Table 1-4 and illustrated on Figures 1-9 through 1-11. As indicated by these results, naphthalene was detected in excess of its FDEP GCTL in four shallow wells and the Site 58 Naphthalene Plume is delineated by naphthalene concentrations greater than the GCTL of 20 µg/L. This plume is located southeast of Building 312 and is approximately 230 feet by 100 feet in size. This Site 58 Naphthalene Plume

encompasses the TRPH exceedance at CEF-B312-01S, which is the only other confirmed GCTL exceedance detected during the RI. The outline of the Site 58 Naphtahlene Plume also encompasses well CEF-B312-08S where three chlorinated VOCs (1,1-DCA, 1,1-DCE, 1,1,1-TCA) and xylenes were detected at concentrations greater than their GCTLs during the September 2001 sampling but not during the December 2001 sampling.

1.3.3 Human Health Risk Assessment

1.3.3.1 Site 57

The PRE performed as part of the RI for Site 57 indicates that exposure to soil and groundwater could potentially result in adverse health effects (TtNUS, 2002). Constituents resulting in incremental cancer risks (ICRs) exceeding the United States Environmental Protection Agency (U.S. EPA) risk range of 1.0E-06 to 1.0E-04 and the FDEP's target risk of 1.0E-06 include benzene, 1,1-DCE, and TCE. Constituents resulting in non carcinogenic risks exceeding the allowable Hazard Quotient (HQ) of 1.0 include cis-1,2-DCE and naphthalene.

1.3.3.2 Site 58

The PRE performed as part of the RI for Site 58 indicates that exposure to groundwater could potentially result in adverse health effects (TtNUS, 2002). Some naphthalene concentrations could result in non carcinogenic risks exceeding a HQ of 1.0. The PRE also established that adverse effects would be expected as a result of direct residential exposure to soil from the drainage ditch.

1.3.4 Ecological Risk Assessment

Sites 57 and 58 consist primarily of buildings and parking lots. Most areas are either paved or consist of buildings. The limited terrestrial habitat is of marginal quality and results in little use of the site by terrestrial wildlife; therefore, the soil exposure pathway is negligible, and an ecological risk assessment was not conducted for soil contaminants.

1.4 DOCUMENT ORGANIZATION

This FS Report has been organized with the intent of meeting the general format requirements specified in the RI/FS Guidance Document (U.S. EPA, 1988). This report features the following five section:

- Section 1.0, Introduction, summarizes the purpose of the report, provides site background information, summarizes findings of the RI, and provides the report outline.

- Section 2.0, RAOs and General Response Actions (GRAs), presents the RAO, identifies Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) criteria, develops soil and groundwater cleanup goals and associated GRAs, and provides an estimate of the volume of contaminated media to be remediated.

- Section 3.0, Screening of Remediation Technologies and Process Options, provides a two-tiered screening of potentially applicable soil and groundwater remediation technologies and identifies the technologies that will be assembled into remedial alternatives.

- Section 4.0, Assembly and Detailed Analysis of Remedial Alternatives, assembles the remedial technologies retained from the Section 3.0 screening process into multiple soil and groundwater remedial alternatives, describes these alternatives, and performs a detailed analysis of these alternatives in accordance with seven CERCLA criteria.

- Section 5.0, Comparative Analysis of Remedial Alternatives, compares the soil and groundwater remedial alternatives on a criterion-by-criterion basis, for each of the seven CERCLA analysis criteria used in Section 4.

TABLE 1-1

SUMMARY OF SITE 58 SOIL/SEDIMENT RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

PARAMETER	FDEP Residential SCTL	FDEP Leachability SCTL	CEF-B312-SD-001		CEF-B312-SD-002	CEF-B312-SD-003
			Sample	Duplicate		
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs) (ug/kg)						
Benzo(a)anthracene	1,400	3,200	**2650**(1)	**430 U**(1)	400 U	420 U
Benzo(a)pyrene	100	8,000	**3030**(1)	**108**(1)	**78.3 J**	84 U
Benzo(b)fluoranthene	1,400	10,000	**1570**(2)	**95**(2)	**70.7 J**	84 U
Benzo(g,h,i)perylene	2,300,000	32,000,000	**3400**	**245**	**152**	84 U
Benzo(k)fluoranthene	15,000	25,000	**775**	**59.1 J**	**44.4 J**	84 U
Chrysene	140,000	77,000	**2770**	430 U	400 U	420 U
Dibenzo(a,h)anthracene	100	30,000	**301 J**(1)	86 U(1)	80 U	84 U
Fluoranthene	2,900,000	1,200,000	**6790**	**240 J**	**169 J**	420 U
Indeno(1,2,3-cd)pyrene	1,500	28,000	**2030**(2)	**134**(2)	**87.7**	84 U
Phenanthrene	2,000,000	250,000	**5790**	430 U	400 U	420 U
Pyrene	2,200,000	880,000	**5820**	**209 J**	**178 J**	420 U
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) (mg/kg)						
TRPH	340	340	**192**(2)	**426**(2)	**127**	**83.8**

NOTES:

U = Not detected at or above detection limit (associated value).

J = Estimated concentration.

FDEP SCTLs = Florida Department of Environmental Protection Soil Cleanup Target Levels from Florida Administrative Code (FAC) 62-777 (FDEP, 1999).

Bolded values exceed detection limit.

Shaded values exceed residential SCTL.

1 Average of sample and duplicate exceeds residential SCTL. If sample or duplicate is non-detect, one-half the detection limit used to calculate average.

2 Average of sample and duplicate does not exceed residential SCTL. If sample or duplicate is non-detect, one-half the detection limit used to calculate average.

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-293-1	CEF-293-3	CEF-293-4	CEF-293-5	CEF-293-8	CEF-293-10	CEF-293-11	
								Sep-01	Dec-01
VOLATILE ORGANIC COMPOUNDS (VOCs) (ug/L)									
Acetone	700	50 U	50 U	50 U	50 U	50 U	50 U	250 U	250 U
Benzene	1	1 U	1 U	1 U	1 U	1 U	1 U	30.5	32
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
cis-1,2-Dichloroethene	70	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
1,1-Dichloroethane	70	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
1,1-Dichloroethene	7	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
Ethylbenzene	30	2 U	2 U	2 U	2 U	2 U	2 U	148	151
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	10 U	10 U	50 U	50 U
Methylene chloride	5	5 U	5 U	5 U	5 U	5 U	5 U	25 U	25 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
Tetrachloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
Toluene	40	2 U	2 U	2 U	2 U	2 U	2 U	66	59.6
trans-1,2-Dichloroethene	31	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
Trichloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	10 U	10 U
Xylenes, total	20	6 U	6 U	6 U	6 U	6 U	6 U	572	549
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) (ug/L)									
Acenaphthene	20	4.4 U	4.4 U	4.4 U	4 U	4.4 U	4.4 U	21 U	20 U
1-Methylnaphthalene	20	2.2 U	2.2 U	2.2 U	2 U	2.2 U	2.2 U	60.4	84.8
2-Methylnaphthalene	20	2.2 U	2.2 U	2.2 U	2 U	2.2 U	2.2 U	57.5	84.8
Naphthalene	20	2.2 U	2.2 U	2.2 U	2 U	**2.2**	**5.6**	126	155
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) (mg/L)									
TRPH	5	**0.254 J**	0.28 U	0.28 U	0.28 U	**0.643**	**0.335**	**2.46**	5.95

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-293-13		CEF-293-14	CEF-293-15D	CEF-293-19	CEF-293-20	CEF-293-21		CEF-293-22
		Sample	Duplicate					Sample	Duplicate	
VOCs (ug/L)										
Acetone	700	50 U	50 U	50 U	50 U	**190**	50 U	50 U	50 U	50 U
Benzene	1	1 U	1 U	1 U	1 U	**1.8**	**0.87 J**	**30.8**	**28.9**	**5.3**
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	70	2 U	2 U	2 U	2 U	**825**	**136**	2 U	2 U	2 U
1,1-Dichloroethane	70	2 U	2 U	2 U	2 U	**58.6**	**1.6 J**	2 U	2 U	2 U
1,1-Dichloroethene	7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene	30	2 U	2 U	2 U	2 U	**5**	2 U	**2.7**	**2.8**	2 U
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	**76.1**	10 U	10 U	10 U	10 U
Methylene chloride	5	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Toluene	40	2 U	2 U	2 U	2 U	**33.4**	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	31	2 U	2 U	2 U	2 U	**5.1**	**0.52 J**	2 U	2 U	2 U
Trichloroethene	3	2 U	2 U	2 U	2 U	**43**	**3.3**	2 U	2 U	2 U
Xylenes, total	20	6 U	6 U	6 U	6 U	**31.8**	6 U	**4.1 J**	**4.9 J**	6 U
SVOCs (ug/L)										
Acenaphthene	20	4 U	4 U	4 U	4.4 U	8 U	4 U	4.4 U	4.4 U	4.4 U
1-Methylnaphthalene	20	**1.4 J**	**2.0**	2 U	2.2 U	4 U	2 U	**2.2**	**2.5**	**10.9**
2-Methylnaphthalene	20	**1.6 J**	**2.4**	2 U	2.2 U	4 U	2 U	**2.2**	**2.6**	**11.6**
Naphthalene	20	2 U	2 U	**2.9**	2.2 U	**46**	**1.2 J**	**2.5**	**3**	**14.7**
TRPH (mg/L)										
TRPH	5	**0.404**	**0.372**	**0.944**	0.28 U	**4.44**	**0.58**	**0.269**	**0.242 J**	**0.946**

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-824A-01S	CEF-824A-01Sa		CEF-824A-2S	CEF-824A-3S	CEF-824A-4S		CEF-824A-5S	CEF-824A-6I
			Sep-01	Dec-01			Sample	Duplicate		
VOCs (ug/L)										
Acetone	700	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Benzene	1	1 U	1 U	1 U	1 U	1 U	254	242	1 U	1 U
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	70	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	70	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethene	7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene	30	2 U	2 U	2 U	2 U	2 U	**27.8**	**20.7**	2 U	2 U
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	5	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Toluene	40	2 U	2 U	2 U	2 U	2 U	**2.3**	**1.7 J**	2 U	2 U
trans-1,2-Dichloroethene	31	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Xylenes, total	20	6 U	6 U	6 U	6 U	6 U	71.6	51.9	6 U	6 U
SVOCs (ug/L)										
Acenaphthene	20	**2.4 J**	4.4 U	4 U	4.4 U	4 U	8.8 U	8.8 U	4.4 U	4.4 U
1-Methylnaphthalene	20	2 U	**2.1 J**	**1.2 J**	**0.93 J**	2 U	**7.8**	**7.4**	2.2 U	2 U
2-Methylnaphthalene	20	2 U	**3.7**	**2**	**1.6 J**	2 U	**8.9**	**8.6**	2.2 U	2 U
Naphthalene	20	2 U	2.2 U	2 U	2.2 U	2 U	30.3	30.8	2.2 U	2 U
TRPH (mg/L)										
TRPH	5	0.28 U	**0.482**	**0.438**	0.28 U	0.25 U	**1.72**	**1.69**	0.28 U	**0.267**

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 4 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-824A-7S		CEF-824A-8S	CEF-824A-9S	CEF-824A-10S	CEF-824A-11S		CEF-824A-12I	CEF-824A-13D
		Sep-01	Dec-01				Sep-01	Dec-01		
VOCs (ug/L)										
Acetone	700	50 U	50 U	50 U	50 U	50 U	50 U	250 U	50 U	50 U
Benzene	1	3.8	2	1.5	1 U	1 U	8.7	7.6	3.5	1 U
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	10 U	2 U	2 U
cis-1,2-Dichloroethene	70	2 U	2 U	0.94 J	2 U	3.7	2 U	10 U	2 U	2 U
1,1-Dichloroethane	70	1.1 J	2.9	9.9	2.4	1.1 J	2 U	10 U	2 U	2 U
1,1-Dichloroethene	7	2 U	2 U	33.8	2 U	2 U	2 U	10 U	2 U	2 U
Ethylbenzene	30	2.3	2.1	2 U	2 U	8.6	84.9	85.4	10.4	2 U
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U	10 U
Methylene chloride	5	5 U	5 U	5 U	5 U	3 J	5 U	25 U	5 U	5 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	10 U	2 U	2 U
Tetrachloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	10 U	1 J	2 U
Toluene	40	2 U	2 U	2 U	2 U	1.0 J	56.6	43.2	2 U	2 U
trans-1,2-Dichloroethene	31	2 U	2 U	2 U	2 U	2 U	2 U	10 U	2 U	2 U
Trichloroethene	3	4.8	0.84 J	2 U	1 J	2 U	2 U	10 U	2 U	2 U
Xylenes, total	20	2.8 J	6 U	1.9 J	6 U	4.0 J	334	305	36.2	6 U
SVOCs (ug/L)										
Acenaphthene	20	4 U	4 U	4.4 U	4 U	20 U	80 U	40 U	4.4 U	4 U
1-Methylnaphthalene	20	25.5	24.6	2.2 U	2 U	15.7	175	145	12.5	2 U
2-Methylnaphthalene	20	30.4	30.9	2.2 U	2 U	16.8	196	172	12.3	2 U
Naphthalene	20	13.9	25.7	2.2 U	2 U	128	438	354	49.1	2 U
TRPH (mg/L)										
TRPH	5	1.67	2.13	0.30 U	0.352	4.83	13.6	15.0	3.28	0.25 U

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 5 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-824A-14S	CEF-824A-15I	CEF-824A-16D	CEF-824A-17I	CEF-824A-18S	CEF-824A-19S	CEF-824A-20S	CEF-824A-21I**
VOCs (ug/L)									
Acetone	700	100 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Benzene	1	2 U	1 U	1 U	1 U	1 U	1 U	1 U	**1.8**
Chloroform	5.7	4 U	4 U	**0.92 J**	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	70	**139**	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	70	**97.2**	2 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1-Dichloroethene	7	**5.0**	2 U	2 U	2 U	2 U	2 U	1 U	2 U
Ethylbenzene	30	**4.4**	**1.0 J**	2 U	2 U	2 U	2 U	1 U	**2.2**
4-Methyl-2-pentanone	560	20 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	5	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	3	4 U	**1.5 J**	2 U	2 U	2 U	2 U	1 U	2 U
Toluene	40	**4.9**	2 U	2 U	2 U	2 U	2 U	1 U	**1.5 J**
trans-1,2-Dichloroethene	31	4 U	2 U	2 U	2 U	2 U	2 U	NA	2 U
Trichloroethene	3	**9.0**	2 U	2 U	2 U	2 U	2 U	1 U	2 U
Xylenes, total	20	**4.9 J**	**5.2 J**	6 U	**4.3 J**	6 U	6 U	1 U	**9**
SVOCs (ug/L)									
Acenaphthene	20	4 U	4 U	4.4 U	4.4 U	4.4 U	4 U	4.4 U	4 U
1-Methylnaphthalene	20	2 U	**2.0**	2.2 U	2.2 U	2.2 U	2 U	2.2 U	**10.5**
2-Methylnaphthalene	20	2 U	2 U	2.2 U	2.2 U	2.2 U	2 U	2.2 U	**13.3**
Naphthalene	20	2 U	**2.4**	2.2 U	2.2 U	2.2 U	2 U	2.2 U	**6.3**
TRPH (mg/L)									
TRPH	5	**2.01**	**1.21**	0.28 U	**0.533**	0.28 U	0.28 U	0.28 U	**0.744**

TABLE 1-2

SUMMARY OF SITE 57 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 6 OF 6

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-824A-22S**		CEF-825LS-1S	CEF-16-38S		CEF-16-39I	CEF-16-40D	REGION IX PRGs(2)	FEDERAL MCLs(3)
		Sample	Duplicate		Sample	Duplicate				
VOCs (ug/L)										
Acetone	700	50 U	50 U	50 U	50 U	50 U	50 U	50 U	610	NC
Benzene	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.35	5
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	0.16	NC
cis-1,2-Dichloroethene	70	2 U	2 U	2 U	NA	2 U	2 U	2 U	61	70
1,1-Dichloroethane	70	2 U	2 U	2 U	1 U	2 U	2 U	2 U	810	NC
1,1-Dichloroethene	7	2 U	2 U	2 U	1 U	2 U	2 U	2 U	0.046	7
Ethylbenzene	30	2 U	2 U	2 U	1 U	2 U	2 U	2 U	1300	700
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	10 U	10 U	10 U	160	NC
Methylene chloride	5	5 U	5 U	5 U	5 U	5 U	5 U	5 U	4.3	NC
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	2 U	20	NC
Tetrachloroethene	3	2 U	2 U	2 U	1 U	2 U	2 U	2 U	1.1	5
Toluene	40	2 U	2 U	2 U	1 U	2 U	2 U	2 U	720	1000
trans-1,2-Dichloroethene	31	2 U	2 U	2 U	1 U	2 U	2 U	2 U	120	100
Trichloroethene	3	2 U	2 U	2 U	1 U	2 U	2 U	2 U	1.6	5
Xylenes, total	20	6 U	6 U	6 U	6 U	6 U	6 U	6 U	1400	10000
SVOCs (ug/L)										
Acenaphthene	20	4 U	4.8 U	4 U	4.4 U	4.4 U	4.4 U	4.4 U	NC	NC
1-Methylnaphthalene	20	2 U	2.4 U	2 U	2.2 U	2.2 U	2.2 U	2.2 U	NC	NC
2-Methylnaphthalene	20	2 U	2.4 U	2 U	2.2 U	2.2 U	2.2 U	2.2 U	NC	NC
Naphthalene	20	2 U	2.4 U	2 U	2.2 U	2.2 U	2.2 U	2.2 U	6.2	NC
TRPH (mg/L)										
TRPH	5	0.28 U	0.28 U	**0.203 J**	0.28 U	0.25 U	0.25 U	0.25 U	NC	NC

U = Not detected at or above method detection limit as listed.
J = Estimated value.
NA = Not analyzed.
NC = No criterion.
Bolded values exceed detection limits.
Shaded values exceed target cleanup goals.

RI sampling was conducted in September/October 2001.
(1) FDEP GCTL, F.A.C. 62-777, 1999.
(2) U.S. EPA Region IX PRGs.
(3) U.S. EPA federal MCLs.
* Total of o-, m-, and p-xylenes.
** Wells CEF-824A-21I and CEF-824A-22S were installed in December 2001.

TABLE 1-3

SUMMARY OF SITE 57 SURFACE WATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-824A-SW01
VOLATILE ORGANIC COMPOUNDS (VOCs) (ug/L)		
Benzene	71.28	1 U
cis-1,2-Dichloroethene	NC	2 U
1,1-Dichloroethane	NC	2 U
1,1-Dichloroethene	3.2	2 U
Ethylbenzene	605	2 U
Tetrachloroethene	8.85	2 U
Toluene	475	2 U
trans-1,2-Dichloroethene	11000	2 U
Trichloroethene	80.7	2 U
Xylenes, total	370	6 U
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) (ug/L)		
1-Methylnaphthalene	95	2 U
2-Methylnaphthalene	30	2 U
Naphthalene	26	2 U
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) (mg/L)		
TRPH	5	0.28 U

NOTES:

(1) Florida Department of Environmental Protection (FDEP) Freshwater Surface Water Criteria, Forida Administrative Code (FAC) Chapter 62-777 (FDEP, 1999).

NC = No criterion.

U = Not detected at or above detection limit (associated value).

CEF-824A-SW01 was collected at Runway Outfall No. 4, the discharge point for storm sewer runoff from the Site 57 area.

TABLE 1-4

SUMMARY OF SITE 58 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 3

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-						
		312-01	312LS-01Sa	B312-01I	B312-01S	B312-02S	B312-03S	B312-04S
VOLATILE ORGANIC COMPOUNDS (VOCs) (ug/L)								
Acetone	700	50 U	50 U	50 U	**122 J**	50 U	50 U	50 U
Benzene	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	4200	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	70	**9.1**	2 U	2 U	**6.8**	**14.3**	2 U	**2.2**
1,1-Dichloroethene	7	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene	30	**0.48 J**	2 U	2 U	2 U	2 U	2 U	2 U
4-Methyl-2-pentanone	560	10 U	10 U	10 U	**36.9**	10 U	10 U	10 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Toluene	40	2 U	2 U	2 U	**1.6 J**	2 U	2 U	2 U
Trichloroethene	3	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1,1-Trichloroethane	200	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Vinyl chloride	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylenes, total	20	**0.60 J**	6 U	6 U	**4.1 J**	6 U	6 U	6 U
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) (ug/L)								
1-Methylnaphthalene	20	2.2 U	2.2 U	2.2 U	16 U	2 U	**2**	2 U
2-Methylnaphthalene	20	2.2 U	2.2 U	2.2 U	16 U	2 U	2 U	2 U
Naphthalene	20	**49.5**	2.2 U	2.2 U	**156**	**8.3**	**1.9 J**	**0.96 J**
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) (mg/L)								
TRPH	5	**1.36**	0.28 U	0.28 U	**9.00**	**3.10**	**1.85**	0.28 U

TABLE 1-4

SUMMARY OF SITE 58 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 3

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-								
		B312-05S		B312-06S	B312-07S	B312-08S*			B312-09S	B312-10S
						Sep-01		Dec-01		
		Sample	Duplicate			Sample	Duplicate			
VOCs (ug/L)										
Acetone	700	50 U	50 U	50 U	50 U	500 U	500 U	50 U	50 U	50 U
Benzene	1	1 U	1 U	1 U	1 U	10 U	10 U	1 U	1 U	1 U
2-Butanone	4200	10 U	10 U	10 U	10 U	100 U	100 U	10 U	10 U	10 U
Chloroform	5.7	2 U	2 U	2 U	2 U	20 U	20 U	2 U	2 U	**1 J**
1,1-Dichloroethane	70	**1.7 J**	**1.7 J**	**1.0 J**	2 U	426	416	**24.1**	2 U	2 U
1,1-Dichloroethene	7	2 U	2 U	2 U	2 U	131	129	2 U	2 U	2 U
Ethylbenzene	30	2 U	2 U	2 U	2 U	**15.1 J**	**12.3 J**	**1.9 J**	2 U	2 U
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	100 U	100 U	10 U	10 U	10 U
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	20 U	20 U	2 U	2 U	2 U
Toluene	40	2 U	2 U	2 U	2 U	**24.6**	**21.7**	**1.3 J**	2 U	2 U
Trichloroethene	3	2 U	2 U	2 U	2 U	20 U	20 U	2 U	2 U	2 U
1,1,1-Trichloroethane	200	2 U	2 U	2 U	2 U	871	811	**66.1**	2 U	2 U
Vinyl chloride	1	1 U	1 U	1 U	1 U	10 U	10 U	1 U	1 U	1 U
Xylenes, total	20	6 U	6 U	6 U	6 U	70.3	59.7 J	**8.7**	6 U	6 U
SVOCs (ug/L)										
1-Methylnaphthalene	20	2.2 U	2.2 U	**4.5**	2 U	**5.1**	**5.1**	NA	2.2 U	2.2 U
2-Methylnaphthalene	20	2.2 U	2.2 U	**3.5**	2 U	**4.7**	**4.6**	NA	2.2 U	2.2 U
Naphthalene	20	2.2 U	**1.3 J**	47.6	2 U	80	76.3	NA	2.2 U	2.2 U
TRPH (mg/L)										
TRPH	5	**0.567**	**0.607 J**	**2.89**	0.25 U	**1.29**	**1.18**	NA	0.28 U	0.28 U

TABLE 1-4

SUMMARY OF SITE 58 GROUNDWATER RI ANALYTICAL DATA
OU 9, SITES 57 AND 58 FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 3

PARAMETER	TARGET CLEANUP GOAL(1)	CEF-					REGION IX PRGs(2)	FEDERAL MCLs(3)
		B312-11S	B312-12S	B312-13S	B312-14S	B312-15I		
VOCs (ug/L)								
Acetone	700	50 U	50 U	50 U	50 U	50 U	610	NA
Benzene	1	1 U	1 U	1 U	1 U	1 U	0.35	5
2-Butanone	4200	10 U	**5.1 J**	10 U	10 U	10 U	1900	NA
Chloroform	5.7	2 U	2 U	2 U	2 U	2 U	0.16	NA
1,1-Dichloroethane	70	**5.7**	**3.7**	**5.1**	2 U	2 U	810	NC
1,1-Dichloroethene	7	**1.6 J**	**1.8 J**	2 U	2 U	2 U	0.046	7
Ethylbenzene	30	**1.1 J**	2 U	2 U	2 U	2 U	1300	700
4-Methyl-2-pentanone	560	10 U	10 U	10 U	10 U	10 U	1600	NA
Methyl tert-butyl ether	50	2 U	2 U	2 U	2 U	2 U	20	NA
Toluene	40	2 U	2 U	2 U	2 U	2 U	720	1000
Trichloroethene	3	2 U	2 U	2 U	2 U	2 U	1.6	5
1,1,1-Trichloroethane	200	2 U	2 U	2 U	2 U	2 U	540	200
Vinyl chloride	1	1 U	1 U	1 U	1 U	1 U	0.014	2
Xylenes, total	20	**3 J**	6 U	6 U	6 U	6 U	1400	10000
SVOCs (ug/L)								
1-Methylnaphthalene	20	**3.5**	2 U	2.2 U	2 U	2.2 U	NC	NC
2-Methylnaphthalene	20	2 U	2 U	2.2 U	2 U	2.2 U	NC	NC
Naphthalene	20	2 U	**1.7 J**	2.2 U	2 U	2.2 U	6.2	NC
TRPH (mg/L)								
TRPH	5	**2.19**	0.25 U	**0.84**	0.25 U	0.28 U	NC	NC

NOTES:
NA = Not analyzed.
Bolded values exceed detection limits.
Shaded values exceed GCTLs.
U = Not detected at or above method detection limit as listed.

RI sampling was conducted in September/October 2001.
* CEF-B312-08S was resampled in December 2001.

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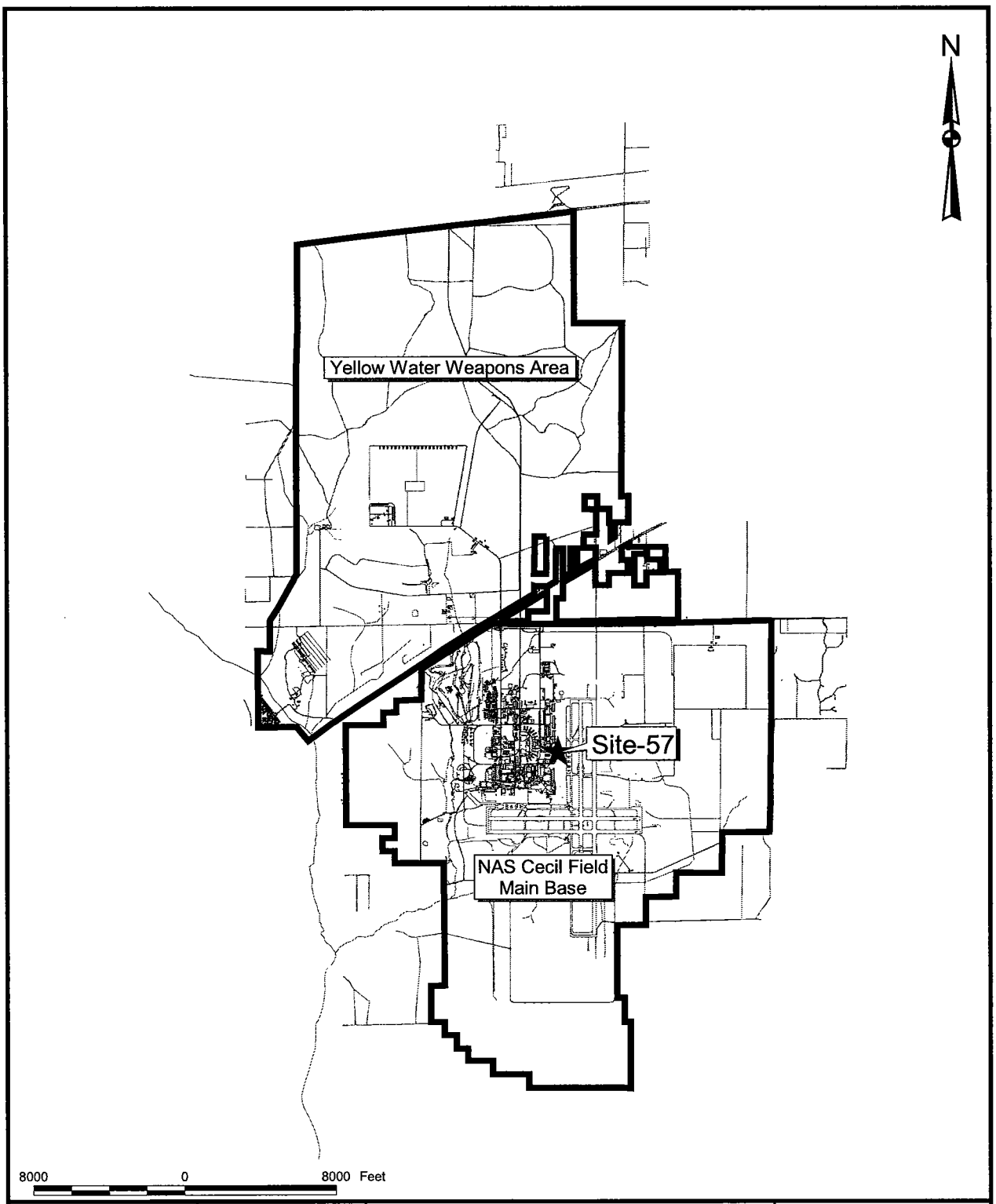

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CHECKED BY	DATE		APPROVED BY DATE 04/08/02
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 REV 0

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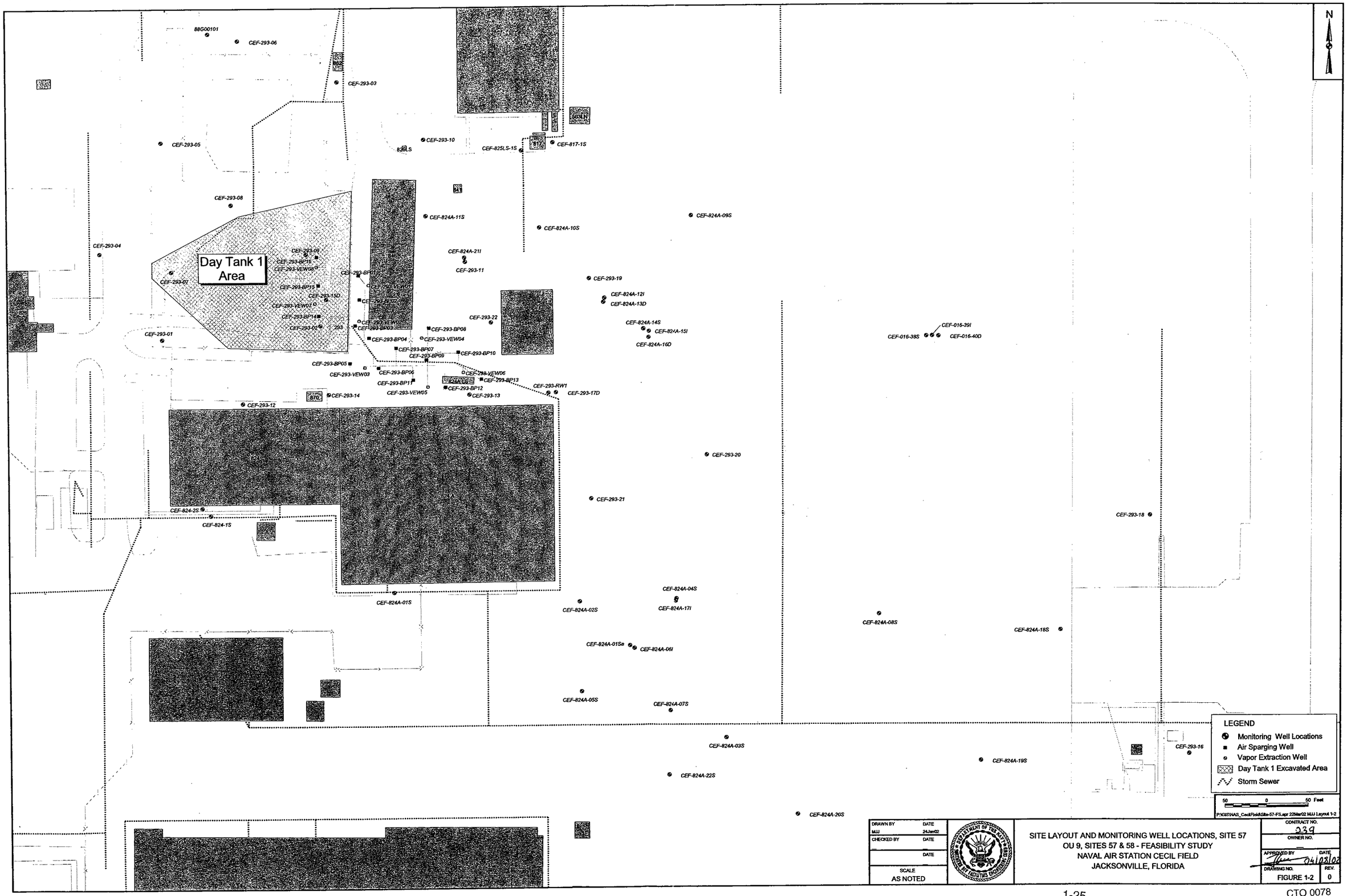
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Day Tank 1 Area
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CEF-293-03
CEF-293-05
CEF-293-10
CEF-825LS-1S
CEF-817-1S
CEF-293-08
CEF-824A-11S
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CEF-824A-19S
CEF-824A-22S
CEF-824A-20S
LEGEND
Monitoring Well Locations
Air Sparging Well
Vapor Extraction Well
Day Tank 1 Excavated Area
Storm Sewer
50 0 50 Feet
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CHECKED BY DATE
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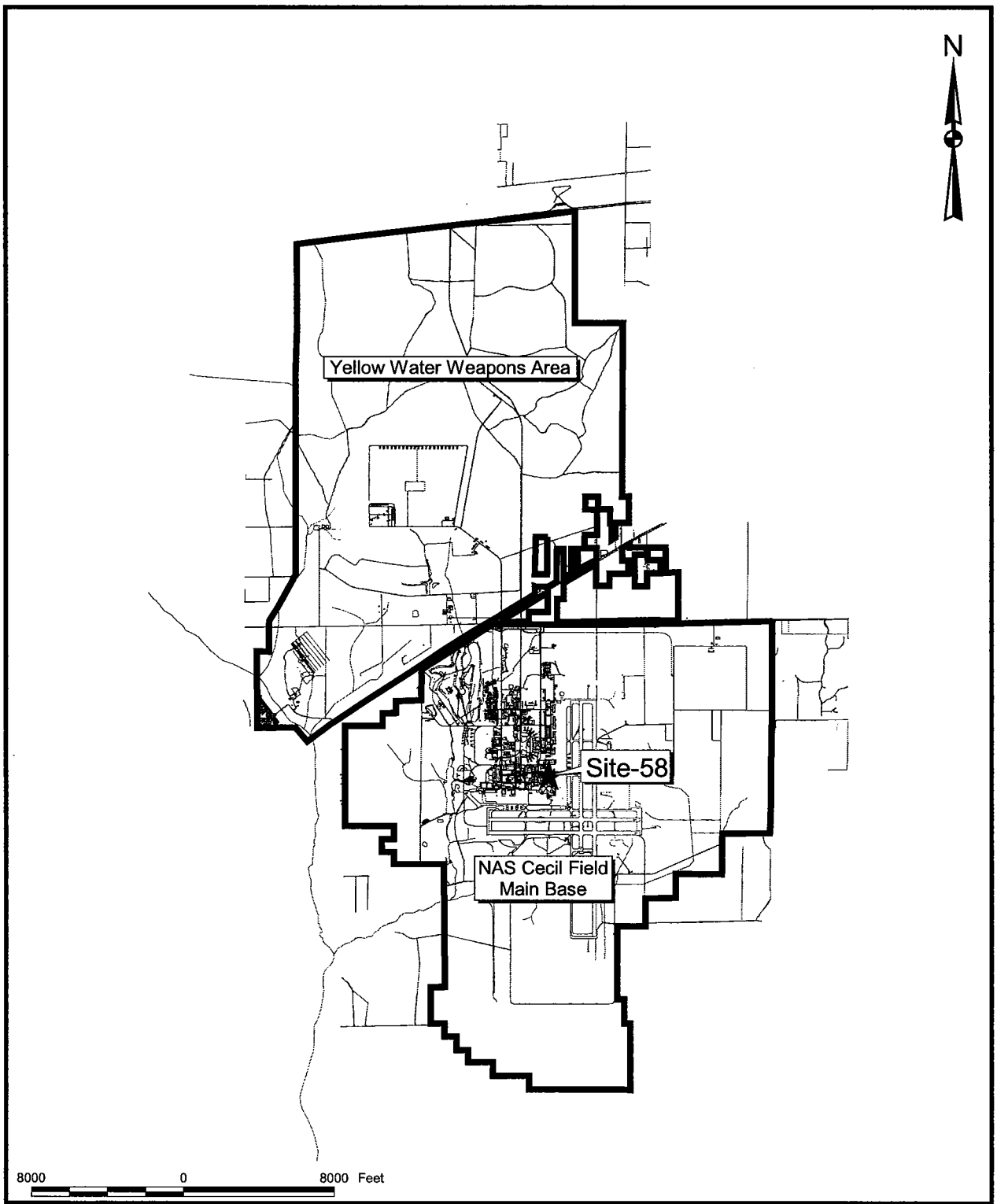
SCALE AS NOTED
SITE LAYOUT AND MONITORING WELL LOCATIONS, SITE 57
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
CONTRACT NO. 239
OWNER NO.
APPROVED BY DATE 04/03/02
DRAWING NO. FIGURE 1-2
REV. 0



DRAWN BY MJJ	DATE 24Jan02	SITE LOCATION MAP, SITE 58 OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE 04/30/02
COST/SCHEDULE-AREA			APPROVED BY DATE
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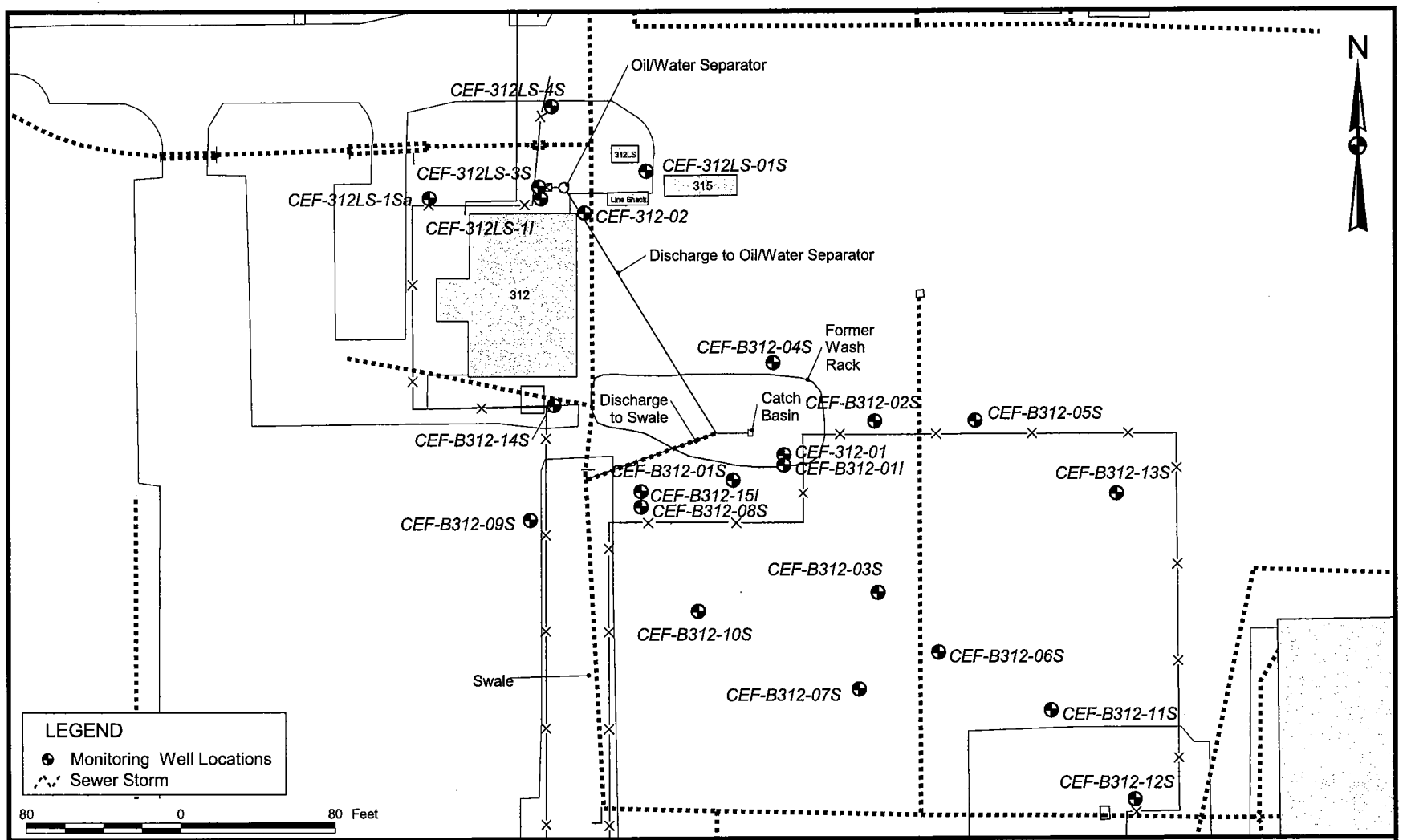

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CHECKED BY	DATE		APPROVED BY	DATE 04/28/02
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-4	REV 0

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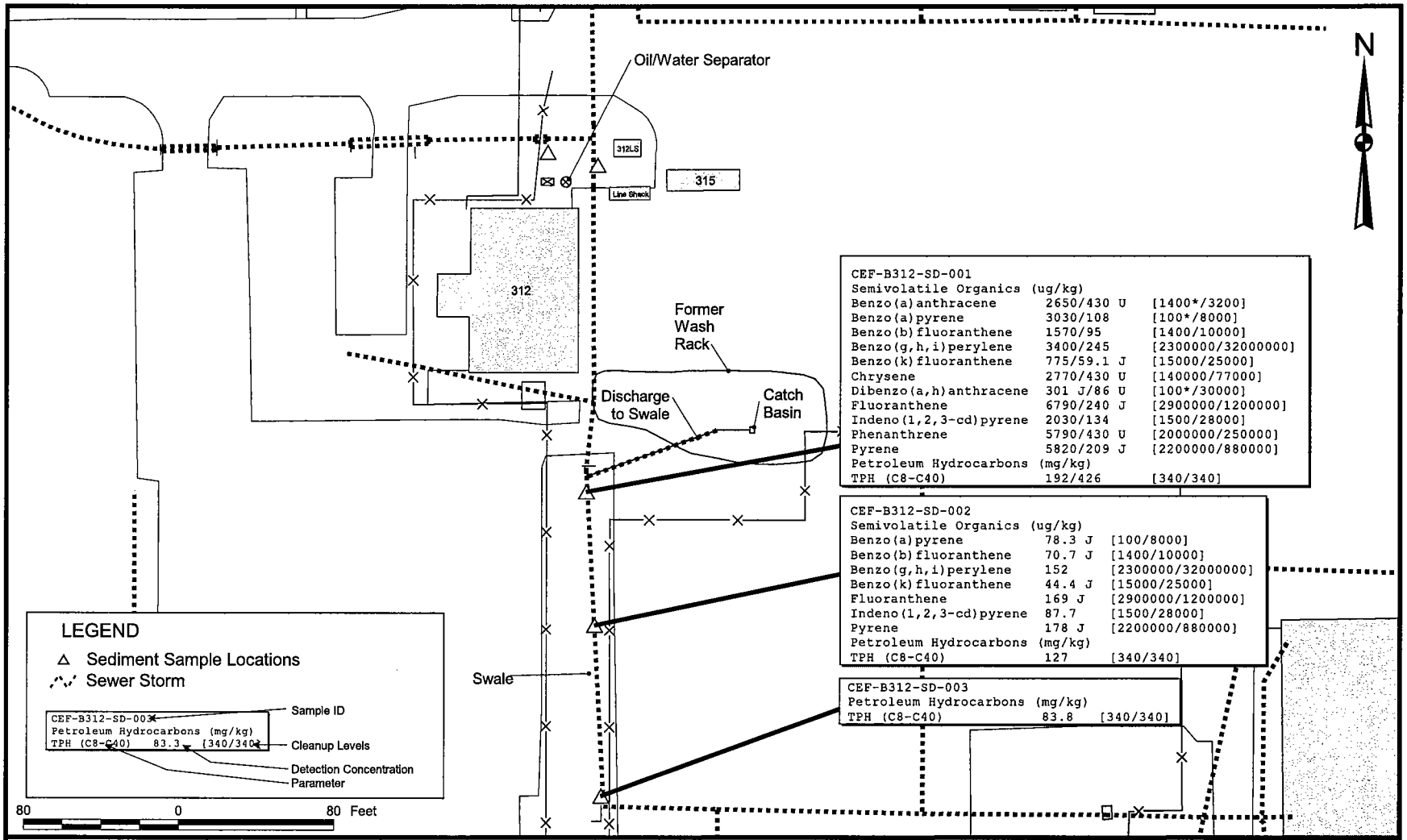

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MJJ	07Feb02
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE	AS NOTED

SITE 58 SOIL RI ANALYTICAL DATA
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NUMBER	
0039	
APPROVED BY	DATE 09/09/02
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DRAWING NO. FIGURE 1-5	REV 0

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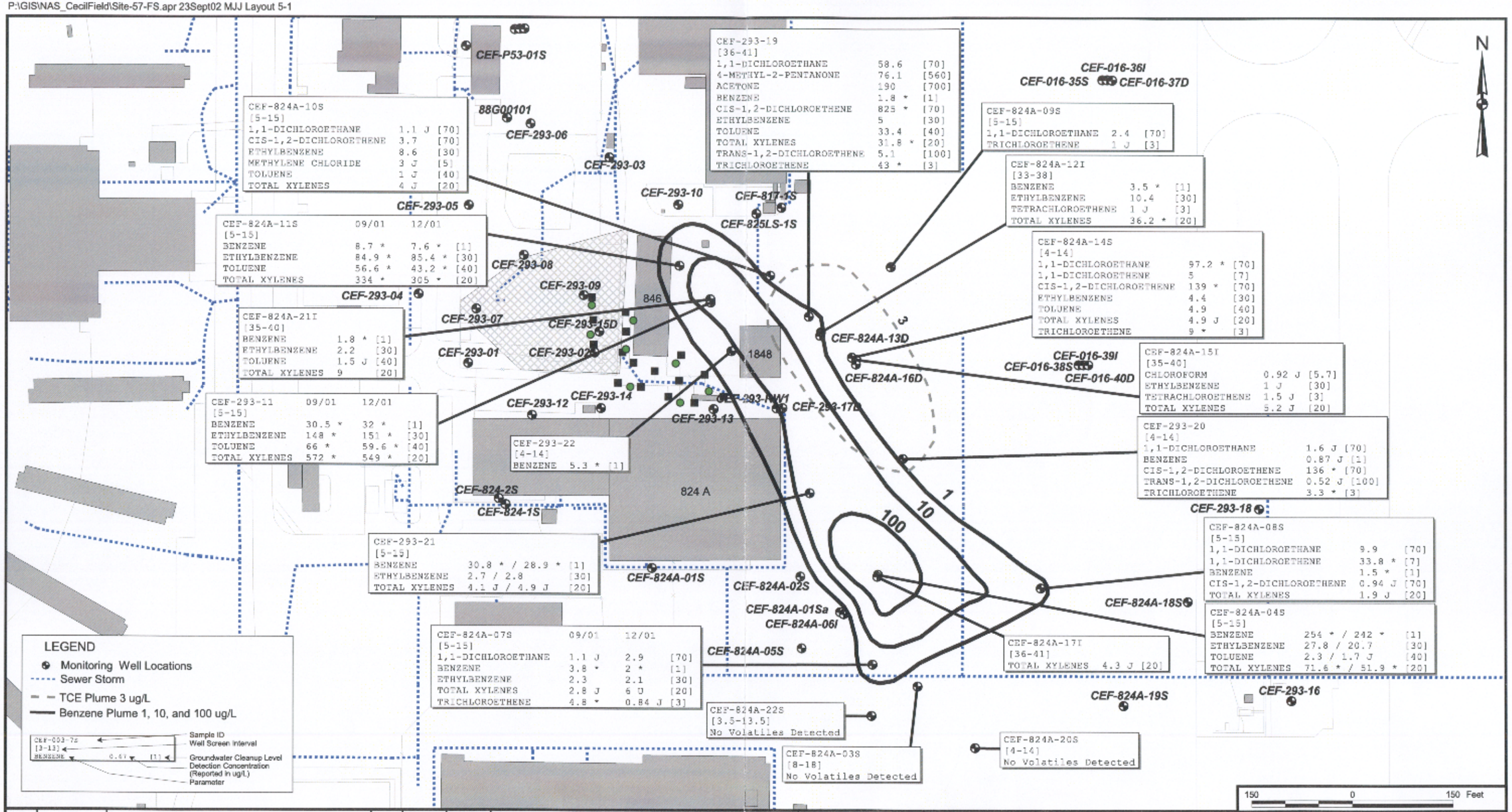

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MJJ DATE 04Feb02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE 57 GROUNDWATER VOCs
RI ANALYTICAL DATA
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 09/30/02
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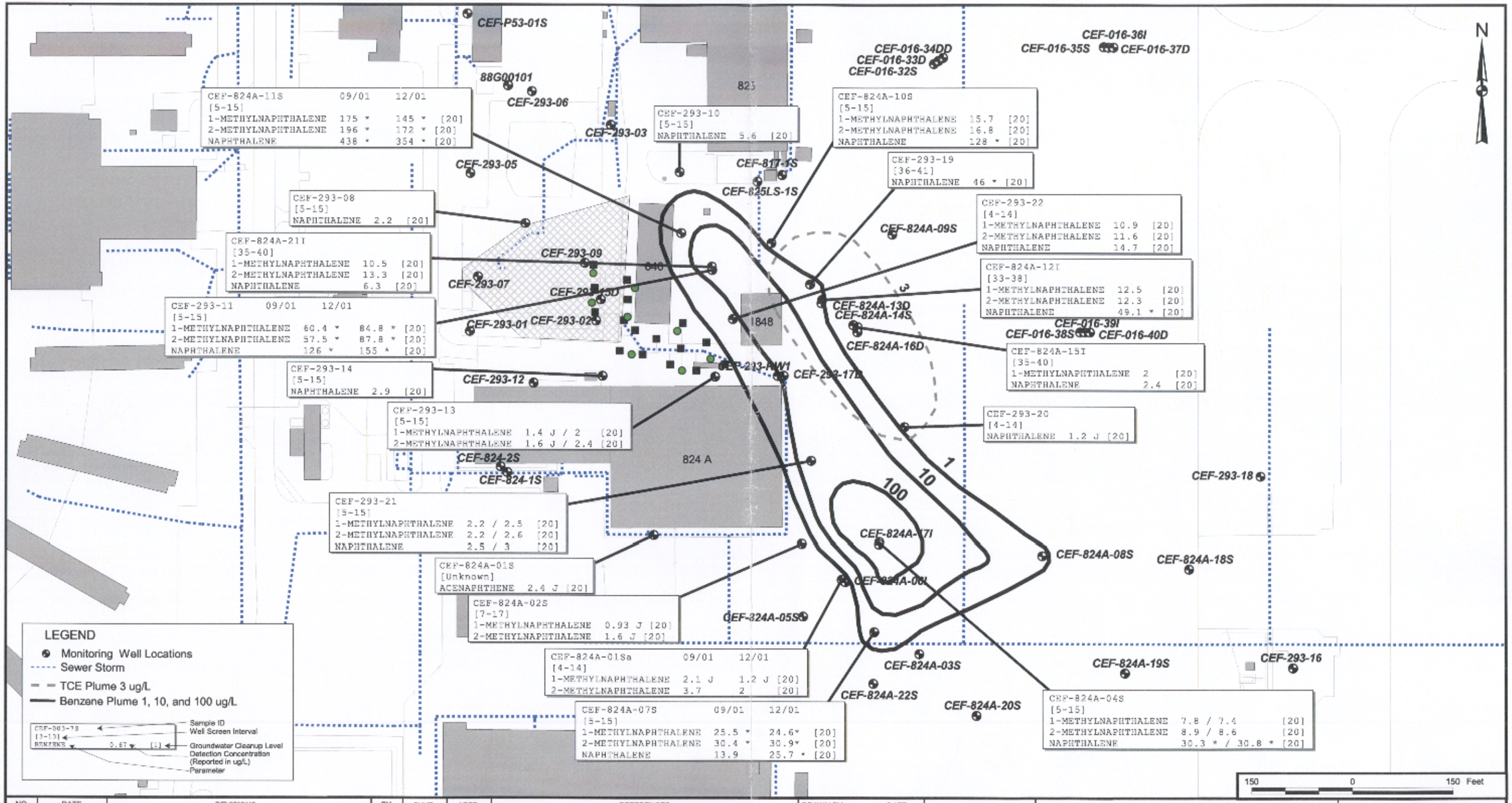

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MJJ DATE 04Feb02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE 57 GROUNDWATER PAHs
RI ANALYTICAL DATA
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 09/30/02
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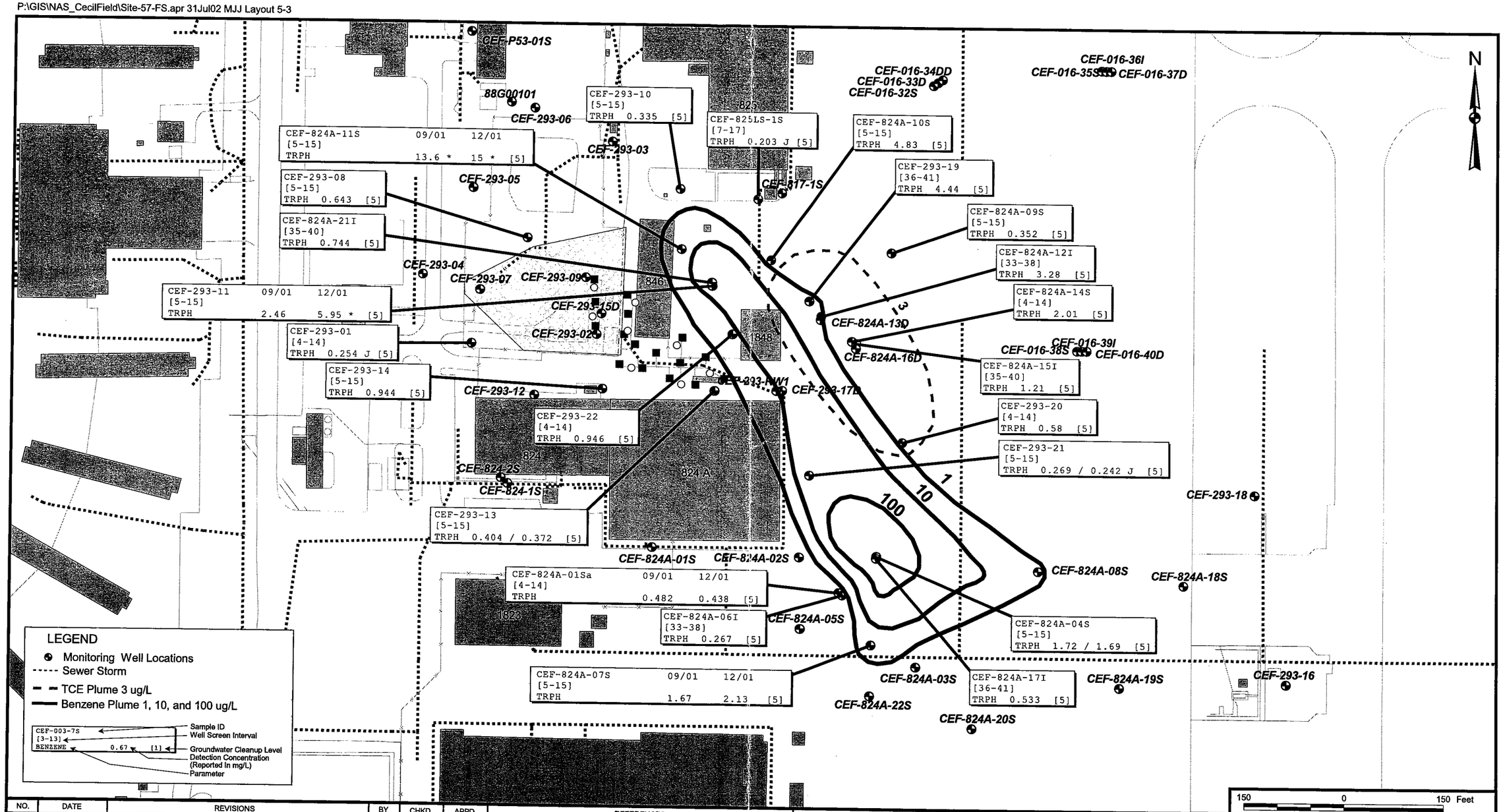

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DRAWN BY MJJ DATE 04Feb02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE 57 GROUNDWATER TRPH
RI ANALYTICAL DATA
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
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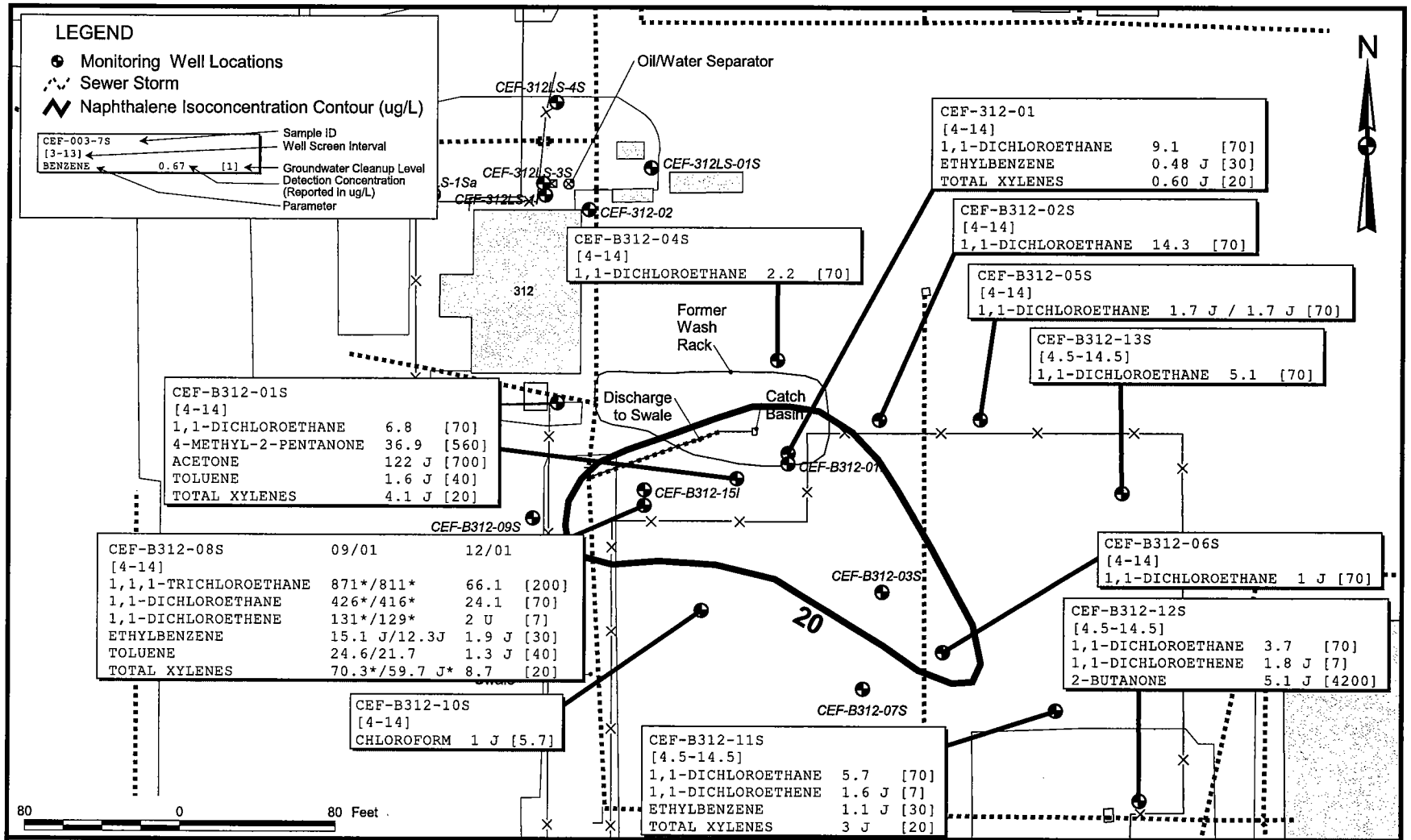

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CHECKED BY	DATE		APPROVED BY DATE 09/09/02
COST/SCHEDULE-AREA			APPROVED BY DATE
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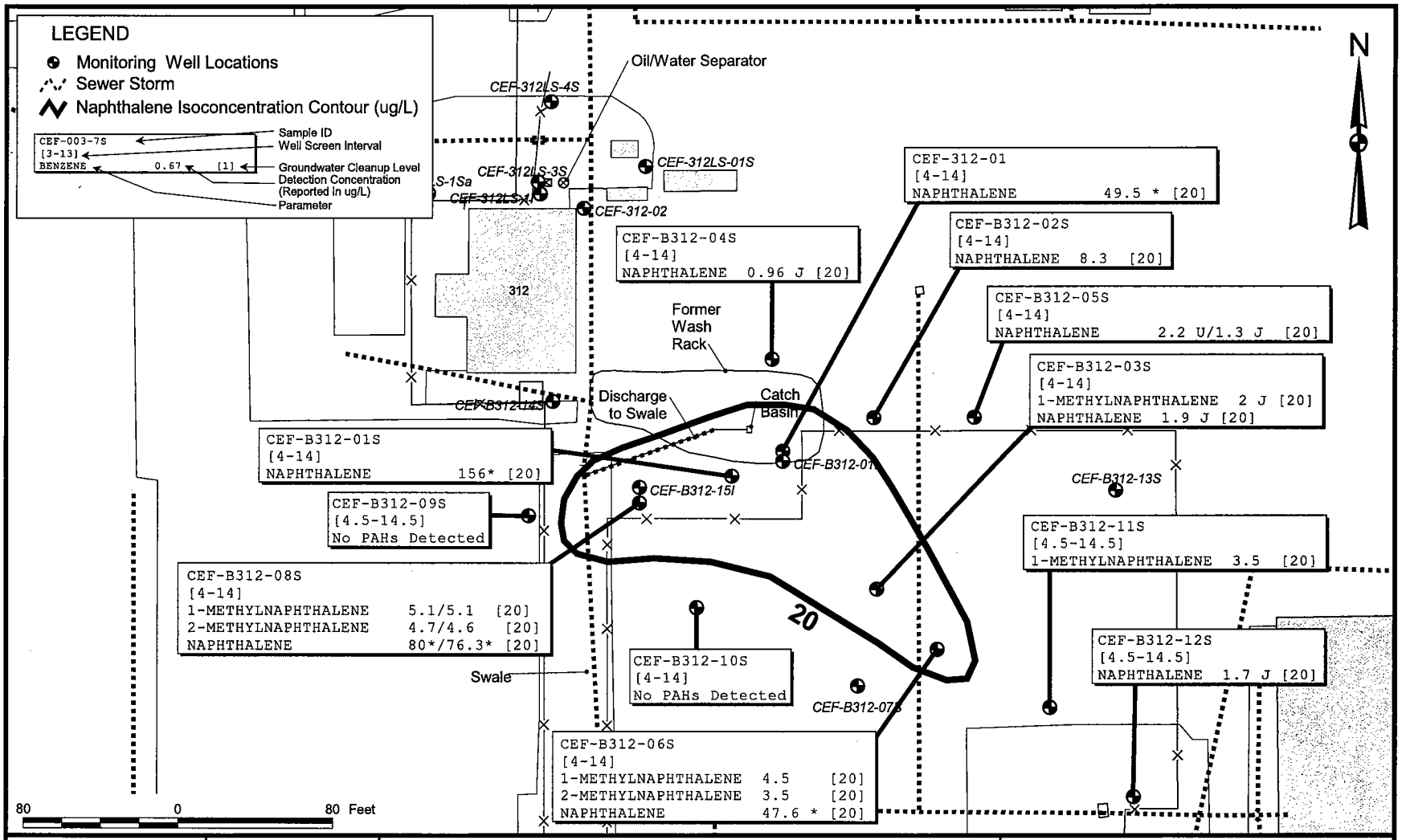

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SCALE	AS NOTED

SITE 58 GROUNDWATER PAHs
RI ANALYTIC DATA
OU 9, SITES 57 & 58 - FEASIBILITY STUDY
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NUMBER	0039
APPROVED BY	DATE 04/09/02
APPROVED BY	DATE
DRAWING NO. FIGURE 1-10	REV 0

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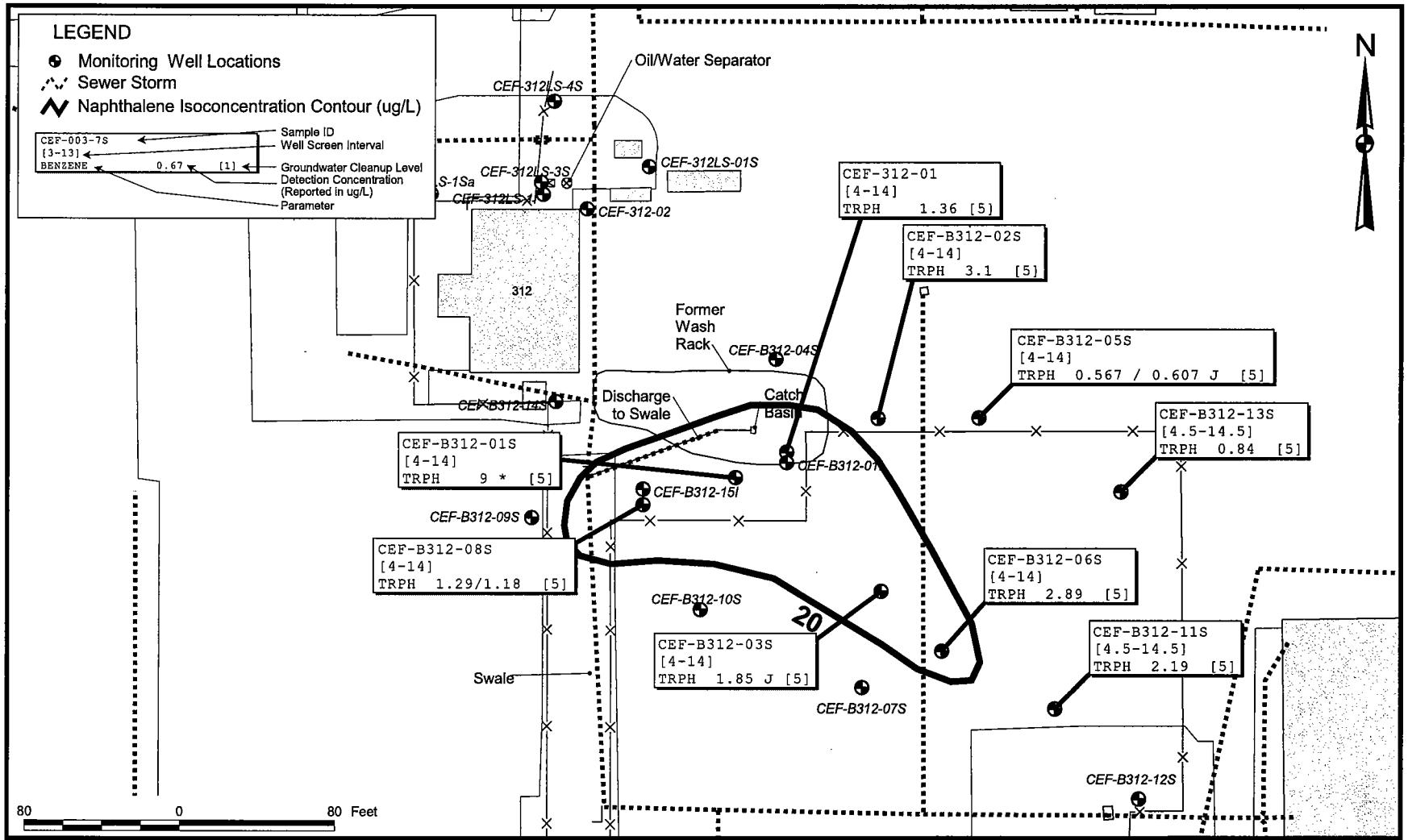

DRAWN BY MJJ	DATE 05Feb02	SITE 58 GROUNDWATER TRPH RI ANALYTICAL DATA OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY — DATE 09/09/02
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-11 / REV 0

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2.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

This section develops RAOs and derives cleanup goals for the contaminated media. The regulatory requirements and guidances (e.g., ARARs) that may potentially govern remedial activities are presented in this section. In addition, this section presents the chemicals of concern (COCs) identified in Section 1.0 and the conceptual pathways through which these chemicals may affect human health and the environment, and thus derives the environmental media of concern. The cleanup goals for the contaminated media are developed in this section, and GRAs that may be suitable to achieve the cleanup goals are presented. Finally, this section presents an estimate of the volumes of contaminated media.

2.1 REMEDIAL ACTION OBJECTIVES

The purpose of this section is to develop RAOs for Sites 57 and 58 at NAS Cecil Field, Jacksonville, Florida. Development of RAOs is an important step in the FS process. The RAOs are medium-specific goals that define the objective of conducting remedial actions to protect human health and the environment. The RAOs specify the COCs, potential exposure routes and receptors, and an acceptable range contaminant level (i.e., cleanup goals) for the site.

The development of cleanup goals takes into consideration ARARs and TBCs. Section 2.1.2 identifies the ARARs and TBCs, Section 2.1.3 identifies the media of concern, and Section 2.1.4 identifies the COCs for remediation.

2.1.1 Statement of Remedial Action Objectives

Site-specific RAOs specify COCs, media of interest, exposure pathways, and cleanup goals or acceptable contaminant concentrations. RAOs may be developed to permit consideration of a range of treatment and containment alternatives. This FS addresses soil contamination at Site 58 and groundwater contamination at Sites 57 and 58. To protect the public from potential current and future health risks, as well as to protect the environment, the following RAOs have been developed:

- Prevent unacceptable risk from exposure to Site 58 soil with concentrations of PAHs greater than the FDEP SCTLs for residential exposure.

- Prevent unacceptable risk from exposure to Site 57 groundwater with concentrations of chlorinated VOCs, BTEX, PAHs, and TRPH greater than the FDEP GCTLs.

- Prevent unacceptable risk from exposure to Site 58 groundwater with concentrations of naphthalene and TRPH greater than the FDEP GCTLs.

- Restore groundwater quality at Sites 57 and 58.

2.1.2 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria

ARARs consist of the following:

- Any standard, requirement, criterion, or limitation under Federal environmental law.
- Any promulgated standard, requirement, criteria, or limitation under a state environmental or facility-siting law that is more stringent than the associated Federal standard, requirement, criterion, or limitation.

TBCs are nonpromulgated, nonenforceable guidelines or criteria that may be useful for developing a remedial action or are necessary for determining what is protective to human health and/or the environment. Examples of TBCs include United States Environmental Protection Agency (U.S. EPA) Drinking Water Health Advisories, Reference Doses (RfDs) and Cancer Slope Factors (CSFs).

One of the primary concerns during the development of remedial action alternatives for hazardous waste sites under CERCLA is the degree of human health and environmental protection offered by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent Federal and state environmental requirements.

2.1.2.1 Definitions

The definitions of ARARs are given below:

- Applicable Requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law, while not "applicable" to a hazardous substance, pollutant, contaminant, or remedial

action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

- TBCs are a category created by the U.S. EPA that includes non-promulgated criteria, advisories, and guidance issued by Federal or state government that are not legally binding and do not have the status of potential ARARs. However, pertinent TBCs will be considered along with the ARARs in determining the necessary level of cleanup or technology requirements.

Under CERCLA Section 121(d)(4), the U.S. EPA may waive compliance with an ARAR if one of the following conditions can be demonstrated:

- The remedial action selected is only part of a total remedial action that will attain the ARAR level or standard of control upon completion;

- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;

- Compliance with the requirement is technically impracticable from an engineering perspective;

- The remedial action selected will attain a standard of performance that is equivalent to that required by the ARAR through the use of another method or approach;

- With respect to a state requirement, the state has not consistently applied the ARAR in similar circumstances at other remedial actions within the state; or

- Compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of Superfund money for response at other facilities (fund-balancing). This condition only applies to Superfund-financed actions.

The National Oil and Hazardous Substance Pollution Contingency Plan (NCP) has identified three categories of ARARs [40 CFR Section 300.400 (g)]:

- <u>Chemical-Specific</u>: Health-risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC).

- Location-Specific: Restrictions on actions or contaminant concentrations in certain environmentally sensitive areas. Examples of these areas regulated under various Federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

- Action-Specific: Technology- or activity-based requirements, limitations on actions, or conditions involving special substances. Examples of action-specific ARARs include wastewater discharge standards.

The following section discusses contaminant- and location-specific ARARs and TBCs. Action-specific ARARs and TBCs are presented in Section 2.3 along with the discussion of GRAs.

2.1.2.2 Chemical-Specific ARARs and TBCs

This section presents a summary of Federal and state chemical-specific ARARs and TBCs. These ARARs and TBCs provide some medium-specific guidance on "acceptable" or "permissible" concentrations of contaminants. Tables 2-1 and 2-2 present a list of Federal and State of Florida chemical-specific ARARs and TBCs for this FS.

2.1.2.3 Location-Specific ARARs and TBCs

This section presents a summary of Federal and state location-specific ARARs and TBCs. These ARARs and TBCs place restrictions on concentrations of contaminants or the conduct of activities based upon the site's particular characteristics or location. Tables 2-3 and 2-4 present a list of Federal and State of Florida location-specific ARARs and TBCs for this FS.

2.1.3 Media of Concern

Based upon the discussion in Section 1.0 involving toxicity and risk assessment for both human and ecological receptors, soil and groundwater from the Surficial Aquifer were determined to be the two media of concern at OU 9, Sites 57 and 58.

2.1.4 Chemicals of Concern for Remediation

2.1.4.1 Soil Chemicals of Concern

The RI PRE identified several chemicals in the surface soil as a concern to human receptors for Site 58. Three PAHs [benzo(a)anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene] were detected in surface

soil at concentrations greater than the FDEP SCTLs for direct residential exposure, and these chemicals were therefore retained as COCs.

2.1.4.2 Groundwater Chemicals of Concern

Site 57

The RI PRE identified several chemicals in the Surficial Aquifer groundwater as a concern to human receptors for Site 57. Groundwater analytical data for the site were compared to the U.S. EPA's current drinking water standards (U.S. EPA, 1998), the U.S. EPA Region IX PRGs (U.S. EPA, 2001), the FDEP drinking water criteria (FDEP, 1999c), and the FDEP GCTLs (FDEP, 1999a).

Three chlorinated VOCs (cis-1,2-DCE, 1,1-DCA, 1,1-DCE), BTEX, three PAHs (1- and 2-methylnaphthalene, naphthalene), and TRPH were detected in groundwater at concentrations greater than the FDEP GCTLs. These chemicals were therefore retained as COCs.

Site 58

The RI PRE also identified chemicals in the Surficial Aquifer groundwater as a concern to human receptors for Site 58. Analytical groundwater data for the site were compared to the U.S. EPA's current drinking water standards (U.S. EPA, 1998), the FDEP drinking water criteria (FDEP, 1999c), and the FDEP GCTLs (FDEP, 1999a). One PAH (naphthalene) and TRPH were detected in the groundwater at concentrations greater than the FDEP GCTLs. These chemicals were therefore retained as COCs.

2.2 CLEANUP GOALS

A cleanup goal is the target concentration that a COC must be reduced to within a particular medium of concern to achieve one or more of the established RAOs. Cleanup goals are developed to ensure that contaminant concentrations left on site are protective of human and ecological receptors.

For OU 9, Sites 57 and 58, Cleanup Goals were established based on the following criteria:

- Protection of human health from direct exposure to contaminated soil and groundwater
- Compliance with ARARs and TBCs to the extent practicable

2.2.1 Site 58 Soil Cleanup Goals

The Site 58 soil cleanup goals can be summarized as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[1]
PAHs (µg/kg)				
Benzo(a)anthracene	1 / 3	1,433	CEF-B312-SD001	1,400
Benzo(a)pyrene	2 / 3	78.3 J – 1,569	CEF-B312-SD001	100
Dibenzo(a,h)anthracene	1 / 3	172	CEF-B312-SD001	100

NOTES:
1 FDEP SCTL for residential exposure (FDEP, 1999a)

2.2.2 Site 57 Groundwater Cleanup Goals

The Site 57 groundwater cleanup goals can be summarized as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[1]
VOCs (µg/L)				
Benzene	11 / 41	0.87 – 248	CEF-824A-4S	1
cis-1,2-DCE	5 / 39	0.94 - 825	CEF-293-19	70
1,1-DCA	7 / 41	1.1 – 97.2	CEF-824A-14S	70
1,1-DCE	2 / 41	5 – 33.8	CEF-824A-8S	7
Ethylbenzene	11 / 41	1 - 150	CEF-293-11	30
Toluene	7 / 41	1 - 63	CEF-293-11	40
TCE	4 / 41	1 - 43	CEF-293-19	3
Xylenes	12 / 41	1.9 - 560	CEF-293-11	20
PAHs (µg/L)				
1-Methylnaphthalene	13 / 41	1.2 - 160	CEF-824A-11S	20
2-Methylnaphthalene	12 / 41	1.6 - 184	CEF-824A-11S	20
Naphthalene	15 / 41	1.2 - 396	CEF-824A-11S	20
TRPH (µg/L)				
TRPH	21 / 41	203 – 14,300	CEF-824A-11S	5,000

NOTES:
1 FDEP GCTL (FDEP, 1999a)

2.2.3 Site 58 Groundwater Cleanup Goals

The Site 58 groundwater cleanup goals can be summarized as follows:

Chemical of Concern	Frequency of Detection	Range of Concentrations	Location of Maximum	Cleanup Goal[1]
VOC (µg/L)				
1,1-DCA	10/18	1.0 -4 21	CEF-B312-08S	70
1,1-DCE	2/18	1.6 - 130	CEF-B312-08S	7
1,1,1-TCA	1/18	841	CEF-B312-08S	200
PAHs (µg/L)				
Naphthalene	9 / 18	1.3 - 156	CEF-B312-01S	20
TRPH (µg/L)				
TRPH	9 / 18	587 - 9,000	CEF-B312-01S	5,000

NOTES:
1 FDEP GCTL (FDEP, 1999a)

2.3 GENERAL RESPONSE ACTIONS AND ACTION-SPECIFIC ARARs

GRAs are broadly defined remedial approaches that may be used (by themselves or in combination with one or more of the others) to attain the RAO. Action-specific ARARs and TBCs are those regulations, criteria, and guidances that must be complied with or taken into consideration during remedial activities on site.

2.3.1 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 action alternatives will then be assembled using GRAs singly or in combination to meet the RAOs. The remedial action alternatives, composed of GRAs, will be capable of achieving the RAOs for each contaminated medium at the site.

The following GRAs were considered for soil and groundwater remediation at OU 9, Sites 57 and 58:

- No Action,
- Limited Action (Natural Attenuation, Institutional Controls, Monitoring),
- Containment.
- Removal,
- In-Situ Treatment,
- Ex-Situ (On-Site or Off-Base) Treatment, and
- Disposal

2.3.2 Action-Specific ARARs

Action-specific ARARs and TBCs are technology- or activity-based regulatory requirements or guidance that would control or restrict remedial action. Tables 2-5 and 2-6 present a list of Federal and state action-specific ARARs and TBCs for this FS.

2.4 ESTIMATED VOLUMES OF CONTAMINATED MEDIA

For remedial action purposes, volumes of contaminated soil at Site 58 and groundwater at Sites 57 and 58 were estimated based on the location of samples where COCs were detected in excess of cleanup goals.

2.4.1 Estimated Volume of Site 58 Contaminated Soil

Based on the analytical results of the RI, it was established that the Site 58 soil contamination where COC concentrations exceed the cleanup goals extends only in the immediate vicinity of sampling point CEF-B312-SD-001, which is located in the fenced-in drainage ditch extending south of Building 312. It is therefore conservatively assumed that the Site 58 area of contaminated soil extends over the entire width of the drainage ditch and from the headwall of that ditch north of sampling point CEF-B312-SD-001 to the halfway point between sampling points CEF-B312-SD-001 and –002. Areal extent of contaminated soil is thus estimated at approximately 2,400 square feet (ft^2). Soil contamination is assumed to extend down to 2 feet bgs, and the estimated volume of contaminated soil at Site 58 was therefore computed at approximately 4,800 cubic feet (ft^3), or 180 cubic yards (yd^3). This estimate represents a worst-case scenario and will be verified by additional sampling prior to remediation. The area of soil contamination at Site 58 is illustrated on Figure 2-1, and volume computations are presented in Appendix C.1.

2.4.2 Estimated Volume of Site 57 Contaminated Groundwater

Based on the analytical results of the RI, two contaminant plumes were delineated at Site 57, including a petroleum plume and a TCE plume. The Site 57 Petroleum Plume is defined as that area of groundwater where concentrations of benzene are greater than the GCTL of 1 µg/L. The Site 57 TCE Plume is defined as that area of groundwater where concentrations of TCE are higher than the GCTL of 3 µg/L.

The Site 57 Petroleum Plume extends over an area approximately 137,000 ft^2 in size (3.1 acres) and to a depth of ranging from 25 to 47.5 feet bgs. Based on a water table elevation of 5 ft bgs and a porosity of 0.35 that are typical at NAS Cecil Field, the estimated volume of the Site 57 Petroleum Plume was computed at approximately 11,100,000 gallons. The extent of the Site 57 Petroleum Plume is illustrated on Figure 2-2, and volume computations are presented in Appendix B.2.

The Site 57 TCE Plume extends over an area approximately 48,000 ft^2 in size (1.1 acres) and to a depth of up to 61 feet bgs. Based on a water table elevation of 5 ft bgs and a porosity of 0.35, the estimated volume of the Site 57 TCE Plume was computed at approximately 7,000,000 gallons. The extent of the Site 57 TCE Plume is illustrated on Figure 2-3, and volume computations are presented in Appendix C.2.

2.4.3 Estimated Volume of Site 58 Contaminated Groundwater

Based on the analytical results of the RI, a naphthalene plume was delineated at Site 58. The Site 58 naphthalene plume is defined as that area of groundwater where concentrations of naphthalene are greater than the GCTL of 20 µg/L. The Site 58 Naphthalene Plume extends over an area approximately 15,500 ft^2 in size (0.4 acres) and to a depth of up to 22 feet bgs. Based on a water table elevation of 5 feet bgs and a porosity of 0.35, the estimated volume of the Site 58 Naphthalene Plume was computed at approximately 695,000 gallons. The extent of the Site 58 Naphthalene Plume is illustrated on Figure 2-4, and volume computations are presented in Appendix C.2.

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TABLE 2-1

FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Safe Drinking Water Act (SWDA) Regulations, Maximum Contaminant Levels (MCLs)	40 Code of Federal Regulations (CFR) Part 141	Relevant and Appropriate	Establishes enforceable standards for potable water for specific contaminants that have been determined to adversely affect human health.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
SDWA Regulations, National Secondary Drinking Water Standards (SMCLs)	40 CFR Part 143	To Be Considered (TBC)	Establishes welfare-based standards for public water systems for specific contaminants or water characteristics that may affect the aesthetic qualities of drinking water.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
USEPA Office of Drinking Water, Health Advisories		Potential TBC	Health advisories are estimates of non-carcinogenic risk due to consumption of contaminated drinking water.	These advisories would be considered for contaminants in surface water and groundwater that is or could be used as a potable water source.
Cancer Slope Factors (CSFs)		TBC	CSFs are guidance value used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	CSFs would be considered for development of human health protection PRGs for soil and groundwater at this site.
Reference Doses (RfDs)		TBC	RfDs are guidance values used to evaluate the potential noncarcinogenic hazard caused by exposure to contaminants.	RfDs would be considered for development of human health protection PRGs for soil and groundwater at this site.

TABLE 2-2

STATE CHEMICAL-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Groundwater Guidance Concentration, Bureau of Groundwater Protection – June, 1994		Potentially Applicable	This document establishes maximum concentration levels for groundwater contaminants in the state of Florida. Groundwater with concentrations less than the listed values are considered "free from" contamination.	The values provided in this document would be considered when determining cleanup levels for groundwater. These guidance values for groundwater are considered ARARs by FDEP. However, by definition of ARARS in the NCP, state requirements must be a state law or regulation; an environmental or facility siting law; promulgated; more stringent than the Federal requirement; identified in a timely manner; and consistently applied. These parameters must be met according to the NCP. The Groundwater Guidance Concentrations are not promulgated as law or regulation; however, it is recognized that the FDEP maintains the position that these guidance concentrations are considered ARARs.
Florida Surface Water Quality Standards	Florida Administrative Code (FAC) Chapter 62-302	Potentially Applicable	Rule distinguishes surface water into five classes based on designated uses and establishes ambient water quality standards (called Florida Water Quality Standards) for listed pollutants.	Because these standards are specifically tailored to Florida waters, they should be used to establish cleanup levels rather than the Federal Ambient Water Quality Criteria (AWQCs).

TABLE 2-2

STATE CHEMICAL-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Florida Groundwater classes, Standards and Exemptions	FAC Chapter 62-520	TBC	This rule designates the groundwater of the state into five classes and establishes minimum "free from" criteria. This rule also specifies that Classes I & II must meet the primary and secondary drinking water standards listed in Chapter 62-550.	These regulations would be used to determine cleanup levels for groundwater that is a potential source of drinking water.
Contaminant Cleanup Target Levels Rule	FAC Chapter 62-777	TBC	This document provides guidance for soil, groundwater, and surface water cleanup levels that can be developed on a site-by-site basis.	These guidelines would be used in determining cleanup goals.

TABLE 2-3

FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Endangered Species Act Regulations	50 CFR Parts 81, 225, 402	Potentially Applicable	This act requires Federal agencies to act to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	If a site investigation or remediation could potentially affect an endangered species, these regulations would apply.
Historic Sites Act Regulations	36 CFR Part 62	Potentially Applicable	Requires Federal agencies to consider to existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	The existence of Natural Landmarks would be identified prior to remedial activities onsite including remedial investigations
Fish and Wildlife Coordination Act Regulations	33 CFR Subsection 320.3	Potentially Applicable	Requires that the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and related state agencies be consulted prior to structural modification of any body of water, including wetlands. If modifications must be conducted, the regulation requires that adequate protection be provided for fish and wildlife resources.	If a remedial alternative involves the alteration of a stream or wetland, these agencies would be consulted.

TABLE 2-3

FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
National Environmental Policy Act (NEPA) Regulations, Wetlands, Floodplains, etc.	40 CFR Subsection 6.302 [a]	Potentially Applicable	These regulations contain the procedures for complying with Executive Order 11990 on wetlands protection. Appendix A states that no remedial alternative adversely affect a wetland if another practicable alternative is available. If no alternative is available, impacts from implementing the chosen alternative must be mitigated.	If remedial action affects a wetland, these regulations would apply.
National Environmental Policy Act (NEPA) Regulations, Floodplain Management, Executive Order 11988	40 CFR Part 6, Appendix A	Potentially Applicable	Appendix A describes the policy for carrying out the Executive Order regarding floodplains. If no practicable alternative exists to performing cleanup in a floodplain, potential harm must be mitigated and actions taken to preserve the beneficial value of the floodplain.	If removal actions take place in a floodplain, alternatives would be considered that would reduce the risk of flood loss and restore and preserve the floodplain.
Fish and Wildlife Conservation Act	40 CFR Section 6.302	Potentially Applicable	Requires action to be taken to protect fish and wildlife from projects affecting streams or rivers.	USFWS officials would be consulted on how to minimize impacts of any remedial activities on any wildlife.

TABLE 2-4

STATE LOCATION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken

There are no State Location-Specific ARARs and TBCs

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Air/Superfund National Technical Guidance	EPA/450/1-89/001-EPA/450/1-89/004	Potential TBC	This guidance describes methodologies for predicting risks due to air release at a Superfund site.	These guidance documents would be considered when risks due to air releases from fugitive dust and thermal desorption are being evaluated.
Clean Air Act (CAA) Regulations, National Ambient Air Quality Standards (NAAQSs)	40 CFR Part 50	Potentially Relevant and appropriate for on-site treatment, storage, and disposal facility (TSDF) and Applicable for off-site TSDF	Establishes primary (health-based) and secondary (welfare-based) air quality standards for carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides emitted from a major source of air emissions. The NAAQSs form the basis for all regulations promulgated under the CAA. However, the NAAQSs themselves are non-enforceable and are not ARARs themselves.	Site remediation activities must comply with NAAQS. The principal application of these standards is during remedial activities resulting in exposures through dust and vapors. In general, emissions from CERCLA activities are not expected to qualify as a major source, and are therefore, not expected to be applicable requirements. However, the requirements may be determined to be relevant and appropriate for non-major sources with significantly similar emissions.
CAA Regulations, New Source Performance Standards (NSPS)	40 CFR Part 60	Potentially Relevant and Appropriate	This rule establishes NSPS for specified sources that are similar to a source that has established NSPSs (such as air stripping technologies). The NSPSs limit the emissions of a number of different pollutants, including the six criteria pollutants list (for which NAAQSs are established) as well fluorides, sulfuric acid mist, and total reduced sulfur (including hydrogen sulfide [H_2S]).	This rule may be a relevant and appropriate requirement for a new source that is similar to a source that has established NSPSs (such as air stripping technologies). If it is determined that the remedy would create potential air impacts, the response action or the equipment for the response action may qualify as a new source; therefore, these requirements would be met.
CAA National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61	Potentially Applicable	NESHAPs are a set of emissions standards for specific chemicals from specific production activities.	Emissions of hazardous air pollutants would be minimized by fugitive dust control and off gas treatment from the thermal desorption facility.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES)	40 CFR Parts 122 through 125, and 131	Potentially Relevant and Appropriate	NPDES (National Pollution Discharge Elimination System) permits are required for any discharges to navigable waters. If remedial activities include such a discharge, the NPDES standards would be ARARs.	Any alternative which would discharge into any navigable water would require compliance with these regulations including treatment, if necessary.
CWA Regulations, National Pretreatment Standards	40 CFR Part 403	Potentially Relevant and Appropriate	Sets pretreatment standards through the National Categorical Standards of the General Pretreatment Regulations for the introduction of pollutants from non-domestic sources into publicly owned treatment works (POTWs) in order to control pollutants that pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	If groundwater is discharged to a POTW or federally owned treatment work (FOTW), the discharge must meet local limits imposed by the POTW. A discharge from a CERCLA site must meet the POTW's pretreatment standards in the effluent of the POTW. Discharge to a POTW is considered an offsite activity and is, therefore subject to both the substantive requirements of this rule.
Federal Facilities Compliance Act of 1992	HR 2194	Potentially Relevant and Appropriate	This act amends the Solid Waste Disposal Act (SWDA) to clarify provisions concerning the application of certain requirements to federal facilities, such as providing a conditional exception to the Resource Conservation and Recovery Act's (RCRA) domestic sewage exclusion for FOTWs. In general, it allows state agencies and the United States Environmental Protection Agency (U.S. EPA) to enforce hazardous waste laws at government sites.	This act expands the domestic sewage exclusion policy to FOTWs. In addition, when wastewater is considered a hazardous waste under RCRA, but is mixed with domestic waste as it flows through the sewer system to the FOTW, the FOTW would not be required to meet the additional regulatory requirements for a RCRA facility.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Occupational Safety and Health Act (OSHA) Regulations, General Industry Standards	29 CFR Part 1910	Applicable	Requires establishment of programs to assure worker health and safety at hazardous waste sites, including employee training requirements.	These regulations would apply to all response activities.
OSHA Regulations, Occupational Health and Safety Regulations	29 CFR Part 1910, Subpart Z	Potentially Applicable	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	Standards are applicable for worker exposure to OSHA hazardous chemicals during remedial activities.
OSHA Regulations, Record Keeping, Reporting, and Related Regulations	29 CFR Part 1904	Potentially Applicable	Provides record keeping and reporting requirements applicable to remedial activities.	These requirements apply to all site contractors and subcontractors and must be followed during all site work.
OSHA Regulations, Health and Safety Standards	29 CFR Part 1926	Potentially Applicable	Specifies the type of safety training, equipment, and procedures to be used during the site investigation and remediation.	All phases of the remedial response project would be executed in compliance with this regulation.
RCRA Regulations, Identification and Listing of Hazardous Wastes	40 CFR Part 261	Potentially Relevant and appropriate for on-site TSDF and Applicable for off-site TSDF	Defines the listed and characteristic hazardous wastes subject to RCRA. Appendix II contains the Toxicity Characteristic Leaching Procedure.	These regulations would apply when determining whether waste onsite is hazardous, either by being listed or by exhibiting a hazardous characteristic, as described in the regulations.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 4 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
RCRA Regulations, Contingency Plan and Emergency Procedures	40 CFR 264, Subpart D	Potentially Relevant and Appropriate	Outlines requirements for emergency procedures to be followed in case of an emergency.	The administrative requirements established in this rule would be met for remedial actions involving the management of hazardous waste.
RCRA Regulations, General Facility Standards	40 CFR Subpart B, 264.10-264.18	Potentially Relevant and Appropriate	Sets the general facility requirements including general waste analysis, security measures, inspections, and training requirements. Section 264.18 establishes that a facility located in a 100-year floodplain must be designed, constructed, and maintained to prevent washout of any hazardous wastes by a 100-year flood.	If the remedial action involves construction of an onsite treatment facility, such as a groundwater treatment facility, the substantive requirements of this rule would be applicable requirements. A permitted treatment facility must be selected for offsite treatment. These regulations do not apply to the aboveground treatment or storage of hazardous waster before it is injected into underground. However, this rule may be an applicable requirement for alternatives that do not involve groundwater reinjection.
RCRA Regulations, Miscellaneous Units	40 CFR Part 264, Subpart X	Potentially Relevant and Appropriate	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations. Subpart X outlines performance requirements that miscellaneous units be designed, constructed, operated, and maintained to prevent releases to the subsurface, groundwater, and wetland that may have adverse effects on human health and the environment.	The design of proposed treatment alternatives, not specifically regulated under other subparts of RCRA, must prevent the release of hazardous constituents and future impacts on the environment. This subpart would apply to onsite construction of any treatment facility that is not previously defined under the RCRA regulation.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 5 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
RCRA Regulations, Preparedness and Prevention	40 CFR Part 264, Subpart C	Potentially Relevant and Appropriate	Outlines requirements for safety equipment and spill control for hazardous waste facilities. Facilities must be designed, maintained, constructed, and operated to minimize the possibility of an unplanned release that could threaten human health or the environment.	Safety and communication equipment would be incorporated into all aspects of the remedial process and local authorities would be familiarized with site operations.
RCRA Regulations, Releases from Solid Waste Management Units (SWMUs)	40 CFR Part 264, Subpart F	Potentially Relevant and Appropriate	Establishes the requirements for SWMUs at RCRA regulated TSDFs. The scope of the regulation encompasses groundwater protection standards, point of compliance, compliance period, and requirements for groundwater monitoring.	These regulations would be followed for the treatment of hazardous waste.
RCRA Regulations, Standards for Owners and Operators of Hazardous Waste TSDF	40 CFR Part 264	Potentially Relevant and Appropriate	Establishes minimum national standards defining the acceptable management of hazardous wastes for owners and operators of facilities that treat, store, or dispose of hazardous wastes.	If remedial actions involving management of RCRA wastes at an off-site TSD F or if RCRA wastes are managed onsite, the requirements of this rule would be followed.
RCRA Regulations, Use and Management of Containers	40 CFR Part 264, Subpart I	Potentially Relevant and Appropriate	Sets standards for the storage of containers of hazardous waste.	This requirement would apply if a remedial alternative involves the storage of a hazardous waste (i.e. contaminated groundwater) in containers, prior to treatment.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 6 OF 6

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
RCRA Regulations, Land Disposal Restrictions (LDRs)	40 CFR Part 268	Potentially Relevant and appropriate for on-site TSDF. Applicable for off-site TSDF	This regulation prohibits the land disposal of untreated hazardous wastes and provides criteria for the treatment of hazardous waste prior to land disposal.	Remedial actions that involve excavating, treating, and redepositing hazardous soil would comply with LDRs.
RCRA, Treatment Standards for Hazardous Debris – Thermal Desorption	40 CFR 268.45	Potentially Applicable	Sets treatment standards for utilizing thermal desorption.	Any thermal desorption unit would be operated in compliance with treatment standards.
SWDA Regulations, Underground Injection Control Regulations	40 CFR Parts 144, 146, 147, and 1000	Potentially Relevant and Appropriate	Establishes minimum program and performance standards for underground injection programs. Technical criteria are included in Part 146. Also requires protection of underground sources of drinking water.	Discharge of treated groundwater, by well injection, would be in accordance with these regulations, as well as meet all State Underground Injection Control Program requirements. Treated groundwater would meet all SWDA standards for reinjection prior to well injection.

TABLE 2-6

STATE ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 3

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Florida Hazardous Waste Rules – October, 1993	FAC Chapter 62-730	Potentially Applicable	Adopts by reference sections of the Federal hazardous waste regulations and establishes minor additions to these regulations concerning the generation, storage, treatment, transportation and disposal of hazardous wastes.	These regulations would apply if waste onsite were deemed hazardous and needed to be stored, transported, or disposed of properly.
Florida Drinking Water Standards	FAC Chapter 62-550	Potentially Applicable	This rule adopts Federal primary and secondary drinking water standards	These regulations would apply to remedial activities that involve discharges to potential sources of drinking water.
Florida Wetland Application Regulations – November, 1989	FAC Chapter 62-611	Potentially Applicable	Sets requirements for discharge of domestic wastewater to wetland. This rule mainly addresses the discharge of domestic wastewater to wetlands. Discharge limits are established for biological oxygen demand (BOD), total suspended solids (TSS), nitrogen, and phosphorus.	This rule would be considered for remedial alternatives that would result in discharges to wetlands where these limits may be approached.
Florida Wastewater Facility Permits	FAC Chapter 62-620	Potentially Applicable	This rule establishes requirements for wastewater permits. It was published in November 1994; however, it is not effective until Florida is recognized as a "delegated" state.	Upon delegation, facilities in Florida requiring a wastewater permit will meet the permitting requirements under this rule. Upon Florida becoming a "delegated" state, facilities will be allowed to have a single permit to meet both Federal and State discharge requirements.

TABLE 2-6

STATE ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 3

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Florida Air Pollution Rules – October, 1992	FAC Chapter 62-2	Potentially Relevant and Appropriate	Establishes permitting requirements for owners or operators of any source that emits any air pollutant. This rule also establishes ambient air quality standards for sulfur dioxide, PM_{10}, carbon monoxide, lead, and ozone.	Although this rule is directly applicable to industrial polluters, these requirements are relevant and appropriate for a remedial action that could result in release of regulated contaminants to the atmosphere, such as may occur during air stripping or excavation.
Florida Regulation of Stormwater Discharge –May, 1993	FAC Chapter 62-25	Potentially Relevant and Appropriate	Establishes requirements for discharges of untreated stormwater to ensure protection of the surface water of the state.	Remedial actions would consider the impact of the discharge of untreated stormwater.
Florida Underground Injection Control Regulations – April,1989	FAC Chapter 62-28	Potentially Applicable	Establishes a State Underground Injection Control Program consistent with federal requirements and appropriate to the hydrogeology of Florida.	These regulations would be considered if remedial actions involve underground injection.
Florida Ambient Air Quality Standards – December, 1994	FAC Chapter 62-272	Potentially Applicable	Establishes ambient air quality standards necessary to protect human health and public welfare. It also establishes maximum allowable increases in ambient concentrations for subject pollutants to prevent significant deterioration of air quality in areas where ambient air quality standards are being met. Approved air quality monitoring methods are also specified.	These ambient air quality standards would be met for remedial actions involving the possible release exposure of contaminants to the atmosphere.

TABLE 2-6

STATE ACTION-SPECIFIC ARARs AND TBCs
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 3

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Air Pollution Episodes – September, 1994	FAC Chapter 62-273	Potentially Relevant and Appropriate	This rule classifies an air episode as an air alert, warning or emergency and establishes criteria for determining the level of the air episode. It also establishes response requirements for each level.	These regulations would be adhered to if remedial actions involve air emissions.
Florida Groundwater Permitting and Monitoring Requirements – April, 1994	FAC Chapter 62-522	Potentially Applicable	Establishes permitting and monitoring requirements for installations discharging to groundwater.	The substantive requirements of this rule would be met when discharge to groundwater is a possible remedial action. If these requirements are met under another permit, a separate discharge permit may not be required.
Florida Water Well Permitting and Construction Requirements – March, 1992	FAC Chapter 62-532	Applicable	Establishes minimum standards for the location, construction, repair, and abandonment of water wells. Permitting requirements and procedures are established.	The substantive requirements for permitting would be met if remedial actions involve the construction, repair, or abandonment of monitoring, extraction, or injection wells.
Florida Rules on Hazardous Waste Warning Signs – July, 1991	FAC Chapter 62-736	Applicable	Requires warning signs at NPL and FDEP identified hazardous waste sites to inform the public of the presence of potentially harmful conditions.	This requirement will be met.
Florida Rules on Permits – November,1994	FAC Chapter 62-4	Potentially Applicable	Establishes procedures for obtaining permits for sources of pollution. This rule also establishes a "mixing zone" rule for facilities that discharge wastewater into the surface waters of the state.	These substantive requirements would be met during remediation. Through dilution, applying the "mixing zone" rule allows wastewater with higher concentrations of pollutants to be discharged into surface water, while still maintaining the Florida water quality standards.

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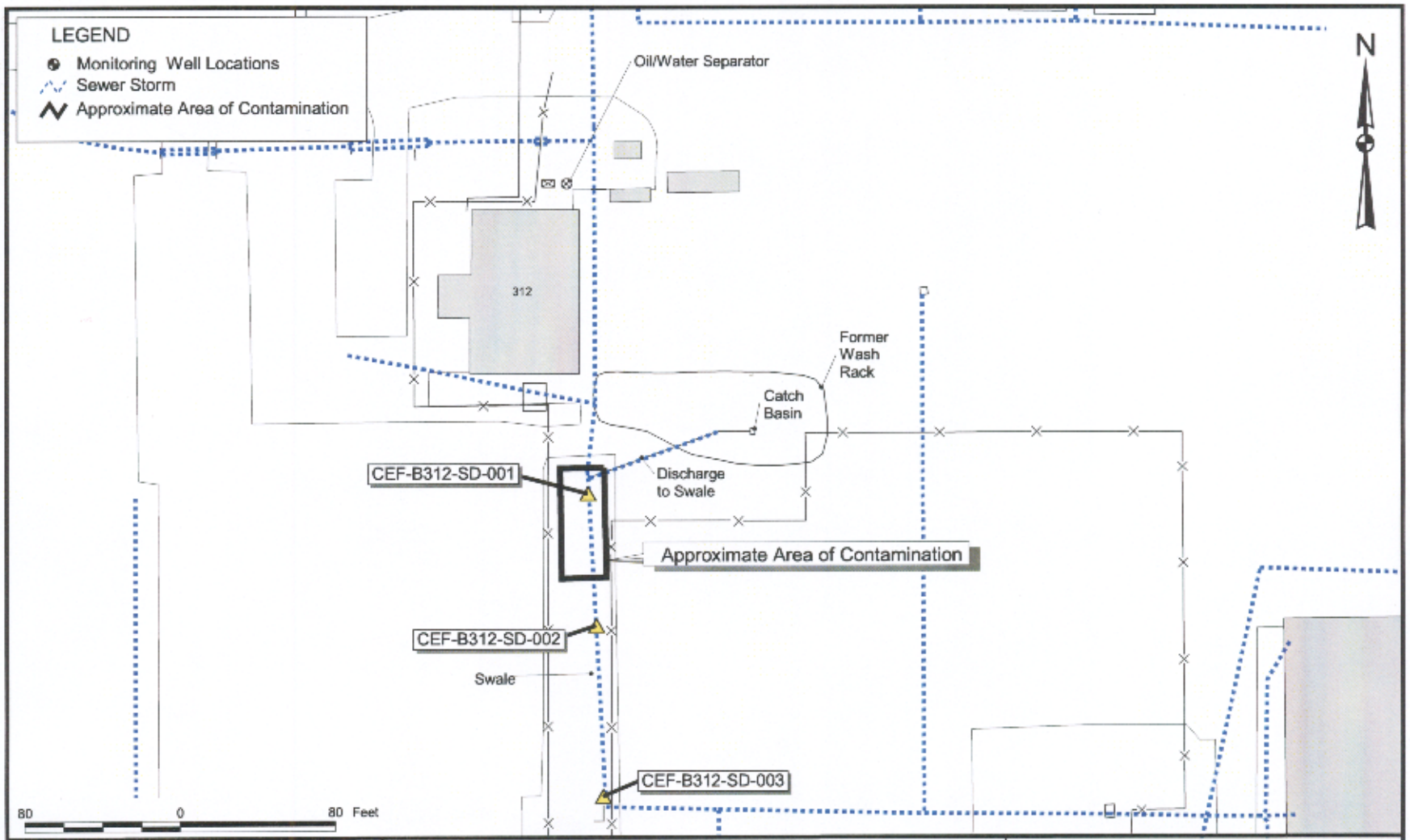

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CHECKED BY	DATE		APPROVED BY — DATE 09/30/02
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-1 / REV 0

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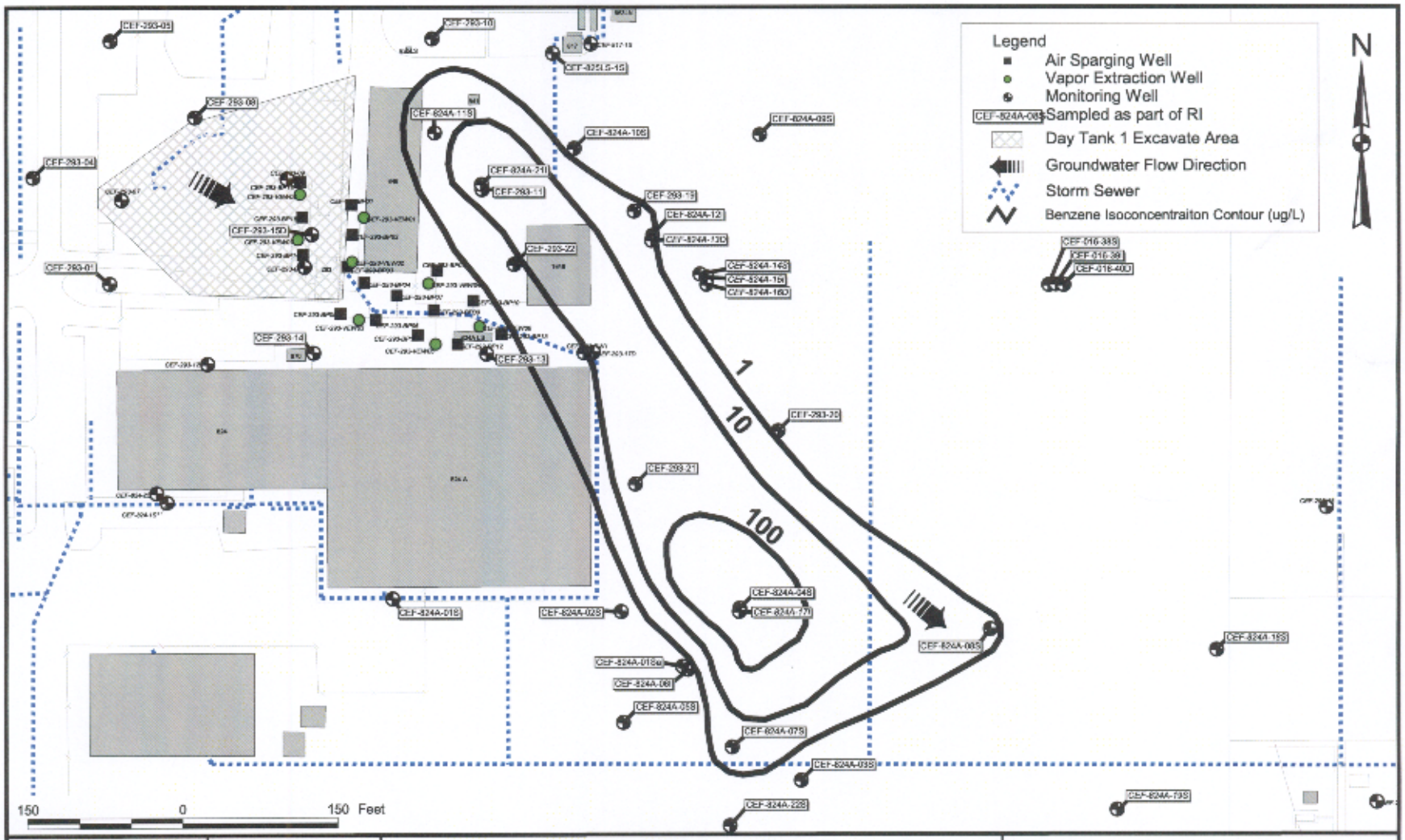

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COST/SCHEDULE-AREA			APPROVED BY — DATE —
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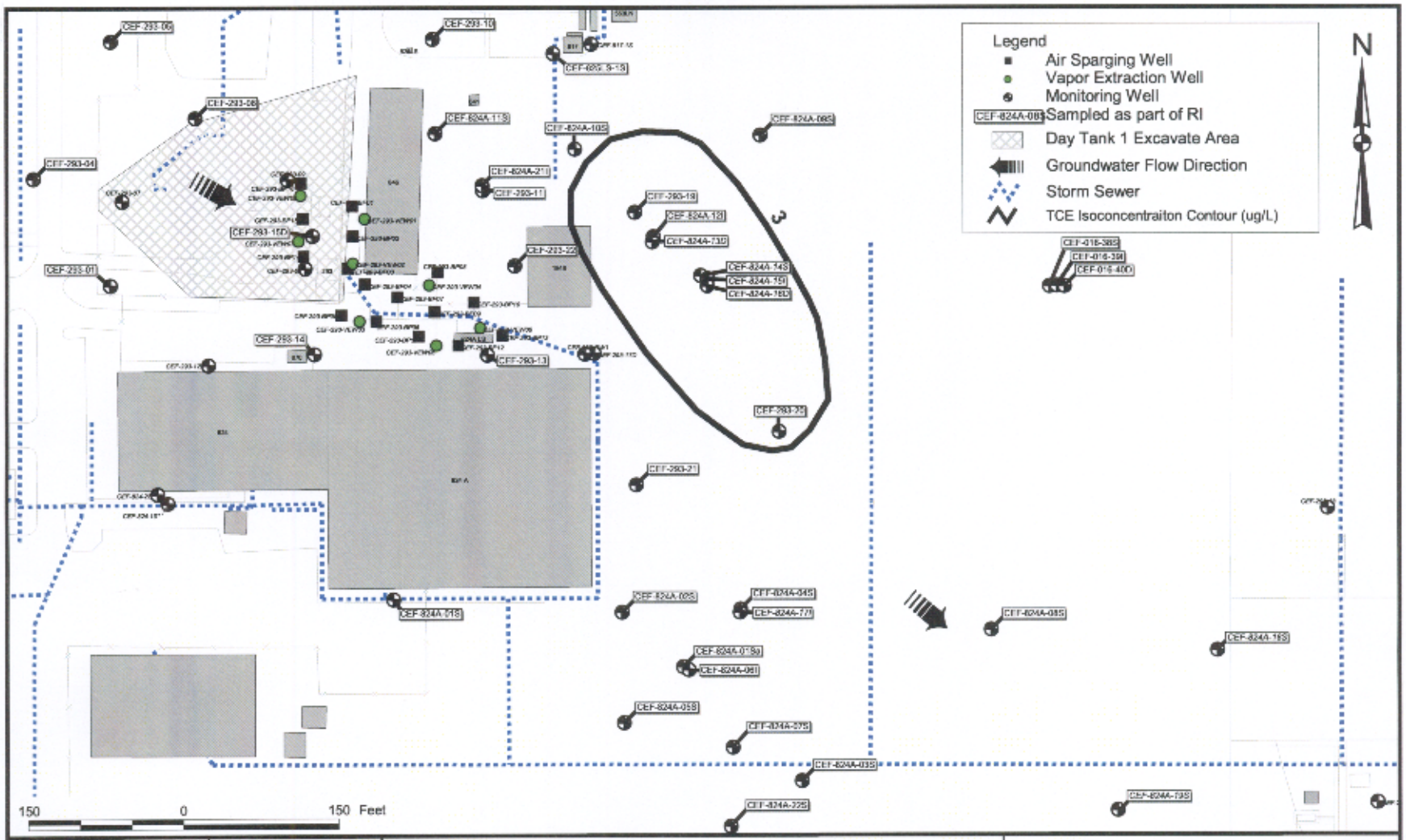

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CHECKED BY —	DATE —		APPROVED BY [signature] DATE 02/30/02
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-3 REV 0

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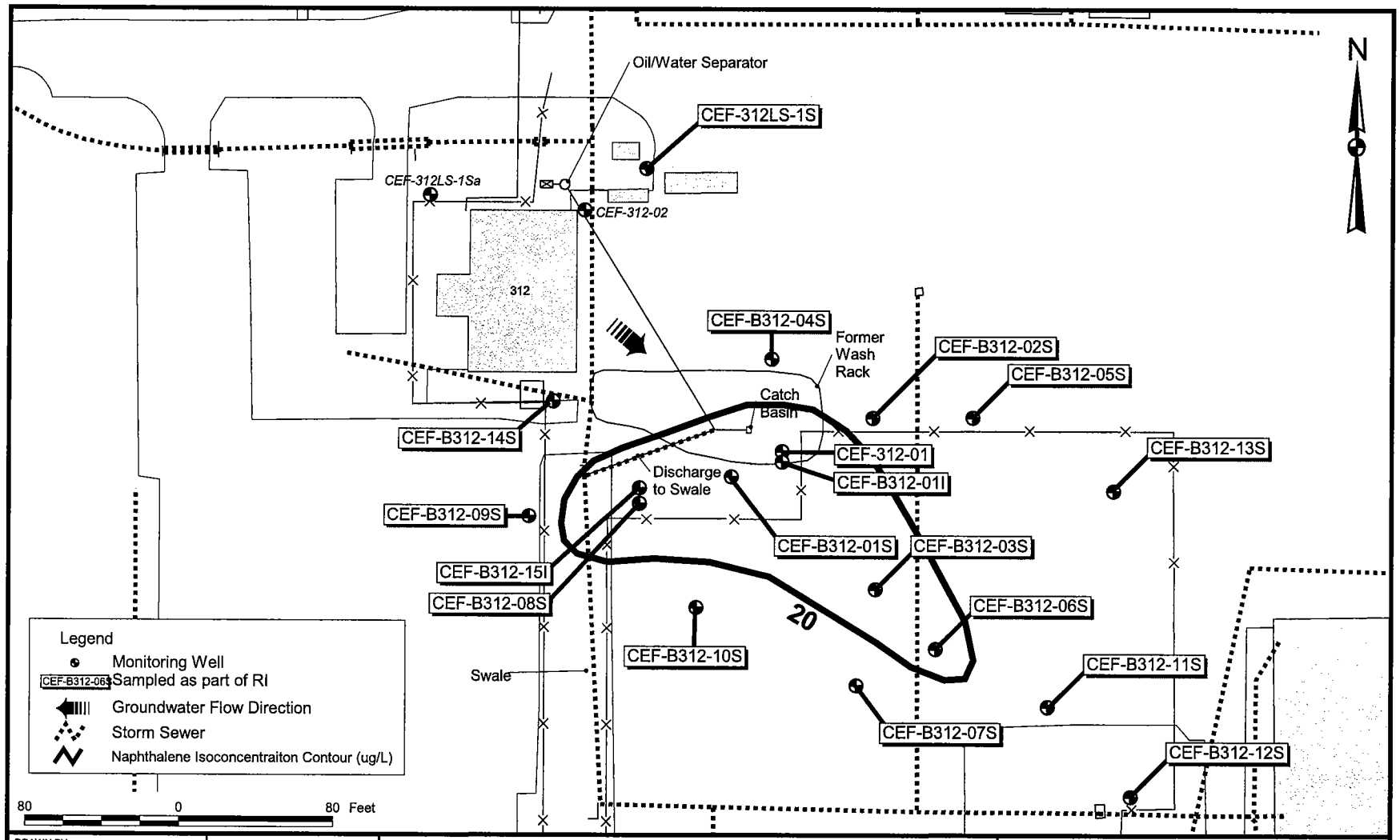

DRAWN BY	DATE			CONTRACT NUMBER
MJJ	14Feb02		EXTENT OF SITE 58 NAPHTHALENE PLUME	0039
CHECKED BY	DATE		OU 9, SITES 57 & 58 - FEASIBILITY STUDY	APPROVED BY / DATE 04/03/02
COST/SCHEDULE-AREA			NAVAL AIR STATION CECIL FIELD	APPROVED BY / DATE
SCALE AS NOTED			JACKSONVILLE, FLORIDA	DRAWING NO. FIGURE 2-4 / REV 0

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3.0 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies, screens, and evaluates the potential technologies and process options that may be applicable to assemble the remedial alternatives for OU 9, Sites 57 and 58 at NAS Cecil Field. 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 the remedial alternatives.

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

- Identification of ARARs
- Development of RAOs
- Identification of GRAs
- Identification of areas and volumes of contaminated soil and groundwater

Technology screening evaluation 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

In this section a variety of technologies and process options are identified under each GRA (discussed in Section 2.3.1) and screened. The selection of technologies and process options for initial screening is based on the "Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA" (U.S. EPA, 1988). The screening is first conducted at a preliminary level to focus on relevant technologies and process options. Then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent the technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of these evaluation criteria:

- Effectiveness
  - Protection of human health and the environment; reduction in toxicity, mobility, or volume; and permanence of solution.
  - Ability of the technology to address the estimated areas or volumes of contaminated media.
  - Ability of the technology to attain the Cleanup Goals required to meet the RAOs.
  - Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions.

- Implementability
  - Overall technical feasibility at the site.
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility.
  - Special long-term maintenance and operation requirements.

- Cost (Qualitative)
  - Capital cost.
  - Operation and maintenance (O&M) costs.

Technologies and process options will be identified in the following sections.

3.1 PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens remediation technologies and process options for soil at a preliminary stage based on implementation with respect to site-specific conditions and COCs. Table 3-1 summarizes the preliminary screening of technologies and process options applicable to soil. It presents the general response actions, identifies the technologies and process options, and provides a brief description of each process option followed by the screening comments.

The following are the soil remediation technologies and process options retained for detailed screening:

General Response Action	Technology	Process Options
No Action	None	Not Applicable
Limited Action	Institutional Controls	Fencing, Posting, and Land Use Controls (LUCs)
	Monitoring	Sampling & Analysis
Containment	Capping	Soil/Multimedia Cover
Removal	Bulk Excavation	Excavation
Ex-situ Treatment	Biological	Off-Base Bio-Slurry Reactor or Bio-Pile

General Response Action	Technology	Process Options
Ex-Situ Treatment	Thermal	Off-Base Incineration
		Off-Base Low-Temperature Thermal Desorption (LTTD)
Disposal	Landfill	Off-Base Landfilling

3.2 DETAILED SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS

3.2.1 No Action

No Action consists of maintaining 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 alternative and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions are conducted under this alternative, there are no costs associated with "walking away from" the site. There is also no reduction in risk through exposure control or treatment. No action would not be effective in evaluating contaminant mobility and potential migration off-site because no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the RAOs. 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 because no action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained because of NCP requirements although it would not be effective.

3.2.2 Limited Action

3.2.2.1 Institutional Controls

Institutional controls would consist of restricting site access through fencing and posting. The existing fence around the Site 58 drainage ditch south of Building 312 would be maintained and upgraded, if

necessary. Warning signs would be posted to clearly indicate the risk associated with exposure to contaminated soil. Institutional controls would also consist of planning and implementing Land Use Controls (LUCs), including deed restrictions to prevent Site 58 from being used in the future as a residential area. As part of institutional controls, regular site inspections would be conducted to verify and enforce the continued application of these controls.

Effectiveness

Fencing and posting of the Site 58 drainage ditch would effectively reduce the risk of unacceptable human health risk from exposure to contaminated soil. Prohibiting future residential development of the site would effectively prevent the aggravation of unacceptable human health risk and the occurrence of unacceptable ecological risk.

Implementability

Institutional controls would be readily implementable. Fencing already exists around the Site 58 drainage ditch area and it could easily be maintained and, if necessary, upgraded. Warning signs would be easy to post. As part of change of the site from military to private ownership, provisions will be incorporated in property transfer documents to insure the continued implementation of institutional controls. Resources are readily available for the preparation of deed restrictions.

Cost

Costs of institutional controls would be low.

Conclusion

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

3.2.2.2 Monitoring

Sampling and analysis of soil in the area of contamination would be used to determine potential changes in concentrations of COCs through either migration or natural attenuation. Groundwater sampling and analysis would also be conducted to determine if COCs are migrating from soil to groundwater.

Effectiveness

Monitoring alone would not reduce the toxicity, mobility, or volume of contaminants in the soil. However, monitoring would allow for a determination to be made of the potential off-site migration of contaminants or of the potential reduction in contaminant concentrations through natural attenuation.

Implementability

A sampling and analysis program could be readily implemented.

Cost

Capital and O&M costs of monitoring would be low.

Conclusion

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

3.2.3 Containment

The only technology considered under this GRA is capping. Capping would consist of providing a horizontal barrier to prevent direct contact with contaminated soil and minimize the extent of potential contaminant migration, either to surface water through soil erosion and/or to groundwater through percolation of precipitation through the vadose zone.

Effectiveness

Capping is a well-proven technology and it would be an effective means of preventing direct contact of potential receptors with the contaminated soil. Capping would also be effective in minimizing the migration of COCs into the environment by preventing erosion of and leaching through the contaminated soil. However, at Site 58, the area of soil contamination is located in a drainage ditch, which would greatly diminish the effectiveness of the cap and make its long-term maintenance very difficult.

Implementability

Installation of a cap at Site 58 would be simple to implement. Resources, equipment, and materials required to implement this technology are readily available. However, as previously mentioned, the location of the cap in a drainage ditch would somewhat complicate its construction and make its long-term maintenance very difficult and demanding.

Cost

Capital and O&M costs for capping would be low to moderate.

Conclusion

Capping is eliminated from further consideration because of effectiveness and implementability concerns.

3.2.4 Removal

The only technology considered under this GRA is excavation. Excavation can be performed by a variety of equipment, such as front-end loaders, backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors, such as the type of material to be excavated, the load-bearing capacity of the ground surrounding the excavation area, the depth and areal extent of excavation, the required rate of excavation, and the elevation of the groundwater table. Excavation is the technology of choice for the removal of well-consolidated material, such as soil, to depths of up to 30 feet bgs and from well-defined areas of ground with significant load-bearing capacity (i.e., greater than 1,500 pounds per ft^2).

The logistics of excavation must take into account the available space for operating the equipment, the staging of the excavated material, the access to and from the site of excavation, etc. Once excavation is completed, the location is backfilled and graded with clean fill material or treated soils. Because of the relative proximity to a flightline, dust and debris produced as a result of excavation would have to be strictly controlled.

Effectiveness

Excavation is a well-proven and effective method of removing contaminated material from a site. Properly designed excavation would remove most of the soil contaminated above cleanup goals and the remaining soil would not pose an unacceptable risk to human health or the environment. Sandy/silty soil, such as that at Site 58, would be amenable to excavation.

Implementability

Excavation of contaminated soil at Site 58 would be implementable. Excavation equipment and/or services are readily available from multiple vendors or contractors. This technology is well-proven and established in the construction/remediation industry. The area to be excavated is relatively open and free of obstructions. The depth of excavation is shallow (2 feet bgs or less), and no shoring or dewatering

would be required. During excavation, site-specific health and safety procedures and Occupational Safety and Health Act (OSHA) regulations would have to be complied with to ensure that the exposure of the workers to COCs is minimized. This would include, the wearing of appropriate personal protective equipment (PPE) and the implementation of dust suppression measures.

Cost

Cost of excavation at Site 58 would be low.

Conclusion

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

3.2.5 Ex-Situ Treatment

3.2.5.1 Off-Base Bio-Slurry Reactor/Bio-Pile

Bio-slurry reactor is a technology that biologically treats the excavated soil in an enclosed vessel. After removal of foreign materials, such as stones and rubble, the contaminated soil is mixed with water to form a slurry containing 10 to 30 percent solids and placed in a tank featuring process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum efficiency. Following treatment, the soil slurry is dried and tested to verify that contaminants have been adequately removed and the treated soil is replaced in its original location or used as fill material somewhere else.

Bio-pile is a technology that mixes the excavated soil with amendments (e.g., wood chips, saw dust) and forms it into an enclosed pile for composting biological treatment. Oxygen is provided either by the inducing of an air current through the pile with air blowers or vacuum pumps or by mixing-in an oxygen-release reagent (e.g., calcium peroxide). Moisture, heat, nutrients, oxygen, and pH are also controlled to enhance biodegradation. Duration of operation may vary from a few weeks to several months, at which time the treated soil is either returned to its original location or used as fill material somewhere else.

Effectiveness

Bio-slurry reactors and bio-piles are relatively well-proven technologies that are effective for the treatment of soil contaminated with a variety of non-chlorinated organic compounds, such as BTEX, TRPH, and low molecular weight PAHs (e.g., naphthalene). However with high molecular weight PAHs such as those detected in the Site 58 soil (e.g., benzo(a)pyrene), the effectiveness of these technologies is not nearly as

well established. Treatability testing would typically be required to determine the biodegradability of contaminants and appropriate oxygenation and nutrient loading rates.

Implementability

Off-base bio-slurry reactor or bio-pile technologies would be implementable but both would require a relatively complex sequence of operations including staging, treatment, and disposal of treated soil. In addition, treated soil from a bio-slurry reactor would also require dewatering and drying prior to disposal. Equipment and resources may not be readily available to implement either of these technologies at most permitted treatment, storage, and disposal facilities (TSDFs).

Cost

Capital and O&M costs for off-base bio-slurry reactors/bio-piles would be moderate to high.

Conclusion

Off-base bio-slurry reactors/bio-piles are eliminated from further consideration because of effectiveness and implementability concerns.

3.2.5.2 Off-Base Incineration

Incineration is a thermal oxidation process that converts organic solids, liquids, and gases to inorganic substances at high temperatures in the presence of oxygen. The technology uses controlled flame combustion in an enclosed reactor to decompose organics. Carbon and hydrogen waste components are converted to carbon dioxide (CO_2) and water, respectively. Other combustion products are also present in smaller quantities. These may include carbon monoxide, nitrogen oxides, chlorine, fluorine, and trace metals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Screening of the contaminated material would be required to remove the noncombustible waste/debris. The noncombustible waste/debris must be treated or disposed of by other means, depending upon the level of contamination.

Rotary kilns are one of the most widely used incinerators for wastes in the form of solids, sludges, liquids, and gases. An integrated system for incineration by rotary kiln includes a solid feed system, a rotary kiln and secondary combustion chamber, air pollution control units for particulate and acid gas removal, and an exhaust stack. Such a system employs a refractory-lined rotary kiln operating at high temperatures (1,470 to 2,910°F or 800 to 1,600°C) to combust wastes in the presence of oxygen. A typical throughput for a transportable rotary kiln is 75 to 200 tons per day. For wastes that have a high heat content, the

throughput may be limited by the capacity of the unit to control the heat generation rate. Fixed-based units such as cement kilns that may be permitted to accept contaminated soil are also available.

Effectiveness

Incineration is a well-proven technology that would be very effective for destroying the PAHs in the Site 58 soil. Incineration would typically achieve in excess of 99.99 percent destruction of organic contaminants with the resulting formation of inert carbon dioxide and water. Incinerated soil could typically be reused as fill material.

Implementability

Off-base incineration would be relatively easy to implement and would only require pre-approval of the waste. Qualified TSDFs would be available to provide the required services.

Cost

Cost of off-base incineration would be high to very high.

Conclusion

Off-base incineration is eliminated from further consideration because, although it would be very effective, it would also be very costly and this degree of treatment is generally reserved for waste material classified as hazardous under the Resource Conservation and Recovery Act (RCRA), which the Site 58 contaminated soil is not expected to be.

3.2.5.3 Off-Base Low Temperature Thermal Desorption (LTTD)

LTTD technology uses direct or indirect heating to thermally desorb or volatilize organic contaminants. The temperatures used are contaminant- and matrix-specific, with a range of approximately 200 to 1,200°F (95 to 650°C). Typically, wastes are processed through an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil. An induced airflow conveys the desorbed organic chemicals through a secondary treatment system, such as a granular activated carbon (GAC) adsorption unit, a catalytic oxidation unit, a condenser unit, or even an afterburner. It should be noted, however, use of an afterburner for secondary treatment has typically resulted in the LTTD unit being considered as an incinerator by regulatory agencies. The off-gas is then discharged through a stack.

Effectiveness

The effectiveness of LTTD is highly contaminant- and matrix-specific. Therefore, a full characterization of the waste to be treated would be required, and treatability testing would have to be performed to verify the level of effectiveness and determine the optimum operating temperature and detention time. LTTD effectiveness is very sensitive to particle size; therefore, pre-treatment might be required with screening and/or size reduction (e.g., crushing, grinding, shredding).

LTTD is a well-proven technology that would be very effective for the removal of the PAHs from the Site 58 soil. Because these PAHs are not particularly volatile, the operating temperature would be expected to be towards the higher end of the range (probably 800 to 900º F).

LTTD would likely require additional treatment of the volatilized contaminants that would be accomplished through treatment of off-gases by such processes as condensation, vapor-phase GAC adsorption, or catalytic oxidation.

Implementability

Off-base treatment of contaminated soil with LTTD would be implementable. Qualified TSDFs would be readily available to provide the necessary services. Treatability testing may have to be performed. Pre-treatment of the excavated soil would probably not be needed but off-gases from the thermal desorption unit would have to be treated, most likely with vapor-phase GAC adsorption.

Cost

Costs of off-base LTTD would be moderate.

Conclusion

Off-base LTTD is eliminated from further consideration because, although effective, this type of treatment is not anticipated to be necessary for the Site 58 contaminated soil because of the experience from the removal action for similarly contaminated soil at NAS Cecil Field Site 21.

3.2.6 Disposal

The only technology considered under this GRA is off-base landfilling. Off-base landfilling consists of transporting the excavated soil for burial in a permitted off-base TSDF. RCRA non-hazardous waste may be disposed of in an RCRA Subtitle D, or solid waste, landfill. RCRA-hazardous waste must be disposed

of in a RCRA Subtitle C, or hazardous waste, landfill. It is anticipated that the excavated soil would be classified as RCRA non-hazardous.

Effectiveness

Off-base landfilling would not permanently or irreversibly reduce COCs concentrations. However, although CERCLA preference for treatment relegates landfilling to a less preferable option, this technology is an effective disposal option for contaminated soil. Off-base landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections, and monitoring. The requirements of a RCRA Subtitle C hazardous waste landfill are typically more stringent than those of a RCRA Subtitle D solid waste landfill.

Implementability

Off-base landfilling would be easily implementable. Permitted TSDFs are available for this purpose. Disposal at a RCRA Subtitle D solid waste landfill may require certain pre-treatment, mainly the removal of free liquids but, because soil would only be excavated to a depth of 2 feet bgs or less, no water is likely to be present. In addition, a waste profile would have to be prepared, including indication of contaminant concentrations and their leachability.

Cost

Cost of off-base landfilling would be low to moderate.

Conclusion

Off-base landfilling is retained in combination with other process options for the development of remedial alternatives.

3.3 SELECTION OF SOIL TECHNOLOGIES AND PROCESS OPTIONS

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

- No Action
- Institutional Controls
- Monitoring

- Excavation
- Off-Base landfilling

3.4 PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens groundwater technologies and process options at a preliminary stage based on implementation with respect to site-specific conditions and COCs. Table 3-2 summarizes the results of this preliminary screening process. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by the screening comments.

The following are the groundwater technologies and process options retained for detailed screening:

General Response Action	Technology	Process Options
No Action	None	Not Applicable
Limited Action	Monitoring	Sampling & Analysis
	Institutional Controls	Passive Restrictions: Groundwater Use Restrictions
	Natural Attenuation	Naturally-Occurring Biodegradation and Dilution
Removal	Groundwater Extraction	Extraction Wells
In-situ Treatment	Biological	Aerobic/Anaerobic biological treatment with oxygen and/or hydrogen release compounds (ORC®/HRC®)
	Physical	Air Sparging (AS) or Air Sparging/ Vapor Extraction (AS/VE)
Ex-situ Treatment	Biological	Aerobic/Anaerobic Treatment
	Physical	Sedimentation
		Filtration
		Air Stripping
		GAC Adsorption
	Chemical	Coagulation/ Flocculation
		Neutralization/pH Adjustment
		Enhanced Oxidation
Disposal	Onsite Surface Discharge	Direct Discharge
		Indirect Discharge

3.5 DETAILED SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

3.5.1 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. Because no remedial actions are conducted under this alternative, there are no costs associated with "walking away from" the site, and there is no reduction in risk through exposure control or treatment.

Effectiveness

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

Implementability

There would be no implementability concerns because No Action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained for comparison to other options.

3.5.2 Limited Action

3.5.2.1 Institutional Controls

Institutional controls would consist of limiting access to groundwater by restricting future land use. LUCs, including deed restrictions, would be formulated and implemented to prevent the use of the groundwater from the Surficial Aquifer at Sites 57 and 58 as a source of drinking water. A formal notice would be issued to the St. John's River Water Management District not to issue permits for installation of wells at Sites 57 and 58 that would draw water from the Surficial Aquifer. As part of institutional controls, regular site inspections would be conducted to verify and enforce the continued application of these controls.

Effectiveness

Groundwater use restrictions would be effective in combination with source control activities. These controls would minimize potential human health risks associated with exposure to contaminated groundwater. At Sites 57 and 58, significant source control activities have either already been implemented (Site 57 Day Tank 1 removal) or are planned (Site 57 free product removal, Site 58 soil

excavation). As such, institutional controls would achieve two of the three groundwater RAOs for Sites 57 and 58.

Implementability

Institutional controls would be readily implementable. As part of change of the sites from military to private ownership, provisions will be incorporated in property transfer documents to insure the continued implementation of institutional controls. Resources are readily available for the preparation of deed restrictions.

Cost

Costs of institutional controls would be low.

Conclusion

Institutional controls are retained in combination with other process options for the development of groundwater remedial alternatives.

3.5.2.2 Monitoring

Sampling and analysis of groundwater throughout the area of potential groundwater contamination could be used to evaluate migration of contaminants and the potential for contamination of onsite drinking water supplies and nearby residential, municipal, and commercial wells. Monitoring can also be used to monitor potential natural attenuation or the progress of active groundwater remediation.

Effectiveness

Monitoring would not of itself reduce the toxicity, mobility, or volume of contaminants in the groundwater; but it would allow the evaluation of potential off-site migration of contaminants and the potential reduction in contaminant concentrations through natural attenuation. By serving as a warning mechanism, periodic groundwater monitoring would enable households to discontinue use of groundwater if a threat of contamination arose in the area. Monitoring would also be helpful in measuring and evaluating the effectiveness of natural attenuation or active remediation technologies.

Implementability

A groundwater monitoring program could be readily implemented at the sites under consideration. Local and state permits would be required for monitoring well installation.

Cost

Capital and O&M costs of monitoring would be low.

Conclusion

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

3.5.2.3 Natural Attenuation

Natural attenuation would consist of monitoring groundwater quality to determine the extent to which naturally-occurring processes such as biodegradation, abiotic transformation, dispersion, and dilution would break down petroleum hydrocarbons and chlorinated VOCs over time. For this purpose, new monitoring wells would be installed as required and samples from these new wells and existing wells would be regularly collected and analyzed for natural attenuation parameters such as oxidation/reduction potential (ORP), dissolved oxygen (DO), pH, alkalinity, temperature, conductivity, total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfides, sulfates), nitrogen compounds (nitrites, nitrates), orthophosphates, chloride, and metabolic gases [methane, ethane, ethene, carbon dioxide (CO_2)].

Effectiveness

Naturally occurring processes are expected to reduce contaminant concentrations in the aquifer over the long term. This is evidenced by the results of the natural attenuation monitoring conducted at Sites 57 and 58 as reported upon in Section 6.3 of the RI report (TtNUS, 2002). These results showed strong evidence of an environment favorable to biodegradation in general, and reductive biodegradation of chlorinated VOCs in particular, in the shallow and intermediate zones of the Surficial Aquifer where the highest concentrations of these contaminants have been detected. Effectiveness of natural attenuation is also supported by the fact that all of the concentrations of COCs in the Site 57 TCE Plume and Site 58 Naphthalene Plume and nearly all of the concentrations of COCs in the Site 57 Petroleum Plume are well within the FDEP's natural attenuation default values (FDEP, 1999b).

Groundwater monitoring would provide an effective means of evaluating the concentrations of COCs in groundwater and of assessing the rate of decrease of these concentrations. Monitoring of indicator parameters would help to evaluate the effectiveness of natural attenuation in reducing COCs concentrations.

Implementability

Natural attenuation would be easy to implement. Monitoring groundwater quality, restricting groundwater use, and periodic reviewing of site conditions could readily be performed, and the necessary resources are available to provide these services.

Cost

Capital and O&M costs for natural attenuation would be low.

Conclusion

Natural attenuation is retained in combination with other process options for the development of groundwater remedial alternatives.

3.5.3 Removal

The only technology considered under this GRA is groundwater extraction. Groundwater extraction uses a pumping system composed of a series of wells that are used to capture contaminated groundwater for treatment. The wells used in the capture system are designed and located to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater.

Effectiveness

Groundwater extraction is a well-established technology for the removal of contaminated groundwater and the containment of groundwater contaminant plumes. While the initial effectiveness of this technology for contaminant capture is high, it has often been shown to decrease over time. This decrease is generally due to one or more of several factors including the presence of preferential flow pathways due to aquifer heterogeneity, contaminant adsorption onto aquifer materials, diffusion of contaminants into the pore spaces of low-permeability materials, and creation of stagnation zones due to pumping operations. It should be noted, however, that no such decrease over time is observed in the effectiveness of this technology for containment of contaminant plumes. The effectiveness of an extraction well system depends largely on the extent of contamination and site-specific geology and hydrogeology. The use of wells to extract groundwater should reduce contaminant concentrations and may attain the cleanup goals over the long term. This technology is reliable, and minimal effects on human health and the environment would be expected during implementation.

Implementability

Groundwater extraction through a pumping well system could be readily implemented at Sites 57 and 58. This technology uses readily available equipment and techniques and has been widely used in similar situations. Implementation of this technology would require long term O&M. Maintenance may require periodic replacement of mechanical components and well flushing to remove fine-grained material that may clog the wells. Local and state permits would be required to install the extraction wells. Removal actions would need to be conducted with consideration to existing structures at Sites 57 and 58.

Cost

Capital and O&M costs for groundwater extraction would be low to moderate, depending on the extent of the contaminant plumes to be remediated.

Conclusion

A pumping well system is retained in combination with other process options for the development of groundwater remedial alternatives.

3.5.4 In-Situ Treatment

3.5.4.1 In-Situ Aerobic/Anaerobic Biological Treatment

Biological treatment involves the use of microorganisms, primarily bacteria, actinomycetes, and fungi, to breakdown hazardous organic compounds into nontoxic or less toxic forms. This technology would enhance natural attenuation of organic COCs.

This option would consist of using an oxygen-release compound (ORC®) and/or an hydrogen-release compound (HRC®) to enhance the growth of indigenous microorganisms and natural biodegradation processes, while monitoring groundwater quality to determine the extent to which these microorganisms and processes would break down contaminants over time. ORC®s such as hydrogen or magnesium peroxide could be used to enhance the aerobic biodegradation of the Site 57 Petroleum and Site 58 Naphthalene Plumes and an HRC® such as lactic acid could be used to enhance the anaerobic biodegradation of the Site 57 TCE Plume. These compounds would initially be injected into the contaminant plume using DPT, after which a maintenance dosage would be periodically fed into monitoring wells. New monitoring wells would be installed as required, and samples from these new wells and existing wells would be regularly collected and analyzed.

Effectiveness

In-situ aerobic biological treatment with ORC® is a well-proven technology that would be effective for the removal of COCs from the Site 57 Petroleum and Site 58 Naphthalene Plumes such as BTEX, low molecular weight PAHs, and TRPH. However, while increasingly documented, the effectiveness of in-situ anaerobic biological treatment with HRC® for the removal of chlorinated VOCs such as those in the Site 57 TCE Plume is not as of yet as well established. This is especially the case with overlapping contaminant plumes such as Site 57, where the injection of ORC® for aerobic treatment of BTEX and TRPH might interfere with the effectiveness of HRC® injection for the anaerobic treatment of TCE. There is also the possibility that anaerobic dechlorination could lead to the formation of vinyl chloride that is more toxic than the original chlorinated VOCs (i.e., TCE or DCE). A treatability study would be needed in order to fully evaluate the process.

Implementability

In-situ aerobic/anaerobic biological treatment processes could be implemented. The DPT application of ORC® and HRC® would be relatively unobtrusive with respect to continued use of existing structures. Coring of DPT injection points through concreted or asphalted surfaces would be avoided as much as possible. Several qualified contractors would be available for the implementation of this technology.

Cost

Capital and O&M costs for in-situ aerobic/anaerobic biological treatment would be low to moderate, depending on the extent of the area treated.

Conclusion

In-situ aerobic/anaerobic biological treatment is retained in combination with other processes options for the development of groundwater remedial alternatives.

3.5.4.2 Air Sparging (AS) or Air Sparging/ Vapor Extraction (AS/VE)

AS consists of injecting air in the contaminant plume to induce an air current through the groundwater that promotes short-term stripping of VOCs and long-term biodegradation of PAHs and TRPH. Air is injected through a network of vertical wells screened at various depths within the contaminant plume. If capture and treatment of vaporized groundwater COCs or if treatment of overlying soil are required, a VE system is added. In this case, a vacuum is applied through a network of vertical wells screened in the vadose zone above the contaminant plume and the extracted vapors are collected and treated through vapor-phase GAC adsorption prior to venting to atmosphere. When saturated, the GAC is replaced and sent

off-site for regeneration or incineration. Groundwater samples are regularly collected and analyzed to monitor the progress of the remedial action and, if a VE system is used, offgas samples are collected and analyzed to evaluate its performance and to verify compliance with regulatory emission requirements.

Effectiveness

AS or AS/VE is a very well proven technology that would be effective for the treatment of contaminated groundwater at Sites 57 and 58. A biosparging system, which is a form of AS/VE treatment, was installed and is currently being successfully operated to treat the Day Tank 1 area that is the main source of the Site 57 Petroleum Plume. AS or AS/VE would effectively remove VOCs in the Site 57 Petroleum and TCE Plumes, primarily through volatilization. AS or AS/VE would also be effective for the removal of TRPH in the Sites 57 and 58 groundwater and, although probably less so, for the removal of the PAHs in the Site 58 Naphthalene Plume, principally through enhanced aerobic biodegradation. However, there are certain limitations associated with AS that should be considered. One of these is that air flow through the saturated zone may not be uniform due to non-homogenous soil conditions. Another limitation is that there may be some uncontrolled movement of potentially dangerous vapors. For Sites 57 and 58, these potential limitations are not expected to be significant. Also, because groundwater COCs concentrations are relatively low and soil contamination is not of concern, no VE system would likely be required.

Implementability

AS or AS/VE would be relatively simple to implement at Sites 57 and 58. AS and VE wells and piping would have to be designed and located for minimum impact on existing structures. Drilling of these wells through concreted or asphalted surfaces would be avoided as much as possible. Several qualified contractors would be available for the implementation of this technology.

Cost

Capital and O&M costs would be low to moderate for AS and moderate to high for AS/VE.

Conclusion

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

3.5.5 Ex-Situ Treatment

3.5.5.1 Aerobic/Anaerobic Biological Treatment

Biological treatment involves the use of microorganisms, primarily bacteria, actinomycetes, and fungi, to breakdown hazardous organic compounds into nontoxic or less toxic forms.

Ex-situ aerobic or anaerobic biological treatment consists of contacting the contaminated groundwater with a concentrated culture of such microorganisms under controlled operating conditions including mixing, presence or absence of oxygen, pH, temperature, and addition of nutrients.

Ex-situ aerobic/anaerobic biological treatment of groundwater may require pre-treatment of groundwater, including neutralization/pH adjustment and/or the removal of excess suspended solids by coagulation/flocculation and sedimentation or filtration. Ex-situ aerobic/anaerobic biological treatment also generates fugitive emissions that must be controlled and solid or liquid residues, such as sludges, that require further treatment and disposal.

Effectiveness

Ex-situ aerobic biological treatment is a well-proven technology that would effectively remove BTEX, low molecular weight PAHs, and TRPH from the Site 57 Petroleum and Site 58 Naphthalene Plumes. However, the effectiveness of ex-situ anaerobic treatment for removal of chlorinated VOCs such as those in the Site 57 TCE Plume is not nearly as well established. A treatability study would be needed in order to fully evaluate the process.

Implementability

Ex-situ aerobic/anaerobic biological treatment would be implementable. Numerous qualified vendors and contractors offer equipment and services for ex-situ aerobic biological treatment of BTEX, low molecular weight PAHs, and TRPH. However, availability of proven technology and know-how for the ex-situ anaerobic biological treatment of chlorinated VOCs is very limited.

Implementation of ex-situ aerobic/anaerobic biological treatment for the Sites 57 and 58 groundwater would require pre-treatment for suspended solids removal and treatment and disposal of the residues generated by these processes.

Cost

Capital and O&M costs for ex-situ aerobic/anaerobic biological treatment would be low to moderate.

Conclusion

Ex-situ aerobic/anaerobic biological treatment is eliminated from further consideration because of concerns regarding its effectiveness for the removal of chlorinated VOCs and because of the relative complexity introduced by the requirement for treatment and disposal of treatment residues.

3.5.5.2 Filtration

Filtration is a process using a porous medium to remove solid particles from a liquid or gas. This technology is generally used as a groundwater pre-treatment to remove suspended solids before other treatment processes and/or for the final cleaning or polishing of treated effluent.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), ultrafiltration, or beds of granular material such as sand. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Most type of liquid filters, except those utilizing disposable filter elements (such as cartridge filters) require periodic cleaning to remove the suspended solids accumulated in the filter medium and to restore filtration efficiency. This cleaning is typically performed with a countercurrent of water, or backwash, which carries away the solids retained on the filter medium.

Effectiveness

Filtration would not be expected to be effective of itself for the removal of COCs from groundwater at Sites 57 and 58. However, this technology would provide an effective pre-treatment by removing moderate concentrations [typically up to 50 milligrams per liter (mg/L)] of particles suspended in the groundwater that might otherwise undermine the efficiency of downstream treatment technologies such as air stripping and liquid-phase GAC adsorption. Filtration would also effectively remove whatever contaminants may be adsorbed on the solid particles suspended in the groundwater. Based on previous characterization of the groundwater at Sites 57 and 58, which typically contains 10 to 20 mg/L suspended solids, it is likely that filtration pre-treatment would be required.

Implementability

Filtration would be readily implementable. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Liquid or solid residues resulting from the periodic cleaning or replacement of the filter medium would have to be properly disposed.

Cost

Capital and O&M costs for filtration would be low.

Conclusion

Because the groundwater of the Surficial Aquifer at NAS Cecil Field typically contains 10 to 20 mg/L of suspended solids, filtration is retained as a pre-treatment technology for the development of groundwater remedial alternatives.

3.5.5.3 Air Stripping

Air stripping is an aeration process that promotes the transfer of VOCs from the aqueous phase to the gas phase. Air stripping is typically most effective for the removal of VOCs with a Henry's Law constant greater than or equal to 3.0 atmosphere-liter per mole (atm-L/mole). Removal efficiencies of VOCs typically exceed 99 percent depending on the operating parameters as well as the physical properties of the organic contaminants.

The counter-current packed tower is the most commonly used air stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. Loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. Key factors that influence process performance include air to water ratio, height of packing and type of packing material, operating temperature, surface hydraulic loading, and contact time.

Effectiveness

Air stripping is a well-proven and reliable technology that would be effective for removing the VOCs in the Site 57 Petroleum and TCE Plumes. Removal efficiencies greater than 99 percent could theoretically be achieved for these compounds. However, air stripping would not be nearly as effective for the removal of the TRPH in the Sites 57 and 58 groundwater and would probably also not be effective for the removal of the SVOCs in the Site 58 Naphthalene Plume. Because air stripping only removes the contaminants from the water and concentrates them in an exhaust gas, this offgas may have to be treated prior to release to atmosphere by such means as vapor-phase GAC adsorption, catalytic oxidation, or thermal destruction to satisfy air emissions regulations. However, VOC concentrations in the groundwater of Sites 57 and 58 is not high enough that such offgas treatment would be required.

Implementability

Air stripping would be readily implementable. There are a significant number of vendors that provide air stripping equipment.

A maintenance problem commonly associated with air stripping is the long-term clogging of the air stripping elements. Typical causes of this clogging include biological growth and/or the deposition of minerals and solids from the groundwater being treated. Low-profile type air strippers with perforated tray elements are less susceptible to this problem than conventional packed tower type air strippers but pre-treatment for suspended solids control is still often required. Based upon the quality of the Sites 57 and 58 groundwater, it is anticipated that filtration would be needed prior to air stripping.

Cost

Capital and O&M costs for air stripping of the Site 57 groundwater would be low would be low because only minimal treatment would be required (filtration) and no offgas treatment would be necessary.

Conclusion

Air stripping is retained in combination with other process options for the development of groundwater remedial alternatives but only for Site 57.

3.5.5.4 GAC Adsorption

GAC adsorption is a frequently applied technology for the removal of contaminants from air or water. GAC adsorbs most organic compounds to some extent but is more effective for the less polar and less soluble compounds. The fundamental principle behind GAC adsorption involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As the contaminated liquid or vapor passes through one or more vessels containing GAC, the organic molecules are captured on the active sites of the carbon grains and eventually occupy all of these sites. The exhausted GAC must then either be regenerated or disposed.

Typical GAC adsorption treatment systems include atmospheric or pressurized columns operating in series and/or parallel configuration. Liquid-phase GAC columns are typically designed with backwashing capability to minimize solids fouling that would increase GAC replacement frequency. Factors such as pH and temperature of the fluid to be treated, empty bed contact time (EBCT), surface area/volume ratio of the GAC, and solubility of the target organic compound(s) will affect the adsorption process.

Effectiveness

Liquid-phase GAC adsorption is a well-proven, reliable technology that would be effective for removing most of the VOCs, PAHs, and TRPH from the groundwater at Sites 57 and 58. Removal efficiency exceeding 99 percent is possible depending on the type of organic compound and system operating parameters such as the retention time. Generally, the most effective application of GAC adsorption is for low concentrations of organic compounds, that result in relatively low GAC consumption. Additionally, other organic compounds could compete with the COCs for removal, although no such other organic compounds have been detected in the groundwater at levels above detection limits.

Implementability

GAC adsorption would be readily implementable. There are a sufficient number of qualified vendors that provide GAC adsorption units.

As with air stripping, a maintenance problem commonly associated with liquid-phase GAC adsorption is long-term clogging in the GAC bed. Typical causes of this clogging include biological growth and/or the deposition of minerals and solids from the groundwater being treated. Based upon the quality of the Sites 57 and 58 groundwater, it is anticipated that filtration would be needed prior to liquid-phase GAC adsorption. Spent GAC containing the concentrated organic contaminants would have to be regenerated, incinerated, or disposed of in a hazardous waste landfill. Thermal, steam, and solvent treatments are the most common types of GAC regeneration technologies and are typically conducted off site. Special handling of the periodically generated backwash liquids must also be taken into account.

Cost

Capital cost for GAC adsorption would be moderate. O&M costs are primarily a function of GAC usage that is expected to be low to moderate based upon the relatively low concentrations of COCs to be removed.

Conclusion

Liquid-phase GAC adsorption is retained in combination with other process options for the development of groundwater remedial alternatives.

3.5.5.5 Coagulation/Flocculation and Sedimentation

Coagulation/flocculation is a process that consists of adding one or more chemical reagents that result in the agglomeration of small suspended solids particles into larger ones, thus increasing significantly the effectiveness of sedimentation.

Sedimentation is a process that removes suspended solid particles from a liquid by producing quiescent hydraulic conditions that promote the gravity settling of these particles. This technology is often used in conjunction with chemical precipitation. Two slightly different sedimentation options, clarification and thickening, can be used. Clarification aims at optimum solids removal and typically produces a 2 to 8 percent (by weight) sludge. Thickening is typically used to further concentrate clarification sludges to 8 to 15 percent (by weight).

Effectiveness

Coagulation/flocculation and sedimentation would not of themselves be effective for the removal of COCs from groundwater at Sites 57 and 58. However, these technologies would provide an effective pre-treatment by removing high concentrations (typically 50 mg/L or more) of suspended solids that would otherwise undermine the efficiency of COC removal technologies such as air stripping and GAC adsorption. Based on previous characterization of the groundwater at Sites 57 and 58, which typically contains only 10 to 20 mg/L suspended solids, it is unlikely that this degree of pre-treatment would be required.

Implementability

Coagulation/flocculation and sedimentation would be readily implementable. Numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for coagulation/flocculation and sedimentation would be low.

Conclusion

Coagulation/flocculation and sedimentation are eliminated because the concentrations of suspended solids in the Surficial Aquifer at Sites 57 and 58 are not anticipated to be sufficiently high to require this degree of pre-treatment.

3.5.5.6 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process for achieving appropriate pH levels for removal of contaminants. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa.

Effectiveness

Neutralization/pH adjustment is generally effective for the removal of certain contaminants, mostly inorganic compounds, by bringing them out of solution. For Sites 57 and 58, neutralization/pH adjustment would not of itself be effective for the removal of COCs in groundwater. However, this technology would enhance the effectiveness of such pretreatment technologies as coagulation/flocculation and sedimentation and may be required prior to discharge of treated groundwater.

Implementability

Neutralization/pH adjustment would be readily implementable. This technology is widely used, and numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for neutralization/pH adjustment would be low.

Conclusion

Neutralization/pH adjustment is eliminated because the pH of the extracted groundwater is anticipated to be acceptable for discharge, and pH adjustment would not be required for removing contaminants out of solution.

3.5.5.7 Enhanced Oxidation

Enhanced oxidation processes use a controlled combination of either ozone or hydrogen peroxide and ultraviolet (UV) light to induce photochemical oxidation of organic compounds. Ozone has been used extensively in Europe for purification, disinfection, and odor control of drinking water. Ozone alone has the ability to break down some organics but has generally proven to be an ineffective oxidant of halogenated organics under conditions normally used for drinking water treatment or for disinfecting wastewaters (i.e., 1 to 10 mg/L concentration and 5- to 10-minute contact times).

UV radiation is electromagnetic energy with wavelengths between those of visible light and X-ray radiation on the electromagnetic spectrum. UV energy is capable of breaking down or rearranging a molecular structure depending on the dissociation energies of the chemical bonds within the structure. The combination of UV radiation with ozone or hydrogen peroxide treatment results in the oxidation of organic contaminants at a rate many times faster than that obtained from applying UV light alone.

A typical continuous-flow hydrogen peroxide/ozone and UV system consists of an oxygen or air source, an ozone generator or hydrogen peroxide feed system, a UV/oxidation reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the wastewater to the UV radiation, supplied by an arrangement of lamps. Typical reactor designs range from mechanically agitated reactors to spray, packed, and tray-type towers. If ozone is utilized, reactor gases are passed through a catalytic ozone decomposer that converts remaining ozone to oxygen and destroys any residual VOCs.

Effectiveness

Enhanced oxidation with hydrogen peroxide/ozone and UV technology has been proven effective for the destruction of halogenated organic compounds, benzene derivatives, and various aliphatics hydrocarbons. TCE has been reduced from 20 mg/L to less than 5 µg/L. Effectiveness varies greatly depending on the COCs. For the Site 57 groundwater, BTEX and chlorinated alkenes, such as, TCE and DCE would be readily removed while chlorinated alkanes, such as DCA, would be more refractory. As with air stripping, UV/oxidation is not expected to be very effective for the removal of PAHs and TRPH.

Implementability

Enhanced oxidation with hydrogen peroxide/ozone and UV would be readily implementable. However, only a few vendors currently offer this technology. Recent improvements have been made by vendors of this technology to minimize energy usage and reduce UV lamp fouling problems. With this treatment, no toxics are emitted to the atmosphere or adsorbed onto media that require further treatment or disposal. Hydrogen peroxide is a strong oxidizing agent; therefore, diking and other engineering controls are required to minimize potential risks associated with peroxide releases.

Cost

Capital cost of enhanced oxidation with hydrogen peroxide/ozone and UV would be moderate to high. O&M costs vary significantly depending on flow rate, and contaminant type, and concentration.

Conclusion

Enhanced oxidation with hydrogen peroxide/ozone and UV is eliminated from further consideration because air stripping is more cost effective at the sites being evaluated.

3.5.6 Disposal

3.5.6.1 Direct Discharge

This technology would consist of discharging the treated (or untreated) groundwater to the storm sewer system located near Sites 57 and 58. This storm sewer system itself discharges to a network of surface drainage ditches that eventually flow into Sal Taylor Creek.

Effectiveness

Direct discharge of groundwater to the storm sewer system would be an effective means of disposal for groundwater at Sites 57 and 58. However, the groundwater would have to undergo adequate treatment for this option to be environmentally acceptable.

Implementability

Direct discharge of groundwater to the storm sewer system would be implementable. Prior to discharge, groundwater would have to be treated to comply with Florida Water Quality Standards. The substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit would have to be met for discharge into the creek, but actually securing such a permit would not be necessary. Ongoing monitoring of discharged water would be required to ensure that Sal Taylor Creek and other areas downstream are not adversely effected. These requirements would be implementable, and the resources necessary to satisfy them are available.

Cost

Capital and O&M costs of direct discharge would be low.

Conclusion

Direct discharge is retained in combination with other process options for the development of groundwater remedial alternatives.

3.5.6.2 Indirect Discharge

This technology would consist of discharging the treated (or untreated) groundwater to a local sewage treatment plant (STP) where it would undergo either the full or incremental treatment required for discharge to Sal Taylor Creek.

Effectiveness

Indirect discharge to a local STP would be an effective mean for the disposal of the Sites 57 and 58 groundwater. The STP would provide the necessary polishing treatment for ultimate discharge to surface water.

Implementability

Indirect discharge to a local STP is unlikely to be implementable due to the large flow rate anticipated for remediation and complications arising from the closing of the Base. A thorough evaluation of impacts to the STP would be required before proceeding with this option. Discharge flow rate, contaminant types, and concentrations would have to comply with the STP permit conditions.

It is highly unlikely that the STP would have adequate excess capacity to address the large flow rates anticipated for groundwater remediation at the sites under consideration. Even if excess capacity were available, the large volume of essentially clean effluent from the groundwater treatment system would significantly alter STP operations.

Cost

Capital and O&M costs for indirect discharge to a local STP would be moderate to high, depending on the distance to the STP and whether upgrading of the STP would be necessary.

Conclusion

Indirect discharge is eliminated from further consideration due to significant implementability concerns.

3.6 SELECTION OF REPRESENTATIVE GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

The following technologies and process options are retained for development of groundwater remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Natural Attenuation
- Groundwater Extraction
- In-situ Aerobic/Anaerobic Biological Treatment
- AS
- Filtration
- Air Stripping (Site 57 only)
- Liquid-Phase GAC Adsorption
- Direct Discharge

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 3

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not applicable	No activities conducted at the site to address contamination.	Required by law. Retain for baseline comparison to other technologies.
Limited Action	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Retain to control access to the Site 58 area of soil contamination.
		Passive Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retain to prevent future residential development.
	Monitoring	Sampling and Analysis	Sampling and analysis of soil and groundwater to evaluate natural attenuation and migration of COCs in the environment.	Retain to assess natural attenuation and/or migration of COCs from site and to evaluate progress of remedial actions.
Containment	Capping	Soil/Multimedia Cover	Use of semi-permeable or impermeable barriers to minimize direct exposure to contaminated soil and potential migration of COCs to groundwater.	Retain.
	Erosion control	Rip-rap cover/vegetation	Use of gravel/cobbles or dense plant growth to minimize migration of contaminated soil.	Eliminate because erosion is not a significant migration pathway due to the flat nature of the terrain.
Removal	Bulk excavation	Excavation	Use of construction equipment such as backhoe, front-end loader, gradall, etc., to remove contaminated soil.	Retain.
In-situ Treatment	Thermal	Vitrification/ Radiofrequency Heating	Use of high-temperature melting to fuse inorganic COCs into a glass matrix or of moderate temperature heating to volatilize COCs and remove them from the soil.	Eliminate because of implementability concerns due to shallow groundwater table elevation.

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 3

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-situ Treatment (continued)	Physical/ Chemical	Soil Flushing	Use of water or other solvents to remove COCs by flushing and collecting and treating or disposing of the contaminated fluids.	Eliminate because polynuclear aromatic hydrocarbons (PAHs) are not particularly soluble, soil has low hydraulic conductivity, and the water table is shallow.
		Dynamic Underground Stripping	Injection of steam at the periphery of the contaminated area to volatilize COCs and removal of these COCs through a centrally located extraction well.	Eliminate because PAHs are not particularly volatile and this technology mostly applies to highly-contaminated soil.
		Soil Vapor Extraction	Use of vacuum and possibly air sparging to volatilize COCs.	Eliminate because PAHs are not particularly volatile.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents in the vadose zone to chemically fix COCs and solidify the matrix.	Eliminate because this technology would not be very effective for PAHs.
Ex-situ Treatment	Physical/ Chemical	Soil Washing/Solvent Extraction	Use of water or other solvents to remove COCs by flushing and collecting and treating or disposing of the contaminated fluids.	Eliminate because PAHs are not particularly soluble and soil is not very permeable.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents to chemically fix COCs and solidify the matrix.	Eliminate because this technology would not be very effective for PAHs.
	Biological	Onsite Landfarming	Spreading and tilling of contaminated soil into layers of clean surface soil to aerate and biodegrade organic COCs.	Eliminate because no on base area is available for this purpose.
		Bioslurry Reactor/Biopile	Treatment of soils in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Retain for the potential off-base treatment of PAHs.

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 3

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-situ Treatment (continued)	Thermal	Incineration	Use of high temperatures to destroy COCs.	Retain for the potential off-base treatment of PAHs.
		Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to volatilize COCs and remove them from soil.	Retain for the potential off-base treatment of PAHs.
	Solids Processing	Crushing/Grinding	Size reduction of wastes as a preliminary process to aid in downstream treatment.	Eliminate. No significant oversize debris material is expected.
		Screening	Removal/segregation of material based on size as a preliminary process to aid in downstream treatment.	Eliminate. No significant oversize debris material is expected.
Disposal	Landfill	On-Site Landfilling	Disposal of excavated soil and treatment residues in an on-base landfill.	Eliminate because no suitable on-base area is available for this purpose.
		Off-Site Landfilling	Disposal of excavated soil and treatment residues in an off-base permitted TSDF.	Retain.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 5

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by law. Retain for baseline comparison to other technologies.
Limited Action	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater and other media to track the spread of contamination.	Retain to assess natural attenuation and/or migration of contaminants from site and evaluate remedial actions.
	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, and warning signs to restrict site access.	Eliminate because it would interfere with use of the sites as commercial airport areas..
		Passive Controls: Deed and Land Use Restrictions	Administrative action using property deeds to restrict future site activities and use of groundwater as source of drinking water.	Retain to limit human exposure to contaminated groundwater.
	Natural Attenuation	Naturally-Occurring Biodegradation and Dilution	Monitoring the groundwater to assess the contaminant dilution or degradation.	Retain
Containment	Vertical Barriers	Slurry Wall	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.
		Grout Curtain	Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.
		Sheet Piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 5

General Response Action	Technology	Process Options	Description	Screening Comment
Containment (Continued)	Vertical Barriers (Continued)	Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate. No suitable area exists reasonably close to Sites 57 and 58 for reinjection.
		Biochemical Barrier	Interception and removal of organic contaminants through injection of nutrients, oxygen release compounds (ORC®s), and hydrogen release compounds (HRC®s).	Eliminate because this technology is better suited to in-situ treatment and is retained for that purpose.
	Horizontal Barriers	Physical Barrier	Injection of bottom sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.
Removal	Groundwater Extraction	Extraction Wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain to remove contaminated groundwater.
		Collection Trench	A permeable trench used to intercept and collect groundwater.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.
In-situ Treatment	Biological	Aerobic/ Anaerobic	Enhancement of biodegradation of organics in an aerobic (oxygen-rich) and/or anaerobic (oxygen-deficient) environment by injection of nutrients and ORC®/HRC®.	Retain for treatment of organic COCs.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 3 OF 5

General Response Action	Technology	Process Options	Description	Screening Comment
In-situ Treatment (continued)	Chemical	AS or AS/VE	Volatilization and enhancement of biodegradation of organic compounds by supply of air with or without capture and treatment of volatilized compounds.	Retain for treatment of VOCs and SVOCs.
		Permeable Reactive Barriers (PRBs)	Use of a permeable barrier which allows the passage of groundwater and reacts with the contaminants.	Eliminate because of interference with existing structures and current and future usage of the sites as commercial airport areas.
		Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well.	Eliminate because inappropriate to the removal of relatively low concentrations of organic COCs.
	Chemical	Enhanced Oxidation	Chemical destruction of organic COCs through oxidation with hydrogen peroxide and ferrous iron (Fenton's Reagent) or potassium permanganate.	Eliminate because inappropriate to the removal of relatively low concentrations of organic COCs.
Ex-situ Treatment	Biological	Aerobic/ Anaerobic	Natural degradation of organic COCs via microorganisms in an aerobic (oxygen-rich) or anaerobic (oxygen-deficient) environment.	Retain for treatment of a wide range of organic compounds.
	Physical	Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain as a potential pretreatment step prior to certain ex-situ organic removal processes.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials from water.	Eliminate because primarily applicable to the removal of dissolved inorganic compounds.
		Air Stripping	Contact of water with air to remove VOCs.	Retain for removal of VOCs.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 4 OF 5

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (continued)	Physical (continued)	GAC Adsorption	Separation of dissolved contaminants from water via adsorption onto activated carbon.	Retain for removal of VOCs and SVOCs.
		Solvent Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	Eliminate because not applicable to the removal of relatively low concentrations of contaminants.
		Distillation	Vaporization of a liquid following by condensation of the vapors to concentrate various constituents.	Eliminate because not applicable to the removal of relatively low concentrations of contaminants.
		Sedimentation	Separation of solids from water via gravity settling.	Retain as a potential pretreatment step prior to certain organics ex-situ removal processes.
	Chemical	Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Retain as a potential pretreatment step prior to certain ex-situ organic removal processes.
		Neutralization/pH Adjustment	Use of acids or bases to counteract excess pHs.	Retain as a potential pretreatment step or final step prior to discharge.
		Chemical Precipitation	Use of reagents to convert soluble compounds into insoluble compounds.	Eliminate because not required with relatively low concentrations of dissolved solids.
		Ion Exchange	Removal of dissolved ions from a liquid through exchange with similarly-charged ions held by electrostatic forces to the active sites on a synthetic resin that is contacted with the liquid to be treated.	Eliminate because primarily applicable to removal of dissolved inorganic compounds.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 5 OF 5

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (continued)	Chemical (continued)	Enhanced Oxidation	Use of oxidizers such as ozone, hydrogen peroxide, or potassium permanganate to breakdown certain organic compounds through cleavage of the C-C bond.	Retain for removal of chlorinated VOCs.
		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate because not applicable to COCs.
Discharge/ Disposal	Surface Discharge	Direct Discharge	Discharge of treated water.	Retain for discharge of treated groundwater.
		Indirect Discharge	Discharge of collected/treated water to local STP.	Retain for discharge of treated groundwater.
		Off-Site Treatment Facility	Treatment and disposal of water at an off-site treatment works.	Eliminate because impractical due to large volume of treated groundwater.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge collected/treated groundwater underground.	Eliminate because groundwater is too shallow for effective discharge to the Surficial Aquifer and because no suitable area is located reasonably close to Sites 57 and 58 for deep well injection.

4.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

This section presents an evaluation of each remedial alternative with respect to the criteria of the NCP of 40 CFR 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 to 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, and Volume through Treatment,
- Short-term Effectiveness,
- Implementability,
- Cost,
- State Acceptance, and
- Community Acceptance

Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and environment in both the short-and long-terms, from unacceptable risks posed by hazardous substances or contaminants present at the site by eliminating, reducing, or controlling exposure to levels exceeding remediation goals. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs

Alternatives must be assessed to determine whether they attain ARARs under Federal environmental laws and state environmental or facility siting laws. If one or more regulations that are applicable cannot be complied with, then a waiver must be invoked. Grounds for invoking a waiver would depend on the circumstances described in Section 2.1.2.1 of this FS report.

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:

Risk 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 reliable. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals, the assessment for the potential need to replace technical components of the alternative (such as a cap, a slurry wall, or a treatment system), and the potential exposure pathways and risks posed should the remedial action need replacement must be considered.

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 reduction(s) are occurring.
- The degree to which the treatment is irreversible.

- The type and quantity of residuals that will remain following treatment considering the presistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents.

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

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 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.

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 necessary approvals and permits from other agencies (for off-site actions).

- 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 necessary additional resources, the availability of services and materials, and availability of prospective technologies.

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.

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

These concerns cannot be evaluated at this time in the FS until the State of Florida has reviewed and commented on the RI/FS. These concerns will be discussed, to the extent possible, in the Proposed Plan to be issued for public comments.

Community Acceptance

This assessment consists of responses of the community to the Proposed Plan. This assessment includes determining which components of the alternatives interested persons 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:

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

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

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria:

- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment

- Short-Term Effectiveness
- Implementability
- Cost

The balancing criteria are used to weigh the relative merits of alternatives.

The remaining two of the nine criteria, namely State Acceptance and Community Acceptance are considered to be modifying criteria that must be considered during remedy selection. These last two criteria can be evaluated after the Proposed Plan has been reviewed by the State of Florida and has been discussed in a public meeting. Therefore, this document addresses only seven out of the nine criteria.

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 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 comments and determination of whether or not the preferred alternative continues to be the most appropriate remedial action for the site, in consultation with the State of Florida.

4.2 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

The following alternatives for soil remediation have been developed for Site 58:

1. No Action
2. Institutional Controls and Monitoring
3. Excavation and Off-Base Disposal

A description and detailed analysis of these alternatives are provided in the following sections.

4.2.1 Soil Alternative 1: No Action

4.2.1.1 Description

This alternative is a "walk-away" alternative that is required under CERCLA to establish a basis for comparison with other alternatives. Under this alternative, the property would be released for unrestricted use. This alternative cannot be chosen if waste remains on site.

4.2.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Soil Alternative 1 would not be protective of human health and the environment. Under the current industrial land use scenario, there would be unacceptable risk from direct human exposure to contaminated soil. Under a possible future residential land use scenario, this unacceptable human health risk would be further aggravated and an unacceptable risk to ecological receptors could also occur. The potential would also continue to exist for the undetected migration of COCs either offsite or from soil to groundwater.

Compliance with ARARs and TBCs

Soil Alternative 1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce COCs concentrations. Alternative 1 would also not comply with location-specific ARARs. Action-specific ARARs are not applicable.

Long-Term Effectiveness and Permanence

Soil Alternative 1 would have no long-term effectiveness and permanence because contaminated soil would remain on site. As there would be no institutional controls to prevent site access and/or residential development, the potential would exist for current and future unacceptable risk to human receptors. Residential development of Site 58 could also result in unacceptable risk to a correspondingly increased population of ecological receptors from exposure to contaminated soil. Because there would be no monitoring, the possible migration of COCs either offsite or from soil to groundwater would not be detected. Although COCs concentrations might eventually decrease to acceptable levels through natural attenuation, no monitoring would verify this.

Reduction of Toxicity, Mobility, or Volume through Treatment

Soil Alternative 1 would not reduce toxicity, mobility, or volume of COCs through treatment because no treatment would occur. Some reduction of toxicity or volume might occur through natural dispersion, dilution, or other attenuation process, but no monitoring would be performed to verify this.

Short-Term Effectiveness

Because no action would occur, implementation of Soil Alternative 1 would not pose a short-term risk to onsite workers or result in adverse impacts to the local community and the environment.

Soil Alternative 1 would not achieve the soil RAO, and although the soil cleanup goals might eventually be achieved through natural attenuation, it would not be known when.

Implementability

Soil Alternative 1 would be readily implementable because there would be nothing to implement. The technical feasibility criteria including constructability, operability, and reliability are not applicable. The implementability of administrative measures is not applicable because no such measures would be taken.

Cost

There would be no costs associated with Soil Alternative 1.

4.2.2 Soil Alternative 2: Institutional Controls and Monitoring

4.2.2.1 Description

Soil Alternative 2 is illustrated on Figure 4-1 and would consist of two major components: (1) institutional controls and (2) monitoring.

Component 1: Institutional Controls

Institutional controls would consist of restricting site access and preventing residential development. The existing fencing around the drainage ditch south of Building 312 would be maintained and upgraded if needed. Warning signs would be posted to clearly identify risks associated with exposure to contaminated soil. LUCs would be developed and implemented to prevent residential development of Site 58.

Regular site inspections would be performed to verify the continued implementation of the institutional controls. The frequency of these inspections would be based on the allowable time of exposure before an unacceptable human health risk associated with residential exposure would develop. Based on the results of the risk analysis provided in Appendix A, this frequency would be less than one year. However, at a minimum, the planning and construction phases for a residence is expected to be 1 year considering the site is located near the flightline. Consequently the frequency of site inspections would be annual.

Component 2: Monitoring

Monitoring would consist of regularly checking PAH concentrations in surface soil by collecting samples near the location where exceedances of the residential SCTLs were detected (CEF-B312-SD001). Monitoring would also consist of collecting groundwater samples from one existing well downgradient of the contaminated soil area (CEF-B312-10S) and analyzing these samples for PAHs.

Monitoring would be conducted for 30 years, and the data would be evaluated to determine the need for additional remedial action at the site. Sampling frequency would be annual, and each sampling event would consist of collecting one surface soil sample and one groundwater sample. Both of these samples would be analyzed for PAHs.

Every 5 years, site reviews would be conducted to evaluate the continued adequacy of the remedial alternative. These site reviews are required because this alternative allows contaminants to remain in soil at levels that exceed cleanup goals.

As part of the change of Site 58 from military to private ownership, provisions will be incorporated into the property transfer documents to ensure continuation of the above-described monitoring.

4.2.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

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

Institutional controls restricting access to the Site 58 area of contaminated soil would be protective of human health by reducing the potential for unacceptable human health risks from direct exposure to that soil. Institutional controls preventing residential development of Site 58 would be protective of human health and the environment by minimizing the potential for unacceptable risks from exposure of future human residents or ecological receptors with contaminated soil.

Monitoring would be protective of the environment by detecting the potential migration of COCs either offsite or from soil to groundwater.

Compliance with ARARs and TBCs

Soil Alternative 2 would comply with location- and action-specific ARARs and TBCs. In the short-term, Soil Alternative 2 would not comply with chemical-specific ARARs and TBCs because COC concentrations would not actively be reduced. However, monitoring would determine whether contamination is being reduced through natural processes.

Long-Term Effectiveness and Permanence

Soil Alternative 2 would provide long-term effectiveness and permanence. Although soil COC concentrations would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring.

Fencing and posting the drainage ditch south of Building 312 would effectively reduce the current risk of exposure to contaminated soil. Restricting Site 58 to industrial use would effectively and permanently prevent its development as a residential area, thereby preventing unacceptable risk from direct exposure of future residents and of an increased ecological population to contaminated soil.

Long-term monitoring would effectively detect potential migration of COCs either offsite or from soil to groundwater and determine whether contamination is being reduced as a result of natural processes.

Reduction of Toxicity, Mobility, or Volume through Treatment

Soil Alternative 2 would not reduce toxicity, mobility, or volume of contaminants through treatment because no treatment would occur. Some reduction in toxicity and volume might occur through natural attenuation, and this would be determined through monitoring.

Short-Term Effectiveness

Soil Alternative 2 would have minimal short-term effectiveness concerns. Exposure of onsite workers to contaminated soil during the collection of soil samples and the maintenance and sampling of existing monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of institutional controls and monitoring would not adversely impact the surrounding community or the environment.

The soil RAO would be achieved immediately upon implementation of institutional controls and monitoring. Eventual attainment of the soil cleanup goals through natural attenuation would be determined through monitoring.

Implementability

Soil Alternative 2 would be readily implementable.

Maintenance and/or upgrade of existing fencing, posting of warning signs, maintenance of existing monitoring wells, sampling and analysis of soil and groundwater, and performance of regular site inspections and five-year reviews could readily be accomplished. The resources, equipment, and materials required for these activities are readily available.

The administrative aspects of Soil Alternative 2 would be relatively simple to implement. No construction permit would be required for this alternative. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land use restrictions and monitoring.

Cost

The estimated costs for Soil Alternative 2 are as follows. These costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates:

- Capital Cost: $20,000
- 30-Year net present worth (NPW) of O&M Cost: $54,000
- 30-Year NPW: $74,000

A detailed cost estimate for this alternative is provided in Appendix D.1.

4.2.3 Soil Alternative 3: Excavation and Off-Base Disposal

4.2.3.1 Description

Soil Alternative 3 is illustrated on Figure 4-2 and would consist of two major components: (1) excavation and (2) off-base transportation and disposal.

Component 1: Excavation

Soil contaminated with concentrations of PAHs in excess of the FDEP SCTLs for direct residential exposure would be excavated. Pre-excavation sampling would be conducted in order to verify the exact extent of the contamination.

An area approximately 2,400 ft^2 in size as shown on Figure 2-1 would be excavated to 2 feet bgs. This corresponds to a volume of approximately 180 yd^3 of excavated material. Following excavation, the excavated area would be backfilled with clean soil and the site would be restored to its original condition.

Component 2: Off-Base Transportation and Disposal

The excavated soil would be transported to an off-base permitted TSDF for disposal. For the purpose of this FS, it is assumed that excavated soil would not require treatment prior to disposal in a solid waste RCRA Subtitle D landfill.

4.2.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Soil Alternative 3 would be protective of human health and the environment.

Excavation of soil with concentrations of COCs in excess of the FDEP SCTLs for direct residential exposure would eliminate the potential for unacceptable human health risk in case of residential development of the site. Excavation of contaminated soil would also minimize the potential for COCs to migrate either offsite or from soil to groundwater.

Off-base disposal of the excavated soil at a permitted TSDF would protect human health and the environment.

Some short-term risks could be incurred by workers from exposure to contaminated soil during on- and off-base remedial activities. However, the potential for exposure would be minimized by the implementation of engineering controls (e.g., dust suppression), the wearing of appropriate PPE, and compliance with OSHA regulations and site-specific health and safety procedures. Potential negative short-term impacts to the surrounding community and environment from emissions and/or spillage of contaminated soil could be minimized through the implementation of appropriate engineering controls (e.g., perimeter air monitoring, spill prevention procedures, etc.).

Compliance with ARARs and TBCs

Soil Alternative 3 would comply with the chemical-, location-, and action-specific ARARs and TBCs.

Long-term Effectiveness and Permanence

Soil Alternative 3 would provide long-term effectiveness and permanence.

Excavation of soil with PAH concentrations in excess of the FDEP SCTLs for direct residential exposure would effectively eliminate the potential for unacceptable human health risk in case of residential development of the site. Excavation would also effectively minimize the potential for COCs to migrate either offsite or from soil to groundwater. Off-base disposal would effectively minimize the adverse impact from contaminated soil on human health and the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although no treatment would be performed, Soil Alternative 3 would reduce mobility and volume of COCs. Approximately 180 yd^3 of contaminated soil containing an estimated 1.2 pounds of PAHs would be removed from Site 58 by this alternative. Mobility of these PAHs would be irreversibly reduced through landfilling.

Short-Term Effectiveness

Implementation of the excavation and off-base disposal components of Soil Alternative 3, could expose construction workers to contaminated soil. This potential for exposure would be minimized by the implementation of engineering controls such as dust suppression and air quality monitoring. The potential for worker exposure would be further reduced by the wearing of appropriate PPE and compliance with applicable OSHA regulations and proper site-specific health and safety procedures.

Implementation of the excavation, and off-base disposal components could adversely impact either the surrounding community or the environment. However, measures such as spill prevention and containment, erosion and sedimentation control, perimeter air monitoring, and traffic control would be taken to insure that the impact remains acceptable.

Soil Alternative 3 could be completed within approximately 2 months of the start of the removal action and would achieve the soil RAO and attain the soil cleanup goals at completion.

Implementability

Soil Alternative 3 would be easily implementable.

The excavation component of this alternative could be performed with normal construction equipment, resources, and materials that would be readily available for this purpose. Because the excavation would be limited to 2 feet bgs, there would be no need for shoring and dewatering.

Permitted TSDFs with non-hazardous landfilling capabilities are available that would make implementation of this alternative relatively easy.

The administrative aspects of Soil Alternative 3 would be relatively simple to implement. A construction permit would have to be obtained for excavation. Off-base transportation of the excavated soil might require the preparation and implementation of a traffic control plan and would require the completion of waste manifests. Off-base disposal of the excavated soil would require prior securing of waste acceptance from the TSDF. These administrative procedures, while constituting a significant effort, could readily be accomplished.

Cost

The estimated costs for Soil Alternative 3 are:

- Capital Cost: $32,000
- NPW of O&M Cost: $0
- NPW: $32,000

A detailed cost estimate for this alternative is provided in Appendix D.2.

4.3 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

The following alternatives have been developed for groundwater remediation at OU 9, Sites 57 and 58:

1. No Action

2. Natural Attenuation, Institutional Controls, and Monitoring

3. In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring

4. In-Situ AS Treatment, Institutional Controls, and Monitoring

5. Extraction, On-site Treatment, and Surface Discharge, Institutional Controls, and Monitoring

Groundwater Alternative 1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP.

Groundwater Alternative 2 was formulated and analyzed to evaluate the adequacy of minimal action. For Site 57 in particular, Groundwater Alternative 2 was evaluated as a supplement to the source control actions performed in the Day Tank 1 area, including the 1999 soil removal and the ongoing biosparging system.

Groundwater Alternatives 3, 4, and 5 were formulated to evaluate active remediation of the entire contaminant plumes at both Site 57 and Site 58. Although the Site 57 Petroleum and TCE Plumes are relatively large (approximately 3.1 and 1.1 acres, respectively), this approach was taken because source control actions have already been taken for the Petroleum Plume and the source for the TCE Plume is believed to be past activities at a former nearby wash rack. For Site 58, this approach was taken because the size of the Naphthalene Plume is small enough (approximately 0.4 acres), and its source is believed to be past activities at a former nearby wash rack. Groundwater Alternatives 3 and 4 represent relatively innovative in-situ treatment approaches while Groundwater Alternative 5 represents a more traditional pump-and-treat approach.

A description and detailed analysis of these alternatives are provided in the following sections.

4.3.1 Groundwater Alternative 1 - No Action

4.3.1.1 Description

This alternative is a "walk-away" alternative that is required under CERCLA to establish a basis for comparison with other alternatives. Under this alternative the property would be released for unrestricted use. This alternative cannot be chosen if waste remains on site.

4.3.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Groundwater Alternative 1 would not provide protection of human health and the environment. The current potential for human exposure to contaminated groundwater would remain. Groundwater COCs

might migrate that could adversely impact additional human and ecological receptors. Because no monitoring would be performed, potential contaminant migration would not be detected.

Compliance with ARARs and TBCs

Groundwater Alternative 1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce concentrations of COCs. Compliance with location-specific ARARs or TBCs would be purely incidental. Action-specific ARARs or TBCs are not applicable.

Long-Term Effectiveness and Permanence

Groundwater Alternative 1 would have no long-term effectiveness and permanence because contaminated groundwater would remain. As there would be no institutional controls to limit groundwater use, the potential would exist for unacceptable risk to develop for human receptors. Because there would be no groundwater monitoring, potential migration of COCs would not be detected. Although concentrations of COCs might eventually decrease to the cleanup goals through natural attenuation, no monitoring would verify this.

Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternative 1 would not reduce toxicity, mobility, or volume of contaminants through treatment because no treatment would occur. Some reduction of contaminant toxicity or volume might occur through natural dispersion, dilution, or other attenuation process, but no monitoring would be performed to verify this.

Short-term Effectiveness

Since no action would occur, implementation of Groundwater Alternative 1 would not pose a short-term risk to onsite workers or result in short-term adverse impacts to the local community and the environment. Alternative 1 would not achieve the groundwater RAOs and, although the cleanup goals might eventually be achieved through natural attenuation, it would not be known when.

Implementability

Because no action would occur, Groundwater 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 Groundwater Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring

4.3.2.1 Description

Groundwater Alternative 2 was formulated and analyzed to evaluate the adequacy of minimal action. For Site 57 in particular, Groundwater Alternative 2 was evaluated as a supplement to the source control actions performed in the Day Tank 1 area, including the 1999 soil removal and the ongoing biosparging system.

Groundwater Alternative 2 is illustrated on Figure 4-3 and would consist of three major components: (1) natural attenuation, (2) institutional controls, and (3) monitoring.

Component 1: Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the Surficial Aquifer to significantly reduce the concentrations of BTEX, chlorinated VOCs, PAHs, and TRPH. These processes include a combination of biodegradation, dispersion, dilution, and adsorption in various proportions depending on the type of contaminant and aquifer conditions. Aquifer conditions would be continually monitored to ensure that they are favorable and to verify that concentrations of COCs are indeed being adequately reduced.

Component 2: Institutional Controls

Institutional controls would consist of prohibiting use of the groundwater from the Surficial Aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through deed restrictions, and formal notification would be given to the St. John's River Water Management District not to issue permits for installation of drinking water wells that would draw water from the Surficial Aquifer at Sites 57 and 58.

Regular site inspections would be performed to verify implementation of the institutional controls until cleanup goals are met. The frequency of these inspections is typically based upon the allowable time of exposure before an unacceptable human health risk associated with residential exposure would develop. Based on the results of the risk analysis provided in Appendix A, this frequency should be less than one year. However, at a minimum, the planning and construction phases for a residence is expected to be

one year considering the sites are located on or near the flightline. Consequently the frequency of site inspections would be annual.

Component 3: Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples both from within the contaminant plume to assess performance of the natural attenuation processes and downgradient of the leading edge of the contaminant plumes to verify that COCs are not migrating.

Based on the results of the modeling presented in Appendix B, performance monitoring would take place over a period of 20 years at Site 57 and 5 years at Site 58. This monitoring would consist of collecting groundwater samples from 8 existing monitoring wells at Site 57 and 4 existing wells at Site 58. Samples would be analyzed for VOCs, SVOCs, and TRPH. In addition, during the first 5 years, samples would also be analyzed for natural attenuation indicator parameters such as ORP, DO, pH, alkalinity, temperature, conductivity, TOC, ferrous and total iron, sulfur compounds (sulfates, sulfides), nitrogen compounds (nitrates, nitrites), orthophosphates, chlorides, and metabolic gases (methane, ethane, ethene, and CO_2). Sampling frequency would be quarterly for the first year, semi-annually for the next 2 years, and annually thereafter.

As agreed by the BCT, if the results of two consecutive sampling events indicate that the cleanup goals have been met, the site would be considered as remediated.

Monitoring to verify that contaminant plumes are not expanding and COCs are not migrating would take place over a period of 20 years at Site 57 and 5 years at Site 58. This monitoring would consist of collecting groundwater samples from 8 existing Site 57 monitoring wells and 3 existing Site 58 monitoring wells. Samples would be analyzed for VOCs, SVOCs, and TRPH. Sampling frequency would be quarterly for the first year, semi-annually for the next two years, and annually thereafter. Based on the results of the COC migration modeling provided in Appendix B.2, one of the 8 existing Site 57 wells (CEF-0824A-19S) and one of the 3 existing Site 58 wells (CEF-B312-12S) would be designated as “sentinel” wells. If analysis of the groundwater collected from these two “sentinel” wells indicate that the groundwater cleanup goals have been exceeded, the following step-by-step actions would be taken as agreed by the BCT:

1. The sentinel well(s) where the exceedance(s) was(were) detected would be re-sampled to verify the exceedance(s).

2. If the exceedance(s) is(are) verified, additional hydrogeological modeling would be performed to determine a revised predicted expansion of the contaminant plume(s) based upon the new monitoring data.

3. If the revised expansion of the contaminant plume(s) predicted by the additional modeling is such that it would be of concern, contingency remedies would be developed.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative allows contaminants to remain in groundwater at concentrations in excess of cleanup goals.

The monitoring component would include the maintenance of the existing wells that are sampled. As part of the change in the ownership of Sites 57 and 58 from the military to the private sector, provisions will be incorporated into the property transfer documents to ensure that monitoring would continue.

4.3.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

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

Natural attenuation would be protective of human health and the environment as it would eventually reduce COC concentrations to the cleanup goals. Results of the cleanup time projections presented in Appendix B also indicate that this attenuation would be achieved within a reasonable timeframe, especially at Site 58.

Institutional controls would be protective of human health by prohibiting the use of the groundwater from the Surficial Aquifer for drinking purposes until the cleanup goals are met, thus preventing unacceptable risks from potential future exposure to contaminated groundwater.

Monitoring would be protective of the environment by evaluating the progress of remediation and detecting potential migration of COCs so that appropriate contingency measures can be taken, if required.

Some short-term risks could be incurred by workers from exposure to contamination during implementation of this alternative. However, the potential for such exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Groundwater Alternative 2 would comply with location- and action-specific ARARs and TBCs. In the short-term, Groundwater Alternative 2 would not comply with chemical-specific ARARs, but compliance would eventually be achieved as natural processes within the aquifer would reduce COC concentrations.

Long-Term Effectiveness and Permanence

Groundwater Alternative 2 would provide long-term effectiveness and permanence.

Naturally-occurring processes would effectively and permanently reduce COC concentrations to the cleanup goals. This is supported by the results of the natural attenuation monitoring conducted at Sites 57 and 58 and reported upon in Section 6.3 of the RI Report (TtNUS, 2002). These results show evidence of an environment favorable to biodegradation in general, and reductive biodegradation of chlorinated VOCs in particular, in the shallow and intermediate zones of the Surficial Aquifer where these COCs have been detected. Long-term effectiveness of natural attenuation for the reduction of groundwater COC concentrations is also supported by the fact that all of the concentrations of COCs in the Site 57 TCE Plume and Site 58 Naphthalene Plume and nearly all of the concentrations of COCs in the Site 57 Petroleum Plume are well within the FDEP's natural attenuation default values (FDEP, 1999b).

Until the cleanup goals are met, risk from exposure to contaminated groundwater would be addressed through institutional controls. Groundwater use restrictions would effectively prevent the use of the Surficial Aquifer as a potable water source.

Long-term monitoring would be an effective means to evaluate the progress of natural attenuation and detect the potential migration of COCs.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although no active treatment is included in this alternative, the toxicity and volume of groundwater COCs would be reduced over time through natural processes. Groundwater Alternative 2 would not provide an immediate reduction in contaminant mobility because neither groundwater containment nor extraction are proposed. This alternative would not increase the rate of natural transformation processes that reduce

the toxicity, mobility, or volume of contaminants in groundwater. No treatment residuals would be produced if Groundwater Alternative 2 were implemented.

Short-term Effectiveness

Groundwater Alternative 2 would have minimal short-term effectiveness concerns. Exposure of workers to contamination during sewer repairs, installation of monitoring wells, and groundwater sampling would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Groundwater Alternative 2 would also not adversely impact the surrounding community or the environment.

The first two groundwater RAOs would be achieved immediately upon implementation of institutional controls and monitoring.

Cleanup time projections, as presented in Appendix B, indicate that Groundwater Alternative 2 would achieve the third groundwater RAO and meet the groundwater cleanup goals through natural attenuation within approximately 18 years at Site 57 and within approximately 3 years at Site 58.

The reasonableness of these remediation timeframes can be evaluated against the eight criteria provided in the Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P (U.S. EPA, 1999) as discussed below:

Classification of the Groundwater – The Surficial Aquifer at the site is classified by the FDEP as G-II. Groundwater in this classification is defined as "potable water use, groundwater in aquifers which has a total dissolved solids content of less than 10,000 mg/l, unless otherwise classified by the Commission." However, the wells that provide water for the Base withdraw water from the Floridan Aquifer and are 400 to 800 feet deep. The wells are located on the northern side of the Base and upgradient of Sites 57 and 58. Thus, while the Surficial Aquifer at Sites 57 and 58 is classified as potable water resource, this water is not used as a drinking water source.

Relative Timeframe in Which the Affected Portion Might Be Used As A Future Source – The Base wells provide sufficient water for current operations and, as water supply will be switched from wells to a municipal source in a few years, no new wells will be needed. Thus, the contaminant plumes are not likely to have any future impact on water supplies at NAS Cecil Field.

Subsurface Conditions and Plume Stability – The Surficial Aquifer is composed primarily of silty fine sand. Some minor variations in lithology were observed over the entire depth of the sand unit, and isolated clay lenses were observed, however, the formation is generally consistent. No materials were observed that

would create a significant change in the direction or velocity of the groundwater flow. The runways and tarmac generally overlie the contaminant plume. These are established and permanent features because the Base will continue to be used by aircraft. Storm water and run-off controls are in place and are unlikely to be moved. Thus, the groundwater flow will not be affected by changes in the distribution of run-off and percolation.

Long-Term Impact of Contamination on Water Supplies – There are no water supplies either within or downgradient of the contaminant plume, so there is no long-term impact on water supplies. In addition, the nearest receiving water where the contaminants in the groundwater could migrate to is approximately 8,000 feet away from the leading edges of the plumes. Based on the results of the modeling presented in Appendix A, the contaminant plumes are not predicted to reach this far.

Uncertainties Regarding Mass of Contaminants And Predictive Analyses – Physical properties of the formation were derived from SPECAP tests and also relied on information from other sites at the Base. The Surficial Aquifer is generally consistent throughout the Base, so information from one part of the base can reasonably be applied at other parts of the base. This information was used for the selection of conservative inputs to the modeling presented in Appendix B. Because of the conservativeness of these inputs, the predicted remediation time is expected to be conservative also.

Reliability of Monitoring And Institutional Controls Over Time – The Base was turned over to the City of Jacksonville which has an environmental staff. The City is aware of and sensitive to the environmental issues at the site and; therefore, long-term maintenance of monitoring and institutional controls is expected.

Public Acceptance of Timeframe – Because this FS has not yet been presented to the public, its acceptance of the remediation timeframe for this alternative cannot yet be evaluated.

Provisions by Responsible Party for Adequate Monitoring and Evaluation – The Navy will be making the provisions for monitoring and evaluation. This includes performing the required five-year reviews to monitor the progress of each site.

In summary:

- There are no current users or anticipated users of the Surficial Aquifer at Sites 57 and 58.
- The subsurface and surface conditions are favorable to stable and consistent groundwater flow conditions.

- No detrimental impacts on other water supplies or environmental resources are predicted.

- The new site owner has the resources to maintain institutional controls and monitor environmental conditions. Similarly, the Navy is committed to continuing monitoring of the site if required, as has been done at other sites.

- Conservative values were used in the model so uncertainties in the time frame are expected to be conservative also.

All of the above factors support the conclusion that the estimated remediation timeframes of 18 years for Site 57 and 3 years for Site 58 may be considered as reasonable.

Implementability

The technical implementation of Groundwater Alternative 2 would be very simple as it would only require routine monitoring activities, and no new monitoring wells would have to be installed.

The administrative implementation of Groundwater Alternative 2 would be simple. No construction permits would be required for this alternative. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of groundwater use restrictions and monitoring.

Cost

The estimated costs for Groundwater Alternative 2 are:

- Capital Cost: $5,000
- 20-Year NPW of O&M Cost: $519,000
- 20-Year NPW: $524,000

A detailed cost estimate for this alternative is provided in Appendix D.3.

4.3.3 Groundwater Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring

4.3.3.1 Description

Groundwater Alternative 3 was formulated to evaluate active remediation of the entire contaminant plumes at both Site 57 and Site 58. Although the Site 57 Petroleum and TCE Plumes are relatively large (approximately 3.1 and 1.1 acres, respectively), this approach was taken because source control actions have already been taken for the Petroleum Plume, and no clear area can be identified as a source for the TCE Plume. For Site 58, this approach was taken because the size of the Naphthalene Plume is small enough (approximately 0.4 acres), and no clear source area can be identified.

Groundwater Alternative 3 is illustrated on Figure 4-4 and would consist of three major components: (1) in-situ biological treatment with ORC®/HRC®injection, (2) institutional controls, and (3) monitoring.

Component 1: In-situ Biological Treatment (ORC®/HRC®)

In-situ biological treatment would consist of using ORC® and/or HRC® to enhance the growth of indigenous microorganisms and augment natural biodegradation processes in the contaminant plumes. ORC® and/or HRC® would be injected using DPT. Areas of groundwater predominantly contaminated with non-chlorinated organic compounds, such as the Site 57 Petroleum Plume and Site 58 Naphthalene Plume would be treated with an ORC® such as magnesium peroxide. An HRC®, such as lactic acid, would be used to remediate the areas of groundwater predominantly contaminated with chlorinated VOCs, such as the Site 57 TCE Plume. Based upon the information obtained from a qualified remediation contractor specializing with this technology (REGENESIS, see Appendix C.3), the following ORC®/HRC® treatment scheme is assumed:

- The Site 57 Petroleum Plume that consists mostly of BTEX, PAHs, and TRPH, would be treated with ORC®. The initial application of ORC® would be performed with an injection system consisting of 138, 35-foot deep DPTs in which ORC® would be injected at the rate of 4 pounds per foot of depth in the 5- to 35-foot bgs interval. For the purposes of this FS, it is assumed that no repeat ORC® application would be required.

- The Site 57 TCE Plume that consists mostly of chlorinated VOCs would be treated with HRC®. The initial application of HRC® would be performed with an injection system consisting of 120, 60-foot deep DPTs in which HRC® would be injected at the rate of 3 pounds per foot in depth in the 5- to

60-foot bgs interval. For the purposes of this FS, it is assumed that no repeat ORC® application would be required.

- The Site 58 Naphthalene Plume that consists mostly of naphthalene and TRPH would be treated with ORC®. The initial application of ORC® would be performed with an injection system consisting of 60, 22-foot deep DPTs in which ORC® would be injected at the rate of 10 pounds per foot of depth in the 5- to 20-foot bgs interval. For the purposes of this FS, it is assumed that no repeat ORC® application would be required.

The exact nature of the treatment scheme would be verified through treatability testing prior to implementation.

Component 2: Institutional Controls

This component would be identical to Component 2 of Groundwater Alternative 2.

Component 3: Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples both from within the contaminant plume to assess performance of the in-situ biodegradation processes and downgradient of the leading edge of the plume to evaluate potential migration of COCs.

Performance monitoring for Groundwater Alternative 3 would be identical to that for Groundwater Alternative 2, except that monitoring would only last 5 years at Site 57.

Monitoring for potential migration of COCs would be identical to that for Groundwater Alternative 2, except that monitoring would only last 5 years for Site 57.

At the end of five years, a review would be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

The monitoring component would include the maintenance of the existing wells that are sampled. As part of the change in the ownership of Sites 57 and 58 from the military to the private sector, provisions will be incorporated into the property transfer documents to ensure that monitoring would continue.

4.3.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Groundwater Alternative 3 would be protective of human health and the environment.

In-situ biological treatment with ORC®/HRC® injection would be protective of human health and the environment as it would actively reduce COCs concentrations to levels that would no longer constitute an unacceptable human health risk.

Institutional controls would be protective of human health by prohibiting the use of the groundwater from the Surficial Aquifer for drinking purposes until the Cleanup Goals are met, thus preventing unacceptable risks from potential exposure to contaminated groundwater.

Monitoring would be protective of the environment by evaluating the progress of remediation and detecting potential migration of COCs so that appropriate contingency measures could be taken, if required.

Some short-term risks could be incurred by workers from exposure to contamination during implementation of this alternative. However, the potential for this exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Groundwater Alternative 3 would eventually comply with chemical-specific ARARs and TBCs through active in-situ biological treatment. Alternative 3 would also comply with location- and action-specific ARARs and TBCs.

Long-Term Effectiveness and Permanence

Groundwater Alternative 3 would provide long-term effectiveness and permanence.

In-situ biological treatment with ORC®/HRC® injection would effectively and permanently remove groundwater COCs. Although ORC® injection is a well-established and proven technology for the treatment of non-chlorinated organic compounds, HRC® injection for the treatment of chlorinated organics is somewhat innovative, and treatability testing would be needed to verify its site-specific effectiveness.

At Site 57, there would also be the possibility that, with the partially overlapping Petroleum and TCE Plumes, the injection of ORC® for aerobic treatment of BTEX and TRPH might interfere with the effectiveness of HRC® injection for the anaerobic treatment of TCE.

Groundwater use restrictions would effectively prevent the use of the Surficial Aquifer as a potable water source until the cleanup goals have been achieved.

Long-term groundwater monitoring would be an effective means to evaluate progress of remediation and verify that no contaminant migration is occurring.

The components proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternative 3 would reduce the toxicity and volume of groundwater COCs through biological treatment. The ORC®/HRC® injection systems of this alternative are designed to irreversibly remove a total of approximately 525 pounds of COCs (504 pounds from Site 57, 21 pounds from Site 58) over their operating life. Because this removal would be achieved through biodegradation, it would be irreversible. However, it should be noted that biological treatment could result in the formation of vinyl chloride that is more toxic than the parent COCs (TCE, DCE). The monitoring portion of this alternative would detect this formation. No treatment residues would be produced during in-situ biological treatment.

Short-Term Effectiveness

There would be minimal short-term concerns associated with implementation of Groundwater Alternative 3. Exposure of onsite workers to contamination during installation of DPT injection points and monitoring wells and groundwater sampling would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of this alternative would also not adversely impact the surrounding community or the environment.

The first two groundwater RAOs would be achieved immediately upon implementation of controls and monitoring.

Based on the information received from a qualified contractor, it is anticipated that ORC®/HRC® treatment would achieve the third groundwater RAO and lower concentrations of groundwater COCs to cleanup goals within approximately 3 years at Site 57 and 2 years at Site 58.

Implementability

Groundwater Alternative 3 would be readily implementable.

Injection of ORC®/HRC® would be technically implementable but would require the installation of a significant number of DPT injection points (a total of 447 in two events over 18 months) at locations where such activities might interfere with the functions of Sites 57 and 58 as active airport facilities. This would especially be the case for treatment of the large contaminant plume at Site 57, which is located in a tarmac and taxiway area. However, any interference would be very temporary in nature. Treatability testing would have to be performed to verify the effectiveness and the design parameters for the in-situ biological treatment of chlorinated VOCs with HRC® injection. Groundwater monitoring and performance of five-year reviews could easily be accomplished. Although the number of contractors qualified for the application of ORC®/HRC® is relatively limited, the resources, equipment, and materials required for these activities are readily available.

The administrative aspects of Groundwater Alternative 3 would be relatively simple to implement. The substantive requirements of an Underground Injection Control (UIC) permit would have to be met for the injection of ORC®/HRC®. A construction permit might also be needed for installation of the DPT injection points, but such a permit would be easy to secure. As part of change of the sites from military to private ownership, appropriate provisions will be incorporated in property transfer documents to insure continued implementation of groundwater use restrictions and monitoring.

Cost

The estimated costs for Groundwater Alternative 3 are:

- Capital Cost: $1,265,000
- 5-Year NPW of O&M Cost: $352,000
- 5-Year NPW: $1,617,000

Detailed cost estimates for this alternative are provided in Appendix D.4.

4.3.4 Groundwater Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring

Groundwater Alternative 4 was formulated to evaluate active remediation of the entire contaminant plumes at both Site 57 and Site 58. Although the Site 57 Petroleum and TCE Plumes are relatively large (approximately 3.1 and 1.1 acres, respectively), this approach was taken because source control actions have already been taken for the Petroleum Plume and no clear area can be identified as a source for the

TCE Plume. For Site 58, this approach was taken because the size of the Naphthalene Plume is small enough (approximately 0.4 acres), and no clear source area can be identified.

Groundwater Alternative 4 is illustrated on Figure 4-5 and would consist of three major components: (1) AS treatment, (2) institutional controls, and (3) monitoring.

4.3.4.1 Detailed Description

Component 1: AS Treatment

This component would consist of installing three AS systems (AS Systems Nos. 1, 2, & 3) and operating these systems for a period of 3 years at Site 57 and 2 years at Site 58. AS System No. 1 system would treat the Site 57 Petroleum Plume, AS System No. 2 would treat the Site 57 TCE Plume, and AS System No. 3 would treat the Site 58 Naphthalene Plume.

Figure 4-6 shows the process flow diagram for a typical AS System. Each AS System would consist of one or more AS compressor systems, each connected to an array of AS wells screened to a specific depth. Each AS compressor system would feature a compressor, a receiver tank, and the necessary instrumentation and controls. The AS compressor systems would each be housed in pre-engineered pre-constructed structures enclosed in a fenced-in area.

Design AS flows would be 10 cubic feet per minute (cfm) per well. Based upon the operating results of similar AS systems at NAS Cecil Field Sites 3 and 16 and factoring in a conservative overlap, it is assumed that the effective treatment area and radius of influence (ROI) of each AS well would be 1,000 ft^2 and 18 feet, respectively, for the shallower wells and 2,500 ft^2 and 28 feet, respectively, for the deeper wells.

AS System No. 1 for the Site 57 Petroleum Plume would feature two air compressor systems (AS Compressor Systems Nos.1.1 and 1.2), each connected to an array of AS wells (AS Well Arrays Nos. 1.1 and 1.2). AS Compressor System No. 1.1 would consist of a 750 cfm compressor and a 1,000-gallon receiver tank. AS Well Array No. 1.1 would consist of 71 wells screened from 23 to 25 feet bgs. AS Compressor System No. 1.2 would consist of a 300 cfm compressor and a 400-gallon receiver tank. AS Well Array No. 1.2 would consist of 26 wells screened from 48 to 50 feet bgs.

AS System No. 2 for the Site 57 TCE Plume would feature one air compressor system (AS Compressor System No. 2) connected to an array of 19 AS wells (AS Well Array No. 2) screened from 63 to 65 feet bgs. AS Compressor System No. 2 would consist of a 200 cfm compressor and a 250-gallon receiver tank.

AS System No. 3 for the Site 58 Naphthalene Plume would feature one air compressor system (AS Compressor System No. 3) connected to an array of 16 AS wells (AS Well Array No. 3) screened from 23 to 25 feet bgs. AS Compressor System No. 3 would consist of a 200 cfm compressor and a 250-gallon receiver tank.

Conceptual design calculations for the AS systems are provided in Appendix C.4.

Component 2: Institutional Controls

This component would be identical to Component 2 of Groundwater Alternative 2.

Component 3: Monitoring

This component would be identical to Component 3 of Groundwater Alternative 3, except that performance monitoring samples would not be analyzed for natural attenuation parameters.

4.3.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Groundwater Alternative 4 would be protective of human health and the environment.

AS treatment would be protective of human health and the environment as it would actively reduce COC concentrations to levels that would no longer constitute a human health risk.

Institutional controls would be protective of human health by prohibiting the use of the groundwater from the Surficial Aquifer for drinking purposes until the cleanup goals are met, thus preventing unacceptable risks from potential future exposure to contaminated groundwater.

Monitoring would be protective of the environment by evaluating the progress of remediation and detecting potential migration of contaminated groundwater so that appropriate contingency measures could be taken, if required.

Some short-term risks could be incurred by workers from exposure to contamination during implementation of this alternative. However, the potential for this exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures. Fugitive emissions would also result from AS treatment, but it is conservatively estimated that the maximum initial level of fugitive emission would be approximately 4 pounds per day at Site 57 and less than one pound

per day at Site 58, after which these levels would decrease. Both of these levels are well under the FDEP allowable de minimis level of 13.75 pounds of VOCs per day.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Groundwater Alternative 4 would eventually comply with chemical-specific ARARs and TBCs through in-situ AS treatment. Alternative 4 would also comply with location- and action-specific ARARs and TBCs.

Long-Term Effectiveness and Permanence

Groundwater Alternative 4 would provide long-term effectiveness and permanence.

AS treatment would effectively and permanently remove groundwater COCs. AS treatment is a well-established technology and its effectiveness has been proven at very similar NAS Cecil Field site (Sites 3 and 16).

Groundwater use restrictions would effectively prevent the use of the Surficial Aquifer as a potable water source until the cleanup goals have been achieved.

Long-term monitoring would be an effective means to evaluate the progress of remediation and verify that no contaminant migration is occurring.

The components proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternative 4 would reduce the toxicity and volume of groundwater COCs through AS treatment. The AS systems of Alternative 4 are designed to irreversibly remove a total of approximately 525 pounds of COCs (504 pounds from Site 57, 21 pounds from Site 58) over their operating life. No treatment residuals would be produced by Groundwater Alternative 4.

Short-Term Effectiveness

There would be minimal short-term concerns associated with implementation of Groundwater Alternative 4. Exposure of workers to contamination during installation of AS and monitoring wells and groundwater sampling would be minimized by wearing of appropriate PPE and complying with site-specific health and

safety procedures. Implementation of this alternative would also not adversely impact the surrounding community or the environment.

The first two groundwater RAOs would be achieved immediately upon implementation of institutional controls and monitoring.

Based on the performance of similar AS systems currently operating at NAS Cecil Field, it is anticipated that the third groundwater RAO and the groundwater cleanup goals would be achieved within approximately 3 years at Site 57 and within approximately 2 years at Site 58.

Implementability

Groundwater Alternative 4 would be implementable.

Although it could be implemented, installation of three AS Systems featuring a total of 132 AS wells (116 at Site 57 and 16 at Site 58) and several thousand feet of air distribution piping over a concrete-paved area approximately 200,000 ft^2 (4.6 acres) in size (185,000 ft^2 at Site 57 and 15,000 ft^2 at Site 58) would have somewhat of an impact on the functions of Sites 57 and 58 as active airport areas. As previously mentioned, this would especially be the case for treatment of the Site 57 contaminant plume. However, any site interference would be relatively temporary in nature. Qualified personnel would be required to operate and maintain this system; and such personnel are available. Installation of new monitoring wells, maintenance of new and existing monitoring wells, sampling and analysis of groundwater, and if necessary of surface water and sediment, and performance of five-year reviews could easily be accomplished. The resources, equipment, and materials required for these activities are readily available.

The administrative aspects of Groundwater Alternative 4 would be relatively simple to implement. This alternative would require construction permits for installation of the AS systems but such permits would be simple to obtain. As part of change of the sites from military to private ownership, appropriate provisions will be incorporated in the property transfer documents to insure continued implementation of groundwater use restrictions and monitoring.

Cost

The estimated costs for Groundwater Alternative 4 are:

- Capital Cost: $1,636,000
- 5-Year NPW of O&M Cost: $564,000

- 5-Year NPW: $2,200,000

A detailed cost estimate for this alternative is provided in Appendix D.5.

4.3.5 Groundwater Alternative 5: Extraction, On-Site Treatment, and Surface Discharge, Institutional Controls, and Monitoring

Groundwater Alternative 5 was formulated to evaluate active remediation of the entire contaminant plumes at both Site 57 and Site 58. Although the Site 57 Petroleum and TCE Plumes are relatively large (approximately 3.1 and 1.1 acres, respectively), this approach was taken because source control actions have already been taken for the Petroleum Plume, and no clear area can be identified as a source for the TCE Plume. For Site 58, this approach was taken because the size of the Naphthalene Plume is small enough (approximately 0.4 acres), and no clear source area can be identified.

Groundwater Alternative 5 is illustrated on Figure 4-7 and would consist of five major components: (1) groundwater extraction (2) on-site treatment (3) discharge to surface water, (4) institutional controls, and (5) monitoring. A typical process flow diagram for Components 1 and 2 is shown on Figure 4-8.

4.3.5.1 Detailed Description

Component 1: Groundwater Extraction

This component would consist of installing two arrays of groundwater extraction wells. One of these arrays (EW Array No. 1) would extract groundwater from the Site 57 Petroleum and TCE Plumes, and the other array (EW Array No. 2) would extract groundwater from the Site 58 Naphthalene Plume. EW Array No. 1 would consist of five extraction wells screened from 10 to 40 feet bgs and would be operated at a combined pumping rate of 30 gallons per minute (gpm) for a period of 14 years. EW Array No. 2 would consist of three extraction wells screened from 10 to 30 feet bgs and would be operated at a combined pumping rate of 18 gpm for a period of 3 years. Figures 4-9 and 4-10 illustrate the location of the extraction wells for EW Array No. 1 and EW Array No. 2, respectively.

A submersible centrifugal pump equipped with level controls would be installed in each groundwater extraction well. Each of these pumps would be connected to a piping network that would convey the extracted groundwater to an on-site treatment system.

Conceptual design calculations for the EW Arrays are provided in Appendices B and C.5.

Component 2: On-Site Treatment

This component would consist of installing two on-site treatment systems (On-Site Treatment Systems Nos. 1 and 2). On-Site Treatment System No. 1 would treat the groundwater extracted from the Site 57 Petroleum and TCE Plumes by EW Array No. 1. On-Site Treatment System No. 2 would treat the groundwater extracted from the Site 58 Naphthalene Plume by EW Array No. 2. On-Site Treatment System No. 1 would be operated for a period of 14 years, and On-Site Treatment System No. 2 would be operated for a period of 3 years. Each treatment system would be housed in a pre-engineered and pre-fabricated structure and would consist of the following sequence of unit processes:

- Equalization
- Filtration
- Liquid-Phase GAC Adsorption

In addition, On-Site Treatment System No. 1 would include an air stripping process unit between the filtration and liquid-phase GAC adsorption process units. The design flow of On-Site Treatment System No. 1 would be 37.5 gpm and that of On-Site Treatment System No. 2 would be 22.5 gpm. Conceptual design calculations for the on-site treatment systems are provided in Appendix C.5.

The extracted groundwater would enter the treatment system through an equalization tank. The purpose of this equalization tank would be to blend the groundwater from the various extraction wells to equalize the quality of the influent to the downstream unit processes. The equalization tank could also be used to provide additional treatment as may be required, such as pH adjustment. For this purpose, the equalization tank would be equipped with a mixer and sized to provide approximately 30 minutes detention time under design flow conditions. Accordingly, the equalization tank of On-Site Treatment System No. 1 would have a design capacity of 1,200 gallons, and the equalization tank of On-Site Treatment No. 2 would have a design capacity of 750 gallons.

The equalized groundwater flow would be pumped from the equalization tank to a filter unit by one of two (one spare) centrifugal pumps. The purpose of this filter unit would be to remove most of the suspended solids that might be present in the groundwater. If these suspended solids are not removed, they could result in premature fouling of the downstream air stripper and liquid-phase GAC adsorption units. The filter unit would be of the pressurized type and would be equipped with multiple disposable filter elements installed in parallel to allow for continued service during the periodic replacement of a clogged element. Clogged filter elements would be disposed off site and replaced with fresh ones. The filter unit of On-Site Treatment System No. 1 would have a 30 ft^2 filtration area and the filter unit of On-Site Treatment System No. 2 would have a 20 ft^2 filtration area

In On-Site Treatment System No. 1, the equalized and filtered groundwater would then cascade down through the multiple trays of a low-profile type air stripper unit where it would be submitted to the frothing action of a countercurrent of air. This frothing action would volatilize most of the BTEX and chlorinated VOCs as well as some of the TRPH. The air-stripped groundwater would be collected in a sump at the bottom of the air stripper unit. The air stripper unit would feature four trays and be equipped with a 300 cfm centrifugal blower to provide the necessary countercurrent of air and a 40 gpm centrifugal pump to convey the treated groundwater to the liquid-phase GAC adsorption unit.

The liquid-phase GAC adsorption unit would be used to remove BTEX, chlorinated VOCs, PAHs, and TRPH down to their surface water discharge criteria. The GAC unit would consist of two activated carbon-packed bed canisters connected in series. Manifolding and valving would be provided so that each canister can operate in either the lead or lag position. Both the lead and lag adsorption canister would feature backwash capabilities to deal with potential long-term accumulation of suspended solids in the GAC beds. The treated groundwater effluent would be conveyed under residual pressure to its discharge point. For On-Site Treatment System No. 1, each canister would contain approximately 900 pounds of GAC and, based upon an estimated total GAC usage of 6,500 pounds, the lead canister would require replacement seven times over the 14-year operating life of the system. For On-Site Treatment System No. 2, each canister would contain approximately 575 pounds of GAC and, based upon an estimated total GAC usage of 265 pounds, no replacement of the lead canister would be required over the 3-year operating life of the system.

Performance of the on-site treatment systems would be regularly monitored. Performance monitoring would consist of collecting monthly water samples from the inlet and outlet of each treatment system and analyzing these samples for VOCs, SVOCs, TRPH, and other criteria as may be required for surface water discharge.

Component 3: Discharge to Surface Water

Treated groundwater would be discharged to the storm sewer system and eventually into Sal Taylor Creek. Treated water sampling would be required to satisfy the substantive requirements of an NPDES permit administered by FDEP. Sampling and analysis of the discharge stream would be completed to ensure compliance with these criteria.

Component 4: Institutional Controls

This component would be identical to Component 2 of Groundwater Alternative 2.

Component 5: Monitoring

This component would be similar to Component 3 of Groundwater Alternative 3 except that performance monitoring and monitoring for potential migration of COCs would both take place over a period of 15 years at Site 57, instead of 5, and that performance monitoring samples would not be analyzed for natural attenuation parameters. Also three five-year reviews would be conducted instead of one.

4.3.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Groundwater Alternative 5 would be protective of human health and the environment.

Extraction of contaminated groundwater and its treatment by use of air stripping followed by discharge of the treated water would be protective of human health and the environment as it would significantly reduce risk from exposure to contaminated groundwater and provide protection to future human receptors who may use the Surficial Aquifer as a source of potable water.

Institutional controls would be protective of human health by prohibiting the use of Surficial Aquifer groundwater for drinking purposes until the cleanup goals are met, thus preventing unacceptable risks from potential future exposure to contaminated groundwater.

Monitoring would be protective by evaluating the effectiveness of groundwater extraction and treatment and detecting potential migration of groundwater contaminants.

Some short-term risks could be incurred by workers from exposure to contamination during the implementation of this alternative. However, the potential for this exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures. Fugitive emissions would also result from on-site air stripping, but it is conservatively anticipated that the maximum level of these emissions would be approximately 1 pound per day, which is well under the FDEP allowable de-minimis level of 13.75 pounds of VOCs per day.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Groundwater Alternative 5 would eventually comply with chemical-specific ARARs and TBCs through groundwater extraction and on-site treatment. Alternative 5 would also comply with location- and action-specific ARARs and TBCs.

Long-Term Effectiveness and Permanence

Groundwater Alternative 5 would provide long-term effectiveness and permanence.

Groundwater extraction and on-site treatment would effectively and permanently remove groundwater COCs. Groundwater extraction and treatment is a well-established remedial approach and results of the cleanup time projections presented in Appendix B predict that such an approach would be effective at Sites 57 and 58.

Groundwater use restrictions would effectively prevent the use of the Surficial Aquifer as a potable water source until the cleanup goals have been achieved.

Long-term monitoring would be an effective means to evaluate the progress of remediation and verify that no contaminant migration is occurring.

The components proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternative 5 would reduce the toxicity, mobility, and volume of groundwater COCs. The two groundwater extraction and treatment systems provided under this alternative are designed to irreversibly remove approximately 525 pounds of COCs (504 pounds from Site 57 and 21 pounds from Site 58) over their operating lives. Implementation of Groundwater Alternative 5 would produce treatment residuals including clogged filter elements and spent GAC.

Short-term Effectiveness

Groundwater Alternative 5 would reduce human health risks in the short term because groundwater use restrictions would be implemented. Exposure of workers to contamination during installation of groundwater extraction and monitoring wells, operation of the groundwater treatment system, and groundwater sampling would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of institutional controls and monitoring would not adversely impact the surrounding community or the environment.

The first two groundwater RAOs would be achieved immediately upon implementation of institutional controls and monitoring.

Cleanup time projections, as presented in Appendix B, indicate that Groundwater Alternative 5 would achieve the third groundwater RAO and reduce the concentrations of groundwater COCs to the cleanup goals within approximately 14 years at Site 57 and approximately 3 years at Site 58.

Implementability

Groundwater Alternative 5 would be readily implementable.

Groundwater extraction and treatment systems could readily be constructed and operated without unduly restricting the ability of Sites 57 and 58 to function as active airport areas. Qualified personnel would be needed to operate and to maintain this system, but such personnel is available. Installation of new monitoring wells, maintenance of existing and new wells, sampling and analysis of groundwater, and if necessary, of surface water and outfall sediment, and performance of five-year reviews could readily be accomplished. Off-site disposal of clogged filter elements and off-site regeneration or disposal of the spent GAC would be easily implementable. The resources, equipment, and materials required for these activities are readily available.

The surface discharge of the treated water would also be implementable. Storm sewers are located in the vicinity of Sites 57 and 58 and would be available for such discharge.

The administrative aspects of Groundwater Alternative 5 would be relatively simple to implement. This alternative would require construction permits for installation of the EW arrays and on-site treatment systems but such permits would be simple to obtain. The substantive requirements of an NPDES permit would have to be met but the actual securing of such a permit would not be necessary. As part of change of the sites from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of groundwater use restrictions and monitoring.

Cost

The estimated costs for Groundwater Alternative 5 are:

- Capital Cost: $1,109,000
- 15-Year NPW of O&M Cost: $1,542,000
- 15-Year NPW: $2,651,000

A detailed cost estimate for this alternative is provided in Appendix D.6.

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INSTITUTIONAL CONTROLS AND MONITORING

INSTITUTIONAL CONTROLS
- MAINTAIN AND/OR UPGRADE EXISTING FENCE AROUND DRAINAGE DITCH AND POST WARNING SIGNS
- PREPARE AND IMPLEMENT LUCs (DEED RESTRICTIONS) TO PERVENT RESIDENTIAL DEVELOPMENT.
- PERFORM ANNUAL SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCs.

→

- COLLECT 1 SOIL SAMPLE PER YEAR AND ANALYZE FOR PAHs,
- COLLECT GROUNDWATER SAMPLES FROM 1 EXISTING WELL AND ANALYZE FOR PAHs,

→

PERFORM FIVE YEAR SITE REVIEWS.

NOTES:

LUCs LAND USE CONTROLS
PAHs POLYNUCLEAR AROMATIC HYDROCARBONS
SVOCs SEMIVOLATILE ORGANIC COMPOUNDS

DRAWN BY HJB DATE 3/11/02	BLOCK FLOW DIAGRAM SOIL ALTERNATIVE 2 (SITE 58) OU9, SITES 57 & 58 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039	
CHECKED BY DATE		APPROVED BY DATE 09/25/02	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4-1	REV. 0

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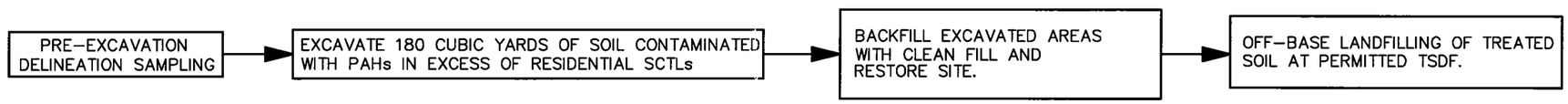
EXCAVATION AND OFF-BASE DISPOSAL



NOTES:

LTTD LOW-TEMPERATURE THERMAL DESORPTION
PAHs POLYNUCLEAR AROMATIC HYDROCARBONS
SCTLs SOIL CLEANUP TARGET LEVELS
TSDF TREATMENT STORAGE AND DISPOSAL FACILITY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 3/11/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

BLOCK FLOW DIAGRAM
SOIL ALTERNATIVE 3 (SITE 58)
OU9, SITES 57 & 58 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 04/08/02
APPROVED BY DATE
DRAWING NO. FIGURE 4-2 REV. 1

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NATURAL ATTENUATION, INSTITUTIONAL CONTROLS, AND MONITORING

INSTITUTIONAL CONTROLS

- PREPARE AND IMPLEMENT LUCs (DEED RESTRICTIONS) TO PREVENT USE OF GROUNDWATER FOR DRINKING PURPOSE.
- PERFORM ANNUAL SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCs.

COCs MIGRATION MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 3 EXISTING WELLS AT SITE 58 ANALYZE FOR VOCs, PAHs & TRPH:

* QUARTERLY FOR 1 YEAR
* SEMI-ANNUALLY FOR 2 YEARS
* ANNUALLY FOR 7 YEARS

PERFORMANCE MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 4 EXISTING WELLS AT SITE 58. ANALYZE FOR VOCs, PAHs, TRPH. ALSO ANALYZE FOR NATURAL ATTENUATION PARAMETERS FOR 5 YEARS:

* QUARTERLY FOR 1 YEAR
* SEMI-ANNUALLY FOR 2 YEARS
* ANNUALLY FOR 17 YEARS

PERFORM FIVE YEAR REVIEWS

NOTES:

COCs	CHEMICALS OF CONCERN
LUCS	LAND USE CONTROLS
PAHs	POLYNUCLEAR AROMATIC HYDROCARBONS
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBON
VOC	VOLATILE ORGANIC COMPOUND

DRAWN BY HJB DATE 3/12/02	BLOCK FLOW DIAGRAM GROUNDWATER ALTERNATIVE 2 OU9, SITES 57 & 58 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039
CHECKED BY DATE		APPROVED BY DATE 09/25/02
COST/SCHED-AREA		APPROVED BY DATE
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4-3 REV. 1

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IN-SITU BIOLOGICAL TREATMENT (ORC®/HRC®) INSTITUTIONAL CONTROLS, AND MONITORING

INSTITUTIONAL CONTROLS
- PREPARE AND IMPLEMENT LUCs (DEED RESTRICTIONS) TO PREVENT USE OF GROUNDWATER FOR DRINKING PURPOSES.
- PERFORM ANNUAL SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCs.

→

INSTALL 3 DPT INJECTION SYSTEMS:
- ORC® SYSTEM NO. 1 TO TREAT SITE 57 PETROLEUM PLUME. INJECT 16,500 LBS. THROUGH 138 POINTS.
- HRC® SYSTEM TO TREAT SITE 57 TCE PLUME. INJECT 19,800 LBS. THROUGH 120 POINTS.
- ORC® SYSTEM NO. 2 TO TREAT SITE 58 NAPTHALENE PLUME. INJECT 10,200 LBS. THROUGH 60 POINTS

→

PERFORMANCE MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 4 EXISTING WELLS AT SITE 58, ANALYZE FOR VOCs, PAHs, TRPH AND NATURAL ATTENUATION PARAMETERS
- QUARTERLY FOR 1 YEAR
- SEMI-ANNUALLY FOR 2 YEARS
- ANNUALLY FOR 2 YEARS

COCs MIGRATION MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 3 EXISTING WELLS AT SITE 58. ANALYZE FOR VOCs, PAHs, & TRPH
- QUARTERLY FOR 1 YEAR
- SEMI-ANNUALLY FOR 2 YEARS
- ANNUALLY FOR 2 YEARS

→

PERFORM FIVE-YEAR SITE REVIEWS

NOTES:

HRC®	HYDROGEN RELEASE COMPOUND
ORC®	OXYGEN RELEASE COMPOUND
LUCs	LAND USE CONTROLS
PAHs	POLYNUCLEAR AROMATIC HYDROCARBONS
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
VOCs	VOLATILE ORGANIC COMPOUNDS

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

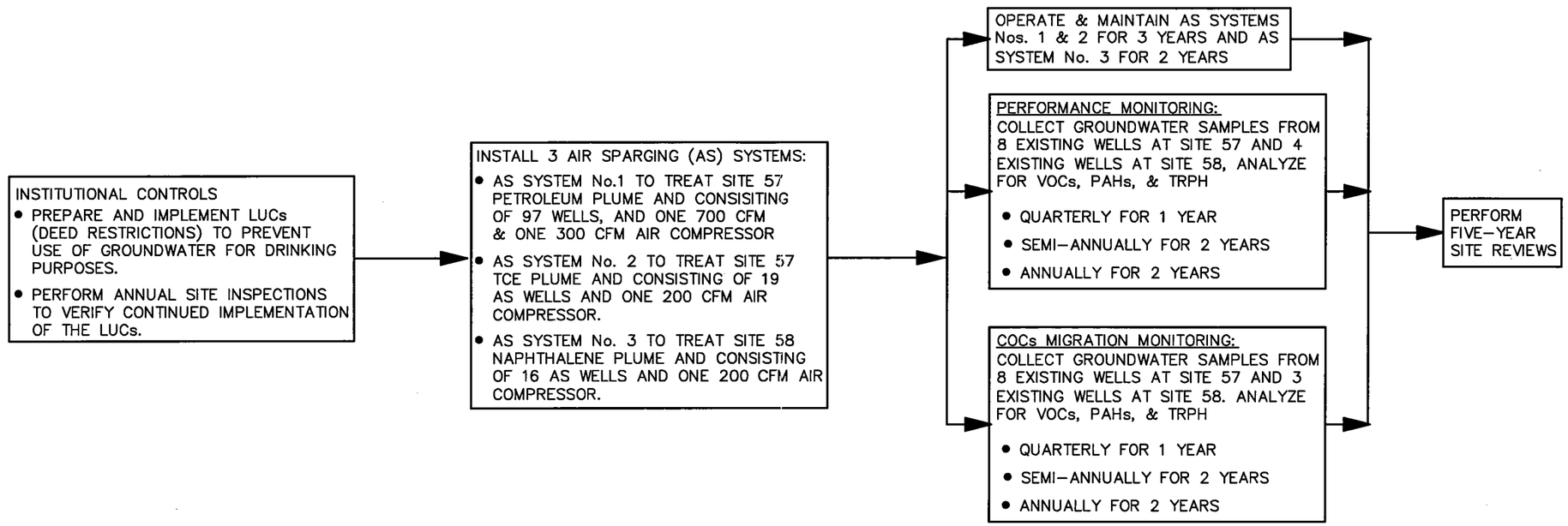
DRAWN BY DM DATE 3/18/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
GROUNDWATER ALTERNATIVE 3
OU9, SITES 57 & 58 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 09/25/02
APPROVED BY DATE
DRAWING NO. FIGURE 4-4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

IN–SITU AIR SPARGING, INSTITUTIONAL CONTROLS, AND MONITORING



NOTES:

AS	AIR SPARGING
COCs	CHEMICALS OF CONCERN
CFM	CUBIC FEET PER MINUTE
LUCs	LAND USE CONTROLS
PAHs	POLYNUCLEAR AROMATIC HYDROCARBONS
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
VOCs	VOLATILE ORGANIC COMPOUNDS

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 3/12/02
CHECKED BY DATE
COST/SCHED–AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
GROUNDWATER ALTERNATIVE 4
OU9, SITES 57 & 58 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 09/25/02
APPROVED BY DATE
DRAWING NO. FIGURE 4–5
REV. 0

FORM CADD NO. SDIV_BH.DWG – REV 0 – 1/20/98

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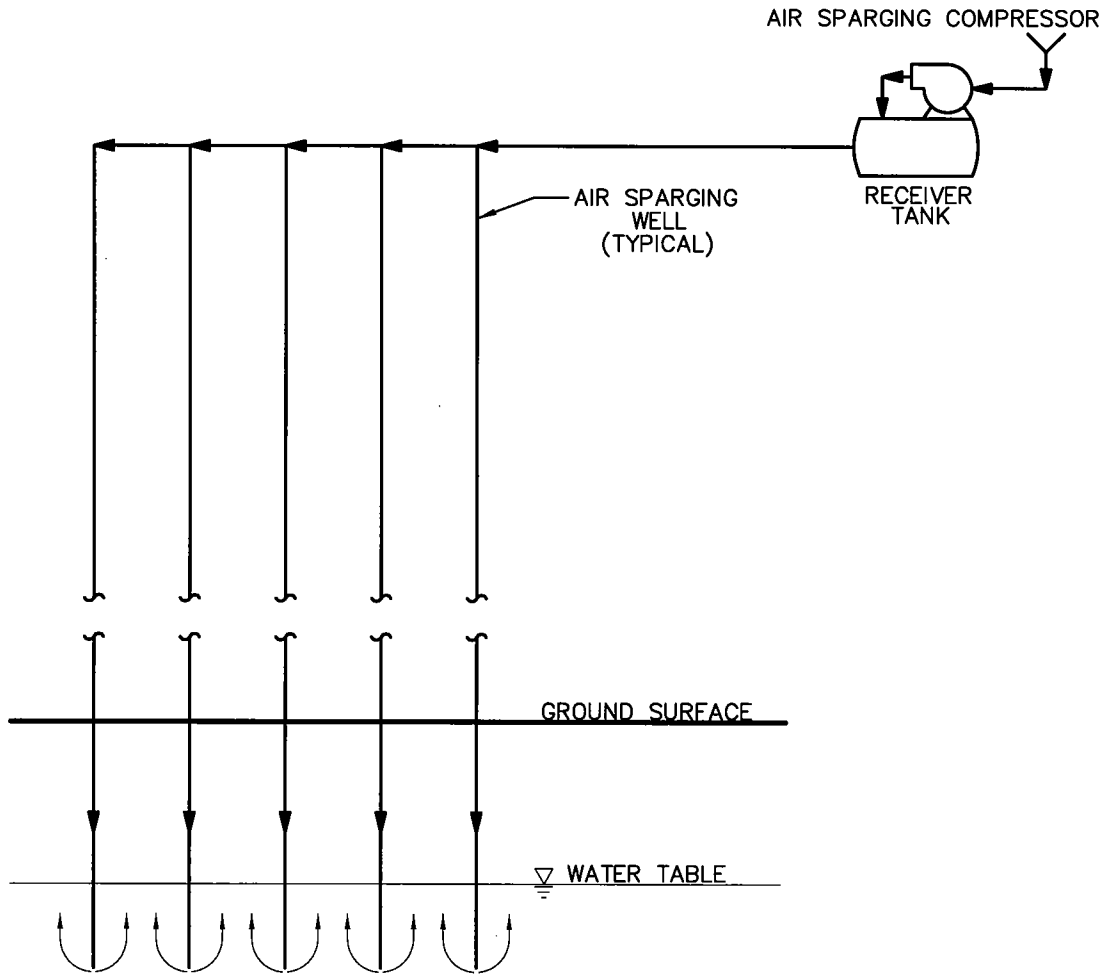

DRAWN BY HJB DATE 3/12/02		PROCESS FLOW DIAGRAM TYPICAL IN –SITU AS SYSTEM OU9, SITES 57 & 58 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039
CHECKED BY DATE			APPROVED BY DATE 04/08/02
COST/SCHED–AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4–6 REV. 0

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EXTRACTION, ON-SITE TREATMENT & SURFACE DISCHARGE; INSTITUTIONAL CONTROLS; AND MONITORING

INSTITUTIONAL CONTROLS
- PREPARE AND IMPLEMENT LUCs (DEED RESTRICTIONS) TO PREVENT USE OF GROUNDWATER FOR DRINKING PURPOSES.
- PERFORM ANNUAL SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCs.

→

INSTALL 2 GROUNDWATER EXTRACTION & ON-SITE TREATMENT SYSTEMS:
- SYSTEM No.1 TO TREAT SITE 57 PETROLEUM PLUME AND TCE PLUMES AND CONSISTING OF 5 EXTRACTION WELLS AND 30 GPM ON-SITE TREATMENT SYSTEM WITH EQUALIZATION, FILTRATION, AIR STRIPPING & LIQUID-PHASE GAC ADSORPTION.
- SYSTEM No. 2 TO TREAT SITE 58 NAPHTHALENE PLUME AND CONSISTING OF 3 EXTRACTION WELLS AND 18 GPM ON-SITE TREATMENT SYSTEM WITH EQUALIZATION, FILTRATION, & LIQUID-PHASE GAC ADSORPTION.

→

OPERATE & MAINTAIN SYSTEM No. 1 FOR 14 YEARS AND SYSTEM No. 2 FOR 3 YEARS

PERFORMANCE MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 4 EXISTING WELLS AT SITE 58. ANALYZE FOR VOCs, PAHs, & TRPH:
- QUARTERLY FOR 1 YEAR
- SEMI-ANNUALLY FOR 2 YEARS
- ANNUALLY FOR 11 YEARS AT SITE 57 AND 2 YEARS AT SITE 58

COCs MIGRATION MONITORING:
COLLECT GROUNDWATER SAMPLES FROM 8 EXISTING WELLS AT SITE 57 AND 3 EXISTING WELLS AT SITE 58. ANALYZE FOR VOCs, PAHs, & TRPH:
- QUARTERLY FOR 1 YEAR
- SEMI-ANNUALLY FOR 2 YEARS
- ANNUALLY FOR 11 YEARS AT SITE 57 AND 2 YEARS AT SITE 58

→

PERFORM FIVE-YEAR SITE REVIEWS

NOTES:

COCs	CHEMICALS OF CONCERN
GAC	GRANULAR ACTIVATED CARBON
LUCs	LAND USE CONTROLS
PAHs	POLYNUCLEAR AROMATIC HYDROCARBONS
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
VOCs	VOLATILE ORGANIC COMPOUNDS

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 3/12/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
GROUNDWATER ALTERNATIVE 5
OU9, SITES 57 & 58 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE 09/23/02
APPROVED BY DATE
DRAWING NO. FIGURE 4-7
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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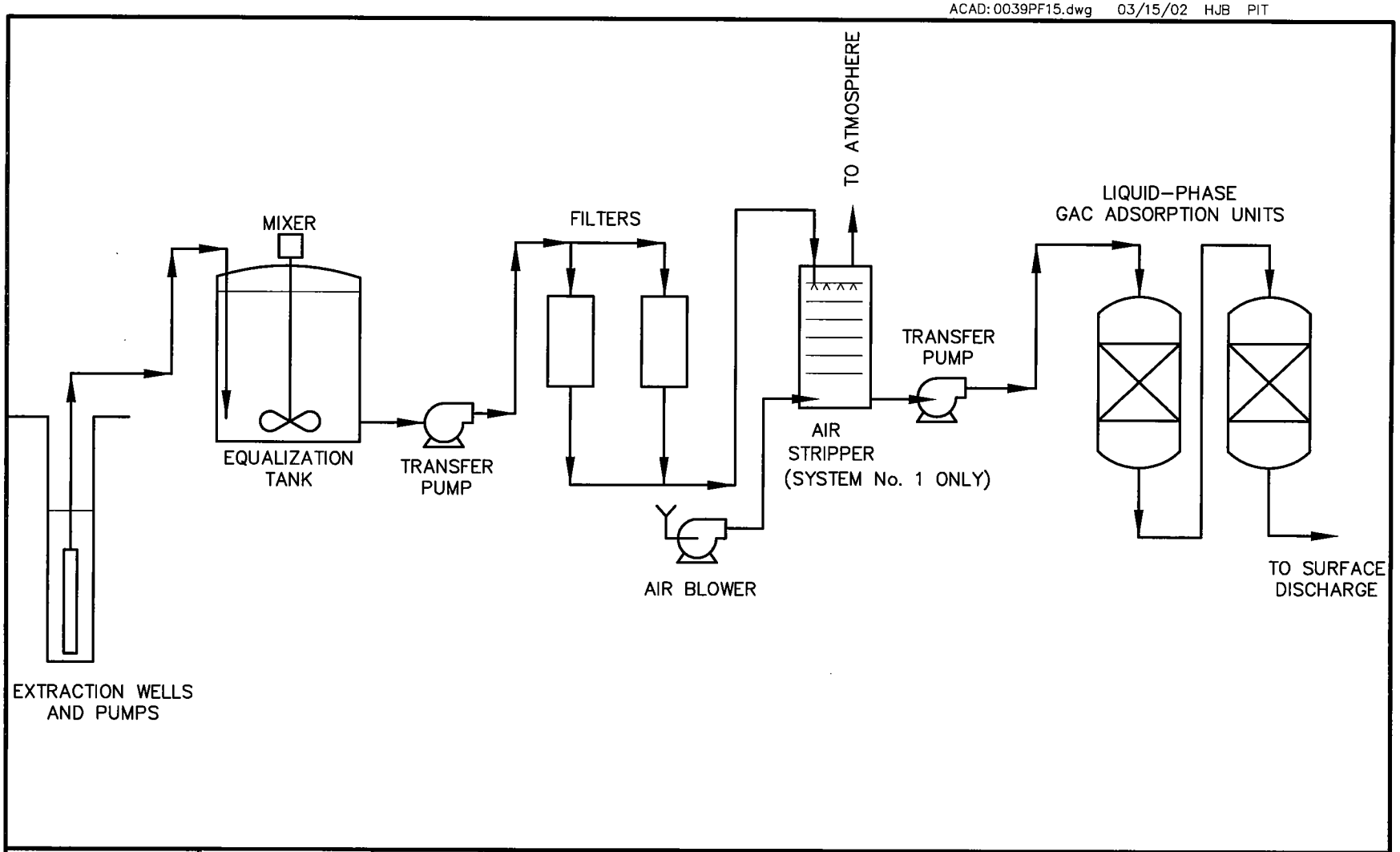

DRAWN BY HJB DATE 3/15/02	PROCESS FLOW DIAGRAM TYPICAL GROUNDWATER EXTRACTION & ON–SITE TREATMENT SYSTEM OU9, SITES 57 & 58 FS JACKSONVILLE, FLORIDA	CONTRACT NO. 0039	
CHECKED BY DATE		APPROVED BY DATE 04/30/02	
COST/SCHED–AREA		APPROVED BY DATE	
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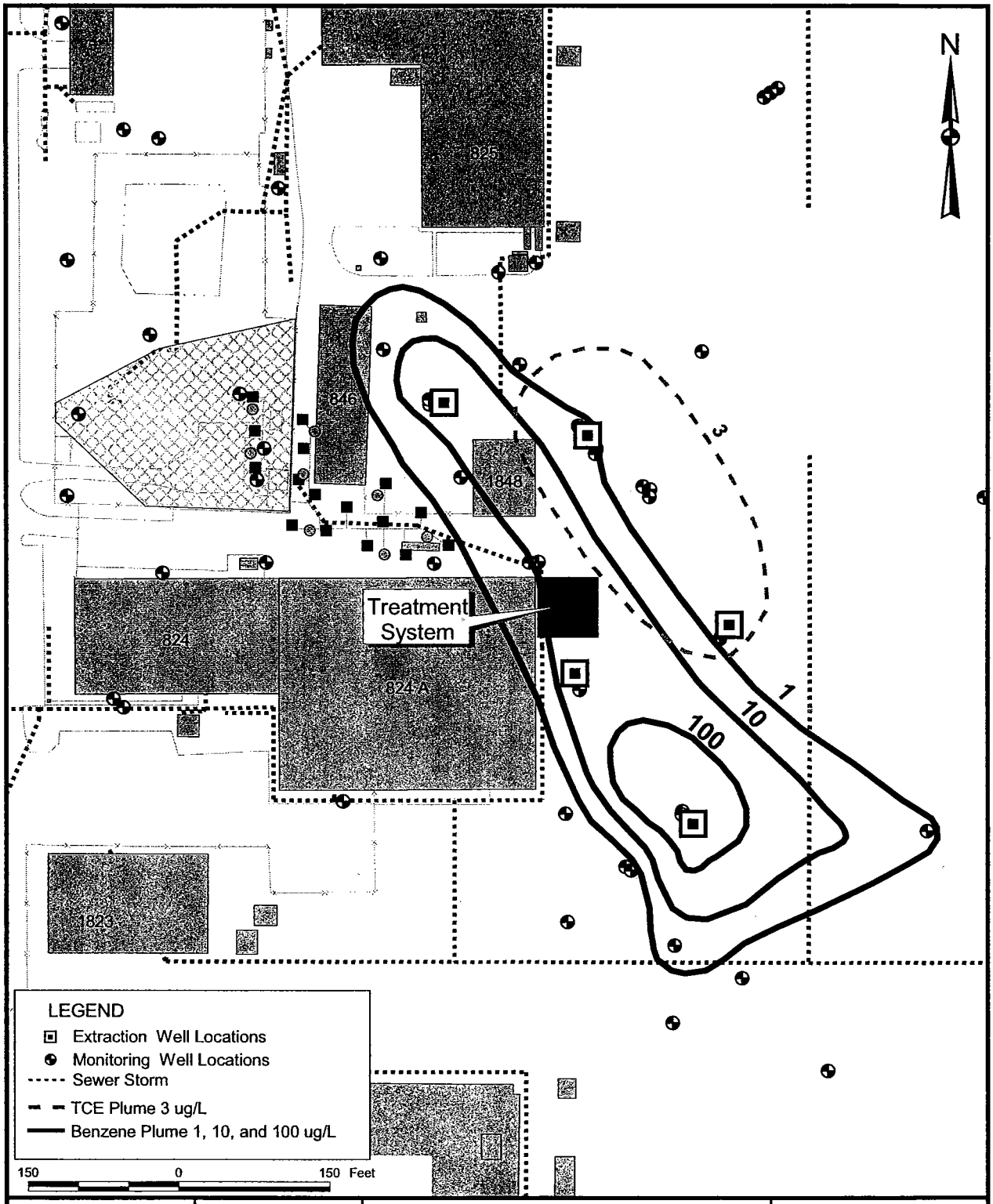
FORM CADD NO. SDIV_AH.DWG – REV 0 – 1/20/98



DRAWN BY MJJ	DATE 24Jan02	EXTRACTION WELL AND TREATMENT SYSTEM LOCATIONS, SITE 57 OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY / DATE 04/08/02
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-9 / REV 0

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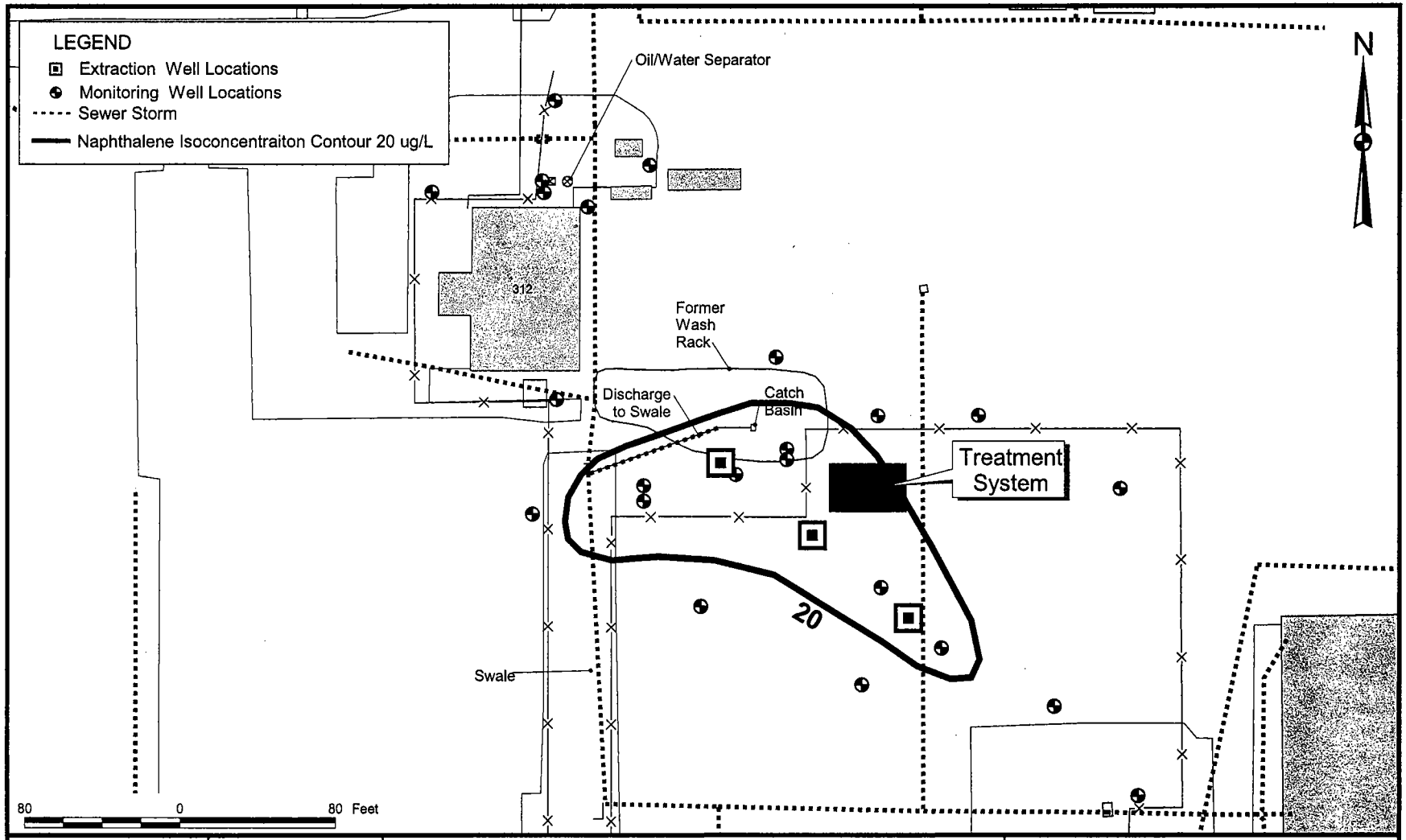

DRAWN BY MJJ	DATE 25Mar02	EXTRACTION WELL AND TREATMENT SYSTEM LOCATIONS, SITE 58 OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY / DATE 24/03/02
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-10 / REV 0

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5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

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

5.1 COMPARISON OF SOIL REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives for soil are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 3: Excavation and Off-Base Disposal

5.1.1 Overall Protection of Health and Environment

Alternative 1 would not be protective of human health and the environment. Under the current industrial land use scenario, unacceptable human health risk could occur from exposure to contaminated soil. Under a potential future residential land use scenario, the human health risk would be further aggravated and an unacceptable ecological risk could also occur. Also, the potential would remain for soil COCs to migrate either offsite or to groundwater, and no monitoring would be performed to detect this potential migration.

Alternative 2 would be protective of human health and the environment. Institutional controls would limit current risks by reducing the potential for human exposure to contaminated soil. Institutional controls would also minimize potential future human health and ecological risk by preventing residential development. Monitoring would provide protection by detecting potential migration of COCs either offsite or from soil to groundwater.

Alternative 3 would be more protective than Alternative 2. Soil contaminated above cleanup goals would be excavated and taken to an off-base permitted TSDF for disposal.

5.1.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs as discussed in Section 4. No action-specific ARARs or TBCs apply to this alternative.

Alternative 2 would comply with the location- and action-specific ARARs and TBCs. Although Alternative 2 would not immediately comply with chemical-specific ARARs, monitoring would determine whether any contaminant reduction is occurring through natural processes.

Alternative 3 would comply with the chemical-, location-, and action-specific ARARs and TBCs.

5.1.3 Long-Term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence. Current unacceptable human health risks would continue unabated, and residential development could occur that would further aggravate these risks and would also result in unacceptable ecological risks. Because there would be no monitoring, potential migration of COCs either offsite or from soil to groundwater would go undetected.

Alternative 2 would have long-term effectiveness and permanence. Institutional controls including fencing, posting, and prevention of residential development would effectively and permanently reduce the risk from direct exposure of human and ecological receptors to contaminated soil. Long-term monitoring would be effective for the detection of potential migration of COCs either offsite or from soil to groundwater and for the determination of contamination reduction through natural processes.

Alternative 3 would offer the best long-term effectiveness and permanence. Soil contaminated above the cleanup goals would be excavated and transported to a permitted off-base TSDF for disposal. These remedial actions would effectively and permanently eliminate the risk from direct exposure to contaminated soil and the potential for soil COCs to migrate to the groundwater.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment. Both alternatives might achieve some reduction of contaminant toxicity and volume through natural processes, but this would only be verified through the monitoring provided under Alternative 2.

Alternative 3 would best reduce contaminant mobility and volume. Alternative 3 would remove approximately 180 yd^3 of contaminated soil containing an estimated 1.2 pounds of PAHs. The excavation of contaminated soil at Site 58 would permanently and irreversibly reduce the volume of these PAHs. Off-base disposal would permanently and irreversibly reduce mobility.

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 not achieve the soil RAO and, although the soil cleanup goals might eventually be achieved over time through natural processes, this would not be verified through monitoring.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to contaminated soil during the sampling of soil and groundwater. However, the risk of exposure would be effectively controlled by wearing appropriate PPE and complying with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would immediately achieve the soil RAO, and the eventual attainment of the soil cleanup goals through natural attenuation would be determined through monitoring.

Implementation of Alternative 3 would result in a significant possibility of exposing construction workers to contaminated soil during the excavation and off-base transportation and disposal activities. However, these risks of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression), by the wearing of appropriate PPE, and by compliance with applicable OSHA regulations and proper site-specific health and safety procedures.

With the implementation of Alternative 3, there will be a slight risk to the surrounding community during the transportation of the contaminated soil to the off-base TSDF. This risk would be controlled through adherence to Department of Transportation (DOT) regulations and implementation of traffic control and spill prevention measures. Alternative 3 would achieve the soil RAO and soil Cleanup Goals within approximately 2 months of the start of the removal action.

5.1.6 Implementability

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

Alternative 2 would be relatively easy to implement. Preparation and implementation of LUCs to restrict Site 58 to industrial use could be readily accomplished. Installation of new monitoring wells, maintenance and sampling of new and existing wells, and performance of five-year reviews as part of the monitoring component could also be readily accomplished. Resources, equipment, and materials are available for these tasks. The administrative implementability of institutional controls and monitoring would also be relatively easy. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure the continuation of these controls and monitoring.

Alternative 3 would be slightly more difficult to implement than Alternative 2. This alternative would consist of excavation and off-base disposal of contaminated soil. Off-base permitted TSDFs are available that make the implementation of this alternative relatively easy. Alternative 3 would not require long-term monitoring. The ease of administrative implementation of Alternative 3 would be similar to that of Alternative 2 because it would also require a construction permit and, although it would not require institutional controls, it would require manifesting of the excavated soil.

5.1.7 Cost

The capital and O&M costs and NPW of the soil alternatives are as follows. Costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. Detailed cost estimates are provided in Appendix D.

Alternative	Capital	NPW of O&M (year)	NPW (year)
1	$0	$0	$0
2	$20,000	$54,000 (30 Years)	$74,000 (30 Years)
3	$32,000	$0	$32,000

5.2 SUMMARY OF COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

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

5.3 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives for groundwater are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring
- Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring
- Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring
- Alternative 5: Extraction, On-site Treatment, and Discharge, Institutional Controls, and Monitoring

5.3.1 Overall Protection of Health and Environment

Alternative 1 would not provide protection of human health and the environment because contaminants would remain in groundwater, and potential use of groundwater for drinking purpose could result in

unacceptable risk to human receptors. Also under this alternative, no warning would be provided of the potential for migration of COCs because no monitoring would occur.

Alternatives 2, 3, 4, and 5 would be protective of human health and the environment.

The natural attenuation component of Alternative 2 would be protective of human health and the environment because it would eventually reduce the concentrations of COCs to the cleanup goals over a reasonable timeframe. The institutional controls component of Alternative 2 would be protective of human health and the environment as it would reduce exposure to contaminated groundwater by prohibiting use of the Surficial Aquifer for drinking purposes until the cleanup goals are met. The monitoring component Alternative 2 would be protective of human health and the environment by evaluating the progress of remediation and detecting potential migration of COCs so that appropriate contingency measures can be taken.

Alternatives 3, 4, and 5 would be more protective than Alternative 2, because, in addition to the same institutional controls and monitoring components, these three alternatives would also include an active treatment component that would remove groundwater COCs faster than natural attenuation. Although Alternatives 3 and 4 would results in fugitive emissions, the rate of these emissions would remain well under the FDEP's allowable de minimis of 13.75 pounds of VOCs per day, and both alternatives would in fact be more protective than Alternative 5 because they would achieve complete protection in a significantly shorter time, especially at Site 57.

5.3.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical- and location-specific ARARs. Action-specific ARARs or TBCs would not apply.

Alternatives 2, 3, 4, and 5 would comply with location- and action-specific ARARs and TBCs.

Alternatives 2, 3, 4, 5 would not immediately comply with chemical-specific ARARs and TBCs, but these four alternatives would eventually achieve compliance as they attain cleanup goals either through natural attenuation alone (Alternative 2) or through active treatment (Alternatives 3, 4, and 5). First to achieve compliance would be Alternatives 3 and 4, followed by Alternative 5, and followed by Alternative 2.

5.3.3 Long-Term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because no contaminant removal or reduction would occur through treatment although, over time, some contaminant reduction

would occur through natural attenuation. As there would be no institutional controls to restrict residential development or use of the Surficial Aquifer groundwater for drinking water purposes, the potential would also exist for unacceptable risk to develop due to direct exposure of human or ecological receptors to contamination. Because there would be no monitoring, potential migration of COCs would remain undetected.

Alternatives 2, 3, 4, and 5 would provide long-term effectiveness and permanence.

Given that significant source control activities have either already been implemented (Site 57 Day Tank 1 removal) or are planned (Site 57 free product removal, Site 58 soil excavation), the natural attenuation component of Alternative 2 would effectively and permanently reduce concentrations of groundwater COCs to cleanup goals. The institutional controls component of Alternative 2 would effectively prevent the use of the Surficial Aquifer as a drinking water source until the cleanup goals have been achieved. The long-term monitoring component of Alternative 2 would provide an effective means of evaluating the progress of remediation and verifying that no COC migration is occurring.

Alternatives 3, 4, and 5 would be more effective than Alternative 2, because, in addition to the same institutional controls and monitoring components, these three alternatives would also include an active treatment component that accelerates the removal of COCs, especially at Site 57. Alternative 4 would be most effective because it would be quickest to meet the cleanup goals and would use a well-proven treatment technology. Alternative 3 would be slightly less effective than Alternative 4 because, although it would meet the cleanup goals in the same timeframe, its application at Site 57 would use an innovative technology (HRC® injection for removal of chlorinated VOCs) that would require treatability testing. Also at Site 57, there might be some interference between the treatment of BTEX, PAHs, and TRPH with ORC® and the treatment of chlorinated VOCs with HRC®. Alternative 5 would be less effective than either Alternatives 3 or 4 because, although it would use a well-established active remedial approach (pump-and-treat), it would take somewhat more time to meet the cleanup goals and would actually not be significantly quicker than Alternative 2.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve any reduction of toxicity, mobility, or volume of COCs through treatment. Both alternatives would achieve reduction of contaminant toxicity and volume through natural attenuation; however, under Alternative 1, this reduction would neither be verified nor quantified.

Alternatives 3, 4, and 5 would achieve a reduction in COC toxicity and volume through treatment.

Alternatives 3, 4, and 5 would irreversibly remove an estimated 525 pounds of COCs from the contaminant plumes (504 pounds from Site 57 and 21 pounds from Site 58) through either in-situ biological or AS treatment or through extraction, on-site air stripping and liquid-phase GAC adsorption, and surface discharge. Alternatives 3 and 4 would not generate treatment residues. Alternative 5 would generate treatment residues including clogged filter bags and spent GAC.

5.3.5 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 not achieve the groundwater RAOs and although the groundwater cleanup goals might eventually be attained through natural processes, this would not be verified.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to contaminated groundwater during the installation, maintenance, and sampling of new and existing monitoring wells. However, these risks of exposure would be effectively controlled by wearing appropriate PPE and compliance with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would achieve the first two groundwater RAOs immediately upon implementation of institutional controls and monitoring. Based on the results of the modeling presented in Appendix B, the third groundwater RAO and the groundwater cleanup goals would be attained within an estimated 18 years at Site 57 and within an estimated 3 years at Site 58.

Implementation of Alternatives 3, 4, or 5 would result in a significant possibility of exposing construction workers to contaminated groundwater during the construction and operation of groundwater treatment systems, the installation of new monitoring wells, and the sampling of new and existing wells. However, these risks of exposure would be effectively controlled by wearing appropriate PPE and compliance with proper site-specific health and safety procedures. Implementation of Alternatives 3, 4, and 5 would not adversely impact the surrounding community or environment. Alternatives 3, 4, and 5 would achieve the first two groundwater RAOs immediately upon implementation of institutional controls. It is estimated that the respective timeframes to achieve the third groundwater RAO and the groundwater cleanup goals at Sites 57 and 58 would be 3 and 2 years, respectively, for Alternatives 3 and 4, and 14 and 3 years, respectively, for Alternative 5.

5.3.6 Implementability

Alternative 1 would be easiest to implement because there would be no activities to implement.

Technical implementation of the various components of Alternatives 2, 3, 4, and 5 would be relatively simple.

The technical implementation of the natural attenuation, institutional controls, and monitoring components of Alternative 2 would be very simple. The resources, equipment, and material required for the activities associated with these components are readily available.

The technical implementation of Alternatives 3, 4, and 5 would be somewhat more difficult than that of Alternative 2 because each of these alternatives would require the installation and O&M of a groundwater treatment system. Of these three alternatives, Alternative 3 would be easiest to implement because it would only require the installation of small diameter ORC®/HRC® injection points and the feeding of these chemicals without installation of permanent equipment. Alternative 5 would be technically harder to implement than Alternative 3 because it would require two groundwater extraction arrays with wells, pumps, and transfer piping and two on-site treatment systems featuring multiple process units. Alternative 5 would also require off-site disposal of clogged filter bags and off-site regeneration or disposal of spent GAC. Alternative 4 would be most technically difficult to implement because it would require three AS systems, each including numerous sparging wells, lengthy interconnecting piping, and one or more compressor systems. However, the resources, equipment, and material necessary to implement any of these three alternatives are readily available.

Administrative implementation of the various components of Alternatives 2, 3, 4, and 5 would be relatively simple.

Administrative implementation of the institutional controls component of Alternative 2 would be simple because, as part of change of the sites from military to private ownership, appropriate provisions will be incorporated in the property transfer documents to ensure continued enforcement of controls. Administrative implementation of the monitoring component of Alternative 2 would also be simple and it would not require permits.

The administrative implementation of Alternatives 3, 4, and 5 would be slightly more difficult than that of Alternative 2. In addition to the same requirements as Alternative 2, Alternative 3 might require a construction permit for installation of DPT injection points, and Alternatives 4 and 5 would need construction permits for the installation of groundwater treatment systems. However, these permits should be relatively easy to obtain. Alternative 3 would also have to meet the substantive requirements of a UIC permit for ORC®/HRC® injection. Alternative 5 would also have to meet the substantive requirements of a NPDES permit for discharge of treated groundwater to surface water.

5.3.7 Cost

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

Alternative	Capital	NPW of O&M (year)	NPW (year)
1	$0	$0	$0
2	$5,000	$519,000 (20 Years)	$524,000 (20 Years)
3	$1,265,000	$352,000 (5 Years)	$1,617,000 (5 Years)
4	$1,636,000	$564,000 (5 Years)	$2,200,000 (5 Years)
5	$1,109,000	$1,542,000 (15 Years)	$2,651,000 (15 Years)

Detailed cost estimates are provided in Appendix D.

5.4 SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

Table 5-2 summarizes the comparative analysis of the remedial alternatives.

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TABLE 5-1

SUMMARY OF COMPARATIVE ANALYSIS OF SITE 58 SOIL REMEDIAL ALTERNATIVES
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Disposal
Overall Protection of Human Health and Environment	Would not be protective because exposure to contaminated soil would continue unabated and residential development could occur that would result in increased human health risks and ecological risks. The potential for soil COCs migrating to the groundwater would remain.	Would be protective of the environment by restricting site access, preventing residential development, and detecting the potential migration of soil COCs to groundwater.	Would be most protective by eliminating the risk of exposure to soil contaminated above SCTLs for direct residential exposure and minimizing the potential for migration of COCs to groundwater.
Compliance with ARARs and TBCs: Chemical-Specific Location-Specific Action-Specific	 Would not comply Would not comply Not applicable	 Would not comply Would comply Would comply	 Would comply Would comply Would comply
Long-Term Effectiveness and Permanence	Would have very limited long-term effectiveness and permanence since all contaminants would remain on-site. Any long-term effectiveness would not be known since monitoring would not occur.	Would be long-term effective and permanent. Fencing, posting, and monitoring would effectively and permanently reduce current unacceptable human health risks. Prohibition of residential development would effectively and permanently prevent future unacceptable human and ecological risks.	Would provide the most long-term effectiveness and permanence. Risks from exposure to contaminated soil and from the potential migration of contaminants would be effectively and permanently eliminated through excavation and disposal.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but may achieve some reduction through natural processes.	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but may achieve some reduction through natural processes.	Would permanently and irreversibly remove 180 yd^3 of contaminated soil containing an estimated 1.2 pounds of COCs from the site. Off-base disposal would reduce mobility.

TABLE 5-1

SUMMARY OF COMPARATIVE ANALYSIS OF SITE 58 SOIL REMEDIAL ALTERNATIVES
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Disposal
Short-Term Effectiveness	Would not result in short-term risks to site workers or adversely impact the surrounding community but would also not achieve RAO through treatment.	Would result in slight risk to site workers during sampling of the soil and groundwater. This risk would be adequately mitigated through compliance with site-specific health and safety procedures. RAO would be achieved immediately upon implementation. Eventual compliance with cleanup goals would be determined through monitoring.	Would result in a significant risk of exposure to site workers to contaminated soil during the excavation and disposal activities. This risk would be adequately mitigated through compliance with site-specific health and safety procedures. The RAO would be achieved immediately upon implementation. Cleanup goals would be attained within 2 months.
Implementability	Would be simple to implement because no action would occur.	Would be easy to implement since the resources, materials, and equipment are readily available. Provisions will be incorporated into the property transfer documents to ensure the continuation of the institutional controls and monitoring when ownership of the site was transferred to the private sector.	Would be the most difficult to implement since contaminated soil would have to be excavated and transported off-base for treatment and disposal. No institutional controls or monitoring would be required. A construction permit and manifesting would also be required.
Costs:			
Capital	$0	$20,000	$32,000
NPW of O&M	$0	$54,000 (30 Years)	$0
NPW	$0	$74,000 (30 Years)	$32,000

Notes:

ARARs Applicable or Relevant and Appropriate Requirements
COCs Chemicals of concern
NPW Net present worth
O&M Operation and maintenance
RAO Remedial Action Objective
TBC To-be-considered (criteria)

TABLE 5-2

SUMMARY OF COMPARATIVE ANALYSIS OF SITES 57 AND 58 GROUNDWATER REMEDIAL ALTERNATIVES
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Natural Attenuation, Institutional Controls and Monitoring	Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring	Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring	Alternative 5: Extraction, On-Site Treatment, & Surface Discharge, Institutional Controls, and Monitoring
Overall Protection of Human Health and Environment	Would not be protective of human health and the environment because no action would occur. Migration of COCs would continue and remain undetected.	Would be protective of human health and the environment because natural attenuation would reduce COC concentrations down to cleanup goals over a reasonable timeframe. Institutional controls and monitoring would provide immediate protection until the cleanup goals are met by restricting use of the aquifer for drinking purposes and checking for potential migration of COCs.	Would be more protective of human health and the environment than Alternative 2 because, in addition of institutional controls and monitoring, it would feature active treatment that would accelerate the removal of COCs.	Would be as protective of human health and the environment as Alternative 3 because it would provide most of the same protective components (i.e., institutional controls, and monitoring) and also accelerate the removal of COCs, but through in-situ AS treatment rather than in-situ bioremediation.	Would be as protective of human health and the environment as Alternatives 3 and 4 because it would provide most of the same protective components (i.e., institutional controls, and monitoring) and also accelerate the removal of COCs, but through extraction and on-site treatment rather than in-situ bioremediation or in-situ AS treatment.
Compliance with ARARs and TBCs: Chemical-Specific Location-Specific Action-Specific	 Would not comply Would not comply Not applicable	 Would eventually comply Would comply Would comply	 Would eventually comply Would comply Would comply	 Would eventually comply Would comply Would comply	 Would eventually comply Would comply Would comply
Long-Term Effectiveness and Permanence	Would have very limited long-term effectiveness and permanence because no action would occur. Contaminant reduction or migration would remain undetected because no monitoring would occur.	Would be long-term effective and permanent. Natural attenuation would eventually reduce COC concentrations down to cleanup goals. Institutional controls would effectively prevent unacceptable human health and ecological risk from exposure to contaminated groundwater. Monitoring would effectively evaluate the progress of remediation and detect potential migration of COCs.	Would be more long-term effective and permanent than Alternative 2 by significantly accelerating the removal of COCs through active in-situ bioremediation. However, the effectiveness of HRC® injection would have to be verified through treatability testing. The long-term effectiveness and permanence of the institutional controls, and monitoring would be the same as for Alternative 2.	Would be more long-term effective and permanent than Alternative 3 because it would provide the same accelerated removal of COCs, but through in-situ AS treatment that does not need to be tested. The long-term effectiveness and permanence of the institutional controls and monitoring would be the same as for Alternative 2.	Would be slightly less long-term effective and permanent than Alternative 4 but more so than Alternative 3. Would provide the same accelerated removal of COCs through active extraction and on-site-treatment, which is as well-proven as in-situ AS treatment but somewhat slower. The long-term effectiveness and permanence of the institutional controls and monitoring would be the same as for Alternative 2.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	Would not reduce contaminant toxicity, mobility or volume through treatment because no treatment would occur.	Would not reduce contaminant toxicity, mobility or volume through treatment because no treatment would occur.	Would irreversibly and permanently reduce contaminant toxicity, mobility and volume by removing an estimated 525 pounds of COCs through in-situ bioremediation.	Would irreversibly and permanently reduce contaminant toxicity, mobility, and volume by removing an estimated 525 pounds of COCs through in-situ AS treatment.	Would irreversibly and permanently reduce contaminant toxicity, mobility, and volume by removing an estimated 525 pounds of COCs through extraction and on-site treatment.
Short-Term Effectiveness	Would not result in any short-term risk to site workers or adversely impact the surrounding community or environment because no action would occur. The RAOs would never be achieved with the implementation of this alternative.	Would result in a slight possibility of exposing site workers to contaminated groundwater as a result of monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. There would be no risk to the surrounding community and environment. The first two RAOs would be achieved immediately upon implementation of the institutional controls and monitoring. The third RAO and the cleanup goals would be met within 18 years at Site 57 and within 3 years at Site 58.	Would result in a possibility of exposing site workers to contaminated groundwater as a result of bioremediation and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. There would be no risk to the surrounding community and environment. The first two RAOs would be achieved immediately upon implementation of the institutional controls and monitoring. The third RAO and the cleanup goals would be met within 3 years at Site 57 and within 2 years at Site 58.	Would result in a possibility of exposing site workers to contaminated groundwater as a result of the installation and O&M of the in-situ AS treatment system and of monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. There would be no risk to the surrounding community and environment. The first two RAOs would be achieved immediately upon implementation of the institutional controls and monitoring. The third RAO and the cleanup goals would be met within 3 years at Site 57 and within 2 years at Site 58.	Would result in a possibility of exposing site workers to contaminated groundwater as a result of extraction and treatment and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. There would be no risk to the surrounding community and environment. The first two RAOs would be achieved immediately upon implementation of the institutional controls and monitoring. The third RAO and the cleanup goals would be met within an estimated 14 years at Site 57 and within 3 years at Site 58.

TABLE 5-2

SUMMARY OF COMPARATIVE ANALYSIS OF SITES 57 AND 58 GROUNDWATER REMEDIAL ALTERNATIVES
OU 9, SITES 57 AND 58 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Natural Attenuation, Institutional Controls and Monitoring	Alternative 3: In-Situ Biological Treatment (ORC®/HRC®), Institutional Controls, and Monitoring	Alternative 4: In-Situ AS Treatment, Institutional Controls, and Monitoring	Alternative 5: Extraction, On-Site Treatment, & Surface Discharge, Institutional Controls, and Monitoring
Implementability	Technical and administrative implementation would be extremely simple because there would be no action to implement.	Technical implementation of the monitoring would be simple. Administrative implementation of the institutional controls would be simple.	Technical implementation of the in-situ bioremediation would be simple although it would create temporary site disruptions, and the number of qualified contractors would be limited. Technical implementation of the monitoring would be simple. Administrative implementation of the institutional controls would be simple. A construction permit might be required for installation of the ORC®/HRC® injection points.	Technical implementation of the in-situ AS treatment would be significantly more complex than that of in-situ bioremediation and create much greater site disruptions. However, implementation would still be technically possible and site disruptions would be acceptable. Technical implementation of the monitoring would be simple. Administrative implementation of the institutional controls would be simple. Construction permits would be required for the installation of the in-situ AS treatment systems.	Technical implementation of the extraction and on-site treatment would be simpler than that of the in-situ AS treatment. Installation and O&M of the limited number of extraction wells and small on-site treatment systems would be simple and would not create significant site disruptions. Implementation of the surface discharge, disposal of treatment residues, and monitoring would be simple. Administrative implementation of the institutional controls would be simple. A construction permit would be required and the substantive requirements of an NPDES permit would have to be met.
Costs:					
Capital	$0	$5,000	$1,265,000	$1,636,000	$1,109,000
NPW of O&M	$0	$519,000 (20 Years)	$352,000 (5 Years)	$564,000 (5 Years)	$1,542,000 (15 Years)
NPW	$0	$524,000 (20 Years)	$1,617,000 (5 Years)	$2,200,000 (5 Years)	$2,651,000 (15 Years)

NOTES:

ARARs Applicable or Relevant and Appropriate Requirements
AS Air sparging
COCs Chemicals of concern
HRC® Hydrogen release compound
NPDES National Pollutant Discharge Eliminatio System
NPW Net present worth
O&M Operation and maintenance
ORC® Oxygen release compound
RAD Remedial Action Objective
TBC To-be-considered (criterion)

REFERENCES

ABB-ES (ABB Environmental Services, Inc.), 1994. *Environmental Baseline Survey Report, Base Realignment and Closure, Naval Air Station Cecil Field, Jacksonville Florida*. Prepared for Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM), North Charleston, South Carolina. November.

ABB-ES, 1997. *Remedial Action Plan, Day Tank 1, Facility 293, Naval Air Station Cecil Field, Jacksonville Florida*. Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. January.

CH2M Hill, 2001. *Quarterly Operation and Maintenance Status Report, Biosparging and Soil Vapor Extraction System, Day Tank 1 Site, February 26, 2001 – July 3, 2001, Naval Air Station Cecil Field, Jacksonville, Florida*. Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. August.

FDEP (Florida Environmental Department of Environmental Protection), 1999a. *Soil and Groundwater Cleanup Target Levels*. Florida Administrative Code (FAC) 62-777, Tables I and II. August.

FDEP, 1999b. *Natural Attenuation Default Concentrations*. FAC 62-777, Table V. August.

FDEP, 1999c. *Primary and Secondary Drinking Water Quality Criteria*. FAC 62-550. September.

FDEP, 1999d. *Petroleum Contamination Site Cleanup Criteria*. FAC 62-770, Table B. August

HLA (Harding Lawson Associates), 1998a. *Inorganic Background Data Set (IBDS)*. July.

HLA, 1999. *Sampling and Analysis Outline Report for Main Base Open Area 18, Revision 1.0, Base Realignment and Closure, Naval Air Station Cecil Field, Jacksonville, Florida*. Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. May.

TtNUS (Tetra Tech NUS, Inc.), 2000. *Sampling and Analysis Work Plans (Phases I through IV), Building 824 Groundwater Resampling, Naval Air Station Cecil Field*. Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. December.

TtNUS, 2002. *Draft Remedial Investigation Report, Operable Unit 9, Sites 57 and 58, Naval Air Station Cecil Field, Jacksonville, Florida*. Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. March.

U.S. EPA (United States Environmental Protection Agency), 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004. Office of Solid Waste and Emergency Response (OSWER), Washington, D.C. October.

U.S. EPA, 1995. *Supplemental Guidance for RAGS: Region IV Building, Human Risk Assessment*. USEPA Region IV Waste Management Division, Atlanta, Georgia. November.

U.S. EPA, 1998. *Current Drinking Water Standards.*

U.S. EPA, 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Site*. OSWER Directive 9200.4-17P. April.

U.S. EPA, 2001. *EPA Region 9 Preliminary Remediation Goals. PRG Tables. http//www.epa.gov/region09/sfund/prg*

APPENDIX A

LUCs RISK ANALYSIS

DETERMINING MONITORING FREQUENCY FOR LAND USE CONTROLS (LUCs)

Introduction

LUCs are typically implemented to restrict a site to industrial use or other uses besides residential. This obviously reduces the amount of cleanup at a specific site. However, implementation of a LUC would require some degree of monitoring to ensure that the site does not become residential. The frequency of this monitoring can be determined using a risk-based approach that considers the post-remedial exposure concentrations for the site and the exposure assumptions used for assessing residential exposure.

Technical Basis

Using the United States Environmental Protection Agency's (U.S. EPA's) *Risk Assessment Guidance for Superfund* (USEPA 1989) in coordination with the Florida Department of Environmental Protection (FDEP*) Development of Soil Cleanup Target Levels [SCTL] for Chapter 62-785, F.A.C.* (FDEP, 1998), the FDEP Groundwater Cleanup Target Levels (GCTLs) in accordance with Chapters 62-777, 62-550 and 62-520, F.A.C., and the U.S. EPA Region IX Preliminary Remediation Goals (PRGs), the monitoring frequency to ensure protection of human health if the site is unknowingly used for residential purposes can be determined. The determination of this frequency of monitoring the land use control is based on the concept that risk is directly proportional to the dose, which is directly proportional to the amount of exposure, as illustrated in equations (1) and (2).

(1) $$\text{Risk} = \text{Dose} \bullet \text{Exposure}$$

(2) $$\text{Exposure} = (C \bullet IR \bullet EF \bullet ED) / (BW \bullet AT)$$

where

C = Exposure point concentration
IR = ingestion rate
EF = exposure frequency
ED = exposure duration
BW = body weight
AT = averaging time

If a site is remediated to be protective of human health based on a use other than residential, the risk associated with residential exposure can be defined by the ratio of the post-remedial exposure point concentration to the FDEP residential SCTL or GCTL, or the U.S. EPA Region IX PRG. This assumes that these levels are also risk-based. Some GCTLs are equivalent to the USEPA's Maximum Contaminant Levels (MCLs) or Secondary MCLs (SMCLs), and are technology or aesthetically-based. For carcinogenic compounds, the SCTL and PRG correspond to an incremental cancer risk (ICR) of 1.0E-06 (one in a million). For noncarcinogenic compounds, the SCTL and PRG correspond to a hazard quotient (HQ) of one. Therefore, the ratio of the site concentration to the SCTL or PRG is equivalent to a multiplier of the ICR or HQ. For example, if the SCTL is 100 μg/kg and the site concentration is 200 μg/kg, this corresponds to an ICR of 2.0E-06 (for a carcinogenic compound) or a HQ of 2 (for a non-carcinogenic compound.

To determine the monitoring frequency to ensure protection of residential exposure, a ratio is established between the existing site risk based on the current exposure concentration and an assumption of an exposure duration of 30 years (the default assumption for residential exposure). This ratio is set equal to a ratio established between the target ICR of 1.0E-06 and some exposure duration, such that this exposure duration at the same exposure concentration would result in the target ICR of 1.0E-06. Specifically:

(3) $(ICR_{site}) / (ED_{residential}) = (\text{Target ICR}) / (ED_{LUC})$

For example, if a carcinogenic compound's site exposure concentration of 200 µg/kg corresponds to an ICR of 2.0E-06 (ICR_{site}), as identified above, this also corresponds to a residential exposure duration ($ED_{residential}$) of 30 years. The target ICR is defined as 1.0E-06. Therefore, the monitoring frequency (ED_{LUC}) would be equal to 15 years. In other words, if someone would take up residence on this site in its current state, 15 years of exposure would result in an ICR risk of 1.0E-06. Therefore, it would follow that one would only need to inspect the site every 15 years to ensure that the target risk to residential exposure would not be exceeded.

For noncarcinogenic compounds, the determination of a monitoring frequency is different than for carcinogenic compounds. This stems from the definition of the averaging time (AT). For carcinogenic compounds, AT is equal to 70 years (an average lifetime). For noncarcinogenic compounds, AT is essentially equal to ED since risks associated with noncarcinogenic compounds are based on a threshold response. Consequently, the ED term in Equation (2) cancels and has no bearing on the value of the exposure intake. Therefore, if the HQ were greater than one because the exposure concentration is greater than the risk-based concentration (RBC) or a regulatory criterion (e.g., SCTL, GCTL or PRG), it would be likely that systemic effects could occur, regardless of time of exposure. Consequently, for noncarcinogenic compounds, an exceedance of a regulatory criterion or a RBC would suggest that some regular degree of monitoring would be required.

In cases, for carcinogens, where the GCTL is equivalent to a non-risk-based value such as a Maximum Contaminant Level (MCL) or a Secondary MCL (SMCL), the GCTL may be greater than the risk-based value (PRG). For groundwater, the greater of the GCTL or the PRG is used as the basis for determining the LUC monitoring frequency. In these cases where the GCTL is equivalent to the MCL, SMCL, or some other non-risk-based value, the following equation is used to determine the ED_{LUC}:

(4) $ED_{LUC} = ED_{residential} \bullet \text{GCTL} / \text{Concentration}$

where Concentration is the groundwater concentration detected at the site.

Monitoring Frequency at Site 57

The primary chemicals of concern (COCs) in groundwater at Site 57 are chlorinated hydrocarbons (cis-1,2-dichloroethene, 1,1-dichloroethane, trichloroethylene, 1,1-dichloroethene), aromatic hydrocarbons (benzene, toluene, ethylbenzene, xylene), naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. The exposure point concentrations for these COCs are represented by the maximum detected concentration. The noncarcinogenic COCs, cis-1,2-dichloroethene, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene, are present at concentrations greater than their respective GCTLs and PRGs. Consequently, the presence of these COCs at these concentrations warrants that the ED_{LUC} be less than one year. However, it was agreed that the ED_{LUC} would be no more than annual because the planning and construction process for a residence would be at least one year, especially in a formerly industrial area of NAS Cecil Field (Table 1).

Monitoring Frequency at Site 58

The primary COCs in soil at Site 58 are carcinogenic polynuclear aromatic hydrocarbons (PAHs) (cPAHs). The exposure point concentration for cPAHs in soil is represented by the maximum detected concentration of benzo[a]pyrene equivalents (BaPEq), or 3,967 µg/kg. This concentration considerably exceeds the residential BaP FDEP SCTL of 100 µg/kg and the U.S. EPA Region IX PRG of 62 µg/kg. This concentraton corresponds to a residential ICR 9f 6.4E-05. Using equation (3), the monitoring frequency is 0.8 years (Table 2).

The primary human health groundwater COCs at Site 58 are chlorinated hydrocarbons (1,1-dichloroethane, 1,1,1-trichloroethane, 1,1-dichloroethene), xylene, and naphthalene. The noncarcinogenic COCs, 1,1,1-trichloroethane and naphthalene, are present at concentrations greater than their respective GCTLs and PRGs. Consequently, the presence of these COCs at these concentrations warrants that the ED_{LUC} be less than one year (Table 3).

The ED_{LUC} for both media at Site 58 are less than one year. Therefore, as was agreed, the ED_{LUC} would be no more than annual because the planning and construction process for a residence would be at least one year, especially in a formerly industrial area of NAS Cecil Field.

TABLE 1

LUC Risk Analysis

Site 57 Groundwater

Constituent	GCTL	Region IX PRG	MCL	C/N	Maximum	Risk	HQ	ED_{LUC}
cis-1,2-Dichloroethene	**70**	61	70	N	825	NA	13.5	**<1**
1,1-Dichloroethane	70	**810**	NA	N	97.2	NA	0.1	NA
Trichloroethylene	**3**	1.6	5	C	43	2.7E-05	NA	**2.1**
Benzene	**1**	0.35	5	C	254	7.3E-04	NA	**0.1**
Ethylbenzene	30	**1300**	700	N	151	NA	0.1	NA
Toluene	40	**720**	1000	N	66	NA	0.1	NA
Xylene	20	**1400**	10000	N	572	NA	0.4	NA
1-Methylnaphthalene (2)	**20**	NA	NA	N	175	NA	8.8	**<1**
2-Methylnaphthalene (2)	**20**	NA	NA	N	196	NA	9.8	**<1**
Naphthalene	**20**	6.2	NA	N	438	NA	70.6	**<1**
1,1-Dichloroethene (3)	**7**	0.046	7	C(1)	33.8	7.3E-04	0.02	**6.2**

GCTL Groundwater Contaminant Target Level (F.A.C. 62-777) (ug/L)
PRG U.S. EPA Region IX Preliminary Remediation Goal (ug/L)
MCL Maximum Contaminant Level (ug/L)
C/N Carcinogen/Noncarcinogen
Maximum Maximum Concentration (ug/L)
Risk Incremental Lifetime Cancer Risk [(Maximum * 1.0E-06) / PRG for Carcinogens]
HQ Hazard Quotient [(Maximum / PRG) for Noncarcinogens]
ED_{LUC} Exposure Duration for the Land Use Control (Monitoring Frequency) (years)

(1) U.S. EPA has recently changed the status of 1,1-Dichloroethene to a Noncarcinogen, but th PRG and MCL still reflect its carcinogenic status.
(2) No PRG is available for these constituents, therefore the GCTL is used to develop the HQ.
(3) Based on the new reference dose of 0.005 mg/kg/day, the HQ was developed using a risk-based concentration (1750 ug/L) that corresponds to the new reference dose.

ED_{LUC} is the exposure duration to a contaminant at its current concentration that would result in a risk equal to the risk or dose associated with a contaminant at its target risk or target concentration.

Bolded values (GCTL or PRG) represent those values used for determining ED_{LUC}.
Bolded constituents are those constituents to which an ED_{LUC} is applicable.

For carcinogens
ED_{LUC} = (ED_{SITE} * TARGET RISK) / RISK
ED_{SITE} = 30 years (residential exposure)
Target Risk = 1E-06

For cases where the MCL or GCTL > PRG
ED_{LUC} = (ED_{SITE} * GCTL) / Maximum

For noncarcinogens, an exceedance of the PRG or the GCTL, whichever is greater, indicates that the LUC monitoring frequency should be annual at a minimum.
None is needed if the GCTL is not exceeded.

Because there are exceedances of the GCTL and PRG for noncarcinogens, the LUC monitoring frequency should be annual. It was agreed that the most frequent monitoring frequency would be annual because the planning and construction process for a residence would be at least one year.

TABLE 2

LUC Risk Analysis

Site 58 Groundwater

Constituent	GCTL	Region IX PRG	MCL	C/N	Maximum	Risk	HQ	ED_{LUC}
1,1-Dichloroethane	70	**810**	NA	N	426	NA	0.5	NA
1,1,1-Trichloroethane	200	**540**	200	N	871	NA	1.6	**<1**
Xylene	20	**1400**	10000	N	70.3	NA	0.1	NA
Naphthalene	**20**	6.2	NA	N	156	NA	25.2	**<1**
1,1-Dichloroethene (2)	**7**	0.046	7	C(1)	131	2.8E-03	0.07	**1.6**

GCTL Groundwater Contaminant Target Level (F.A.C. 62-777) (ug/L)
PRG U.S. EPA Region IX Preliminary Remediation Goal (ug/L)
MCL Maximum Contaminant Level (ug/L)
Maximum Maximum Concentration (ug/L)
C/N Carcinogen/Noncarcinogen
Risk Incremental Lifetime Cancer Risk [(Maximum * 1.0E-06) / PRG for Carcinogens]
HQ Hazard Quotient [(Maximum / PRG) for Noncarcinogens]
ED_{LUC} Exposure Duration for the Land Use Control (Monitoring Frequency) (years)

(1) U.S. EPA has recently changed the status of 1,1-Dichloroethene to a Noncarcinogen, but PRG and MCL still reflect its carcinogenic status.
(2) Based on the new reference dose of 0.005 mg/kg/day, the HQ was developed using a risk-based concentration (1750 ug/L) that corresponds to the new reference dose.

Bolded values (GCTL or PRG) represent those values used for determining ED_{LUC}.
Bolded constituents are those constituents to which an ED_{LUC} is applicable.

ED_{LUC} is the exposure duration to a contaminant at its current concentration that would result in a risk equal to the risk or dose associated with a contaminant at its target risk or target concentration.

For carcinogens
ED_{LUC} = (ED_{SITE} * TARGET RISK) / RISK
ED_{SITE} = 30 years (residential exposure)
Target Risk = 1E-06

For cases where the MCL or GCTL > PRG
ED_{LUC} = (ED_{SITE} * GCTL) / Maximum

For noncarcinogens, an exceedance of the PRG or the GCTL, whichever is greater, indicates that the LUC monitoring frequency should be annual at a minimum.
None is needed if the GCTL is not exceeded.

Because there are exceedances of the GCTL and PRG for noncarcinogens, the LUC monitoring frequency should be annual. It was agreed that the most frequent monitoring frequency would be annual because the planning and construction process for a residence would be at least one year.

TABLE 3

LUC Risk Analysis

Site 58 Soil

Constituent	SCTL	Region IX PRG	C/N	Maximum	Risk	HQ	ED_{LUC}
Benzo[a]pyrene Equivalents (cPAH) (1)	**100**	62	C	3967	6.3984E-05	NA	**0.8**

SCTL Soil Contaminant Target Level (F.A.C. 62-777) (ug/kg)
PRG U.S. EPA Region IX Preliminary Remediation Goal (ug/kg)
C/N Carcinogen/Noncarcinogen
Maximum Maximum Concentration (ug/kg)
Risk Incremental Lifetime Cancer Risk [(Maximum * 1.0E-06) / PRG for Carcinogens]
HQ Hazard Quotient [(Maximum / PRG) for Noncarcinogens]
ED_{LUC} Exposure Duration for the Land Use Control (Monitoring Frequency) (years)

(1) Carcinogenic PAHs are grouped together in terms of Benzo[a[pyrene Equivalents using the Toxicity Equivalency Factors developed by EPA.

Bolded values (SCTL or PRG) represent those values used for determining ED_{LUC}.
Bolded constituents are those constituents to which an ED_{LUC} is applicable.

ED_{LUC} is the exposure duration to a contaminant at its current concentration that would result in a risk equal to the risk or dose associated with a contaminant at its target risk or target concentration.

For carcinogens
ED_{LUC} = (ED_{SITE} * TARGET RISK) / RISK
ED_{SITE} = 30 years (residential exposure)
Target Risk = 1E-06

For cases where the SCTL > PRG
ED_{LUC} = (ED_{SITE} * SCTL) / Maximum

The monitoring frequency is defined as being less than one year. Therefore, the monitoring frequency would be one year. It was agreed that the most frequent monitoring frequency would be annual because the planning and construction process for a residence would be at least one year.

APPENDIX B

GROUNDWATER MODELING

B.1 GROUNDWATER CLEANUP TIME PROJECTIONS AND EXTRACTION SYSTEM DESIGN

B.2 MIGRATION MODELING

B.1 GROUNDWATER CLEANUP TIME PROJECTIONS AND EXTRACTION SYSTEM DESIGNS

APPENDIX B
GROUNDWATER CLEANUP TIME PROJECTIONS AND EXTRACTION SYSTEM DESIGNS SITES 57 AND 58 FEASIBILITY STUDY NAS CECIL FIELD, JACKSONVILLE FLORIDA

Shallow groundwater at Sites 57 and 58 has been impacted by releases of organic contaminants. Trichloroethene (TCE), benzene, and naphthalene are the contaminants that have been most frequently detected in groundwater at concentrations exceeding their established cleanup goals. Based on site investigation information, Day Tank 1 (which has been removed), located within Site 57, was the primary source of the benzene contamination. The former aircraft wash rack associated with Site 58 is the presumed source of the observed naphthalene contamination in groundwater. The source for the TCE contamination in the Site 57 area is assumed to be related to the wash rack and associated sewer lines east of Building 846. Due to their widespread occurrence at levels above cleanup goals in comparison to other groundwater contaminants, TCE, benzene, and naphthalene were selected as the key contaminants to focus on for groundwater remediation evaluations.

Spreadsheet calculations were performed to project TCE (Site 57), benzene (Site 57), and naphthalene (Site 58) concentration trends over time in groundwater, under natural (no-pumping) conditions. In addition, several conceptual groundwater extraction system designs were developed to evaluate possible approaches to accelerate the cleanup of groundwater. These evaluations were performed to support the Sites 57/58 Feasibility Study (FS) by addressing the following questions:

- How long will it take for TCE, benzene, and naphthalene concentrations to decline to cleanup goals through natural processes (natural attenuation), assuming no active remedial measures are taken?

- What active remediation scenarios involving groundwater extraction and treatment will substantially accelerate the cleanup of contamination, and how long will it take for Chemicals of Concern (COCs) to reach cleanup goals?

The spreadsheet calculations determine the number of groundwater pore volume exchanges required to reach a selected target contaminant concentration, based on soil/water partitioning relationships. The rate at which pore volumes are naturally flushed is calculated using the

groundwater flow gradient, aquifer hydraulic conductivities and their distributions, and cross-sectional area/volume of the contaminant plume. For active remediation scenarios, the pore volume flushing rate is determined by the pumping rate of the groundwater extraction system.

It was assumed for cleanup rate projection purposes that there is no residual source of contamination currently leaching to groundwater, and that the groundwater and soil matrix are in equilibrium in terms of contaminant partitioning. In addition, biodegradation and other chemical and physical breakdown effects on the contaminants were factored into the calculations by the use of contaminant-specific half-lives. The half lives were conservatively selected considering literature values (Howard, et. al., 1991, groundwater half-lives: benzene, 10 days – 2 years; TCE, 0.9 – 4.5 years; napthalene, 2 – 258 days) and site-specific calculations based on sampling results over time in site monitoring wells (Table 1). Key data inputs to the spreadsheet calculations include:

- Hydraulic conductivity – 4.68 ft/day (overall average K for surficial aquifer)
  1.6 ft/day (top 20 ft of aquifer)
  5.5 ft/day (bottom 75 ft of aquifer)

- Flow gradient – 0.005 (Site 57) and 0.01 (Site 58), from site data

- Porosity – 0.35 (from RI)

- Aquifer thickness – 95 feet (based on site data)

- Fractional total organic carbon (TOC) content of subsurface sediments – 0.0038 (geometric mean TOC for Cecil Field samples)

- Contaminant Koc's (from Table 6-1 of the RI Report) -
  TCE: 166
  Benzene: 59
  Naphthalene: 2000

- Contaminant half-lives (from Table 1 calculations, literature values) –
  TCE: 5 yrs
  Benzene: 2 yrs
  Naphthalene: 1 yr

- Plume characteristics:

Site/ COC	Plume Length (ft)	Plume Width (ft)	Plume Thickness (ft)	Average Concentration (ug/L)	Maximum Concentration (ug/L)
Site 57 TCE	500	250	45	18	43
Site 57 Benzene	950	500	40	33	248
Site 58 Naphthalene	240	130	30	82	156

Plume areas, thicknesses, and volumes were conservatively estimated for plume cleanup and remedial design calculation purposes, as shown on Figures 1 and 2. The plume dimensions were based on both the groundwater sampling results and groundwater flow directions.

Four sets of spreadsheet calculations were performed for each COC to project aquifer cleanup time frames (Attachment A). The initial set of calculations for each COC was used to estimate the time required to reach cleanup goals under current (no active remediation, i.e., natural attenuation) conditions. The remaining sets of calculations estimated cleanup times for each plume under various scenarios involving the installation and operation of groundwater extraction systems at differing pumping rates.

In addition, a set of groundwater extraction system design calculations was prepared for each plume (Attachment B). The design calculations determine the minimum required pumping rate for plume containment, the achievable per-well pumping rate, the minimum number of wells needed for a given total extraction system pumping rate, and limitations regarding well spacings and positioning with respect to the plume. Per-well pumping rate calculations were based on an allowable drawdown in the pumping well of no more than 5 feet, to minimize the aquifer drawdown and thus maximize contaminant desorbing from aquifer materials to groundwater. Based on a calculated maximum attainable per-well pumping rate of 10 gallons per minute (gpm), a final per-well pumping rate of 6 gpm was used for design purposes, to provide for design/operation flexibility, factor in overlapping cones of depression, and allow for aquifer heterogeneity.

All of the pumping scenarios involve groundwater extraction at a rate that is at least 2 times the natural groundwater flow-through rate, thus they should be adequate for plume containment with

proper well positioning. For the higher pumping rate options, some of the wells can be positioned within hot spot areas to maximize contaminant removal.

Based on the flushing rate and extraction system design calculations, the following summarizes the cleanup times projected under the various remedial scenarios evaluated:

Site	Contaminant	Remedial Scenario	Flushing Rate, gpm	Number of Wells	Cleanup Time, yrs
57	Benzene	Natural Attenuation	1.8	NA	16
		Pumping	12	2	13.7
		Pumping	20	4	13.2
		Pumping	30	5	11.8
	TCE	Natural Attenuation	1.1	NA	18
		Pumping	6	1	14.1
		Pumping	12	2	11.6
		Pumping	18	3	10
58	Naphthalene	Natural Attenuation	0.6	NA	3
		Pumping	6	1	3
		Pumping	12	2	2.9
		Pumping	18	3	2.9

As mentioned previously, contaminant biodegradation and/or decay (which accelerate the rate of cleanup substantially) were factored into the cleanup time calculations through the inclusion of contaminant half-lives. Under- or over-estimation of the half-lives could lead to significant inaccuracies regarding the calculations of the time required for plume cleanup, as could the assumption that there is no residual source continuing to release contamination to groundwater. Also, estimates had to be made regarding the plume size, concentrations, and several of the aquifer characteristics. All of these parameters affect the spreadsheet calculations, thus the results should be considered as rough approximations only.

Reference: Howard, et. al., 1991. Environmental Degradation Rates. CRC Press LLC.

TABLE 1
RATE CONSTANT CALCULATIONS
SITES 57 AND 58
NAS CECIL FIELD

Site	Well	Contaminant	C_0, ug/L	C_t, ug/L	t, years	k	Half-life, years	C_x, ug/L	t_x, years
57	824A-07S	TCE	14.9	0.84	1.25	2.30081	0.301	3	-0.55
57	293-20	TCE	15	3.3	3.4	0.44538	1.556	3	0.21
57	293-19	TCE	48.9	43	0.92	0.13977	4.958	3	19.05
57	824-01S	TCE	35	1	5.75	0.61839	1.121	3	-1.78
57	824A-11S	Benzene	12.2	7.6	0.92	0.51450	1.347	1	3.94
57	293-11	Benzene	63.2	32	0.92	0.73982	0.937	1	4.69
57	824A-12I	Benzene	8.1	3.5	0.92	0.91216	0.760	1	1.37
57	293-21	Benzene	160	28.9	2.4	0.71313	0.972	1	4.72
57	293-22	Benzene	20	5.3	1	1.32816	0.522	1	1.26
58	312-01	Napthalene	95	49.5	1	0.65197	1.063	20	1.39
58	312-02S	Napthalene	35	8.3	1	1.43924	0.482	20	-0.61
58	B312-01S	Napthalene	680	156	1.4	1.05171	0.659	20	1.95
58	B312-06S	Napthalene	58	47.6	1	0.19763	3.507	20	4.39

NOTE: Concentration data (C_0, C_t) used for the calculation of rate constants/half lives obtained from Tables 1-1, 5-2, and 5-5 of the OU-9 (Sites 57 and 58) RI Report

C_0 = Concentration at time 0 C_t = Concentration at time t C_x = Target concentration

t = Elapsed time t_x = Time required to reach target concentration, from current time

$C_t = C_0 \times e^{-kt}$ $C_x = C_0 \times e^{-ktx}$ half-life = 0.693/k

k = rate constant (1st order coefficient) = $-(\ln (C_t/C_0))/t$

ATTACHMENT A
FLUSHING RATE CALCULATIONS

Benzene

Natural Attenuation - benzene

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	benzene	K_{OC} (K_d*) :	59
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	X	ug/L & ug/Kg:

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.248	Cw_{02}	0.248	Cw_{03}	0.248
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.224	K_d	0.224	K_d	0.224
M_W	0.087	M_W	0.087	M_W	0.087
C_S	0.056	C_S	0.056	C_S	0.056
M_S	0.096	M_S	0.096	M_S	0.096
M_T	0.183	M_T	0.183	M_T	0.183
M_S/M_T	0.5246	M_S/M_T	0.5246	M_S/M_T	0.5246

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
1.84	354.22	19,009,333

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
66.45	143.89	143.89	3326633.275	1663316.638	1663316.638	50064.88	11559.71	11559.71

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	730	1st order decay coef. (k):	0.000949

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.001	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	50064.88	0.000	0.000	137.07
2	100129.75	0.000	0.000	274.14
3	150194.63	0.000	0.000	411.21
5	250324.38	0.000	0.000	685.35
7	350454.14	0.000	0.000	959.49
9	450583.89	0.000	0.000	1233.63
12	600778.52	0.000	0.000	1644.84
15	750973.15	0.000	0.000	2056.05
20	1001297.53	0.000	0.000	2741.40
25	1251621.91	0.000	0.000	3426.75
0.1	5006.49	0.002	0.002	13.71
0.11	5507.14	0.001	0.001	15.08
0.12	6007.79	0.001	0.001	16.45
0.13	6508.43	0.000	0.000	17.82
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 12 gpm

Pore Volume Contaminant Concentration Calculations

Project:	**Cecil Field**	**Proj. No.:**	**0039.DS011H105**
Chemical :	**benzene**	**K_{OC} (K_d*) :**	**59**
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	**X**	ug/L & ug/Kg:

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.248	Cw_{02}	0.248	Cw_{03}	0.248
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.224	K_d	0.224	K_d	0.224
M_W	0.087	M_W	0.087	M_W	0.087
C_S	0.056	C_S	0.056	C_S	0.056
M_S	0.096	M_S	0.096	M_S	0.096
M_T	0.183	M_T	0.183	M_T	0.183
M_S/M_T	0.5246	M_S/M_T	0.5246	M_S/M_T	0.5246

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
12	2310.16	19,009,333

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
433.35	938.41	938.41	3326633.275	1663316.638	1663316.638	7676.61	1772.49	1772.49

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	730	1st order decay coef. (k):	0.000949

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.001	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	7676.61	0.000	0.000	21.02
2	15353.23	0.000	0.000	42.03
3	23029.84	0.000	0.000	63.05
5	38383.07	0.000	0.000	105.09
7	53736.30	0.000	0.000	147.12
9	69089.53	0.000	0.000	189.16
12	92119.37	0.000	0.000	252.21
15	115149.22	0.000	0.000	315.26
20	153532.29	0.000	0.000	420.35
25	191915.36	0.000	0.000	525.44
0.5	3838.31	0.002	0.003	10.51
0.6	4605.97	0.001	0.001	12.61
0.55	4222.14	0.001	0.002	11.56
0.65	4989.80	0.001	0.001	13.66
0.7	5373.63	0.000	0.001	14.71
0.75	5757.46	0.000	0.000	15.76
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 20 gpm

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	benzene	K_{OC} (K_d*) :	59
Concentration units, water & soil (pick 1):	mg/L & mg/Kg: X	ug/L & ug/Kg:	

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.248	Cw_{02}	0.248	Cw_{03}	0.248
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.224	K_d	0.224	K_d	0.224
M_W	0.087	M_W	0.087	M_W	0.087
C_S	0.056	C_S	0.056	C_S	0.056
M_S	0.096	M_S	0.096	M_S	0.096
M_T	0.183	M_T	0.183	M_T	0.183
M_S/M_T	0.5246	M_S/M_T	0.5246	M_S/M_T	0.5246

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
20	3850.27	19,009,333

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
722.24	1564.01	1564.01	3326633.275	1663316.638	1663316.638	4605.97	1063.49	1063.49

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	730	1st order decay coef. (k):	0.000949

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.001	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	4605.97	0.000	0.001	12.61
2	9211.94	0.000	0.000	25.22
3	13817.91	0.000	0.000	37.83
5	23029.84	0.000	0.000	63.05
7	32241.78	0.000	0.000	88.27
9	41453.72	0.000	0.000	113.49
12	55271.62	0.000	0.000	151.33
15	69089.53	0.000	0.000	189.16
20	92119.37	0.000	0.000	252.21
25	115149.22	0.000	0.000	315.26
0.8	3684.77	0.001	0.003	10.09
0.9	4145.37	0.001	0.002	11.35
1	4605.97	0.000	0.001	12.61
1.1	5066.57	0.000	0.001	13.87
1.2	5527.16	0.000	0.000	15.13
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = $\log (Cw_x/Cw_0) / \log (M_S/M_T)$, for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 30 gpm

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	benzene	K_{OC} (K_d*) :	59
Concentration units, water & soil (pick 1):	mg/L & mg/Kg: X	ug/L & ug/Kg:	

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

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Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.248	Cw_{02}	0.248	Cw_{03}	0.248
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.224	K_d	0.224	K_d	0.224
M_W	0.087	M_W	0.087	M_W	0.087
C_S	0.056	C_S	0.056	C_S	0.056
M_S	0.096	M_S	0.096	M_S	0.096
M_T	0.183	M_T	0.183	M_T	0.183
M_S/M_T	0.5246	M_S/M_T	0.5246	M_S/M_T	0.5246

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

Fraction of total flow, flow unit N (FQ_N) $= K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
30	5775.40	19,009,333

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
1083.37	2346.02	2346.02	3326633.275	1663316.638	1663316.638	3070.65	709.00	709.00

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	730	1st order decay coef. (k):	0.000949

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.001	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	3070.65	0.002	0.004	8.41
2	6141.29	0.000	0.000	16.81
3	9211.94	0.000	0.000	25.22
5	15353.23	0.000	0.000	42.03
7	21494.52	0.000	0.000	58.85
9	27635.81	0.000	0.000	75.66
12	36847.75	0.000	0.000	100.88
15	46059.69	0.000	0.000	126.10
20	61412.92	0.000	0.000	168.14
25	76766.14	0.000	0.000	210.17
1.2	3684.77	0.001	0.002	10.09
1.3	3991.84	0.001	0.001	10.93
1.4	4298.90	0.000	0.001	11.77
1.5	4605.97	0.000	0.001	12.61
1.6	4913.03	0.000	0.000	13.45
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00
0	0.00	0.248	0.248	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

TCE

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039
Chemical :	TCE	K_{OC} (K_d*) :	166
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	ug/L & ug/Kg:	X

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	43.000	Cw_{02}	43.000	Cw_{03}	43.000
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.631	K_d	0.631	K_d	0.631
M_W	15.050	M_W	15.050	M_W	15.050
C_S	27.124	C_S	27.124	C_S	27.124
M_S	46.722	M_S	46.722	M_S	46.722
M_T	61.772	M_T	61.772	M_T	61.772
M_S/M_T	0.7564	M_S/M_T	0.7564	M_S/M_T	0.7564

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{I+1} = [Cw_I](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
1.1	211.76	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
39.72	86.02	86.02	984375	492187.5	492187.5	24780.72	5721.74	5721.74

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	1826	1st order decay coef. (k):	0.000380

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			3	ug/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	24780.72	0.001	0.002	67.85
2	49561.44	0.000	0.000	135.69
3	74342.16	0.000	0.000	203.54
5	123903.60	0.000	0.000	339.23
7	173465.05	0.000	0.000	474.92
9	223026.49	0.000	0.000	610.61
12	297368.65	0.000	0.000	814.15
15	371710.81	0.000	0.000	1017.69
20	495614.42	0.000	0.000	1356.92
25	619518.02	0.000	0.000	1696.15
0.1	2478.07	15.150	15.603	6.78
0.2	4956.14	5.345	5.674	13.57
0.3	7434.22	1.889	2.068	20.35
0.23	5699.57	3.912	4.191	15.60
0.25	6195.18	3.177	3.424	16.96
0.26	6442.99	2.863	3.096	17.64
0.27	6690.79	2.580	2.799	18.32
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x:

PVs = $\log (Cw_x/Cw_0) / \log (M_S/M_T)$, for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039
Chemical :	TCE	K_{OC} (K_d*) :	166
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	ug/L & ug/Kg:	X

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	43.000	Cw_{02}	43.000	Cw_{03}	43.000
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.631	K_d	0.631	K_d	0.631
M_W	15.050	M_W	15.050	M_W	15.050
C_S	27.124	C_S	27.124	C_S	27.124
M_S	46.722	M_S	46.722	M_S	46.722
M_T	61.772	M_T	61.772	M_T	61.772
M_S/M_T	0.7564	M_S/M_T	0.7564	M_S/M_T	0.7564

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

Fraction of total flow, flow unit N (FQ_N) $= K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
6	1155.08	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
216.67	469.20	469.20	984375	492187.5	492187.5	4543.13	1048.99	1048.99

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	1826	1st order decay coef. (k):	0.000380

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :		3	ug/L	
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	4543.13	2.947	4.044	12.44
2	9086.26	0.246	0.452	24.88
3	13629.40	0.025	0.056	37.32
5	22715.66	0.000	0.001	62.19
7	31801.93	0.000	0.000	87.07
9	40888.19	0.000	0.000	111.95
12	54517.59	0.000	0.000	149.26
15	68146.98	0.000	0.000	186.58
20	90862.64	0.000	0.000	248.77
25	113578.30	0.000	0.000	310.96
1.1	4997.45	2.277	3.227	13.68
1.2	5451.76	1.763	2.579	14.93
1.15	5224.60	2.003	2.884	14.30
1.13	5133.74	2.108	3.017	14.06
1.14	5179.17	2.055	2.950	14.18
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x:

PVs = $\log (Cw_x/Cw_0) / \log (M_S/M_T)$, for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039
Chemical :	TCE	K_{OC} (K_d*) :	166
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	ug/L & ug/Kg:	X

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	43.000	Cw_{02}	43.000	Cw_{03}	43.000
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.631	K_d	0.631	K_d	0.631
M_W	15.050	M_W	15.050	M_W	15.050
C_S	27.124	C_S	27.124	C_S	27.124
M_S	46.722	M_S	46.722	M_S	46.722
M_T	61.772	M_T	61.772	M_T	61.772
M_S/M_T	0.7564	M_S/M_T	0.7564	M_S/M_T	0.7564

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{I+1} = [Cw_I](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
12	2310.16	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
433.35	938.41	938.41	984375	492187.5	492187.5	2271.57	524.49	524.49

Groundwater discharged per day from flow unit N (Q_N) = $Q_T \times FQ_N$

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = $PV_T \times FV_N \times n$

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	1826	1st order decay coef. (k):	0.000380

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			3	ug/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	2271.57	6.979	9.577	6.22
2	4543.13	1.378	2.535	12.44
3	6814.70	0.333	0.744	18.66
5	11357.83	0.028	0.072	31.10
7	15900.96	0.003	0.007	43.53
9	20444.09	0.000	0.001	55.97
12	27258.79	0.000	0.000	74.63
15	34073.49	0.000	0.000	93.29
20	45431.32	0.000	0.000	124.38
25	56789.15	0.000	0.000	155.48
1.5	3407.35	3.019	4.843	9.33
1.7	3861.66	2.192	3.725	10.57
1.8	4088.82	1.873	3.273	11.19
1.9	4315.98	1.605	2.879	11.82
1.85	4202.40	1.733	3.069	11.51
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x:

PVs = $\log (Cw_x/Cw_0) / \log (M_S/M_T)$, for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039
Chemical :	TCE	K_{OC} (K_d*) :	166
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	ug/L & ug/Kg:	X

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	43.000	Cw_{02}	43.000	Cw_{03}	43.000
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	0.631	K_d	0.631	K_d	0.631
M_W	15.050	M_W	15.050	M_W	15.050
C_S	27.124	C_S	27.124	C_S	27.124
M_S	46.722	M_S	46.722	M_S	46.722
M_T	61.772	M_T	61.772	M_T	61.772
M_S/M_T	0.7564	M_S/M_T	0.7564	M_S/M_T	0.7564

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.5	0.188	1
5.5	3.438	0.25	0.406	2
5.5	3.438	0.25	0.406	3

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue; the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
18	3465.24	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
650.02	1407.61	1407.61	984375	492187.5	492187.5	1514.38	349.66	349.66

Groundwater discharged per day from flow unit N (Q_N) = $Q_T \times FQ_N$

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = $PV_T \times FV_N \times n$

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	1826	1st order decay coef. (k):	0.000380

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			3	ug/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	1514.38	9.302	12.765	4.15
2	3028.75	2.448	4.504	8.29
3	4543.13	0.788	1.761	12.44
5	7571.89	0.117	0.304	20.73
7	10600.64	0.021	0.055	29.02
9	13629.40	0.004	0.010	37.32
12	18172.53	0.000	0.001	49.75
15	22715.66	0.000	0.000	62.19
20	30287.55	0.000	0.000	82.92
25	37859.43	0.000	0.000	103.65
2.5	3785.94	1.358	2.791	10.37
2.4	3634.51	1.522	3.067	9.95
2.41	3649.65	1.504	3.038	9.99
2.42	3664.79	1.487	3.009	10.03
2.43	3679.94	1.470	2.981	10.08
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00
0	0.00	43.000	43.000	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = $\log (Cw_x/Cw_0) / \log (M_S/M_T)$, for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Naphthalene

Natural Attenuation - naphthalene

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	napthalene	K_{OC} (K_d*) :	2000
Concentration units, water & soil (pick 1):	mg/L & mg/Kg: X	ug/L & ug/Kg:	

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.156	Cw_{02}	0.156	Cw_{03}	0.156
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	7.600	K_d	7.600	K_d	7.600
M_W	0.055	M_W	0.055	M_W	0.055
C_S	1.186	C_S	1.186	C_S	1.186
M_S	2.042	M_S	2.042	M_S	2.042
M_T	2.097	M_T	2.097	M_T	2.097
M_S/M_T	0.9740	M_S/M_T	0.9740	M_S/M_T	0.9740

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.667	0.268	1
5.5	3.438	0.167	0.367	2
5.5	3.438	0.166	0.365	3

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
0.6	115.51	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
31.00	42.34	42.17	1313156.25	328781.25	326812.5	42354.76	7765.86	7750.33

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	365	1st order decay coef. (k):	0.001899

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :		0.02	mg/L	
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	42354.76	0.000	0.000	115.96
2	84709.53	0.000	0.000	231.92
3	127064.29	0.000	0.000	347.88
5	211773.81	0.000	0.000	579.81
7	296483.34	0.000	0.000	811.73
9	381192.86	0.000	0.000	1043.65
12	508257.15	0.000	0.000	1391.53
15	635321.44	0.000	0.000	1739.42
20	847095.25	0.000	0.000	2319.22
25	1058869.07	0.000	0.000	2899.03
0.02	847.10	0.031	0.031	2.32
0.03	1270.64	0.014	0.014	3.48
0.025	1058.87	0.021	0.021	2.90
0.026	1101.22	0.019	0.019	3.01
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x:

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 6 gpm

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	napthalene	K_{OC} (K_d*) :	2000
Concentration units, water & soil (pick 1):	mg/L & mg/Kg: X	ug/L & ug/Kg:	

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.156	Cw_{02}	0.156	Cw_{03}	0.156
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	7.600	K_d	7.600	K_d	7.600
M_W	0.055	M_W	0.055	M_W	0.055
C_S	1.186	C_S	1.186	C_S	1.186
M_S	2.042	M_S	2.042	M_S	2.042
M_T	2.097	M_T	2.097	M_T	2.097
M_S/M_T	0.9740	M_S/M_T	0.9740	M_S/M_T	0.9740

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.667	0.268	1
5.5	3.438	0.167	0.367	2
5.5	3.438	0.166	0.365	3

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
6	1155.08	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
310.04	423.37	421.68	1313156.25	328781.25	326812.5	4235.48	776.59	775.03

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	365	1st order decay coef. (k):	0.001899

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.02	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	4235.48	0.000	0.000	11.60
2	8470.95	0.000	0.000	23.19
3	12706.43	0.000	0.000	34.79
5	21177.38	0.000	0.000	57.98
7	29648.33	0.000	0.000	81.17
9	38119.29	0.000	0.000	104.36
12	50825.72	0.000	0.000	139.15
15	63532.14	0.000	0.000	173.94
20	84709.53	0.000	0.000	231.92
25	105886.91	0.000	0.000	289.90
0.1	423.55	0.069	0.069	1.16
0.2	847.10	0.031	0.031	2.32
0.3	1270.64	0.014	0.014	3.48
0.25	1058.87	0.020	0.021	2.90
0.26	1101.22	0.019	0.019	3.01
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 12 gpm

Pore Volume Contaminant Concentration Calculations

Project:	Cecil Field	Proj. No.:	0039.DS011H105
Chemical :	napthalene	K_{OC} (K_d*) :	2000
Concentration units, water & soil (pick 1):	mg/L & mg/Kg: X	ug/L & ug/Kg:	

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.156	Cw_{02}	0.156	Cw_{03}	0.156
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	7.600	K_d	7.600	K_d	7.600
M_W	0.055	M_W	0.055	M_W	0.055
C_S	1.186	C_S	1.186	C_S	1.186
M_S	2.042	M_S	2.042	M_S	2.042
M_T	2.097	M_T	2.097	M_T	2.097
M_S/M_T	0.9740	M_S/M_T	0.9740	M_S/M_T	0.9740

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.667	0.268	1
5.5	3.438	0.167	0.367	2
5.5	3.438	0.166	0.365	3

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
12	2310.16	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
620.07	846.73	843.35	1313156.25	328781.25	326812.5	2117.74	388.29	387.52

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	365	1st order decay coef. (k):	0.001899

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.02	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	2117.74	0.003	0.003	5.80
2	4235.48	0.000	0.000	11.60
3	6353.21	0.000	0.000	17.39
5	10588.69	0.000	0.000	28.99
7	14824.17	0.000	0.000	40.59
9	19059.64	0.000	0.000	52.18
12	25412.86	0.000	0.000	69.58
15	31766.07	0.000	0.000	86.97
20	42354.76	0.000	0.000	115.96
25	52943.45	0.000	0.000	144.95
0.2	423.55	0.068	0.069	1.16
0.4	847.10	0.030	0.030	2.32
0.5	1058.87	0.020	0.020	2.90
0.48	1016.51	0.021	0.022	2.78
0.49	1037.69	0.021	0.021	2.84
0.51	1080.05	0.019	0.019	2.96
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x :
PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

Q = 18 gpm

Pore Volume Contaminant Concentration Calculations

Project:	**Cecil Field**	**Proj. No.:**	**0039.DS011H105**
Chemical :	**napthalene**	**K_{OC} (K_d*) :**	**2000**
Concentration units, water & soil (pick 1):	mg/L & mg/Kg:	**X**	ug/L & ug/Kg:

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue: the remaining cells are fixed.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg.

Heterogeneous Aquifer Flushing Rate, With or Without Contaminant Decay

This spreadsheet calculates pore volume flushing rates and cleanup times for a groundwater flow system that consists of up to 3 identified groundwater "flow units". Flow units are defined as discrete portions of the aquifer that have unique properties, i.e., a higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher or lower average contaminant concentrations, and/or different organic carbon contents. The spreadsheet allows for factoring in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction, through the optional use of contaminant half-life data. For simple,homogeneous aquifer flushing time simulations, the input parameters for all three flow units can be set at the same values.

Groundwater Flow Unit Physical/Chemical Data

Flow Unit 1 (U1)		Flow Unit 2 (U2)		Flow Unit 3 (U3)	
Cw_{01}	0.156	Cw_{02}	0.156	Cw_{03}	0.156
n	0.350	n	0.350	n	0.350
S_G	2.650	S_G	2.650	S_G	2.650
f_{OC}*	0.0038	f_{OC}*	0.0038	f_{OC}*	0.0038
K_d	7.600	K_d	7.600	K_d	7.600
M_W	0.055	M_W	0.055	M_W	0.055
C_S	1.186	C_S	1.186	C_S	1.186
M_S	2.042	M_S	2.042	M_S	2.042
M_T	2.097	M_T	2.097	M_T	2.097
M_S/M_T	0.9740	M_S/M_T	0.9740	M_S/M_T	0.9740

Cw_{0N} = Initial contaminant concentration in groundwater flow unit N

Groundwater Flow Unit Hydrogeologic Characteristics

Avg. K, ft/day listed highest to lowest	Relative average K, K_U	Fraction of aquifer volume, FV_U	Fraction of total flow, FQ_U	Flow unit designation, U
1.6	1.000	0.667	0.268	1
5.5	3.438	0.167	0.367	2
5.5	3.438	0.166	0.365	3

Contaminant Partitioning Formulas :

$M_W = C_W \times n$

$C_S = K_{OC} \times f_{OC} \times C_W$, or, $K_d \times C_W$

$K_d = K_{OC} \times f_{OC}$, or, C_S/C_W

$M_S = S_G \times (1-n) \times C_S$

$M_T = M_W + M_S$

$Cw_{i+1} = [Cw_i](M_S/M_T)$

where:

C_W = contaminant concentration in groundwater

n = aquifer porosity

S_G = specific gravity of aquifer solids (default value = 2.65)

M_W = mass of contaminants per unit volume of aquifer water

C_S = contaminant concentration on aquifer solids

M_S = mass of contaminants per unit volume of aquifer solids

M_T = total mass of contaminants per unit volume of aquifer

K_{OC} = organic carbon partition coefficient

f_{OC} = fractional organic carbon content of solids

K_d = soil/water distribution coefficient

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's K_d is input directly into the K_{OC} entry cell, with f_{OC} then set to 1.**

Fraction of total flow, flow unit N (FQ_N) = $K_N \times FV_N^{2/3}/(K_1 \times FV_1^{2/3} + K_2 \times FV_2^{2/3} + K_3 \times FV_3^{2/3})$

where K_1, K_2, K_3 = the relative average hydraulic conductivities of 3 flow units or zones within the aquifer; FV_1, FV_2, FV_3 = fractional volume of the aquifer represented by each flow unit or flow zone

Pore Volumes and Pore Volume Removal Rates

Groundwater discharge rate, gpm	Groundwater discharge rate, ft^3/day, Q_T	Total volume of plume, ft^3, PV_T
18	3465.24	5,625,000

Discharge rate, Unit 1 ft^3/day, Q_1	Discharge rate, Unit 2 ft^3/day, Q_2	Discharge rate, Unit 3 ft^3/day, Q_3	Plume pore Vol., Unit 1 ft^3, PV_1	Plume pore Vol., Unit 2 ft^3, PV_2	Plume pore Vol., Unit 3 ft^3, PV_3	Time for 1 PV flush, Unit 1, days, t_1	Time for 1 PV flush, Unit 2, days, t_2	Time for 1 PV flush, Unit 3, days, t_3
930.11	1270.10	1265.03	1313156.25	328781.25	326812.5	1411.83	258.86	258.34

Groundwater discharged per day from flow unit N (Q_N) = Q_T x FQ_N

Time required for 1 pore volume flush, flow unit N (t_N) = PV_N / Q_N

One plume pore volume, flow unit N (PV_N) = PV_T x FV_N x n

Contaminant Half-Life Data

Does contaminant have a decay half-life (yes/no):	yes	If yes, give half-life (days):	365	1st order decay coef. (k):	0.001899

Average Pumped/Discharged and Residual Plume Concentrations Over Time

Ist order decay coefficient = 0.693/half-life

Target Cleanup Concentration :			0.02	mg/L
Time period	Time span, days, t	Avg pumped concentration	Avg residual GW conc.	Time span, years
1	1411.83	0.010	0.010	3.87
2	2823.65	0.001	0.001	7.73
3	4235.48	0.000	0.000	11.60
5	7059.13	0.000	0.000	19.33
7	9882.78	0.000	0.000	27.06
9	12706.43	0.000	0.000	34.79
12	16941.91	0.000	0.000	46.38
15	21177.38	0.000	0.000	57.98
20	28236.51	0.000	0.000	77.31
25	35295.64	0.000	0.000	96.63
0.4	564.73	0.051	0.052	1.55
0.6	847.10	0.029	0.030	2.32
0.7	988.28	0.022	0.023	2.71
0.75	1058.87	0.019	0.020	2.90
0.76	1072.99	0.019	0.019	2.94
0.74	1044.75	0.020	0.020	2.86
0.73	1030.63	0.020	0.021	2.82
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00
0	0.00	0.156	0.156	0.00

Residual groundwater concentration @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FV_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FV_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FV_3] \times 2.718^{-kt}$

where t_1, t_2, t_3 = times required to remove 1 pore volume from groundwater flow units 1, 2, and 3; Cw_{01}, Cw_{02}, Cw_{03} = initial contaminant concentrations for flow units 1, 2, and 3; $2.718^{-kt} = e^{-kt}$ = the 1st order decay term (= 1 if there is no decay half-life for the contaminant)

Average pumped (discharged) conc. @ time T = $[Cw_{01} \times (M_S/M_T)_1^{t/t_1} \times FQ_1 + Cw_{02} \times (M_S/M_T)_2^{t/t_2} \times FQ_2 + Cw_{03} \times (M_S/M_T)_3^{t/t_3} \times FQ_3] \times 2.718^{-kt}$

where FQ_1, FQ_2, FQ_3 = Fraction of total flow per day from each groundwater flow unit, either through pumping or the natural groundwater flow rate.

Number of pore volumes (PVs) required to reach a target gw concentration Cw_x:

PVs = log (Cw_x/Cw_0) / log (M_S/M_T), for each groundwater flow unit

The last 15 time periods can be modified to evaluate contaminants w/ long cleanup times or more precisely determine the time required to meet a specific residual concentration.

Spreadsheet developed by J. P. Orient, 6/2001

ATTACHMENT B

GROUNDWATER EXTRACTION SYSTEM DESIGN CALCULATIONS

Benzene

Project:	**Cecil Field**	**Project No.:**	**0039 DSO 11H105**
Subject:	**Site 57 Groundwater Extraction System FS Design**		
By:	JPO	**Date:**	3/12/2002
Checked:		**Date:**	4/3/2002

Project/Design Objective:

Design a groundwater extraction system for cleanup of benzene contamination. Project cleanup rates/times assuming that the source has been removed or is otherwise isolated from the groundwater. The final design should be capable of remediating groundwater within a reasonable time frame (< 15 years), and should offer significant advantages over natural processes in terms of cleanup rate and/or protection of receptors. This design should be considered a conceptual design only - additional field data, i.e., aquifer characteristics, contaminant distributions are needed for a final design.

Basis of Design Data:

Groundwater Plume Information

Plume Width (W):	500	ft.
Plume Thickness:	40	ft.
Plume Area:	475,000	ft^2
Plume Volume:	6650000	ft^3

Aquifer Characteristics

Thickness (B):	95	ft.
Avg. Hydraulic Conductivity (K):	4.68	ft/day
Transmissivity (T):	444.6	ft^2/day
Porosity (n):	0.35	
Storativity (S):	0.15	
Fractional organic carbon content (foc):	0.0038	
Flow Gradient (i):	0.005	

Contaminant Characteristics

Contaminant A representative gw conc.:	Benzene	248	ug/L
Contaminant B representative gw conc.:			
Koc, Contaminant A:		59	
Koc, Contaminant B:			
Kd, Contaminant A:		0.2242	
Kd, Contaminant B:		0	
Half-life, Contaminant A:		2	years
Half-life, Contaminant B:			
Target Cleanup Level, Contaminant A:		1	ug/L
Target Cleanup Level, Contaminant B:			

Remedial System Information

Extraction Well Radius, (r) :	0.25	ft.
Time to Reach Steady-State Drawdown (t):	30	days
Allowable Drawdown, Single Well, (s):	5	ft.

Technical Approach:

Using aquifer characteristics, plume volume, Kd, half-life, and representative groundwater concentration data, calculate the number of pore volumes and times required to reach the target groundwater concentration (performed using the attached spreadsheets). Use standard equations to calculate the minimum required pumping rate for plume containment, per-well achievable pumping rates, and well spacings. Develop a preliminary extraction system design based on the calculations, adjusting the design as appropriate based on data limitation considerations and best scientific judgement.

Minimum Required Total Pumping Rate (Qt)

Qt = TiW x 2 (2x the natural groundwater flow-thru rate for entire aquifer)

Qt = 1111.50 ft^3/day x 2, or 5.77 gpm x 2

Qt = 2223.00 ft^3/day, or 11.55 gpm

Maximum Achievable Pumping Rate in a Single Well (Qa)

Qa = $[4\pi Ts/2.3] / \log [2.25Tt/r^2S]$

Qa = 1867.05 ft^3/day, or 9.70 gpm

Minimum Number of Extraction Wells Required

= Qt/Qa

= 1.19 wells

Plume Cleanup Rate Projections (From Spreadsheet Program or Other Source)

At	12.00	gpm,	13.7	years
At	20.00	gpm,	13.2	years
At	30.00	gpm,	11.8	years
At natural GW flow rate: (plume area only)	1.84	gpm,	16	years

Based on the limiting conditions calculated above, projections regarding cleanup times at various pumping rates (see accompanying spreadsheets), a suitable safety factor based on the degree of confidence in the design data, and best scientific judgement, the following are the number of extraction wells and pumping rates selected:

Number of Wells:	5		
Per-well Pumping Rate (Qw):	6	gpm, or	1155.06 ft^3/day
Total System Pumping Rate (Qes):	30	gpm, or	5775.30 ft^3/day

Extraction Well Spacings, (WSp), ft Perpendicular to Groundwater Flow Direction

WSp = $Qw/\pi Ti$, for a 2-well extraction system

WSp = 165.39 ft

or

WSp = $1.26(Qw)/\pi Ti$, for a 3-well extraction system

WSp = 208.39 ft

or

WSp = $1.2(Qw)/\pi Ti$, for an extraction system with 4+ wells

WSp = 198.47 ft

Downgradient Stagnation Point (SPd) Approximation

SPd = $Qes/2\pi Ti$, Qes = total extraction system pumping rate, ft^3/day

SPd = 413.48 ft

Alternate Layout of Extraction Well System (I.e., parallel to GW flow direction):

Install extraction wells within the plume interior, positioned along axis of plume and within benzene hot spot areas to miximize the flushing efficiency of the extraction wells in terms of contaminant removal. The system extraction rate is sufficient to contain the entire plume w/out precise positioning, thus the well siting focus can be on maximizing contaminant removal efficiency.

Final Configuration, Groundwater Extraction System:

Five 6-inch diameter extraction wells, screened from 10 to 40 feet below ground, installed within the plume interior at benzene hot spot locations. Each well will pump at an approximate rate of 6 gpm, for a total extraction system pumping rate of 30 gpm and projected cleanup time of approximately 11.8 years.

TCE

Project:	**Cecil Field**	**Project No.:**	**0039 DSO 11H105**
Subject:	**Site 57 Groundwater Extraction System FS Design**		
By:	JPQ	**Date:**	3/12/2002
Checked:		**Date:**	8/9/2002

Project/Design Objective:

Design a groundwater extraction system for cleanup of TCE contamination. Project cleanup rates/times assuming that the source has been removed or is otherwise isolated from the groundwater. The final design should be capable of remediating contaminated groundwater to target cleanup levels within a reasonable time frame (< 15 years), and should offer significant advantages over natural processes in terms of cleanup rate and/or protection of receptors. This design should be considered a conceptual design only - additional field data, i.e., aquifer characteristics, contaminant distributions are needed for a final design.

Basis of Design Data: (Input cells yellow, blue automatically calculated)

Groundwater Plume Information

Plume Width (W):	250	ft.
Plume Thickness:	45	ft.
Plume Area:	125,000	ft^2
Plume Volume:	1968750	ft^3
Avg Hydraulic Conductivity, Plume Area:	3.77	ft/day

Aquifer Characteristics

Thickness (B):	95	ft.
Avg. Hydraulic Conductivity (K):	4.68	ft/day
Transmissivity (T):	444.6	ft^2/day
Porosity (n):	0.35	
Storativity (S):	0.15	
Fractional organic carbon content (foc):	0.0038	
Flow Gradient (i):	0.005	

Contaminant Characteristics

Contaminant A representative gw conc.:	TCE	43	ug/L
Contaminant B representative gw conc.:			
Koc, Contaminant A:		166	
Koc, Contaminant B:			
Kd, Contaminant A:		0.6308	
Kd, Contaminant B:		0	
Half-life, Contaminant A:		5	years
Half-life, Contaminant B:			
Target Cleanup Level, Contaminant A:		3	ug/L
Target Cleanup Level, Contaminant B:			

Remedial System Information

Extraction Well Radius, (r) :	0.25	ft.
Time to Reach Steady-State Drawdown (t):	30	days
Allowable Drawdown, Single Well, (s):	5	ft.

Technical Approach:

Using aquifer characteristics, plume volume, Kd, half-life, and representative groundwater concentration data, calculate the number of pore volume flushes and times required to reach the target groundwater concentration (performed using the attached spreadsheets). Use standard equations to calculate the minimum required pumping rate for plume containment, per-well achievable pumping rates, and well spacings. Develop a preliminary extraction system design based on the calculations, adjusting the design as appropriate based on data limitation considerations and best scientific judgement.

Minimum Required Total Pumping Rate (Qt)

Qt = TiW x 2 (2x the natural groundwater flow-thru rate for entire aquifer)

Qt = 555.75 ft^3/day x 2, or 2.89 gpm x 2

Qt = 1111.50 ft^3/day, or 5.77 gpm

Maximum Achievable Pumping Rate in a Single Well (Qa)

Qa = $[4\pi Ts/2.3] / \log [2.25Tt/r^2S]$

Qa = 1867.05 ft^3/day, or 9.70 gpm

Minimum Number of Extraction Wells Required

= Qt/Qa

= 0.60 wells

Plume Cleanup Rate Projections (From Spreadsheet Program or Other Source)

At	6.0	gpm,	14.1	years
At	12.0	gpm,	11.6	years
At	18.0	gpm,	10	years
At natural GW flow rate: (plume area only)	1.1	gpm,	18	years

Based on the limiting conditions calculated above, projections regarding cleanup times at various pumping rates (see accompanying spreadsheets), a suitable safety factor based on the degree of confidence in the design data, and best scientific judgement, the following are the number of extraction wells and pumping rates selected:

Number of Wells:	2		
Per-well Pumping Rate (Qw):	6	gpm, or	1155.06 ft^3/day
Total System Pumping Rate (Qes):	12	gpm, or	2310.12 ft^3/day

Extraction Well Spacings, (WSp), ft Perpendicular to Groundwater Flow Direction

WSp = $Qw/\pi Ti$, for a 2-well extraction system

WSp = 165.39 ft

or

WSp = $1.26(Qw)/\pi Ti$, for a 3-well extraction system

WSp = 208.39 ft

or

WSp = $1.2(Qw)/\pi Ti$, for an extraction system with 4+ wells

WSp = 198.47 ft

Downgradient Stagnation Point (SPd) Approximation

SPd = $Qes/2\pi Ti$, Qes = total extraction system pumping rate, ft^3/day

SPd = 165.39 ft

Alternate Layout of Extraction Well System (I.e., parallel to GW flow direction):

Install extraction wells within the plume interior, positioned along axis of plume and within benzene hot spot areas to miximize the flushing efficiency of the extraction wells in terms of contaminant removal. The system extraction rate is sufficient to contain the entire plume w/out precise positioning, thus the well siting focus can be on maximizing contaminant removal efficiency.

Final Configuration, Groundwater Extraction System:

Two 6-inch diameter extraction wells, screened from 10 to 40 feet below ground, installed within the plume interior at TCE hot spot locations. Each well will pump at an approximate rate of 6 gpm, for a total extraction system pumping rate of 12 gpm and projected cleanup time of approximately 11.6 years. System is also to be part of larger, overlapping benzene plume remediation system.

Naphthalene

Project:	**Cecil Field**	**Project No.:**	**0039 DSO 11H105**
Subject:	**Site 58 Groundwater Extraction System FS Design**		
By:	JPO	**Date:**	3/12/2002
Checked:		**Date:**	4/3/2002

Project/Design Objective:

Design a groundwater extraction system for cleanup of napthalene contamination. Project cleanup rates/times assuming that the source has been removed or is otherwise isolated from the groundwater. The final design should be capable of remediating groundwater within a reasonable time frame (< 15 years), and should offer significant advantages over natural processes in terms of cleanup rate and/or protection of receptors. This design should be considered a conceptual design only - additional field data, i.e., aquifer characteristics, contaminant distributions are needed for a final design.

Basis of Design Data: (Input cells shaded yellow, blue cells automatically calculated)

Groundwater Plume Information

Plume Width (W):	130	ft.
Plume Thickness:	30	ft.
Plume Area:	31,200	ft^2
Plume Volume:	327600	ft^3

Aquifer Characteristics

Thickness (B):	95	ft.
Avg. Hydraulic Conductivity (K):	4.68	ft/day
Transmissivity (T):	444.6	ft^2/day
Porosity (n):	0.35	
Storativity (S):	0.15	
Fractional organic carbon content (foc):	0.0038	
Flow Gradient (i):	0.01	

Contaminant Characteristics

Contaminant A representative gw conc.:	napthalene	156	ug/L
Contaminant B representative gw conc.:			
Koc, Contaminant A:		2,000	
Koc, Contaminant B:			
Kd, Contaminant A:		7.6	
Kd, Contaminant B:		0	
Half-life, Contaminant A:		1	years
Half-life, Contaminant B:			
Target Cleanup Level, Contaminant A:		20	ug/L
Target Cleanup Level, Contaminant B:			

Remedial System Information

Extraction Well Radius, (r) :	0.25	ft.
Time to Reach Steady-State Drawdown (t):	30	days
Allowable Drawdown, Single Well, (s):	5	ft.

Technical Approach:

Using aquifer characteristics, plume volume, Kd, half-life, and representative groundwater concentration data, calculate the number of pore volumes and times required to reach the target groundwater concentration (performed using the attached spreadsheets). Use standard equations to calculate the minimum required pumping rate for plume containment, per-well achievable pumping rates, and well spacings. Develop a preliminary extraction system design based on the calculations, adjusting the design as appropriate based on data limitation considerations and best scientific judgement.

Minimum Required Total Pumping Rate (Qt)

Qt =	TiW x 2 (2x the natural groundwater flow-thru rate for entire aquifer)	
Qt =	577.98 ft^3/day x 2, or	3.00 gpm x 2
Qt =	1155.96 ft^3/day, or	6.00 gpm

Maximum Achievable Pumping Rate in a Single Well (Qa)

Qa =	$[4\pi Ts/2.3] / \log [2.25Tt/r^2S]$	
Qa =	1867.05 ft^3/day, or	9.70 gpm

Minimum Number of Extraction Wells Required

=	Qt/Qa	
=	0.62	wells

Plume Cleanup Rate Projections (From Spreadsheet Program or Other Source)

At	6.0	gpm,	3	years
At	12.0	gpm,	2.9	years
At	18.0	gpm,	2.9	years
At natural GW flow rate: (plume area only)	0.6	gpm,	3	years

Based on the limiting conditions calculated above, projections regarding cleanup times at various pumping rates (see accompanying spreadsheets), a suitable safety factor based on the degree of confidence in the design data, and best scientific judgement, the following are the number of extraction wells and pumping rates selected:

Number of Wells:	3		
Per-well Pumping Rate (Qw):	6	gpm, or	1155.06 ft^3/day
Total System Pumping Rate (Qes):	18	gpm, or	3465.18 ft^3/day

Extraction Well Spacings, (WSp), ft Perpendicular to Groundwater Flow Direction

WSp =	$Qw/\pi Ti$,	for a 2-well extraction system
WSp =	82.70 ft	
or		
WSp =	$1.26(Qw)/\pi Ti$,	for a 3-well extraction system
WSp =	104.20 ft	
or		
WSp =	$1.2(Qw)/\pi Ti$,	for an extraction system with 4+ wells
WSp =	99.24 ft	

Downgradient Stagnation Point (SPd) Approximation

SPd =	$Qes/2\pi Ti$,	Qes = total extraction system pumping rate, ft^3/day
SPd =	124.04 ft	

Alternate Layout of Extraction Well System (I.e., parallel to GW flow direction):

None proposed.

Final Configuration, Groundwater Extraction System:

Due to the fact that natural processes actively reduce napthalene concentrations in groundwater, and that very liitle increase in cleanup rate is achieved through pumping due to the low mobility of napthalene, it is recommended that the napthalene plume be allowed to naturally decline to target concentrations (estimated to take about 3 years, assuming that there is no continuing source).

B.2 MIGRATION MODELING

CLIENT SOUTHDIV		JOB NUMBER 39	
SUBJECT Cecil Field Site 57 FS			
BASED ON		DRAWING NUMBER	
BY RRM	CHECKED BY	APROVED BY	DATE

Objective: To determine the maximum benzene concentration at well CEF-824A-19S, 220 feet downgradient of the edge of the benzene plume.

Site Data:

Plume length = 750 feet
Plume width = 225 feet

Porosity (n) = 0.35 (Site 57 RI geotechnical sample value)
Hydraulic conductivity (K) = 4.68 ft/day (overall Cecil Field average for surficial aquifer)
Hydraulic gradient (i) = 0.005 (Site 57 RI calculated value)
Aquifer thickness (b) = 95 ft
Infiltration = 1.13 ft/yr
Horizontal seepage velocity (V) = Ki/n

$$V = 4.86 \text{ ft/day}(0.005)/0.35 = 6.7 \times 10^{-2} \text{ ft/day} = 24.4 \text{ ft/yr}$$

Contaminant Data:

K_{oc} benzene = 59 L/kg (published value)
f_{oc} = 0.0038 (Geometric mean of Cecil Field TOC samples)
Average benzene groundwater concentration = 33 ug/L
FDEP GCTL = 1.0 ug/L
Initial soil concentration = 1.6 mg/kg (Industrial SCTL - no benzene detected in soil)
$K_d = K_{oc} \times f_{oc}$ = 59 L/kg x 0.0038 = 0.2242 L/kg
Benzene half-life = 2 years

Using ECTran with parameters as previously defined, estimated maximum benzene groundwater concentration at CEF-824A-20S is:

4.10E-01 ug/L

See attached ECTran printouts

ECTran Version 2.0 for Excel 4.0 & 5.0

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Ectran 57-220ft

SITE: SWMU 14, NWS Cha Job # 0039 **INVESTIGATOR:** RRM **DATE:** 9/25/2002

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT: (UNDERS, FL)	FL	LEACHATE CONCENTRATION (YES,NO) ?	NO
CONTAMINANT:	Benzene	UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	1.600E+00
		WATER CRITERIA (UG/L):	1.00E+00	CONSTANT CONCENTRATION (YES,NO)?	NO
HALF-LIFE (YRS):	2.00E+00			TRY NEW GOAL:	3.91E+00
SPECIFIC ACTIVITY (Ci/g):	0.00E+00	TIME FRAME (YRS):	20	ACCEPTABLE!	INCREASE

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	1.13E+00
Kl (L/KG):	2.24E-01	LENGTH (FT):	950
		WIDTH (FT):	500
DEPLETING SOURCE:		**IS THERE A CLAY LINER LAYER (YES,NO)?**	NO
WASTE CHARACTERISTICS:			
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	1.60E+00	THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
INPUT FOLLOWING PARAMETERS:		HOW MANY SUBLAYERS (1 - 10)?	3
THICKNESS (FT):	5	TOTAL THICKNESS (UP TO 30 FT) (FT):	10
SATURATION RATE:	0.6	SATURATION RATE:	0.95
POROSITY:	0.35	POROSITY:	0.2
BULK DENSITY (G/CM^3)	1.5	BULK DENSITY (G/CM^3):	1.78
		Kd (L/KG):	1.00E-05

IS THERE A TYPE 1 LAYER (YES,NO)?	NO	**IS THERE A TYPE 2 LAYER (YES,NO)?**	NO
THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
HOW MANY SUBLAYERS (1 - 10)?	6	HOW MANY SUBLAYERS (1 - 10)?	5
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	TOTAL THICKNESS (UP TO 30 FT) (FT):	20
SATURATION RATE:	0.95	SATURATION RATE:	0.13
POROSITY:	0.2	POROSITY:	0.3
BULK DENSITY (G/CM^3)	1.5	BULK DENSITY (G/CM^3)	1.5
Kd (L/KG):	1.00E-05	Kd (L/KG):	1.00E-05
INITIAL SOIL CONC. (MG/KG):	0	INITIAL SOIL CONC. (MG/KG):	0

SATURATED LAYER

TOTAL SATURATED ZONE THICKNESS, B (FT):	95	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	2.1
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR):	24.4	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	0
Kd (L/KG):	2.24E-01	SPECIFY MIXING DEPTH (Computed from formula if input NO)	no
POROSITY:	0.35	MIXING DEPTH, H (FT):	95.0
VERTICAL DISPERSIVITY, Az (FT):	1.4	TIME OF PUMPING STOP, P&T (YEARS):	0
LONGITUDINAL DISPERSIVITY, Ax (FT):	14.0	AGE (YRS):	0
LATERAL DISPERSIVITY, Ay (FT):	5.0	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	0
INITIAL CONC. (ug/L):	33	DISTANCE TO F.L.:	220

PREDICTED IMPACTS:		TIME OF MAXIMUM (YR)
SATURATED LAYER CONCENTRATION:	8.76E+01 (UG/L)	1.6
FENCE LINE CONCENTRATION:	4.10E-01 (UG/L)	13.6

an Version 2.0 for Excel 4.0 & 5.0

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE:	Job # 0039	**CONTAMINANT:**	**Benzene**		
		HALF-LIFE (YRS):			
		LAYER 2:	2.00E+00		
INVESTIGATOR:	RRM	**SATURATED LAYER**	2.00E+00		
DATE:	9/25/2002	**DOWNGRADIENT**	2.00E+00	INITIAL CONC. (ug/L):	3.30E+01

SATURATED LAYER

INFILT (FT/YR):	1.13					B (FT):	95	Vzo (FT/YR):	2.1
LENGTH (FT):	950					GW Q3 (L/DAY):	7.31E+04		
WIDTH (FT):	500			Kd (L/KG):	2.24E-01	GW V. (FT/YR):	24.40	Kd (L/KG):	0.2242
POROSITY 2:	0.3			SATURATION:	1.00	H (FT):	95.0000	RETARDATION:	1.960857
POROSITY SAT. LAYER:	0.35			THICKNESS (FT):	95.00	EFF. POROSITY:	0.35	q (FT/YR) :	0
DENSITY 2 (G/CM3):	1.5			DECAY (1/DAY):	9.50E-04	DISPERSIVITY:		DECAY (1/YR):	3.5E-01
DENSITY GMA (G/CM3):	1.50			CBo (PPB):	3.30E+01	Az (FT):	1.40		
				CU2 (PPB):	0.00E+00	Ax (FT):	14.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	4.16E+04	Q2 (L/DAY):	3.15E+04	Ay (FT):	5.00	DISTANCE TO F.L. (FT):	220

TIME INTERVAL (YRS)	0.4	SOURCE AREA CONC.(GMA)	FENCE LINE CONC.
ELAPSED TIME - YRS	LAYER 2(PPB)	(UG/L)	(UG/L)
0	7.14E+03	3.30E+01	0.00E+00
0.4	5.26E+03	6.23E+01	0.00E+00
0.8	3.88E+03	7.86E+01	0.00E+00
1.2	2.87E+03	8.60E+01	0.00E+00
1.6	2.11E+03	8.76E+01	0.00E+00
2	1.56E+03	8.54E+01	1.30E-12
2.4	1.15E+03	8.08E+01	3.86E-10
2.8	8.49E+02	7.50E+01	2.18E-08
3.2	6.26E+02	6.85E+01	4.43E-07
3.6	4.62E+02	6.19E+01	4.55E-06
4	3.41E+02	5.54E+01	2.91E-05
4.4	2.51E+02	4.93E+01	1.31E-04
4.8	1.85E+02	4.36E+01	4.55E-04
5.2	1.37E+02	3.84E+01	1.29E-03
5.6	1.01E+02	3.36E+01	3.09E-03
6	7.45E+01	2.94E+01	6.50E-03
6.4	5.49E+01	2.56E+01	1.23E-02
6.8	4.05E+01	2.23E+01	2.12E-02
7.2	2.99E+01	1.94E+01	3.40E-02
7.6	2.21E+01	1.68E+01	5.10E-02
8	1.63E+01	1.46E+01	7.24E-02
8.4	1.20E+01	1.26E+01	9.80E-02
8.8	8.86E+00	1.09E+01	1.27E-01
9.2	6.53E+00	9.41E+00	1.59E-01
9.6	4.82E+00	8.13E+00	1.93E-01
10	3.56E+00	7.01E+00	2.27E-01
10.4	2.62E+00	6.05E+00	2.61E-01
10.8	1.94E+00	5.21E+00	2.93E-01
11.2	1.43E+00	4.49E+00	3.22E-01
11.6	1.05E+00	3.87E+00	3.48E-01
12	7.77E-01	3.33E+00	3.70E-01
12.4	5.73E-01	2.87E+00	3.87E-01
12.8	4.23E-01	2.47E+00	3.99E-01
13.2	3.12E-01	2.13E+00	4.07E-01
13.6	2.30E-01	1.83E+00	4.10E-01
14	1.70E-01	1.58E+00	4.08E-01
14.4	1.25E-01	1.36E+00	4.03E-01
14.8	9.24E-02	1.17E+00	3.94E-01
15.2	6.82E-02	1.00E+00	3.83E-01
15.6	5.03E-02	8.64E-01	3.68E-01
16	3.71E-02	7.43E-01	3.52E-01
16.4	2.74E-02	6.39E-01	3.35E-01
16.8	2.02E-02	5.50E-01	3.16E-01
17.2	1.49E-02	4.73E-01	2.97E-01
17.6	1.10E-02	4.07E-01	2.77E-01
18	8.11E-03	3.50E-01	2.57E-01
18.4	5.98E-03	3.01E-01	2.38E-01
18.8	4.41E-03	2.59E-01	2.19E-01
19.2	3.26E-03	2.23E-01	2.01E-01
19.6	2.40E-03	1.92E-01	1.84E-01
20	1.77E-03	1.65E-01	1.67E-01
MAXIMUM:	7.14E+03	8.76E+01	4.10E-01

CLIENT	SOUTHDIV		JOB NUMBER 39	
SUBJECT	Cecil Field Site 58 FS			
BASED ON			DRAWING NUMBER	
BY	RRM	CHECKED BY	APROVED BY	DATE

Objective: To determine the maximum naphthalene concentration at well CEF-B312-12S, 100 feet downgradient of the edge of the naphthalene plume.

Site Data:

Plume length = 230 feet
Plume width = 100 feet

Porosity (n) = 0.35 (from RI)
Hydraulic conductivity (K) = 4.68 ft/day (overall Cecil Field average for surficial aquifer)
Hydraulic gradient (i) = 0.01 (Site 58 RI calculated value)
Aquifer thickness (b) = 95 ft
Infiltration = 1.13 ft/yr
Horizontal seepage velocity (V) = Ki/n

V = 4.86 ft/day(0.01)/0.35 = 0.14 ft/day = 50.7 ft/yr

Contaminant Data:

K_{oc} naphthalene = 2000 L/kg (published value)
f_{oc} = 0.0038 (Geometric mean of Cecil Field TOC samples)
Average naphthalene groundwater concentration = 82 ug/L
FDEP GCTL = 20 ug/L
Initial soil concentration = 270 mg/kg (Industrial SCTL)
$K_d = K_{oc} \times f_{oc}$ = 2000 L/kg x 0.0038 = 7.6 L/kg
Naphthalene half-life = 1 year

Using ECTran with parameters as previously defined, estimated maximum naphthalene groundwater concentration at CEF-B312-12S is:

1.40E-06 ug/L

See attached ECTran printouts

ECTran Version 2.0 for Excel 4.0 & 5.0

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Ectran 58

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SITE: SWMU 14, NWS Cha Job # 0039 **INVESTIGATOR:** RRM **DATE:** 9/25/2002

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT: (UNDERS, FL)	FL	LEACHATE CONCENTRATION (YES,NO) ?	NO
CONTAMINANT:	Naphthalene	UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	1.600E+00
		WATER CRITERIA (UG/L):	2.00E+01	CONSTANT CONCENTRATION (YES,NO)?	NO
HALF-LIFE (YRS):	1.00E+00			TRY NEW GOAL:	2.29E+07
SPECIFIC ACTIVITY (Ci/g):	0.00E+00	TIME FRAME (YRS):	20	ACCEPTABLE!	INCREASE

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	1.13E+00
Kl (L/KG):	7.60E+00	LENGTH (FT):	230
		WIDTH (FT):	100
DEPLETING SOURCE:		**IS THERE A CLAY LINER LAYER (YES,NO)?**	NO
WASTE CHARACTERISTICS:		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	2.70E+02	HOW MANY SUBLAYERS (1 - 10)?	3
INPUT FOLLOWING PARAMETERS:		TOTAL THICKNESS (UP TO 30 FT) (FT):	10
THICKNESS (FT):	5	SATURATION RATE:	0.95
SATURATION RATE:	0.6	POROSITY:	0.2
POROSITY:	0.35	BULK DENSITY (G/CM^3):	1.78
BULK DENSITY (G/CM^3)	1.5	Kd (L/KG):	1.00E-05

IS THERE A TYPE 1 LAYER (YES,NO)?	NO	**IS THERE A TYPE 2 LAYER (YES,NO)?**	NO
THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
HOW MANY SUBLAYERS (1 - 10)?	6	HOW MANY SUBLAYERS (1 - 10)?	5
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	TOTAL THICKNESS (UP TO 30 FT) (FT):	20
SATURATION RATE:	0.95	SATURATION RATE:	0.13
POROSITY:	0.2	POROSITY:	0.3
BULK DENSITY (G/CM^3)	1.5	BULK DENSITY (G/CM^3)	1.5
Kd (L/KG):	7.60E+00	Kd (L/KG):	1.00E-05
INITIAL SOIL CONC. (MG/KG):	0	INITIAL SOIL CONC. (MG/KG):	0

SATURATED LAYER

TOTAL SATURATED ZONE THICKNESS, B (FT):	95	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	2.1
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR):	50.7	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	0
Kd (L/KG):	7.60E+00	SPECIFY MIXING DEPTH (Computed from formula if input NO)	no
POROSITY:	0.35	MIXING DEPTH, H (FT):	30.5
VERTICAL DISPERSIVITY, Az (FT):	1	TIME OF PUMPING STOP, P&T (YEARS):	0
LONGITUDINAL DISPERSIVITY, Ax (FT):	10.0	AGE (YRS):	0
LATERAL DISPERSIVITY, Ay (FT):	3.3	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	0
INITIAL CONC. (ug/L):	82	DISTANCE TO F.L.:	100

PREDICTED IMPACTS:		TIME OF MAXIMUM (YR)
SATURATED LAYER CONCENTRATION:	9.13E+01 (UG/L)	0.4
FENCE LINE CONCENTRATION:	1.40E-06 (UG/L)	16.8

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SITE:	Job # 0039	CONTAMINANT:	Naphthalene
		HALF-LIFE (YRS):	
		LAYER 2:	1.00E+00
INVESTIGATOR:	RRM	SATURATED LAYER	1.00E+00
DATE:	9/25/2002	DOWNGRADIENT	1.00E+00
		INITIAL CONC. (ug/L):	8.20E+01

SATURATED LAYER

INFILT (FT/YR):	1.13			B (FT):	95	Vzo (FT/YR):	2.1
LENGTH (FT):	230			GW Q3 (L/DAY):	6.22E+03		
WIDTH (FT):	100	Kd (L/KG):	7.60E+00	GW V. (FT/YR):	50.70	Kd (L/KG):	7.6
POROSITY 2:	0.3	SATURATION:	1.00	H (FT):	30.5121	RETARDATION:	33.57143
POROSITY SAT. LAYER:	0.35	THICKNESS (FT):	30.51	EFF. POROSITY:	0.35	q (FT/YR) :	0
DENSITY 2 (G/CM3):	1.5	DECAY (1/DAY):	1.90E-03	DISPERSIVITY:		DECAY (1/YR):	6.9E-01
DENSITY GMA (G/CM3):	1.50	CBo (PPB):	8.20E+01	Az (FT):	1.00		
		CU2 (PPB):	0.00E+00	Ax (FT):	10.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY): 2.02E+03	Q2 (L/DAY): 4.20E+03	Ay (FT):	3.30	DISTANCE TO F.L. (FT):	100

TIME INTERVAL (YRS)	0.4	SOURCE AREA CONC.(GMA)	FENCE LINE CONC.
ELAPSED TIME - YRS	LAYER 2(PPB)	(UG/L)	(UG/L)
0	3.55E+04	8.20E+01	0.00E+00
0.4	2.67E+04	9.13E+01	0.00E+00
0.8	2.01E+04	9.10E+01	0.00E+00
1.2	1.51E+04	8.53E+01	0.00E+00
1.6	1.14E+04	7.69E+01	0.00E+00
2	8.54E+03	6.74E+01	0.00E+00
2.4	6.42E+03	5.80E+01	0.00E+00
2.8	4.83E+03	4.91E+01	0.00E+00
3.2	3.63E+03	4.10E+01	0.00E+00
3.6	2.73E+03	3.40E+01	0.00E+00
4	2.05E+03	2.79E+01	3.88E-17
4.4	1.54E+03	2.28E+01	1.35E-15
4.8	1.16E+03	1.85E+01	2.51E-14
5.2	8.73E+02	1.49E+01	2.88E-13
5.6	6.57E+02	1.20E+01	2.26E-12
6	4.94E+02	9.58E+00	1.31E-11
6.4	3.71E+02	7.64E+00	5.89E-11
6.8	2.79E+02	6.08E+00	2.17E-10
7.2	2.10E+02	4.82E+00	6.75E-10
7.6	1.58E+02	3.81E+00	1.82E-09
8	1.19E+02	3.01E+00	4.33E-09
8.4	8.93E+01	2.37E+00	9.31E-09
8.8	6.72E+01	1.86E+00	1.83E-08
9.2	5.05E+01	1.46E+00	3.31E-08
9.6	3.80E+01	1.14E+00	5.61E-08
10	2.86E+01	8.96E-01	8.93E-08
10.4	2.15E+01	7.00E-01	1.35E-07
10.8	1.61E+01	5.46E-01	1.94E-07
11.2	1.21E+01	4.26E-01	2.67E-07
11.6	9.13E+00	3.31E-01	3.54E-07
12	6.87E+00	2.58E-01	4.53E-07
12.4	5.16E+00	2.00E-01	5.61E-07
12.8	3.88E+00	1.55E-01	6.76E-07
13.2	2.92E+00	1.21E-01	7.94E-07
13.6	2.20E+00	9.34E-02	9.10E-07
14	1.65E+00	7.23E-02	1.02E-06
14.4	1.24E+00	5.60E-02	1.12E-06
14.8	9.34E-01	4.33E-02	1.21E-06
15.2	7.02E-01	3.34E-02	1.28E-06
15.6	5.28E-01	2.58E-02	1.34E-06
16	3.97E-01	1.99E-02	1.38E-06
16.4	2.98E-01	1.54E-02	1.39E-06
16.8	2.24E-01	1.19E-02	1.40E-06
17.2	1.69E-01	9.13E-03	1.38E-06
17.6	1.27E-01	7.03E-03	1.35E-06
18	9.54E-02	5.42E-03	1.31E-06
18.4	7.18E-02	4.17E-03	1.26E-06
18.8	5.40E-02	3.21E-03	1.19E-06
19.2	4.06E-02	2.46E-03	1.12E-06
19.6	3.05E-02	1.89E-03	1.05E-06
20	2.29E-02	1.45E-03	9.74E-07
MAXIMUM:	3.55E+04	9.13E+01	1.40E-06

APPENDIX C

CONCEPTUAL DESIGN CALCULATIONS

C.1 SITE 58 CONTAMINATED SOIL COMPUTATIONS

C.2 CONTAMINATED GROUNDWATER COMPUTATIONS

C.3 GROUNDWATER ALTERNATIVE 3: IN-SITU BIOREMEDIATION (ORC®/HRC®)

C.4 GROUNDWATER ALTERNATIVE 4: AS TREATMENT

C.5 GROUNDWATER ALTERNATIVE 5: EXTRACTION AND ON-SITE TREATMENT

C.1 SITE 58 CONTAMINATED SOIL COMPUTATIONS

1.0 ASSUMPTIONS

The following design assumptions are made based upon RI results:

- The Site 58 soil contamination is defined as the area of soil surrounding sampling location CEF-B312-SD-001 where benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene concentrations exceed their respective FDEP residential SCTLs of 1,400, 100, and 100 μg/kg.
- The Site 58 soil contamination is assumed to extend over the entire fenced-in width of the drainage ditch where sediment samples were collected and from the headwall of that ditch, north of sampling location CEF-B312-SD-001 to the halfway point between sampling locations CEF-B312-SD-001 and –002.
- The Site 58 soil contamination extends to a depth of 2 ft bgs.

2.0 SITE 58 CONTAMINATED SOIL SURFACE AREA, VOLUME, AND COCS QUANTITIES

2.1 Site 58 Contaminated Soil Surface Area

Based upon the above assumptions and as illustrated on Figure 2-1, the width of the Site 58 contaminated soil area is equal to that of the fenced-in drainage ditch that extends in south of Building 312, or 40 ft. Also, the length of the Site 58 contaminated soil, area extends from the drainage ditch headwall to the halfway point between locations CEF-B312-SD-001 and –002, a distance of 60 ft. Therefore:

Surface Area of Site 58 contaminated soil: 60 ft x 40 ft = 2,400 ft^2 ✓

2.2 Site 58 Contaminated Soil Volume

Based upon the above assumption, the Site 58 soil contamination extends to a depth of 2 ft bgs. Therefore:

Volume of Site 58 contaminated soil: 2,400 ft^2 x 2 ft = 4,800 ft^3 or 177.8, say 180 yd^3 ✓

2.3 Site 58 Soil COC Quantities

The quantities of COCs within the Site 58 contaminated soil can be computed based upon the volume of that soil and the average concentration of COCs within the soil. Average concentrations are assumed to be the mathematical average of the maximum COC concentrations, as detected at sampling location CEF-B312-SD-001 and their respective FDEP residential SCTLs.

Average concentrations (in μg/kg) of COCs in the Site 58 contaminated soil are as follows:

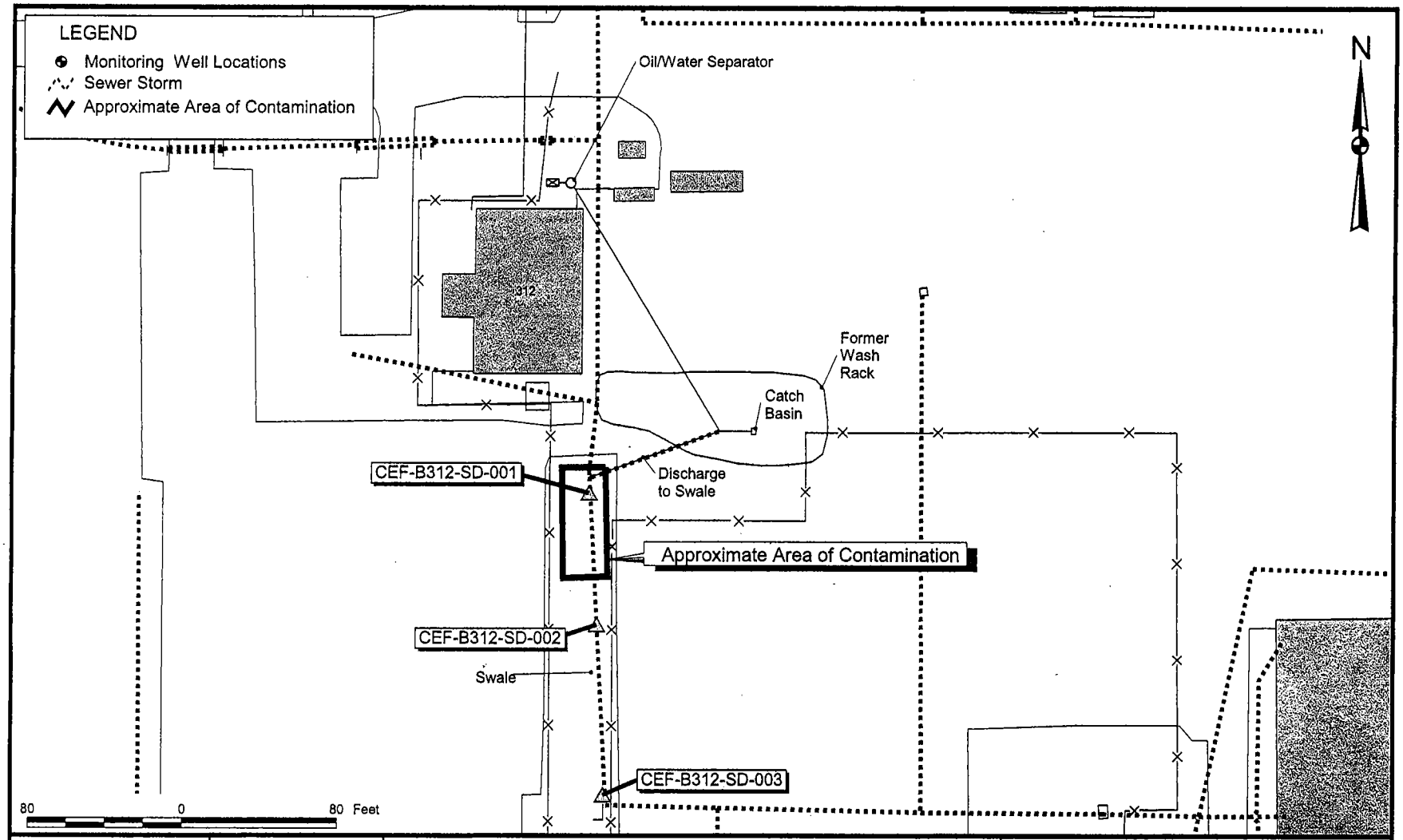
COC	Maximum Concentration	Residential SCTL	Average Concentration
Benzo(a)anthracene	1433	1400	1417
Benzo(a)pyrene	1569	100	830
Dibenzo(a,h)anthracene	172	100	136

Quantities (in pounds) of COCs in the Site 58 contaminated soil can be calculated according to the following formula:

$$\text{Quantity} = 180\ yd^3 \times 2{,}700\ lbs/yd^3 \times \text{average concentration} \times 10^{-9}$$

Accordingly, COC quantities are as follows:

COC	Quantity
Benzo(a)anthracene	0.69
Benzo(a)pyrene	0.40
Dibenzo(a,h)anthracene	0.07
Total COCs	1.16



DRAWN BY MJJ	DATE 08Jun01	EXTENT OF SITE 58 SOIL CONTAMINATED IN EXCESS OF PRGs OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY —	DATE —		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-1 / REV 0

P:\GIS\NAS_CecilField\Site-58-FS.apr 22Mar02 MJJ Layout 2-5

C.2 CONTAMINATED GROUNDWATER COMPUTATIONS

1.0 ASSUMPTIONS

The following design assumptions are made based upon RI results:

- The Site 57 Petroleum Plume is defined as the area of groundwater where benzene concentration exceeds 1.0 μg/L.
- The Site 57 TCE Plume is defined as the area of groundwater where TCE concentration exceeds 3.0 μg/L.
- The Site 58 Naphthalene Plume is defined as the area of groundwater where naphthalene concentration exceeds 20 μg/L.
- The Site 57 Petroleum Plume extends to the upper intermediate zone of the Surficial Aquifer (5-50 ft bgs).
- The Site 57 TCE Plume extends to the upper intermediate zone of the Surficial Aquifer (5-50 ft bgs).
- The Site 58 Naphthalene Plume extends to in the shallow zone of the Surficial Aquifer (5-30 ft bgs).

2.0 PLUMES AREAS, THICKNESS, VOLUMES, AND COCS QUANTITIES COMPUTATIONS

2.1 Site 57 Petroleum Plume

2.1.1 Plume Area

The Figure 2-2 benzene 100, 10, and 1 μg/L isocontours show the following surface areas for the Site 57 Petroleum Plume:

Area with benzene concentrations greater than 100 μg/L: 12,640 ft^2
Area with benzene concentrations of 10 to 100 μg/L: 58,435 ft^2
Area with benzene concentrations of 1 to 10 μg/L: 65,780 ft^2

Total Site 57 Petroleum Plume surface area: 12,640 ft^2 + 58,435 ft^2 + 65,780 ft^2 = 136,855 ft^2 or 3.1 acres

2.1.2 Plume Thickness

Assuming a typical groundwater table depth of 5 ft bgs and that groundwater contamination extends halfway between the deepest contaminated well and the shallowest clean well, the thickness of the various areas of the Site 57 Petroleum Plume can be computed as follows:

Thickness = [(depth of shallowest clean well + depth of deepest contaminated well) ÷ 2] – 5 ft

Thickness of area with benzene concentrations greater than 100 μg/L: [(36 ft + 14 ft) ÷ 2] – 5 ft = 20 ft
Thickness of area with benzene concentrations of 10-100 μg/L: [(35 ft + 15 ft) ÷ 2] – 5 ft = 20 ft
Thickness of area with benzene concentrations of 1-10 μg/L: [(81 ft + 14 ft) ÷ 2] – 5 ft = 42.5 ft

2.1.3 Plume Volume

Assuming a typical porosity of 0.35, the design volumes of the various areas of the Site 57 Petroleum Plume are as follows:

Volume of area with benzene concentrations greater than 100 μg/L:
12,640 ft^2 x 20 ft x 0.35 = 88,480 ft^3 or 663,600 gallons
Volume of area with benzene concentrations of 10-100 μg/L:
58,435 ft^2 x 20 ft x 0.35 = 409,045 ft^3 or 3,067,800 gallons
Volume of area with benzene concentrations of 1-10 μg/L:

65,780 ft^2 x 42.5 ft x 0.35 = 978,477 ft^3 or 7,338,600 gallons

Total Site 57 Petroleum Plume volume: 663,600 + 3,067,800 + 7,338,600 = 11,070,000 gallons

2.1.4 COCs Quantities

Assuming that the average benzene concentration in the various areas of the Site 57 Petroleum Plume is the mathematical average between the highest and lowest detected concentrations, average benzene concentrations of the various areas can be computed as follows:

Average benzene concentration of area with benzene concentrations greater than 100 μg/L:
[248 μg/L (detected at CEF-824A-4S) + 100 μg/L (isocontour)] ÷ 2 = 174 μg/L
Average benzene concentration of area with benzene concentrations of 10-100 μg/L:
[100 μg/L (isocontour) + 10 μg/L (isocontour)] ÷ 2 = 55 μg/L
Average benzene concentration of area with benzene concentrations of 1-10 μg/L:
[10 μg/L (isocontour) + 1 μg/L (isocontour)] ÷ 2 = 5.5 μg/L

The quantity of benzene in each area of the Site 57 Petroleum Plume can be computed as follows:

Quantity of benzene in area of benzene concentrations greater than 100 μg/L:
663,600 gallons x 8.34 lbs/gal x 174 μg /L x 10^{-9} = 0.96 pounds
Quantity of benzene in area with benzene concentrations of 10-100 μg/L:
3,067,800 gallons x 8.34 lbs/gal x 55 μg /L x 10^{-9} = 1.41 pound
Quantity of benzene in area with benzene concentrations of 1-10 μg/L:
7,338,600 gallons x 8.34 lbs/gal x 5.5 μg /L x 10^{-9} = 0.34 pounds

Total benzene quantity in Site 57 Petroleum Plume: 0.96 + 1.41 + 0.34 = 2.71 pounds

The quantities of other COCs within the Site 57 Petroleum Plume can be computed based upon the volume of that plume and the average concentration of these COCs within the plume. Average concentrations are assumed to be the mathematical average of the concentrations detected in samples collected from wells located within the plume.

Average concentrations (in μg/L) of other COCs in the Site 57 Petroleum Plume are as follows:

COC	824A-04S	824A-07S	824A-08S	824A-11S	293-11	293-21	293-22	Average
Toluene	2 U	2 U	2 U	49.9	62.8	2 U	2 U	17.5
Ethylbenzene	24	2.2	2 U	85.1	149.5	2.7	2 U	38.2
Xylenes	62	4 U	1.9 J	319.5	560.5	4.5 J	2 U	136.3
1,1-DCA	2 U	2	9.9	2 U	10 U	2 U	2 U	4.2
1,1-DCE	2 U	2 U	33.8	2 U	10 U	2 U	2 U	7.7
1,2-DCE	2 U	2 U	0.94	2 U	10 U	2 U	2 U	3.0
TCE	2 U	2.8	2 U	2 U	10 U	2 U	2 U	3.0
1-Methylnaphthalene	7.6	25	2.2 U	160	72.6	2.3	10.9	40.1
2-Methylnaphthalene	8.7	30.6	2.2 U	184	71	2.4	11.6	44.3
Naphthalene	30.5	19.8	2.2 U	396	140.5	2.7	14.7	86.6
TRPH	1705	1900	300 U	14300	4205	255	946	3373

Quantities (in pounds) of other COCs in the Site 57 Petroleum Plume can be calculated according to the following formula:

Quantity = 11,070,000 gallons x 8.34 lbs/gallon x average concentration x 10^{-9}

Accordingly, COC quantities are as follows:

COC	Quantity
Toluene	1.61
Ethylbenzene	3.53
Xylenes	12.58
1,1-DCA	0.39
1,1-DCE	0.71
1,2-DCE	0.28
TCE	0.28
1-Methylnaphthalene	3.70
2-Methylnaphthalene	4.09
Naphthalene	7.99
TRPH	311.4

Total quantities of COCs in the Site 57 Petroleum Plume are as follows:

- BTEX: 2.71 + 1.61 + 3.53 + 12.58 = 20.43 pounds
- Chlorinated VOCs: 0.39 + 0.71 + 0.28 + 0.28 = 1.66 pounds
- PAHs: 3.70 + 4.09 + 7.99 = 15.78 pounds
- TRPH: 311.4 pounds
- Total COCs: 349.27 pounds

2.2 Site 57 TCE Plume

2.2.1 Plume Area

The Figure 2-3 TCE 3 μg/L isocontour show the following surface area for the Site 57 TCE Plume:

Area of TCE concentrations greater than 3 μg/L: 47,800 ft^2 or 1.1 acres

2.2.2 Plume Thickness

Assuming a typical groundwater table depth of 5 ft bgs and that groundwater contamination extends halfway between the deepest contaminated and shallowest clean well, the thickness of the Site 57 TCE Plume can be computed as follows:

Thickness = [(depth of shallowest clean well + depth of deepest contaminated well) ÷ 2] – 5 ft

Thickness of the Site 57 TCE Plume: [(81 ft + 41 ft) ÷ 2] – 5 ft = 56 ft

2.2.3 Plume Volume

Assuming a typical porosity of 0.35, the design volume of the Site 57 TCE Plume is as follows:

Volume of the Site 57 TCE Plume: 47,800 ft^2 x 56 ft x 0.35 = 936,880 ft^3 or 7,026,600 gallons

2.2.4 COCs Quantities

Assuming that the average TCE concentration in the Site 57 TCE Plume is the mathematical average between the highest and lowest detected concentrations:

Average TCE concentration in the Site 57 TCE Plume:
[43 μg/L (detected at CEF-293-19) + 3 μg/L (isocontour)] ÷ 2 = 23 μg/L

The quantity of TCE in the Site 57 TCE Plume can be computed as follows:

7,026,600 gallons x 8.34 lbs/gal x 23 μg /L x 10^{-9} = 1.35 pounds

The quantities of other COCs within the Site 57 TCE Plume can be computed based upon the volume of that plume and the average concentration of these COCs within the plume. Average concentrations are assumed to be the mathematical average of the concentrations detected in samples collected from wells located within the plume.

Average concentrations (in μg/L) of other COCs in the Site 57 TCE Plume are as follows:

COC	824A-12I	824A-14S	824A-15I	293-19	293-20	Average
Benzene	3.5	2 U	1 U	1.8	0.87 J	1.8
Toluene	2 U	4.9	2 U	33.4	2 U	8.9
Ethylbenzene	10.4	4.4	1.0 J	5	2 U	4.6
Xylenes	36.2	4.9 J	5.2 J	31.8	6 U	16.8
1,1-DCA	2 U	97.2	2 U	58.6	1.6 J	32.3
1,1-DCE	2 U	5.0	2 U	2 U	2 U	2
1,2-DCE	2 U	139	2 U	825	136	220.8
1-Methylnaphthalene	12.5	2 U	2.0	4 U	2 U	4.5
2-Methylnaphthalene	12.3	2 U	2 U	4 U	2 U	4.5
Naphthalene	49.1	2 U	2.4	46	1.2 J	20.1
TRPH	3280	2010	1210	4440	580	2304

Quantities (in pounds) of other COCs in the Site 57 TCE Plume can be calculated according to the following formula:

$$\text{Quantity} = 7{,}026{,}600 \text{ gallons} \times 8.34 \text{ lbs/gallon} \times \text{average concentration} \times 10^{-9}$$

Accordingly, COC quantities are as follows:

COC	Quantity
Benzene	0.10
Toluene	0.52
Ethylbenzene	0.27
Xylenes	0.98
1,1-DCA	1.89
1,1-DCE	0.11
1,2-DCE	12.94
1-Methylnaphthalene	0.26
2-Methylnaphthalene	0.26
Naphthalene	1.18
TRPH	135.02

Total quantities of COCs in the Site 57 TCE Plume are as follows:

- BTEX: 0.10 + 0.52 + 0.27 + 0.98 = 1.88 pounds
- Chlorinated VOCs: 1.35 + 1.89 + 0.11 + 12.94 = 16.29 pounds
- PAHs: 0.26 + 0.26 + 1.18 = 1.7 pounds
- TRPH: 135.02 pounds
- Total COCs: 154.89 pounds

2.3 Site 58 Naphthalene Plume

2.3.1 Plume Area

The Figure 2-4 20 μg/L naphthalene isocontour shows the following surface area for the Site 58 Naphthalene Plume:

Area of naphthalene concentrations greater than 20 μg/L: 15,575 ft^2 or 0.36 acres

2.3.2 Plume Thickness

Assuming a typical groundwater table depth of 5 ft bgs and that groundwater contamination extends halfway between the deepest contaminated and shallowest clean well, the thickness of the Site 58 Naphthalene Plume can be computed as follows:

Thickness = [(depth of shallowest clean well + depth of deepest contaminated well) ÷ 2] – 5 ft

Thickness of the Site 58 Naphthalene Plume: [(30 ft + 14 ft) ÷ 2] – 5 ft = 17 ft

2.3.3 Plume Volume

Assuming a typical porosity of 0.35, the design volume of the Site 58 Naphthalene Plume is as follows:

Volume of the Site 58 Naphthalene Plume: 15,575 ft^2 x 17 ft x 0.35 = 92,671 ft^3 or 695,000 gallons

2.3.4 COCs Quantities

Assuming that the average naphthalene concentration in the Site 58 Naphthalene Plume is the mathematical average between the highest and lowest detected concentrations:

Average naphthalene concentration in the Site 58 Naphthalene Plume:
[156 μg/L (detected at CEF-B312-01S) + 20 μg/L (isocontour)] ÷ 2 = 88 μg/L

The quantity of naphthalene in the Site 58 Naphthalene Plume can thus be computed as follows:

695,000 gallons x 8.34 lbs/gal x 88 μg /L x 10^{-9} = 0.51 pounds

Average concentrations (in μg/L) of COCs in the Site 58 Naphthalene Plume are as follows:

COC	312-01	B312-01S	B312-03S	B312-06S	B312-08S	Average
Xylenes	0.60 J	4.1 J	6 U	6 U	46.2	12.6
1,1-DCA	9.1	6.8	2 U	1.0 J	288.7	61.5
1,1-DCE	2 U	2 U	2 U	2 U	87.3	19.1
1,1,1-TCA	2 U	2 U	2 U	2 U	582.7	118.1
TRPH	1360	9000	1850	2890	1235	3267

Quantities (in pounds) of other COCs in the Site 58 Naphthalene Plume can be calculated according to the following formula:

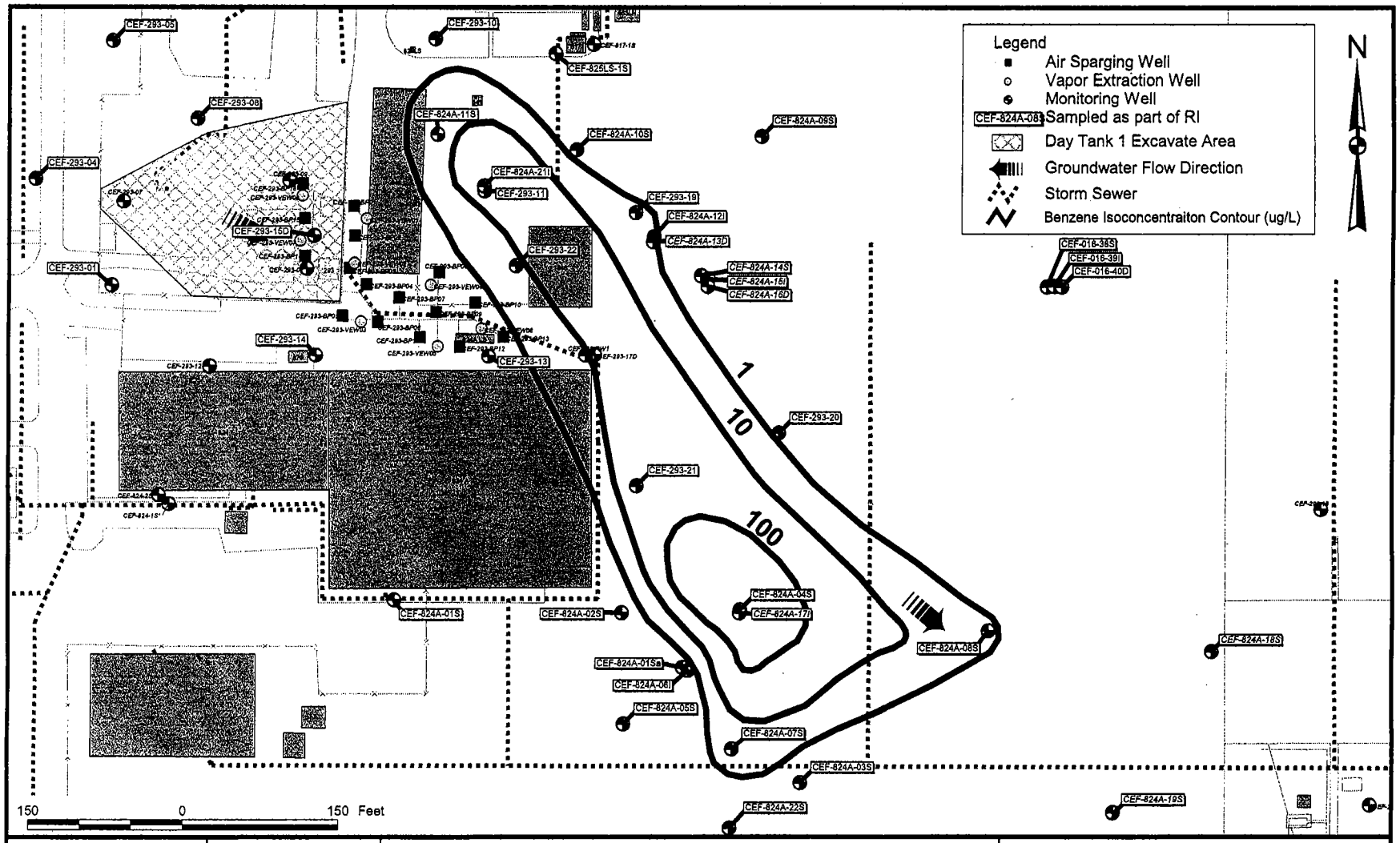
$$\text{Quantity} = 695{,}000 \text{ gallons} \times 8.34 \text{ lbs/gallon} \times \text{average concentration} \times 10^{-9}$$

Accordingly, COC quantities are as follows:

COC	Quantity
Xylenes	0.07
1,1-DCA	0.36
1,1-DCE	0.11
1,1,1-TCA	0.68
TRPH	18.94

Total quantities of COCs in the Site 58 Naphthalene Plume are as follows:

- BTEX: 0.07 pounds
- Chlorinated VOCs: 0.36 + 0.11 + 0.68 = 1.15 pounds
- PAHs: 0.51 pounds
- TRPH: 18.94 pounds
- Total COCs: 20.67 pounds



DRAWN BY: MJJ — DATE: 14Feb02	EXTENT OF SITE 57 PETROLEUM PLUME OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER: 0039	
CHECKED BY: — DATE: —		APPROVED BY: — DATE: —	
COST/SCHEDULE-AREA		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 2-2	REV: 0

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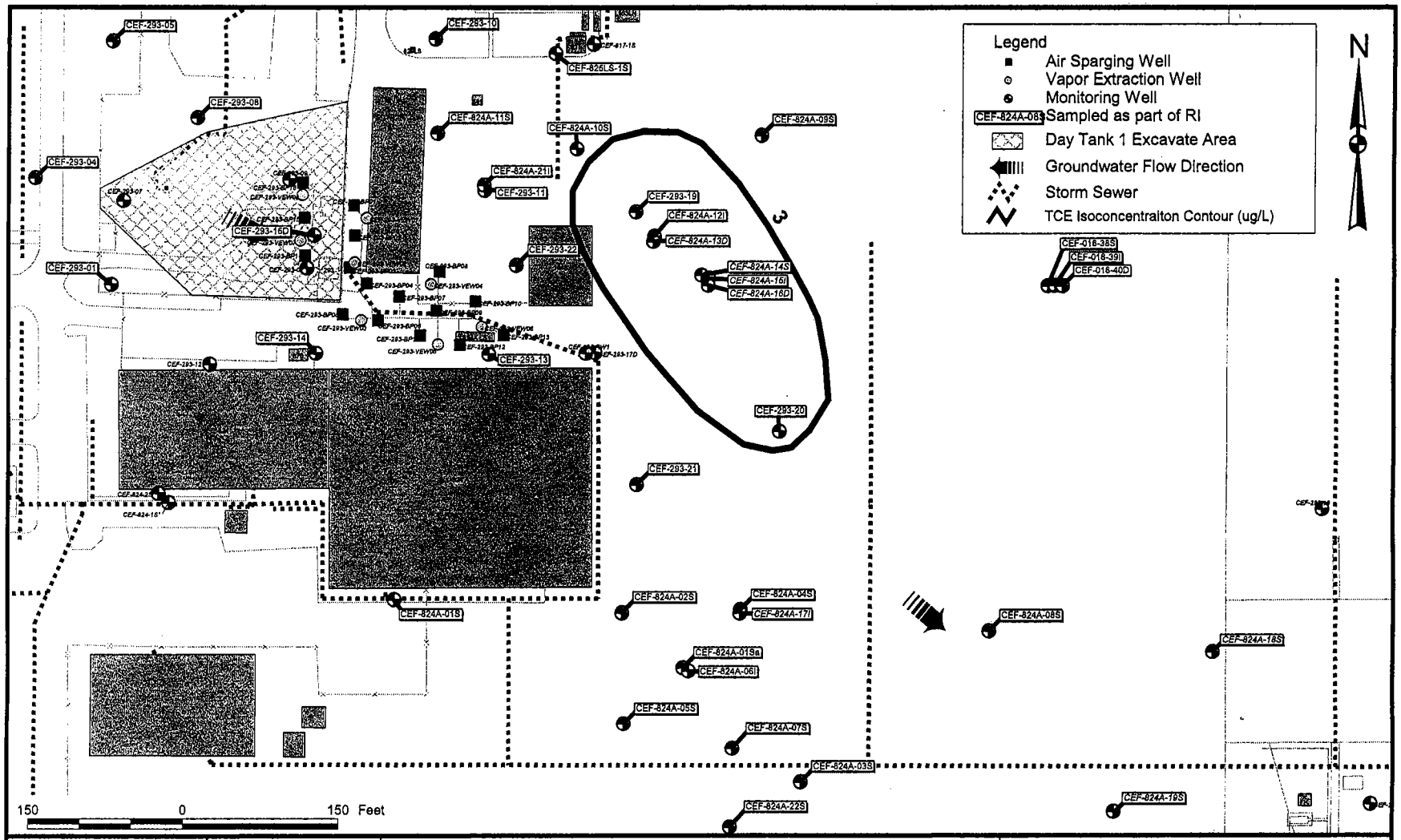

DRAWN BY MJJ	DATE 14Feb02	EXTENT OF SITE 57 TCE PLUME OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-3 REV 0

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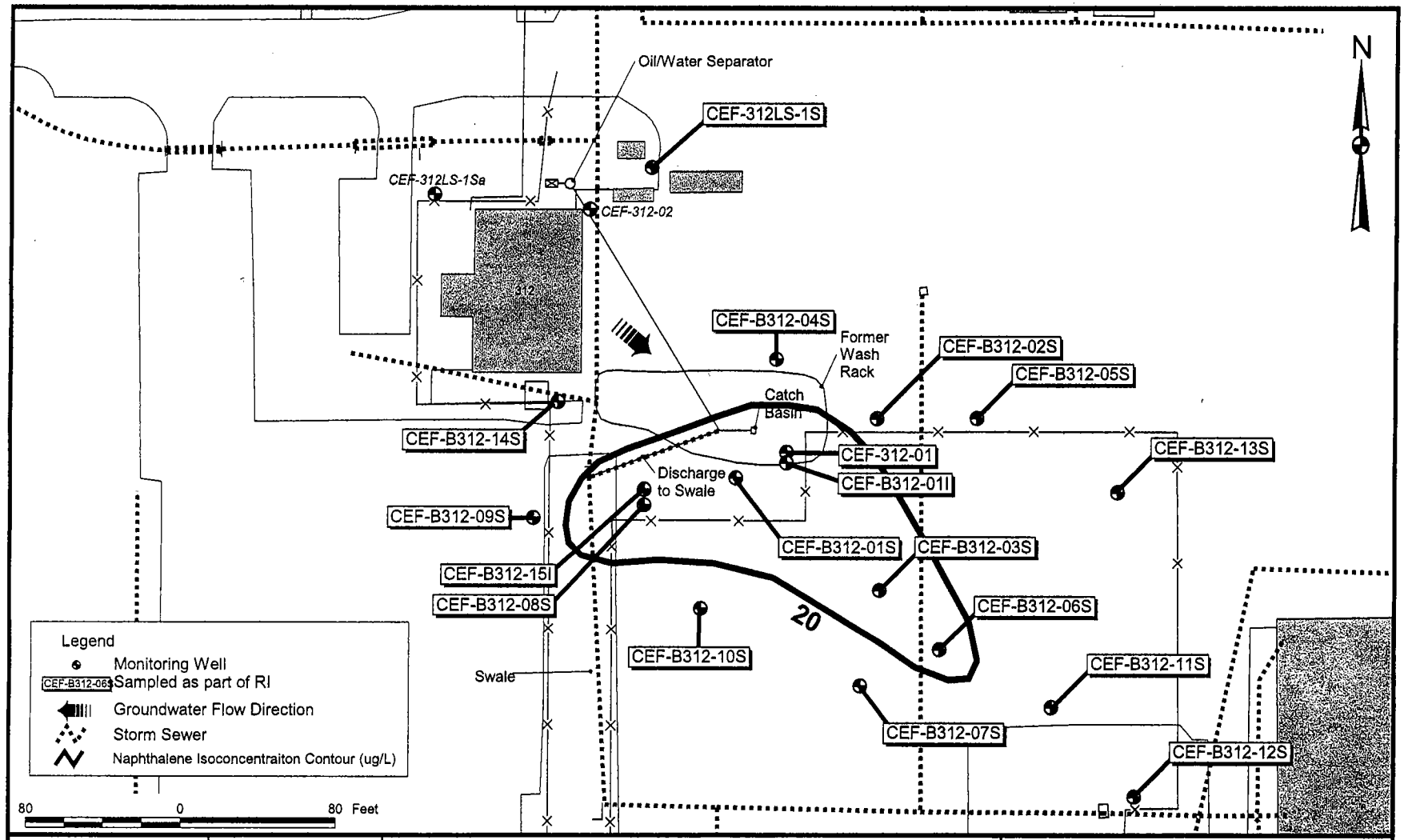

DRAWN BY MJJ	DATE 14Feb02	EXTENT OF SITE 58 NAPHTHALENE PLUME OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2-4 / REV 0

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C.3 GROUNDWATER ALTERNATIVE 3 IN-SITU BIOREMEDIATION (ORC®/HRC®)

REGENESIS

March 13, 2002

Proposal No. H870

Jean-Luc Glorieux
Tetra Tech NUS, Inc.
661 Anderson Drive
Pittsburgh, PA 15220
Fax: 412-921-4040
Ph: 412-921-8568

Subject: Acceleration of Natural Attenuation at the Jacksonville NAS, Cecil Field - Site 57 Site

Dear Mr. Glorieux:

We have reviewed the information that you provided for the above-referenced site. In the following sections, we provide design and cost information for a potential site remediation approach. This information should be considered preliminary since a number of assumptions have been made concerning site conditions and the extent of the contaminant plume requiring remediation. We look forward to working with you to develop a specific strategy that meets your objectives.

Use of HRC and ORC to Accelerate Bioremediation

Hydrogen Release Compound (HRC®) is used to enhance in situ biodegradation rates for chlorinated hydrocarbons (CHs) by fueling anaerobic reductive dechlorination processes. Reductive dechlorination is recognized as one of the primary attenuation mechanisms by which chlorinated solvent groundwater plumes can be contained and/or remediated.

HRC is a proprietary polylactate ester that, upon being deposited into the subsurface, slowly releases lactate. Lactate is metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic aquifer conditions and the production of hydrogen. Naturally occurring microorganisms capable of reductive dechlorination then use the hydrogen to progressively remove chlorine atoms from the chlorinated hydrocarbon contaminants (i.e. convert trichloroethene [TCE] to dichloroethene [DCE] to vinyl chloride [VC] to ethene). HRC is manufactured as a viscous gel that can be injected into the saturated zone for plume area- or cutoff barrier-based remediation designs.

Oxygen Release Compound (ORC®) is used to provide oxygen to support the aerobic biodegradation of petroleum hydrocarbons and CHs such as chlorobenzene, DCE, and VC. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be mixed with water for slurry injection into the saturated zone.

The use of HRC and ORC for groundwater remediation offers a comparatively simple and cost effective remediation alternative for sites that would otherwise require unacceptably long periods of time for natural attenuation or the high levels of capital investment and operating expense associated with active remediation technologies.

Preliminary Design and Cost Information for Full Scale Remediation

It is assumed that the full-scale remediation approach for the site would consist of a combination of grid-based applications of ORC to reduce contaminant levels in two sections of the "benzene plume" and a downgradient ORC barrier application to reduce risk associated with downgradient benzene contaminant migration. A series of 5 barrier-based HRC applications are proposed to address the "TCE plume". The proposed ORC and HRC treament areas are shown on the attached figure.

Design/Proposal Assumptions

Using the information you provided, we have made the following assumptions to estimate system design variables and dose amounts.

- Plume area requiring treatment:

  Benzene Plume – Total size of 750 feet long x 225 feet wide specified by Tetra Tech NUS

  ORC gird application - 150 feet long x 100 feet wide grid in plume core

  ORC grid application - 150 feet long x 50 feet wide grid in secondary area of plume

  ORC barrier application - 200 feet long downgradient barrier

  TCE Plume – Total size of 250 long x 180 feet wide specified by tetra Tech NUS

  Series of five HRC barrier applications – 5, 180 feet long barriers

- Representative contaminant concentration:

  Benzene Plume - 0.254 mg/L benzene, 0.066 mg/L toluene, 0.151 mg/L ethylbenzene, 0.572 mg/L total xylenes, and 0.155 mg/L naphthalene

  TCE Plume - 0.043 mg/L TCE, 0.825 mg/L cis-1,2-DCE and 0.097 mg/L 1,1-DCA

- Contaminated saturated zone thickness requiring treatment:

  Benzene Plume - 30 feet (5 to 35 feet bgs).

  TCE Plume - 55 feet (5 to 60 feet bgs).

- Estimated groundwater velocity: up to 98.6 feet/year. Note that groundwater velocity controls the extent to which new contaminant is brought into the treatment zone. This contaminant loading must be considered when specifying time release compound dosing requirements.

- Current groundwater geochemistry: Assumed to be generally anaerobic with oxygen <1 mg/L, nitrate <1 mg/L, ferrous iron <1.5 mg/L, and oxidation reduction potential approximately in the negative mV range.

- Competing electron acceptor demand for HRC-supplied electron donor (assumed): potential manganese reduction demand <5 mg/L, potential ferric iron reduction demand <25 mg/L, and potential sulfate reduction demand <20 mg/L. Higher competing electron acceptor-based demand may require increased amounts of HRC to achieve remedial goals.

The design specifications and costs provided below represent a preliminary design for an accelerated bioremediation project. This design may need to be adjusted as detailed design and regulatory oversight issues are finalized. For instance, the following design variables may need to be adjusted prior to the implementation:

- Treatment areas may need to be increased or decreased depending on the overall site remediation strategy.
- Exact delivery locations should be selected in the final design process. Delivery locations may need to be adjusted to take into account site features such as underground utilities and other site structures.

Regenesis' Applications engineering staff is available to assist in the selection of an appropriate final design.

TCE PLUME

HRC Barrier Treatment	
Design Feature	**Specification**
Saturated thickness requiring treatment	55 feet
Treatment Area	5, 180 foot long barriers
Delivery Pt. Spacing and Configuration	15 ft-on-center within rows 2 rows of 12 points; 24 total points per barrier x 5 barrier = 120 total points
HRC dose rate in lbs/vertical foot of injection	3 lbs/foot, (165 lbs/point)
Material requirement	120 pts. x 55 feet x 3 lbs/ft = 19,800 lbs*
Material cost at $5.50/lb*	$108,900 plus shipping and applicable sales tax

* It would be more cost effective to purchase 20,010 lbs of HRC since the cost per pound decreases to $5.25 per pound for purchases over 20,000 lbs (see attached price sheet). The total cost of 20,010 pounds of HRC will be $105,052.50, therefore saving $3,847.50, over buying only 19,800 pounds.

BENZENE PLUME

ORC Grid Treatment – Plume Hot Spot	
Design Feature	**Specification**
Saturated thickness requiring treatment	30 feet
Treatment Area	150 feet x 100 feet
Delivery Pt. Spacing and Configuration	15 ft-on-center bet. rows, 15 ft-on-center within rows 10 rows of 7 points; 70 total points
ORC dose rate in lbs/vertical foot of injection	4 lbs/foot, (120 lbs/point)
Material requirement	70 pts. x 30 feet x 4 lbs/ft = 8,400 lbs
Material cost at $8.50/lb*	*$71,400 plus shipping and applicable sales tax

** ORC Grid Treatment – Secondary Area of Plume	
Design Feature	**Specification**
Saturated thickness requiring treatment	30 feet
Treatment Area	150 feet x 50 feet
Delivery Pt. Spacing and Configuration	15 ft-on-center bet. rows, 15 ft-on-center within rows 10 rows of 4 points; 40 total points
ORC dose rate in lbs/vertical foot of injection	4 lbs/foot, (120 lbs/point)
Material requirement	40 pts. x 30 feet x 4 lbs/ft = 4,800 lbs
Material cost at $9.00/lb*	*$43,200 plus shipping and applicable sales tax

** This grid has been proposed pursuant to the request of Tetra Tech NUS. Please be aware that Regenesis is concerned that the location of this proposed ORC grid may inhibit the HRC treatment/enhanced reductive dechlorination process proposed for the TCE plume located down- to cross-gradient of the proposed ORC grid. Tetra Tech NUS may want to alter the location of this grid, change the timing of its installation so as not to be coincident with HRC treatment, or eliminate it altogether.

ORC Barrier Treatment	
Design Feature	**Specification**
Saturated thickness requiring treatment	30 feet
Treatment Area	200 foot long barrier
Delivery Pt. Spacing and Configuration	15 ft-on-center within rows 2 rows of 14 points; 28 total points
ORC dose rate in lbs/vertical foot of injection	4 lbs/foot, (120 lbs/point)
Material requirement	28 pts. x 30 feet x 4 lbs/ft = 3,360 lbs
Material cost at $9.00/lb*	*$30,240 plus shipping and applicable sales tax

*Based on the above-proposed ORC application, the total amount of ORC proposed for this injection is 16,560 pounds. If all of the ORC is purchased in the same order, the cost will be $8.00 per pound. Therefore, the total cost of 16,560 pounds of ORC is $132,480 plus applicable sales tax and shipping. If less or more ORC is purchased than the total amount proposed, the cost per pound may be greater or less than the $8.00 per pound quoted above. Please see the attached price sheet for ORC volume pricing structure.

Total Project Cost

The total cost of an accelerated bioremediation project can be estimated as the sum of the following items:

- HRC/ORC material and shipping costs.
- HRC/ORC application fieldwork costs. Customers are responsible for selecting a local injection/application subcontractor.
- Groundwater monitoring well construction (if necessary to monitor project performance).
- Periodic groundwater sampling and analysis.
- Consultant oversight and reporting. Regenesis data evaluation and technical support are provided free of charge.

The costs provided in this letter apply to HRC/ORC material costs for *one application*. The need for re-applications will depend on your plume management strategy, site specific biodegradation performance, remedial goals for the site, and other technical or regulatory considerations. For plume area treatments, one to two re-applications could be necessary over the course of the project, although each re-application would most likely be done over a reduced area and dose amount

compared to the initial application. For barrier-based designs, re-applications will be necessary every one to two years as long as there is a need to prevent contaminant migration.

HRC Delivery to Contaminated Zone

Typically, HRC is applied using direct push hydraulic equipment. Drive rods are pushed to the bottom of the contaminated saturated zone and then HRC is injected as the rods are withdrawn. The minimum recommended rod size is a 0.625-inch inner diameter.

For sites where direct push is not feasible, auger-based equipment can be used to deliver HRC. Also, the use of permanent, small diameter re-injection wells may be a more cost-effective approach for sites requiring repeated applications of HRC. Technical support personnel at Regenesis are available to discuss the suitability of alternate HRC delivery methods.

Costs for HRC injection should be obtained from local subcontractors. If necessary, Regenesis can assist in locating qualified HRC injection subcontractors. Budgetary cost estimates for direct push-based injection range from $1,000 to $2,000 per day. Typically, one to two HRC injection points can be completed per hour and up to 20 points can be completed per day, depending on soil type, depths of injection, and subcontractor experience.

HRC should be injected using an appropriate pump capable of processing a material with a viscosity of 20,000 centipoise at flow rates of 3 to 10 gallons per minute at pressures ranging from 200 psig to 1,500 psig. Failure to use appropriate equipment could increase field time and result in improper application of the HRC. Regenesis has evaluated a number of pumps and has found that the RE Rupe and the Geoprobe GS-2000 pumps provide suitable volume and pressure. The RE Rupe as well as the GS-2000 pumps can be purchased directly from the manufacturers. RE Rupe Co. can be contacted at (515) 682-7029, while Geoprobe Systems can be reached at (800) 436-7762. The Geoprobe GS-2000 is available for rent through Probe-Lease. Probe-Lease can be reached at (800) 645-2009.

ORC Delivery to Contaminated Zone

Typically, ORC is applied using direct push hydraulic equipment. Drive rods are pushed to the bottom of the contaminated saturated zone and then an ORC/water slurry is injected as the rods are withdrawn.

For sites where direct push technology is not feasible, auger-based equipment can be used to deliver ORC; and, for cases where repeated injections will be necessary, the use of permanent, small diameter re-injection wells may be a more cost-effective approach. Technical support personnel at Regenesis are available to discuss the suitability of other delivery methods.

The ORC/water slurry mixture is typically 20% to 40% ORC solids by weight. An average ORC solids content is 30%, but this value may need to be adjusted in the field so that the required mass of ORC can be injected at each location. For example, tighter soil types may require a higher ORC solids content since less slurry volume can be injected per location.

The volume of water per injection location can be calculated from the following equation:

$$\text{Volume of water (gallons/injection point)}: \frac{\text{ORC lbs/hole}}{(8.34\ \text{lbs/gal water})(\%\ \text{ORC solids})}[1-(\%\ \text{ORC solids})]$$

Most geoprobe contractors are equipped with grout pumps capable of injecting ORC. Typical pump specifications call for a pumping rate of 1 to 5 gpm and injection pressures from 100 to 500 psig.

Costs for ORC injection should be obtained from local subcontractors. Regenesis can assist in locating ORC injection subcontractors. Budgetary cost estimates for direct push-based injection range from $1,000 to $2,000 per day. Typically, two to three ORC injection points can be completed per hour and from 20 to 30 points can be completed per day, depending on soil type, depths of injection, and subcontractor experience.

Recommended Groundwater Monitoring Program for Pilot/Full Scale Treatment

Monitoring of selected wells should be conducted to validate the enhancement of biodegradation processes. Ideally, samples should be collected from the following site locations:

- an upgradient or background location to identify groundwater conditions outside the treatment area
- inside the treatment area
- an appropriate distance downgradient of the treatment area to identify potential residence time requirements for complete biodegradation
- downgradient compliance point to confirm offsite migration is not occurring

An initial or "baseline" round of sampling should be performed to identify pre-remediation groundwater conditions. After application, samples can be collected every other month for a six to eight month period. After the initial biodegradation and geochemical trends have been identified, the monitoring frequency can be decreased to a quarterly, semiannual, or annual program.

<u>HRC Treatment Area</u>

- field redox parameters: dissolved oxygen, ORP, pH, and ferrous iron (optional field measurement)
- laboratory redox parameters: natural attenuation/inorganic parameters: dissolved iron, dissolved manganese, nitrate, sulfate, sulfide, chloride, and alkalinity
- available electron donor: total organic carbon and metabolic acids (lactic, pyruvic, acetic, propionic, and butyric)
- dissolved gas end-products: carbon dioxide, methane, ethane, and ethene

A specially qualified laboratory should do the analytical testing for the metabolic acids, otherwise most laboratories can provide testing for the remaining parameters. A typical cost for the above testing program is approximately $300 per sample.

ORC Treatment Area

- field redox parameters: dissolved oxygen, ORP, pH, and ferrous iron
- biochemical oxygen demand (5 day) and chemical oxygen demand at selected wells within treatment area

Performance Goals for HRC Bioremediation Projects

As with most bioremediation approaches, the primary goals are contaminant mass reduction and plume stabilization and size reduction. Goals focusing on numerical criteria such as drinking water standards should be considered secondary. Current HRC sites have been successful at reducing concentrations from mg/L to tens of μg/L, but there is no guarantee that sub-10 ug/L concentrations will be achieved. HRC-based projects are subject to the same asymptotic limitations that confront all other remediation technologies.

The duration of an accelerated bioremediation cleanup is very difficult to predict with any accuracy due to uncertainty about the total mass (especially sorbed and/or residual phase) and site specific biodegradation rates that can be achieved. The benefits of bioremediation for chlorinated hydrocarbons are a less costly and intrusive remedial alternative as opposed to a costly, well-defined cleanup schedule. For the sake of estimation, it can be assumed that biodegradation half- lives can be reduced by 10x and that an average project may require 2 to 4 years to complete.

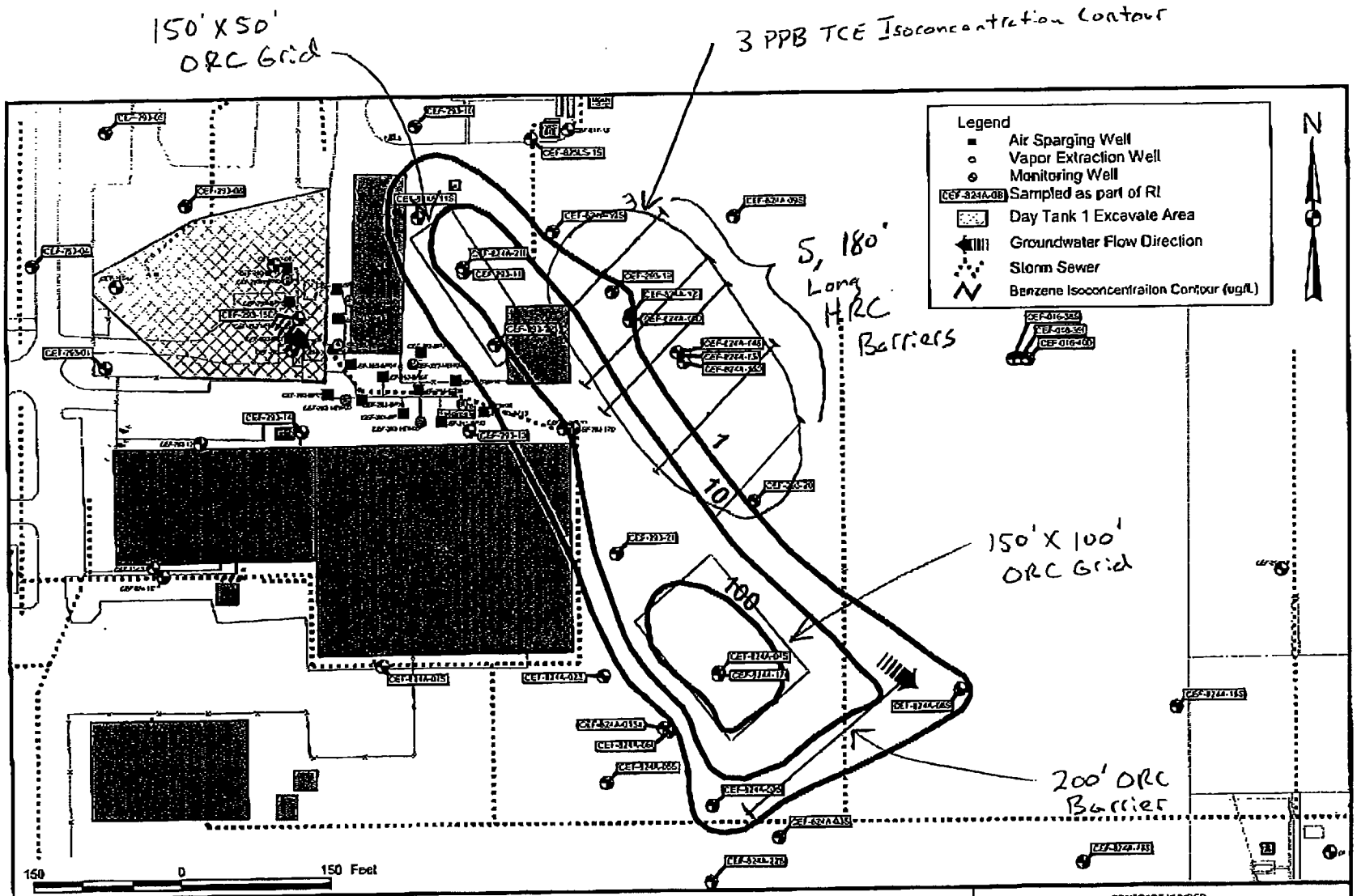
Regenesis appreciates the opportunity to provide this information for your project. Please feel free to contact Rick Gillespie, Regenesis' Southeast District Business Development Manager, at 972.377.7288 (e-mail at rick@regenesis.com) or me at 949.366.8000 (e-mail at dreilly@regenesis.com).

Sincerely,

David C. Reilly
Applications Engineer

Craig A. Sandefur
Vice President, Remediation Services

Attachments



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BENZENE ISOCONCENTRATION CONTOURS - SHALLOW AQUIFER
OU 9, SITE-57 - BUILDING 624A / DAY TANK 1 AREA
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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REGENESIS

Oxygen Release Compound (ORC®)

Price Sheet: Effective November 1, 2000

Cost Effective Groundwater and Soil Cleanup

Oxygen Release Compound (ORC) offers a passive, low cost approach to rapidly cleaning up contaminated groundwater and soil. ORC is a unique magnesium peroxide-based chemical formulation with a patented slow release feature. When placed into the contaminated subsurface, ORC releases oxygen for up to a year. This unique slow release of oxygen cost-effectively stimulates naturally occurring microbes to rapidly degrade a wide range of aerobically degradable contaminants.

ORC Powder* Pricing

Regenesis offers the following volume discount structure for the purchase of ORC powder:

Quantity (lbs.)	Price/lb - (US $)	Quantity (lbs.)	Price/lb - (US $)
60	$11.00	6,000	$8.50
500	$10.00	10,000	$8.00
1500	$9.50	20,000	$7.75
3000	$9.00	40,000	$7.50

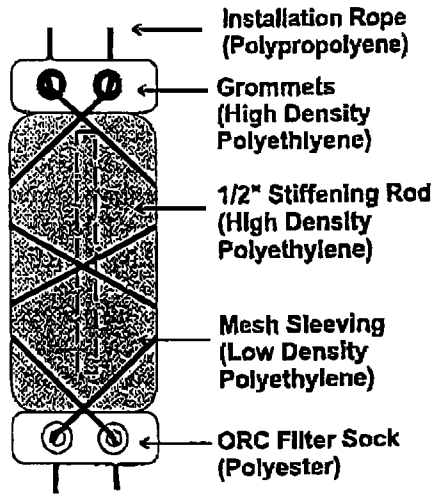
* ORC is shipped in five gallon containers weighing approximately 30 pounds. Material Safety Data Sheet and installation instructions are included with each shipment.

ORC Filter Sock Prices-

Filter Sock Prices

	Well Inside Diameter*		
ORC Filter Sock	6 inches	4 inches	2 inches
Price (ea.)	$70.00	$50.00	$35.00
Minimum Weight	12.0 lbs.	4.4 lbs.	.8 lbs.
Approximate Height	12 inches	12 inches	12 inches
Approx. Diameter	5 1/8"	3 3/8"	1 3/8"
Canisters	6 inches	4 inches	n/a
Price (ea.)	$150.00	$100.00	n/a
Sock Capacity	5 custom	5 custom	n/a

*Canisters are recommended for use in deep wells (>40 feet deep).
Custom filter socks are used in canisters at no additional charge; call for details.



Freight — FOB San Clemente, CA (socks & powder); *FOB Lynbrook, NY or Elk Grove Village, IL (powder only)
*Satellite warehouses stock pre-filled buckets (increments of 30 lbs.)/partial buckets available only from main warehouse in California.

Minimum Order—$660.00

Payment Terms — Net 30 Days. Accounts outstanding after 30 days will be assessed 1.5% monthly interest. Accounts outstanding for purchase of ORC powder over 90 days will be re-invoiced at the undiscounted price of $11.00/lb.

Return Policy — A 15% re-stocking fee will be charged for all returned goods. Return freight must be prepaid. All requests to return product must be pre-approved by Regenesis. Returned product must be in original condition and no product will be accepted for return after a period of 90 days from time of delivery.

Terms & Conditions — Other Terms & Conditions are on reverse side.

Order From—REGENESIS----- 1011 Calle Sombra • San Clemente, CA 92673-6244
Tel: 949.366.8000 • Fax: 949.366.8090 • www.regenesis.com • orc@regenesis.com

Remittance Address: Department 8873
Los Angeles, CA 90084-8873

* Registered trademark of REGENESIS Bioremediation Products

REGENESIS
Oxygen Release Compound, ORC®
TERMS AND CONDITIONS

1. CASUALTY AND AVAILABILITY OF RAW MATERIALS. REGENESIS Bioremediation Products ("Seller") shall not be liable for delays in delivery or failure to manufacture or deliver due to causes beyond its reasonable control, including but not limited to acts of God, acts of buyer, acts of military or civil authorities, fires, strikes, flood, epidemic, war, riot, delays in transportation or car shortages, or inability to obtain necessary labor, materials, components or services through seller's usual and regular sources at usual and regular prices. In any such event seller may, without notice to buyer, at any time and from time to time, postpone the delivery dates under this contract or make partial delivery or cancel all or any portion of this and any other contract with buyer without further liability to buyer. Cancellation of any part of this order shall not affect seller's right to payment for any product delivered hereunder.

2. LIMITED WARRANTY. Seller warrants that the product sold hereunder is made with ORC as specified on face of invoice. Seller makes no other warranty of any kind respecting the product, and expressly DISCLAIMS ALL OTHER WARRANTIES OF WHATEVER KIND RESPECTING THE PRODUCT, INCLUDING ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE. BUYER'S SOLE REMEDY FOR BREACH OF THIS LIMITED WARRANTY SHALL BE REFUND OF THE PURCHASE PRICE, PROVIDED THAT ANY UNUSED PORTION OF THE PRODUCT IS PROMPTLY RETURNED TO SELLER. UNDER NO CIRCUMSTANCES WILL SELLER BE LIABLE FOR ANY CONSEQUENTIAL OR OTHER DAMAGES.

3. DISCLAIMER. Seller disclaims to the full extent permitted by law all warranties, expressed or implied, including any implied warranty of merchantability, fitness for any particular purpose or against infringement, to any person other than buyer. Where warranties to a person other than buyer may not be disclaimed under law, seller extends to such a person the same warranty seller makes to buyer or lessee as set forth herein, subject to all disclaimers, exclusions and limitations of warranties, all limitations of liability and all other provisions set forth in the Terms and Conditions herein. Buyer agrees to transmit a copy of the Terms and Conditions set forth herein to any and all persons to whom buyer sells, or otherwise furnishes the products and/or services provided buyer by seller and buyer agrees to indemnify seller for any liability, loss, costs and attorneys' fees which seller may incur by reason, in whole or in part, of failure by buyer to transmit the Terms and Conditions as provided herein.

4. LIMITATION OF SELLER'S LIABILITY AND LIMITATION OF BUYER'S REMEDY. Seller's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair or use of any goods or services covered by or furnished hereunder, shall in no case exceed the lesser of the cost of repairing or replacing goods failing to conform to the forgoing warranty or the price of the goods or services or part thereof which gives rise to the claim. IN NO EVENT SHALL SELLER BE LIABLE FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR FOR DAMAGES IN THE NATURE OF PENALTIES.

5. INDEMNIFICATION. Buyer agrees to defend and indemnify seller of and from any and all claims or liabilities asserted against seller in connection with the manufacture, sale, delivery, resale or repair or use of any goods covered by or furnished hereunder arising in whole or in part out of or by reason of the failure of buyer, its agents, servants, employees or customers to follow instructions, warnings or recommendations furnished by seller in connection with such goods, by reason of the failure of buyer, its agents, servants, employees or customers to comply with all federal, state and local laws applicable to such goods, or the use thereof, including the Occupational Safety and Health Act of 1970, or by reason of the negligence of buyer, its agents, servants, employees or customers.

6. EXPENSES OF ENFORCEMENT. In the event Seller undertakes any action to collect amounts due from Buyer, or otherwise enforce its rights hereunder, Buyer agrees to pay and reimburse Seller for all such expenses, including, without limitation, all attorneys and collection fees.

7. TAXES. Liability for all taxes and import or export duties, imposed by any city, state, federal or other governmental authority, shall be assumed and paid by buyer. Buyer further agrees to defend and indemnify seller against any and all liabilities for such taxes or duties and legal fees or costs incurred by seller in connection therewith.

8. ASSISTANCE AND ADVICE. Upon request, seller in its discretion will furnish as an accommodation to buyer such technical advice or assistance as is available in reference to the goods. Seller assumes no obligation or liability for the advice or assistance given or results obtained, all such advice or assistance being given and accepted at buyer's risk.

9. ENTIRE AGREEMENT. This agreement constitutes the entire contract between buyer and seller relating to the goods or services identified herein. No modifications hereof shall be binding upon the seller unless in writing and signed by seller's duly authorized representative, and no modification shall be effected by seller's acknowledgment or acceptance of buyer's purchase order forms containing different provisions. Trade usage shall neither be applicable nor relevant to this agreement, nor be used in any manner whatsoever to explain, qualify or supplement any of the provisions hereof. No waiver by either party of default shall be deemed a waiver of any subsequent default.

* Registered trademark of REGENESIS Bioremediation Products

REGENESIS

Hydrogen Release Compound, HRC®

Price Sheet: Effective September 1, 2000

Cost Effective Treatment of Chlorinated Solvents

Hydrogen Release Compound (HRC) offers a passive, low-cost approach to rapid remediation of chlorinated solvent impacted sites. HRC is a proprietary, environmentally safe polylactate ester specially formulated for slow release of lactic acid upon hydration. When placed within a contaminated aquifer, HRC stimulates a multi-step process resulting in the degradation of chlorinated solvent compounds such as PCE, TCE and their derivatives as well as other groundwater contaminants. ***The use of HRC results in the cost-effective and rapid restoration of property values.***

HRC* Pricing

Regenesis offers a volume discount structure for the purchase of HRC as follows:

Quantity (lbs.)	HRC Price/lb. (US $)	Quantity (lbs.)	HRC Price/lb. (US $)
150	$8.00	6,000	$5.75
500	$7.50	10,000	$5.50
1,500	$7.00	20,000	$5.25
3,000	$6.00	40,000	$5.00

* HRC is shipped in four-and-a-quarter gallon containers weighing approximately 30 pounds. Material Safety Data Sheet is included with each shipment.

Freight – All freight is FOB San Clemente, CA unless otherwise specified when order is placed.

Minimum Order – 150 lbs. ($1,200.00)

Bench-Scale Laboratory Testing

Laboratory testing of soil and groundwater is available to confirm the ability of HRC to stimulate dechlorination. However, such testing is generally not required. Testing cost is $2,500 per groundwater/soil slurry sample.

Payment Terms – Net 30 days. Accounts outstanding after 30 days will be assessed 1.5% interest per month. Accounts outstanding over 90 days will be re-invoiced at the undiscounted price of $8.00 per pound.

Return Policy – A 15% restocking fee will be charged for all returned product. Return freight must be prepaid. All requests to return product must be pre-approved by Regenesis. Returned product must be in original condition and no product will be accepted for return after a period of 90 days from time of delivery.

Terms & Conditions – Other terms and conditions are on reverse side.

Order From – **REGENESIS**----- 1011 Calle Sombra• San Clemente, CA 92673-6244
Tel: 949.366.8000 • Fax: 949.366.8090 • www.regenesis.com • orc@regenesis.com

Remittance Address: Department 8873
Los Angeles, CA 90084-8873

REGENESIS

Hydrogen Release Compound, HRC®

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6. EXPENSES OF ENFORCEMENT. In the event Seller undertakes any action to collect amounts due from Buyer, or otherwise enforce its rights hereunder, Buyer agrees to pay and reimburse Seller for all such expenses, including, without limitation, all attorneys and collection fees.

7. TAXES. Liability for all taxes and import or export duties, imposed by any city, state, federal or other governmental authority, shall be assumed and paid by buyer. Buyer further agrees to defend and indemnify seller against any and all liabilities for such taxes or duties and legal fees or costs incurred by seller in connection therewith.

8. ASSISTANCE AND ADVICE. Upon request, seller in its discretion will furnish as an accommodation to buyer such technical advice or assistance as is available in reference to the goods. Seller assumes no obligation or liability for the advice or assistance given or results obtained, all such advice or assistance being given and accepted at buyer's risk.

9. ENTIRE AGREEMENT. This agreement constitutes the entire contract between buyer and seller relating to the goods or services identified herein. No modifications hereof shall be binding upon the seller unless in writing and signed by seller's duly authorized representative, and no modification shall be effected by seller's acknowledgment or acceptance of buyer's purchase order forms containing different provisions. Trade usage shall neither be applicable nor relevant to this agreement, nor be used in any manner whatsoever to explain, qualify or supplement any of the provisions hereof. No waiver by either party of default shall be deemed a waiver of any subsequent default.

REGENESIS

March 11, 2002

Proposal No. 2554

Jean-Luc Glorieux
Tetra Tech NUS, Inc.
661 Anderson Drive
Pittsburgh, PA 15220
Fax: 412-921-4040
Ph: 412-921-8568

Subject: Acceleration of Natural Attenuation at the Jacksonville NAS, Cecil Field - Site 58 Site

Dear Mr. Glorieux:

We have reviewed the information that you provided for the above-referenced site. In the following sections, we provide design and cost information for a potential site remediation approach. This information should be considered preliminary since a number of assumptions have been made concerning site conditions and the extent of the contaminant plume requiring remediation. We look forward to working with you to develop a specific strategy that meets your objectives.

Use of ORC to Accelerate Bioremediation

Oxygen Release Compound (ORC®) is used to provide terminal electron acceptors to support the oxidative biodegradation of many types of petroleum-based hydrocarbons as well as chlorinated hydrocarbons such as dichloroethenes and vinyl chloride. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be (1) mixed with water for slurry injection into the saturated zone, (2) included in excavation backfill material, or (3) enclosed in specially designed socks for placement in monitoring wells.

The use of ORC for groundwater remediation offers a comparatively simple and cost effective remediation alternative for sites that would otherwise require unacceptably long periods of time for natural attenuation or the high levels of capital investment and operating expense associated with active remediation technologies.

Preliminary Design and Cost Information for Full Scale Remediation

It is assumed that the full-scale remediation approach for the site would consist of a grid-based application to reduce contaminant levels within the dissolved-phase naphthalene plume. The proposed treatment area will be approximately 100 feet long by 60 feet wide, centered in the area of the 20 ug/L naphthalene isoconcentration contour shown on the attached figure. The exact

dimensions of the ORC treatment grid (i.e. length of rows) can be adjusted as needed to fit the contours of the plume. A typical ORC treatment grid layout is shown on an attached figure.

Design/Proposal Assumptions

Using the information you provided, we have made the following assumptions to estimate system design variables and dose amounts.

- Plume area requiring treatment: 100 feet long X 60 feet wide
- Representative contaminant concentration: 0.156 mg/L naphthalene; 9 mg/L TRPH
- Contaminated saturated zone thickness requiring treatment: 17 feet (5 to 22 feet bgs, exact depth to be determined by Tetra Tech NUS).
- Estimated groundwater velocity: up to 206 feet/year. Note that groundwater velocity controls the extent to which new contaminant is brought into the treatment zone. This contaminant loading must be considered when specifying ORC compound dosing requirements.
- Current groundwater geochemistry: Assumed to be generally anaerobic with oxygen <1 mg/L, nitrate <0.5 mg/L, ferrous iron <6 mg/L, and oxidation reduction potential approximately -140 mV.

The design specifications and costs provided below represent a preliminary design for an accelerated bioremediation project. This design may need to be adjusted as detailed design and regulatory oversight issues are finalized. For instance, the following design variables may need to be adjusted prior to the implementation:

- Treatment areas may need to be increased or decreased depending on the overall site remediation strategy.
- Exact delivery locations should be selected in the final design process. Delivery locations may need to be adjusted to take into account site features such as underground utilities and other site structures.

Regenesis' applications engineering staff is available to assist in the selection of an appropriate final design.

ORC Grid Treatment	
Design Feature	**Specification**
Saturated thickness requiring treatment	17 feet
Treatment Area	100 feet x 60 feet
Delivery Pt. Spacing and Configuration	10 ft-on-center bet. rows, 10 ft-on-center within rows 10 rows of 6 points; 60 total points
ORC dose rate in lbs/vertical foot of injection	10 lbs/foot, (170 lbs/point)
Material requirement	60 pts. x 17 feet x 10 lbs/ft = 10,200 lbs
Material cost at $8.00/lb	$81,600 plus shipping and applicable sales tax

Total Project Cost

The total cost of an accelerated bioremediation project can be estimated as the sum of the following items:

- ORC material and shipping costs.
- ORC application fieldwork costs. Customers are responsible for selecting a local injection/application subcontractor.
- Groundwater monitoring well construction (if necessary to monitor project performance).
- Periodic groundwater sampling and analysis.
- Consultant oversight and reporting. Regenesis data evaluation and technical support are provided free of charge.

The costs provided in this letter apply to ORC material costs for *one application*. The need for re-applications will depend on your plume management strategy, site specific biodegradation performance, remedial goals for the site, and other technical or regulatory considerations. For plume area treatments, one to two re-applications could be necessary over the course of the project, although each re-application would most likely be done over a reduced area and dose amount compared to the initial application. For barrier-based designs, re-applications will be necessary every one to two years as long as there is a need to prevent contaminant migration.

ORC Delivery to Contaminated Zone Using Direct Push Equipment

It is assumed ORC will be applied using direct push hydraulic equipment. Drive rods are pushed to the bottom of the contaminated saturated zone and then an ORC/water slurry is injected as the rods are withdrawn.

The ORC/water slurry mixture is typically 20% to 40% ORC solids by weight. An average ORC solids content is 30%, but this value may need to be adjusted in the field so that the required mass of ORC can be injected at each location. For example, tighter soil types may require a higher ORC solids content since less slurry volume can be injected per location.

The volume of water per injection location can be calculated from the following equation:

Volume of water (gallons/injection point): $\frac{\text{ORC lbs/hole}}{(8.34\ \text{lbs/gal water})(\%\ \text{ORC solids})}[1-(\%\ \text{ORC solids})]$

Most geoprobe contractors are equipped with grout pumps capable of injecting ORC. Typical pump specifications call for a pumping rate of 1 to 5 gpm and injection pressures from 100 to 500 psig.

Costs for ORC injection should be obtained from local subcontractors. Regenesis can assist in locating ORC injection subcontractors. Budgetary cost estimates for direct push-based injection range from $1,000 to $2,000 per day. Typically, two to three ORC injection points can be completed per hour and from 20 to 30 points can be completed per day, depending on soil type, depths of injection, and subcontractor experience.

Recommended Groundwater Monitoring Program for Pilot/Full Scale Treatment

Monitoring of selected wells should be conducted to validate the enhancement of natural attenuation processes. Also, an initial or "baseline" round of sampling should be performed to identify pre-remediation groundwater conditions. After delivery of ORC to the subsurface, samples can be collected every 2 to 3 months. After the initial biodegradation and geochemical trends have been identified, the monitoring frequency can be decreased to a semiannual or annual program. The monitoring program should employ low flow groundwater sampling techniques and include the measurement of the following field/chemical parameters:

- all contaminants of concern
- field redox parameters: ORP, pH, dissolved oxygen, and ferrous iron
- biochemical oxygen demand (5 day) and chemical oxygen demand at selected wells within treatment area

Ideally, samples should be collected from the following site locations:

- an upgradient or background location to identify groundwater conditions outside the treatment area
- inside the treatment area
- an appropriate distance downgradient of the treatment area to identify potential residence time requirements for complete biodegradation
- downgradient compliance point to confirm offsite migration is not occurring

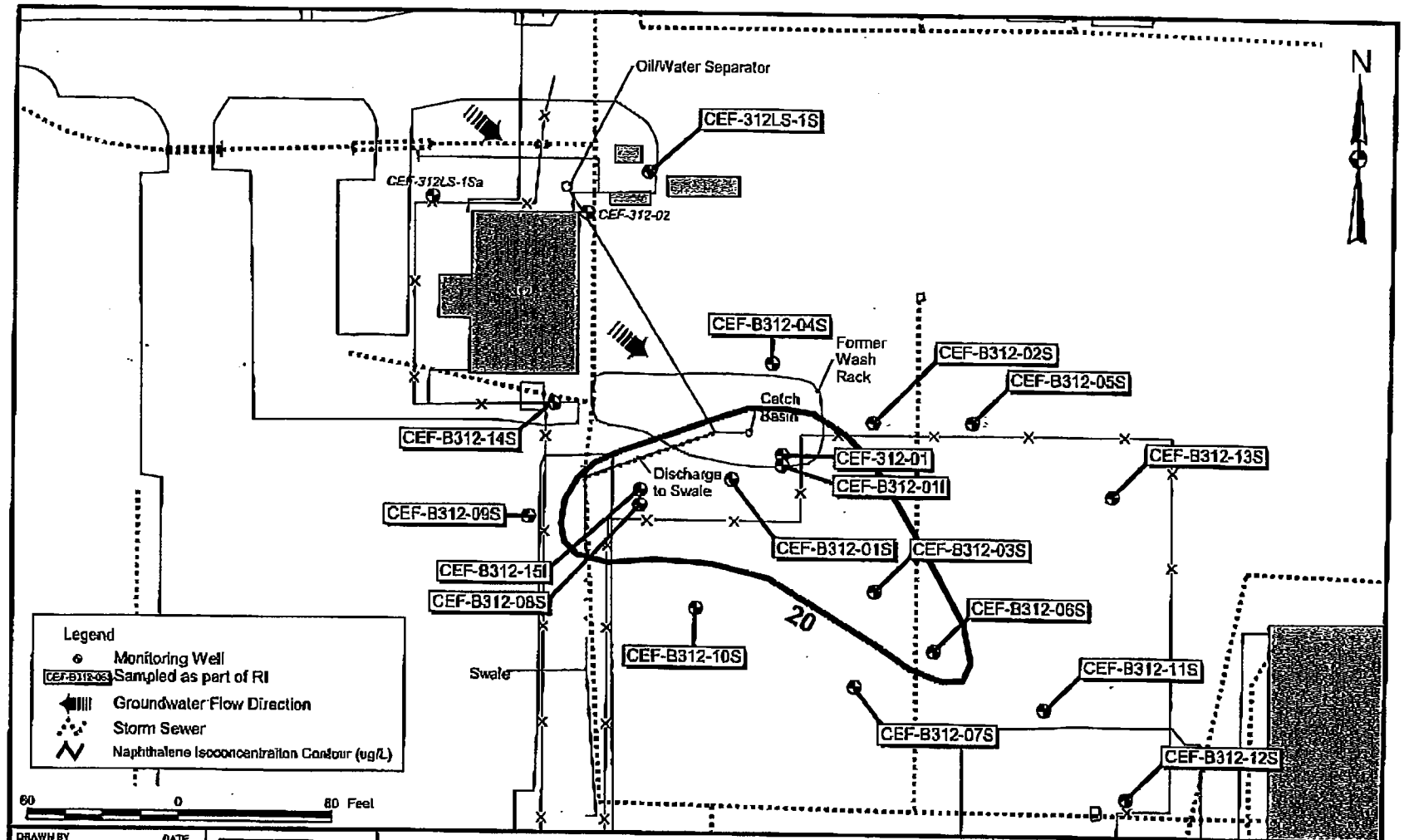
March 11, 2002

Regenesis appreciates the opportunity to provide this information for your project. Please feel free to contact us with any questions or comments.

Sincerely,

David C. Reilly
Applications Engineer

Attachments



DRAWN BY	DATE
MJJ	14Feb02
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

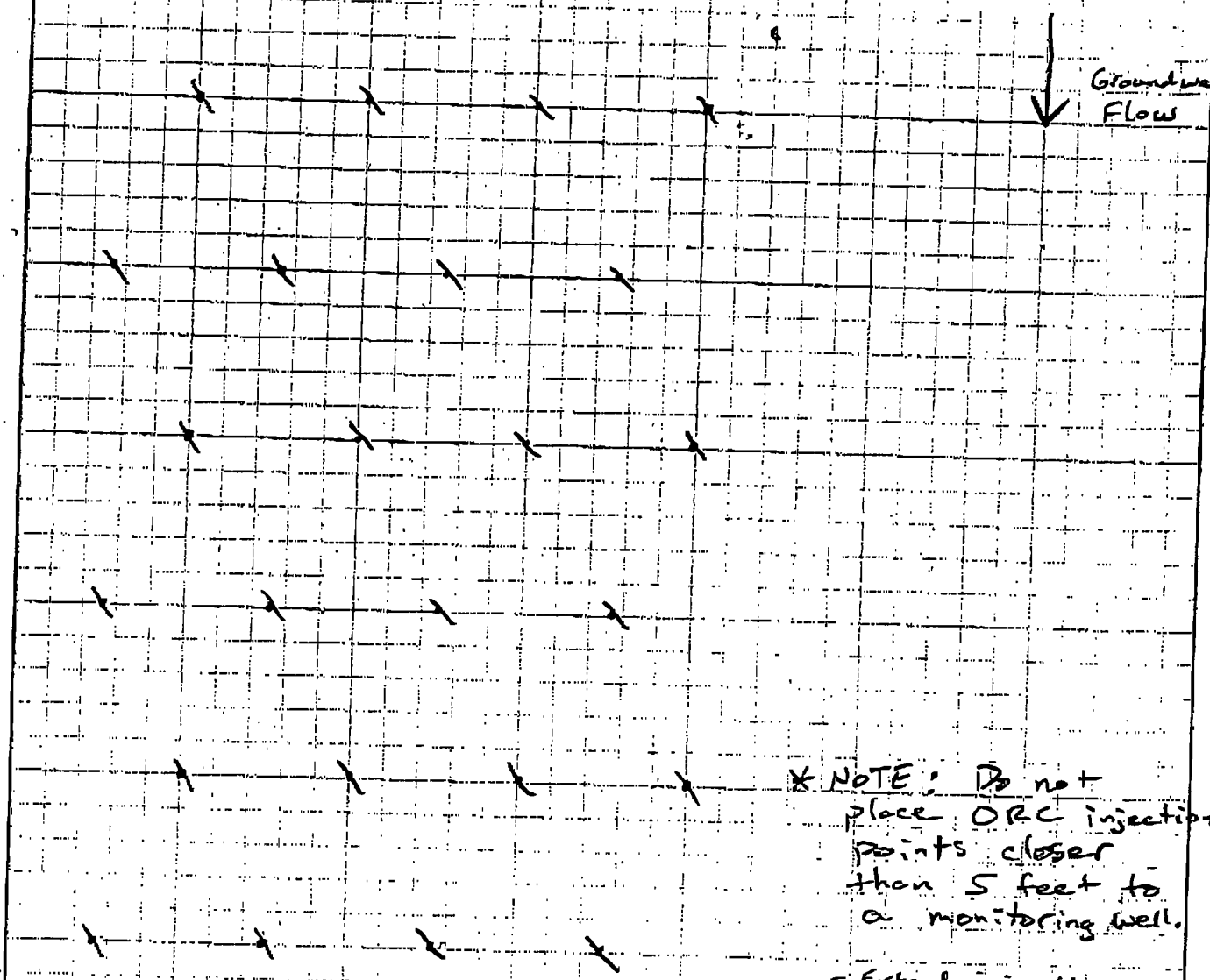
NAPHTHALENE ISOCONCENTRATION CONTOURS - SHALLOW AQUIFER
OU 9, SITE 58 - BUILDING 312
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NUMBER 0039	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE	REV 0

P:\GIS\NAS_Cecil\fgdc\site-58.apr 14Feb02 MJJ Layout

STAEDTLER® No. 937 811E Engineer's Computation Pad

ORC Injection Grid Layout



* NOTE: Do not place ORC injection points closer than 5 feet to a monitoring well.

- Extend injection point layout over the entire grid.

Legend

ORC Injection Point

0 — 10 feet

Scale

C.4 GROUNDWATER ALTERNATIVE 4 AS TREATMENT

1.0 TREATMENT SCHEME

Groundwater Alternative 4 would consist of three (3) air sparging (AS) systems, including one system each to treat the Site 57 Petroleum Plume, Site 57 TCE Plume, and Site 58 Naphthalene Plume. Each AS system would feature the following elements:

- AS well array
- AS compressor system

Typical remedial action duration for AS systems ranges from one to five years. For the purpose of this FS, it is assumed that remedial action duration would be three years.

2.0 AS WELL ARRAYS

Based upon results of pilot tests and full-scale systems operation at similar NAS Cecil Field sites (Sites 3 & 16), the typical radius of influence (ROI) of AS wells is approximately 30 ft. This ROI is used for the Site 57 TCE Plume and the deeper portion of the Site 57 Petroleum Plume. For the shallower portion of the Site 57 Petroleum Plume and the Site 58 Naphthalene Plume, an ROI of 20 ft is selected instead to account for reduced depth.

Area of influence per deep AS well: $(30)^2 \times \pi = 2{,}827\ ft^2$, rounded down to $2{,}500\ ft^2$ for overlap

Area of influence per shallow AS well: $(20)^2 \times \pi = 1{,}257\ ft^2$, rounded down to $1{,}000\ ft^2$ for overlap

2.1 AS Well Array No. 1: Site 57 Petroleum Plume

AS wells will be installed at two different depths (AS Well Arrays Nos. 1.1 & 1.2), corresponding to the Site 57 Petroleum Plume thickness determined in Appendix B.2 (Section 2.1.2):

- AS Well Array No. 1.1 would be installed to a depth of 25 ft bgs in the areas with benzene concentrations greater than 100 μg/L and concentrations from 100 to 10 μg/L.

- AS Well Array No. 1.2 would be installed to a depth of 50 ft bgs in the area with benzene concentrations from 10 to 1 μg/L.

Number of wells in AS Well Array No. 1.1: $(12{,}640\ ft^2 + 58{,}435\ ft^2) \div 1{,}000\ ft^2 = 71$ wells

Number of wells in AS Well Array No. 1.2: $65{,}780\ ft^2 \div 2{,}500\ ft^2/well = 26$ wells

⇒ The total number of AS wells for AS Well Array No. 1 would be 97, including 71 wells installed to 25 ft bgs (AS Well Array No. 1.1) and 26 wells installed to 50 ft bgs (AS Well Array No. 1.2).

2.2 AS Well Array No. 2: Site 57 TCE Plume

AS Well Array No. 2 would be installed to a depth of 65 ft bgs based upon the Site 57 TCE Plume thickness determined in Appendix B.2 (Section 2.2.2).

Number of wells in the AS Well Array No. 2: $47{,}800\ ft^2 \div 2{,}500\ ft^2/well = 19$ wells

⇒ The total number of AS wells for AS Well Array No. 2 would be 19, all of them installed to 65 ft bgs.

2.3 AS Well Array No. 3: Site 58 Naphthalene Plume

AS Well Array No. 3 would be installed to a depth of 25 ft bgs based upon the Site 58 Naphthalene Plume thickness determined in Appendix B.2 (Section 2.3.2):

Number of wells in AS Well Array No. 3: 15,575 ft^2 ÷ 1,000 ft^2/well = 16 wells

⇒ The total number of AS wells for AS Well Array No. 3 would be 16, all of them installed to 25 ft bgs.

3.0 AS COMPRESSOR SYSTEMS

Based upon results of pilot tests at similar NAS Cecil Field sites the typical air sparging flow is approximately 10 cfm per well.

For each AS System, an individual AS Compressor System would supply air to the AS Well Array installed at a given depth.

3.1 AS Compressor System No. 1: Site 57 Petroleum Plume

AS Compressor System No. 1 would feature two (2) compressors. One compressor (AS Compressor No. 1.1) would provide air to the 71 wells of AS Well Array No. 1.1he other (AS Compressor No. 1.2) would provide air to the 26 wells of AS Well Array No. 1.2.

Discharge rate of AS Compressor No. 1.1: 71 wells x 10 cfm/well = 710, say 750 cfm
Discharge rate of AS Compressor No. 1.2: 26 wells x 10 cfm/well = 260, say 300 cfm

Static head required for AS Compressor No. 1.1: 20 ft H_2O x 0.433 ft/psi = 8.7 psi
Static head required for AS Compressor No. 1.2: 50 ft H_2O x 0.433 ft/psi = 21.6 psi

To accommodate line friction losses, design compressor discharge pressure is approximately twice the required static head. AS Compressor No. 1.1 would be designed for a discharge head of 20 psi and AS Compressor No. 1.2 would be designed for a discharge head of 50 psi.

Each compressor would feature a pressure receiver tank providing a compressed air surge capacity to control compressor operation. Typically, such receiver tanks are sized to provide a few seconds detention time. For the AS compressor systems, receiver tanks are sized to provide 10 seconds detention time.

AS Compressor No. 1.1 receiver tank capacity: 750 cfm ÷ 60 sec/min x 10 sec x 7.5 gal/ft^3 = 937, say 1,000 gallons

AS Compressor No. 1.2 receiver tank capacity: 300 cfm ÷ 60 sec/min x 10 sec x 7.5 gal/ft^3 = 375, say 400 gallons

⇒ AS Compressor System No.1 would feature two (2) compressors. AS Compressor No. 1.1 would be rated for 750 cfm @ 20 psi and equipped with a 1,000-gallon receiver tank. AS Compressor No. 1.2 would be rated for 300 cfm @ 50 psi and equipped with a 400-gallon receiver tank.

3.2 AS Compressor System No. 2: Site 57 TCE Plume

AS Compressor System No. 2 would feature a single compressor (AS Compressor No. 2) to provide air to the 19 wells of AS Well Array No. 2.

Discharge rate of AS Compressor No. 2: 19 wells x 10 cfm/well = 190, say 200 cfm

Static head required for AS Compressor No, 2: 60 ft H_2O x 0.433 ft/psi = 26 psi

To accommodate line friction losses, AS Compressor No. 2 would be designed for a discharge head of 50 psi.

Receiver tank capacity: 200 cfm ÷ 60 sec/min x 10 sec x 7.5 gal/ft^3 = 250 gallons

⇒ AS Compressor System No.2 would feature a single compressor, AS Compressor No. 2, that would be rated for 200 cfm @ 50 psi and equipped with a 250-gallon receiver tank.

3.3 AS Compressor System No. 3: Site 58 Naphthalene Plume

AS Compressor System No. 3 would feature a single compressor (AS Compressor No. 3) to provide air to the 6 wells of AS Well Array No. 3.

Discharge rate of AS Compressor No. 3: 16 wells x 10 cfm/well = 160, say 200 cfm

Static head required for AS Compressor No. 3: 20 ft H_2O x 0.433 ft/psi = 8.7 psi

To accommodate line friction losses, AS Compressor No. 3 would be designed for a discharge head of 20 psi.

Receiver tank capacity: 200 cfm ÷ 60 sec/min x 10 sec x 7.5 gal/ft^3 = 250 gallons

⇒ AS Compressor System No.3 would feature a single compressor, AS Compressor No. 3, that would be rated for 200 cfm @ 20 psi and equipped with a 250-gallon receiver tank.

4.0 FUGITIVE EMISSIONS

4.1 Site 57

As per computations presented in Appendix C.2 (Sections 2.1.4 & 2.2.4), the total quantities of COCs for the Site 57 Petroleum and TCE Plumes are estimated as follows:

- BTEX: 20.43 + 1.88 = 22.31 pounds
- Chlorinated VOCs: 1.66 + 16.29 = 17.95 pounds
- PAHs: 15.78 + 1.7 = 17.48 pounds
- TRPH: 311.4 + 135.02 = 446.42 pounds
- Total COCs: 504.16 pounds

Of all these, it is assumed that 100% of the BTEX and chlorinated VOCs, 0% of the PAHs, and 50% of the TRPH will eventually be removed by stripping and generate fugitive emissions:

Total Fugitive Emissions: 22.31 + 17.95 + (0.5 x 446.42) = 263.5, say 300 pounds

It is assumed that 75% of these emissions will occur during the first year of operation of the AS treatment systems and that, within, that first year, half of of the emissions would occur during the first 30 days:

Maximum Daily Rate of Fugitive Emissions: 300 pounds x 0.75 x 0.5 ÷ 30 = 3.75 pounds per day

This well below the FDEPs deminimis level of 13.75 pounds per day; therefore, no fugitive emissions controls are required.

4.2 Site 58

As per computations presented in Appendix C.2 (Section 2.3.4), the total quantities of COCs for the Site 58 Naphthalene Plume are estimated as follows:

- BTEX: 0.07 pounds
- Chlorinated VOCs: 1.15 pounds
- PAHs: 0.51 pounds
- TRPH: 18.94 pounds
- Total COCs: 20.67 pounds

As for Site 57. it is assumed that, of all these, 100% of the BTEX and chlorinated VOCs, 0% of the PAHs, and 50% of the TRPH will eventually be removed by stripping and generate fugitive emissions:

Total Fugitive Emissions: 0.07 + 1.15 + (0.5 x 18.94) = 10.69, say 15 pounds

As with Site 57, it is assumed that 75% of these emissions will occur during the first year of operation of the AS treatment systems and that, within, that first year, half of of the emissions would occur during the first 30 days:

Maximum Daily Rate of Fugitive Emissions: 15 pounds x 0.75 x 0.5 ÷ 30 = 0.19 pounds per day

This well below the FDEPs deminimis level of 13.75 pounds per day; therefore, no fugitive emissions controls are required.

C.5 GROUNDWATER ALTERNATIVE 5 EXTRACTION AND ON-SITE TREATMENT

1.0 TREATMENT SCHEME

Groundwater Alternative 5 would consist of installing and operating two (2) "pump-and-treat" systems. Each of this systems would consist of an Extraction Wells (EW) System and an On-site Treatment System. EW System No. 1 and On-site Treatment System No. 1 would to extract and treat groundwater from the Site 57 Petroleum and TCE Plumes. EW System No. 2 and On-site Treatment System No. 2 would extract and treat groundwater from the Site 58 Naphthalene Plume. Each On-site treatment System would feature the following process units:

- Equalization
- Filtration
- Air Stripping (On-site Treatment System No. 1 only)
- Liquid-phase GAC Adsorption

According to the computations presented in Appendix A, EW System No. 1 and On-site Treatment System No. 1 could remove the Site 57 Petroleum and TCE Plumes within an estimated 12 years and EW System No. 2 and On-site Treatment System No. 2 could remove the Site 58 Naphthalene Plume within an estimated 3 years.

2.0 EW SYSTEMS

2.1 Extraction Wells and Pumping Rates

2.1.1 EW System No.1: Site 57 Petroleum and TCE Plumes

The design of the groundwater extraction wells and extraction rates for the Site 57 BTEX and TCE Plumes may be summarized as follows:

Well Number	Screened Depth (ft)	Extraction Rate (gpm)
EW-1 to EW-5	10-40	6.0
Total		30.0

Approximate locations of extraction wells are shown on Figure 4-9.

2.1.2 EW System No. 2: Site 58 Naphthalene Plume

The design of the groundwater extraction wells and extraction rates for the Site 58 Naphthalene Plume may be summarized as follows:

Well Number	Screened Depth (ft)	Extraction Rate (gpm)
EW-1 to EW-3	10-30	6.0
Total		18.0

Approximate locations of extraction wells are shown on Figure 4-10

2.2 Extracted Groundwater Quality

2.2.1 EW System No. 1: Site 57 Petroleum and TCE Plumes

Based on the estimates of average concentrations of COCs computed in Appendix B.2, the anticipated quality of the groundwater extracted by EW System No. 1 could be summarized as follows:

COC	Site 57 Petroleum Plume		Site 57 TCE Plume		Overall
	Average Concentration	Weigh Factor	Average Concentration	Weigh Factor	Avg. Concentration.
Benzene	30.4	0.61	1.8	0.39	19.2
Toluene	17.5	0.61	8.9	0.39	14.1
Ethylbenzene	38.2	0.61	4.6	0.39	25.1
Xylenes	136.3	0.61	16.8	0.39	89.7
1,1-DCA	4.2	0.61	32.3	0.39	15.1
1,1-DCE	7.7	0.61	2	0.39	5.5
1,2-DCE	3.0	0.61	220.9	0.39	89.0
TCE	3.0	0.61	23.0	0.39	10.8
1-Methylnaphthalene	40.1	0.61	4.5	0.39	26.2
2-Methylnaphthalene	44.3	0.61	4.5	0.39	28.8
Naphthalene	86.6	0.61	20.1	0.39	60.7
TRPH	3373	0.61	2304	0.39	2956

2.2.1 EW System No. 2: Site 58 Naphthalene Plume

Based on the estimates of average concentrations of COCs computed in Appendix B.2, the anticipated quality of the groundwater extracted by EW System No. 2 could be summarized as follows:

COC	Average Concentration
Xylenes	12.6
1,1-DCA	61.5
1,1-DCE	19.1
1,1,1-TCA	118.1
TRPH	3267

2.3 Groundwater Extraction Pumps Design

2.3.1 EW System No. 1: Site 57 Petroleum and TCE Plumes

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	**Pump Design**		
	Flow Rate (gpm)	**Total Discharge Head** (ft)	**Motor Size** (HP)
EW-1 to EW-5	7.5	100	0.5
Total	37.5		

2.3.2 EW System No. 2: Site 58 Naphthalene Plume

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	Pump Design		
	Flow Rate (gpm)	Total Discharge Head (ft)	Motor Size (HP)
EW-1 to EW-3	7.5	75	0.5
Total	22.5		

3.0 ON-SITE TREATMENT SYSTEMS

3.1 Equalization

Each On-site Treatment System would feature an equalization tank to blend groundwater from various extraction wells. Equalization tank would be equipped with a mixer and would feature a closed-top design to control VOCs emission. Equalization tank would be vented to the inlet of the air stripper blower. Equalization tank would be sized to provide 30 minutes detention under design flow conditions.

3.1.1 <u>On-site Treatment System No. 1: Site 57 Petroleum and TCE Plumes</u>

Equalization Tank Volume: 37.5 gallons/minute x 30 minutes = 1,125 , say 1,200 gallons

⇒ Call for a 5.5-foot diameter 8 feet high equalization tank with a working capacity of 1,200 gallons. Tank to be of cylindrical vertical configuration and manufactured of fiberglass or painted carbon steel. Tank to be of closed-top design with vent.

Mixer size @ 0.5 HP/1,000 gal: 1,200 gallons x 0.5 HP ÷ 1,000 gallons = 0.75 HP

⇒ Call for a top-mounted 3/4 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

⇒ Call for two (one spare) horizontal-centrifugal 40 gpm equalized groundwater transfer pumps (75 ft design TDH – 1.5 HP motor).

3.1.2 <u>On-site Treatment System No. 2: Site 58 Naphthalene Plume</u>

Equalization Tank Volume: 22.5 gallons/minute x 30 minutes = 675 , say 750 gallons

⇒ Call for a 5-foot diameter 6 feet high equalization tank with a working capacity of 750 gallons. Tank to be of cylindrical vertical configuration and manufactured of fiberglass or painted carbon steel. Tank to be of closed-top design with vent.

Mixer size @ 0.5 HP/1,000 gal: 750 gallons x 0.5 HP ÷ 1,000 gallons = 0.37 HP

⇒ Call for a top-mounted 1/3 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

⇒ Call for two (one spare) horizontal-centrifugal 25 gpm equalized groundwater transfer pumps (75 ft design TDH – 1/2 HP motor).

3.2 Filtration

Use bag type filter unit to avoid liquid residual stream from backwashing.

Size bag filter unit for replacement of filter bag element no more frequently than once a week.

3.2.1 <u>On-site Treatment System No. 1: Site 57 Petroleum and TCE Plumes</u>

Assuming approximately 10 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

37.5 gal/min x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(10 – 1) mg/l] x 10^{-6} = 28.4 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element, required surface of bag element is:

28.4 lbs ÷ 1.0 lbs/ft^2 = 28.4, say 30 ft^2

⇒ Call two (one spare) multi-bag pressurized filter unit with a total filter area of 30 ft^2

3.2.2 <u>On-site Treatment System No. 2: Site 58 Naphthalene Plume</u>

Assuming approximately 10 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

22.5 gal/min x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(10 – 1) mg/l] x 10^{-6} = 17 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element, required surface of bag element is:

17 lbs ÷ 1.0 lbs/ft^2 = 17, say 20 ft^2

⇒ Call two (one spare) multi-bag pressurized filter unit with a total filter area of 20 ft^2

3.3 Air Stripping (On-site Treatment System No. 1 Only)

Filtered groundwater would be treated in a low-profile multi-tray air stripper for the removal of most of the BTEX and chlorinated VOCs as well as some of the TRPH. According to the attached calculations sheet, the design of this air stripper may be summarized as follows:

Groundwater Flow:	37.5 gpm
Avg / Max VOCs In:	250 / 750 μg/L
Avg VOCs Out:	15 μg/L
VOCs Removal Efficiency:	98%

Avg / Max TRPH In:	3000 / 9000 μg/L
Avg TRPH Out:	2700 μg/L
TRPH Removal Efficiency:	10%
Air-to-Water Ratio:	50:1
No. of Stripper Trays:	4
Air Blower Flow:	300 cfm
Air Blower Discharge Pressure:	1.5 psi
Air Blower Motor Size:	3 HP

Air-stripped groundwater would be pumped from the sump of the air stripper to a liquid-phase GAC adsorption unit by one of two horizontal centrifugal pumps (one spare). Pump operation (start/stop) would be controlled by the liquid level in the air stripper sump.

⇒ Call for one low-profile multi-tray type air stripper Carbonair Model STAT 80 or equivalent with four (4) trays and a 300 cfm air blower.

⇒ Call for two (one spare) horizontal-centrifugal 40 gpm treated groundwater discharge pumps (100 ft design TDH - 2 HP motor).

Maximum quantity of VOCs and TRPH in air stripper offgas:

(750 μg/L x 0.98 + 9,000 μg/L x 0.1) x 37.5 gpm x 1,440 min/day x 8.34 lbs/gal x 10^{-9} = 0.736, say 0.75 pounds per day

This is well below the FDEP's deminimis level of 13.75 pounds per day; therefore, no offgas treatment system is required for the air stripper.

3.4 Liquid-Phase GAC Adsorption

The filtered and air-stripped (On-site Treatment System No. 1) or filtered (On-site Treatment System No. 2) groundwater would be treated in a liquid-phase granular activated carbon (GAC) system to remove residual BTEX and chlorinated VOCs, as well as PAHs and TRPH.

3.4.1 On-site Treatment System No. 1: Site 57 Petroleum and TCE Plumes

Quantities of COCs in filtered and air-stripped groundwater (from Appendix C.2):

- BTEX: (20.43 + 1.88) x 0.02 = 0.45 pounds
- Chlorinated VOCs: (1.66 + 16.29) x 0.02 = 0.36 pounds
- PAHs: 15.78 + 1.7 = 17.48 pounds
- TRPH: (311.4 + 135.02) x 0.9 = 401.78 pounds
- Total COCs: 420.07 pounds

It is assumed that approximately 15 pounds of GAC would be consumed for each pound of organic compound removed.

GAC required for COCs removal: 420.07 lbs COCs x 15 lbs GAC/lb COC = 6,301, say 6,500 pounds

Recommended GAC unit capacity to accommodate a liquid flow of 37.5 gpm is 900 lbs (see attached chart)

⇒ Call for a liquid-phase GAC adsorption system consisting of two (2) adsorption units (Carbonair Model PC 7F or equivalent) operating in series and each holding 900 lbs GAC. System to be designed such that either unit can be placed in the lead or lag position.

Estimated replacement frequency of lead GAC adsorption unit:
(6,500 lbs GAC use ÷ 900 lbs in lead GAC unit) – 1 (initial charge) = 6.2, say 7 times
Seven (7) changes required during the operating life of On-site Treatment System No. 1 (Years 0.5, 1, 2, 3, 5, 8, and 12).

3.4.2 On-site Treatment System No. 2: Site 58 Naphthalene Plume

Quantities of COCs in filtered groundwater (from Appendix C.2):

- BTEX: 0.07 pounds
- Chlorinated VOCs: 1.15 pounds
- PAHs: 0.51 pounds
- TRPH: 18.94 pounds
- Total COCs: 20.67 pounds

It is assumed that approximately 20 pounds of GAC would be consumed for each pound of organic compound removed.

GAC required for COCs removal: 20.67 lbs COCs x 20 lbs GAC/lb COC = 413 pounds

Recommended GAC unit capacity to accommodate a liquid flow of 25 gpm is 575 lbs (see attached chart)

⇒ Call for a liquid-phase GAC adsorption system consisting of two (2) adsorption units (Carbonair Model PC 5F or equivalent) operating in series and each holding 575 lbs GAC. System to be designed such that either unit can be placed in the lead or lag position.

Estimated replacement frequency of lead GAC adsorption unit:
(413 lbs GAC use ÷ 575 lbs in lead GAC unit) – 1 (initial charge) = - 0.28 times
No changes required during the operating life of On-site Treatment System No. 2.

STRIP
STAT MODEL CALCULATIONS
VERSION 4.1

03/25/02
07:53:21

CARBONAIR ENVIRONMENTAL SYSTEMS
2731 NEVADA AVENUE NORTH, NEW HOPE, MN 55427
PHONE: 612-544-2154 FAX: 612-544-2151

UNIT MODEL:	STAT 80	WATER TEMPERATURE (F):	60.0
WATER FLOW RATE (GPM):	37.5	AIR TEMPERATURE (F):	60.0
AIR FLOW RATE (ACFM):	300.0	AIR-TO-WATER RATIO:	60:1
OPERATING PRESS (ATM):	1.0	SAFETY FACTOR (%):	0.0

Influent Conc. for BENZENE 60.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	71.15089	17.3095	0.7115	0.0192
2	91.28228	5.2306	0.9128	0.0247
3	97.32980	1.6021	0.9733	0.0263
→ 4	99.17877	0.4927	0.9918	0.0268
5	99.74711	0.1517	0.9975	0.0269
6	99.92209	0.0467	0.9992	0.0270

Influent Conc. for TOLUENE 35.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	66.52314	11.7169	0.3881	0.0105
2	88.22501	4.1212	0.5146	0.0139
3	95.78869	1.4740	0.5588	0.0151
→ 4	98.48495	0.5303	0.5745	0.0155
5	99.45380	0.1912	0.5801	0.0157
6	99.80294	0.0690	0.5822	0.0157

Influent Conc. for ETHYLBENZENE 75.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	69.34808	22.9889	0.8669	0.0234
2	90.24474	7.3164	1.1281	0.0305
3	96.85904	2.3557	1.2107	0.0327
→ 4	98.98494	0.7613	1.2373	0.0334
5	99.67157	0.2463	1.2459	0.0337
6	99.89369	0.0797	1.2487	0.0337

Influent Conc. for XYLENES (TOTAL) 270.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	70.12546	80.6613	3.1556	0.0852
2	90.75028	24.9743	4.0838	0.1103
3	97.10512	7.8162	4.3697	0.1180
→ 4	99.09096	2.4544	4.4591	0.1204
5	99.71425	0.7715	4.4871	0.1212
6	99.91015	0.2426	4.4960	0.1214

Influent Conc. for 1,2-DICHLOROETHENE (CIS) 270.0 ppb

STRIP

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	66.68838	89.9414	3.0010	0.0811
2	88.22554	31.7910	3.9701	0.1072
3	95.75440	11.4631	4.3089	0.1164
4	98.45829	4.1626	4.4306	0.1197
5	99.43873	1.5154	4.4747	0.1209
6	99.79548	0.5522	4.4908	0.1213

Influent Conc. for TRICHLOROETHENE 33.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	75.14780	8.2012	0.4133	0.0112
2	93.62730	2.1030	0.5150	0.0139
3	98.35301	0.5435	0.5409	0.0146
4	99.57349	0.1407	0.5477	0.0148
5	99.88949	0.0365	0.5494	0.0148
6	99.97136	0.0095	0.5498	0.0149

Influent Conc. for TOTAL VOCs 743.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	68.93416	230.8192	8.5363	0.2306
2	89.83357	75.5366	11.1244	0.3005
3	96.60100	25.2546	11.9624	0.3231
4	98.85033	8.5421	12.2410	0.3307
5	99.60799	2.9127	12.3348	0.3332
6	99.86545	0.9997	12.3667	0.3340

CARBONAIR®
ENVIRONMENTAL SYSTEMS

2731 Nevada Avenue North
New Hope, MN 55427
612-544-2154 phone 800-526-4999
612-544-2151 fax

On-Site Treatment System No. 2

On-Site Treatment System No. 1

SPECIFICATIONS

MODELS	PC 1	PC 3	PC 5	PC 5F	PC 7	PC 7F	PC 13	PC 20	PC 28	PC 50	PC 78
VESSEL DIAMETER	1.2 ft. (0.37 m)	1.8 ft. (0.55 m)	2.5 ft. (0.76 m)	2.5 ft. (0.76 m)	3 ft. (0.91 m)	3 ft. (0.91 m)	4 ft. (1.22 m)	5 ft. (1.52 m)	6 ft. (1.83 m)	8 ft. (2.44 m)	10 ft. (3.05 m)
OVERALL HEIGHT	3.9 ft. (1.19 m)	4.5 ft. (1.37 m)	7.5 ft. (2.23 m)	7.5 ft. (2.23 m)	8 ft. (2.23 m)	7.5 ft. (2.23 m)	8.5 ft. (2.29 m)	9 ft. (2.29 m)	12.5 ft. (4.57 m)	13.5 ft. (5.19 m)	18 ft. (5.64 m)
BED AREA	1.1 ft^2 (0.10 m^2)	2.4 ft^2 (0.22 m^2)	4.9 ft^2 (0.46 m^2)	4.9 $ft.^2$ (0.46 m^2)	7 ft^2 (0.65 m^2)	7 ft^2 (0.65 m^2)	12.6 ft^2 (1.2 m^2)	19.6 ft^2 (1.82 m^2)	28 ft^2 (2.6 m^2)	50 ft^2 (4.7 m^2)	78.5 ft^2 (7.3 m^2)
FLOW RANGE	0.5-10 gpm. (2-38 L/Min)	1-20 gpm. (4-76 L/Min)	3-35 gpm. (11-132 L/Min)	3-35 gpm. (11-132 L/Min)	4-70 gpm. (15-265 L/Min)	4-70 gpm. (15-265 L/Min)	6-100 gpm. (23-340 L/Min)	10-138 gpm. (38-522 L/Min)	14-200 gpm. (53-761 L/Min)	25-280 gpm. (95-1363 L/Min)	4-550 gpm. (150-2082 L/Min)
CARBON CAPACITY	90 lbs. (41 kg)	250 lbs. (114 kg)	575 lbs. (261 kg)	575 lbs. (261 kg)	900 lbs. (409 kg)	900 lbs. (409 kg)	1,500 lbs. (681 kg)	2,500 lbs. (1,135 kg)	5,000 lbs. (2,270 kg)	10,000 lbs. (4,540 kg)	20,000 lbs. (9,080 kg)
FITTINGS	Two 1" influent/ effluent connections	Two 1" influent/ effluent connections	Two 2" influent/ effluent flanges (2) 6" x 8" access ports	Two 2" influent/ effluent flanges	Two 2" influent/ effluent flanges (2) 6" x 8" access ports	Two 2" influent/ effluent flanges	Two 2" influent/ effluent flanges, (2) 12" x 16" access ports One 3" air pressure relief coupling	Two 3" influent/ effluent flanges, (2) 12" x 16" access ports One 3" air pressure relief coupling	Two 4" influent/ effluent flanges, (2) 12" x 16" access ports, (2) 4" carbon slurry flanges	Two 6" influent/ efflent flanges, (2) 12" x 16" access ports, (2) 4" carbon slurry flanges	Two 6" influent/ effluent flanges (2) 12" x 16" access ports, (2) 4" carbon slurry flanges
DESIGN PRESSURE	150 psi	150 psi	100 psi	150 psi	90 psi	150 psi	90 psi, optional ASME inspected and stamped relief coupling	75 psi, optional ASME inspected and stamped relief coupling	75 psi, optional ASME inspected and stamped	75 psi, optional ASME inspected	70 psi, optional ASME inspected
EMPTY WEIGHT	23 lbs. (10 kg)	53 lbs. (24 kg)	1,200 lbs. (545 kg)	250 lbs. (114 kg)	1,400 lbs. (635 kg)	300 lbs. (139 kg)	1,510 lbs. (686 kg)	2,100 lbs. (953 kg)	4,000 lbs. (1,816 kg)	8,100 lbs. (3,677 kg)	10,900 lbs. (4,949 kg)
LOADED WEIGHT	130 lbs. (59 kg)	320 lbs. (145 kg)	1,775 lbs. (806 kg)	825 lbs. (375 kg)	2,300 lbs. (1,044 kg)	1,200 lbs. (545 kg)	3,010 lbs. (1,367 kg)	4,600 lbs. (2,088 kg)	9,000 lbs. (1,816 kg)	18,100 lbs. (8,217 kg)	30,000 lbs. (13,620 kg)
OPERATING WEIGHT	290 lbs. (132 kg)	775 lbs. (352 kg)	2,830 lbs. (1,285 kg)	1,900 lbs. (862 kg)	3,730 lbs. (1,693 kg)	2,250 lbs. (1,021 kg)	5,750 lbs. (2,610 kg)	9,476 lbs. (4,302 kg)	24,000 lbs. (10,896 kg)	36,500 lbs. (16,571 kg)	67,900 lbs. (30,827 kg)
SPENT & DRAINED WEIGHT	215 lbs. (98 kg)	560 lbs. (254 kg)	2,350 lbs. (1,067 kg)	1,400 lbs. (635 kg)	3,200 lbs. (1,453 kg)	1,750 lbs. (794 kg)	4,510 lbs. (2,048 kg)	7,100 lbs. (3,233 kg)	14,000 lbs. (6,356 kg)	28,100 lbs. (12,557 kg)	50,900 lbs. (23,109 kg)

Product Data Sheet EE203-97
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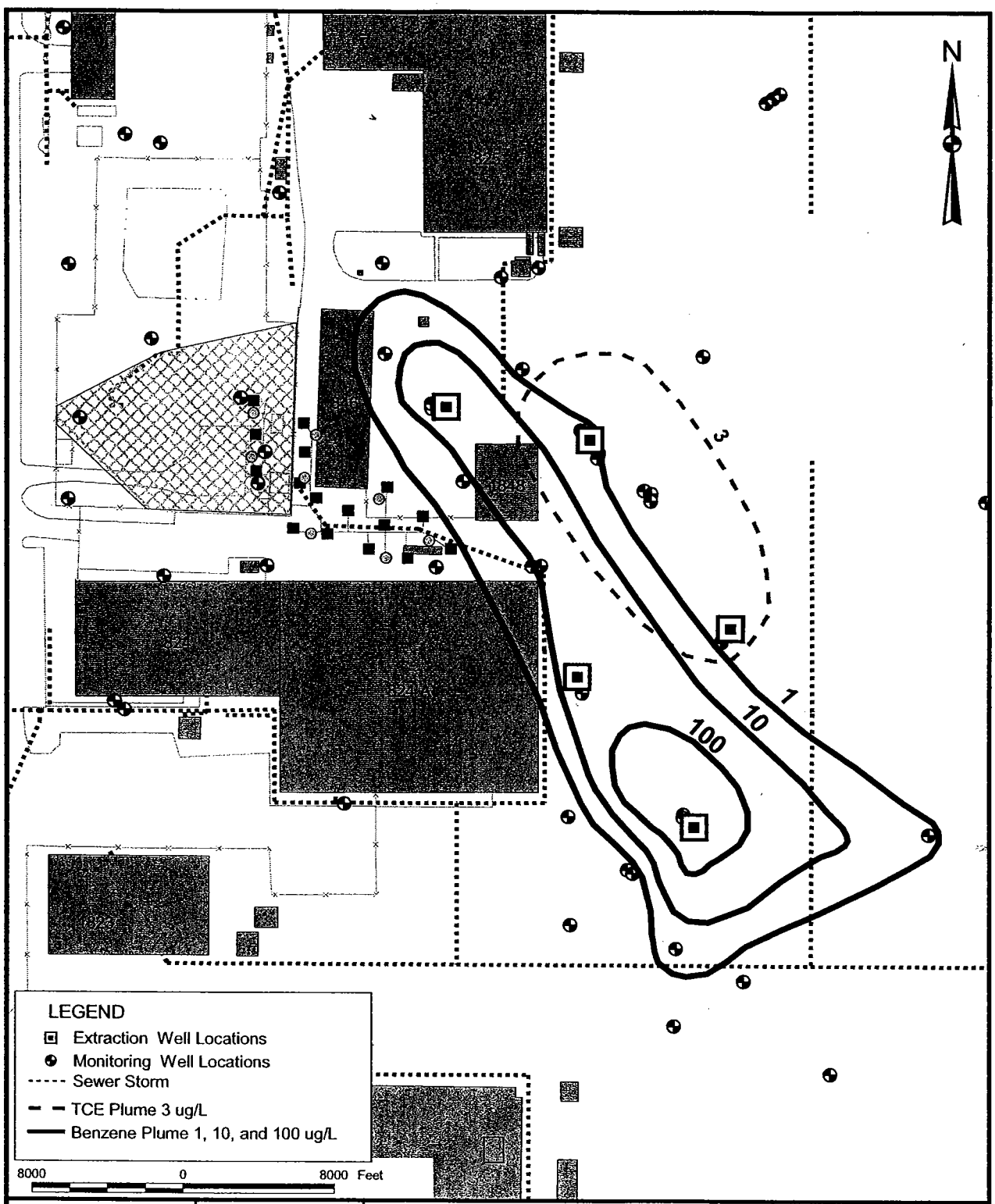

DRAWN BY MJJ	DATE 24Jan02	EXTRACTION WELL LOCATIONS, SITE 57 OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-9 REV 0

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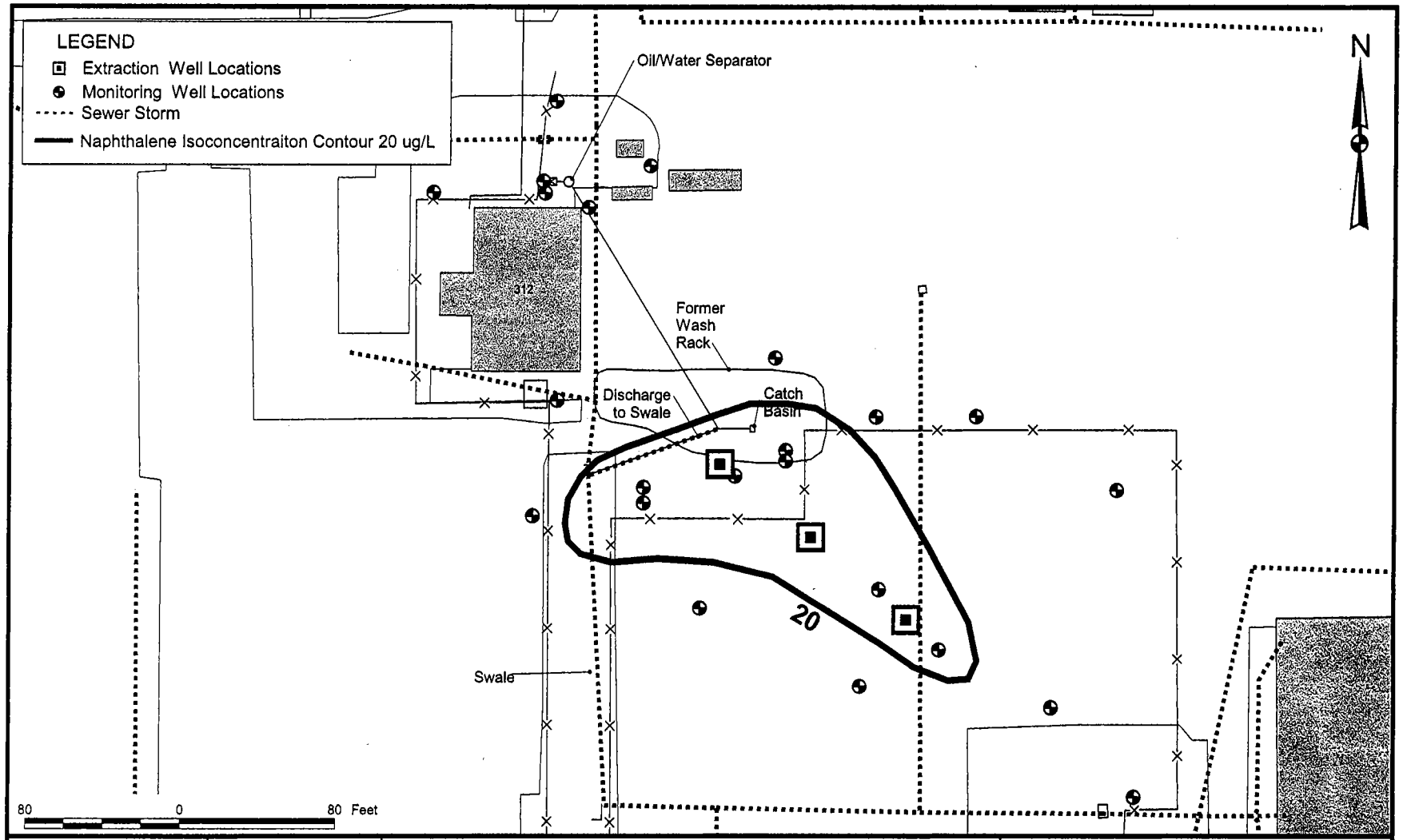

DRAWN BY MJJ	DATE 25Mar02	EXTRACTION WELL LOCATIONS, SITE 57 OU 9, SITES 57 & 58 - FEASIBILITY STUDY NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY —	DATE —		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-10 REV 0

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APPENDIX D

DETAILED COST ESTIMATES

D.1 SOIL ALTERNATIVE 2

D.2 SOIL ALTERNATIVE 3

D.3 GROUNDWATER ALTERNATIVE 2

D.4 GROUNDWATER ALTERNATIVE 3

D.5 GROUNDWATER ALTERNATIVE 4

D.6 GROUNDWATER ALTERNATIVE 5

D.1 SOIL ALTERNATIVE 2

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Soil Remedial Alternative 2: Institutional Controls and Monitoring
Capital Cost

8/20/2002 10:48 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 INSTITUTION CONTROLS											
1.1 Prepare Deed Restrictions & LUC	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
2 SITE CONTROL											
2.1 Fence Removal	280	lf	$2.15				$602	$0	$0	$0	$602
2.2 Fence Disposal	12	cy	$11.95				$143	$0	$0	$0	$143
2.3 Chain Link Fence, 6' high	280	lf	$25.50				$7,140	$0	$0	$0	$7,140
2.4 Fence Gate, 12' wide	1	ea	$1,100.00				$1,100	$0	$0	$0	$1,100
2.5 Warning Sign	4	ea	$44.82				$179	$0	$0	$0	$179
Subtotal							$9,165	$0	$3,000	$0	$12,165
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$9,165	$0	$2,640	$0	$11,805
Overhead on Labor Cost @ 30%									$792		$792
G & A on Labor Cost @ 10%									$264		$264
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$916				$916
Total Direct Cost							$10,081	$0	$3,696	$0	$13,777
Indirects on Total Direct Cost @ 20%											$2,755
Profit on Total Direct Cost @ 10%											$1,378
Subtotal											$17,910
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$17,910
Contingency on Total Field Costs @ 10%											$1,791
Engineering on Total Field Cost @ 0%											$0
TOTAL CAPITAL COST											**$19,701**

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Soil Remedial Alternative 2: Institutional Controls and Monitoring
Annual Cost

Item	Item Cost years 1 to 30	Item Cost every 5 years	Notes
LUC Inspection and Sampling	$800		Labor, Field Supplies, Local Travel
Analysis/Water	$156		Analyze one groundwater sample for PAHs including blanks and duplicates. Monitor for 30 years.
Analysis/Soil	$156		Analyze one surface soil sample for PAHs including blanks and duplicates. Monitor for 30 years.
Report	$2,000		Document site inspections, sampling events and results.
Site Review		$7,500	Perform 5-Year review (10% of total cost)
TOTALS	$3,112	$7,500	

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Soil Remedial Alternative 2: Institutional Controls and Monitoring
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$19,701		$19,701	1.000	$19,701
1		$3,112	$3,112	0.935	$2,910
2		$3,112	$3,112	0.873	$2,717
3		$3,112	$3,112	0.816	$2,539
4		$3,112	$3,112	0.763	$2,374
5		$10,612	$10,612	0.713	$7,566
6		$3,112	$3,112	0.666	$2,073
7		$3,112	$3,112	0.623	$1,939
8		$3,112	$3,112	0.582	$1,811
9		$3,112	$3,112	0.544	$1,693
10		$10,612	$10,612	0.508	$5,391
11		$3,112	$3,112	0.475	$1,478
12		$3,112	$3,112	0.444	$1,382
13		$3,112	$3,112	0.415	$1,291
14		$3,112	$3,112	0.388	$1,207
15		$10,612	$10,612	0.362	$3,842
16		$3,112	$3,112	0.339	$1,055
17		$3,112	$3,112	0.317	$987
18		$3,112	$3,112	0.296	$921
19		$3,112	$3,112	0.277	$862
20		$10,612	$10,612	0.258	$2,738
21		$3,112	$3,112	0.242	$753
22		$3,112	$3,112	0.226	$703
23		$3,112	$3,112	0.211	$657
24		$3,112	$3,112	0.197	$613
25		$10,612	$10,612	0.184	$1,953
26		$3,112	$3,112	0.172	$535
27		$3,112	$3,112	0.161	$501
28		$3,112	$3,112	0.150	$467
29		$3,112	$3,112	0.141	$439
30		$10,612	$10,612	0.131	$1,390
				TOTAL PRESENT WORTH	**$74,488**

D.2 SOIL ALTERNATIVE 3

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
Sites 57 & 58
Soil Remedial Alternative 3: Excavation and Offsite Disposal
Capital Cost

8/20/2002 9:46 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING/FIELD MANAGEMENT											
1.1 Prepare Construction Completion Report	50	hr			$30.00		$0	$0	$1,500	$0	$1,500
1.2 Field Construction Mgt. (3p * 5 days/week)	2	mwk			$2,400.00		$0	$0	$4,800	$0	$4,800
2 DECONTAMINATION											
2.1 Decontamination Services	0.5	mo	$3,400.00				$1,700	$0	$0	$0	$1,700
3 EXCAVATION AND SITE RESTORATION											
3.1 Excavate Ditch, (level D)	180	cy			$5.77	$2.01	$0	$0	$1,039	$362	$1,400
3.2 Import Fill	135	cy		$7.50			$0	$1,013	$0	$0	$1,013
3.3 Place/Grade/Compact Fill	135	cy			$0.43	$1.00	$0	$0	$58	$135	$193
3.4 Import Topsoil, 6" thick	45	cy		$10.00			$0	$450	$0	$0	$450
3.5 Place/Grade Topsoil	45	cy			$0.33	$0.74	$0	$0	$15	$33	$48
3.6 Erosion Control Matting	270	sy		$1.00	$0.23		$0	$270	$62	$0	$332
3.7 Revegetation	325	sy		$0.26	$1.16	$0.18	$0	$85	$377	$59	$520
4 TREATMENT AND DISPOSAL											
4.1 Waste Characterization Testing (TCLP),1 per 1000 cy	1	ea	$785.00	$5.00	$30.00		$785	$5	$30	$0	$820
4.2 Off-Site Transportation & Disposal	180	cy	$40.00				$7,200	$0	$0	$0	$7,200
Subtotal							$9,685	$1,822	$7,881	$589	$19,976
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$9,685	$2,196	$6,935	$518	$19,333
Overhead on Labor Cost @ 30%									$2,080		$2,080
G & A on Labor Cost @ 10%									$693		$693
G & A on Material Cost @ 10%								$220			$220
G & A on Subcontract Cost @ 10%							$969				$969
Total Direct Cost							$10,654	$2,415	$9,709	$518	$23,295
Indirects on Total Direct Cost @ 20%		(excluding transportation & disposal cost)									$3,055
Profit on Total Direct Cost @ 10%											$2,330
Subtotal											$28,680
Health & Safety Monitoring @ 2%											$574
Total Field Cost											$29,254
Contingency on Total Field Costs @ 10%											$2,925
Engineering on Total Field Cost @ 0%											$0
TOTAL CAPITAL COST											**$32,179**

D.3 GROUNDWATER ALTERNATIVE 2

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring
Capital Cost

8/20/2002 10:52 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 INSTITUTION CONTROLS											
1.1 Prepare Deed Restrictions & LUC	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
Subtotal							$0	$0	$3,000	$0	$3,000
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$0	$0	$2,640	$0	$2,640
Overhead on Labor Cost @ 30%									$792		$792
G & A on Labor Cost @ 10%									$264		$264
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$0				$0
Total Direct Cost							$0	$0	$3,696	$0	$3,696
Indirects on Total Direct Cost @ 0%											$0
Profit on Total Direct Cost @ 10%											$370
Subtotal											$4,066
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$4,066
Contingency on Total Field Costs @ 20%											$813
Engineering on Total Field Cost @ 0%											$0
TOTAL CAPITAL COST											**$4,879**

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring
Annual Cost

Item	Item Cost year 1	Item Cost years 2 and 3	Item Cost years 4 to 5	Item Cost years 6 to 20	Item Cost every 5 years	Notes
LUC Inspection and Sampling	$44,000	$22,000	$11,000	$7,700		Labor, Field Supplies, Local Travel
Analysis/Water(1) (Performance)	$61,488	$30,744	$15,372	$4,352		Analyze twelve groundwater sample for TCL VOCs, TCL SVOCs, TRPH, natural attenuation, and including blanks and duplicates for years 1 through 5. Analyze eight groundwater sample for TCL VOCs, TCL SVOCs, TRPH, and including blanks and duplicates for years 6 through 20.
Analysis/Water(1) (Migration)	$23,936	$11,968	$5,984	$4,353		Analyze eleven groundwater sample for TCL VOCs, TCL SVOCs, and TRPH including blanks and duplicates for years 1 through 5. Analyze eight groundwater sample for TCL VOCs, TCL SVOCs, TRPH, and including blanks and duplicates for years 6 through 20.
Report	$32,000	$16,000	$8,000	$8,000		Document site inspections, sampling events and results.
Site Review					$7,500	Perform 5-Year review (10% of the total cost)
TOTALS	$161,424	$80,712	$40,356	$24,405	$7,500	

(1) Sampling frequency will occur quarterly the first year, semi-annual for years 2 & 3, and annually for years 4 through 20.

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,879		$4,879	1.000	$4,879
1		$161,424	$161,424	0.935	$150,931
2		$80,712	$80,712	0.873	$70,462
3		$80,712	$80,712	0.816	$65,861
4		$40,356	$40,356	0.763	$30,792
5		$47,856	$47,856	0.713	$34,121
6		$24,405	$24,405	0.666	$16,254
7		$24,405	$24,405	0.623	$15,204
8		$24,405	$24,405	0.582	$14,204
9		$24,405	$24,405	0.544	$13,276
10		$31,905	$31,905	0.508	$16,208
11		$24,405	$24,405	0.475	$11,592
12		$24,405	$24,405	0.444	$10,836
13		$24,405	$24,405	0.415	$10,128
14		$24,405	$24,405	0.388	$9,469
15		$31,905	$31,905	0.362	$11,550
16		$24,405	$24,405	0.339	$8,273
17		$24,405	$24,405	0.317	$7,736
18		$24,405	$24,405	0.296	$7,224
19		$24,405	$24,405	0.277	$6,760
20		$31,905	$31,905	0.258	$8,231
				TOTAL PRESENT WORTH	**$523,992**

D.4 GROUNDWATER ALTERNATIVE 3

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 3: In-situ Biological Treatment (ORC/HRC), Institutional Controls, and Monitoring
Capital Cost

8/20/2002 10:54 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS											
1.1 Prepare Construction Completion Report	50	hr			$30.00		$0	$0	$1,500	$0	$1,500
1.2 Prepare Deed Restrictions & LUC	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
2 MOBILIZATION/DEMOBILIZATION											
2.1 Construction Survey	1	ls	$2,400.00				$2,400	$0	$0	$0	$2,400
2.2 Equipment Mobilization/Demobilization	2	ea			$96.00	$396.00	$0	$0	$192	$792	$984
2.3 Field Construction Mgt. (3p * 5 days/week)	12	mwk			$2,400.00		$0	$0	$28,800	$0	$28,800
3 DECONTAMINATION											
3.1 Decontamination Services	3	mo	$1,000.00				$3,000	$0	$0	$0	$3,000
3.2 Temporary Equipment Decon Pad	1	ls		$1,500.00	$2,000.00	$200.00	$0	$1,500	$2,000	$200	$3,700
3.3 Decon Water	3,000	gal		$0.20			$0	$600	$0	$0	$600
3.4 Decon Water Storage Tank, 6,000 gallon	3	mo				$600.00	$0	$0	$0	$1,800	$1,800
3.5 Clean Water Storage Tank, 4,000 gallon	3	mo				$540.00	$0	$0	$0	$1,620	$1,620
3.6 PPE (4 p * 5 days * 12 weeks)	240	day		$30.90			$0	$7,416	$0	$0	$7,416
3.7 Disposal of Decon Waste (liquid & solid)	3	mo	$900.00				$2,700	$0	$0	$0	$2,700
4 IN-SITU BIOLOGICAL TREATMENT											
4.1 Treatability Study	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
4.2 Subcontractor's Mobilization & Demobilization	1	ea	$2,750.00				$2,750	$0	$0	$0	$2,750
4.3 Probe/Pump/Injection Subcontractor	45	day	$2,000.00				$90,000	$0	$0	$0	$90,000
4.4 Core & Repair Injection Points	318	ea		$16.27	$47.97	$9.71	$0	$5,174	$15,254	$3,088	$23,516
4.5 ORC Cost (26,760 lb. + 10%)	29,440	lb		$8.00			$0	$235,520	$0	$0	$235,520
4.6 HRC Cost (19,800 lb. + 10%)	21,780	lb		$5.50			$0	$119,790	$0	$0	$119,790
Subtotal							$110,850	$370,000	$50,746	$7,500	$539,096
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$110,850	$445,850	$44,657	$6,600	$607,957
Overhead on Labor Cost @ 30%									$13,397		$13,397
G & A on Labor Cost @ 10%									$4,466		$4,466
G & A on Material Cost @ 10%								$44,585			$44,585
G & A on Subcontract Cost @ 10%							$11,085				$11,085
Total Direct Cost							$121,935	$490,435	$62,520	$6,600	$681,489
Indirects on Total Direct Cost @ 30%											$204,447
Profit on Total Direct Cost @ 10%											$68,149
Subtotal											$954,085
Health & Safety Monitoring @ 2%											$19,082
Total Field Cost											$973,167
Contingency on Total Field Costs @ 20%											$194,633
Engineering on Total Field Cost @ 10%											$97,317
TOTAL CAPITAL COST											**$1,265,117**

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 3: In-situ Biological Treatment (ORC/HRC), Institutional Controls, and Monitoring
Annual Cost

Item	Item Cost year 1	Item Cost years 2 and 3	Item Cost years 4 and 5	Item Cost every 5 years	Notes
LUC Inspection and Sampling	$44,000	$22,000	$11,000		Labor, Field Supplies, Local Travel
Analysis/Water(1) (Performance)	$61,488	$30,744	$15,372		Analyze twelve groundwater sample for TCL VOCs, TCL SVOCs, TRPH, natural attenuation and including blanks and duplicates for years 1 through 5.
Analysis/Water(1) (Migration)	$23,936	$11,968	$5,984		Analyze eleven groundwater sample for TCL VOCs, TCL SVOCs, TRPH including blanks and duplicates. Monitor for 5 years.
Report	$32,000	$16,000	$8,000		Document site inspections, sampling events and results.
Site Review				$7,500	Perform 5-Year review (10% of total cost)
TOTALS	$161,424	$80,712	$40,356	$7,500	

(1) Sampling frequency will occur quarterly the first year, semi-annual for years 2 & 3, and annually for years 4 & 5.

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 3: In-situ Biological Treatment (ORC/HRC), Institutional Controls, and Monitoring
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$1,265,117		$1,265,117	1.000	$1,265,117
1		$161,424	$161,424	0.935	$150,931
2		$80,712	$80,712	0.873	$70,462
3		$80,712	$80,712	0.816	$65,861
4		$40,356	$40,356	0.763	$30,792
5		$47,856	$47,856	0.713	$34,121
				TOTAL PRESENT WORTH	**$1,617,284**

D.5 GROUNDWATER ALTERNATIVE 4

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 4: AS Treatment, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS											
1.1 Prepare Construction Completion Report	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
1.2 Prepare Deed Restrictions & LUC	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
2 MOBILIZATION/DEMOBILIZATION											
2.1 Construction Survey	1	ls	$1,200.00				$1,200	$0	$0	$0	$1,200
2.2 Equipment Mobilization/Demobilization	5	ea			$96.00	$396.00	$0	$0	$480	$1,980	$2,460
2.3 Field Construction Mgt. (3p * 5 days/week)	26	mwk			$2,400.00		$0	$0	$62,400	$0	$62,400
3 DECONTAMINATION											
3.1 Decontamination Services	6	mo	$3,400.00				$20,400	$0	$0	$0	$20,400
3.2 Temporary Equipment Decon Pad	1	ls		$1,500.00	$2,000.00	$200.00	$0	$1,500	$2,000	$200	$3,700
3.3 Decon Water	6,000	gal		$0.20			$0	$1,200	$0	$0	$1,200
3.4 Decon Water Storage Tank, 6,000 gallon	6	mo				$600.00	$0	$0	$0	$3,600	$3,600
3.5 Clean Water Storage Tank, 4,000 gallon	6	mo				$540.00	$0	$0	$0	$3,240	$3,240
3.6 PPE (4 p * 5 days * 26 weeks)	520	day		$30.90			$0	$16,068	$0	$0	$16,068
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 AIR SPARGING SYSTEM NO. 1											
4.1 Core & Repair Pavement for Wells	97	ea		$16.27	$47.97	$9.71	$0	$1,578	$4,653	$942	$7,173
4.2 Install Air Sparging Wells (71 @ 25' & 26 @ 50')	3,075	lf	$30.00				$92,250	$0	$0	$0	$92,250
4.3 Well Covers	97	ea	$97.50				$9,458	$0	$0	$0	$9,458
4.4 Well Development	97	ea	$75.00				$7,275	$0	$0	$0	$7,275
4.5 Collect/Containerize IDW	220	drum	$55.00				$12,100	$0	$0	$0	$12,100
4.6 Transport/Dispose IDW	220	drum	$170.00				$37,400	$0	$0	$0	$37,400
4.7 Installation Labor	245	hr	$50.00				$12,250	$0	$0	$0	$12,250
4.8 Concrete Removal/Replacement for 2" pipe	1,000	lf		$10.47	$7.27	$4.88	$0	$10,470	$7,270	$4,880	$22,620
4.9 Asphalt Removal/Replacement for 2" pipe	1,000	lf		$2.69	$7.62	$4.10	$0	$2,690	$7,620	$4,100	$14,410
4.10 Excavate/Backfill Pipe Trench for 2" pipe	2,000	lf			$0.26	$0.22	$0	$0	$520	$440	$960
4.11 PVC 2" Pressure Pipe	2,000	lf		$1.08	$1.05		$0	$2,160	$2,100	$0	$4,260
4.12 Concrete Removal/Replacement for 4" pipe	1,250	lf		$11.09	$7.86	$5.18	$0	$13,863	$9,825	$6,475	$30,163
4.13 Asphalt Removal/Replacement for 4" pipe	1,250	lf		$3.05	$8.48	$4.13	$0	$3,813	$10,600	$5,163	$19,575
4.14 Excavate/Backfill Pipe Trench for 4" pipe	2,500	lf			$0.29	$0.25	$0	$0	$725	$625	$1,350
4.15 PVC 4" Pressure Pipe	2,500	lf		$4.34	$2.20		$0	$10,850	$5,500	$0	$16,350
4.16 Concrete Removal/Replacement for 6" pipe	500	lf		$12.35	$8.99	$5.74	$0	$6,175	$4,495	$2,870	$13,540
4.17 Asphalt Removal/Replacement for 6" pipe	500	lf		$3.79	$10.24	$4.75	$0	$1,895	$5,120	$2,375	$9,390
4.18 Excavate/Backfill Pipe Trench for 6" pipe	1,000	lf			$0.32	$0.27	$0	$0	$320	$270	$590
4.19 PVC 6" Pressure Pipe	1,000	lf		$9.43	$2.66		$0	$9,430	$2,660	$0	$12,090
4.20 Small Equipment Building	1	ls	$9,750.00				$9,750	$0	$0	$0	$9,750
4.21 Electrical Service, 1000 A, 480 V	1	ea	$14,440.00				$14,440	$0	$0	$0	$14,440
4.22 Air Compressor, 750 cfm/50 hp, w/1000 gal tank	1	ea		$30,919.00	$488.00		$0	$30,919	$488	$0	$31,407
4.23 Air Compressor, 300 cfm/40 hp, w/400 gal tank	1	ea		$23,214.00	$366.00		$0	$23,214	$366	$0	$23,580
4.24 Instruments and Controls	1	ls		$8,500.00	$2,300.00		$0	$8,500	$2,300	$0	$10,800
4.25 Systems Start-up and Testing	1	ls		$1,000.00	$1,500.00		$0	$1,000	$1,500	$0	$2,500
5 AIR SPARGING SYSTEM NO. 2											
5.1 Core & Repair Pavement for Wells	19	ea		$16.27	$47.97	$9.71	$0	$309	$911	$184	$1,405
5.2 Install Air Sparging Wells (19 @ 65')	1,235	lf	$30.00				$37,050	$0	$0	$0	$37,050
5.3 Well Covers	19	ea	$97.50				$1,853	$0	$0	$0	$1,853
5.4 Well Development	19	ea	$75.00				$1,425	$0	$0	$0	$1,425
5.5 Collect/Containerize IDW	76	drum	$55.00				$4,180	$0	$0	$0	$4,180
5.6 Transport/Dispose IDW	76	drum	$170.00				$12,920	$0	$0	$0	$12,920
5.7 Installation Labor	48	hr	$50.00				$2,400	$0	$0	$0	$2,400
5.8 Concrete Removal/Replacement for 2" pipe	600	lf		$10.47	$7.27	$4.88	$0	$6,282	$4,362	$2,928	$13,572
5.9 Asphalt Removal/Replacement for 2" pipe	600	lf		$2.69	$7.62	$4.10	$0	$1,614	$4,572	$2,460	$8,646
5.10 Excavate/Backfill Pipe Trench for 2" pipe	1,200	lf			$0.26	$0.22	$0	$0	$312	$264	$576

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
5.11 PVC 2" Pressure Pipe	1,200	lf		$1.08	$1.05		$0	$1,296	$1,260	$0	$2,556
5.12 Concrete Removal/Replacement for 4" pipe	250	lf		$11.09	$7.86	$5.18	$0	$2,773	$1,965	$1,295	$6,033
5.13 Asphalt Removal/Replacement for 4" pipe	250	lf		$3.05	$8.48	$4.13	$0	$763	$2,120	$1,033	$3,915
5.14 Excavate/Backfill Pipe Trench for 4" pipe	500	lf			$0.29	$0.25	$0	$0	$145	$125	$270
5.15 PVC 4" Pressure Pipe	500	lf		$4.34	$2.20		$0	$2,170	$1,100	$0	$3,270
5.16 Small Equipment Building	1	ls	$9,750.00				$9,750	$0	$0	$0	$9,750
5.17 Electrical Service, 1000 A, 480 V	1	ea	$14,440.00				$14,440	$0	$0	$0	$14,440
5.18 Air Compressor, 400 cfm/40 hp, w/250 gal tank	1	ea		$21,357.00	$244.00		$0	$21,357	$244	$0	$21,601
5.19 Instruments and Controls	1	ls		$8,500.00	$2,300.00		$0	$8,500	$2,300	$0	$10,800
5.20 Systems Start-up and Testing	1	ls		$1,000.00	$1,500.00		$0	$1,000	$1,500	$0	$2,500
6 AIR SPARGING SYSTEM NO. 3											
6.1 Core & Repair Pavement for Wells	16	ea		$16.27	$47.97	$9.71	$0	$260	$768	$155	$1,183
6.2 Install Air Sparging Wells (16 @ 25')	400	lf	$30.00				$12,000	$0	$0	$0	$12,000
6.3 Well Covers	16	ea	$97.50				$1,560	$0	$0	$0	$1,560
6.4 Well Development	16	ea	$75.00				$1,200	$0	$0	$0	$1,200
6.5 Collect/Containerize IDW	32	drum	$55.00				$1,760	$0	$0	$0	$1,760
6.6 Transport/Dispose IDW	32	drum	$170.00				$5,440	$0	$0	$0	$5,440
6.7 Installation Labor	40	hr	$50.00				$2,000	$0	$0	$0	$2,000
6.8 Concrete Removal/Replacement for 2" pipe	200	lf		$10.47	$7.27	$4.88	$0	$2,094	$1,454	$976	$4,524
6.9 Asphalt Removal/Replacement for 2" pipe	200	lf		$2.69	$7.62	$4.10	$0	$538	$1,524	$820	$2,882
6.10 Excavate/Backfill Pipe Trench for 2" pipe	400	lf			$0.26	$0.22	$0	$0	$104	$88	$192
6.11 PVC 2" Pressure Pipe	400	lf		$1.08	$1.05		$0	$432	$420	$0	$852
6.12 Concrete Removal/Replacement for 4" pipe	250	lf		$11.09	$7.86	$5.18	$0	$2,773	$1,965	$1,295	$6,033
6.13 Asphalt Removal/Replacement for 4" pipe	250	lf		$3.05	$8.48	$4.13	$0	$763	$2,120	$1,033	$3,915
6.14 Excavate/Backfill Pipe Trench for 4" pipe	500	lf			$0.29	$0.25	$0	$0	$145	$125	$270
6.15 PVC 4" Pressure Pipe	500	lf		$4.34	$2.20		$0	$2,170	$1,100	$0	$3,270
6.16 Small Equipment Building	1	ls	$9,750.00				$9,750	$0	$0	$0	$9,750
6.17 Electrical Service, 1000 A, 480 V	1	ea	$14,440.00				$14,440	$0	$0	$0	$14,440
6.18 Air Compressor, 200 cfm/25 hp, w/250 gal tank	1	ea		$16,433.00	$366.00		$0	$16,433	$366	$0	$16,799
6.19 Instruments and Controls	1	ls		$8,500.00	$2,300.00		$0	$8,500	$2,300	$0	$10,800
6.20 Systems Start-up and Testing	1	ls		$1,000.00	$1,500.00		$0	$1,000	$1,500	$0	$2,500
Subtotal							$354,090	$226,350	$171,499	$49,940	$801,879
Local Area Adjustments							100.0%	99.9%	70.3%	88.0%	
							$354,090	$226,123	$120,564	$43,947	$744,725
Overhead on Labor Cost @ 30%									$36,169		$36,169
G & A on Labor Cost @ 10%									$12,056		$12,056
G & A on Material Cost @ 10%								$22,612			$22,612
G & A on Subcontract Cost @ 10%							$35,409				$35,409
Total Direct Cost							$389,499	$248,736	$168,789	$43,947	$850,971
Indirects on Total Direct Cost @ 35%											$297,840
Profit on Total Direct Cost @ 10%											$85,097
Subtotal											$1,233,908
Health & Safety Monitoring @ 2%											$24,678

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 4: AS Treatment, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Total Field Cost											$1,258,587
Contingency on Total Field Costs @ 20%											$251,717
Engineering on Total Field Cost @ 10%											$125,859
TOTAL CAPITAL COST											**$1,636,163**

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 4: AS Treatment, Institutional Controls, and Monitoring
Operation and Maintenance Cost

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
YEARS 1 and 2 (AS Systems 1, 2 & 3)						
1	Energy - Electric	1,013,000	kWh	$0.06	$60,780	
2	System Maintenance	1	ls	$14,008.05	$14,008	15% of Installation Cost
3	Sampling labor, travel & living, supplies	12	ea	$2,730	$32,760	2 at 2 day trip per month
4	Analysis of Offgas sampling	3	ea	$650	$1,950	BTEX, chlorinated VOCs one per year
5	Quarterly Reports	4	ea	$4,000	$4,000	
			O & M per year for years 1 & 2		**$113,498**	
YEAR 3 (AS Systems 1 & 2)						
1	Energy - Electric	850,000	kWh	$0.06	$51,000	
2	System Maintenance	1	ls	$11,488.20	$11,488	15% of Installation Cost
3	Sampling labor, travel & living, supplies	12	ea	$2,730	$32,760	2 at 2 day trip per month
4	Analysis of Offgas sampling	2	ea	$650	$1,300	BTEX, chlorinated VOCs one per year
5	Quarterly Reports	4	ea	$4,000	$4,000	
			O & M per year for year 3		**$100,548**	

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 4: AS Treatment, Institutional Controls, and Monitoring
Annual Cost

Item	Item Cost year 1	Item Cost years 2 and 3	Item Cost years 4 and 5	Item Cost every 5 years	Notes
LUC Inspection and Sampling	$44,000	$22,000	$11,000		Labor, Field Supplies, Local Travel
Analysis/Water(1) (Performance)	$26,112	$13,056	$6,528		Analyze twelve groundwater sample for TCL VOCs, TCL SVOCs, TRPH, and including blanks and duplicates for years 1 through 5.
Analysis/Water(1) (Migration)	$23,936	$11,968	$5,984		Analyze eleven groundwater sample for TCL VOCs, TCL SVOCs, and TRPH including blanks and duplicates. Monitor for 5 years.
Report	$32,000	$16,000	$8,000		Document site inspections, sampling events and results.
Site Review				$7,500	Perform 5-Year review (10% of total cost)
TOTALS	$126,048	$63,024	$31,512	$7,500	

(1) Sampling frequency will occur quarterly the first year, semi-annual for years 2 & 3, and annually for years 4 & 5.

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 4: AS Treatment, Institutional Controls, and Monitoring
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$1,636,163			$1,636,163	1.000	$1,636,163
1		$113,498	$126,048	$239,546	0.935	$223,976
2		$113,498	$63,024	$176,522	0.873	$154,104
3		$100,548	$63,024	$163,572	0.816	$133,475
4			$31,512	$31,512	0.763	$24,044
5			$39,012	$39,012	0.713	$27,816
					TOTAL PRESENT WORTH	**$2,199,576**

D.6 GROUNDWATER ALTERNATIVE 5

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS											
1.1 Prepare Construction Completion Report	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
1.2 Prepare Deed Restrictions & LUC	100	hr			$30.00		$0	$0	$3,000	$0	$3,000
2 MOBILIZATION/DEMOBILIZATION											
2.1 Construction Survey	1	ls	$500.00				$500	$0	$0	$0	$500
2.2 Equipment Mobilization/Demobilization	5	ea			$96.00	$396.00	$0	$0	$480	$1,980	$2,460
2.3 Field Construction Mgt. (3p * 5 days/week)	26	mwk			$2,400.00		$0	$0	$62,400	$0	$62,400
3 DECONTAMINATION											
3.1 Decontamination Services	6	mo	$3,400.00				$20,400	$0	$0	$0	$20,400
3.2 Temporary Equipment Decon Pad	1	ls		$1,500.00	$2,000.00	$200.00	$0	$1,500	$2,000	$200	$3,700
3.3 Decon Water	6,000	gal		$0.20			$0	$1,200	$0	$0	$1,200
3.4 Decon Water Storage Tank, 6,000 gallon	6	mo				$600.00	$0	$0	$0	$3,600	$3,600
3.5 Clean Water Storage Tank, 4,000 gallon	6	mo				$540.00	$0	$0	$0	$3,240	$3,240
3.6 PPE (4 p * 5 days * 26 weeks)	520	day		$30.90			$0	$16,068	$0	$0	$16,068
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 EW ARRAY NO. 1 (SITE 57)											
4.1 Core & Repair Pavement for Wells	5	ea		$16.27	$47.97	$9.71	$0	$81	$240	$49	$370
4.2 Install Wells (5 wells @ 40' deep)	200	lf	$65.00				$13,000	$0	$0	$0	$13,000
4.3 Well Covers	5	ea	$97.50				$488	$0	$0	$0	$488
4.4 Well Development (4 hours per well)	20	ea	$75.00				$1,500	$0	$0	$0	$1,500
4.5 Collect/Containerize IDW	20	drum	$55.00				$1,100	$0	$0	$0	$1,100
4.6 Transport/Dispose IDW	20	drum	$170.00				$3,400	$0	$0	$0	$3,400
4.7 Well Installation Labor	13	hr	$50.00				$650	$0	$0	$0	$650
4.8 Concrete Removal/Replacement for 4" pipe	1,000	lf		$11.09	$7.86	$5.18	$0	$11,090	$7,860	$5,180	$24,130
4.9 Asphalt Removal/Replacement for 4" pipe	1,000	lf		$3.05	$8.48	$4.13	$0	$3,050	$8,480	$4,130	$15,660
4.10 Excavate/Backfill Pipe Trench for 4" pipe	2,000	lf			$0.29	$0.25	$0	$0	$580	$500	$1,080
4.11 PVC 2"/4" Double-/Wall Pipe w/fittings	2,000	lf		$14.65	$14.65	$0.02	$0	$29,300	$29,300	$40	$58,640
4.12 Extraction Pump, 7.5 gpm, 0.5 HP w/controls	5	ea		$1,877.00	$154.00		$0	$9,385	$770	$0	$10,155
4.13 Vault Boxes and Misc. Piping/Valves at Well Head	5	ea		$399.50	$299.63		$0	$1,998	$1,498	$0	$3,496
4.14 Leak Detection Monitor	2,000	lf		$9.50	$4.75		$0	$19,000	$9,500	$0	$28,500
4.15 Leak Detection Loop	5	ea		$580.00	$1,109.00		$0	$2,900	$5,545	$0	$8,445
5 EW ARRAY NO. 2 (SITE 58)											
5.1 Core & Repair Pavement for Wells	3	ea		$16.27	$47.97	$9.71	$0	$49	$144	$29	$222
5.2 Install Wells (3 wells @ 30' deep)	90	lf	$65.00				$5,850	$0	$0	$0	$5,850
5.3 Well Covers	5	ea	$97.50				$488	$0	$0	$0	$488
5.4 Well Development (4 hours per well)	12	ea	$75.00				$900	$0	$0	$0	$900
5.5 Collect/Containerize IDW	12	drum	$55.00				$660	$0	$0	$0	$660
5.6 Transport/Dispose IDW	12	drum	$170.00				$2,040	$0	$0	$0	$2,040
5.7 Well Installation Labor	8	hr	$50.00				$400	$0	$0	$0	$400
5.8 Concrete Removal/Replacement for 4" pipe	250	lf		$11.09	$7.86	$5.18	$0	$2,773	$1,965	$1,295	$6,033
5.9 Asphalt Removal/Replacement for 4" pipe	250	lf		$3.05	$8.48	$4.13	$0	$763	$2,120	$1,033	$3,915
5.10 Excavate/Backfill Pipe Trench for 4" pipe	500	lf			$0.29	$0.25	$0	$0	$145	$125	$270
5.11 PVC 2"/4" Double-/Wall Pipe w/fittings	500	lf		$14.65	$14.65	$0.02	$0	$7,325	$7,325	$10	$14,660
5.12 Extraction Pump, 7.5 gpm, 0.5 HP w/controls	3	ea		$1,877.00	$154.00		$0	$5,631	$462	$0	$6,093
5.13 Vault Boxes and Misc. Piping/Valves at Well Head	3	ea		$399.50	$299.63		$0	$1,199	$899	$0	$2,097
5.14 Leak Detection Monitor	500	lf		$9.50	$4.75		$0	$4,750	$2,375	$0	$7,125
5.15 Leak Detection Loop	3	ea		$580.00	$1,109.00		$0	$1,740	$3,327	$0	$5,067
6 ON-SITE TREATMENT SYSTEM NO. 1 (SITE 57)											
6.1 Building Foundation	500	sf	$3.87				$1,935	$0	$0	$0	$1,935
6.2 Treatment Building	500	sf	$11.03				$5,515	$0	$0	$0	$5,515
6.3 Building Misc. (doors/vent/insulation/lighting/misc.)	1	ls	$5,725.00				$5,725	$0	$0	$0	$5,725
6.4 Electrical Service, 1000 A, 480 V	1	ea	$14,440.00				$14,440	$0	$0	$0	$14,440

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
6.5 Equalization Tank (1,200 gal)	1	ea		$1,370.20	$636.64		$0	$1,370	$637	$0	$2,007
6.6 Top Mounted Mixer (0.75 hp)	1	ea		$4,433.00	$73.20		$0	$4,433	$73	$0	$4,506
6.7 Centrifugal Transfer Pump, 40 gpm (1.5 hp)	2	ea		$2,520.00	$738.50		$0	$5,040	$1,477	$0	$6,517
6.8 Bag Filter, Dual-Element, 25-micron, 40 gpm	1	ea		$1,413.00	$10.03		$0	$1,413	$10	$0	$1,423
6.9 Air Stripper, 4 tray, 300 cfm	1	ea		$29,500.00	$7,800.00	$2,500.00	$0	$29,500	$7,800	$2,500	$39,800
6.10 Centrifugal Transfer Pump, 40 gpm (2 hp)	2	ea		$2,898.00	$849.28		$0	$5,796	$1,699	$0	$7,495
6.11 GAC, liquid-phase, 900 lbs	2	ea		$4,188.00	$290.47	$100.33	$0	$8,376	$581	$201	$9,158
6.12 Instruments and Controls	1	ls		$13,500.00	$8,520.00		$0	$13,500	$8,520	$0	$22,020
6.13 Plumb/Electrify System	1	ls		$3,000.00	$2,500.00		$0	$3,000	$2,500	$0	$5,500
6.14 System Start-Up and Testing	1	ls		$1,000.00	$925.00		$0	$1,000	$925	$0	$1,925
7 ON-SITE TREATMENT SYSTEM NO. 2 (SITE 58)											
7.1 Building Foundation	300	sf	$3.87				$1,161	$0	$0	$0	$1,161
7.2 Treatment Building	300	sf	$11.03				$3,309	$0	$0	$0	$3,309
7.3 Building Misc. (doors/vent/insulation/lighting/misc.)	1	ls	$5,725.00				$5,725	$0	$0	$0	$5,725
7.4 Electrical Service, 1000 A, 480 V	1	ea	$14,440.00				$14,440	$0	$0	$0	$14,440
7.5 Equalization Tank (900 gal)	1	ea		$1,054.00	$489.72		$0	$1,054	$490	$0	$1,544
7.6 Rim Mounted Mixer (0.5 hp)	1	ea		$2,695.00	$48.80		$0	$2,695	$49	$0	$2,744
7.7 Centrifugal Transfer Pump, 25 gpm (1.5 hp)	2	ea		$2,021.00	$508.61		$0	$4,042	$1,017	$0	$5,059
7.8 Bag Filter, Dual-Element, 25-micron, 25 gpm	1	ea		$1,334.00	$100.30		$0	$1,334	$100	$0	$1,434
7.9 GAC, liquid-phase, 575 lbs	2	ea		$2,525.00	$87.14	$30.10	$0	$5,050	$174	$60	$5,284
7.10 Instruments and Controls	1	ls		$13,500.00	$8,520.00		$0	$13,500	$8,520	$0	$22,020
7.11 Plumb/Electrify System	1	ls		$3,000.00	$2,500.00		$0	$3,000	$2,500	$0	$5,500
7.12 System Start-Up and Testing	1	ls		$1,000.00	$925.00		$0	$1,000	$925	$0	$1,925
Subtotal							$109,025	$224,903	$191,411	$24,171	$549,511
Local Area Adjustments							100.0%	99.9%	70.3%	88.0%	
							$109,025	$224,678	$134,562	$21,271	$489,536
Overhead on Labor Cost @ 30%									$40,369		$40,369
G & A on Labor Cost @ 10%									$13,456		$13,456
G & A on Material Cost @ 10%								$22,468			$22,468
G & A on Subcontract Cost @ 10%							$10,903				$10,903
Total Direct Cost							$119,928	$247,146	$188,387	$21,271	$576,732
Indirects on Total Direct Cost @ 35%											$201,856
Profit on Total Direct Cost @ 10%											$57,673
Subtotal											$836,261
Health & Safety Monitoring @ 2%											$16,725
Total Field Cost											$852,986
Contingency on Total Field Costs @ 20%											$170,597
Engineering on Total Field Cost @ 10%											$85,299
TOTAL CAPITAL COST											**$1,108,882**

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Operation and Maintenance Cost

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
Treatment System #1 (for 14 years)						
1	Energy - Electric	64,000	kWh	$0.06	$3,840	
2	System Maintenance	1	ls	$14,352	$14,352	10% of Installation Cost
3	Sampling labor, travel & living, supplies	52	ea	$410	$21,320	1 person/1 day per week
4	Analysis of influent and effluent water	104	ea	$545	$56,680	TCL VOC, TCL SVOC, TRPH, two per week
5	Quarterly Reports	4	ea	$5,000	$5,000	
				Subtotal	**$101,192**	
	System # 1 Carbon Replacement	900	lb	$3.25	$2,925	Years 0.5, 1, 2, 3, 5, 8, 12
				O & M for year 1	**$107,042**	
				O & M for years 2, 3, 5, 8, 12	**$104,117**	
				O & M for years 4, 6, 7, 9, 10, 11, 13, 14	**$101,192**	
Treatment System #2 (for 3 years)						
1	Energy - Electric	25,000	kWh	$0.06	$1,500	
2	System Maintenance	1	ls	$5,846.79	$5,847	10% of Installation Cost
3	Sampling labor, travel & living, supplies	52	ea	$410	$21,320	1 person/1 day per week
4	Analysis of influent and effluent water	104	ea	$545	$56,680	TCL VOC, TCL SVOC, TRPH, two per week
5	Quarterly Reports	4	ea	$5,000	$5,000	
				O & M for years 1, 2, 3	**$90,347**	

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Annual Cost

Item	Item Cost year 1	Item Cost years 2 and 3	Item Cost years 4 and 5	Item Cost years 6 to 15	Item Cost every 5 years	Notes
LUC Inspection and Sampling	$44,000	$22,000	$11,000	$7,700		Labor, Field Supplies, Local Travel
Analysis/Water(1) (Performance)	$26,112	$13,056	$6,528	$4,352		Analyze twelve groundwater sample for TCL VOCs, TCL SVOCs, TRPH, including blanks and duplicates for years 1 through 5 at Sites 57 & 58. Analyze eight groundwater sample for TCL VOCs, TCL SVOCs, TRPH, and including blanks and duplicates for years 6 through 15 at Site 57 only.
Analysis/Water(1) (Migration)	$23,936	$11,968	$5,984	$4,352		Analyze eleven groundwater sample for TCL VOCs, TCL SVOCs, and TRPH, including blanks and duplicates for years 1 through 5 at Sites 57 & 58. Analyze eigth groundwater sample for TCL VOCs, TCL SVOCs, and TRPH including blanks and duplicates for years 6 through 15 at Site 57 only.
Report	$32,000	$16,000	$8,000	$8,000		Document site inspections, sampling events and results.
Site Review					$7,500	Perform 5-Year review (10% of total cost)
TOTALS	$126,048	$63,024	$31,512	$24,404	$7,500	

(1) Sampling frequency will occur quarterly the first year, semi-annual for years 2 & 3, and annually for years 4 & 5 for Sites 57 & 58 and annually for years 6 through 15 for Sites 57 only.

NAVAL AIR STATION CECIL FIELD
Jacksonville, Florida
SITES 57 & 58
Groundwater Remedial Alternative 5: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$1,108,882			$1,108,882	1.000	$1,108,882
1		$197,389	$126,048	$323,437	0.935	$302,413
2		$194,464	$63,024	$257,488	0.873	$224,787
3		$194,464	$63,024	$257,488	0.816	$210,110
4		$101,192	$31,512	$132,704	0.763	$101,253
5		$104,117	$39,012	$143,129	0.713	$102,051
6		$101,192	$24,404	$125,596	0.666	$83,647
7		$101,192	$24,404	$125,596	0.623	$78,246
8		$104,117	$24,404	$128,521	0.582	$74,799
9		$101,192	$24,404	$125,596	0.544	$68,324
10		$101,192	$31,904	$133,096	0.508	$67,613
11		$101,192	$24,404	$125,596	0.475	$59,658
12		$104,117	$24,404	$128,521	0.444	$57,063
13		$101,192	$24,404	$125,596	0.415	$52,122
14		$101,192	$24,404	$125,596	0.388	$48,731
15			$31,904	$31,904	0.362	$11,549
					TOTAL PRESENT WORTH	**$2,651,251**