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FINAL

FEASIBILITY STUDY FOR OPERABLE UNIT NO. 12 (SITE 3)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0274

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Prepared For:

DEPARTMENT OF THE NAVY
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LIST OF ACRONYMS AND ABBREVIATIONS

AOCs	areas of concern
ARARs	applicable or relevant and appropriate requirements
AT	averaging time
Baker	Baker Environmental, Inc.
bgs	below ground surface
BEHP	bis (2-ethyl hexyl) phthalate
CDI	chronic daily intake
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/s	centimeters per second
COC	contaminant of concern
COPC	contaminant of potential concern
CP	Concrete Pad Area
CSF	carcinogenic slope factor
CWA	Clean Water Act
DoN	Department of the Navy
DOT	Department of Transportation
ED	exposure duration
EF	exposure frequency
FFA	Federal Facilities Agreement
FS	Feasibility Study
gpm	gallons per minute
HDPE	high density polyethylene
HI	hazard index
HPIA	Hadnot Point Industrial Area
i	hydraulic gradient
ICR	incremental lifetime cancer risk
IR	ingestion rate
IRP	Installation Restoration Program
K	hydraulic conductivity
kg	kilograms
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MCB	Marine Corps Base
MCL	Maximum Contaminant Level

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

mg/kg	milligram per kilogram
mg/L	milligram per liter
ml	milliliter
msl	mean sea level
MW	monitoring well
NA	Northern Area
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCP	National Contingency Plan
NCWQS	North Carolina Water Quality Standards
ND	nondetect
NPL	National Priorities List
NPW	net present worth
O&M	operation and maintenance
OU	operable unit
PAH	polynuclear aromatic hydrocarbons
POTW	publicly owned treatment works
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PRAP	Proposed Remedial Action Plan
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RAA	remedial action alternative
RAO	remediation action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RGO	remediation goal option
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	remediation level
RME	responsible maximum exposure
ROD	Record of Decision
RS	Rail Spur Area
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SMP	Site Management Plan

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

S/S	solidification/stabilization
SSSV	surface soil screening value
STP	sewage treatment plant
SVOCs	semivolatile organic compounds
TA	Treatment Area
TAL	target analyte list
TBC	to be considered
TCL	target compound list
TCLP	toxicity characteristics leaching procedure
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
TRC	Technical Review Committee
TSS	total suspended solids
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

INTRODUCTION

This report documents the Feasibility Study (FS) conducted for Operable Unit No. 12 (Site 3), otherwise known as the Old Creosote Plant, at Marine Corps Base (MCB), Camp Lejeune, North Carolina. Baker Environmental, Inc. (Baker) has prepared this FS for Contract Task Order 0274 under the Department of the Navy (DoN) Atlantic Division Naval Facilities Engineering Command (LANTDIV) Comprehensive Long-Term Environmental Action Navy (CLEAN) program. The FS has been primarily based on data collected during the Remedial Investigation (RI) for Site 3, which was conducted from September 1994 through January 1996.

SITE DESCRIPTION AND HISTORY

Site 3 is located along Holcomb Boulevard within the Mainside Supply and Storage areas at MCB, Camp Lejeune. Open Storage Lots 201 and 203 (i.e., Site 6) are located nearby along Holcomb Boulevard approximately 1-1/2 miles from the site.

Site 3 encompasses an area of approximately five acres and is generally flat and unpaved. Two roadways intersect the site: a dirt path that runs north-south and forms a loop in the southern portion of the site, and a gravel road that runs east-west and leads directly to Holcomb Boulevard. Access to the site via these roadways is currently unrestricted. In addition, the Camp Lejeune Railroad line runs parallel to the site's western edge and intersects an old railroad spur line at the site's southern extreme. The intersection of these two lines creates a spike formation that points south. Wooded areas lie north and east of the site.

The old creosote plant reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base railroad. Reportedly, an on site sawmill, located in the northern portion of the site, was used to trim logs into railroad ties. The ties were then treated with hot creosote in pressure cylinder chambers. Records show that preservatives (i.e., creosote) were stored for reuse in a railroad tank car.

In typical pressure treatment processes, wood ties are placed inside cylindrical chambers which are filled with wood-treating preservatives. Then, hydrostatic or pneumatic pressures, ranging from 50 to 200 pounds per square inch (psi), are applied within the treatment chamber until the wood absorbs the desired amount of preservatives. When the treatment process is complete, a pump removes the excess preservatives from the chamber and sends it to a storage vessel for reuse. Excess preservative is then removed from the wood by applying a vacuum, or by allowing the wood to drip dry. In the past, treated wood lay in open areas for several days , allowing preservative to drip. Today, treated wood is typically placed on lined and covered drip pads to collect excess preservative.

The main treatment area at Site 3 was most likely located within and immediately surrounding the dirt path loop in the southern portion of the site. This area contains an abandoned chimney that was probably associated with creosote heating/thinning activities. (Creosote is heated and mixed with fuel oil to create a less viscous consistency.) The 240 foot long concrete pad encircled by the dirt path loop was probably used as a drip track for pressure cylinder chambers or treated wood ties. However, the concrete pad does not contain visual evidence of contamination. South of the pad, evidence of rail lines was observed indicating that a railroad connection may have been located in this area. The railroad connection may have transported creosote or ties to and from the treatment area.

NATURE AND EXTENT OF CONTAMINATION

Based on the results of a previous investigation and the RI, the most frequently detected organic contaminants at Site 3 were polynuclear aromatic hydrocarbons (PAHs). Because creosote is made up of PAH compounds, the PAHs detected at Site 3 are believed to be associated with operations at the former creosote plant. Soil and groundwater (both shallow and deep) contained the highest levels of PAH compounds. In soil, the maximum PAH concentrations occurred in the treatment area of the site. In groundwater, the maximum PAH concentrations occurred in the treatment area and in the southern rail spike area. In addition to PAHs, fuel constituents, including benzene, were detected in soil and groundwater (both shallow and deep) at Site 3. The maximum concentrations of these fuel constituents, however, were scattered sporadically across the site.

HUMAN HEALTH RISK ASSESSMENT

As part of the RI, a human health risk assessment (RA) was conducted to identify contaminants of potential concern (COPCs) and to assess potential human health risks associated with these COPCs. Semivolatile organic compounds (SVOCs) were identified as COPCs for surface and subsurface soil, and volatile organic compounds (VOCs) and SVOCs were identified as COPCs for groundwater. Table ES-1 presents the incremental cancer risk (ICR) and hazard index (HI) values that were generated for each environmental medium and relevant receptor. ICR values that exceed the USEPA limit of 1E-04, and HI values that exceed the USEPA limit of 1.0, indicate unacceptable human health risks. These unacceptable risk values are shaded in Table ES-1. Because three groundwater sampling rounds were conducted, the risk values were generated under two approaches: 1) the evaluation of Round 2 groundwater data, and 2) the evaluation of Rounds 1, 2, and 3 groundwater data combined (referred to as the "Worst Case" approach).

ECOLOGICAL RISK ASSESSMENT

During the RI, an ecological RA was conducted to address the impacts that COPCs may be having on terrestrial receptors, threatened or endangered species, and wetlands at Site 3. Under the terrestrial receptor evaluation, several COPCs exceeded surface soil screening values (SSSVs) in open grass areas or along tree lines. However, most of the studies used to develop the SSSVs do not take into account the soil type, which may have a large influence on the toxicity of the contaminants. In addition, most of the SSSVs are based on one or two studies which limits their reliability for a wide range of site-specific circumstances. As a result, the SSSVs have a high degree of uncertainty associated with them, and are not well-established. Consequently, the potential ecological risks based on these SSSVs may not be completely accurate and most likely err on the conservative side. In addition, none of the quotient indices (QIs) generated for terrestrial receptors exceeded the acceptable limit of 1.0 so potential impacts to terrestrial mammals or birds are not expected. No threatened or endangered species or wetlands are known to occur at Site 3.

MEDIA OF CONCERN, CONTAMINANTS OF CONCERN, AND REMEDIATION LEVELS

Based on the results of the RAs, subsurface soil and groundwater were determined to be the media of concern at Site 3. Tables ES-2 and ES -3 present the final set of contaminants of concern (COCs) and remediation levels (RLs) developed for soil and groundwater, respectively.

AREAS OF CONCERN

Subsurface Soil

Several semivolatile organics were detected in the subsurface soil at concentrations exceeding the soil RLs. Based on the locations of these exceedences, a subsurface soil area of concern (AOC) was identified in the area immediately surrounding monitoring well 03-MW02. This AOC extends from 3 feet below ground surface (bgs) to a depth of approximately 9 feet bgs which is just above the water table. The amount of soil contained within this AOC is approximately 1,340 cubic yards. It appears as though this subsurface soil AOC is the main source of PAH-contaminated groundwater in the shallow aquifer.

Groundwater

Volatile organics, semivolatile organics, and inorganics were detected at concentrations exceeding the groundwater RLs in both the shallow and Castle Hayne aquifers. However, the main problem at Site 3 appears to be semivolatile organic contaminants (in particular, naphthalene) in the shallow aquifer. Thus, two shallow groundwater AOCs were identified at the site. One AOC is centered around well 03-MW02; the other AOC is centered around well 03-MW06 in the southern rail spike portion of the site.
Volatile organics in the shallow aquifer, volatile and semivolatile organics in the Castle Hayne aquifer, and inorganics in the shallow aquifer were not included in the groundwater AOCs. This is because there was no apparent pattern to their detections, and/or the contaminant concentrations only slightly exceeded RLs. However, these contaminants will not be ignored in the FS. Instead, they will be addressed with long-term monitoring/institutional control alternatives, as opposed to active treatment alternatives.

REMEDIAL ACTION OBJECTIVES

The following remedial action objectives (RAOs) were developed for soil at Site 3:

- Soil RAO #1
  Prevent the leaching of PAH contaminants from the subsurface soil to the groundwater.

- Soil RAO #2
  Remediate subsurface soil at the site to the specified remediation levels.

The following remedial action objectives were developed for groundwater at Site 3:

- Groundwater RAO #1
  Prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater.

- Groundwater RAO #2
  Remediate groundwater in the shallow aquifer to the specified remediation levels.

REMEDIAL ACTION ALTERNATIVES FOR SOIL

Soil Remedial Action Alternative (RAA) No. 1: No Action

•	Capital Cost:	$0
•	Annual Operation and Maintenance (O&M) Cost:	$0
•	Net Present Worth (NPW):	$0
•	Time to Implement:	0

Under the no action alternative, subsurface soil will remain as is. No active remedial actions will be implemented. Because contaminated soil will be left on site, this alternative will require five-year reviews by the lead agency.

Soil RAA No. 2: Institutional Controls

•	Capital Cost:	Negligible
•	Annual O&M Cost:	$0
•	NPW:	Assumed to be $0
•	Time to Implement:	Less than one year

Under Soil RAA No. 2, the subsurface soil will be left in place under its current conditions; no active remedial actions will be implemented. However, institutional controls, including land use controls and deed restrictions, will be implemented to limit future land use at the site. The land use controls will be implemented via the Base Master Plan and the deed restrictions will be implemented if the Base were to close. Because contaminated soil will be left on site, this alternative will require five-year reviews by the lead agency.

Soil RAA No. 3: Source Removal and Off Site Landfill Disposal

•	Capital Cost:	$917,000
•	Annual O&M Cost:	$0
•	NPW:	$917,000
•	Time to Implement:	Less than one year

Under Soil RAA No. 3, the soil AOC will be excavated and transported off site for landfill disposal. Since creosote is a listed hazardous waste, the soil will be transported to a RCRA-permitted Subtitle C facility. Five-year reviews by the lead agency will not be required for soil. However, these reviews may be required for contaminated groundwater at Site 3.

Soil RAA No. 4: Source Removal and Off Site Incineration

•	Capital Cost:	$3,150,000
•	Annual O&M Cost:	$0
•	NPW:	$3,150,000
•	Time to Implement:	Less than one year

Under Soil RAA No. 4, the soil AOC will be excavated then transported to a permitted incineration facility for treatment and disposal. Five-year reviews by the lead agency will not be required for soil. However, these reviews may be required for contaminated groundwater at Site 3.

Soil RAA No. 5: Source Removal and Biological Treatment

- Capital Cost: $362,000
- Annual O&M Cost: $35,000
- NPW: $514,000
- Time to Implement: Assumed to be 5 years

Under Soil RAA No. 5, the soil AOC will be excavated and transported to the existing biocell at Lot 203, MCB, Camp Lejeune. The biocell, a landfarm unit with a 1,000 cubic yard capacity, is currently permitted to treat total petroleum hydrocarbon (TPH)-contaminated soil, so permit modifications will be required. Biocell maintenance will include monthly soil sampling for total organic carbon, nutrients (i.e., nitrogen and phosphorous), pH, moisture content, and bacterial population density, and bimonthly tilling of the contaminated soil for aeration. Initially, the contaminated soil will be mixed with dry, granular fertilizer, but periodic nutrient/fertilizer mixing may also be required. Prior to implementation, a pilot-scale treatability study will be conducted at Site 3 to further determine the effectiveness of this alternative. Under Soil RAA No. 5, five-year reviews by the lead agency will not be required for soil. (However, these reviews may be required for contaminated groundwater at Site 3.)

REMEDIAL ACTION ALTERNATIVES FOR GROUNDWATER

Groundwater RAA No. 1: No Action

- Capital Cost: $0
- Annual O&M Cost: $0
- NPW: $0
- Time to Implement: 0

Under the no action alternative, groundwater will remain as is. No active remedial actions will be implemented. Because contaminated groundwater will be left untreated, this alternative will require five-year reviews by the lead agency.

Groundwater RAA No. 2: Institutional Controls and Monitoring

- Capital Cost: $0
- Annual O&M Cost (Years 1-5): $64,000
- Annual O&M Cost (Years 6-30): $33,000
- NPW: $643,000
- Time to Implement: 30 years

Under Groundwater RAA No. 2, contaminated groundwater at Site 3 will remain as is; no remedial actions involving treatment will be implemented. However, institutional controls (including aquifer use restrictions and deed restrictions) and a long-term groundwater monitoring program will be implemented. The aquifer use restrictions, implemented via the Base Master Plan, will prohibit future use of the shallow and Castle Hayne aquifers, within the immediate vicinity of Site 3, as potable water sources. The deed restrictions will prevent future placement of wells at the site. Under the proposed monitoring program, samples will be periodically collected from seven existing monitoring wells (03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW07, 03-MW08, and

03-MW11IW) and analyzed for target compound list (TCL) VOCs and SVOCs. For cost estimating purposes, quarterly sampling was assumed for years 1-5, and semiannual sampling was assumed for years 6-30. Because contaminated groundwater will be left untreated, this alternative will require five-year reviews by the lead agency.

<u>Groundwater RAA No. 3: Extraction and On Site Carbon Adsorption Treatment</u>

- Capital Cost: $422,000
- Annual O&M Cost for Monitoring (Years 1-5): $64,000
- Annual O&M Cost for Monitoring (Years 6-30): $33,000
- Annual O&M Cost for Treatment Plant: $85,000
- NPW: $2,369,000
- Time to Implement: 30 years for treatment plant O&M; 30 years for long-term monitoring

Groundwater RAA No. 3 involves the installation of two extraction wells (in the shallow aquifer) that will intercept the two groundwater AOCs. One extraction well will be positioned near existing well 03-MW02, and one extraction well will be positioned near existing well 03-MW06. Once the groundwater is extracted, it will undergo pretreatment for oil/water separation and suspended solids/metals removal, then liquid-phase carbon adsorption treatment, at an on site treatment plant. The treated groundwater will be discharged into a nearby sanitary sewer line for subsequent discharge to one of the sewage treatment plants located on Base. In addition to groundwater extraction and treatment, Groundwater RAA No. 3 includes the same institutional controls and long-term groundwater monitoring program that are described under Groundwater RAA No. 2. Because contamination will remain in the groundwater indefinitely, Groundwater RAA No. 3 will require five-year reviews by the lead agency.

TABLE ES-1

SUMMARY OF HUMAN HEALTH RISKS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Round 2 Groundwater		Worst Case Groundwater		Total with Round 2 Groundwater Contamination		Total with Worst Case Groundwater Contamination	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Military Personnel	1.7E-06 (100)	NA	NE	NE	NE	NE	1.7E-06	NA	1.7E-06	NA
Future Child Resident	1.4E-05 (74)/(<1)	NA	5.3E-06 (26)	1.7 (100)	7.5E-04 (100)	2.3 (100)	1.9E-05	1.7	7.6E-04	2.3
Future Adult Resident	5.4E-06 (34)/(<1)	NA	1.1E-05 (66)	0.7 (100)	1.8E-03 (100)	3.7 (100)	1.7E-05	0.7	1.8E-03	3.7
Future Construction Worker	1.0E-07 (100)	<0.01 (100)	NE	NE	NE	NE	1.0E-07	<0.01	1.0E-07	<0.01

Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
Total = Soil + Groundwater
NE = Not Evaluated for Potential Receptor
NA = Not Applicable (no noncarcinogenic COPCs)
() = Percent contribution to total risk
()/() = First is percent contribution to total risk with round 2 groundwater results; Second is percent contribution to total risk with worst case groundwater results (combined Rounds 1, 2, 3)

TABLE ES-2

SOIL COCs AND REMEDIATION LEVELS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL	Basis of Goal
Naphthalene	30,000	SSL
2-Methylnaphthalene	30,000	SSL
Carbazole	500	SSL
Benzo(a)anthracene	700	SSL
Chrysene	1,000	SSL
4-Nitrophenol	0	SSL
N-nitrosodiphenylamine	200	SSL

Notes:

RL - Remediation Level in microgram per kilogram (µg/kg)
SSL - USEPA Region III Soil Screening Level (USEPA, 1996)

TABLE ES-3

GROUNDWATER COCs AND REMEDIATION LEVELS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL	Basis of Goal	Corresponding Risk
Benzene	1	NCWQS	
Phenol	300	NCWQS	
2-Methylphenol	78	Groundwater Ingestion	HI = 0.1
2,4-Dimethylphenol	31	Groundwater Ingestion	HI = 0.1
Naphthalene	21	NCWQS	
2-Methylnaphthalene	63	Groundwater Ingestion	HI = 0.1
Dibenzofuran	6	Groundwater Ingestion	HI = 0.1
Phenanthrene	210	NCWQS	
Benzo(a)anthracene	0.05	NCWQS	
Chrysene	5	NCWQS	
Chloroform	0.19	Groundwater Ingestion	ICR - 1×10^{-6}
Carbazole	4	Groundwater Ingestion	ICR = 1×10^{-6}
Benzo(b)fluoranthene	0.12	Groundwater Ingestion	ICR - 1×10^{-6}
Benzo(k)fluoranthene	1	MCL	
Benzo(a)pyrene	2	MCL	
Iron	300	NCWQS	
Aluminum	50	SMCL	

Notes:

RL - Remediation Level in microgram per liter (ppb)
NCWQS - North Carolina Water Quality Standard
MCL - Maximum Contaminant Level
SMCL - Secondary Maximum Contaminant Level
HI - Hazard Index
ICR - Incremental Cancer Risk

TABLE ES-4

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Source Removal and Landfill Disposal	RAA No. 4 Source Removal and Incineration	RAA No. 5 Source Removal and Composting
OVERALL PROTECTIVENESS					
• Human Health	If left as is, subsurface soil will continue to be a source of groundwater contamination. As such, the soil will be contributing to unacceptable human health risks associated with groundwater.	If left as is, subsurface soil will continue to be a source of groundwater contamination. As such, the soil will be contributing to unacceptable human health risks associated with groundwater. However, institutional controls and monitoring will reduce the risks.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.
• Environmental Protection	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.
COMPLIANCE WITH ARARs					
• Chemical-Specific ARARs/TBCs	Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil.	Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil.	Subsurface soil at the site will meet chemical-specific TBCs; the landfilled soil will not meet chemical-specific TBCs.	Subsurface soil at the site will meet chemical-specific TBCs; the excavated soil is expected to meet chemical-specific TBCs via thermal treatment.	Subsurface soil at the site will meet chemical-specific TBCs; the excavated soil is expected to meet chemical-specific TBCs via biological treatment.
• Location-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet location-specific ARARs.	Can be designed to meet location-specific ARARs.	Can be designed to meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet action-specific ARARs.	Can be designed to meet action-specific ARARs.	Can be designed to meet action-specific ARARs.

TABLE ES-4 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Source Removal and Landfill Disposal	RAA No. 4 Source Removal and Incineration	RAA No. 5 Source Removal and Composting
LONG-TERM EFFECTIVENESS AND PERMANENCE					
• Magnitude of Residual Risk	Risks to contaminated groundwater will remain unchanged.	Institutional controls and monitoring will reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Adequate controls for preventing exposure to the creosote contaminants.	Adequate controls for preventing exposure to the creosote contaminants.	Adequate controls for preventing exposure to the creosote contaminants.	Adequate controls for preventing exposure to the creosote contaminants.
• Need for 5-year Review	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.	Review will not be required.	Review will not be required.	Review will be required to ensure adequate protection of human health and the environment.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
• Treatment Process Used	No treatment process.	No treatment process.	No treatment process.	Incineration.	Biological treatment.
• Amount Destroyed or Treated	None.	None.	None.	None.	None.
• Reduction of Toxicity, Mobility, or Volume Through Treatment	None.	None.	None.	Reduction in toxicity, mobility, and volume of soil contaminants.	Overall reduction in toxicity, mobility, and volume of soil contaminants.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Not applicable - no treatment.	No treatment residuals will remain on site.	Treatment residuals will include the compost itself which may be beneficially reused as fertilizer material.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Not satisfied.	Satisfied.	Satisfied.

TABLE ES-4 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Source Removal and Landfill Disposal	RAA No. 4 Source Removal and Incineration	RAA No. 5 Source Removal and Composting
SHORT-TERM EFFECTIVENESS					
• Community Protection	Potential risks to the community will not be increased.	Potential risks to the community will not be significantly increased.	Potential risks to the community will be temporarily increased during soil excavation and transportation activities.	Potential risks to the community will be temporarily increased during soil excavation and transportation activities; also, incinerator off-gases will increase risks to the community.	Potential risks to the community will be temporarily increased during soil excavation and during the life of the compost piles.
• Worker Protection	No risks to workers.	No significant risks to workers (only during groundwater sampling).	Potential risks to workers will be temporarily increased during soil excavation and transportation activities.	Potential risks to workers will be temporarily increased during soil excavation and transportation activities.	Potential risks to workers will be temporarily increased during soil excavation and during compost O&M.
• Environmental Impact	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.
• Time Until Action is Complete	Not applicable.	Not applicable.	Approximately one month.	Approximately one month.	Amount of time is unknown; 5 years has been assumed for cost estimating purposes.

TABLE ES-4 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Source Removal and Landfill Disposal	RAA No. 4 Source Removal and Incineration	RAA No. 5 Source Removal and Composting
IMPLEMENTABILITY					
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Easy to implement if excavation remains above the water table; no O&M after soil is disposed; requires appropriate materials handling procedures.	Easy to implement if excavation remains above the water table; no O&M after soil is disposed; requires appropriate materials handling procedures.	Easy to implement if excavation remains above O&M for an extended period of time; O&M utilizes simple equipment and procedures.
• Ability to Monitor Effectiveness	No monitoring plan for measuring effectiveness.	Monitoring plan will measure the alternatives effectiveness.	Monitoring plan will measure the alternatives effectiveness.	Monitoring plan will measure the alternatives effectiveness.	Monitoring plan will measure the alternatives effectiveness.
• Availability of Services and Capacities; Equipment	No services or equipment required.	No services or equipment required.	Services and equipment should be readily available.	Services and equipment should be readily available.	Services and equipment should be readily available.
• Requirements for Agency Coordination	None required.	No significant requirements.	Must submit semiannual reports to document sampling.	Air and water discharge permits may be required.	Coordination with Department of Transportation for off site transport of soils; federal and state acceptance of off site facility is required.
COST (Net Present Worth)	**$0**	**$341,000**	**$872,000**	**$2,395,000**	**$947,000**

TABLE ES-5

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
OVERALL PROTECTIVENESS			
• Human Health	No reduction in potential human health risks.	Institutional controls and long-term monitoring will reduce potential human health risks.	Institutional controls, long-term monitoring, and groundwater extraction/treatment will reduce potential human health risks.
• Environmental Protection	No reduction in potential risks to ecological receptors.	No reduction in potential risks to ecological receptors.	No reduction in potential risks to ecological receptors.
COMPLIANCE WITH ARARs			
• Chemical-Specific ARARs	Contaminant levels exceeding chemical-specific ARARs will remain in the groundwater.	Contaminant levels exceeding chemical-specific ARARs will remain in the groundwater.	Contaminant levels exceeding chemical-specific ARARs will most likely remain in the groundwater.
• Location-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE			
• Magnitude of Residual Risk	Risks to contaminated groundwater will remain unchanged; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.	Institutional controls and monitoring will reduce the risks associated with contaminated groundwater; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.	Institutional controls and monitoring will reduce the risks associated with contaminated groundwater; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.
• Adequacy and Reliability of Controls	Not applicable - no controls.	The monitoring program is adequate and reliable for determining the alternative's effectiveness. If they are enforced over time, aquifer use and deed restrictions will be adequate and reliable for preventing human exposure to the groundwater.	Once designed/sized in accordance with site-specific characteristics, extraction/treatment should be both adequate and reliable. The monitoring program is adequate and reliable for determining the alternative's effectiveness. If they are enforced over time, aquifer use and deed restrictions will be adequate and reliable for preventing human exposure to the groundwater.

TABLE ES-5 (Continued)

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
LONG-TERM EFFECTIVENESS AND PERMANENCE (continued)			
• Need for 5-year Review	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
• Treatment Process Used	No treatment process.	No treatment process.	Extraction wells, liquid-phase carbon adsorption, metals pretreatment, oil/water separation.
• Amount Destroyed or Treated	None.	None.	Some of the contamination will be treated; some will remain adsorbed to subsurface soil particles or trapped in pores spaces and fissures.
• Reduction of Toxicity, Mobility, or Volume Through Treatment	None.	None.	Some.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Treatment residuals will include sludge, separated oil, exhausted carbon, and treated groundwater.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Satisfied.
SHORT-TERM EFFECTIVENESS			
• Community Protection	Potential risks to the community will not be increased during implementation.	Potential risks to the community will not be significantly increased.	Potential risks to the community will be increased during installation of the extraction/treatment system, and during system operation.
• Worker Protection	No risks to workers.	Potential risks to workers will be slightly increased; worker protection is required.	Potential risks to workers will be increased; worker protection is required.
• Environmental Impact	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.
• Time Until Action is Complete	Not applicable.	Not applicable.	Unknown; 30 years has been assumed for cost estimating purposes.

TABLE ES-5 (Continued)

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls and Monitoring	RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
IMPLEMENTABILITY			
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Based on past experience, a pump and treat system will be easy to construct and operate. Utilities may make pipeline construction challenging. Disposal of treatment residuals (i.e., sludge and oil) and inorganics precipitation on the well screens may also make system operation challenging.
• Reliability of Technology	Not applicable.	Monitoring wells are a reliable technology.	Inorganics may precipitate on the well screens creating the need for well replacement. Also, the long operation time for the system may necessitate equipment replacement. If contaminants migrate into inaccessible regions, the pump and treat system will be less effective at collecting them (MacDonald, 1995).
• Ease of Undertaking Additional Remedial Actions	Additional remedial actions can be easily implemented.	Additional remedial actions can be easily implemented.	Additional remedial actions can be easily implemented.
• Ability to Monitor Effectiveness	No monitoring plan. Failure to detect contamination could result in human/environmental exposure.	Monitoring plan will detect contaminants before significant exposure can occur.	Monitoring plan will detect contaminants before significant exposure can occur.
• Availability of Services and Equipment	No services or equipment required.	Services and equipment are readily available.	Services and equipment are readily available.
• Requirements for Agency Coordination	No requirements.	Must submit semiannual reports to document sampling.	The substantive requirements of water discharge permits must be met; must submit semiannual reports to document sampling.
COST (Net Present Worth)	**$0**	**$341,000**	**$2,061,000**

1.0 INTRODUCTION TO THE FEASIBILITY STUDY

Marine Corps Base (MCB), Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) on October 4, 1989 (54 Federal Register 41015, October 4, 1989). The United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of the Environment, Health, and Natural Resources (NC DEHNR), and the United States Department of the Navy (DoN) then entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA is to ensure that environmental impacts associated with past and present activities at MCB, Camp Lejeune are thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and the environment (Camp Lejeune FFA, 1989).

The Fiscal Year 1995-96 Site Management Plan (SMP) for MCB, Camp Lejeune (Baker, 1994a), a primary document identified in the FFA, identifies 33 sites at the Base that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 33 sites have been grouped into 17 Operable Units (OUs) to simplify RI/FS activities. OU No. 12 contains one site known as Site 3 - the Old Creosote Plant. This report documents the FS conducted for OU No. 12 (Site 3).

Baker Environmental, Inc. (Baker) has prepared this FS for Contract Task Order 0274 under the DoN Atlantic Division Naval Facilities Engineering Command (LANTDIV) Comprehensive Long-Term Environmental Action Navy (CLEAN) program. The FS has been conducted in accordance with the requirements delineated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 300.430]. These NCP regulations were promulgated under CERCLA, commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. In addition, the USEPA's document <u>Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA</u> (USEPA, 1988) was used as a guidance in preparing this document.

The FS has been based on the RI that Baker conducted for OU No. 12 (Site 3). Field investigations for the RI, conducted from September 1994 through July 1995, included three phases of surface soil, subsurface soil, and groundwater investigations. Results of these field investigations are summarized in the RI report under separate cover (Baker, 1996).

1.1 <u>Purpose of the FS</u>

The purpose of the FS for Site 3 is to identify remedial action alternatives that are protective of human health and the environment, attain federal and state requirements that are applicable or relevant and appropriate, and are cost-effective. In general, the FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated, such that relevant information concerning the remedial action options can be presented and an appropriate remedy selected.

The FS involves two major phases:

1) Development and Screening of Remedial Action Alternatives
2) Detailed Analysis of Remedial Action Alternatives

The first phase includes the following major activities: (1) developing remediation levels and remedial action objectives, (2) identifying volumes or areas of affected media, (3) developing general response actions, (4) identifying and screening potential technologies and process options, (5) evaluating process options, (6) assembling alternatives, (7) defining alternatives, and (8) screening and evaluating alternatives.

Section 121(b)(1) of CERCLA requires that an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant be conducted. In addition, according to CERCLA, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management of alternatives, to alternatives which involve treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no-action alternative should also be developed.

The second major phase of the FS consists of: (1) evaluating the potential alternatives in detail with respect to nine evaluation criteria to address statutory requirements and preferences of CERCLA; and (2) performing a comparative analysis of the evaluated alternatives.

1.2 Report Organization

This FS report is divided into seven main sections. Section 1.0 is an introductory section that presents an overview of the FS process. Section 2.0 provides background information describing conditions (e.g., a site description and history, geology, and hydrogeology) at Site 3. Section 3.0 presents the development of remediation goal options, remediation levels, and remedial action objectives. This section also identifies the media of concern and contaminants of concern at the site. Section 4.0 presents the identification and screening of applicable remediation technologies and process options. Based on the results of this technology screening, Section 5.0 identifies remedial action alternatives that may be appropriate for soil and groundwater at Site 3. Sections 6.0 presents a detailed evaluation of the remedial action alternatives developed for soil, and Section 7.0 presents a detailed evaluation of the alternatives developed for groundwater. Finally, Section 8.0 contains references for the entire report. Please note that tables and figures are located at the end of each section.

2.0 BACKGROUND INFORMATION

Section 2.0 presents background information that describes conditions at Site 3. This information includes an operable unit description, a site description and history, a summary of the previous investigation conducted at Site 3, a summary of the field activities associated with the Remedial Investigation, the physical characteristics of the study area, the nature and extent of contamination, the results of the human health risk assessment, and the results of the ecological risk assessment. This background information is a summary of more comprehensive information that can be found in the RI Report (Baker, 1996).

2.1 Operable Unit Description

Figure 2-1 presents a map of MCB, Camp Lejeune. Located in Onslow County, North Carolina, the Base currently covers approximately 234 square miles and is bisected by the New River. As shown in Figure 2-1, the New River flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The borders of MCB, Camp Lejeune are defined by U. S. Route 17 and State Route 24 to the west and northwest, respectively. The eastern and southern borders are defined by the Atlantic Ocean shoreline, and the northern border is defined by the City of Jacksonville, North Carolina. More extensive background information on MCB, Camp Lejeune is located in the RI report (Baker, 1996).

Operable units at MCB, Camp Lejeune were formed as an incremental step toward addressing individual site concerns. The purpose of an operable unit is to simplify the specific problems associated with a site or group of sites. There are currently 33 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune which have been grouped into 17 OUs.

OU No. 12 contains only one site - Site 3, the Old Creosote Plant. This site is the former location of a creosote wood-treating plant that reportedly operated from 1951 to 1952. Figure 2-1 depicts the location of OU No. 12 (Site 3) within MCB, Camp Lejeune. As shown, OU No. 12 (Site 3) is located in the northeast portion of the Base, approximately 1/4 of a mile east of Holcomb Boulevard and 3/4 of a mile north of Wallace Creek.

2.2 Site Description and History

Figure 2-2 presents a map of Site 3. Located within the Mainside Supply and Storage areas at MCB, Camp Lejeune, Site 3 encompasses an area of approximately five acres and is generally flat and unpaved. Open Storage Lots 201 and 203 (i.e., Site 6) are located nearby along Holcomb Boulevard approximately 1-1/2 miles from Site 3. However, Site 3 itself is not currently used for open storage.

As shown in Figure 2-2, the site is intersected by two roadways: a dirt path that runs north-south and forms a loop in the southern portion of the site, and a gravel road that runs east-west and leads directly to Holcomb Boulevard. Access to the site via these roadways is currently unrestricted. In addition, the Camp Lejeune Railroad line runs parallel to the site's western edge and intersects an old railroad spur line at the site's southern extreme. The intersection of these two lines creates a spike formation that points south. Wooded areas lie north and east of the site.

The old creosote plant reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base railroad. Reportedly, an on site sawmill, located in the northern portion of the site, was used to trim logs into railroad ties (Baker, 1994b). The ties were then treated with hot creosote in pressure cylinder chambers. Records show that preservatives (i.e., creosote) were stored for reuse in a railroad tank car.

In typical pressure treatment processes, wood ties are placed inside cylindrical chambers which are filled with wood-treating preservatives. Then, hydrostatic or pneumatic pressures, ranging from 50 to 200 pounds per square inch (psi), are applied within the treatment chamber until the wood absorbs the desired amount of preservatives. When the treatment process is complete, a pump removes the excess preservatives from the chamber and sends it to a storage vessel for reuse. Excess preservative is then removed from the wood by applying a vacuum, or by allowing the wood to drip dry. In the past, treated wood lay in open areas for several days , allowing preservative to drip. Today, treated wood is typically placed on lined and covered drip pads to collect excess preservative (USEPA, 1992).

The main treatment area at Site 3 was most likely located within and immediately surrounding the dirt path loop in the southern portion of the site. This area contains an abandoned chimney that was probably associated with creosote heating/thinning activities. (Creosote is heated and mixed with fuel oil to create a less viscous consistency.) The 240 foot long concrete pad encircled by the dirt path loop was probably used as a drip track for pressure cylinder chambers or treated wood ties. However, the concrete pad does not contain visual evidence of contamination. South of the pad, evidence of rail lines was observed indicating that a railroad connection may have been located in this area. The railroad connection may have transported creosote or ties to and from the treatment area. The portable steel bridge identified in Figure 2-2 is not associated with the former creosote plant. It was more recently stationed in the area by Base personnel.

Several concrete pads, which may also be remnants of the former creosote plant, are scattered throughout the northern and southern portions of Site 3. However, these pads do not contain visual evidence of contamination. In addition, a small trash pile containing palettes and metal debris is located in the northern portion of Site 3. However, this trash pile does not appear to have been associated with the former creosote plant.

2.3 Previous Investigation

The previous investigation at Site 3 was a Site Inspection conducted by Halliburton/NUS in June 1991. This Site Inspection consisted of soil, groundwater, and sediment investigations which are briefly described in the following subsections. More detailed information is located in the Halliburton/NUS Site Inspection Report, 1991. In addition, Figure 2-3 identifies the sampling locations associated with this Site Inspection.

2.3.1 Soil Investigation

During the soil investigation, seven surface soil samples (0 to 2 feet below ground surface [bgs]) and seven subsurface soil samples (3 to 17 feet bgs) were collected. Figure 2-3 identifies the monitoring well and soil boring locations where the soil samples were collected. All soil samples were analyzed for target compound list (TCL) semivolatile organic compounds (SVOCs). Table 2-1 summarizes the analytical results from this soil investigation.

The surficial soil samples from locations 03-SB04 and 03-MW02 (0 to 2 feet bgs) contained polyaromatic hydrocarbons (PAHs) at concentrations ranging from 260 microgram per kilogram (μg/kg) for benzo(g,h,i)perylene to 2,200 μg/kg for benzo(b)fluoranthene. Several PAHs, including chrysene, benzo(k)fluoranthene, benzo(a)pyrene, fluoranthene, pyrene, and indeno(1,2,3-cd)pyrene, were detected at concentrations exceeding 1,000 μg/kg.

PAHs were not detected in the shallow subsurface soil samples collected from 3 to 5 feet bgs. However, a deep subsurface soil sample from boring 03-MW02 (15 to 17 feet bgs) contained elevated PAH concentrations. In this sample, several PAHs, including acenaphthene, fluoranthene, fluorene, naphthalene, and phenanthrene, were detected at concentrations exceeding 35,000 μg/kg; dibenzofuran was detected at 35,000 μg/kg. Based on the depth of this sample and sampling logs, it may have been collected from the saturated zone.

2.3.2 Groundwater Investigation

As shown in Figure 2-3, three shallow monitoring wells (03-MW01, 03-MW02, and 03-MW03) were installed to depths ranging from 17 to 25 feet bgs during the Site Inspection. One round of groundwater samples was collected from each monitoring well and the samples were analyzed for full TCL SVOCs. Table 2-2 summarizes the analytical results of this groundwater investigation.

Of the three groundwater samples collected during the Site Inspection, only the sample collected from well 03-MW02 contained SVOCs. Several PAHs, including acenaphthene, 2-methylnaphthalene, naphthalene, and phenanthrene, were detected at concentrations exceeding 1,000 microgram per liter (μg/L). Other detected PAHs included anthracene (260 μg/L), chrysene (96 μg/L), fluoranthene (640 μg/L), fluorene (890 μg/L), and pyrene (460 μg/L). In addition, dibenzofuran was detected at a concentration of 1,100 μg/L.

2.3.3 Sediment Investigation

As shown in Figure 2-3, two sediment samples were collected during the Site Inspection. These samples were located in low lying areas that collect runoff water from the site. Both samples were analyzed for TCL SVOCs. The only SVOC detected was bis(2-ethylhexyl)phthalate (BEHP). It was detected at a concentration of 750 μg/kg in sample 03-SD01.

2.4 Remedial Investigation

Baker conducted an RI at Site 3 to evaluate the nature and extent of the threat to public health and the environment resulting from the potential release of hazardous substances, pollutants, or contaminants. The RI consisted of a site survey, soil investigations, groundwater investigations, and a habitat evaluation.

The soil and groundwater investigations were conducted in three phases. Phase 1, conducted in September 1994, consisted of a surface soil investigation using enzyme linked immunosorbent assay (ELISA) field screening. A total of 84 surface soil samples were collected and analyzed in the field using EnSys Polyaromatic Hydrocarbon [PAH RISC R Draft Method USEPA 4035] soil test, while 37 of the 84 samples were sent to a laboratory for confirmatory analyses. The results of the Phase 1 surface soil investigation assisted in locating soil borings and monitoring wells at Site 3 during Phases 2 and 3 of the RI. Phase 2, conducted from October through December 1994, included surface soil, subsurface soil, and groundwater investigations. During this second phase, five shallow monitoring wells and one intermediate monitoring well (i.e., a well screened at the top of the Castle Hayne aquifer) were installed. Phase 3, conducted in June 1995, included surface soil, subsurface soil, and groundwater investigations. During this third phase, five additional shallow monitoring wells, one additional intermediate monitoring, and one deep monitoring well (i.e., a well screened in the middle of the Castle Hayne aquifer) were installed.

In addition to these three phases, monitoring well 03-MW02DW was resampled a third time in January 1996.

Figures 2-4, 2-5, and 2-6 identify the soil sampling locations during all three soil sampling phases. Figure 2-4 identifies the sampling locations in the site's northern area (NA), Figure 2-5 identifies the sampling locations in the treatment area (TA)/concrete pad area (CP), and Figure 2-6 identifies the sampling locations in the railroad spur area (RS). Figure 2-7 identifies the monitoring well sampling locations during all groundwater sampling rounds conducted at Site 3. In addition, Tables 2-3 and 2-4 present soil sampling and monitoring well sampling summaries, respectively.

The remaining portions of Section 2.0 summarize the results and findings of the RI. Section 2.5 briefly describes the physical characteristics (i.e., topography, surface water hydrology and drainage features, geology and hydrogeology, and potable water supply wells) of Site 3. Section 2.6 describes the nature and extent of contamination identified in soil and groundwater. Finally, Sections 2.7 and 2.8 summarize the results of the human health and ecological risk assessments, respectively. More detailed information is located in the RI Report (Baker, 1996).

2.5 Physical Characteristics of the Study Area

The physical characteristics of the study area include the site's topography, surface water hydrology and drainage features, geology and hydrogeology, and nearby potable water supply wells.

2.5.1 Topography

The topography at Site 3 is relatively flat with elevations around 30 feet above mean sea level (msl). This generally flat topography is typical of MCB, Camp Lejeune and most of the seaward portions of the North Carolina coastal plain. Elevations at the Base vary from sea level to 72 feet above msl. The average elevation at the Base is between 20 and 40 feet above msl.

2.5.2 Surface Water Hydrology and Drainage Features

There are no standing water bodies located within Site 3. However, there are drainage paths flanking the eastern and western edges of the site that contain ponded water during periods of heavy rain (see Figure 2-2). One small drainage path is located along the site's eastern woodline. Two other drainage paths, which eventually discharge into Wallace Creek, are located parallel to and on either side of the Camp Lejeune Railroad line. (Wallace Creek is located approximately 3/4 of a mile south of Site 3). Another drainage path is located in a depressional area that occurs approximately 200 feet west of the Camp Lejeune Railroad line. The final drainage path is located adjacent to nearby Holcomb Boulevard. Due to the locations of these drainage paths, surface water runoff on the eastern half of the site flows in an easterly direction and surface water runoff on the western half of the site flows in a westerly direction.

2.5.3 Geology and Hydrogeology

The important geologic/hydrogeologic units at Site 3 are the shallow aquifer, the Castle Hayne semi-confining unit, and the Castle Hayne aquifer. The shallow aquifer is comprised of fine grained sand with varying amounts of silt. The thickness of the shallow aquifer ranges between 11 and 32 feet at the site. The Castle Hayne semi-confining unit, which lies below the shallow aquifer, is a discontinuous silty clay layer that ranges in thickness from 0 to 12 feet at the site. Below this semi-confining unit lies the Castle Hayne aquifer. This deeper aquifer consists of a silty sand with varying amounts of shell and limestone fragments, and exhibits an increasing density with increasing depth. Regional geologic information indicates that the Castle Hayne aquifer ranges from 150 to 350 feet in thickness, increasing in thickness toward the ocean (Harned, et al., 1989).

During the RI, the hydraulic properties of the shallow and Castle Hayne aquifers were characterized by performing in situ rising and falling head slug tests. For the shallow aquifer, the average hydraulic conductivity was determined to be 1.1E-03 centimeters per second (cm/s) (or 3.2 feet/day) with an average hydraulic gradient of 0.045 feet/feet and an average groundwater velocity of 0.41 feet/day. For the upper portion of the Castle Hayne aquifer (i.e., the portion of the aquifer where the intermediate wells are screened), the average hydraulic conductivity was determined to be 1.4E-03 cm/s (or 4 feet/day) with an average hydraulic gradient of 0.002 feet/day and an average groundwater velocity of 0.02 feet/day. For both the shallow and Castle Hayne aquifers, the effective porosity was estimated to be 0.35.

Groundwater in the shallow aquifer appears to be flowing in a west-southwesterly direction (see Figure 2-2). Assuming a linear groundwater flow in the Castle Hayne aquifer, the groundwater elevation difference between wells 03-MW02IW and 03-MW11IW indicates a southwesterly flow direction in the Castle Hayne. The differentiation between the shallow and Castle Hayne aquifers is based on lithology (i.e., the semi-confining silty clay layer), groundwater parameters from the evaluation of slug test data, and usage (the shallow aquifer is not used as a water supply on the Base). Evaluation of groundwater elevations indicates an average potential vertical gradient between the two aquifers of 0.2 feet/feet.

2.5.4 Potable Water Supply Wells

Potable water at MCB, Camp Lejeune is supplied entirely from the Castle Hayne aquifer. In the MCB, Camp Lejeune area, the Castle Hayne is a highly permeable, semiconfined aquifer capable of yielding several hundred to 1,000 gallons per minute (gpm). The water retrieved is typically hard, calcium bicarbonate type.

There are approximately 110 water supply wells (71 active) and 5 active water treatment plants located at the Base. Four Base supply wells, labeled HP-613, HP-616, HP-654, and OW-3, are located within a one-mile radius of Site 3 (Harned, et al., 1989). Figure 2-8 identifies the locations of these supply wells with respect to Site 3. Well OW-3 is out of service while the other three wells (HP-613, HP-616, and HP-654) are still in service. Organic contaminants have not been detected in groundwater samples collected from the three in service wells (Bionomics Laboratory, Inc., 1995).

2.6 Nature and Extent of Contamination

Tables 2-5, 2-6, and 2-7 summarize the analytical results from the surface soil, subsurface soil, and groundwater investigations conducted during the RI. Table 2-5 summarizes the surface soil results including background concentrations, Table 2-6 summarizes the subsurface soil results including background concentrations, and Table 2-7 summarizes the groundwater results. These tables present concentration ranges for positively detected contaminants, and a comparison of contaminant concentrations to relevant comparison criteria (i.e., federal, state, and/or local standards, or background concentrations).

The most frequently detected organic contaminants were PAHs, which exhibited the highest concentrations in both soil and groundwater. Because creosote is made up of PAH compounds, the PAHs detected at Site 3 are believed to be associated with operations at the former creosote plant. The highest PAH concentrations in soil occurred in the treatment area of the site (i.e., the area encircled by the dirt path loop). Fuel constituents, such as ethylbenzene and xylene, were also detected in surface and subsurface soil at the former treatment area.

In the shallow aquifer, benzene was detected above state and/or federal standards in the central portion of the treatment area during the first and third groundwater sampling rounds, but not during the second round. Several PAHs, including naphthalene, phenanthrene, benzo(a)anthracene, chrysene, and benzo(a)pyrene, were detected above state and/or federal standards during the first sampling round. However, naphthalene was the only PAH that was detected above standards during the subsequent sampling rounds. Naphthalene was detected in the treatment area and in the rail spur area, but the locations and concentrations of detections were not consistent between the three sampling rounds.

In the Castle Hayne aquifer, volatile organic compounds (VOCs) (in particular, fuel constituents) and SVOCs (in particular, PAHs and phenols) were detected during all three sampling rounds. Benzene, chloroform, naphthalene, and phenol were the only organic contaminants detected above state and/or federal standards. Benzene was detected above standards in intermediate well 03-MW02IW during the first sampling round. During the second sampling round, benzene, phenol, and naphthalene were detected above standards in deep well 03-MW02DW (located in the treatment area). During the third sampling round, no contaminants were detected above state and federal standards in the Castle Hayne aquifer. When 03-MW02DW was resampled a third time (in January 1996) no contaminants were detected above state and federal standards.

2.7 Human Health Risk Assessment

As part of the RI, a human health risk assessment (RA) was conducted to assess the potential risks associated with the contaminants of potential concern (COPCs) at Site 3. Figure 2-9 presents a Site Conceptual Model. Table 2-8 summarizes the Site 3 risk values (i.e., incremental cancer risk [ICR] and hazard index [HI] values) calculated with respect to each environmental medium and relevant receptor. ICR values exceeding the USEPA limit of 1E-04, and HI values exceeding the USEPA limit of 1.0, are considered to represent unacceptable risks. ICR and HI values indicating unacceptable risks are shaded in Table 2-8.

As shown in Table 2-8, the risk values for Site 3 were generated under two approaches: 1) the evaluation of Round 2 groundwater data, and 2) the evaluation of Rounds 1, 2, and 3 groundwater data combined (referred to as the "Worst Case" approach). Data collected during the three groundwater sampling rounds exhibited different results. The number of contaminants detected, and the concentrations of those contaminants, varied among sampling rounds. In evaluating groundwater risk using data from one single sampling round, it is most conservative to use the single results which include the most contaminants, at the highest concentrations. When taking this approach, Round 2 data is the most conservative, in comparison to Rounds 1 and 3. However, it is even more conservative to combine COPCs selected from Round 1, Round 2, and Round 3, as this is a way to incorporate the greatest number of contaminants, at the highest concentrations detected between rounds.

2.8 Ecological Risk Assessment

During the RI, an ecological RA was conducted to address the impacts that COPCs may be having on the ecological integrity of Site 3. The following paragraphs describe the results of terrestrial receptor, threatened and endangered species, and wetlands evaluations that were conducted during the ecological RA.

Under the terrestrial receptor evaluation, several COPCs at Site 3 exceeded surface soil screening values (SSSVs) in open grass areas or along tree lines. These exceedences indicate the potential for a decrease in the terrestrial invertebrate population in these areas. However, most of the studies used to develop the SSSVs do not take into account the soil type, which may have a large influence on the toxicity of the contaminants. In addition, most of the SSSVs are based on one or two studies which limits their reliability for a wide range of site-specific circumstances. As a result, the SSSVs have a high degree of uncertainty associated with them, and are not well-established. Consequently, the potential ecological risks based on these SSSVs may not be completely accurate and most likely err on the conservative side. In addition, none of the quotient indices (QIs) generated for terrestrial receptors exceeded the acceptable limit of 1.0, so potential impacts to terrestrial mammals or birds are not expected.

No threatened or endangered species are known to inhabit Site 3, and no wetlands have been identified at Site 3.

SECTION 2.0 TABLES

TABLE 2-1

SITE INSPECTION, 1991
ANALYTICAL RESULTS FOR SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil (0-2 feet)		Subsurface Soil (3-12 feet)		Subsurface Soil (> 12 feet)	
	No. of Positive Detections/ No. of Samples	Range of Positive Detections	No. of Positive Detections/ No. of Samples	Range of Positive Detections	No. of Positive Detections/ No. of Samples	Range of Positive Detections
Acenaphthene	0/7	ND	0/5	ND	1/2	37,000
Antracene	1/7	1,900	0/5	ND	1/2	8,600
Benzo(a)anthracene	2/7	460-660	0/5	ND	1/2	5,600
Benzo(b)fluoranthene	2/7	520-2,200	0/5	ND	1/2	2,300
Benzo(k)fluoranthene	2/7	420-1,200	0/5	ND	1/2	2,100
Benzo(g,h,i)perylene	2/7	260-720	0/5	ND	0/2	ND
Benzo(a)pyrene	2/7	320-1,300	0/5	ND	0/2	ND
Chrysene	2/7	750-1,400	0/5	ND	1/2	5,900
Flouranthene	2/7	1,000-1,600	0/5	ND	1/2	35,000
Fluorene	0/7	ND	0/5	ND	1/2	35,000
Indeno(1,2,3-cd)pyrene	2/7	340-1,000	0/5	ND	0/2	ND
2-Methylnaphthalene	0/7	ND	0/5	ND	1/2	26,000
Naphthalene	1/7	550	0/5	ND	1/2	52,000
Phenanthrene	1/7	310	0/5	ND	1/2	81,000
Pyrene	2/7	920-1,400	0/5	ND	1/2	27,000
Dibenzofuran	0/7	ND	0/5	ND	1/2	35,000

Notes:

Concentrations expressed in µg/kg (microgram per kilogram)
ND - Not Detected
Reference: Halliburton/NUS, 1991

TABLE 2-2

SITE INSPECTION, 1991
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	North Carolina Standards	USEPA MCLs	No. of Positive Detections/ No. of Samples	Range of Positive Detection	Location of Maximum Concentration
Acenaphthene	80	--	1/3	1,500	3MW02
Anthracene	2,100	--	1/3	260	3MW02
Chrysene	5	2	1/3	96	3MW02
Fluoranthene	280	--	1/3	640	3MW02
Fluorene	--	--	1/3	890	3MW02
2-Methylnaphthalene	--	--	1/3	1,500	3MW02
Naphthalene	--	--	2/3	9-4,400	3MW02
Phenanthrene	--	--	1/3	1,600	3MW02
Pyrene	210	--	1/3	460	3MW02
Dibenzofuran	--	--	1/3	1,100	3MW02

Notes:

Concentrations expressed in µg/L (microgram per liter)
-- = No criteria established.
Reference: Halliburton/NUS, 1991

TABLE 2-3

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®)[1]	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters[3]	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
Rail Spur Area											
3-RS-SB01	00	1.0	0.0 - 1.0	X		X [2]					
	03	7.0	5.0 - 7.0			X [4]					
3-RS-SB02	00	1.0	0.0 - 1.0	X		X [2]				X	
	04	9.0	0.0 - 9.0			X [4]					
3-RS-SB03	00	1.0	0.0 - 1.0	X		X [2]					
3-RS-SB04	00	1.0	0.0 - 1.0	X							
3-RS-SB05	00	1.0	0.0 - 1.0	X		X [2]					
	03	7.0	5.0 - 7.0			X [4]					
	04	9.0	7.0 - 9.0			X [4]					
3-RS-SB06	00	1.0	0.0 - 1.0	X		X [2]					
	04	9.0	7.0 - 9.0			X [4]					
3-RS-SB07	00	1.0	0.0 - 1.0	X		X [2]					
	04	9.0	7.0 - 9.0			X [4]					
3-RS-SB08	00	1.0	0.0 - 1.0	X							
3-RS-SB09	00	1.0	0.0 - 1.0	X							
3-RS-SB10	00	1.0	0.0 - 1.0	X						X	

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®)(1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
Concrete Pad Area											
3-CP-SB01	00	1.0	0.0 - 1.0	X							
3-CP-SB02	00	1.0	0.0 - 1.0	X		X (2)				X (6)	
3-CP-SB03	00	1.0	0.0 - 1.0	X							
3-CP-SB04	00	1.0	0.0 - 1.0	X		X (2)					
3-CP-SB05	00	1.0	0.0 - 1.0	X		X (2)					
3-CP-SB06	00	1.0	0.0 - 1.0	X							
3-CP-SB07	00	1.0	0.0 - 1.0	X							
3-CP-SB08	00	1.0	0.0 - 1.0	X							
3-CP-SB09	00	1.0	0.0 - 1.0	X		X (2)					
3-CP-SB10	00	1.0	0.0 - 1.0	X							
Treatment Area											
3-TA-SB01	00	1.0	0.0 - 1.0	X						X	
3-TA-SB02	00	1.0	0.0 - 1.0	X							
3-TA-SB03	00	1.0	0.0 - 1.0	X						X	
3-TA-SB04	00	1.0	0.0 - 1.0	X							

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®)[1]	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters[3]	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-TA-SB05	00	1.0	0.0 - 1.0	X							
3-TA-SB06	00	1.0	0.0 - 1.0	X							
3-TA-SB07	00	1.0	0.0 - 1.0	X							
3-TA-SB08	00	1.0	0.0 - 1.0	X		X [2]				X	
	04	9.0	7.0 - 9.0			X [4]					
3-TA-SB09	00	1.0	0.0 - 1.0	X		X [2]					
3-TA-SB10	00	1.0	0.0 - 1.0	X		X [2]					
	04	9.0	7.0 - 9.0			X [4]					
3-TA-SB11	00	1.0	0.0 - 1.0	X							
3-TA-SB12	00	1.0	0.0 - 1.0	X		X [2]					
3-TA-SB13	00	1.0	0.0 - 1.0	X		X [2]					
	03	7.0	5.0 - 7.0			X [4]					
3-TA-SB14	00	1.0	0.0 - 1.0	X		X [2]					
	02	5.0	3.0 - 5.0			X [4]					
3-TA-SB15	00	1.0	0.0 - 1.0	X							
3-TA-SB16	00	1.0	0.0 - 1.0	X							

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-TA-SB17	00	1.0	0.0 - 1.0	X		X (2)					
	04	9.0	7.0 - 9.0			X (4)					
3-TA-SB18	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					
3-TA-SB19	00	1.0	0.0 - 1.0	X							
3-TA-SB20	00	1.0	0.0 - 1.0	X							
3-TA-SB21	00	1.0	0.0 - 1.0	X		X (2)				X (6)	
	03	7.0	5.0 - 7.0			X (4)				X	
3-TA-SB22	00	1.0	0.0 - 1.0	X							
3-TA-SB23	00	1.0	0.0 - 1.0	X							
3-TA-SB24	00	1.0	0.0 - 1.0	X							
3-TA-SB25	00	1.0	0.0 - 1.0	X		X (2)					
	02	5.0	3.0 - 5.0			X (4)					
3-TA-SB26	00	1.0	0.0 - 1.0	X							
3-TA-SB27	00	1.0	0.0 - 1.0	X							
3-TA-SB28	00	1.0	0.0 - 1.0	X							

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®)(1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-TA-SB29	00	1.0	0.0 - 1.0	X		X (2)				X	
	02	5.0	3.0 - 5.0			X (4)					
3-TA-SB30	00	1.0	0.0 - 1.0	X							
3-TA-SB31	00	1.0	0.0 - 1.0	X							
3-TA-SB32	00	1.0	0.0 - 1.0	X							
3-TA-SB33	00	1.0	0.0 - 1.0	X							
3-TA-SB34	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					
3-TA-SB35	00	1.0	0.0 - 1.0	X							
3-TA-SB36	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-TA-SB37	00	1.0	0.0 - 1.0	X		X (2)					
	02	5.0	3.0 - 5.0			X (4)					
3-TA-SB38	00	1.0	0.0 - 1.0	X							
3-TA-SB39	00	1.0	0.0 - 1.0	X		X (2)					
	04	9.0	7.0 - 9.0			X (4)					
3-TA-SB40	00	1.0	0.0 - 1.0	X		X (2)					
3-TA-SB41	00	1.0	0.0 - 1.0	X		X (2)					
	02	5.0	3.0 - 5.0			X (4)					
3-TA-SB42	00	1.0	0.0 - 1.0	X							
3-TA-SB43	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					
3-TA-SB44	00	1.0	0.0 - 1.0	X		X (2)					
3-TA-SB45 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®)[1]	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters[3]	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-TA-SB46 [5]	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-TA-SB47 [5]	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-TA-SB48 [5]	00	1.0	0.0 - 1.0		X	X					
	04	9.0	7.0 - 9.0		X	X					
3-TA-SB49 [5]	00	1.0	0.0 - 1.0		X	X					
	04	9.0	7.0 - 9.0		X	X					
3-TA-SB50 [5]	00	1.0	0.0 - 1.0		X	X					
	04	9.0	7.0 - 9.0		X	X					
North Area											
3-NA-SB01	00	1.0	0.0 - 1.0	X		X [2]				X [6]	
3-NA-SB02	00	1.0	0.0 - 1.0	X							
3-NA-SB03	00	1.0	0.0 - 1.0	X		X [2]					
	03	7.0	5.0 - 7.0			X [4]					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-NA-SB04	00	1.0	0.0 - 1.0	X						X	
3-NA-SB05	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					
3-NA-SB06	00	1.0	0.0 - 1.0	X							
3-NA-SB07	00	1.0	0.0 - 1.0	X		X (2)					
3-NA-SB08	00	1.0	0.0 - 1.0	X		X (2)					
	03	7.0	5.0 - 7.0			X (4)					
3-NA-SB09	00	1.0	0.0 - 1.0	X							
3-NA-SB10	00	1.0	0.0 - 1.0	X		X (2)					
3-NA-SB11	00	1.0	0.0 - 1.0	X							
3-NA-SB12	00	1.0	0.0 - 1.0	X							
3-NA-SB13	00	1.0	0.0 - 1.0	X						X	
3-NA-SB14	00	1.0	0.0 - 1.0	X							
3-NA-SB15	00	1.0	0.0 - 1.0	X							
3-NA-SB16	00	1.0	0.0 - 1.0	X							
3-NA-SB17	00	1.0	0.0 - 1.0	X		X (2)					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-NA-SB17A (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-NA-SB18 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-NA-SB19 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
EnSys Background											
3-BB-SB01	00	1.0	0.0 - 1.0	X							
3-BB-SB02	00	1.0	0.0 - 1.0	X							
3-BB-SB03	00	1.0	0.0 - 1.0	X		X(2)				X	
Soil Investigation Background											
3-BB-SB01 (4)	00	1.0	0.0 - 1.0			X					
	03	7.0	5.0 - 7.0			X					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-BB-SB02 (4)	00	1.0	0.0 - 1.0			X					
	02	5.0	3.0 - 5.0			X					
3-BB-SB03 (4)	00	1.0	0.0 - 1.0			X					
	03	7.0	5.0 - 7.0			X					
Monitoring Wells											
3-MW02IW (4)	00	1.0	0.0 - 1.0		X	X	X	X		X	X
	03	7.0	5.0 - 7.0		X	X	X	X		X	X
	09	19.0	17.0 - 19.0			X					
3-MW02DW (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-MW04 (4)	00	1.0	0.0 - 1.0			X					
	04	9.0	7.0 - 9.0			X					
3-MW05 (4)	00	1.0	0.0 - 1.0		X	X	X	X	X		
	10	21.0	19.0 - 21.0		X	X	X	X	X		

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-MW06 (4)	00	1.0	0.0 - 1.0			X					
	04	9.0	7.0 - 9.0			X					
3-MW07 (4)	00	1.0	0.0 - 1.0			X					
	02	5.0	3.0 - 5.0			X					
3-MW08 (4)	00	1.0	0.0 - 1.0			X					
	02	5.0	3.0 - 5.0			X					
3-MW09 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-MW10 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-MW11 (5)	00	1.0	0.0 - 1.0		X	X					
	08	19.0	17.0 - 19.0		X	X					
3-MW11IW (5)	00	1.0	0.0 - 1.0		X	X					
	08	19.0	17.0 - 19.0		X	X					

TABLE 2-3 (Continued)

REMEDIAL INVESTIGATION, 1994-95
SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	EnSys Sample (PAH RISC ®) (1)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Metals	Engineering Parameters(3)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-MW12 (5)	00	1.0	0.0 - 1.0		X	X					
	02	5.0	3.0 - 5.0		X	X					
3-MW13 (5)	00	1.0	0.0 - 1.0		X	X					
	04	9.0	7.0 - 9.0		X	X					

Notes:

(1) Sample was collected during the first phase of the soil investigation (September 19 through September 22, 1994)
(2) EnSys confirmation sample
(3) Engineering Parameters includes Particle Size, Atterberg limits, and TOC
(4) Sample was collected during the second phase of the soil investigation (November 15 through November 22, 1994)
(5) Sample was collected during the third phase of the soil investigation (June 13 through June 20, 1995)
(6) Duplicate samples were collected for both PAH RISC ® and TCL Semivolatiles

TABLE 2-4

REMEDIAL INVESTIGATION, 1994-95
MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Inorganics	TAL Dissolved Metals	Engineering Parameters (1)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
Shallow Monitoring Wells, Round 1									
3-MW02-01	12/1/94		X						
3-MW03-01	12/1/94		X						
3-MW04-01	12/1/94		X						
3-MW05-01	12/2/94		X						
3-MW06-01	12/1/94		X						
3-MW07-01	12/1/94	X	X	X	X	X			
3-MW08-01	12/1/94	X	X	X	X	X			
Intermediate Monitoring Well, Round 1									
3-MW02IW-01	12/3/94	X	X	X	X	X		X	X
Shallow Monitoring Wells, Round 2									
3-MW01-01	7/13/95	X	X						

TABLE 2-4 (Continued)

REMEDIAL INVESTIGATION, 1994-95
MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Inorganics	TAL Dissolved Metals	Engineering Parameters (1)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-MW02-02	7/11/95	X	X				X		
3-MW03-02	7/13/95	X	X						
3-MW04-02	7/11/95	X	X						
3-MW05-02	7/11/95	X	X						
3-MW06-02	7/12/95	X	X						
3-MW07-02	7/12/95	X	X						
3-MW08-02	7/11/95	X	X				X		
3-MW09-01	7/13/95	X	X						
3-MW10-01	7/12/95	X	X						
3-MW11-01	7/12/95	X	X						
3-MW12-01	7/12/95	X	X						
3-MW13-01	7/13/95	X	X						

TABLE 2-4 (Continued)

REMEDIAL INVESTIGATION, 1994-95
MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Inorganics	TAL Dissolved Metals	Engineering Parameters (1)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
Intermediate and Deep Monitoring Wells, Round 2									
3-MW02IW-02	6/12/95	X	X						
3-MW02DW-01	7/13/95	X	X				X		
3-MW11IW-01	7/12/95	X	X						
Shallow Monitoring Wells, Round 3									
3-MW01-02	9/28/95	X	X						
3-MW02-03	9/28/95	X	X						
3-MW03-03	9/28/95	X	X						
3-MW04-03	9/28/95	X	X						
3-MW05-03	9/28/95	X	X						
3-MW06-03	9/28/95	X	X						
3-MW07-03	9/29/95	X	X						
3-MW08-03	9/29/95	X	X						

TABLE 2-4 (Continued)

REMEDIAL INVESTIGATION, 1994-95
MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/ PCBs	TAL Inorganics	TAL Dissolved Metals	Engineering Parameters (1)	Duplicate Samples	Matrix Spike/Matrix Spike Duplicate
3-MW09-02	9/29/95	X	X						
3-MW10-02	9/29/95	X	X						
3-MW11-02	9/29/95	X	X						
3-MW12-02	9/29/95	X	X						
3-MW13-02	9/29/95	X	X						
Intermediate and Deep Monitoring Wells, Round 3									
3-MW02IW-03	9/29/95	X	X						
3-MW02DW-02	9/28/95	X	X						
3-MW11IW-02	9/29/95	X	X						
Deep Monitoring Well, Round 4									
3-MW02DW-03	1/29/96	X	X						

Note:

(1) Engineering Parameters include (BOD, COD, TDS, TSS, and TOC)

TABLE 2-5

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR SURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			RBC Residential Soils (µg/kg)		(µg/kg)	(µg/kg)			RBC Residential Soils		
Surface Soils (Collected from 0 to 1 foot bgs)	Volatile Organic Compounds	Toluene	1,600,000	NE	2J	2J	3-MW13-00	2/17	0	NA	Treatment Area
		Ethylbenzene	780,000	NE	2J	2J	3-TA-SB50-00	1/17	0	NA	Treatment Area
		Xylenes (total)	16,000,000	NE	6J	6J	3-TA-SB50-00	1/17	0	NA	Treatment Area
	Semivolatile Organic Compounds	Phenol	4,700,000	NE	38J	38J	3-RS-SB03-00	1/58	0	NA	Rail Spur
		Naphthalene	310,000	NE	38J	200J	3-NA-SB05-00	2/58	0	NA	North Area, Rail Spur
		2-Methyl-naphthalene	310,000	NE	41J	41J	3-RS-SB02-00	1/58	0	NA	Rail Spur
		Acenaphthylene	230,000	NE	40J	2,700	3-NA-SB03-00	16/58	0	NA	North Area, Rail Spur, Treatment Area
		Acenaphthene	470,000	NE	44J	460J	3-NA-SB05-00	2/58	0	NA	North Area, Rail Spur
		Dibenzofuran	31,000	NE	370J	370J	3-NA-SB05-00	1/58	0	NA	North Area
		Fluorene	310,000	NE	39J	620J	3-NA-SB05-00	5/58	0	NA	North Area, Rail Spur, Treatment Area
		Penanthrene	230,000	NE	37J	2,900	3-NA-SB05-00	9/58	0	NA	North Area, Rail Spur, Treatment Area
		Anthracene	2,300,000	NE	40J	7,700	3-NA-SB03-00	26/58	0	NA	Scattered
		Carbazole	32,000	NE	40J	830J	3-NA-SB03-00	14/58	0	NA	Scattered
		di-n-Butyl-phthalate	780,000	NE	37J	340J	3-TA-SB13-00	37/58	0	NA	Scattered
		Fluoranthene	310,000	NE	42J	11,000	3-NA-SB03-00	32/58	0	NA	Scattered
		Pyrene	230,000	NE	39J	14,000	3-NA-SB03-00	34/58	0	NA	Scattered
		Benzo(a)anthracene	880	NE	32J	8,300	3-NA-SB03-00	24/58	5(1)	NA	Scattered
		Chrysene	88,000	NE	40J	12,000	3-NA-SB03-00	32/58	0	NA	Scattered
		bis(2-Ethylhexyl)phthalate	46,000	NE	36J	91J	3-NA-SB01-00	30/58	0	NA	Scattered
		Benzo(b)fluoranthene	880	NE	39J	13,000	3-NA-SB03-00	37/58	6	NA	Scattered
		Benzo(k)fluoranthene	8,800	NE	37J	9,000	3-NA-SB03-00	34/58	1	NA	Scattered
		Benzo(a)pyrene	88	NE	38J	8,700	3-NA-SB03-00	30/58	20	NA	Scattered
		Indeno(1,2,3-cd)pyrene	880	NE	40J	6,800	3-NA-SB03-00	26/58	5	NA	Scattered
		Dibenzo(a,h)anthracene	88	NE	40J	2,900	3-NA-SB03-00	16/58	6	NA	North Area, Rail Spur, Treatment Area
		Benzo(g,h,i)perylene	230,000	NE	39J	4700	3-NA-SB03-00	22/58	0	NA	North Area, Rail Spur, Treatment Area

TABLE 2-5 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR SURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			RBC Residential Soils (mg/kg)	Base Background (mg/kg)	(mg/kg)	(mg/kg)			RBC Residential Soils	Base Background	
Surface Soils (Collected from 0 to 1 foot bgs) (Cont.)	Inorganics	Aluminum	7,800	9,570	1,740	4,240	3-MW05-00	2/2	0	0[2]	--
		Barium	550	20.8	6.4J	7.8J	3-MW05-00	2/2	0	0	--
		Calcium	NE	10,700	4,020	67,700	3-MW02IW-00	2/2	NA	1	Treatment Area
		Chromium	39	12.5	2.7	7.1	3-MW02IW-00	2/2	0	0	--
		Iron	23,000	9,640	1,390	1,970	3-MW05-00	2/2	0	0	--
		Lead	400	142	4.4J	4.4J	3-MW02IW-00	1/2	0	0	--
		Magnesium	NE	610	150	1,020	3-MW02IW-00	2/2	NA	1	Treatment Area
		Manganese	1,100	66	11.7	13.1	3-MW05-00	2/2	0	0	--
		Sodium	NE	126	112	112	3-MW02IW-00	1/2	NA	0	--
		Vanadium	55	28.3	3.3	5.2	3-MW05-00	2/2	0	0	--
		Zinc	2,300	2.4	16.6	16.6	3-MW02IW-00	1/2	0	0	--

Notes:

(1) Shaded boxes indicate detections above comparison criteria.
(2) Detections compared to maximum base background concentrations.

NE = No Criteria Established
NA = Not Applicable
J - estimated value
RBC - Risk-Based Concentration
µg/kg - microgram per kilogram (ppb)
mg/kg - milligram per kilogram (ppm)

TABLE 2-6

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR SUBSURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			RBC Residential Soils (µg/kg)		(µg/kg)	(µg/kg)			RBC Residential Soils		
Subsurface Soils	Volatile Organic Compounds	Acetone	780,000	NE	120	120	3-NA-SB17A-02	1/18	0	NA	North Area
		Carbon Disulfide	780,000	NE	1J	1J	3-MW12-02	1/18	0	NA	West of North Area
		Chloroform	100,000	NE	3J	3J	3-MW11IW-08	1/18	0	NA	West of Treatment Area
		2-Butanone	4,700,000	NE	3J	3J	3-NA-SB19-02	1/18	0	NA	North Area
		Benzene	22,000	NE	2J	2J	3-MW02IW-03	2/18	0	NA	Treatment Area
		Toluene	1,600,000	NE	3J	13	3-TA-SB49-04	4/18	0	NA	Treatment Area
		Ethylbenzene	780,000	NE	3J	110	3-TA-SB49-04	4/18	0	NA	Treatment Area
		Styrene	1,600,000	NE	4J	5J	3-MW09-02	2/18	0	NA	Treatment Area
		Xylenes (total)	16,000,000	NE	7J	300	3-TA-SB49-04	4/18	0	NA	Treatment Area
	Semivolatile Organic Compounds	Phenol	4,700,000	NE	7,200J	7,200J	3-TA-SB48-08	1/47	0	NA	Treatment Area
		2-Methylphenol	390,000	NE	2,000J	2,000J	3-TA-SB48-08	1/47	0	NA	Treatment Area
		4-Methylphenol	39,000	NE	5,900J	5,900J	3-TA-SB48-08	1/47	0	NA	Treatment Area
		Naphthalene	310,000	NE	55J	95,000	3-TA-SB48-08	9/47	0	NA	Treatment Area
		2-Methylnaphthalene	310,000	NE	100J	31,000	3-TA-SB48-08	6/47	0	NA	Treatment Area
		Acenaphthylene	230,000	NE	190J	190J	3-MW02IW-09	1/47	0	NA	Treatment Area
		Acenaphthene	470,000	NE	560	47,000	3-TA-SB48-08	6/47	0	NA	Treatment Area
		4-Nitrophenol	480,000	NE	570J	570J	3-TA-SB50-04	1/47	0	NA	Treatment Area
		Dibenzofuran	31,000	NE	440	36,000J	3-TA-SB48-08	6/47	0	NA	Treatment Area
		Fluorene	310,000	NE	710	35,000J	3-TA-SB48-08	6/47	0	NA	Treatment Area
		N-nitrosodiphenylamine	13,000	NE	400J	1,100J	3-TA-SB48-08	2/47	0	NA	Treatment Area
		Phenanthrene	230,000	NE	61J	110,000J	3-TA-SB50-04	8/47	0	NA	Treatment Area
		Anthracene	2,300,000	NE	42J	12,000J	3-TA-SB48-08	7/47	0	NA	Treatment Area
		Carbazole	32,000	NE	200J	4,900	3-TA-SB50-04	6/47	0	NA	Treatment Area
		di-n-Butyl-phthalate	780,000	NE	39J	170J	3-TA-SB43-03	18/47	0	NA	Scattered
		Fluoranthene	310,000	NE	51J	66,000	3-TA-SB50-04	7/47	0	NA	Treatment Area

TABLE 2-6 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR SUBSURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			RBC Residential Soils (µg/kg)		(µg/kg)	(µg/kg)			RBC Residential Soils		
Subsurface Soils (Cont.)		Pyrene	230,000	NE	43J	38,000J	3-TA-SB48-08	10/47	0	NA	Treatment Area, North Area, Rail Spur
		Benzo(a)anthracene	880	NE	77J	8,000	3-TA-SB50-04	7/47	5[1]	NA	Treatment Area
		Chrysene	88,000	NE	86J	8,400J	3-TA-SB48-08	7/47	0	NA	Treatment Area
		Bis(2-ethylhexyl)phthalate	46,000	NE	53J	240J	3-MW11IW-08	2/47	0	NA	West of Treatment Area
		Benzo(b)fluoranthene	880	NE	96J	3,500J	3-TA-SB48-08	7/47	4	NA	Treatment Area
		Benzo(k)fluoranthene	8,800	NE	79J	3,300J	3-TA-SB50-04	6/47	0	NA	Treatment Area
		Benzo(a)pyrene	88	NE	55J	3,300J	3-TA-SB48-08	7/47	6	NA	Treatment Area
		Indeno(1,2,3-cd)pyrene	880	NE	46J	3,100J	3-TA-SB48-08	5/47	1	NA	Treatment Area
		Benzo(g,h,i)perylene	230,000	NE	71J	1,200J	3-TA-SB48-08	4/47	0	NA	Treatment Area
			RBC Residential Soils (mg/kg)	Base Background (mg/kg)	(mg/kg)	(mg/kg)			RBC Residential Soils	Base Background	
	Inorganics	Aluminum	7,800	11,000	3,950	6,570	3-MW021W-03	2/2	0	0[2]	--
		Barium	550	22.6	4.6J	6.6J	3-MW02IW-03	2/2	0	0	--
		Calcium	NE	4,410	77.4	638	3-MW02IW-03	2/2	NA	0	--
		Chromium	39	66.4	3.7	7.5	3-MW02IW-03	2/2	0	0	--
		Iron	23,000	90,500	734	1,030	3-MW02IW-03	2/2	0	0	--
		Lead	400	21.4	5.7J	5.7J	3-MW02IW-03	1/2	0	0	--
		Magnesium	NE	852	104	112	3-MW02IW-03	2/2	NA	0	--
		Manganese	1,100	19.9	2.8J	2.8J	3-MW02IW-03	1/2	0	0	--
		Vanadium	55	69.4	3.7	5	3-MW02IW-03	2/2	0	0	--

TABLE 2-6 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR SUBSURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Notes:

(1) Shaded boxes indicate detections above comparison criteria.
(2) Detections compared to maximum base background concentrations.

NE = No Criteria Established
NA = Not Applicable
J - estimated value
RBC - Risk-Based Concentrations
µg/kg - microgram per kilogram (ppb)
mg/kg - milligram per kilogram (ppm)

TABLE 2-7

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Groundwater - Surficial Aquifer (Round One)	Volatile Organic Compounds	Carbon Disulfide	NE	700	1 J	1 J	3-MW07-01	1/2	NA	0	Treatment Area
		Benzene	5	1	13J	40J	3-MW08-01	2/2	2[1]	2	Treatment Area
		Toluene	1,000	1,000	5 J	10 J	3-MW08-01	2/2	0	0	Treatment Area
		Xylenes (total)	10,000	530	6 J	9 J	3-MW08-01	2/2	0	0	Treatment Area
	Semivolatile Organic Compounds	Phenol	NE	300	3 J	3 J	3-MW02-01	1/7	NA	0	Treatment Area
		2-Methylphenol	NE	NE	1 J	1 J	3-MW02-01	1/7	NA	NA	Treatment Area
		4-Methylphenol	NE	NE	3 J	3 J	3-MW02-01	1/7	NA	NA	Treatment Area
		2-Nitrophenol	NE	NE	2 J	2 J	3-MW02-01	1/7	NA	NA	Treatment Area
		2,4-Dimethylphenol	NE	NE	2 J	2 J	3-MW02-01	1/7	NA	NA	Treatment Area
		Naphthalene	NE	21	5 J	64	3-MW02-01	4/7	NA	1	Treatment Area
		2-Methylnaphthalene	NE	NE	65	65	3-MW02-01	1/7	NA	NA	Treatment Area
		Acenaphthylene	NE	210	3 J	3 J	3-MW02-01	1/7	NA	0	Treatment Area
		Acenaphthene	NE	800	2 J	280	3-MW02-01	2/7	NA	0	Treatment Area
		Dibenzofuran	NE	NE	2 J	230	3-MW02-01	2/7	NA	NA	Treatment Area
		Fluorene	NE	280	1 J	210	3-MW02-01	2/7	NA	0	Treatment Area
		Phenanthrene	NE	210	410	410	3-MW02-01	1/7	NA	1	Treatment Area
		Anthracene	NE	2,100	33	33	3-MW02-01	1/7	NA	0	Treatment Area
		Carbazole	NE	NE	39 J	39 J	3-MW02-01	1/7	NA	NA	Treatment Area
		di-n-Butylphthalate	NE	700	1 J	1 J	3-MW02-01	1/7	NA	0	Treatment Area
		Fluoranthene	NE	280	100	100	3-MW02-01	1/7	NA	0	Treatment Area
		Pyrene	NE	210	58	58	3-MW02-01	1/7	NA	0	Treatment Area
		Benzo(a)anthracene	NE	0.05	8 J	8 J	3-MW02-01	1/7	NA	1	Treatment Area
		Chrysene	NE	5	8 J	8 J	3-MW02-01	1/7	NA	1	Treatment Area
		Benzo(b)fluroanthene	NE	NE	3 J	3 J	3-MW02-01	1/7	NA	NA	Treatment Area
		Benzo(k)fluoranthene	NE	NE	3 J	3 J	3-MW02-01	1/7	NA	NA	Treatment Area
		Benzo(a)pyrene	2	NE	3 J	3 J	3-MW02-01	1/7	1	NA	Treatment Area

TABLE 2-7 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (μg/L)	NCWQS (μg/L)	(μg/L)	(μg/L)			MCL	NCWQS	
Groundwater - Surficial Aquifer (Round One)	Inorganics	Aluminum	50	NE	447	4,030	3-MW08-01	2/2	2	NA	--
		Barium	2,000	2,000	88.1	120	3-MW07-01	2/2	0	0	--
		Calcium	NE	NE	2,870	3,870	3-MW08-01	2/2	0	0	--
		Chromium	100	50	31.6	31.6	3-MW08-01	1/2	0	0	--
		Iron	300	300	840	2,190	3-MW08-01	2/2	2	2	--
		Lead	15	15	3.2J	3.2J	3-MW08-01	1/2	0	0	--
		Magnesium	NE	NE	2,080	4,200	3-MW07-01	2/2	NA	NA	--
		Manganese	50	50	17.1J	21.7J	3-MW08-01	2/2	0	0	--
		Nickel	100	100	34.1	34.1	3-MW08-01	1/2	0	0	--
		Potassium	NE	NE	1,490	1,900	3-MW08-01	2/2	NA	NA	--
		Sodium	NE	NE	4,750	8,890	3-MW08-01	2/2	NA	NA	--
		Zinc	500	2,100	114	114	3-MW08-01	1/2	0	0	--
Groundwater - Castle Hayne (Round One)	Volatile Organic Compounds	Benzene	5	1	11 J	11 J	3-MW02IW-01	1/1	1	1	--
		Toluene	1,000	1,000	4 J	4 J	3-MW02IW-01	1/1	0	0	--
		Xylenes (total)	100,000	530	7 J	7 J	3-MW02IW-01	1/1	0	0	--
	Semivolatile Organic Compounds	Naphthalene	NE	21	3 J	3 J	3-MW02IW-01	1/1	NA	0	--
		Acenaphthylene	NE	210	3 J	3 J	3-MW02IW-01	1/1	NA	0	--
		Acenaphthene	NE	800	95	95	3-MW02IW-01	1/1	NA	0	--
		Dibenzofuran	NE	NE	57	57	3-MW02IW-01	1/1	NA	NA	--
		Fluorene	NE	280	59	59	3-MW02IW-01	1/1	NA	0	--
		Phenanthrene	NE	210	75	75	3-MW02IW-01	1/1	NA	0	--
		Anthracene	NE	2,100	5 J	5 J	3-MW02IW-01	1/1	NA	0	--
		Fluoranthene	NE	280	10	10	3-MW02IW-01	1/1	NA	0	--
		Pyrene	NE	210	7 J	7 J	3-MW02IW-01	1/1	NA	0	--

TABLE 2-7 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/kg)	(µg/L)	(µg/L)			MCL	NCWQS	
Groundwater - Surficial Aquifer (Round Two)	Volatile Organic Compounds	Chloroform	100	0.19	1 J	1 J	3-MW02-02	1/13	0	1	Treatment Area
		Trichloroethene	5	NE	1 J	1 J	3-MW12-01	2/13	0	NA	Treatment Area
	Semivolatile Organic Compounds	Naphthalene	NE	21	4 J	110	3-MW06-02	2/13	NA	1	Rail Spur
		2-Methylnaphthalene	NE	NE	10	10	3-MW06-02	1/13	NA	NA	Rail Spur
		Acenaphthene	NE	800	24	24	3-MW06-02	1/13	NA	0	Rail Spur
		Dibenzofuran	NE	NE	25	25	3-MW06-02	1/13	NA	NA	Rail Spur
		Fluorene	NE	280	28	28	3-MW06-02	1/13	NA	0	Rail Spur
		Phenanthrene	NE	210	21	21	3-MW06-02	1/13	NA	0	Rail Spur
		Anthracene	NE	2,100	1 J	1 J	3-MW06-02	1/13	NA	0	Rail Spur
		Carbazole	NE	NE	10	10	3-MW06-02	1/13	NA	NA	Rail Spur
		Fluoranthenene	NE	280	2 J	2 J	3-MW06-02	1/13	NA	0	Rail Spur
		bis(2-Ethylhexyl)phthalate	6	3	2 J	11	3-MW09-01	4/13	1	2	Scattered

TABLE 2-7 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Groundwater - Castle Hayne (Round Two)	Volatile Organic Compounds	1,1-Dichloroethene	7	7	1 J	1 J	3-MW02IW-02	1/3	0	0	Treatment Area
		Chloroform	100	0.19	1 J	1 J	3MW11IW-01	1/3	0	1	West of Treatment Area
		Trichloroethene	5	NE	1 J	1 J	3-MW02IW-02	1/3	0	NA	Treatment Area
		Benzene	5	1	3 J	3 J	3-MW02DW-01	2/3	0	1	Treatment Area
		Toluene	1,000	1000	2 J	15 J	3-MW02DW-01	1/3	0	0	Treatment Area
		Ethylbenzene	700	29	14 J	14 J	3-MW02DW-01	1/3	0	0	Treatment Area
		Xylenes (total)	10,000	530	32 J	32 J	3-MW02DW-01	1/3	0	0	Treatment Area
	Semivolatile Organic Compounds	Phenol	NE	300	430 J	430 J	3-MW02DW-01	1/3	NA	1	Treatment Area
		2-Methylphenol	NE	NE	300 J	300 J	3-MW02DW-01	1/3	NA	NA	Treatment Area
		4-Methylphenol	NE	NE	690 J	690 J	3-MW02DW-01	1/3	NA	NA	Treatment Area
		2,4-Dimethylphenol	NE	NE	170 J	170 J	3-MW02DW-01	1/3	NA	NA	Treatment Area
		Naphthalene	NE	21	2,400 J	2,400 J	3-MW02DW-01	1/3	NA	1	Treatment Area
		2-Methylnaphthalene	NE	NE	250 J	250 J	3-MW02DW-01	1/3	NA	0	Treatment Area
		Acenaphthylene	NE	210	1 J	1 J	3-MW02DW-01	1/3	NA	NA	Treatment Area
		Acenaphthene	NE	800	34	320 J	3-MW02IW-02	2/3	NA	0	Treatment Area
		Dibenzofuran	NE	NE	17	140 J	3-MW02DW-01	2/3	NA	0	Treatment Area
		Fluorene	NE	280	23	160 J	3-MW02DW-01	2/3	NA	NA	Treatment Area
		Phenanthrene	NE	210	130 J	130 J	3-MW02DW-01	1/3	NA	0	Treatment Area
		Anthracene	NE	2,100	3 J	13 J	3-MW02DW-01	2/3	NA	0	Treatment Area
		Carbazole	NE	NE	3 J	87 J	3-MW02DW-01	2/3	NA	0	Treatment Area
		Fluoranthene	NE	280	17	21 J	3-MW02DW-01	2/3	NA	0	Treatment Area
		Pyrene	NE	210	11	14 J	3-MW02DW-01	2/3	NA	0	Treatment Area

TABLE 2-7 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Groundwater - Surficial Aquifer (Round Three)	Volatile Organic Compounds	Benzene	5	1	3 J	3 J	3-MW02-03	1/13	0	1	Treatment Area
		Toluene	1,000	1,000	8 J	11	3-MW02-03	2/13	0	0	Treatment Area
		Ethylbenzene	700	29	1 J	10	3-MW02-03	2/13	0	0	Treatment Area
		Xylenes (total)	10,000	530	20	20	3-MW02-03	1/13	0	0	Treatment Area
	Semivolatile Organic Compounds	Phenol	NE	300	68	68	3-MW02-03	1/13	NA	0	Treatment Area
		2-Methylphenol	NE	NE	160 J	160 J	3-MW02-03	1/13	NA	NA	Treatment Area
		4-Methylphenol	NE	NE	200 J	200 J	3-MW02-03	1/13	NA	NA	Treatment Area
		2,4-Dimethylphenol	NE	NE	64 J	64 J	3-MW02-03	1/13	NA	NA	Treatment Area
		Naphthalene	NE	21	360	1,500	3-MW02-03	2/13	NA	2	Treatment Area
		2-Methylnaphthalene	NE	NE	23	94	3-MW02-03	2/13	NA	NA	Treatment Area
		Acenaphthylene	NE	210	2 J	2 J	3-MW02-03	1/13	NA	0	Treatment Area
		Acenaphthene	NE	800	45 J	55	3-MW02-03	2/13	NA	0	Treatment Area
		Dibenzofuran	NE	NE	24	120 J	3-MW02-03	2/13	NA	NA	Treatment Area
		Fluorene	NE	280	20	80	3-MW02-03	2/13	NA	0	Treatment Area
		Phenanthrene	NE	210	23	97 J	3-MW02-03	2/13	NA	0	Treatment Area
		Anthracene	NE	2,100	5 NJ	5 NJ	3-MW02-03	1/13	NA	0	Treatment Area
		Carbazole	NE	NE	11 J	82	3-MW02-03	2/13	NA	NA	Treatment Area
		Fluoranthene	NE	280	3 J	10 J	3-MW02-03	2/13	NA	0	Treatment Area
		Pyrene	NE	210	2 J	8 J	3-MW02-03	2/13	NA	0	Treatment Area
		bis(2-Ethylhexyl)phthalate	6	3	1 J	1 J	3-MW02-03	2/13	0	0	Treatment Area

TABLE 2-7 (Continued)

REMEDIAL INVESTIGATION, 1994-95
ANALYTICAL RESULTS FOR GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Groundwater - Castle Hayne (Round Three)	Semivolatile Organic Compounds	Phenol	NE	300	1 J	1 J	3-MW11IW-02	1/3	NA	0	Treatment Area
		Naphthalene	NE	21	4 J	4 J	3-MW02IW-03	1/3	NA	0	Treatment Area
		2-Methylnaphthalene	NE	NE	1 J	1 J	3-MW02IW-03	1/3	NA	NA	Treatment Area
		Acenaphthene	NE	800	25	25	3-MW02IW-03	1/3	NA	0	Treatment Area
		Dibenzofuran	NE	NE	29	29	3-MW02IW-03	1/3	NA	NA	Treatment Area
		Fluorene	NE	280	35	35	3-MW02IW-03	1/3	NA	0	Treatment Area
		Phenanthrene	NE	210	120	120	3-MW02IW-03	1/3	NA	0	Treatment Area
		Anthracene	NE	2,100	11 NJ	11 NJ	3-MW02IW-03	1/3	NA	0	Treatment Area
		Carbazole	NE	NE	J	4 J	3-MW02IW-03	1/3	NA	NA	Treatment Area
		Fluoranthene	NE	280	28	28	3-MW02IW-03	1/3	NA	0	Treatment Area
		Pyrene	NE	210	16	16	3-MW02IW-03	1/3	NA	0	Treatment Area

Notes:

(1) Shaded boxes indicate detections above comparison criteria.

NE = No Criteria Established
NA = Not Applicable
J =Estimated Value
NJ = Estimated Value/Tentative Identification
μg/L = microgram per liter (ppb)

TABLE 2-8

SUMMARY OF HUMAN HEALTH RISKS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Round 2 Groundwater		Worst Case Groundwater		Total with Round 2 Groundwater Contamination		Total with Worst Case Groundwater Contamination	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Military Personnel	1.7E-06 (100)	NA	NE	NE	NE	NE	1.7E-06	NA	1.7E-06	NA
Future Child Resident	1.4E-05 (74)/(<1)	NA	5.3E-06 (26)	1.7 (100)	7.5E-04 (100)	2.3 (100)	1.9E-05	1.7	7.6E-04	2.3
Future Adult Resident	5.4E-06 (34)/(<1)	NA	1.1E-05 (66)	0.7 (100)	1.8E-03 (100)	3.7 (100)	1.7E-05	0.7	1.8E-03	3.7
Future Construction Worker	1.0E-07 (100)	<0.01 (100)	NE	NE	NE	NE	1.0E-07	<0.01	1.0E-07	<0.01

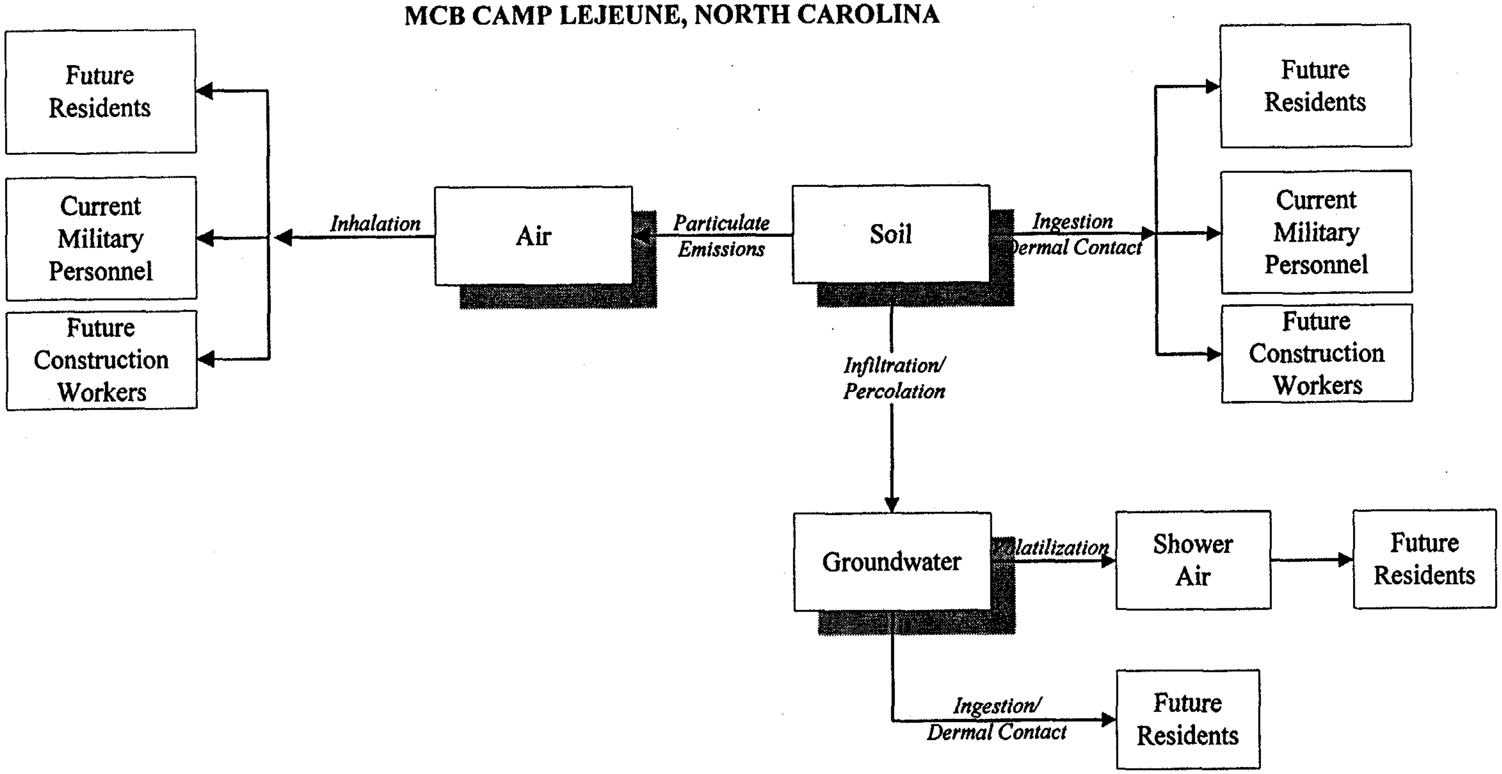
Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
Total = Soil + Groundwater
NE = Not Evaluated for Potential Receptor
NA = Not Applicable (no noncarcinogenic COPCs)
( ) = Percent contribution to total risk
( )/( ) = First is percent contribution to total risk with round 2 groundwater results; Second is percent contribution to total risk with worst case groundwater results (combined Rounds 1, 2, 3)

Shaded blocks indicate an ICR value that exceeds the acceptable limit of 1E-04, or an HI value that exceeds the acceptable limit of 1.0.

FIGURE 2-9

SITE CONCEPTUAL MODEL
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA



SECTION 2.0 FIGURES

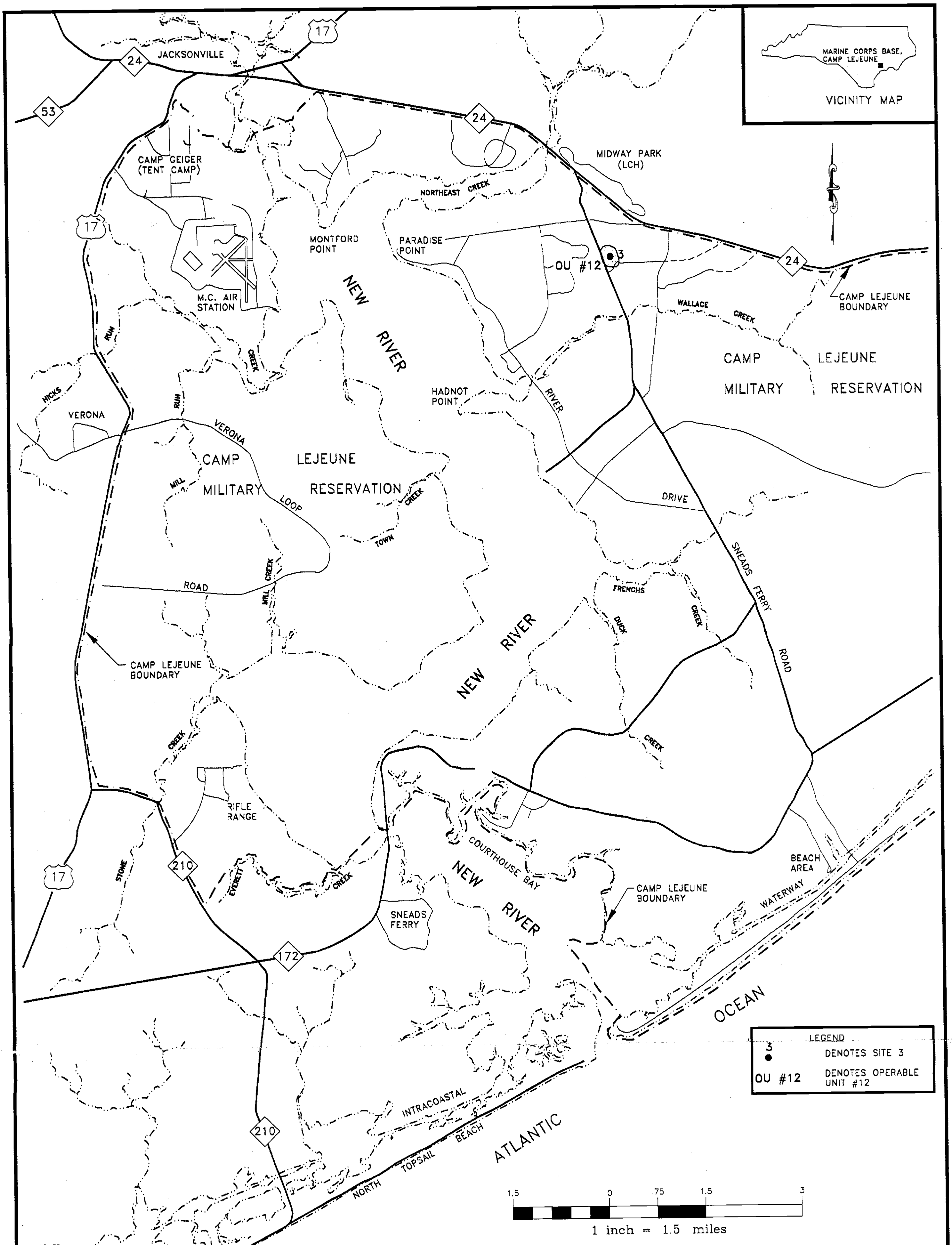
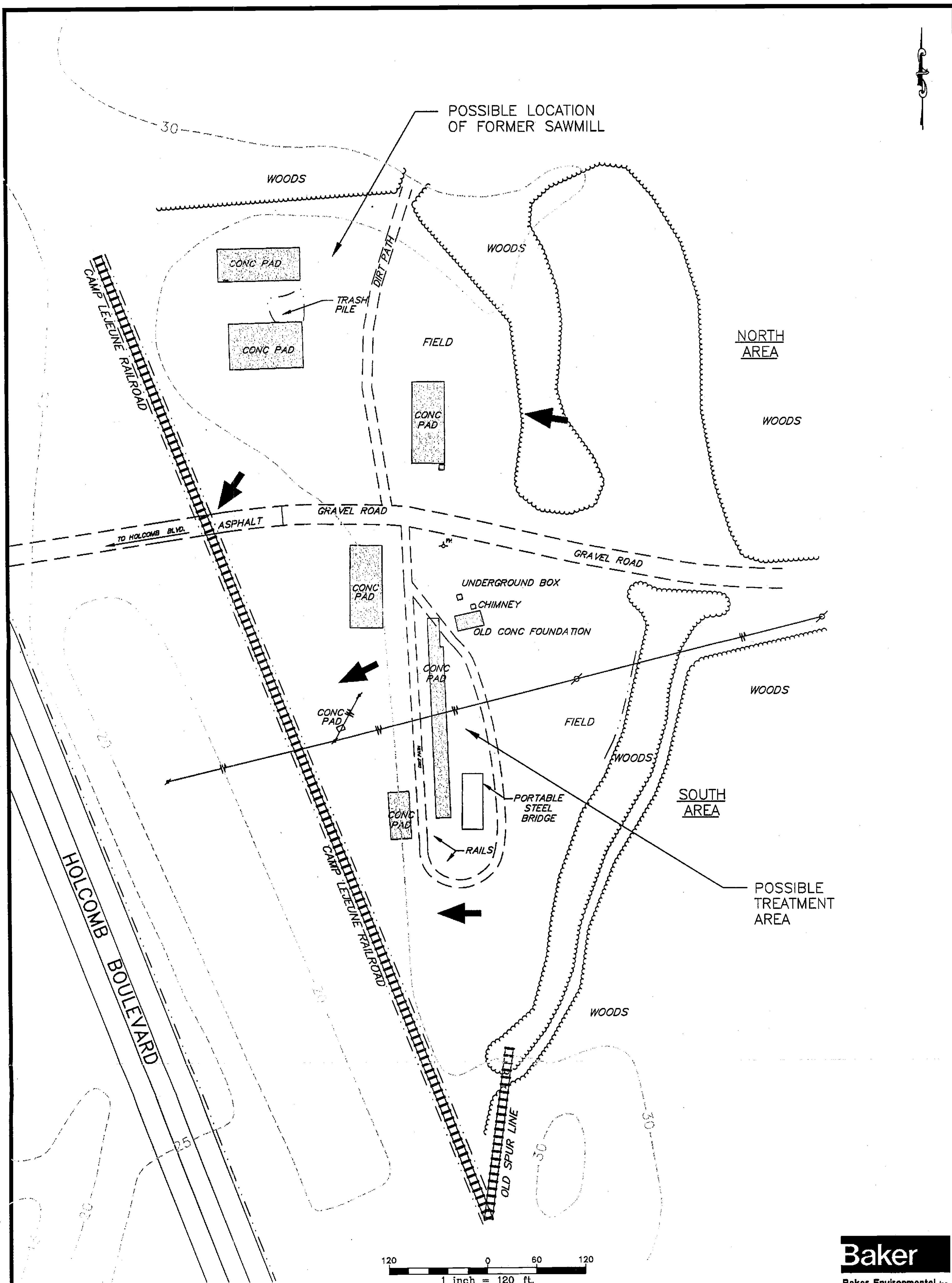


FIGURE 2-1
OPERABLE UNIT NO. 12 (SITE 3)
MARINE CORPS BASE, CAMP LEJEUNE
FEASIBILITY STUDY CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721DDB12



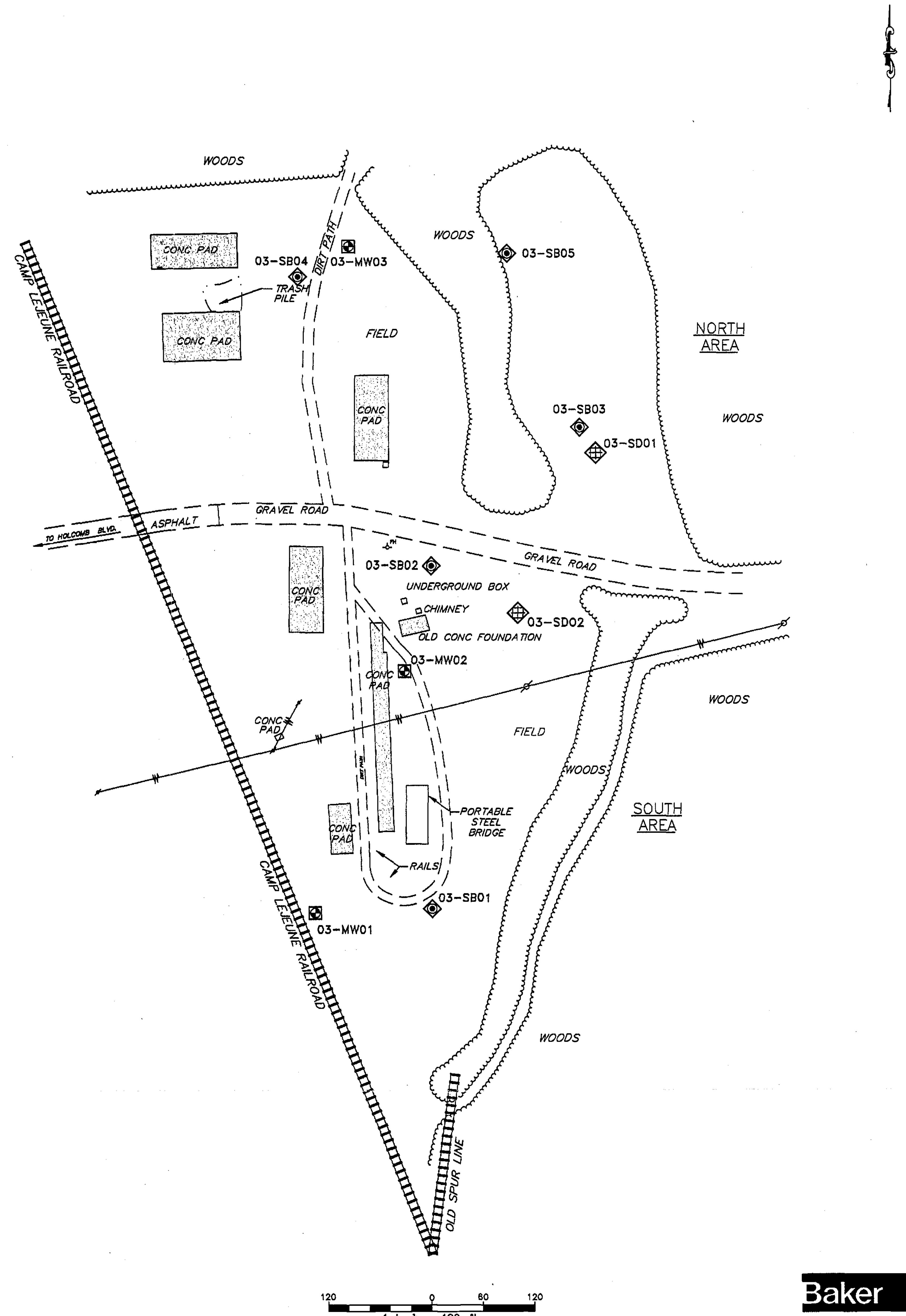
LEGEND

- DRAINAGE PATH
- GRAVEL ROAD/DIRT PATH
- GROUNDWATER FLOW DIRECTION IN THE SHALLOW AQUIFER
- TOPOGRAPHIC ELEVATION LINE (FEET, MSL)

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 2-2
SITE MAP
SITE 3 – OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

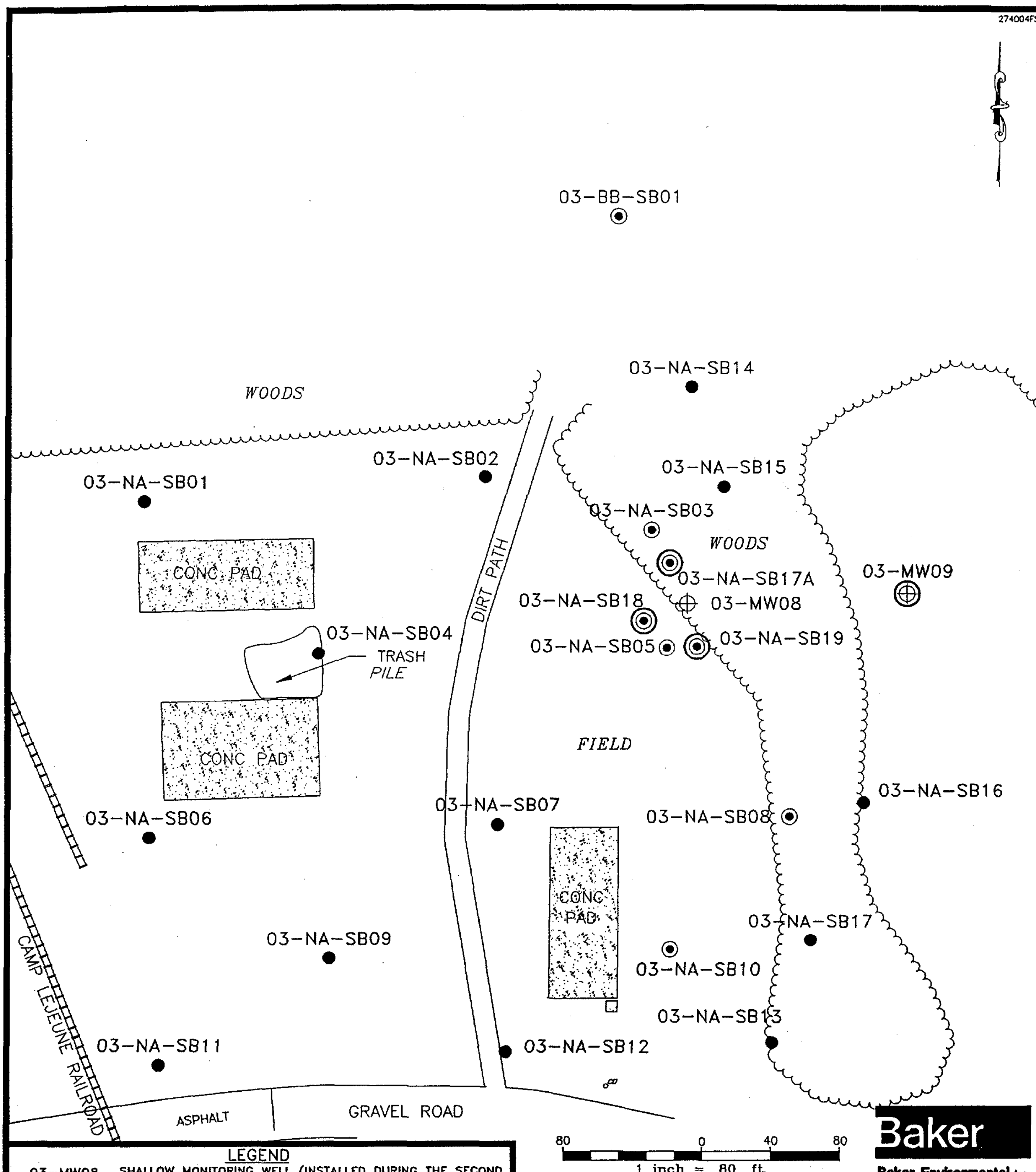
03-MW01 MONITORING WELL INSTALLED BY HALLIBURTON NUS, NOVEMBER 1991

03-SB03 SOIL BORING INSTALLED BY HALLIBURTON NUS, NOVEMBER 1991

03-SD01 SEDIMENT SAMPLE COLLECTED BY HALLIBURTON NUS, NOVEMBER 1991

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 2-3
SAMPLING LOCATIONS
SITE INSPECTION, 1991
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

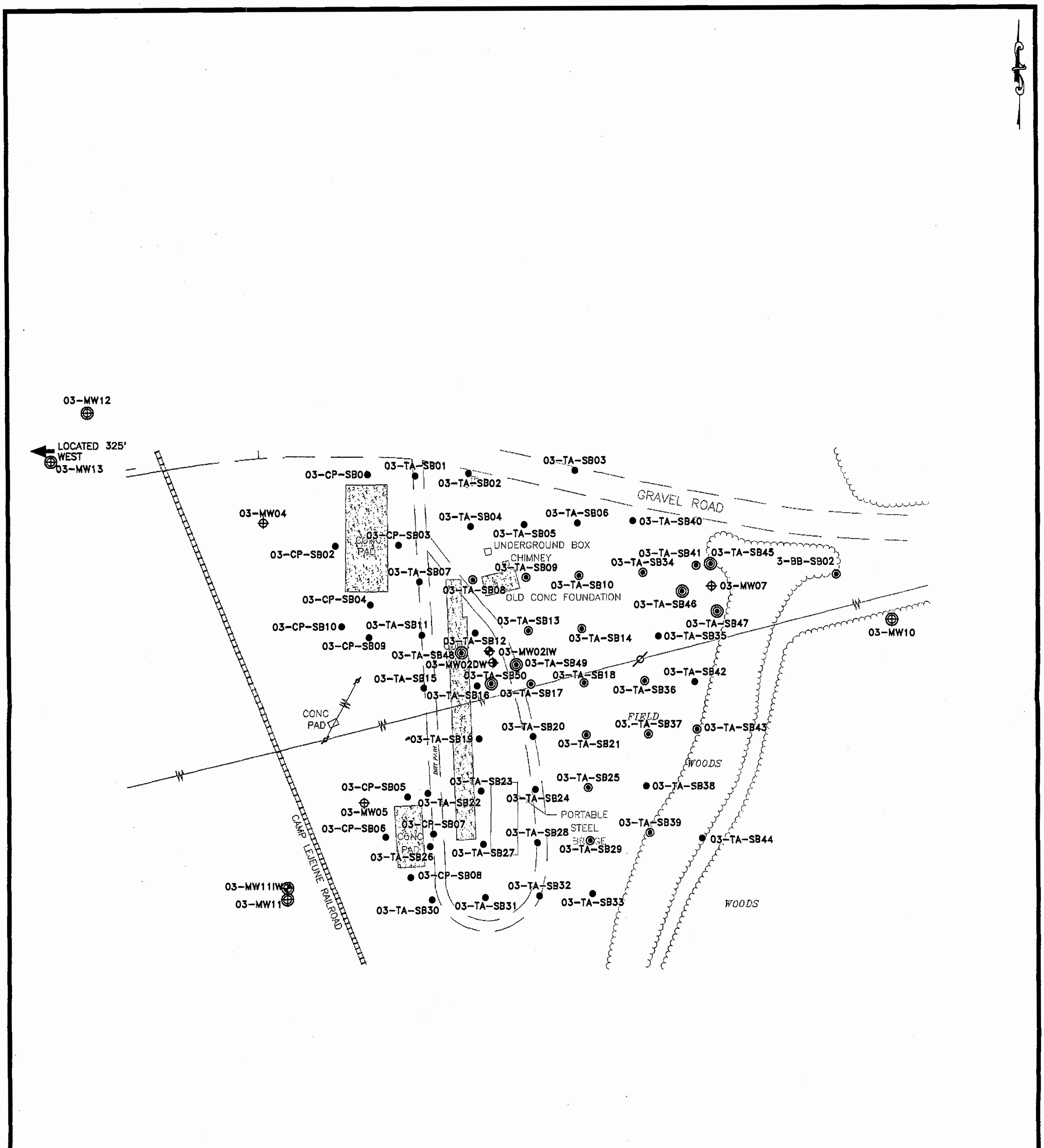


LEGEND

03-MW08	SHALLOW MONITORING WELL (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-NA-SB03	SOIL BORING LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-NA-SB01	ENSYS SURFACE SOIL BORING (INSTALLED DURING THE FIRST PHASE OF THE SOIL INVESTIGATION SEPTEMBER 19 THROUGH SEPTEMBER 22, 1994).
03-MW09	SHALLOW MONITORING WELL (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-NA-SB17A	SOIL BORING LOCATION (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).

W.K. DICKSON & CO.,INC., JANUARY 1995

FIGURE 2-4
SOIL SAMPLING LOCATIONS
REMEDIAL INVESTIGATION, 1994-95
SITE 3 - OLD CREOSOTE PLANT
(NORTHERN AREA)
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

03-MW04	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PART OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-MW02IW	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PART OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-TA-SB08	SOIL BORING LOCATION (INSTALLED DURING THE FIRST AND SECOND PART OF THE SOIL INVESTIGATION AUGUST 19 THROUGH AUGUST 22, 1994 AND NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-TA-SB01	ENSYS SURFACE SOIL BORING (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION AUGUST 19 THROUGH AUGUST 22, 1994).
03-MW10	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-MW11IW	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-MW02DW	DEEP MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-TA-SB45	SOIL BORING LOCATION (INSTALLED DURING THE THIRD PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).

SOURCE: LANTDIV, OCT. 1991

100 0 50 100

1 inch = 100 ft.

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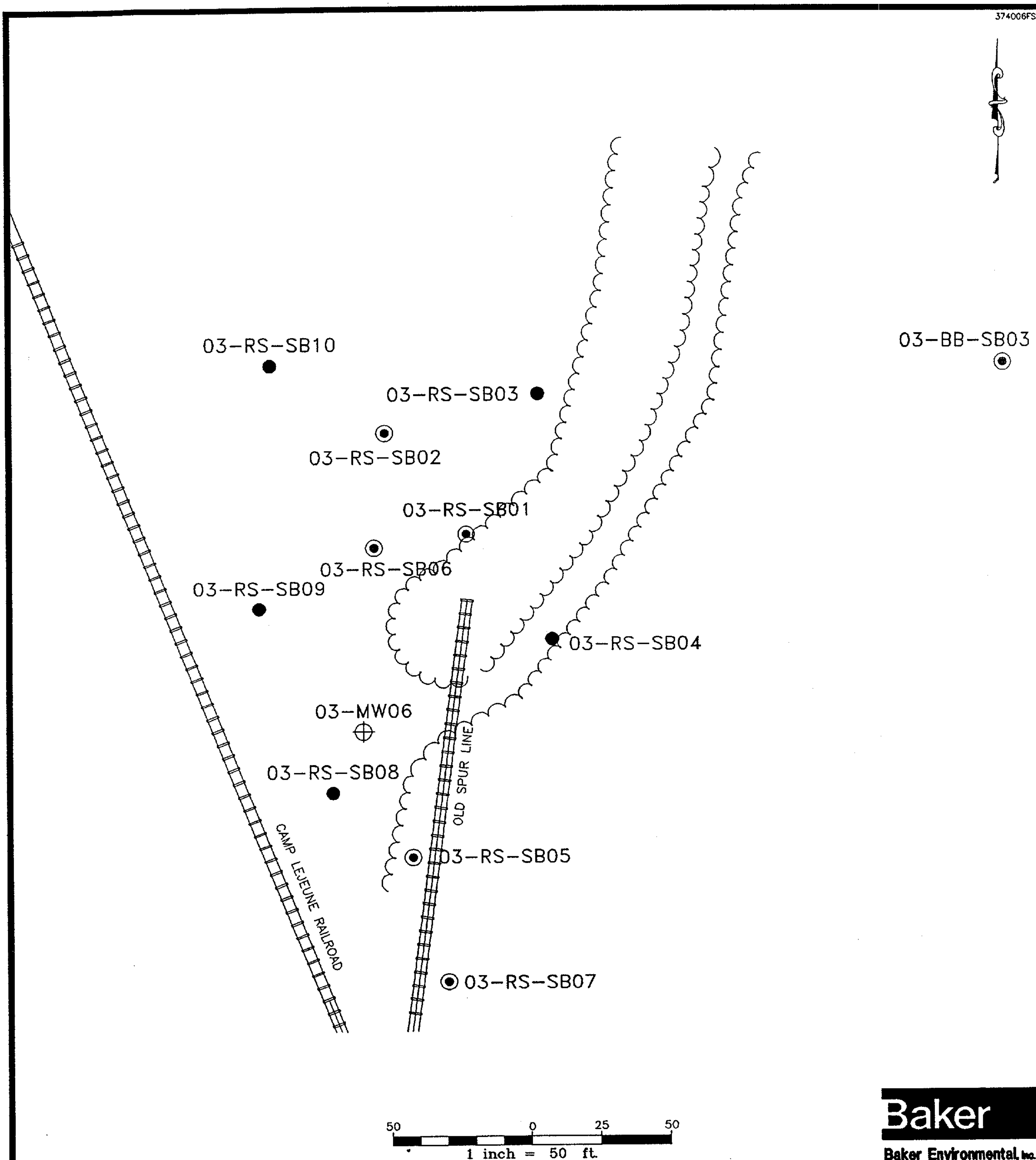
FIGURE 2-5
SOIL SAMPLING LOCATIONS
REMEDIAL INVESTIGATION, 1994-95
SITE 3 - OLD CREOSOTE PLANT
(TREATMENT AND CONCRETE PAD AREAS)
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721DD01Z



LEGEND

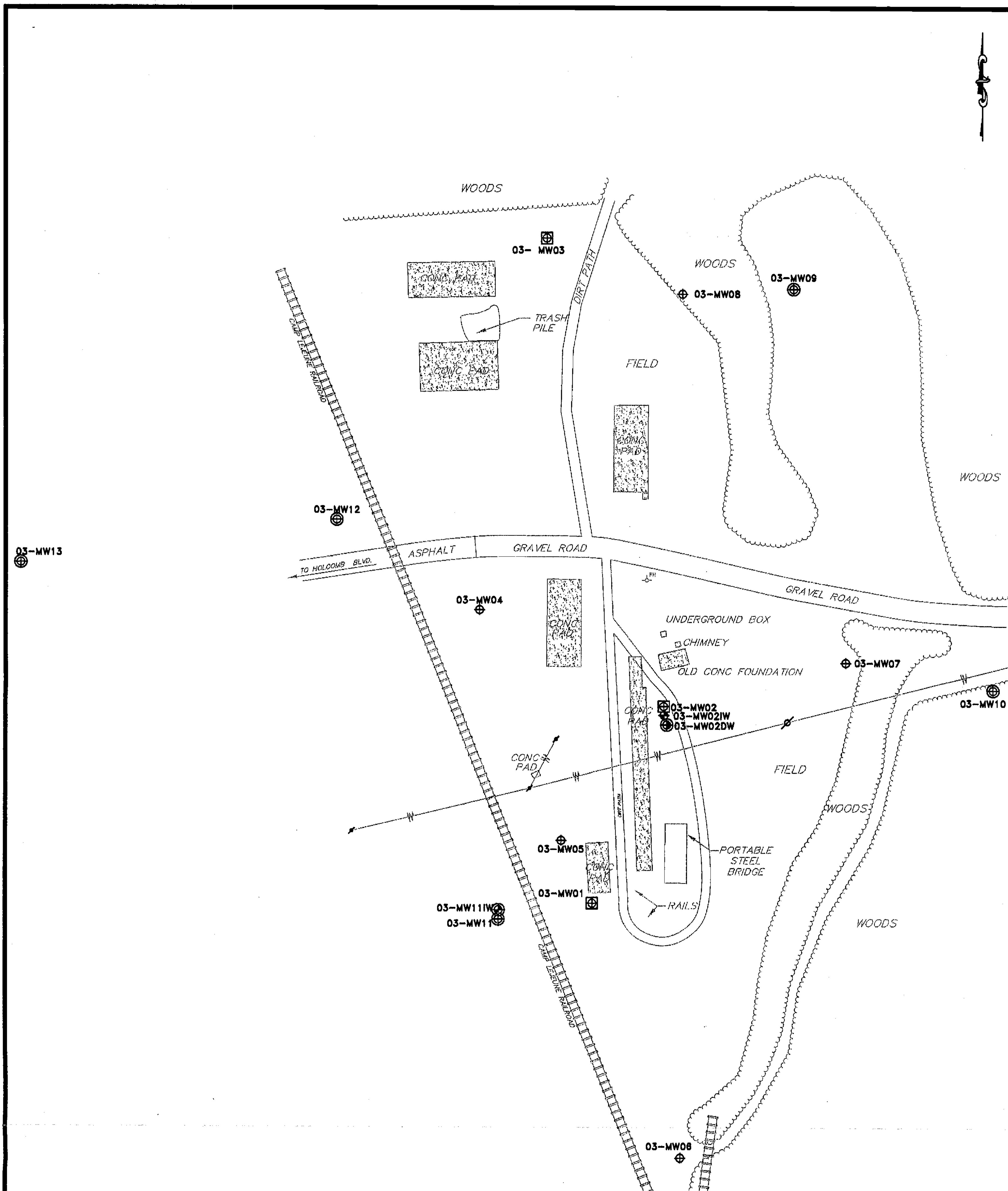
03-MW06 — SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).

03-RS-SB01 — SOIL BORING LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).

03-RS-SB03 — ENSYS SURFACE SOIL BORING (INSTALLED DURING THE FIRST PHASE OF THE SOIL INVESTIGATION SEPTEMBER 19 THROUGH SEPTEMBER 22, 1994).

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 2-6
SOIL SAMPLING LOCATIONS
REMEDIAL INVESTIGATION, 1994-95
SITE 3 - OLD CREOSOTE PLANT
(RAIL SPUR AREA)
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

03-MW01	SHALLOW MONITORING WELL LOCATION (INSTALLED PRIOR TO THE REMEDIAL INVESTIGATION CONDUCTED IN OCTOBER OF 1994).
03-MW04	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-MW02IW	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-MW09	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-MW11IW	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-MW02DW	DEEP MONITORING WELL LOCATION (INSTALLED DURING THE THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

120 0 60 120
1 inch = 120 ft.

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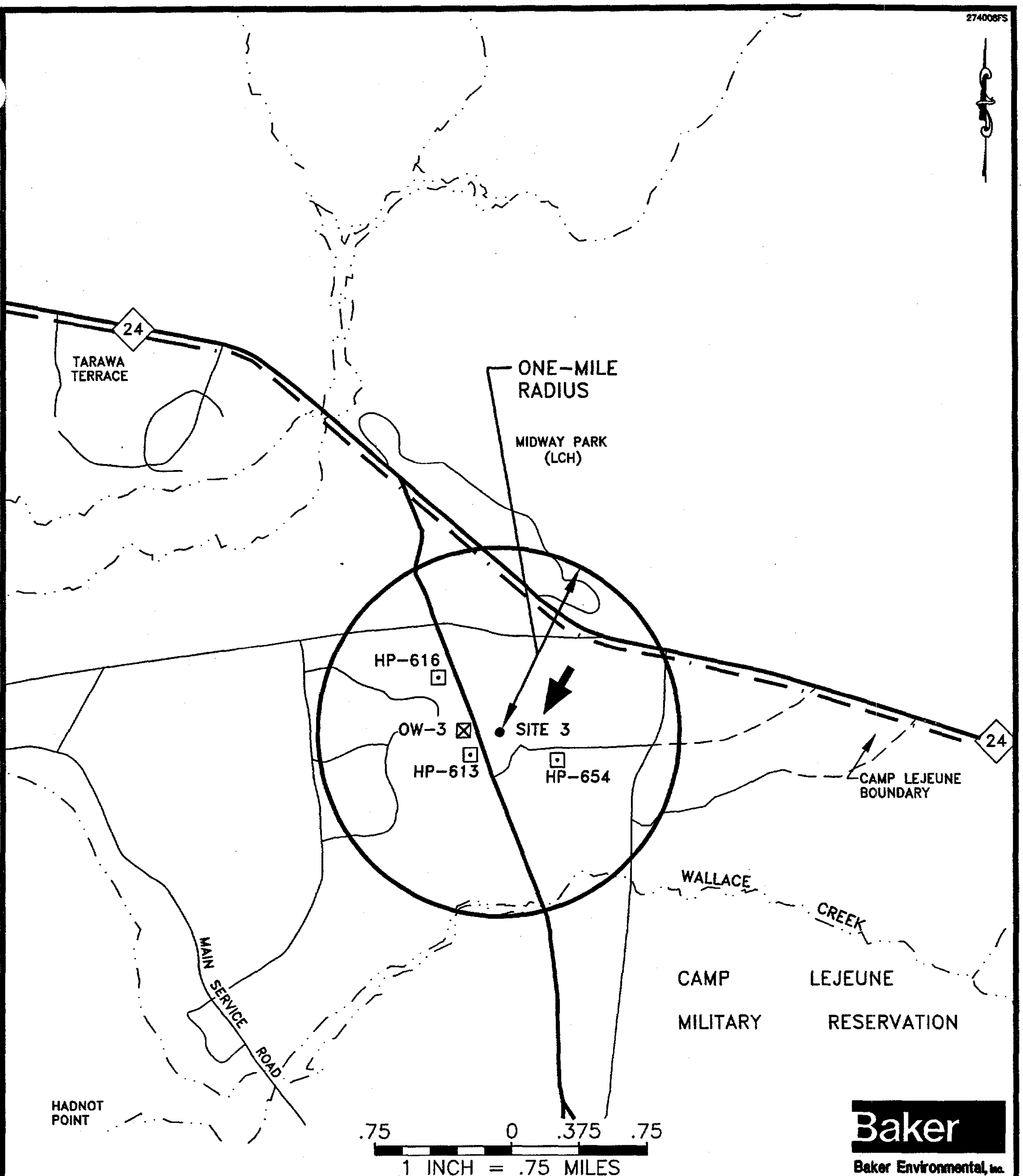
FIGURE 2-7
MONITORING WELL SAMPLING LOCATIONS
REMEDIAL INVESTIGATION, 1994-95
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721DD02Z



LEGEND

HP-613 WATER SUPPLY WELL, IN SERVICE

OW-3 WATER SUPPLY WELL, OUT OF SERVICE

APPROXIMATE GROUNDWATER FLOW DIRECTION IN SURFICIAL AQUIFER

FIGURE 2-8
WATER SUPPLY WELL LOCATIONS
IN THE VICINITY OF SITE 3
MARINE CORPS BASE, CAMP LEJEUNE
FEASIBILITY STUDY, CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 DEVELOPMENT OF REMEDIATION GOAL OPTIONS, REMEDIATION LEVELS, AND REMEDIAL ACTION OBJECTIVES

This section presents the development of remediation goal options (RGOs), remediation levels (RLs), and remedial action objectives (RAOs) for Site 3. RGOs are chemical-specific concentration goals established for the protection of human health and the environment; each RGO is established for a specific medium and land use combination. There are two general sources of chemical-specific RGOs: (1) concentrations based on applicable or relevant and appropriate requirements (ARARs) and, (2) risk-based concentrations for the protection of public health and the environment. The selection of RGOs includes: identification of the media of concern, selection of contaminants of concern (COCs), evaluation of state and federal standards and criteria, and identification of site-specific exposure pathway information (i.e., exposure frequency, duration, and intake rate data). The development of RGOs for Site 3 is detailed in Sections 3.1 through 3.5. The resulting RLs, areas of concern, and RAOs are presented in Sections 3.6, 3.7, and 3.8, respectively.

3.1 Media of Concern

The results of the baseline human health and ecological RAs indicate that under the current land use scenario, exposure to soil and groundwater at Site 3 does not present unacceptable human health risks. Currently, the only human exposure pathway is associated with soil, not groundwater. This exposure pathway involves military personnel coming in contact with soil. From an ecological standpoint, contaminants at Site 3 are not expected to cause significant adverse risk to terrestrial mammals or birds.

Under future potential land use scenarios (residential adult and child), groundwater is the medium of concern that may result in unacceptable human health risks. The results of the human health RA for the future construction worker did not identify adverse health effects associated with exposure to subsurface soil. However, subsurface soil contamination has been detected at levels that may not be protective of groundwater (i.e., contaminants in subsurface soil may be leaching and contributing to groundwater contamination). In addition, PAHs and fuel constituents were detected in the Castle Hayne aquifer at concentrations exceeding state and federal standards. As a result, the subsurface soil at Site 3 was evaluated, along with groundwater (both shallow and deep), as a medium of concern.

In summary, the following media of concern were identified for Site 3:

- Subsurface Soil
- Groundwater (Shallow and Deep)

3.2 Contaminants of Concern

Table 3-1 presents a set of COCs that will be evaluated during this section of the FS. The soil COCs include all volatile and semivolatile organics that were positively detected during the RI. (Inorganics are not included as soil COCs because leaching of inorganics from soil to groundwater is not a concern.) The groundwater COCs include all contaminants that were retained as COCs during the human health and ecological RAs, and all contaminants that exceeded state or federal criteria. In the remaining portion of Section 3.0, RGOs will be established for the soil and groundwater COCs. COCs that exceed the RGOs will be retained as a final set of COCs to be addressed in the FS. The final set of COCs will become the basis for defining remediation levels, areas of concern, and remedial action objectives.

3.3 Remediation Goal Options

RGOs are based on state and federal criteria or risk-based concentrations. State and federal criteria will be identified and evaluated in Section 3.3.1. Site specific risk-based RGOs for the COCs at Site 3 will be developed in Section 3.3.2. The results from both of these sections will be used to develop the initial set of RGOs for the operable unit.

3.3.1 Applicable or Relevant and Appropriate Federal and State Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from both federal and state laws. USEPA Interim Guidance (52 Fed. Reg. 32, 496, August 27, 1987) provides the following definition of "Applicable Requirements":

> ...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 or contaminant, remedial action, location, or other circumstance at a CERCLA site.

Drinking water criteria may be an applicable requirement for a site with contaminated groundwater that is used as a drinking water source. The definition of "Relevant and Appropriate Requirements" is:

> ...cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, 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.

There are three types of ARARs. The first type, chemical-specific ARARs, are requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

The second type of ARARs, location-specific, set restrictions on activities based upon the characteristics of the site and/or the nearby suburbs. Examples of this type of ARAR include state and federal citing laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARARs, action-specific, refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly-owned treatment works (POTWs) are examples of action-specific ARARs.

Subsection 121(d) of CERCLA requires that the remedial action meet a level or standard which at least attains federal and state substantive requirements that qualify as ARARs. Federal, state, or local permits do not need to be obtained for removal or remedial actions implemented on site, but their substantive requirement must be obtained. "On site" is interpreted by the USEPA to include the areal extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

ARARs can be identified only on a site-specific basis. They depend on the detected contaminants at a site, specific site characteristics, and particular remedial actions proposed for the site. ARARs identified for Site 3 are presented in the following sections.

3.3.1.1 Contaminant-Specific ARARs

A summary of chemical-specific ARARs and their applicability to the areas of concern is provided in Table 3-2.

The following criteria were used in the selection of contaminant-specific ARARs: the North Carolina Water Quality Standards (NCWQSs) applicable to groundwaters and the Federal MCLs and secondary MCLs. A brief description of each these standards/guidance is presented below.

North Carolina Water Quality Standards (Groundwater) - Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the NC DEHNR has established groundwater standards (NCWQSs) for three classifications of groundwater within the State: GA, GSA, and GC. Class GA waters are those groundwaters in the state naturally containing 250 milligram per liter (mg/L) or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the state naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The shallow and Castle Hayne aquifers at Site 3 are Class GA groundwaters.

The water quality standards for the groundwaters are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the state, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the practical quantitation limit, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration as determined by the state. Substances which are not naturally occurring, and for which no standard is specified, are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15A-NCAC-2L.0202).

The NCWQSs for substances in Class GA and Class GSA groundwaters are established as the lesser of:

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of 1.0E-6
- Taste threshold limit value
- Odor threshold limit value
- Federal MCL
- National Secondary Drinking Water Standard (or secondary MCL)

Note that the water quality standards for Class GA and Class GSA groundwaters are the same except for chloride and total dissolved solids concentrations (15A NCAC 2L.0202).

Federal Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the SDWA and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. These standards are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

Secondary MCLs are nonenforceable guidelines established under the SDWA. The secondary MCLs are set to control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water.

A comparison of Site 3 groundwater contaminants to NCWQSs and MCLs is presented in Table 3-3.

Soil Screening Levels - The SSLs provide reasonable maximum estimates of transfers of contaminants from soil which are protective of groundwater. "Protective" is defined in the same terms as the risk-based concentrations for tap water and air -- that residential contact scenarios will yield a fixed upper bound risk of 10^{-6} or a fixed hazard quotient of 1 (whichever occurs at the lower concentration). MCLs are used as target groundwater concentrations if available. If MCLs were unavailable the risk-based concentration for "tap water" is used as the target groundwater concentration. All SSLs for groundwater are based on a dilution-attenuation factor (DAF) of 10. Since these SSLs scale linearly with DAF, the SSLs for DAF=1 would be ten times lower.

A comparison of Site 3 subsurface soil contaminants to SSLs is presented in Table 3-4.

3.3.1.2 Location-Specific ARARs

Potential location-specific ARARs identified for Site 3 are listed in Table 3-5. An evaluation determining the applicability of these location-specific ARARs with respect to Site 3 is also presented and summarized in Table 3-5. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to Site 3:

- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Please note that the citations listed in Table 3-5 should not be interpreted as though the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

3.3.1.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for Site 3. A set of potential action-specific ARARs are listed in Table 3-6. These ARARs are based on RCRA, CWA, SDWA, and Department of Transportation (DOT) requirements. Note that the citations listed in Table 3-6 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

These ARARs will be evaluated after the remedial action alternatives have been identified for Site 3. Additional action-specific ARARs may also be identified and evaluated at that time.

3.3.2 Risk-Based Remediation Goal Options

In conjunction with the RGOs based on state and federal criteria (Section 3.3.1), risk-based RGOs were developed for the groundwater COCs. The methodology used for the derived RGOs was in accordance with USEPA risk assessment guidance (USEPA, 1989) (USEPA, 1991). For noncarcinogenic effects, an RGO was calculated that corresponds to an HI range of 0.1, 1.0, and 10. An HI of 1.0 or unity, is the level of exposure to a contaminant from all significant exposure pathways in a given medium below which it is unlikely for even sensitive populations to experience health effects. For carcinogenic effects, an action level was calculated that corresponds to a one in a million to one in ten thousand ICR over a lifetime as a result of exposure to the potential carcinogen from all significant exposure pathways for a given medium. 1.0E-06 was used as a conservative risk level for determining RGOs. Based on the NCP (40 CFR 300.430), for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an ICR between 1.0E-04 and 1.0E-06. The RGOs for Site 3 are representative of acceptable incremental risks based on current and probable future use of the area.

Three steps were involved in estimating the risk-based RGOs for the Site 3 COCs. These steps are generally conducted for a specific medium and land-use combination and involve identifying: (1) the most significant exposure pathways and routes, (2) the most significant exposure parameters, and (3) equations. The equations included calculations of total intake from a given medium and were based on identified exposure pathways and associated parameters.

3.3.2.1 Derivation of Risk Equations

The determination of contaminant-specific RGOs was performed in accordance with USEPA guidance (USEPA, 1989) (USEPA, 1991). Reference doses (RfDs) were used to evaluate noncarcinogenic contaminants, while cancer slope factors (CSFs) were used to evaluate carcinogenic contaminants.

Potential exposure pathways and receptors used to determine RGOs are site-specific and consider the current and future land use of a site. The following exposure scenario was used in the determination of RGOs for Site 3:

- Ingestion of groundwater (future resident)

The potential risk estimated in the human health RA indicated that the majority of the site-specific risk is likely to occur from future potential exposure to groundwater. Currently, soil does not appear to pose an appreciable risk with respect to both dermal contact and incidental ingestion at any of the sites. For this FS, the most conservative exposure pathway (i.e., groundwater ingestion) was used in the development of RGOs. The RGOs were calculated for future (adult and child) receptors in order to provide site-specific RGOs from which remedial action alternatives could be developed.

Consistent with USEPA guidance, noncarcinogenic health effects were estimated using the concept of an average annual exposure. The action level incorporated the exposure time and/or frequency that represented the number of days per year and number of years that exposure occurs. This is used with a term known as the averaging time, which converts the daily exposure to an annual exposure. Carcinogenic health effects were calculated as an incremental lifetime cancer risk, and therefore represented the exposure duration (years) over the course of a potentially exposed individual's lifetime (70 years).

The estimation methods and models used in this section were consistent with current USEPA risk assessment guidance (USEPA, 1989) (USEPA, 1991). Exposure estimates associated with groundwater ingestion are presented below. RGOs were developed, with site-specific inputs, for groundwater COCs presented in the human health RA. However, in order to determine if a medium at a site requires remediation, estimated RGOs were compared to site-specific contaminant levels. This assessment was conducted to assure that media and contamination at each site would be addressed on a site-specific basis. The following sections present the equations and inputs used in the estimation of groundwater RGOs developed for Site 3.

Ingestion of Groundwater

Currently, there are no receptors who are exposed to potential groundwater contamination at Site 3 since groundwater is obtained from "noncontaminated" supply wells, pumped to water treatment plants, and distributed via a potable water system. However, it is assumed for the purposes of calculating remediation goals, that potable wells will pump groundwater from the site area for public consumption. Groundwater ingestion RGOs are characterized using the following equation:

$$Cw = \frac{TR \ or \ THI * BW * AT_C \ or \ AT_{nc} * DY}{CSF \ or \ 1/RfD * EF * ED * IR}$$

Where:

Cw	=	contaminant concentration in groundwater (mg/L)
TR	=	total lifetime risk
THI	=	total hazard index
BW	=	body weight (kg)
AT_c	=	averaging time carcinogens (yr)
AT_{nc}	=	averaging time noncarcinogens (yr)
DY	=	days per year (day/year)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	reference dose (mg/kg-day)
EF	=	exposure frequency (day/year)
ED	=	exposure duration (yr)
IR	=	ingestion rate (L/day)

Future On-Site Residents

Exposure to COCs via ingestion of groundwater was retained as a potential future exposure pathway for both children and adults.

An ingestion rate (IR) of 1.0 liter/day was used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)]. An averaging time (AT) of 2,190 days (6 years x 365 days/year) is used for noncarcinogenic compound exposure.

The IR for adults was 2 liters/day (USEPA, 1989). The exposure duration (ED) used for the estimation of adult chronic daily intakes (CDIs) was 30 years (USEPA, 1989), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens was 10,950 days (30 years x 365 days/year). An AT of 25,550 days (70 years x 365 days/year) was used to evaluate exposure for both children and adults to potential carcinogenic compounds.

Table 3-7 presents a summary of the input parameters for the ingestion of groundwater scenarios.

3.3.2.2 Summary of Site-Specific Risk-Based Remediation Goal Options

The risk-based RGOs for the cleanup of a specific medium are used in the FS to identify areas of concern. COCs were chosen based on available toxicity data and frequency of detection and available ARARs. RGOs were generated for contaminants with available toxicity data. Separate RGOs for future adult residents and children have been calculated. In addition, both carcinogenic and noncarcinogenic RGOs have been calculated. Calculations are provided in Appendix A of this report.

Ingestion of Groundwater

Groundwater ingestion RGOs were estimated for the groundwater at Site 3. Currently, there are no known receptors who are exposed to contaminated groundwater. Base personnel receive potable water via a Base water distribution system. However, a hypothetical future ingestion RGO was estimated for the COCs. In order to estimate conservative RGOs for subpopulations (i.e., adult resident and child resident), specific input variables were developed for each subpopulation. Tables 3-8 and 3-9 present the RGOs calculated for the carcinogenic and noncarcinogenic COCs in the groundwater, respectively.

3.4 Comparison of Remediation Goal Options to Maximum Contaminant Concentrations in Groundwater

Generally, RGOs are not required for a contaminant in a medium with a cumulative cancer risk of less than 1.0E-04, where an HI is less than or equal to 1.0, or where the RGOs are clearly defined by ARARs. In order to decrease uncertainties in the estimation of the reasonable maximum exposure (RME), which is the maximum exposure that is reasonably expected to occur at the site, the maximum concentration of a contaminant in a medium can be compared to the estimated risk-based RGO if chemical-specific criteria are not available.

Table 3-10 presents a comparison of the NCWQSs, federal MCLs, and carcinogenic and noncarcinogenic risk-based RGOs for groundwater ingestion with respect to future residential receptors (adult and children), and the groundwater contaminant concentrations detected during all three sampling rounds. Additionally, the NCWQSs and MCLs are presented in this table.

As shown in Table 3-10, the maximum concentration of benzene (40 μg/L) exceeded the NCWQS, the Federal MCL, and the estimated risk-based RGO. Additionally, the maximum concentrations of phenol (420 μg/L), naphthalene (2,400 μg/L), phenanthrene (410 μg/L), benzo(a)anthracene (8 μg/L), chrysene (8 μg/L), benzo(a)pyrene (3 μg/L), and chloroform (1 μg/L) exceeded the NCWQS and/or federal MCL. Phenol and chrysene were not retained for evaluation in the human health RA, but were evaluated against state and federal groundwater criteria. Because groundwater criteria has not been published for carbazole, benzo(b)fluoranthene, and benzo(k)fluorenthene, the estimated RGOs were used to evaluate contaminant levels. Maximum concentrations of carbazole (87 μg/L), benzo(b)fluoranthene (3 μg/L), and benzo(k)fluoranthene (3 μg/L) exceeded the estimated RGO. (Please note that maximum concentrations were based on a data set combining three groundwater sampling rounds.)

3.5 Uncertainty Associated with Risk-Based RGOs

The uncertainties associated with calculating risk-based RGOs are summarized below. The RGO estimations presented in this section are quantitative in nature, and their results are highly dependent upon the accuracy of the input. The accuracy with which input values can be quantified is critical to the degree of confidence that the decision maker has in the action levels.

Most scientific computation involves a limited number of input variables, which are tied together by a scenario to provide a desired output. Some RGO inputs are based on literature values rather than measured values. In such cases the degree of certainty may be expressed as whether the estimate was based on literature values or measured values, not on how well defined the distribution of the input was. Some RGOs are based on estimated parameters.

The toxicity factors, CSFs and RfDs, have uncertainties built into the assumptions used to calculate them. Because the toxicity factors are determined from high doses administered to experimental animals and extrapolated to low doses to which humans may be exposed, uncertainties exist. Thus, toxicity factors could either overestimate or underestimate the potential effects on humans. However, because human data exists for very few chemicals, risks are based on these values. In addition, the exposure assumption (e.g., 10 events per year, etc.) also have uncertainties associated with them.

Although RGOs are believed to be fully protective for the RME individual(s), the existence of the same contaminants in multiple media or of multiple chemicals affecting the same population(s), may lead to a situation where, even after attainment of all RGOs, protectiveness is not fully achieved (i.e., cumulative risk may fall outside the risk range).

3.6 Remediation Levels

This section presents the RLs chosen for Site 3 groundwater and soil. RLs are chosen by the risk manager for the COCs and are addressed in the FS and the Record of Decision (ROD). Derived from the RGOs, RLs are no longer goals and should be considered required levels for the remedial actions to achieve, if possible.

The RLs for groundwater and soil at Site 3 are presented in Tables 3-11 and 3-12, respectively. This list was based on a comparison of contaminant-specific standards (or standard-based RGOs) and the site-specific risk-based RGOs. If a COC had a standard, the most limiting (or conservative) standard was selected as the RL. If a COC did not have a standard, the most conservative risk-based RGO was selected.

In order to determine the final COCs for groundwater at Site 3, the maximum contaminant concentrations detected at each site were compared to the standard-based and risk-based RGOs. The contaminants which exceeded at least one of the RGOs were retained as final COCs. The contaminants that did not exceed any of the RGOs were no longer considered as COCs with respect to this FS. The contaminants acenaphthene and fluorene were not selected as final COCs. These contaminants were not evaluated in the human health RA and were detected at concentrations less than their established groundwater standard. The final COCs for Site 3 groundwater and soil and their associated RLs are presented in Table 3-11 and 3-12, respectively.

3.7 Areas of Concern

The results of the baseline human health RA and the ecological RA were evaluated, along with state and federal standards, to determine the areas of concern (AOCs) within Site 3 that may warrant remediation or institutional controls to protect the public health and the environment. Section 3.7.1 describes the groundwater AOCs, Section 3.7.2 describes the soil AOC, and Section 3.7.3 describes the remediation approach adopted for the FS.

3.7.1 Groundwater Areas of Concern

During the RI at Site 3, volatile organics, semivolatile organics, and inorganics were detected at concentrations exceeding the groundwater RLs. (Figures 3-1, 3-2, and 3-3 identify contaminant concentrations that exceeded RLs during the first, second, and third groundwater sampling rounds, respectively.) However, the main problem at Site 3 appears to be semivolatile organic contaminants (in particular, naphthalene) in the shallow aquifer. This contamination appears to be centered around a source area of PAH-contaminated subsurface soil that is located near well 03-MW02. The semivolatile contamination also occurs to a lesser extent in the southern, railroad spike portion of

Site 3, near well 03-MW06. Thus, two groundwater AOCs were identified at Site 3 as shown in Figure 3-5. (Please note that the AOC boundaries identified in Figure 3-5 are approximate.)

The following subsections explain why volatile organics in the shallow aquifer, volatile and semivolatile organics in the Castle Hayne aquifer, and inorganics in the shallow aquifer do not appear to represent significant problems at Site 3.

3.7.1.1 Volatile Organics in the Shallow Aquifer

Two volatile organics (benzene and chloroform) were detected in the shallow aquifer at concentrations exceeding RLs. However, these volatile organics do not appear to represent a significant problem for the following reasons:

- There is no apparent pattern or consistency between sampling rounds to the positive detections of benzene and chloroform in the shallow aquifer. During the first sampling round, benzene was detected above standards at wells 03-MW07 and 03-MW08; during the second sampling round, benzene was not detected above standards; and during the third sampling round, benzene was detected above standards at well 03-MW02. These benzene detections were not consistent between the three sampling rounds. Similarly, chloroform was only detected above standards in the second sampling round. Chloroform was not detected in the first and third sampling rounds.

- The benzene concentration detected during the third sampling round (3J μg/L) only slightly exceeded the state standard (1 μg/L) and did not exceed the federal standard (5 μg/L).

- The maximum chloroform concentration detected in the shallow aquifer (1J μg/L) only slightly exceeded the state standard (0.19 μg/L) and did not exceed the federal standard (100 μg/L). In addition, chloroform is a common laboratory contaminant so its occurrence may be laboratory-related rather than site-related.

Because volatile organics in the shallow aquifer do not appear to represent a significant site-related problem, they were not used to delineate groundwater AOCs. However, these volatile organics will not be ignored in the FS. Instead, they will be addressed as a secondary concern that may not require active remediation, but may require long-term monitoring. If three consecutive rounds of quarterly groundwater samples from each well (03-MW02, 03-MW06, 03-MW07, and 03-MW08) exhibit VOC concentrations below the state and federal standards, the shallow aquifer will be considered non-impacted.

3.7.1.2 Volatile and Semivolatile Organics in the Castle Hayne Aquifer

Two volatile organics (benzene and chloroform) and two semivolatile organics (phenol and naphthalene) were detected in the Castle Hayne aquifer at concentrations exceeding RLs. However, these contaminants do not appear to represent a significant problem for the following reasons:

- There is no apparent pattern or consistency to the positive detections of volatile organics in the Castle Hayne aquifer. During the first round, benzene was only detected above standards at well 03-MW02IW, but it was not detected at this well during the second and third sampling rounds. During the second sampling round, benzene was only detected above standards at well 03-MW02DW, but it was not detected at this well during the first and third sampling rounds. Similarly, chloroform was only detected above standards during the second round, but it was not detected during the first and third sampling rounds.

- Benzene concentrations detected in the Castle Hayne (ranging from 3J µg/L to 11J µg/L) only slightly exceeded the federal and state standards (5 µg/L and 1 µg/L, respectively).

- The maximum chloroform concentration detected in the Castle Hayne (1J µg/L) only slightly exceeded the state standard (0.19 µg/L) and did not exceed the federal standard (100 µg/L). In addition, chloroform is a common laboratory contaminant so its occurrence may not be site-related.

- There is no apparent pattern or consistency to the positive detections of semivolatile organics in the Castle Hayne. During the second sampling round, naphthalene and phenol were detected above standards at well 03-MW02DW. This deep well was installed a short time before it was sampled for the first time, so it is possible that well installation activities pulled some semivolatile contamination from the shallow aquifer down into the Castle Hayne aquifer. Semivolatile organics were not detected in 03-MW02DW the second time it was sampled. Between the first and second sampling events, these semivolatiles may have diluted/dispersed in the Castle Hayne aquifer explaining their absence in well 03-MW02DW during the second sampling event. Due to this inconsistency, 03-MW02DW was resampled a third time (in January 1996). Semivolatile organics were not detected in the deep well during this third sampling event which reinforces the theory that the semivolatile organics detected during the first sampling event were the result of well installation activities.

Because volatile and semivolatile organics in the Castle Hayne aquifer do not appear to represent a significant site-related problem, they were not used to delineate groundwater AOCs. However, these volatile and semivolatile organics will not be ignored in the FS. Instead, they will be addressed as a secondary concern that may not require active remediation, but may require long-term monitoring. If four consecutive rounds of quarterly groundwater samples from each well (03-MW02IW, 03-MW02DW, and 03-MW11IW) exhibit VOC and SVOC concentrations below the state and federal standards, the Castle Hayne aquifer will be considered non-impacted.

3.7.1.3 Inorganics in the Shallow Aquifer

Two inorganics (aluminum and iron) were detected in the shallow aquifer at concentrations exceeding remediation levels. However, these inorganics do not appear to represent a significant problem for the following reasons:

- The remediation level for aluminum is a secondary MCL (SMCL) so it is not an enforceable, promulgated standard; there is not a primary MCL or an NCWQS established for aluminum. As a result, unless there is a significant site-related source of aluminum, the occurrence of this inorganic most likely does not represent a significant problem at the site. At Site 3, there does not appear to be a site-related source of aluminum.

- Iron levels exceeding state and federal standards have been detected in groundwater throughout MCB, Camp Lejeune (Baker, 1994c). Therefore, it appears that iron levels exceeding state and federal standards are a natural occurrence at the Base. At Site 3, there does not appear to be a significant site-related source of iron. Its presence in the groundwater appears to be a natural occurrence that is not indicative of a site-related problem.

Because inorganics in the shallow aquifer do not appear to represent a significant problem, they were not used to delineate groundwater AOCs. However, these inorganics will not be ignored in the FS. Instead, they will be addressed as a secondary concern that may not require active remediation, but may require long-term monitoring.

3.7.2 Soil Area of Concern

During the RI at Site 3, several semivolatile organics were detected at concentrations exceeding the soil RLs. Figure 3-4 identifies the contaminant concentrations in subsurface soil that exceeded RLs. Based on the locations of these exceedences, a soil AOC (approximately 1,340 cubic yards) was identified as shown in Figure 3-5. (Please note that the AOC boundaries depicted in this figure are approximate.) This soil AOC extends to a depth of approximately 9 feet bgs which is just above the water table. The soil AOC is believed to be a source of the semivolatile organic contamination detected in the shallow groundwater at Site 3.

As shown in Figure 3-4, three semivolatile organics exceeded RLs in a soil sample collected from 17 to 19 feet bgs (03-MW02IW-09), which is located below the water table. However, the soil AOC does not extend beyond 9 feet bgs to include these exceedences at 03-MW02IW-09. This soil sample was collected from below the water table when an odorous, product-like substance was encountered during the drilling of 03-MW02IW. This product-like substance was not encountered during the drilling of 03-MW02DW, which is located approximately 10 feet from 03-MW02IW. Based on this information, it appears as though the substance may have been a small creosote slug that sank below the water table near 03-MW02IW. This isolated creosote slug was not included as part of the soil AOC because: 1) creosote contaminants are hydrophobic so a small slug will not contribute significantly to the groundwater contamination, and 2) soil excavation below the water table is not typically conducted. This creosote slug, however, will not be ignored in the FS. Instead, it will be addressed as a secondary concern that may not require active remediation, but may require long-term monitoring of groundwater in the the shallow aquifer.

3.7.3 Approach for the FS

Based on the information presented in Sections 3.7.1 and 3.7.2, semivolatile organics in the shallow aquifer appear to be the main groundwater problem at Site 3. Consequently, the FS will focus on the remediation of this semivolatile groundwater contamination, and active remediation alternatives (e.g., pump and treat) will be developed for this contamination. Volatile organics in the shallow aquifer, volatile and semivolatile organics in the Castle Hayne aquifer, and inorganics in the shallow aquifer will not be ignored in the FS. Instead, they will be addressed with long-term monitoring/institutional control alternatives, as opposed to active remediation alternatives. Since these contaminants do not appear to represent significant problems at the site, a reasonable approach to remediating their inconsistent occurrences could not be developed.

In addition to addressing semivolatile organics in the shallow aquifer, the FS will address what appears to be the source of the groundwater contamination - an area of PAH-contaminated subsurface soil (around well 03-MW02) that extends to about 9 feet bgs. Although this contaminated subsurface soil did not generate unacceptable risk values, it may continue to be an on-going source of semivolatile groundwater contamination. Because of this, the soil AOC will be addressed in the FS, and remedial action alternatives will be developed for both the contaminated groundwater and soil at Site 3.

3.8 Remedial Action Objectives

The following RAOs were developed for soil at Site 3:

- Soil RAO #1
  Prevent the leaching of PAH contaminants from the subsurface soil to the groundwater.

- Soil RAO #2
  Remediate subsurface soil at the site to the specified remediation levels.

The following RAOs were developed for groundwater at Site 3:

- Groundwater RAO #1
  Prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater.

- Groundwater RAO #2
  Remediate groundwater in the shallow aquifer to the specified remediation levels.

SECTION 3.0 TABLES

TABLE 3-1

PRELIMINARY SET OF COCs TO BE EVALUATED DURING THE FS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Soil	Groundwater
Volatiles:		
Acetone	X	
Carbon Disulfide	X	
1,1-Dichloroethene		X
Chloroform	X	X
2-Butanone	X	
Trichloroethene		X
Benzene	X	X
Toluene	X	X
Ethylbenzene	X	X
Styrene	X	
Xylenes (total)		X
Semivolatiles:		
Phenol	X	X
2-Methylphenol	X	X
4-Methylphenol	X	X
2,4-Dimethylphenol		X
Naphthalene	X	X
2-Methylnaphthalene	X	X
Acenaphthene	X	X
Acenaphthylene	X	X
Dibenzofuran	X	X
Fluorene	X	X
N-nitrosodiphenylamine	X	
Phenanthrene	X	X
Anthracene	X	X
Carbazole	X	X
di-n-Butylphthalate	X	
Fluoranthene	X	X
Pyrene	X	X
Bis(2-ethylhexyl)phthalate	X	X
Benzo(a)anthracene	X	X
Benzo(b)fluoranthene	X	X
Benzo(k)fluoranthene	X	X
Benzo(a)pyrene	X	X
Indeno(1,2,3-cd)pyrene	X	
Benzo(g,h,i)perylene	X	
Chrysene	X	
4-Nitrophenol	X	
2-Nitrophenol		X

TABLE 3-1 (Continued)

PRELIMINARY SET OF COCs TO BE EVALUATED DURING THE FS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Soil	Groundwater
Inorganics:		
Aluminum		X
Chromium		X

Notes:

X = Selected as a preliminary COC for the FS.

TABLE 3-2

CONTAMINANT-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL/CONTAMINANT-SPECIFIC		
Safe Drinking Water Act a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing remediation levels for contaminated groundwater used as a potable water supply.
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, trichloroethylene, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.
National Ambient Air Quality Standards (40 CFR 50)	Standards for the following six criteria pollutants: particulate matter; sulfur dioxide; carbon monoxide; ozone; nitrogen dioxide; and lead. The attainment and maintenance of these standards are required to protect the public health and welfare.	Not enforceable and therefore not an ARAR. May be a TBC for excavation activities.

TABLE 3-2 (Continued)

CONTAMINANT-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
EPA Ambient Water Quality Criteria (Section 304(a)(1) of CWA)	Non-enforceable criterion for water quality for the protection of human health from exposure to contaminants in drinking water and from ingestion of aquatic biota and for the protection of fresh-water and salt-water aquatic life.	Potentially relevant and appropriate for discharge of treated groundwater to a surface water.
STATE/CONTAMINANT-SPECIFIC		
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2B.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina	Surface water quality standards based on water use and criteria class of surface water.	Relevant and appropriate for remedial actions requiring discharge to surface water.
North Carolina Anti-Degradation Policy for Surface Water (Water Quality Standards Title 15A, Chapter 2, Subchapter 2B)	Provides for an anti-degradation policy for surface water quality. Pursuant to this policy, the requirements of 40 CFR 131.12 are adopted by reference in accordance with General Statute 150B-14(b).	This policy is a TBC requirement for remedial actions requiring discharge to surface water.
State of North Carolina Department of Environment, Health and Natural Resources Division of Environmental Management 15A NCAC 2L.0200 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina	Establishes groundwater classifications and maximum contaminant concentrations to protect groundwater. These standards are mandatory.	Potentially relevant and appropriate for remedial actions requiring discharge to groundwater.
North Carolina DEHNR Toxic Air Pollutant Rule Statutory Authority G.S. 143-215.107(a)(1),(3),(4),(5); 143-B-282	A facility shall not emit any toxic air pollutants (as listed in Rule .1104) that may cause or contribute beyond the premises (contiguous property boundary) to any significant ambient air concentration that may adversely affect human health.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.

TABLE 3-3

COMPARISON OF GROUNDWATER CONTAMINANT LEVELS
TO CRITERIA-BASED RGOs
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	NCWQS (µg/L)	Federal MCL (µg/L)	Concentration Range[1] (µg/L)	Location of Maximum Concentration[2]
Benzene	1	5	3 - 40	3-MW08
Toluene	1,000	1,000	2 - 15	3-MW02DW
Xylenes (total)	530	10,000	6 - 32	3-MW02DW
1,1-Dichloroethene	7	7	1	3-MW02IW
Trichloroethene	NE	5	1	3-MW12
Ethylbenzene	29	700	1 - 14	3-MW02DW
Phenol	300	NE	3 - 420	3-MW02DW
2-Methylphenol	NE	NE	1 - 300	3-MW02DW
2,4-dimethylphenol	NE	NE	2 - 170	3-MW02DW
Naphthalene	21	NE	4 - 2,400	3-MW02DW
2-Methylnaphthalene	NE	NE	10 - 250	3-MW02DW
Acenaphthylene	210	NE	1 - 3	3-MW02
Acenaphthene	800	NE	2 - 550	3-MW02
Dibenzofuran	NE	NE	2 - 230	3-MW02
Fluorene	280	NE	1 - 210	3-MW02
Phenanthrene	210	NE	21 - 410	3-MW02
Anthracene	2,100	NE	1 - 33	3-MW02
Carbazole	NE	NE	3 - 87	3-MW02DW
Fluoranthene	280	NE	2 - 100	3-MW02
Pyrene	210	NE	2 - 58	3-MW02

TABLE 3-3 (Continued)

COMPARISON OF GROUNDWATER CONTAMINANT LEVELS TO CRITERIA-BASED RGOs OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	NCWQS (µg/L)	Federal MCL (µg/L)	Concentration Range(1) (µg/L)	Location of Maximum Concentration(2)
Benzo(a)anthracene	0.05	NE	8	3-MW02
Chrysene	5	NE	8	3-MW02
Benzo(b)fluoranthene	NE	NE	3	3-MW02
Benzo(k)fluoranthene	NE	NE	3	3-MW02
Benzo(a)pyrene	NE	2	3	3-MW02
Chloroform	0.19	200	1	3-MW11IW
4-Methylphenol	NE	NE	3 - 690	3-MW02DW

Notes:

NCWQS - North Carolina Water Quality Standard
MCL - Maximum Contaminant Level
µg/L - microgram per liter (ppb)

(1) Concentration range obtained from three groundwater sampling rounds
(2) Location of Maximum groundwater concentration

TABLE 3-4

COMPARISON OF SUBSURFACE SOIL CONTAMINANT LEVELS TO SOIL SCREENING LEVELS OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	SSL (μg/kg)	Concentration Range (μg/kg)	Maximum Sample Location	Depth (feet, bgs)
Volatiles:				
Acetone	8,000	120-120	3-NA-SB17A-02	3-5
Carbon Disulfide	14,000	1J-1J	3-MW12-02	3-5
Chloroform	300	3J-3J	3-MW11IW-02	17-19
2-Butanone	NE	3J-3J	3-NA-SB19-02	3-5
Benzene	200	2	03-TA-SB48-04	7 - 9
Toluene	5,000	3 - 13	03-TA-SB49-04	7 - 9
Ethylbenzene	5,000	4 - 5	03-MW09-02	3 - 5
Styrene	2,000	4J-5J	3-MW09-02	3-5
Xylenes (total)	74,000	7 - 300	03-TA-SB49-04	7 - 9
Semivolatiles:				
Phenol	49,000	7,200	03-TA-SB48-04	7 - 9
2-Methylphenol	6,000	2,000	03-TA-SB48-04	7 - 9
4-Methylphenol	60,000	5,900	03-TA-SB48-04	7 - 9
Naphthalene	30,000	55 - 95,000	03-TA-SB48-04	7 - 9
2-Methylnaphthalene	30,000	100 - 31,000	03-TA-SB48-04	7 - 9
Acenaphthylene*	200	190J-190J	3-MW02IW-09	17-19
Acenaphthene	200,000	560 - 47,000	03-TA-SB48-04	7 - 9
4-Nitrophenol	0	570J-570J	3-TA-SB50-04	7-9
Dibenzofuran	120,000	440 - 36,000	03-TA-SB48-04	7 - 9

TABLE 3-4 (Continued)

COMPARISON OF SUBSURFACE SOIL CONTAMINANT LEVELS
TO SOIL SCREENING LEVELS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	SSL (µg/kg)	Concentration Range (µg/kg)	Maximum Sample Location	Depth (feet, bgs)
Phenanthrene	NE	61 - 110,000	03-TA-SB50-04	7 - 9
Anthracene	4,300,000	42 - 12,000	03-TA-SB48-04	7 - 9
Carbazole	500	200 - 4,900	03-TA-SB50-04	7 - 9
di-n-Butyl-phthalate	NE	39J-170J	3-TA-SB43-03	5-7
Fluoranthene	980,000	58J-660,000	3-TA-SB50-04	7-9
Pyrene	140,000	43 - 38,000	03-TA-SB48-04	7 - 9
Benzo(a)anthracene	700	77 - 8,000	03-TA-SB50-04	7 - 9
Chrysene	1,000	86 - 8,400	03-TA-SB48-04	7 - 9
Bis(2-ethylhexyl)phthalate	11,000	53J-240J	3-MW11IW-08	17-19
Benzo(b)fluoranthene	4,000	79 - 3,500	03-TA-SB48-04	7 - 9
Benzo(k)fluoranthene	4,000	79 - 3,300	03-TA-SB50-04	7 - 9
Benzo(a)pyrene	4,000	55 - 3,300	03-TA-SB48-04	7 - 9
Indeno(1,2,3-cd)pyrene	35,000	46 - 3,100	03-TA-SB48-04	7 - 9
Benzo(g,h,i)perylene	NE	71 - 1,200	03-TA-SB48-04	7 - 9

Notes:

SSL - USEPA Region III Soil Screening Level (USEPA, 1996)
bgs - below ground surface
µg/kg - microgram per kilogram (ppb)
NE - Not established
* - Acenaphthene used as a surrogate.
Shading indicates an exceedence of the SSL.

TABLE 3-5

EVALUATION OF LOCATION-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Historic Preservation Act of 1966 - requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	No known historic properties are within or near OU No. 12, therefore, this act will not be considered as an ARAR.
Archeological and Historic Preservation Act - establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	16 USC 469 and 40 CFR 6.301(c)	No known historical or archeological data is known to be present at the sites, therefore, this act will not be considered as an ARAR.
Historic Sites, Buildings and Antiquities Act - requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	16 USC 461467 and 40 CFR 6.301(a)	No known historic sites, buildings or antiquities are within or near OU No. 12, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act - requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	16 USC 661-666	Wallace Creek and Henderson Pond are located near Site 3 boundaries. If remedial actions are implemented that modify these creeks, this will be an applicable ARAR.
Federal Endangered Species Act - requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	16 USC 1531, 50 CFR 200, and 50 CFR 402	Many protected species have been cited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991),(Fussell, 1991),(Walters, 1991). In addition, the alligator has been sighted on Base. Therefore, this will be considered as an ARAR.

TABLE 3-5 (Continued)

EVALUATION OF LOCATION-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
North Carolina Endangered Species Act - per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rare species, and the State watch list.	GS 113-331 to 113-337	Since the American alligator has been sighted within MCB Camp Lejeune, this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) - requires permit for structures or work in or affecting navigable waters.	33 USC 403	There are no navigable waters in the vicinity of Site 3. Therefore, this act will not be considered as an ARAR.
Executive Order 11990 on Protection of Wetlands - establishes special requirements for Federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Executive Order Number 11990, and 40 CFR 6	Based on a review of Wetland Inventory Maps, Site 3 is not surrounded by wetlands. Therefore, this will not be an applicable ARAR.
Executive Order 11988 on Floodplain Management - establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Executive Order Number 11988, and 40 CFR 6	The U.S. Corps of Engineers has mapped out the limits of the 100-year floodplain at MCB Camp Lejeune at seven feet above msl in the upper reaches of the New River. Site 3 is not located within the 100-year floodplain. therefore, this will not be an applicable ARAR.

TABLE 3-5 (Continued)

EVALUATION OF LOCATION-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
Wilderness Act - requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	16 USC 1131 and 50 CFR 35.1	No known federally owned wilderness areas near the operable unit, therefore, this act will not be considered as an ARAR.
National Wildlife Refuge System - restricts activities within a National Wildlife Refuge.	16 USC 668 and 50 CFR 27	No known National Wildlife Refuge areas near the operable unit, therefore, this will not be considered as an ARAR.
Scenic Rivers Act - requires action to avoid adverse effects on designated wild or scenic rivers.	16 USC 1271 and 40 CFR 6.302(e)	No known wild or scenic rivers near the operable unit, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act - requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	16 USC 1451	No activities will affect land or water uses in a coastal zone, therefore, this act will not be considered as an ARAR.
Clean Water Act (Section 404) - prohibits discharge of dredged or fill material into wetland without a permit.	33 USC 404	No actions to discharge dredged or fill material into wetlands will be considered for the operable unit, therefore, this act will not be considered as an ARAR.
RCRA Location Requirements - limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	40 CFR 264.18	These requirements may be relevant and appropriate if the remedial actions for the operable unit include the on-site storage, treatment, or disposal of RCRA hazardous waste for more than a 90-day period. On-site storage treatment or disposal of RCRA hazardous waste is not anticipated. Therefore, these requirements will not be considered an ARAR.

TABLE 3-6

POTENTIAL ACTION-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ACTION-SPECIFIC		
DOT Rules for Hazardous Materials Transportation (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Remedial actions may include off-site treatment and disposal of contaminated soil or waste. Applicable for any action requiring off-site transportation of hazardous materials.
Resource Conservation and Recovery Act (RCRA) Subtitle C		
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Primary site contaminants are not considered to be listed wastes. However, contaminated media may be considered hazardous by characteristic.
Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262-265, and 266)	Regulates the treatment, storage, and disposal of hazardous waste.	During remediation, treatment, storage, and disposal activities may occur. Materials may be classified as hazardous wastes.
RCRA Subtitle D	Regulates the treatment, storage, and disposal of solid waste and materials designated by the State as special waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid and/or special waste.
RCRA Land Disposal Restrictions (LDRs) Requirements (40 CFR Part 268)	Restricts certain listed or characteristic hazardous waste from placement or disposal on land (includes injection wells) without treatment. Provides treatment standards and Best Demonstrated Available Technology (BAT).	LDRs may prohibit or govern the implementation of certain remedial alternatives. Excavation and treatment, disposal, or movement of RCRA hazardous waste out of the area of contamination may trigger LDR requirements for the waste.
North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section .0100)	Regulates point-source discharges through the North Carolina permitting program. Substantive requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	May be applicable for actions requiring discharge of treated groundwater to surface water.

TABLE 3-6 (Continued)

POTENTIAL ACTION-SPECIFIC ARARs AND TBC CRITERIA
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
Protection of Archaeological Resources (32 CFR Parts 229 and 229.4; 43 CFR Parts 107 and 171.1-5)	Develops procedures for the protection of archaeological resources.	Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and State archaeologists.
North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A)	Regulates stormwater management and erosion/sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities (i.e., excavation of soil and waste).
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2L.0106 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina, Corrective Action	Regulates corrective actions taken to restore contaminated groundwater or terminate and control the discharge of a waste, hazardous substance, or oil to groundwaters of the state.	May be applicable to groundwater remedial actions and institutional controls.

TABLE 3-7

INGESTION OF GROUNDWATER
RGO PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Ingestion of Groundwater Input Parameters			
Input Parameter	Description	Value	Rationale
C_w	Exposure Concentration	Calculated	USEPA, 1989a
TR	Total Lifetime Risk	1.0E−04	USEPA, 1991a
THI	Total Hazard Index	1.0	USEPA, 1991a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 70 yr	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 6 yr Adult 30 yr	USEPA, 1989a
DY	Days Per Year	365 days/yr	USEPA, 1989a
CSF	Carcinogenic Slope Factor	Chemical Specific	IRIS, HEAST, USEPA
RfD	Reference Dose	Chemical Specific	IRIS, HEAST, USEPA
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child 6 yr Adult 30 yr	USEPA, 1991b
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, 1989a

TABLE 3-8

GROUNDWATER CARCINOGENIC RGOs
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Carcinogenic Remediation Goal Options for Groundwater					
	Future Adult Resident			Future Child Resident		
	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-4}	1×10^{-5}	1×10^{-6}
Benzene(1)	300	30	3	600	60	6
Carbazole(1)	400	40	4	900	90	9
Chloroform(1)	1,400	140	14	3,000	300	30
Trichloroethene(2)	800	80	8	1,700	170	17
1,1-Dichloroethene(1)	14	1.4	0.14	30	3	0.3
Benzo(a)anthracene(3)	12	1.2	0.12	30	3	0.3
Benzo(b)fluoranthene(3)	12	1.2	0.12	30	3	0.3
Benzo(k)fluoranthene(3)	100	10	1	300	30	3.0
Benzo(a)pyrene(3)	1	0.1	0.01	3	0.3	0.03
Chrysene(2)	1,200	120	12	2,500	250	25

Notes:

(1) Retained as risk-based COPC in Worst Case and Round 2 groundwater selection
(2) Retained as criteria-based COPC only
(3) Retained as risk-based COPC in Worst Case groundwater selection only

Remediation Goal Option concentrations expressed in microgram per liter (μg/L).

TABLE 3-9

GROUNDWATER NONCARCINOGENIC RGOs
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic Remediation Goal Options for Groundwater					
	Future Adult Resident			Future Child Resident		
	0.1	1	10	0.1	1	10
1,1-Dichloroethene(1)	33	330	3,300	14	140	1,400
Chloroform(1)	37	370	3,700	16	160	1,600
Trichloroethene(2)	22	220	2,200	9	90	900
Toluene(2)	730	7,300	73,000	313	3,130	31,300
Ethylbenzene(2)	365	3,650	36,500	156	1,560	15,600
Xylene(2)	7,300	73,000	730,000	3,129	31,290	312,900
Phenol(2)	2,190	21,900	219,000	939	9,390	93,900
Acenaphthylene(2)	219	2,190	21,900	94	940	9,400
Anthracene(2)	1,095	20,950	109,500	469	4,690	46,900
Fluoranthene(1)	146	1,460	14,600	63	630	6,300
Pyrene(2)	110	1,100	11,000	48	470	4,700
2-Methylphenol(1)	183	1,830	18,300	78	780	7,800
4-Methylphenol(1)	18	180	1,800	8	80	800
2,4-Dimethylphenol(1)	73	730	7,300	31	310	3,100
Naphthalene(1)	146	1,460	14,600	63	630	6,300
Acenaphthene(1)	219	2,190	21,900	94	940	9,400
Dibenzofuran(1)	15	150	1,500	6	60	600

TABLE 3-9 (Continued)

GROUNDWATER NONCARCINOGENIC RGOs
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic Remediation Goal Options for Groundwater					
	Future Adult Resident			Future Child Resident		
	0.1	1	10	0.1	1	10
Fluorene[3]	146	1,460	14,600	63	630	6,300
Phenanthrene[1]	110	1,100	11,000	47	470	4,700
2-Methylnaphthalene[1]	146	1,460	14,600	63	630	6,300

Notes:

(1) Retained as risk-based COPC in Worst Case and Round 2 groundwater selection
(2) Retained as criteria-based COPC only
(3) Retained as risk-based COPC in Worst Case groundwater selection only

Remediation Goal Option concentrations expressed in microgram per liter (µg/L).

TABLE 3-10

COMPARISON OF GROUNDWATER CONTAMINANT LEVELS TO CRITERIA-BASED AND RISK-BASED RGOs OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Criteria-based RGO		Risk-based RGO		Concentration Range[1]	Location of Maximum Concentration[2]
	NCWQS	Federal MCL	Adult	Child		
Benzene	1	5	3	6	3 - 40	3-MW08
Toluene	1,000	1,000	730	782	2 - 15	3-MW02DW
Xylenes (total)	530	10,000	7,300	7,821	6 - 32	3-MW02DW
1,1-Dichloroethene	7	7	0.14	0.3	1	3-MW02IW
Trichloroethene	NE	5	8	17	1	3-MW12
Ethylbenzene	29	700	365	391	1 - 14	3-MW02DW
Phenol	300	NE	2,190	939	3 - 420	3-MW02DW
2-Methylphenol	NE	NE	183	78	1 - 300	3-MW02DW
2,4-Dimethylphenol	NE	NE	73	31	2 - 170	3-MW02DW
Naphthalene	21	NE	146	63	4 - 2,400	3-MW02DW
2-Methylnaphthalene	NE	NE	146	63	10 - 250	3-MW02DW
Acenaphthylene	210	NE	219	94	1 - 3	3-MW02
Acenaphthene	800	NE	219	94	2 - 550	3-MW02
Dibenzofuran	NE	NE	15	6	2 - 230	3-MW02
Fluorene	280	NE	146	63	1 - 210	3-MW02
Phenanthrene	210	NE	110	47	21 - 410	3-MW02
Anthracene	2,100	NE	1,095	469	1 - 33	3-MW02
Carbazole	NE	NE	4	9	3 - 87	3-MW02DW
Fluoranthene	280	NE	146	63	2 - 100	3-MW02

TABLE 3-10 (Continued)

COMPARISON OF GROUNDWATER CONTAMINANT LEVELS TO CRITERIA-BASED AND RISK-BASED RGOs OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Criteria-based RGO		Risk-based RGO		Concentration Range[1]	Location of Maximum Concentration[2]
	NCWQS	Federal MCL	Adult	Child		
Pyrene	210	NE	110	47	2 - 58	3-MW02
Benzo(a)anthracene	0.05	NE	0.12	0.3	8	3-MW02
Chrysene	5	NE	12	25	8	3-MW02
Benzo(b)fluoranthene	NE	NE	0.12	0.3	3	3-MW02
Benzo(k)fluoranthene	NE	NE	1	3.0	3	3-MW02
Benzo(a)pyrene	NE	NE	0.01	0.03	3	3-MW02
Chloroform	0.19	100	14	30	1	3-MW11IW
4-Methylphenol	NE	NE	1,800	800	3 - 690	3-MW02DW
Aluminum	NE	50	NE	NE	447 - 4,030	3-MW08
Iron	300	300	NE	NE	43.2 - 2,190	3-MW08

Notes:

Concentrations expressed in microgram per liter (µg/L)
NCWQS - North Carolina Water Quality Standard
MCL - Maximum Contaminant Level
RGO - Remedial Goal Option
NE - Not Established

(1) Concentration range obtained from three groundwater sampling rounds

TABLE 3-11

GROUNDWATER REMEDIATION LEVELS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL	Basis of Goal	Corresponding Risk
Benzene	1	NCWQS	
Phenol	300	NCWQS	
2-Methylphenol	78	Groundwater Ingestion	HI = 0.1
2,4-Dimethylphenol	31	Groundwater Ingestion	HI = 0.1
Naphthalene	21	NCWQS	
2-Methylnaphthalene	63	Groundwater Ingestion	HI = 0.1
Dibenzofuran	6	Groundwater Ingestion	HI = 0.1
Phenanthrene	210	NCWQS	
Benzo(a)anthracene	0.05	NCWQS	
Chrysene	5	NCWQS	
Chloroform	0.19	Groundwater Ingestion	ICR - 1×10^{-6}
Carbazole	4	Groundwater Ingestion	ICR = 1×10^{-6}
Benzo(b)fluoranthene	0.12	Groundwater Ingestion	ICR - 1×10^{-6}
Benzo(k)fluoranthene	1	MCL	
Benzo(a)pyrene	2	MCL	
Iron	300	NCWQS	
Aluminum	50	SMCL	

Notes:

RL - Remediation Level in microgram per liter (ppb)
NCWQS - North Carolina Water Quality Standard
MCL - Maximum Contaminant Level
SMCL - Secondary Maximum Contaminant Level
HI - Hazard Index
ICR - Incremental Cancer Risk

TABLE 3-12

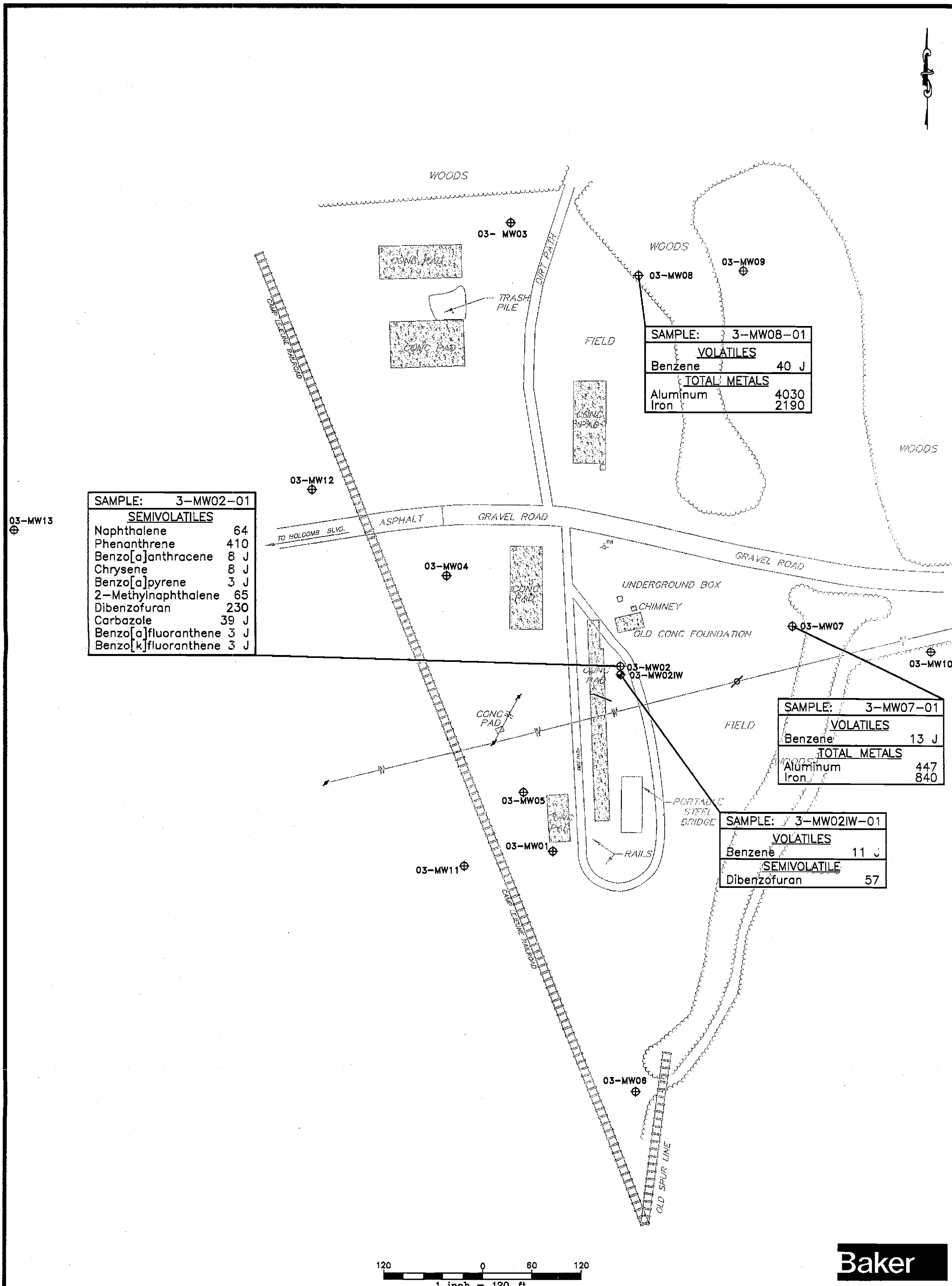
SOIL REMEDIATION LEVELS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL	Basis of Goal
Naphthalene	30,000	SSL
2-Methylnaphthalene	30,000	SSL
Carbazole	500	SSL
Benzo(a)anthracene	700	SSL
Chrysene	1,000	SSL
4-Nitrophenol	0	SSL
N-nitrosodiphenylamine	200	SSL

Notes:

RL - Remediation Level in microgram per kilogram (μg/kg)
SSL - USEPA Region III Soil Screening Level (USEPA, 1996)

SECTION 3.0 FIGURES



LEGEND

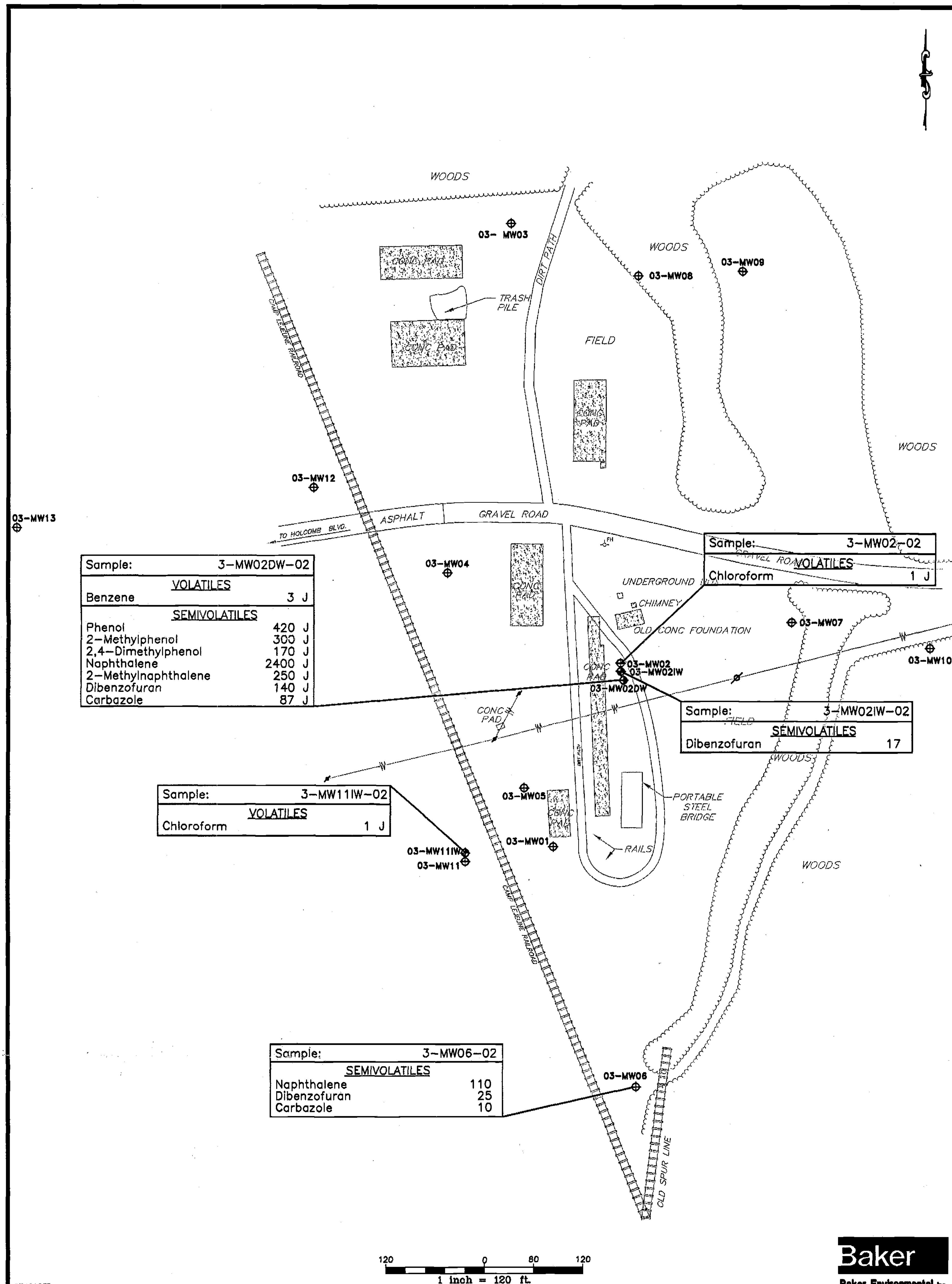
03-MW01 SHALLOW MONITORING WELL LOCATION

03-MW02IW INTERMEDIATE MONITORING WELL LOCATION

NOTE:
-CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER LITER (ug/L).
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-1
CONTAMINANT CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
GROUNDWATER, ROUND ONE
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721 DD B2Z



LEGEND

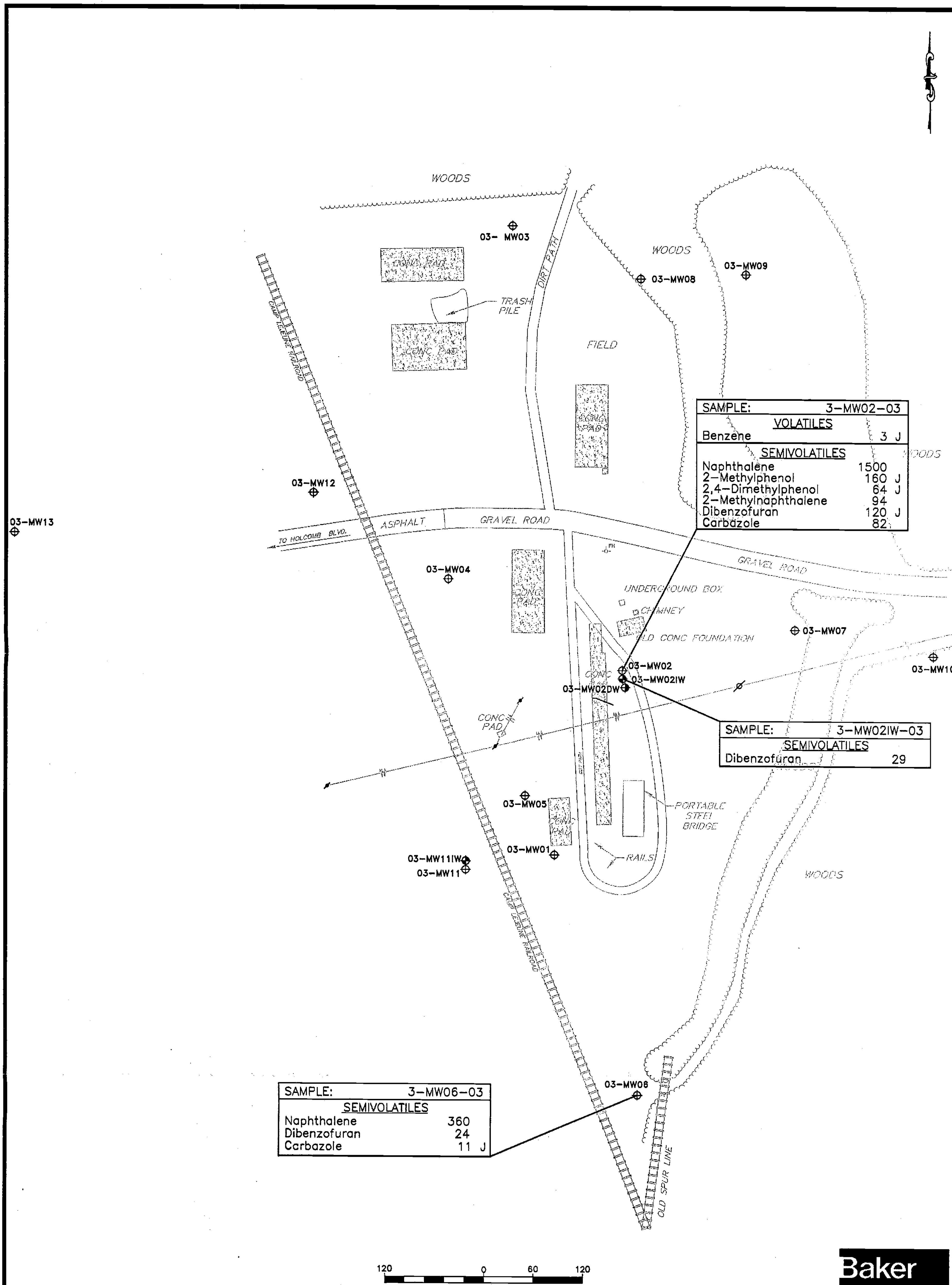
03-MW01 SHALLOW MONITORING WELL LOCATION

03-MW02IW INTERMEDIATE MONITORING WELL LOCATION

03-MW02DW DEEP MONITORING WELL LOCATION

NOTE:
-CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER LITER (ug/L).
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-2
CONTAMINANT CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
GROUNDWATER, ROUND TWO
SITE 3 - OLD CREOSOTE PLANT
FEASIBILTY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

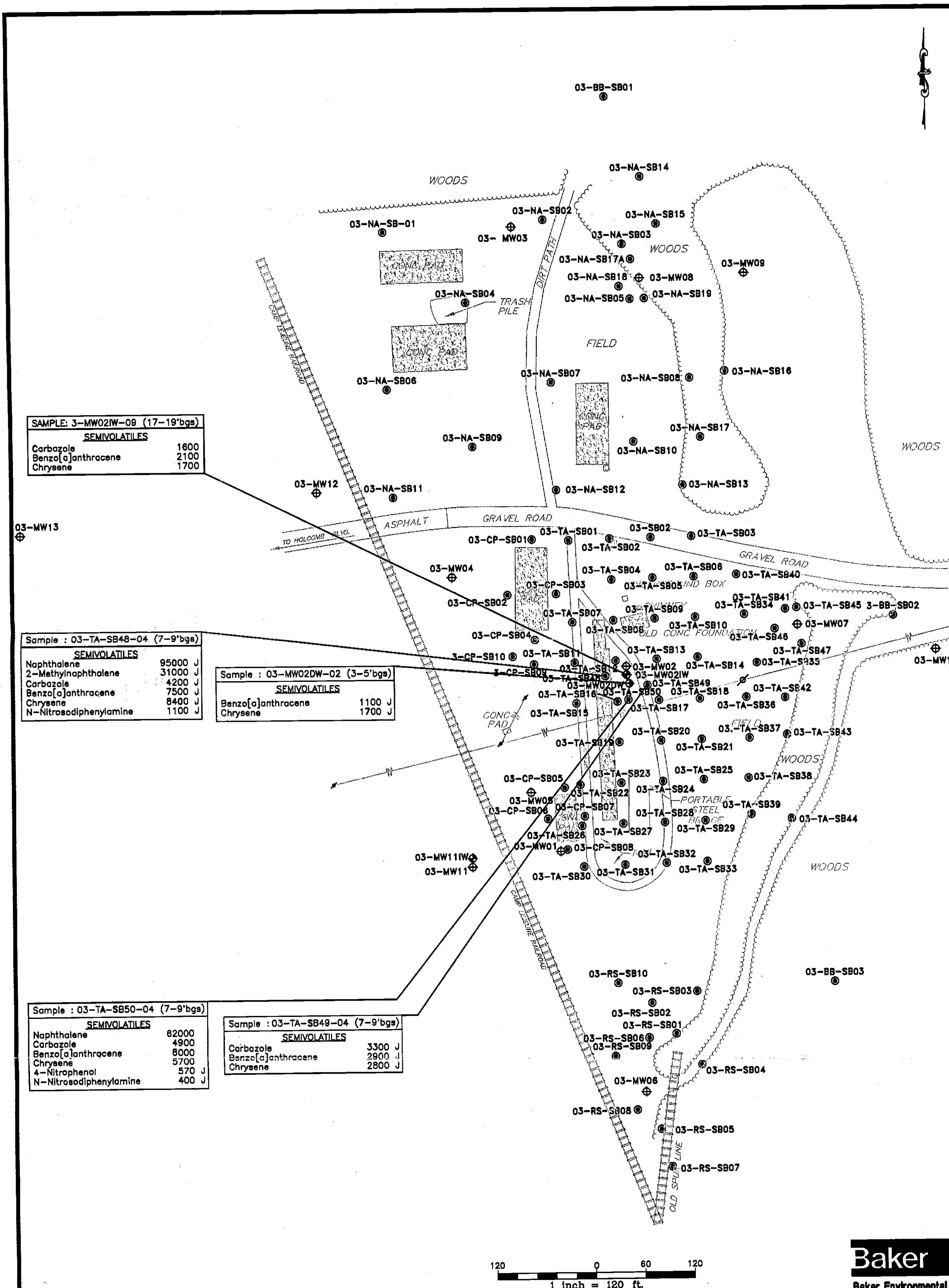


LEGEND

- 03-MW01 SHALLOW MONITORING WELL LOCATION
- 03-MW02IW INTERMEDIATE MONITORING WELL LOCATION
- 03-MW02DW DEEP MONITORING WELL LOCATION

NOTE:
-CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER LITER (ug/L).
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-3
CONTAMINANT CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
GROUNDWATER, ROUND THREE
SITE 3 - OLD CREOSOTE PLANT
FEASIBILTY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SAMPLE: 3-MW02IW-09 (17-19'bgs)

SEMIVOLATILES	
Carbazole	1600
Benzo[a]anthracene	2100
Chrysene	1700

Sample : 03-TA-SB48-04 (7-9'bgs)

SEMIVOLATILES	
Naphthalene	95000 J
2-Methylnaphthalene	31000 J
Carbazole	4200 J
Benzo[a]anthracene	7500 J
Chrysene	8400 J
N-Nitrosodiphenylamine	1100 J

Sample : 03-MW02DW-02 (3-5'bgs)

SEMIVOLATILES	
Benzo[a]anthracene	1100 J
Chrysene	1700 J

Sample : 03-TA-SB50-04 (7-9'bgs)

SEMIVOLATILES	
Naphthalene	62000
Carbazole	4900
Benzo[a]anthracene	8000
Chrysene	5700
4-Nitrophenol	570 J
N-Nitrosodiphenylamine	400 J

Sample : 03-TA-SB49-04 (7-9'bgs)

SEMIVOLATILES	
Carbazole	3300 J
Benzo[a]anthracene	2900 J
Chrysene	2800 J

Baker

Baker Environmental, Inc.

LEGEND

03-MW01 SHALLOW MONITORING WELL LOCATION

03-MW02IW INTERMEDIATE MONITORING WELL LOCATION

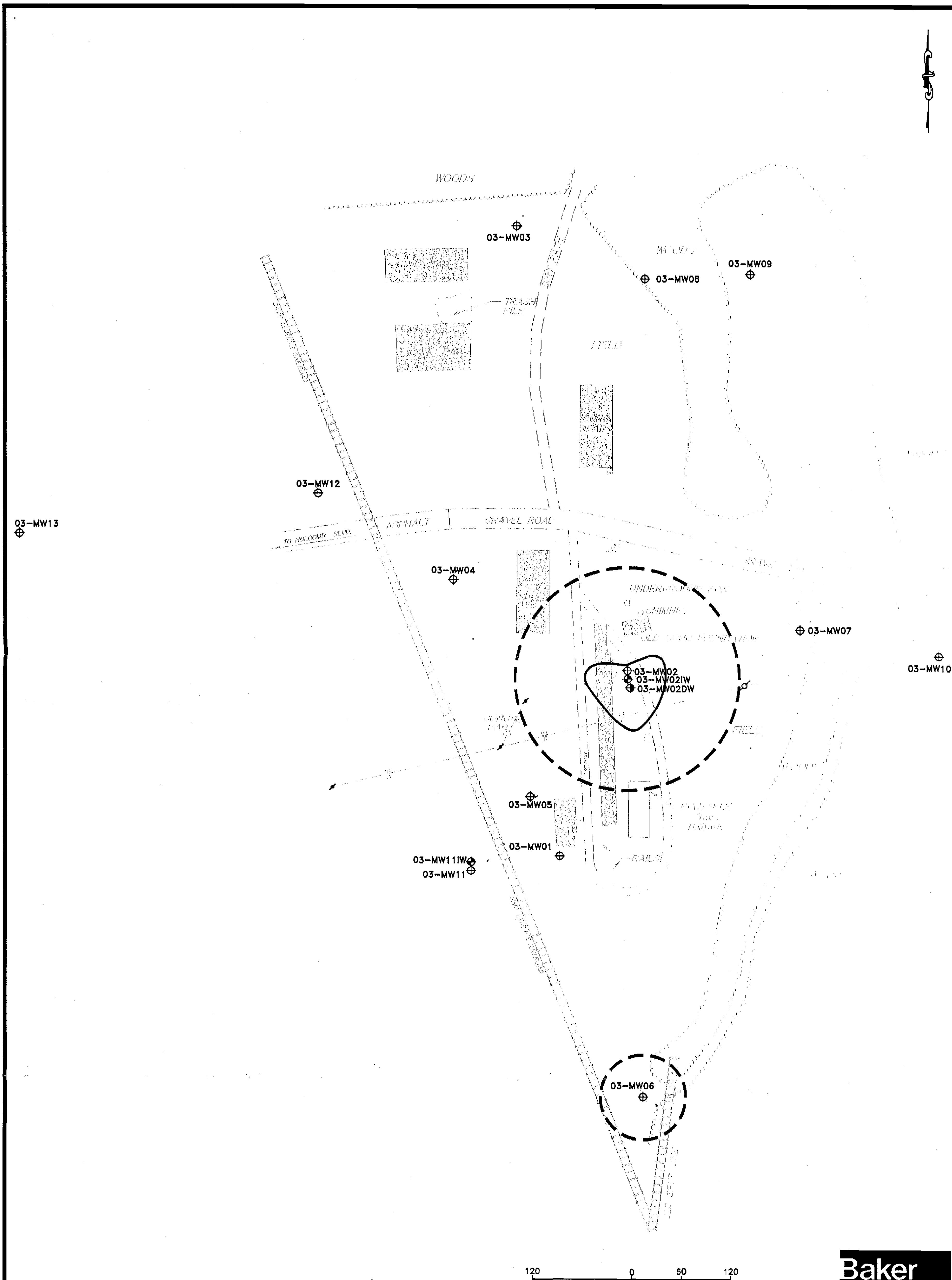
03-MW02DW DEEP MONITORING WELL LOCATION

03-RS-SB01 SOIL BORING LOCATION

NOTE:
-CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-4
CONTAMINANT CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
SUBSURFACE SOIL
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
Baker Environmental, Inc.

LEGEND

03-MW01 SHALLOW MONITORING WELL LOCATION
03-MW02IW INTERMEDIATE MONITORING WELL LOCATION
03-MW02DW DEEP MONITORING WELL LOCATION
GROUNDWATER AREA OF CONCERN
SUBSURFACE SOIL AREA OF CONCERN
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-5
AREAS OF CONCERN
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

4.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

Section 4.0 presents the identification and preliminary screening of remedial action technologies and process options. More specifically, Section 4.1 identifies a set of general response actions for soil and groundwater, Section 4.2 identifies remedial action technologies and process options for each general response action, and Section 4.3 presents the preliminary screening of remedial action technologies and process options. After this preliminary screening, the remaining technologies/process options undergo a process option evaluation in Section 4.4. The technologies/process options that are retained after the process option evaluation will be combined in Section 5.0 to form remedial action alternatives.

4.1 General Response Actions

General response actions (broad-based, medium-specific categories of remedial action technologies and process options) were identified to satisfy the remedial action objectives of this FS. Seven response actions were developed for soil, and six response actions were identified for groundwater. These soil and groundwater response actions are briefly described in Sections 4.1.1 and 4.1.2, respectively.

4.1.1 General Response Actions for Soil

- No Action

The NCP requires the evaluation of a no action response as part of the FS process. A no action response provides a baseline assessment for comparisons involving other remedial alternatives that have a greater level of response. A no action alternative may be considered appropriate when there are no adverse or unacceptable risks to human health or the environment, or when a response action may cause a greater environmental or health danger than the no action alternative itself.

- Institutional Controls

Institutional controls are various "institutional" actions that can be implemented as part of a complete remedial action alternative to minimize exposure to potential hazards. With respect to soil, institutional controls may include land use controls, deed restrictions, and monitoring programs.

- Containment Actions

Containment actions include technologies which contain and/or isolate contaminants by covering, sealing, chemically stabilizing, or providing an effective barrier against specific areas of concern. These actions prevent direct exposure with and/or migration of the contaminated soil without disturbing or removing the waste from the site.

- Removal Actions

Removal actions include the excavation of contaminated soil and the removal of this soil from the site. Once the contaminated soil is removed from the site, it may undergo off site treatment and/or disposal.

- Off Site Disposal

Off site disposal actions may occur at a landfill or a soil recycling facility. This general response action is implemented after the contaminated soil is removed (i.e., excavated and transported) from the site premises.

- Ex Situ Treatment

Ex situ treatment actions include physical/chemical, solidification/stabilization, biological, and thermal treatment technologies. These technologies are implemented after the contaminated soil has been removed (i.e., excavated) from its in situ state. The ex situ treatment actions may be conducted at an off site facility, an on site facility, or a mobile facility.

- In Situ Treatment

In situ treatment actions include physical/chemical, solidification/stabilization, and biological treatment technologies that are implemented while the contaminated soil remains in its in situ state.

4.1.2 General Response Actions for Groundwater

- No Action

The NCP requires the evaluation of a no action response as part of the FS process. A no action response provides a baseline assessment for comparisons involving other remedial alternatives that have a greater level of response. A no action alternative may be considered appropriate when there are no adverse or unacceptable risks to human health or the environment, or when a response action may cause a greater environmental or health danger than the no action alternative itself.

- Institutional Controls

Institutional controls are various "institutional" actions that can be implemented as part of a complete remedial action alternative to minimize exposure to potential hazards. With respect to groundwater, institutional controls may include aquifer use restrictions, deed restrictions, and monitoring programs.

- Containment/Collection Actions

Containment/collection actions include subsurface barriers and extraction well systems that may isolate or prevent the migration of contaminated groundwater. The same subsurface barriers may also collect the contaminated groundwater for further treatment as they contain the contamination.

- Ex Situ Treatment

Ex situ treatment actions include physical/chemical, biological, and thermal treatment technologies that are implemented after the contaminated groundwater has been extracted from the subsurface. These treatment actions may be conducted at an off site facility, an on site facility, or a mobile facility.

- In Situ Treatment

In situ treatment actions include physical/chemical, biological, and passive remediation technologies that are implemented while the contaminated groundwater remains in an in situ state.

- Discharge Actions

Discharge actions are usually implemented after groundwater has been treated to acceptable remediation levels. These actions include on site and off site discharge options.

4.2 Identification of Remedial Action Technologies and Process Options

In this step, an extensive set of potentially applicable technologies and process options will be identified for each soil and groundwater general response action. The term "technology type" will refer to general categories of technologies such as physical/chemical treatment, biological treatment, and thermal treatment. The term "process option" will refer to specific processes, or technologies, within each generalized technology type. For example, carbon adsorption, solvent extraction, and chemical oxidation are process options that fall under the technology type known as physical/chemical treatment. Several technology types may be identified for each general response action, and numerous process options may exist within each generalized technology type.

Remedial action technology types that are potentially applicable for soil and groundwater are listed in Table 4-1. Each technology type is listed with respect to its corresponding general response action. (These technology types are listed in the column titled "Remedial Action Technology".) Also identified on the table are applicable process options associated with each of the listed technology types.

4.3 Preliminary Screening of Remedial Action Technologies and Process Options

In this step, the set of remedial action technologies and process options identified in the previous section will be screened (or reduced) by evaluating the technologies with respect to technical implementability and site-specific factors. This screening step will be accomplished by using readily available information from the RI (with respect to contaminant types, contaminant concentrations, and on site characteristics) to screen out technologies and process options that cannot be effectively implemented at the site (USEPA, 1988). In general, all technologies and process options which appear to be applicable to the site contaminants and to the site conditions will be retained for further evaluation. This preliminary screening is presented in Tables 4-2 and 4-3. Table 4-2 presents the screening for soil, and Table 4-3 presents the screening for groundwater. Following the preliminary screening, each remaining process option will be evaluated in Section 4.4.

As shown in Tables 4-2 and 4-3, several technologies and/or process options were eliminated from further evaluation because they were determined to be inappropriate for the site-specific characteristics and/or contaminant-specific characteristics. The soil technologies/process options that were eliminated include:

- Vertical Barriers
- Horizontal Barriers
- Capping
- Ex Situ Soil Vapor Extraction
- Chemical Dichlorination
- Chemical Reduction
- Ex Situ Anaerobic Bioremediation
- In Situ Soil Flushing
- In Situ Soil Vapor Extraction
- In Situ Steam Extraction
- Dual Phase Vacuum Extraction
- In Situ Anaerobic Bioremediation

The groundwater technologies/process options that were eliminated include:

- Vertical Barriers
- Horizontal Barriers
- Capping
- Extraction/Injection Wells
- Air Stripping
- Steam Stripping
- Chemical Reduction
- Ion Exchange
- Electrochemical Ion Generation
- Distillation
- Ex Situ Anaerobic Bioremediation
- Incineration
- Pyrolysis
- POTW Treatment
- RCRA Facility Treatment
- Sewage Treatment Plant
- Air Sparging
- In Well Aeration
- Dual Phase Extraction
- In Situ Anaerobic Bioremediation
- Passive Treatment Wall
- On Site Surface Water Discharge
- On Site Reinjection

The soil and groundwater technologies/process options that passed this preliminary screening are listed in Table 4-4.

4.4 Process Option Evaluation

The objective of the process option evaluation is to select only one process option for each applicable remedial technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. More than one process option may be selected for a technology type if the processes are sufficiently different in their performance that one would not adequately represent the other. In addition, an entire response action may be eliminated if all of the process options listed under the response are eliminated. The representative process options that are retained provide a basis for developing performance specifications during preliminary design. However, the specific process options used to implement the remedial action may not be selected until the remedial design phase.

The process options listed in Table 4-4 were evaluated based on three criteria: effectiveness, implementability, and relative cost. The effectiveness evaluation focused on: the potential effectiveness of process options in meeting the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phase; and how reliable the process will be when addressing the contaminants of concern. The implementability evaluation focused on the administrative feasibility of implementing a technology (e.g., obtaining permits), since the technical implementability was previously considered in the preliminary screening. The cost evaluation played a limited role in this screening. Only relative capital and operation and maintenance (O&M) costs were used instead of detailed estimates. As per the USEPA guidance, the cost analysis was made on the basis of engineering judgement.

Summaries of the process option evaluations are presented in Tables 4-5 and 4-6 for soil and groundwater, respectively. It is important to note that the elimination of a process option does not mean that the process option/technology can never be reconsidered for the site. As previously stated, the purpose of this part of the FS process is to simplify the development and evaluation of potential alternatives.

4.5 Final Set of Remedial Action Technologies and Process Options

Table 4-7 identifies the final set of feasible technologies/process options for soil and groundwater. This final set will be used to develop remedial action alternatives in Section 5.0.

As shown in Table 4-7, two soil process options, solid-phase aerobic bioremediation and incineration, may be implemented using several different remedial approaches. The approaches for solid-phase bioremediation include prepared beds, heap piles, composting, landfarming, and constructed wetlands; the approaches for incineration include rotary kiln, infrared incineration, and circulating fluidized bed units. To facilitate the development of remedial action alternatives, landfarming was retained as the preferred remedial approach for the bioremediation process option. Landfarming is preferred because a landfarm biocell already exists at Lot 203, MCB, Camp Lejeune. In addition, landfarming has proven to be effective at treating creosote contaminants. In the case of the incineration process option, however, one specific remedial approach was not specified. This is because: 1) all of the approaches can effectively treat the contaminants of concern, and 2) the effectiveness of an incineration alternative will rely more upon the location of incineration facilities rather than the type of incineration (i.e., rotary kiln, infrared incineration, circulating fluidized beds) that the facilities employ.

SECTION 4.0 TABLES

TABLE 4-1

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Soil	No Action	None	Not Applicable
	Institutional Controls	Access Restrictions	Fencing
		Land Use Controls	Base Master Plan
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Containment Actions	Vertical Barriers	Slurry Wall, Sheet Piling, Grout Curtain, Rock Grouting
		Horizontal Barriers	Grout Injection, Jet Grouting
		Capping	Clay/Soil Cap, Asphalt Cap, Synthetic Membrane, Composite Cap, Multi-Layered Cap, Soil Cover
	Removal Actions	Excavation	Excavation
	Off Site Disposal	Landfill	Hazardous Waste Landfill
			Solid Waste Landfill
		Soil Recycling	Soil Recycling (Asphalt Incorporation, Cement Production, or Brick Manufacturing)
	Ex Situ Treatment	Physical/Chemical Treatment	Soil Washing
			Solvent Extraction
			Soil Vapor Extraction
			Chemical Dechlorination
			Chemical Reduction
			Chemical Oxidation
		Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clays)
			Vitrification

TABLE 4-1 (Continued)

POTENTIAL SET OF REMEDIAL ACTION
TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Soil (Continued)	Ex Situ Treatment (Continued)	Biological Treatment	Aerobic Bioremediation, Slurry-Phase (Bioslurry Reactors, Rotating Biological Contactors, Lagoons)
			Aerobic Bioremediation, Solid-Phase (Prepared Beds, Heap Piles, Composting, Landfarming, Wetlands)
			Anaerobic Bioremediation
		Thermal Treatment	Incineration (Rotary Kiln, Infrared Incineration, Circulating Fluidized Beds)
			Pyrolysis
			Thermal Desorption
	In Situ Treatment	Physical/Chemical Treatment	Soil Flushing
			Soil Vapor Extraction
			Steam Extraction
			Dual Phase Vacuum Extraction
		Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clay)
			Vitrification
		Biological Treatment	Aerobic Bioremediation
			Anaerobic Bioremediation
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Ordinances	Aquifer Use Restrictions
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Containment/ Collection Actions	Vertical Barriers	Slurry Wall, Sheet Piling, Grout Curtain, Rock Grouting

TABLE 4-1 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater (Continued)	Containment/ Collection Actions (Continued)	Horizontal Barriers	Grout Injection, Jet Grouting
		Capping	Clay/Soil Cap, Asphalt Cap, Synthetic Membrane, Composite Cap, Multilayered Cap, Soil Cover
		Extraction	Extraction Wells
			Extraction/Injection Wells
		Subsurface Drains	Interceptor Trenches
	Ex Situ Treatment	Physical/Chemical Treatment	Air Stripping
			Steam Stripping
			Carbon Adsorption
			Chemical Dechlorination
			Chemical Reduction
			Chemical Oxidation
			Membrane Separation
			Ion Exchange
			Electrochemical Ion Generation
			Distillation
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
			Oil/Water Separation
		Biological Treatment	Aerobic Bioremediation (Aerated Lagoon, Activated Sludge, Trickling Filter, Rotating Biological Contactor)
			Anaerobic Bioremediation
		Thermal Treatment	Incineration (Liquid Injection, Rotary Kiln, Circulating Fluidized Bed, Multiple Hearth, Molten Salt)
			Pyrolysis, Plasma Arc Torch

TABLE 4-1 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater (Continued)	Ex Situ Treatment (Continued)	Off Site Treatment	POTW
			RCRA Facility
			Sewage Treatment Plant
			Site 82 or HPIA Treatment System
	In Situ Treatment	Air Stripping	Air Sparging
			In Well Aeration
		Dual Phase Extraction	Dual Phase Extraction
		Biological Treatment	Aerobic Biodegradation
			Anaerobic Biodegradation
		Passive Remediation	Passive Treatment Wall
	Discharge Actions	On Site Discharge	Surface Water
			Reinjection (Injection Wells, Infiltration Galleries)
		Off Site Discharge	POTW
			Pipeline to Stream
			Sewage Treatment Plant
			Deep Well Injection

TABLE 4-2

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	None	Not Applicable	No action.	Potentially applicable	Retained
Institutional Controls	Access Restrictions	Fencing	Erect fencing to reduce site access.	Potentially applicable.	Retained
	Land Use Controls	Base Master Plan	Use of Base Master Plan to restrict current and future land use on Base.	Potentially applicable.	Retained
	Legal Restrictions	Deed Restrictions	Use of deed restrictions to restrict future land use at the site if the Base were to close.	Potentially applicable.	Retained
	Monitoring	Monitoring	Periodic sampling and analysis.	Potentially applicable.	Retained
Containment Actions	Vertical Barriers	Slurry Wall, Sheet Piling, Grout Curtain, Rock Grouting	A subsurface, impervious, vertical barrier is constructed to restrict the horizontal migration of a contaminated area.	No continuous cofining layer under the site for the wall to adjoin to; wood preserving constituents may decrease the impermeability of grout.	Eliminated
	Horizontal Barriers	Grout Injection, Jet Grouting	A subsurface, impervious, horizontal barrier is constructed to restrict the vertical migration of a contaminated area.	Technique is in the experimental stage; wood preserving constituents may decrease the impermeability of grout.	Eliminated
	Capping	Clay/Soil Cap, Asphalt Cap, Synthetic Membrane, Composite Cap, Multi-Layered Cap, Soil Cover	Capping of contaminated areas to prevent contact with soil and to restrict water infiltration.	Because the soil contamination is located at depth, a cap is not necessary to prevent direct contact. In addition, a cap alone will not prevent water infiltration (vertical and horizontal barriers were already eliminated).	Eliminated
Removal Actions	Excavation	Excavation	Removal of contaminated soil using conventional excavation equipment.	Potentially applicable.	Retained
Off Site Disposal	Landfill	Hazardous Waste Landfill	Excavated soils are transported to a RCRA-permitted (Subtitle C) facility for disposal.	Potentially applicable if the soil is determined to be hazardous.	Retained
		Solid Waste Landfill	Excavated soils are transported to a RCRA-permitted (Subtitle D) facility, such as a sanitary landfill, for disposal.	Potentially applicable if the soil is determined to be non-hazardous.	Retained

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Off Site Disposal (Continued)	Soil Recycling	Soil Recycling (Asphalt Incorporation, Cement Production, or Brick Manufacturing)	Excavated soils are included as raw materials in the asphalt, cement, or brick manufacturing processes. Contaminants are stabilized in the finished product.	Potentially applicable.	Retained
Ex Situ Treatment	Physical/Chemical Treatment	Soil Washing	Washing the contaminated soil with a water-based solution to dissolve or suspend contaminants, and to concentrate the contaminants into a smaller volume (via size separation, gravity separation, or attrition scrubbing). The water-based solution may contain wash-enhancing additives such as surfactants, acids, and chelating agents.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Solvent Extraction	Washing the contaminated soil with organic chemical solvents to remove contaminants and concentrate them in the extract phase.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Soil Vapor Extraction	Applying a vacuum to a stockpile of excavated soil and extracting volatilized contaminants. The target contaminant group is volatile organics; the technology will have only limited effectiveness on semivolatile organics.	The soil contamination consists of semivolatile, not volatile, organics.	Eliminated
		Chemical Dechlorination	Use of specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to detoxify them into other harmless compounds. Effective for PCB/dioxin/furan and halogenated phenol/creosol groups.	Not applicable to the soil contaminants of concern.	Eliminated

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment (Continued)	Physical/Chemical Treatment (Continued)	Chemical Reduction	Use of reducers, such as sulfur dioxide, sulfite compounds, or ferrous iron compounds, to chemically decrease contaminants' oxidation states. Effective for inorganics.	Inorganics are not contributing to the soil contamination.	Eliminated
		Chemical Oxidation	Use of oxidizers, such as ozone, hydrogen peroxide, chlorine, and permanganate, to chemically increase contaminants' oxidation states. Ultraviolet light, or high pressures and temperatures may enhance the oxidation process. Effective for organics and inorganics.	Potentially applicable to the organic, oxidizable contaminants of concern.	Retained
	Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clays)	Converting the contaminated soil into a solid, stable matrix by mixing with Portland cement; mixing with siliceous material and setting agents; sealing the waste in an asphalt, bitumen, paraffin, or polyethylene matrix; or sealing the waste in an organic binder or resin. Most effective for soil contaminated with inorganics; less effective for soil contaminated with organics.	Because the soil is contaminated with organics, not inorganics, S/S will not be effective as a primary treatment. However, S/S may be effective as a secondary treatment to facilitate handling of the contaminated material.	Retained
		Vitrification	Melting of contaminated materials (using thermal methods such as plasma arc, microwave heating, or kiln) to glassify inorganics and volatilize/pyrolyze organics. The target contaminant group is inorganics, although the high temperatures used for the process will effectively volatilize and pyrolyze organics.	Because the soil is contaminated with organics, not inorganics, vitrification will not be effective as a primary treatment. However, vitrification may be effective as a secondary treatment to facilitate handling of the contaminated material.	Retained

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment (Continued)	Biological Treatment	Aerobic Bioremediation, Slurry-Phase (Bioslurry Reactors, Rotating Biological Contactors, Lagoons)	Degradation of organic contaminants via microorganisms in an aerobic (oxygen-sufficient) environment. Nutrients may be added and oxygen, pH, and temperature may be adjusted to optimize contaminant removal.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Aerobic Bioremediation, Solid-Phase (Prepared Beds, Heap Piles, Composting, Landfarming, Wetlands)	Degradation of organic contaminants via microorganisms in an aerobic (oxygen-sufficient) environment. Nutrients may be added and oxygen, pH, and temperature may be adjusted to optimize contaminant removal.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Anaerobic Bioremediation	Degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Compared to aerobic bioremediation, an anaerobic environment will be less effective for the organic contaminants of concern.	Eliminated
	Thermal Treatment	Incineration (Rotary Kiln, Infrared Incineration, Circulating Fluidized Beds)	Use of high temperatures and oxygen to volatilize and combust contaminants. Effective for a wide range of organic and inorganic contaminants.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Pyrolysis	Use of high temperatures, in the absence of oxygen, to volatilize contaminants and induce chemical decomposition.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Thermal Desorption	Use of direct or indirect heat exchange to volatilize soil contaminants. Bed temperatures determine which organics will be removed.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
In Situ Treatment	Physical/Chemical Treatment	Soil Flushing	An aqueous solution is injected or sprayed into the contaminated soil to desorb contaminants; flushing fluids and groundwater are extracted at a downgradient location then treated. Recovered fluids may be reinjected. Applicable to a wide range of organics and inorganics.	The contaminated zone exhibits marginal to low permeability (1 x 10^{-3} cm/sec); flushing may promote contaminant leaching from the soil to the groundwater.	Eliminated
		Soil Vapor Extraction	Extraction of volatilized contaminants from soil via an induced vacuum created by soil vapor extraction wells. The process may be enhanced by an air injection well system. The target contaminant group is volatile organics; the technology will have only limited effectiveness on semivolatile organics.	The soil contamination consists of semivolatile, not volatile, organics.	Eliminated
		Steam Extraction	Thermal and mechanical energies (generated from steam, hot air, infrared elements, or electrical systems) are used to volatilize contaminants. The target contaminant group is volatile organics; the technology will have only limited effectiveness on semivolatile organics.	The soil contamination consists of semivolatile, not volatile, organics.	Eliminated
		Dual Phase Vacuum Extraction	A high vacuum system is applied to simultaneously remove groundwater and volatilized soil contaminants from the subsurface. The target contaminant group is volatile organics; the technology will have only limited effectiveness on semivolatile organics.	The soil contamination consists of semivolatile, not volatile, organics.	Eliminated

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
In Situ Treatment (Continued)	Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clay)	Converting the contaminated soil into a solid, stable matrix by mixing with Portland cement; mixing with siliceous material and setting agents; sealing the waste in an asphalt, bitumen, paraffin, or polyethylene matrix; or sealing the waste in an organic binder or resin. Most effective for soil contaminated with organics; less effective for soil contaminated with organics.	Because the soil is contaminated with organics, not inorganics, S/S will not be effective as a primary treatment. However, S/S may be effective as a secondary treatment to facilitate handling of the contaminated material.	Retained
		Vitrification	In situ melting of contaminated material, using an electric current, to form a durable glass and crystalline substance. Immobilizes inorganics and destroys organics via pyrolysis. The target contaminant group is inorganics, although the high temperatures used for the process will effectively volatilize and pyrolyze organics.	Because the soil is contaminated with organics, not inorganics, vitrification will not be effective as a primary treatment. However, vitrification may be effective as a secondary treatment to facilitate handling of the contaminated material.	Retained
	Biological Treatment	Aerobic Bioremediation	Degradation of organic contaminants via microorganisms in an aerobic (oxygen-sufficient) environment. Nutrients may be added and oxygen, pH, and temperature may be adjusted to optimize contaminant removal.	Potentially applicable to the semivolatile organic contaminants of concern.	Retained
		Anaerobic Bioremediation	Degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Compared to aerobic bioremediation, an anaerobic environment will be less effective for the organic contaminants of concern.	Eliminated

TABLE 4-3

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No action - contaminated groundwater remains as is.	Potentially applicable to any site; required by the NCP.	Retained
Institutional Controls	Ordinances	Aquifer Use Restrictions	Restrictions that prohibit use of the contaminated aquifer as a potable water source.	Potentially applicable.	Retained
	Legal Restrictions	Deed Restrictions	Restrictions that limit the future use of land, including placement of wells.	Potentially applicable.	Retained
	Monitoring	Monitoring	Periodic sampling and analysis.	Potentially applicable.	Retained
Containment/Collection Actions	Vertical Barriers	Slurry Wall, Sheet Piling, Grout Curtain, Rock Grouting	A subsurface, impervious, vertical barrier is constructed to restrict the horizontal migration of a contaminated area.	No continuous confining layer under the site for the wall to adjoin to; wood preserving constituents may decrease the impermeability of grout.	Eliminated
	Horizontal Barriers	Grout Injection, Jet Grouting	A subsurface, impervious, horizontal barrier is constructed to restrict the vertical migration of a contaminated area.	Technique is in the experimental stage; wood preserving constituents may decrease the impermeability of grout.	Eliminated
	Capping	Clay/Soil Cap, Asphalt Cap, Synthetic Membrane, Composite Cap, Multilayered Cap, Soil Cover	Capping of contaminated areas to restrict water infiltration.	A cap alone will not prevent water infiltration (vertical and horizontal barriers were already eliminated).	Eliminated
	Extraction	Extraction Wells	Series of extraction wells used to pump contaminated groundwater to the surface.	Potentially applicable.	Retained
		Extraction/Injection Wells	Injection of uncontaminated groundwater to enhance collection of contaminated groundwater via extraction wells. Injection wells can also inject material into an aquifer to remediate groundwater.	Based on the marginal permeability of the shallow aquifer ($1x10^{-3}$ cm/sec), injected liquid may mound in the subsurface formations or move in preferential pathways; reinjection may promote contaminant leaching from the soil to the groundwater.	Eliminated
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater. Generally limited to shallow depths.	Potentially applicable.	Retained

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed volume to promote transfer of volatile organics to air; limited effectiveness on semivolatile organics.	The majority of the groundwater contamination consists of semivolatile, not volatile, organics.	Eliminated
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of volatile organics to air; limited effectiveness on semivolatile organics.	The majority of the groundwater contamination consists of semivolatile, not volatile, organics.	Eliminated
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through a carbon column. Effective for a wide range of organics.	Potentially applicable to the volatile organic and semivolatile organic contaminants of concern.	Retained
		Chemical Dechlorination	Use of specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to detoxify them into other harmless compounds. Effective for PCB/dioxin/furan and halogenated phenol/creosol groups.	Potentially applicable to dibenzofuran, 2-methylphenol, and 2,4-dimethylphenol in the groundwater.	Retained
		Chemical Reduction	Use of reducers, such as sulfur dioxide, sulfite compounds, or ferrous iron compounds, to chemically decrease contaminants' oxidation states. Effective for inorganics.	Inorganics are not contributing to the majority of the groundwater contamination.	Eliminated
		Chemical Oxidation	Use of oxidizers, such as ozone, hydrogen peroxide, chlorine, and permanganate, to chemically increase contaminants' oxidation states. Ultraviolet light, or high pressures and temperatures may enhance the oxidation process. Effective for organics and inorganics.	Potentially applicable to the organic, oxidizable contaminants of concern.	Retained

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment (Continued)	Physical/Chemical Treatment (Continued)	Membrane Separation (Reverse Osmosis, Electrodialysis)	Groundwater passes through a membrane that separates contaminants from the liquid phase. Effective for dissolved solids (organic and inorganic).	Potentially applicable.	Retained
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Effective for inorganics (but not iron).	Inorganics are not contributing to the majority of the groundwater contamination.	Eliminated
		Electrochemical Ion Generation	Electrical currents are used to put ferrous and hydroxyl ions into solution for subsequent removal via precipitation. Effective for inorganics.	Inorganics are not contributing to the majority of the groundwater contamination.	Eliminated
		Distillation	Contaminated water is heated so it evaporates leaving contaminants behind. The water vapor is then cooled resulting in a condensate of purified water. Highly energy intensive.	Because it is highly energy intensive, this method is only appropriate for treating groundwater with high contaminant concentrations.	Eliminated
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. Applicable to acidic or basic waste streams. Typically used as a pretreatment technology.	Potentially applicable as a pretreatment technology.	Retained
		Precipitation	Materials in solution are transferred into a solid phase for removal. Effective for particulates and metals; typically used as a pretreatment technology.	Potentially applicable as a pretreatment technology.	Retained
		Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids; typically used as a pretreatment technology.	Potentially applicable as a pretreatment technology.	Retained

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment (Continued)	Physical/Chemical Treatment (Continued)	Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into large particles by the addition of flocculating agents. Applicable to particulates and inorganics; typically used as a pretreatment technology.	Potentially applicable as a pretreatment technology.	Retained
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. Effective for suspended solids; typically used as a pretreatment technology.	Potentially applicable as a pretreatment technology.	Retained
		Oil/Water Separation	Petroleum hydrocarbon materials in solution are separated for removal.	Potentially applicable.	Retained
	Biological Treatment	Aerobic Bioremediation (Aerated Lagoon, Activated Sludge, Trickling Filter, Rotating Biological Contactor)	Degradation of organic contaminants via microorganisms in an aerobic (oxygen-sufficient) environment. Nutrients may be added and oxygen, pH, and temperature may be adjusted to optimize contaminant removal.	Potentially applicable to the volatile organic and semivolatile organic contaminants of concern.	Retained
		Anaerobic Bioremediation	Degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Potentially applicable to the volatile organic and semivolatile organic contaminants of concern.	Eliminated
	Thermal Treatment	Incineration (Liquid Injection, Rotary Kiln, Circulating Fluidized Bed, Multiple Hearth, Molten Salt)	Use of high temperatures and oxygen to volatilize and combust contaminants. Effective for a wide range of organics and inorganics.	Incineration is a relatively expensive alternative for groundwater because extensive dewatering may be required.	Eliminated
		Pyrolysis, Plasma Arc Torch	Advanced incineration; thermal conversion of organic material into solid, liquid, and gaseous components (takes place in an oxygen-deficient atmosphere). Effective for organics and inorganics.	Incineration is a relatively expensive alternative for groundwater because extensive dewatering may be required.	Eliminated

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Ex Situ Treatment (Continued)	Off Site Treatment	POTW	Extracted groundwater discharged to the Jacksonville POTW for treatment.	Not applicable since this POTW will not accept contaminated groundwater.	Eliminated
		RCRA Facility	Extracted groundwater transported to a licensed RCRA facility for treatment and/or disposal.	Distance to nearest RCRA Facility, and the volume of groundwater that must be transported, make this option impractical.	Eliminated
		Sewage Treatment Plant	Extracted groundwater discharged to Base STP for treatment.	Not applicable since this POTW will not accept highly contaminated groundwater.	Eliminated
		Site 82 or HPIA Treatment Systems	Extracted groundwater discharged to the Site 82 treatment system or the HPIA treatment system which include air stripping and carbon adsorption units.	Potentially applicable to the volatile organic and semivolatile organic contaminants of concern.	Retained
In Situ Treatment	Air Stripping	Air Sparging	"In situ air stripping"; air is injected into the aquifer creating an underground air stripper; used in conjunction with soil vapor extraction to capture volatilized contaminants.	The majority of the contamination consists of semivolatile, not volatile, organics.	Eliminated
		In Well Aeration	"In well air stripping". Process of inducing air into a well by applying a vacuum. The result is an in-well air lift pump effect that serves to strip volatiles from groundwater inside the well.	The majority of the contamination consists of semivolatile, not volatile, organics.	Eliminated
	Dual Phase Extraction	Dual Phase Extraction	A high vacuum placed in a well to remove liquid and volatilized contaminants; applicable to volatile organics in low permeability or heterogeneous formations.	The majority of the contamination consists of semivolatile, not volatile, organics.	Eliminated
	Biological Treatment	Aerobic Biodegradation	Degradation of organic contaminants via microorganisms in an aerobic (oxygen-sufficient) environment. Nutrients may be added and oxygen, pH, and temperature may be adjusted to optimize contaminant removal.	Potentially applicable to the volatile organic and semivolatile organic contaminants of concern.	Retained

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
In Situ Treatment (Continued)	Biological Treatment (Continued)	Anaerobic Biodegradation	Degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Compared to aerobic bioremediation, an anaerobic environment will be less effective for the contaminants of concern.	Eliminated
	Passive Remediation	Passive Treatment Wall	A permeable reaction wall is installed across the flow path of a contaminant plume, treating the plume as it passively moves through the wall. Effective for volatile organics and inorganics.	The majority of the contamination consists of semivolatile organics, not volatile organics or inorganics.	Eliminated
Discharge Actions	On Site Discharge	Surface Water	Treated water discharged to stream on the site.	On site drainage paths do not have the capacity to accept the amount of discharge expected.	Eliminated
		Reinjection (Injection Wells, Infiltration Galleries)	Treated water is reinjected into the site aquifer using shallow infiltration galleries (trenches) or injection wells.	Based on the marginal permeability of the shallow aquifer ($1x10^{-3}$ cm/sec), injected liquid may mound in the subsurface formations or move in preferential pathways; reinjection may also spread contamination from the soil to the groundwater.	Eliminated
	Off Site Discharge	POTW	Treated water discharged to Jacksonville POTW.	Potentially applicable.	Retained
		Pipeline to Stream	Treated water discharged to river off site (e.g., Wallace Creek or the New River).	Potentially applicable.	Retained
		Sewage Treatment Plant	Treated water discharged to Hadnot Point STP.	Potentially applicable.	Retained
		Deep Well Injection	Treated water is reinjected into the brine aquifer located under the Castle Hayne aquifer.	Potentially applicable.	Retained

TABLE 4-4

SET OF POTENTIAL TECHNOLOGIES AND PROCESS OPTIONS
THAT PASSED THE PRELIMINARY SCREENING
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Soil	No Action	None	Not Applicable
	Institutional Controls	Access Restrictions	Fencing
		Land Use Controls	Base Master Plan
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Removal Actions	Excavation	Excavation
	Off Site Disposal	Landfill	Hazardous Waste Landfill
			Solid Waste Landfill
		Soil Recycling	Soil Recycling (Asphalt Incorporation, Cement Production, or Brick Manufacturing)
	Ex Situ Treatment	Physical/Chemical Treatment	Soil Washing
			Solvent Extraction
			Chemical Oxidation
		Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clays)
			Vitrification
		Biological Treatment	Aerobic Bioremediation, Slurry-Phase (Bioslurry Reactors, Rotating Biological Contactors, Lagoons)
			Aerobic Bioremediation, Solid-Phase (Prepared Beds, Heap Piles, Composting, Landfarming, Wetlands)
		Thermal Treatment	Incineration (Rotary Kiln, Infrared Incineration, Circulating Fluidized Beds)
			Pyrolysis
			Thermal Desorption

TABLE 4-4 (Continued)

SET OF POTENTIAL TECHNOLOGIES AND PROCESS OPTIONS THAT PASSED THE PRELIMINARY SCREENING OPERABLE UNIT NO. 12 (SITE 3) FEASIBILITY STUDY CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Soil (Continued)	In Situ Treatment	Solidification/ Stabilization	Solidification/Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsulation, or Organophilic Clay)
			Vitrification
		Biological Treatment	Aerobic Bioremediation
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Ordinances	Aquifer Use Restrictions
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Containment/ Collection Actions	Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Ex Situ Treatment	Physical/Chemical Treatment	Carbon Adsorption
			Chemical Dechlorination
			Chemical Oxidation
			Membrane Separation (Reverse Osmosis, Electrodialysis)
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
			Oil/Water Separation
		Biological Treatment	Aerobic Bioremediation (Aerated Lagoon, Activated Sludge, Trickling Filter, Rotating Biological Contactor)
		Off Site Treatment	Site 82 or HPIA Treatment Systems
	In Situ Treatment	Biological Treatment	Aerobic Biodegradation
	Discharge Actions	Off Site Discharge	POTW
			Pipeline to Stream
			Sewage Treatment Plant
			Deep Well Injection

TABLE 4-5

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
No Action	No Action	Not Applicable	• Not applicable	• Easily implemented	• No cost	Retained as per the requirements of the NCP
Institutional Controls	Access Restrictions	Fencing	• Will effectively reduce site access	• Easily implemented	• Low capital	Retained because of its effectiveness and low cost
	Land Use Controls	Base Master Plan	• Will effectively restrict land use at the site while the Base is open • Effectiveness is dependent on continued future implementation	• Easily implemented	• Negligible cost	Retained because of its effectiveness and negligible cost
	Legal Restrictions	Deed Restrictions	• Will effectively restrict future use of the site if the Base were to close • Effectiveness is dependent on continued future implementation	• Easily implemented • Legal requirements	• Negligible cost	Retained because of its effectiveness and negligible cost
	Monitoring	Monitoring	• Will effectively detect increases in contaminant levels so that exposure can be avoided • Will monitor the effectiveness of remedial action plans implemented at the site	• Easily implemented	• Low capital • Low O&M	Retained because of its effectiveness and low cost

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Removal Actions	Excavation	Excavation	• Conventional and well-demonstrated • Becomes less effective as the amount of soil that needs to be excavated increases	• Contaminated soil excavated below the water table will require dewatering • Deep excavations may require support structures • Generation of fugitive emissions may be a problem during excavation	• Low to moderate capital • No O&M	Retained because it is a conventional, well-demonstrated soil removal method
Off Site Disposal	Landfill	Hazardous Waste Landfill	• Effective disposal method for hazardous material • The closest hazardous waste facility is located in Pinewood, South Carolina; this distance may increase transportation costs • Transportation of the soil through populated areas may affect community acceptability	• Soil must be transported in adequate receptacles that will fully contain the contaminated material	• Moderate capital • No O&M	Retained because of its moderate cost and effectiveness
		Solid Waste Landfill	• Effective disposal method for non-hazardous material • The soil will have to be treated before it will be accepted at a solid waste landfill	• Easily implemented	• Low capital • No O&M	Due to its low cost, retained as a disposal option if the soil is non-hazardous

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Off Site Disposal (Continued)	Soil Recycling	Soil Recycling (Asphalt Incorporation, Cement Production, or Brick Manufacturing)	• Effective disposal method for both hazardous and non-hazardous material • Beneficial reuse of soil rather than disposal at a landfill • Finished product may not provide complete stabilization of the semivolatile organics	• Soil must be transported in adequate receptacles that will fully contain the contaminated material • TPH contaminated soil from the Base has been recycled in a brick manufacturing process in Sanfred, N.C. • Compared to TPH contaminated soil, there may be fewer recycling facilities that will accept creosote-contaminated soil	• Moderate capital • No O&M	Eliminated due to its questionable effectiveness for semivolatile organics
Ex Situ Treatment	Physical/ Chemical Treatment	Soil Washing	• Contaminant separation/ concentration technology (rather than a contaminant destruction technology) • Target contaminant group is semivolatile organics • Best-suited for sandy soil with low organic matter and low clay content • Contaminant removal is dependent on washing fluid and additives used • Additives that improve washing may complicate washwater treatment/disposal later • Widely demonstrated in Europe, less demonstrated in the U.S.	• Generates four residual streams (treated soil or sludge, washwater, contaminated soil fines, and air emissions) that require further treatment and/or disposal • Mobile units are available • Requires excavation and handling of the contaminated soil • Requires treatability testing	• Moderate capital • Moderate O&M	Eliminated because contaminant destruction technologies can effectively handle the volume of contaminated material; separating/ concentrating the contaminants is not necessary and will generate residual waste streams that must be treated and/or disposed

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Solvent Extraction	• Contaminant separation/concentration technology (rather than a contaminant destruction technology) • Slightly more effective for PAHs than soil washing with a water-based solution • Best-suited for sandy soil with low organic matter and low clay content • The toxicity of the solvent must be considered because it may complicate wash fluid treatment/disposal later • Air emissions are typically not generated	• Generates three residual streams (concentrated contaminants, treated soil or sludge, and separated solvent) that require further treatment and/or disposal • Mobile units are available • Requires excavation and handling of the contaminated soil • Requires treatability testing	• Moderate capital • Moderate O&M • Relatively more expensive than soil washing	Eliminated because contaminant destruction technologies can effectively handle the volume of contaminated material; separating/ concentrating the contaminants is not necessary and will generate residual waste streams that must be treated and/or disposed

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Chemical Oxidation	• Effectively treats liquids, slurried soil, and sludge containing oxidizable contaminants; soil from Site 3 will have to be slurried • Contaminant destruction technology • Incomplete oxidation or formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents used • Chemical oxidants are non-selective; they may oxidize other compounds prior to the contaminants of concern (increasing treatment time) • Conventional, well-demonstrated technology for disinfecting drinking water and wastewater; not well demonstrated for environmental remediation • Not cost-effective for high contaminant concentrations because of the large amounts of oxidizing agents required • UV-enhanced oxidation does not work well for turbid water and slurries due to reduced light transmission	• The soil must be slurried prior to treatment which may be difficult to accomplish • Treatability tests should be conducted • Extensive air pollution control is usually not required • Employs standard equipment that is readily available; mobile units are available • Requires excavation and handling of contaminated soil	• Moderate to high capital; high capital for ozonation because an ozone generator and an ozone decomposition unit are required • Moderate O&M	Eliminated because of the non-selective nature of chemical oxidants (which may indefinitely increase the treatment time) and the expense associated with oxidizing agents

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Solidification/ Stabilization	Solidification/ Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsul a-tion, or Organophilic Clays)	• Most effective for inorganics • Using typical S/S methods, organic compounds can retard or prevent the setting of the matrix, hinder bonding reactions and matrix strength, and volatilize into the atmosphere creating the need for off-gas control • S/S methods employing organophilic clays, organic polymers, and asphalts may be effective for organics, but these methods are still in the experimental stage • Contaminant immobilization technology (rather than a contaminant destruction technology) • S/S may increase the matrix volume, possibly up to double the orginal volume • The solidified matrix will facilitate handling of the waste for treatment/disposal • Most effective for sandy soil	• Treatability study may be required • Well-demonstrated technology for inorganics; experimental technology for organics • Requires excavation and handling of the contaminated soil	• Low capital • Low O&M	Eliminated because it is only an experimental technology for organics

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Solidification/ Stabilization (Continued)	Vitrification	• The vitrified matrix will facilitate handling of the waste for treatment/disposal • The process may yield saleable end products in the form of glass and glass ceramics • Emerging technology	• Relatively high energy process which increases O&M costs • Relatively complex process which makes it labor-intensive and increases costs • Requires off-gas control; volatilized contaminants will require further treatment • Requires excavation and handling of contaminated material	• High capital • Moderate to High O&M	Eliminated because of its high cost

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Biological Treatment	Aerobic Bioremediation, Slurry-Phase (Bioslurry Reactors, Rotating Biological Contactors, Lagoons)	• Contaminant destruction technology • More effective for PAHs with lower molecular weights and fewer rings (2-3); e.g., naphthalene and benzo(a)anthracene • Contaminants with low water solubility are more difficult to degrade • Compounds may degrade into intermediate compounds that are more toxic or more mobile • Contaminated soil must be slurried • The presence of heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts can inhibit microbial metabolism • Compared to in situ bioremediation, treats contaminants more quickly, and does not contribute to the contamination of underlying groundwater • Compared to in situ bioremediation, offers more system control • More suitable than in situ bioremediation for low permeability soil because there is less dependence on soil characteristics (due to amendments and mixing processes)	• Treatability study is required • Pretreatment may be required for heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts • Slurry requires dewatering after treatment • If treated solids contain heavy metals, solidification/stabilization may be necessary • Must dispose of wastewater and possibly treat process off-gases • Mobile units are available • Requires excavation and handling of contaminated materials	• Moderate capital • Moderate O&M	Eliminated because it is more expensive and more difficult to implement than solid-phase bioremediation

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Biological Treatment (Continued)	Aerobic Bioremediation, Solid-Phase (Prepared Beds, Heap Piles, Composting, Landfarming, Wetlands)	• Contaminant destruction technology • More effective for PAHs with lower molecular weights and fewer rings (2-3); e.g., naphthalene and benzo(a)anthracene • Contaminants with low water solubility are more difficult to degrade • Compounds may degrade into intermediate compounds that are more toxic or more mobile • The presence of heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts can inhibit microbial metabolism • Compared to in situ bioremediation, treats contaminants more quickly, and does not contribute to the contamination of underlying groundwater • Compared to in situ bioremediation, offers more system control • More suitable than in situ bioremediation for low permeability soil because there is less dependence on soil characteristics (due to amendments and mixing processes) • Compared to in situ and slurry-phase treatment, solid-phase treatment is more widely used	• May require a large amount of space • Treatability study is required • Pretreatment may be required for heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts • Employs standard, conventional equipment; simple farming and irrigation techniques can optimize pH and nutrient control (unlike slurry-phase bioremediation technologies) • Utilizes a more simple treatment process compared to slurry-phase treatment • May require a leachate collection system • Drainage from the soil pile can be recycled • If treated solids contain heavy metals, solidification/stabilization may be necessary • May require an off-gas collection system • Must dispose of wastewater and possibly treat process off-gases • Addition of bulking agents (which improve texture, workability, and aeration) will increase the soil volume • Particulate matter may cause a dust generation problem	• Low capital • Moderate O&M	Retained because it is less expensive and more easily implemented compared to slurry-phase bioremediation technologies

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Thermal Treatment	Incineration	• Capable of treating organics in soil to stringent cleanup levels • Effective for a wide range of organics and inorganics • Contaminant destruction technology • Fully proven in commercial use • High moisture content and a high heating value reduce the incinerator's capacity • Heavy metals produce a residual ash that may require further treatment	• Air pollution control system (for off-gases) is required • Sandy soil is easy to feed to the incineration units • Dewatering of the soil, or mixing the soil with a low BTU soil, may be required prior to treatment • Requires excavation and handling of contaminated material	• Moderate to high capital • Low O&M	Retained because it is highly effective for a wide variety of organic contaminants
		Pyrolysis	• Capable of treating organics in soil to stringent cleanup levels • Contaminant destruction technology • Produces fewer air pollutants, allows more control, permits higher throughput, and operates at lower temperatures than incineration • Emerging technology that has not been widely demonstrated • High moisture content and a high heating value increase the treatment cycles required • Heavy metals in residual solids and fly ash will require further treatment	• Requires a treatability study • Air pollution control system (for volatilized contaminants) is required • Soil should be dryed to achieve a moisture content less than 1% (the soil at Site 3 has a moisture content of 12.8%) • Requires excavation and handling of contaminated material	• Moderate capital • Low O&M	Eliminated because it is not well demonstrated compared to incineration

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Thermal Treatment (Continued)	Thermal Desorption	• Contaminant separation/concentration technology (rather than a contaminant destruction technology) • Applicable to a wide range of volatile and semivolatile organics, including furans • High temperature TD is effective for wood-treating wastes; low temperature TD is less effective • Not effective for high moisture content	• Process may create up to seven residual streams (treated media, oversized contaminated rejects, condensed contaminants, water, particulates, clean off-gas, and spent carbon) that may require further treatment • Treatability test required • Requires excavation and handling of contamiated material	• Moderate capital • Moderate O&M	Eliminated because it is less easily implemented than conventional incineration

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
In Situ Treatment	Solidification/ Stabilization	Solidification/ Stabilization (Cement-Based, Silicate-Based, Thermoplastic, Microencapsula-tion, or Organophilic Clay)	• Contaminant immobilization technology (rather than a contaminant destruction technology) • Using typical S/S methods, organic compounds can retard or prevent the setting of the matrix, hinder bonding reactions and matrix strength, and volatilize into the atmosphere creating the need for off-gas control • S/S methods employing organophilic clays, organic polymers, and asphalts may be effective for organics, but these methods are still in the experimental stage • S/S may increase the matrix volume, possibly up to double the orginal volume, which may affect the local terrain • Future use of the site may "weather" the matrix and weaken the contaminants' immobility • Effective for sandy soil	• Treatability study is required • Subsurface obstructions (boulders, debris) and heterogenities may inhibit the mixing process • Limited control over the effectiveness of mixing processes • Off-gas control will be required during mixing • When the S/S process is complete, leaching and durability tests will be required; conducting these tests at subsurface depths will be difficult	• Moderate capital • Moderate O&M	Eliminated because it is only an experimental technology for organics, and because of the difficulties associated with implementation

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
In Situ Treatment (Continued)	Solidification/ Stabilization (Continued)	Vitrification	• Heating of the soil may cause subsurface migration of contaminants into clean areas • Not a widely demonstrated technology • Future use of the site will be limited by the engineering characteristics of the vitrified material	• Requires a hood above the treatment area to collect off-gases • The process fuel is electricity which is the most expensive fuel for glass production • Subsurface heterogenities may limit the achievable process depth • Organic material may cause the molten glass to erupt, showering large areas with molten, semi-molten, and untreated material • High water table will impact implementability; site will need to be dewatered	• High capital • High O&M	Eliminated because it may spread contaminants into clean areas, it is difficult to implement, and it is costly

TABLE 4-5 (Continued)

SUMMARY OF SOIL PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
In Situ Treatment (Continued)	Biological Treatment	Aerobic Bioremediation	• Contaminant destruciton technology • More effective for PAHs with lower molecular weights and fewer rings (2-3); e.g., naphthalene and benzo(a)anthracene • Contaminants with low water solubility are more difficult to degrade • Compounds may degrade into intermediate compounds that are more toxic or more mobile • Will not effectively destroy concentrated masses of NAPLs • Highly dependent on soil characteristics; cleanup goals may not be attained if the soil matrix prohibits contaminant-microorganism contact • Less certainty about treatment results because of subsurface variability and difficulties in monitoring • Circulating water-based solutions through the soil may spread contamination • Minimizes volatilized contaminants	• Requires a treatability study • Requires more treatment time than ex situ bioremediation • Less system control compared to ex situ bioremediation • Microbes may colonize and clog injection wells	• Low to moderate capital • Moderate to high O&M	Eliminated because it will have limited effectiveness compared to ex situ bioremediation, also there is much less control over the results of the treatment

TABLE 4-6

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
No Action	No Action	Not Applicable	• Not applicable	• Easily implemented	• No cost	Retained as per the requirements of the NCP
Institutional Controls	Ordinances	Aquifer Use Restrictions	• Will effectivly prevent future exposure to groundwater • Effectiveness dependent on continued future implementation	• Easily implemented	• Negligible cost	Retained because of its effectiveness and negligible cost
	Access Restrictions	Deed Restrictions	• Will effectively prevent future exposure to groundwater • Effectiveness dependent on continued future implementation	• Easily implemented • Legal requirements	• Negligible cost	Retained because of its effectiveness and negligible cost
	Monitoring	Monitoring	• Will effectively detect increases in contaminant levels so that exposure can be avoided • Will monitor the effectiveness of remedial action plans that may be implemented at the site	• Easily implemented	• Low capital • Low O&M	Retained because of its effectiveness and low cost

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Containment/ Collection Actions	Extraction	Extraction Wells	• Effective for collecting and/or containing a contaminated groundwater plume • Inorganics may precipitate and clog well screens; this necessitates frequent maintenance and equipment replacement • Conventional, widely demonstrated technology	• Easily implemented • Uses standard equipment that is readily available	• Moderate capital • Moderate O&M	Retained because it is a conventional technology and more easily implemented than an interceptor trench
	Subsurface Drains	Interceptor Trenches	• Effective for collecting and/or containing a contaminated groundwater plume • More effective for shallow groundwater plumes • Slower recovery than extraction wells • Potential exposures during installation	• Requires extensive excavation trenching • Requires more surface area than extraction wells • There is no continuous confining layer under the site for the trench to adjoin to • Requires an experienced specialty contractor • Equipment readily available	• High capital • Moderate O&M	Eliminated because trenches require more surface area and are less cost effective than extraction wells

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment	Physical/ Chemical Treatment	Carbon Adsorption	• Effective for a wide range of organic compounds, including PAHs, other polar organic compounds, PCP, non-halogenated aromatics, dioxins, and furans • Loses efficiency for compounds with low molecular weight • Loses efficiency for compounds with high polarity • Loses efficiency for compounds that are water-soluble • Contaminant transfer technology (rather than a contaminant destruction technology) • Suspended solids, inorganics, and oil and grease can foul the system • Commercially proven and widely used technology • Less cost effective if used as the primary treatment on a wastestream with high contaminant concentrations (greater than 1 mg/L)	• Readily available, conventional technology • Spent carbon must be properly regenerated or disposed • Pretreatment may be required to reduce or remove suspended solids, oil and grease, and unstable chemical compounds • For waste with mixed contaminants, bench tests should be conducted to estimate carbon usage • A carbon adsorption unit is located at the HPIA treatment plant (HPIA operable unit) • Requires groundwater extraction	• Low to moderate capital • Moderate O&M (O&M is dependent on loading rates and carbon life)	Retained because of its commercial availability and performance record, and its relatively moderate cost

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Chemical Dechlorination	• Dibenzofuran, 2-methylphenol, and 2,4-dimethylphenol are the only site contaminants that dechlorination will effectively treat (effective for PCB/dioxin/furan and halogenated phenol/creosol groups); the other non-halogenated contaminants will not be treated • Contaminant destruction technology • Oil and grease and suspended solids may interfere with the efficiency of the system • Most research has been conducted on PCBs • Not cost-effective for high contaminant concentrations because of the large amounts of reagents required	• The toxicity of the reagents must be considered because they may necessitate further treatment • Further treatment will be required for the nonhalogenated contaminants • Employs standard equipment that is readily available; mobile units are available • Requires groundwater extraction	• Moderate capital • Moderate O&M	Eliminated because the technology will not be effective for the non-halogenated semivolatile organic contaminants; they will require further treatment

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Physical/ Chemcial Treatment (Continued)	Chemical Oxidation	• Effectively treats liquids containing oxidizable contaminants • Contaminant destruction technology • Incomplete oxidation or formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents used • Chemical oxidants are non-selective; they may oxidize other compounds prior to the contaminants of concern (increasing treatment time) • Conventional, well-demonstrated technology for disinfecting drinking water and wastewater; not well demonstrated for environmental remediation • Not cost-effective for high contaminant concentrations because of the large amounts of oxidizing agents required • UV-enhanced oxidation does not work well for turbid water and slurries due to reduced light transmission	• Treatability tests should be conducted • Extensive air pollution control is usually not required, although the process may volatilize contaminants • Employs standard equipment that is readily available; mobile units are available • Requires groundwater extraction	• Moderate to high capital; high capital for ozonation because an ozone generator and an ozone decomposition unit are required • Moderate O&M	Eliminated because of the non-selective nature of chemical oxidants (which may indefinitely increase the treatment time) and the expense associated with oxidizing agents

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Physical/ Chemcial Treatment (Continued)	Membrane Separation (Reverse Osmosis, Electrodialysis)	• Effective for PCP, heterocyclics, simple nonhalongenated aromatics, PAHs, and other polar organic compounds • Contaminant concentration/ separation technology (rather than a contaminant destruction technology) • Inability to handle fluctuations in organic concentrations	• Separated contaminants will require further treatment • Requires groundwater extraction	• High capital • Moderate O&M	Eliminated because of its high cost compared to other contaminant separation/ concentration technologies and its inability to handle fluctuations in contaminant concentrations
		Neutralization	• Can be used in a treatment train for pH adjustment • Many treatment technologies for organics require neutralization as pretreatment	• Widely used and well demonstrated • Simple and readily available equipment/materials	• Low capital • Low to moderate O&M	Retained because it may be necessary as pretreatment
		Precipitation	• Effective, reliable, permanent, and conventional technology for inorganics removal • Typically used for removal of heavy metals • Followed by solids-separation methods	• Widely used and well demonstrated • Equipment is basic and easily designed • Compact, single units that are deliverable to the site • Generates sludge which can be voluminous, difficult to dewater, and may require treatment	• Low capital • Moderate O&M	Retained because it may be necessary as pretreatment

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Filtration	• Conventional, proven method of removing suspended solids from wastewater • Does not remove contaminants other than suspended solids	• Equipment is relatively simple to install and no chemicals are required • Package units available • Pretreatment for oil and grease required • Generates a sludge which requires proper handling	• Low capital • Moderate O&M	Retained because it may be necessary as pretreatment
		Flocculation	• Conventional, proven technology • Applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to other types of treatment • Performance depends on the variability of the composition of the waste being treated	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	• Low capital • Moderate O&M	Retained because it may be necessary as pretreatment

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Sedimentation	• Conventional, proven technology • Effective for removing suspended solids and precipitated materials from wastewater • Performance depends on density and particle size of the solids, effective charge on the suspended particles, types of chemicals used in pretreatment, surface loading, upflow rate, and reinjection time • Feasible for large volumes of water to be treated	• Effluent streams include the effluent water, scum, and settled solids	• Low capital • Moderate O&M	Retained because it may be necessary as pretreatment
		Oil/Water Separation	• Effective as oil and grease pretreatment for an organics removal technology	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	• Low capital • Low O&M	Retained because it may be necessary as pretreatment

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Ex Situ Treatment (Continued)	Biological Treatment	Aerobic Bioremediation (Aerated Lagoon, Activated Sludge, Trickling Filter, Rotating Biological Contactor)	• Contaminant destruction technology • More effective for PAHs with lower molecular weights and fewer rings (2-3); e.g., naphthalene, phenanthrene, benzo(a)anthracene • Contaminants with low water solubility are more difficult to degrade • Compounds may degrade into intermediate compounds that are more toxic or more mobile • The presence of heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts can inhibit microbial metabolism • Technology is still under development so it is not widely demonstrated • Very slow process • Effectiveness is susceptible to variation in waste stream characteristics and environmental parameters • Rotating Biological Contactors are susceptible to excessive biomass growth which may damage the equipment	• Low contaminant concentrations may make operation difficult • Treatability study is required • Pretreatment may be required for for heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts • Must dispose of wastewater and possibly treat process off-gases • Methane gas is produced and must be utilized or disposed • Mobile units are available • Requires groundwater extraction	• Moderate capital • Moderate O&M	Eliminated because it is a very slow process for groundwater remediation and it is not widely demonstrated

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Ex Situ Treatment (Continued)	Off Site Treatment	Site 82 or HPIA Treatment Systems	• The systems contain air stripping and liquid-phase carbon adsorption units; combined, these treatment units will effectively treat the volatile organic and semivolatile organic contaminants of concern • site 82 is located approximately 3/4 of a mile from Site 3, and the HPIA operable unit is located approximately 3 miles from Site 3; these distances may reduce the effectiveness of this treatment option	• The HPIA system was designed with enough capacity to accept contaminated groundwater from other operable units at the Base • Groundwater transportation via pipeline may not be feasible due to the distance to the system and utilities • Transportation via tanker trucks may not be cost effective (it will be labor-intensive due to the quantity of water that must be transported)	• Moderate capital • Moderate to high O&M	Eliminated because of the difficulties associated with transporting contaminated groundwater to the treatment system

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
In Situ Treatment	Biological Treatment	Aerobic Biodegradation	• Contaminant destruction technology • More effective for PAHs with lower molecular weights and fewer rings (2-3), e.g., naphthalene, phenanthrene, and benzo(a)anthracene • Contaminants with low water solubility are more difficult to degrade • Compounds may degrade into intermediate compounds that are more toxic or more mobile • The presence of heavy metals, highly chlorinated organics, pesticides, herbicides, and inorganic salts can inhibit microbial metabolism • Technology is still under development so it is not widely demonstrated • Very slow process • Will not effectively destroy concentrated masses of NAPLs • Highly dependent on soil characteristics; cleanup goals may not be attained if the soil matrix prohibits contaminant-microorganism contact	• Requires a treatability study • Very little control over the system compared to ex situ technologies • Microbes may colonize and clog injection wells • Injection of substrate and nutrients into groundwater may require a permit • Equipment readily available	• Moderate capital • Low to moderate O&M	Eliminated because it has not been widely demonstrated and it will be less effective than ex situ treatment technologie due to subsurface variability and heterogenity

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
In Situ Treatment (Continued)	Biological Treatment (Continued)	Aerobic Biodegradation (Contineud)	• Less certainty about treatment results because of subsurface variability and difficulties in monitoring at depth			
Discharge Actions	Off Site Discharge	POTW	• Effective and reliable discharge method	• Discharge permits required • Acceptance by a local POTW may be difficult to obtain • The water must be transported by pipeline or tanker trucks	• High capital • Moderate O&M	Eliminated because of the difficulties associated with transporting the water to the POTW
		Pipeline to Stream	• Effective and reliable discharge method • Wallace Creek will have the capacity to handle discharge from a pump and treat system	• Discharge permits required • Distance toWallace Creek from the site (approximately 3/4 of a mile) may make this option difficult to implement; groundwater transportation via pipeline may not be feasible due to the distance to the system and utilities • Groundwater transportation via tanker truck may not be cost effective (it will be labor-intensive due to the quantity of water that must be transported)	• Moderate to high capital • Low O&M	Eliminated because of the distance to Wallace Creek

TABLE 4-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Discharge Actions (Continued)	Off Site Discharge (Continued)	Sewage Treatment Plant	• Effective and reliable discharge method • Capacity of the STP may not be able to accept the flow • Eight STPs are located on the Base	• Discharge permit may need to be modified • It may be difficult to gain acceptance of the treated groundwater • Distance to the nearest STP may make this option difficult to implement; groundwater transportation via pipeline may not be feasible due to the distance to the system and utilities • Groundwater transportation via tanker truck may not be cost effective (it will be labor-intensive due to the quantity of water that must be transported)	• High capital • Moderate O&M	Retained because it is the nearest discharge option
		Deep Well Injection	• Injection wells' effectiveness is highly dependent on site geology/ hydrogeology • Wells may clog due to inorganics precipitation over time • Treatment must achieve high remediation levels since the Castle Hayne aquifer is used as a potable water source on Base	• Discharge permit required • Injection wells must be installed	• Moderate capital • Moderate O&M	Eliminated because the Castle Hayne aquifer is used as a potable water source on Base so its high quality must be protected

TABLE 4-7

FINAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Soil	No Action	None	Not Applicable
	Institutional Controls	Access Restrictions	Fencing
		Land Use Controls	Base Master Plan
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Removal Actions	Excavation	Excavation
	Off Site Disposal	Landfill	Hazardous Waste Landfill
			Solid Waste Landfill
	Ex Situ Treatment	Biological Treatment	Aerobic Bioremediation, Solid-Phase (Prepared Beds, Heap Piles, Composting, Landfarming*, Wetlands)
		Thermal Treatment	Incineration (Rotary Kiln, Infrared Incineration, Circulating Fluidized Beds)
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Ordinances	Aquifer Use Restrictions
		Legal Restrictions	Deed Restrictions
		Monitoring	Monitoring
	Containment/ Collection Actions	Extraction	Extraction Wells
	Ex Situ Treatment	Physical/Chemical Treatment	Carbon Adsorption
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
			Oil/Water Separation
	Discharge Actions	Off Site Discharge	Sewage Treatment Plant

Note:

* - Landfarming retained as the remedial approach for solid-phase aerobic bioremediation.

5.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

In this section, potentially applicable remedial technologies and process options will be combined to form remedial action alternatives (RAAs) for soil and groundwater at Site 3. Section 5.1 presents the development of soil alternatives, and Section 5.2 presents the development of groundwater alternatives. Detailed evaluations of these soil and groundwater alternatives (with respect to nine USEPA evaluation criteria) will be presented in Sections 6.0 and 7.0, respectively.

In some cases, this section of the FS may contain a preliminary alternative screening, in which the alternatives are evaluated with respect to three criteria - effectiveness, implementability, and cost. The objective of this screening, which is an optional step in the FS process, is to preliminarily evaluate the alternatives and retain only the most promising ones for the detailed evaluation. Consequently, this screening is usually conducted when the number of RAAs is too large to be manageable. In the case of Site 3, the number of RAAs will be amenable to proceeding directly with detailed evaluations which are presented in Sections 6.0 and 7.0.

Note that the RAAs developed within this section are only meant to include conceptual system designs. The conceptual designs were based on information available to date and will be adequate for developing FS cost estimates. However, they are subject to change during the design phase based on new and/or more accurate information that may become available.

5.1 Soil Alternatives

Five alternatives were developed for soil: No Action, Institutional Controls, Source Removal and Off Site Landfill Disposal, Source Removal and Off Site Incineration, and Source Removal and Biological Treatment.

5.1.1 Soil RAA No. 1: No Action

Under Soil RAA No. 1, no remedial actions will be implemented to reduce the toxicity, mobility, or volume of soil contaminants at Site 3. The soil AOC identified in Figure 3-5 will remain in place under its current conditions. The no action RAA is required by the NCP to provide a baseline for comparison with other remedial action alternatives that provide a greater level of response.

Since contaminants will remain in the subsurface soil under this alternative, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

5.1.2 Soil RAA No. 2: Institutional Controls

Under Soil RAA No. 2, no remedial actions will be implemented to reduce the toxicity, mobility, or volume of soil contaminants at Site 3. However, institutional controls, including land use controls and deed restrictions, will be implemented to limit the future land use at the site so that exposure to subsurface soil contaminants can be avoided. Land use controls, implemented via the Base Master Plan, will restrict land use at the site while the Base is in operation, and deed restrictions will restrict land use at the site if the Base were to close.

Since contaminants will remain in the subsurface soil under this alternative, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

5.1.3 Soil RAA No. 3: Source Removal and Off Site Landfill Disposal

Under Soil RAA No. 3, the subsurface soil AOC (see Figure 3-5), which is considered the source of groundwater contamination at Site 3, will be excavated to a depth of 9 feet bgs. Confirmatory soil samples will be collected from the excavation area to ensure that all contaminated soil above the water table has been removed. Based on the results of this confirmatory sampling, further excavation may be required. Because creosote is a listed hazardous waste, the excavated soil will be transported for off-site disposal at a RCRA-permitted Subtitle C landfill facility. The nearest permitted facility is located in Pinewood, South Carolina. Finally, the excavation area will be backfilled with clean fill from an on Base borrow pit.

5.1.4 Soil RAA No. 4: Source Removal and Off Site Incineration

Under Soil RAA No. 4, the subsurface soil AOC (see Figure 3-5), which is considered the source of groundwater contamination at Site 3, will be excavated to a depth of 9 feet bgs. Confirmatory soil samples will be collected from the excavation area to ensure that all contaminated soil above the water table has been removed. Based on the results of this confirmatory sampling, further excavation may be required. The excavated soil (approximately 2,000 cubic yards) will be sent off site for thermal treatment at a permitted incineration facility. Depending on the incineration facility, a soil characterization sample or a trial burn sample may be required before the soil will be accepted. Incineration employs combustion processes under controlled conditions to convert waste materials into inert mineral residues and gases. Incinerators typically operate at 900 to 1,200 degrees Celsius and are applicable to a wide variety of organics and inorganics (USEPA, 1992). Destruction and removal efficiencies exceeding 99.99 percent have been achieved for hazardous waste (USEPA, 1994). Finally, the excavation area will be backfilled with clean fill from an on Base borrow pit.

5.1.5 Soil RAA No. 5: Source Removal and Biological Treatment

Under Soil RAA No. 5, the subsurface soil AOC (see Figure 3-5), which is considered the source of groundwater contamination at Site 3, will be excavated to a depth of 9 feet bgs. Confirmatory soil samples will be collected from the excavation area to ensure that all contaminated soil above the water table has been removed. Based on the results of this confirmatory sampling, further excavation may be required. The excavated soil (approximately 2,000 cubic yards) will be transported to Lot 203 at MCB, Camp Lejeune where it will undergo biological treatment in the existing biocell landfarm unit.

Treatment at the Lot 203 biocell was selected as the preferred biological treatment method for Soil RAA No. 5 based on a preliminary evaluation of four different treatment options. These treatment options included: 1) treatment of 2,000 cubic yards at the Lot 203 biocell; 2) treatment of 1,340 cubic yards (from 3 to 9 feet bgs) at the lot 203 biocell, and landfill disposal of 660 cubic yards (from 0 to 3 feet bgs); 3) treatment of 2,000 cubic yards in a landfarm unit constructed at Site 3; and 4) treatment of 2,000 cubic yards using biopiles (i.e., heap pile bioremediation) constructed at Site 3. All four options were determined to be equally effective and implementable so the decision to focus on treatment at the Lot 203 biocell was based on cost. Tables C-3 (A), C-3 (B), C-3(C), and C-3(D) in Appendix C present cost estimates for the four options. As shown, treatment of 2,000 cubic yards at the Lot 203 biocell appears to be the least expensive option.

Before biological treatment begins, a pilot-scale treatability study will be conducted to: 1) assess the technical implementability and effectiveness of bioremediation as a means of remediating the contaminated soil, 2) assess the effectiveness of using the existing Lot 203 biocell for full-scale treatment, and 3) obtain preliminary design data for full-scale treatment (e.g., nutrient, moisture, pH, oxygen, and temperature requirements). In addition, the treatability study will indicate the approximate duration of time in which the biological treatment will be complete. If the study indicates that biological treatment or treatment at the Lot 203 biocell will not be effective, an alternative remedial action may be considered.

The Lot 203 biocell, a landfarm unit with a 1,000 cubic yard capacity, is located approximately 1-1/2 miles south of Site 3 along Holcomb Boulevard. The biocell was constructed to treat TPH-contaminated soil from another site at MCB, Camp Lejeune. Thus, permit modifications will be required in order to treat the PAH-contaminated soil from Site 3. Figure 5-1 presents a plan view of the biocell, and Figure 5-2 presents a cross-section view. As shown, the cell is constructed on a one percent slope to facilitate leachate collection and surface water runoff. The contaminated soil is placed in a 12 inch lift underlain by a 24 inch lift of coarse sand, a non-woven geotextile liner, and a 30 mil high density polyethylene (HDPE) geomembrane. In addition, the entire biocell is surrounded by a six foot wide earthen berm. A leachate recovery line runs through the center of the cell and connects with a 1,500 gallon leachate collection sump. Leachate collected in the sump is resprayed onto the contaminated soil.

Because the biocell has a 1,000 cubic yard capacity, treatment of the contaminated soil will be conducted in three batches. (The 2,000 cubic yard AOC is expected to increase slightly in volume after excavation.) Contaminated soil that is not undergoing treatment will be stored within a stockpile area. The treatment time for each batch is expected to be three to six months. However, a more accurate treatment duration will be estimated after the treatability study has been conducted. To develop a conservative cost estimate (see Appendix C), five years of treatment time, with three treatment batches, have been assumed.

Maintenance of the biocell will most likely include monthly soil sampling for total organic carbon, nutrients (ammonium-nitrogen and phosphate-phosphorous), pH, moisture content, and bacterial population density, and bimonthly mixing/tilling of the contaminated soil for aeration. Initially, the contaminated soil will be mixed with dry, granular fertilizer, but periodic nutrient/fertilizer addition may also be required. Periodically, water collected in the sump will be applied to the contaminated soil for moisture control as needed. Maintenance requirements will be determined more definitely following the pilot-scale treatability study.

Finally, the excavation area will be backfilled with clean fill from an on Base borrow pit. The treated soil will be reused on Base as fill material.

If contaminated soil remains indefinitely within a stockpile area, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

5.2 Groundwater Alternatives

Three alternatives were developed for groundwater: No Action, Institutional Controls and Monitoring, and Extraction and On Site Carbon Adsorption Treatment.

5.2.1 Groundwater RAA No. 1: No Action

Under Groundwater RAA No. 1, no additional remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in the groundwater. The groundwater AOCs identified in Figure 3-5 will remain in place under their current conditions. The no action alternative is required by the NCP to provide a baseline for comparison with other remedial action alternatives that provide a greater level of response.

Since contaminants will remain in the groundwater, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative no less often than once every five years.

5.2.2 Groundwater RAA No. 2: Institutional Controls and Monitoring

Under Groundwater RAA No. 2, no remedial actions will be performed to reduce the toxicity, mobility, or volume of groundwater contaminants at Site 3. However, institutional controls, including aquifer use and deed restrictions, and a long-term groundwater monitoring program, will be implemented.

The groundwater monitoring program will include periodic sampling and analysis at wells 03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW07, 03-MW08, and 03-MW11IW. These are the wells where VOCs and SVOCs were detected in excess of the remediation levels. (For cost estimating purposes, 5 years of quarterly sampling followed by 25 years of semiannual sampling will be assumed.) Additional wells may be added to this monitoring program if necessary. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, and TAL inorganics to monitor contaminant concentrations in the shallow and Castle Hayne aquifers over time.

In addition to groundwater monitoring, the Base Master Plan will be modified to include aquifer use restrictions which will prohibit future use of the shallow and Castle Hayne aquifers, in the immediate vicinity of Site 3, as potable water sources. Also, deed restrictions will be implemented to limit future land use at the site, including placement of new wells.

Since contaminants will remain in the groundwater, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

5.2.3 Groundwater RAA No. 3: Extraction and On Site Carbon Adsorption Treatment

Under Groundwater RAA No. 3, extraction wells will be installed to remove contaminated groundwater from the shallow aquifer and send it to an on site treatment plant containing a liquid-phase carbon adsorption unit. According to the radius of influence calculations provided in Appendix B, an extraction well in the shallow aquifer at Site 3 may be able to pump at 5 gpm with a 223 foot radius of influence. Consequently, the conceptual system layout for Groundwater RAA No. 3, which is depicted in Figure 5-3, will include two shallow extraction wells (less than 20 feet deep). One extraction well will be located near existing well 03-MW02, and one extraction well will be located near existing well 03-MW06. The pumping rates of the wells will allow their cones of influence to intercept the groundwater AOCs identified in Figure 3-5.

Once extracted, the contaminated groundwater will be transported via pipeline to an on site treatment plant located between existing wells 03-MW02 and 03-MW06 (Figure 5-3). At the treatment plant, the groundwater will undergo pretreatment via oil/water separation, neutralization, precipitation, filtration, flocculation, and sedimentation. Then the groundwater will undergo liquid-phase carbon adsorption treatment. Figure 5-4 presents a typical process flow diagram. The treated groundwater will be discharged by pipeline to a force main servicing Building 620 (the Base water treatment facility located near Site 2) which will discharge the water to the nearest sewage treatment plant. The force main is located approximately 4,400 feet northwest of Site 3 along Holcomb Boulevard.

In addition to groundwater extraction, treatment, and discharge, Groundwater RAA No. 3 incorporates a long-term groundwater monitoring program to measure the effects of this alternative. Wells to be periodically monitored under this program include 03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW07, 03-MW08, and 03-MW11IW. (Five years of quarterly sampling and 25 years of semiannual sampling will be assumed for cost estimating purposes.) Additional wells may be added to this monitoring program if necessary. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, and TAL inorganics to monitor contaminant concentrations in the shallow and Castle Hayne aquifers over time. Also, aquifer-use and deed restrictions will be implemented. Aquifer-use restrictions will prohibit use of the shallow and Castle Hayne aquifers, in the immediate vicinity of the site, as potable water sources. Deed restrictions will limit future land use at Site 3, including placement of new wells.

Since contaminants will remain in the groundwater, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

SECTION 5.0 FIGURES

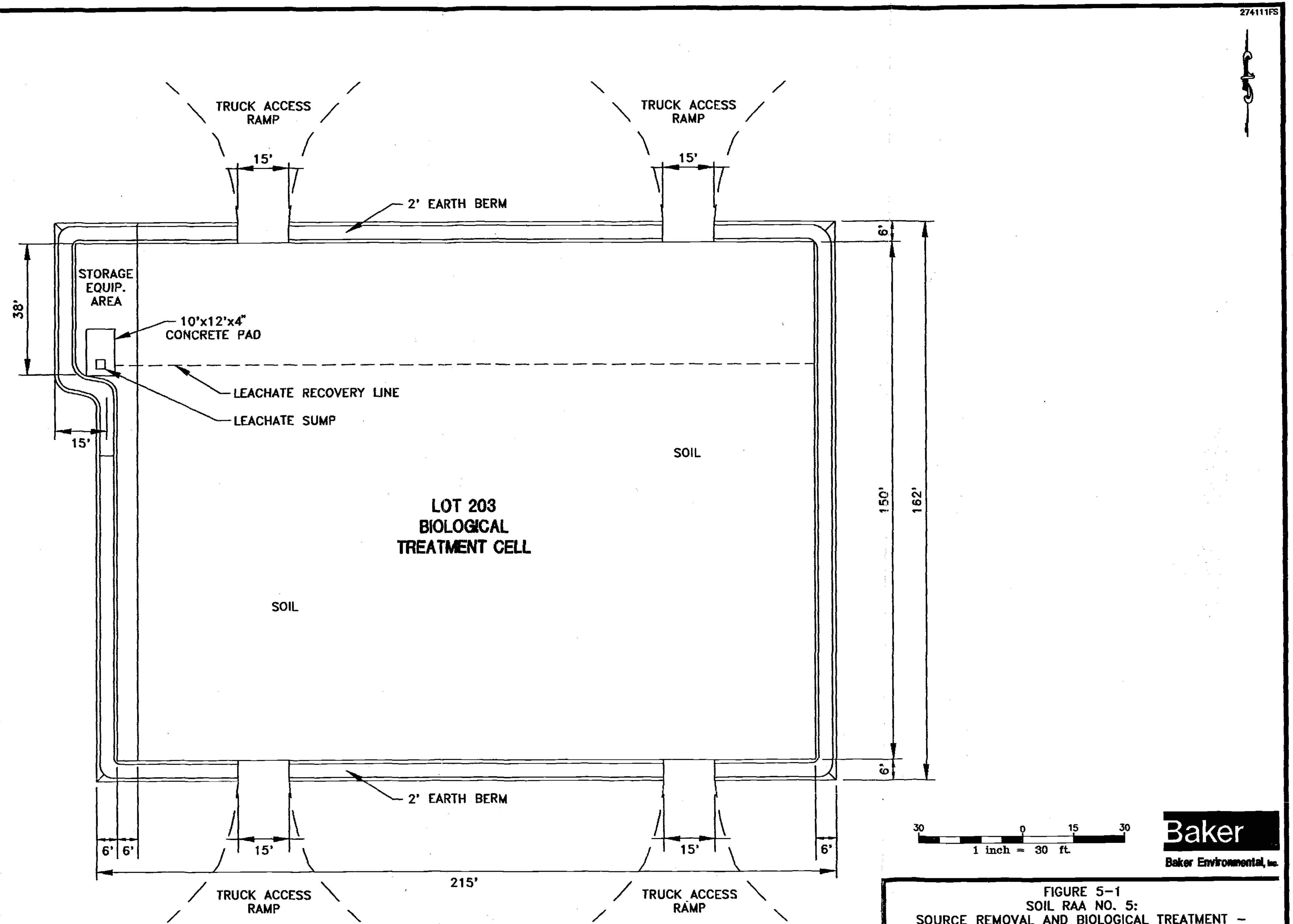


FIGURE 5-1
SOIL RAA NO. 5:
SOURCE REMOVAL AND BIOLOGICAL TREATMENT –
PLAN VIEW OF THE LOT 203 BIOCELL
SITE 3 – OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721DD03Z

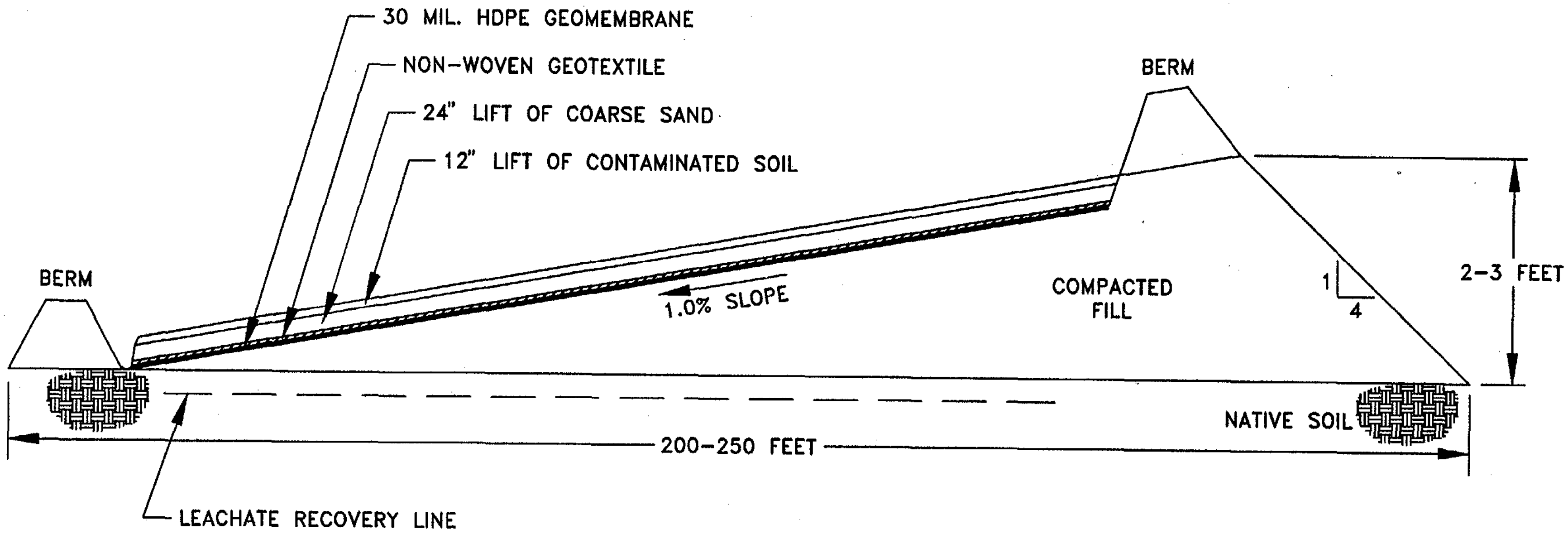


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FIGURE 5-2
SOIL RAA NO. 5:
SOURCE REMOVAL AND BIOLOGICAL TREATMENT –
CROSS-SECTION OF A LANDFARM UNIT
SITE 3 – OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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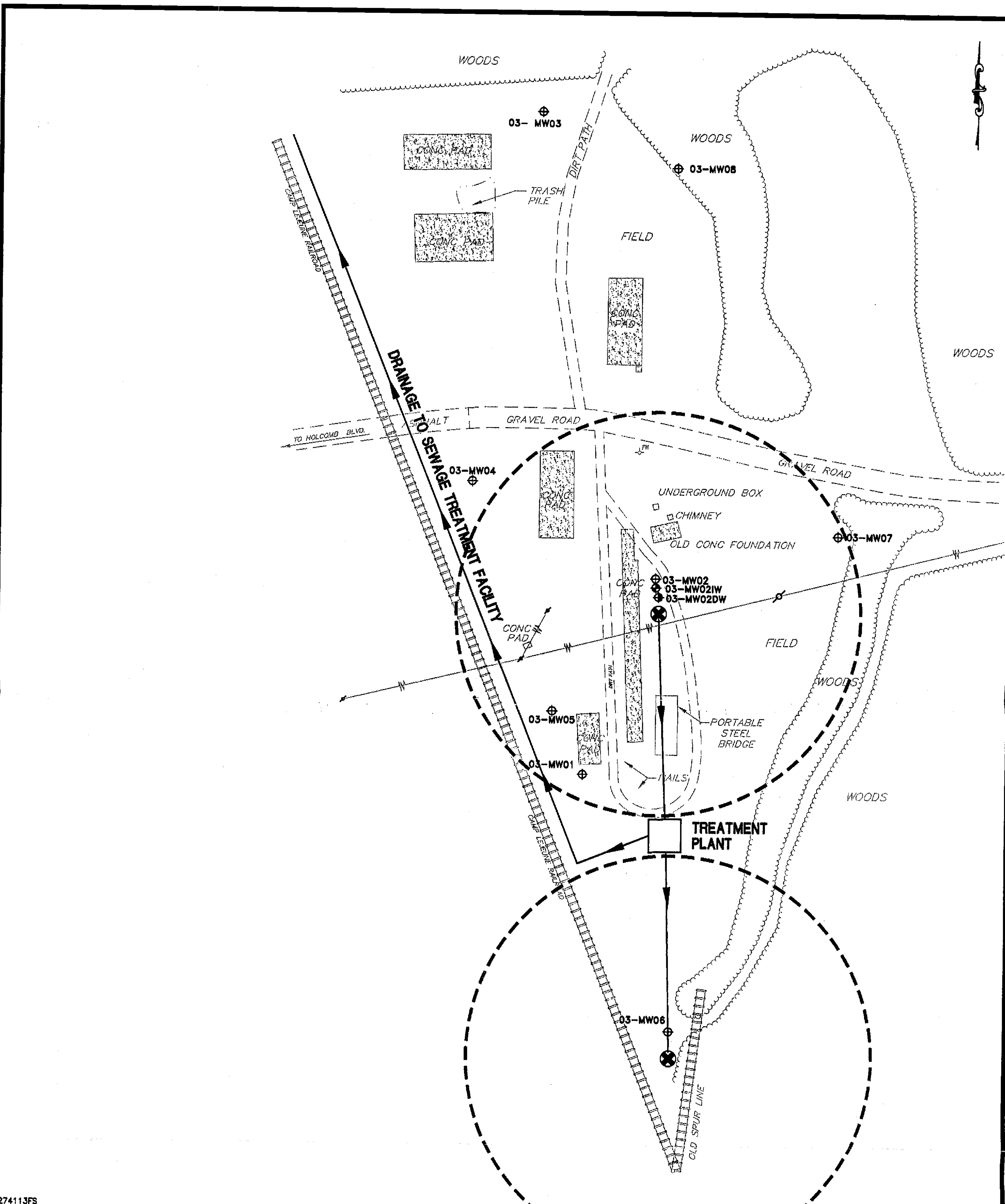

LEGEND

03-MW01	SHALLOW MONITORING WELL LOCATION
03-MW02IW	INTERMEDIATE MONITORING WELL LOCATION
03-MW02DW	DEEP MONITORING WELL LOCATION
	EXTRACTION WELL LOCATION
	RADIUS OF INFLUENCE

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

120 0 60 120
1 inch = 120 ft.

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FIGURE 5-3
GROUNDWATER RAA NO. 3:
EXTRACTION AND ON SITE CARBON ADSORPTION TREATMENT - PLAN VIEW
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01721DD03Z

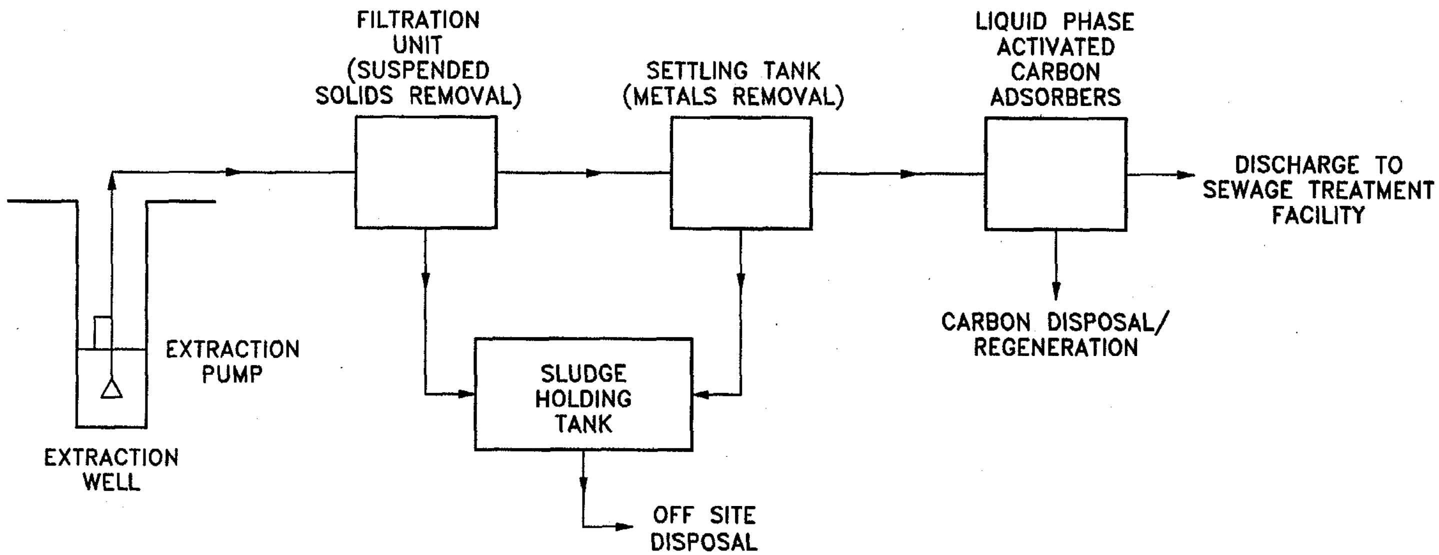

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FIGURE 5-4
GROUNDWATER RAA NO. 3:
EXTRACTION AND ON SITE CARBON ADSORPTION TREATMENT - PROCESS FLOW DIAGRAM
SITE 3 - OLD CREOSOTE PLANT
FEASIBILITY STUDY CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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6.0 DETAILED ANALYSIS OF THE SOIL ALTERNATIVES

This section contains a detailed analysis of the five Soil RAAs that were developed in Section 5.0. Section 6.1 presents an overview of the nine USEPA evaluation criteria that will be used in the detailed analysis. An individual analysis of each soil alternative, with respect to the evaluation criteria, is presented in Section 6.2, and a comparative analysis of all the soil alternatives is presented in Section 6.3. (Please note that the detailed analysis of the Groundwater RAAs will be conducted in Section 7.0.)

This detailed analysis has been conducted to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD (USEPA, 1988). The extent to which alternatives are assessed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening (USEPA, 1988). (An initial screening of alternatives was not conducted.)

The detailed analysis was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988) and the NCP, including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were used for the detailed analysis:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance (not evaluated at this time)
- Community Acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the ROD by addressing comments received after the technical review committee (TRC) has reviewed the FS and Proposed Remedial Action Plan (PRAP). The TRC includes participants from the NC DEHNR, USEPA Region IV, and the public.

6.1 Overview of Evaluation Criteria

The following paragraphs describe the evaluation criteria that are used in the detailed analysis.

Overall Protection of Human Health and the Environment: Overall protection of human health and the environment is the primary criterion that a remedial action must meet. A remedy is considered protective if it adequately eliminates, reduces, or controls all current and potential site risks posed through each exposure pathway at the site. A site where hazardous substances remain without engineering or institutional controls allows for unlimited exposure for human and environmental receptors. Adequate engineering controls, institutional controls, or some combination of the two, can be implemented to control exposure and thereby ensure reliable protection over time.

In addition, implementation of a remedy cannot result in unacceptable short-term risks or cross-media impacts on human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): Compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all ARARs or that there is a sound rationale for waiving an ARAR. During the detailed analysis, the alternatives will be analyzed based on the federal and state contaminant-specific ARARs, the action-specific ARARs, and the location-specific ARARs that were presented in Section 3.0 of this FS.

Long-Term Effectiveness and Permanence: This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the distant future, as well as in the near future. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis will focus on the residual risks present at the site after the completion of the remedial action. The analysis will also include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.
- Adequacy of any controls (e.g., engineering and institutional controls) used to manage the hazardous substances remaining at the site.
- Reliability of those controls.
- Potential impacts on human health and the environment, should the remedy fail, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume Through Treatment: This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The criterion ensures that the relative performance of the various treatment alternatives in reducing the toxicity, mobility, or volume will be assessed. Specifically, the analysis will examine the magnitude, significance, and irreversibility of reductions.

Short-Term Effectiveness: This criterion examines the short-term impacts associated with implementing the alternative. Implementation may impact the neighboring community, workers, or the surrounding environment. Short-term effectiveness also includes potential threats to human health and the environment associated with the excavation, treatment, and transportation of hazardous substances, the potential cross-media impacts of the remedy, and the time required to achieve protection of human health and the environment.

Implementability: Implementability considerations include the technical and administrative feasibility of the alternatives, as well as the availability of goods and services (including treatment, storage, or disposal capacity) associated with the alternative. Implementability considerations often affect the timing of remedial actions (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps, and the need to secure technical services). On site activities must comply with the substantive portions of applicable permitting regulations.

Cost: Cost includes all capital costs and annual O&M costs incurred over the life of the project. The focus during the detailed analysis is on the net present worth (NPW) of these costs. The selected remedy will be the most cost-effective alternative that is still capable of achieving the remedial action objectives.

As per the USEPA guidance (USEPA, 1988), the cost estimates will have an accuracy of -30 to +50 percent. The exact accuracy of each cost estimate depends upon the assumptions made and the availability of costing information. For this FS, the NPW costs were calculated assuming a five percent discount factor and a zero percent inflation rate. Appendix C presents the cost estimates developed for both the soil and groundwater remedial action alternatives.

State Acceptance: This criterion, which is an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. State comments will be addressed during the development of the FS, the PRAP, and the ROD, as appropriate.

Community Acceptance: This criterion addresses the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include all interested parties. These comments are taken into account throughout the FS process. However, formal public comments will not be received until after the public comment period for the PRAP is held, so only preliminary assessment of community acceptance can be conducted during the development of the FS.

6.2 Individual Analysis of Alternatives

The following subsections present the detailed analysis of the Soil RAAs on an individual basis. This individual analysis includes a brief description of each RAA and an assessment of how well the RAA performs against the evaluation criteria. Table 6-1 summarizes the individual, detailed analysis of alternatives.

6.2.1 Soil RAA No. 1: No Action

Description

Under the no action alternative, no remedial actions will be implemented for the contaminated soil at Site 3. The soil AOC will remain in place under its current conditions.

Assessment

Overall Protection of Human Health and the Environment: Because no remedial actions will be implemented under RAA No. 1, subsurface soil will continue to be a source of groundwater contamination because soil contaminants will continue to leach into the groundwater. Thus, RAA No. 1 will not achieve Soil RAO #1 ("prevent the leaching of PAH contaminants from the subsurface soil to the groundwater"). The degree or magnitude to which the contaminants will continue to leach is difficult to predict. Semivolatile organic contaminants such as PAHs are relatively immobile. Some of the more mobile contaminants, such as naphthalene, will leach more readily from soil to groundwater. However, given the age of the site, it is suspected that a lesser amount of semivolatile organics will continue to leach than the amount that has already leached.

By contributing to groundwater contamination, the subsurface soil will also be contributing to unacceptable future potential human health risks associated with groundwater. As a result, this alternative does not provide adequate protection of human health.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. Therefore, RAA No. 1 will provide overall protection of the environment.

Compliance With ARARs/TBCs: Under the no action alternative, no active effort is made to reduce contaminant levels to below their chemical-specific TBCs (i.e., the USEPA Region III SSLs). Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil indefinitely. As a result, RAA No. 1 does not achieve Soil RAO # 2 ("remediate subsurface soil at the site to the specified remediation levels"). No action-specific or location-specific ARARs apply to this no action alternative.

Long-Term Effectiveness and Permanence: Because RAA No. 1 allows an on-going source of groundwater contamination to remain in the subsurface soil, this alternative may not provide long-term effectiveness and permanence. Contaminants may continue to leach from the subsurface soil to the groundwater thereby contributing to unacceptable human health risks.

The no action alternative does not include any controls for managing the soil contaminants that will remain in the subsurface. Therefore, RAA No. 1 will require 5-year reviews by the lead agency to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The no action alternative does not provide an active means for contaminant treatment. Therefore, there will be no toxicity, mobility, or volume reduction through treatment. RAA No. 1 does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: Since there are no remedial action activities associated with RAA No. 1, implementation of this alternative does not increase risks to the community or to workers. Implementation also does not present any environmental impacts.

Implementability: The no action alternative is technically implementable since no construction or operation activities will be conducted. In terms of administrative feasibility, RAA No. 1 will not require additional coordination with other agencies. In addition, the availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the NPW is $0.

USEPA/State Acceptance: To be assessed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance: To be assessed following the public comment period.

6.2.2 Soil RAA No. 2: Institutional Controls

<u>Description</u>

Under Soil RAA No. 2, the subsurface soil will be left in place under its current conditions; no active remedial actions will be implemented. However, RAA No. 2 differs from the no action alternative by including land use controls and deed restrictions as institutional controls that will limit the future land use at the site. The land use controls will be implemented via the Base Master Plan and the deed restrictions will be implemented if the Base were to close.

Assessment

Overall Protection of Human Health and the Environment: Because the subsurface soil will be left in place, it will continue to be a source of groundwater contamination because soil contaminants will continue to leach into the groundwater. Thus, RAA No. 2 will not achieve RAO #1 ("prevent the leaching of PAH contaminants from the subsurface soil to the groundwater"). The degree or magnitude to which the contaminants will continue to leach is difficult to predict. Semivolatile organic contaminants such as PAHs are relatively immobile. Some of the more mobile contaminants, such as naphthalene, will leach more readily from soil to groundwater. However, given the age of the site, it is suspected that a lesser amount of semivolatile organics will continue to leach than the amount that has already leached.

By contributing to groundwater contamination, the subsurface soil will also be contributing to unacceptable future potential human health risks associated with groundwater. However, RAA No. 2 includes land use controls and deed restrictions that will limit future land use at the site, including placement of wells. The institutional controls will mitigate the potential for human health risks, but not eliminate it. As a result, this alternative will provide some protection of human health, but not a high level of protection.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. Therefore, RAA No. 2 will provide overall protection of the environment.

Compliance With ARARs/TBCs: Under RAA No. 2, no active effort is made to reduce contaminant levels to below their chemical-specific TBCs (i.e., the USEPA Region III SSLs). Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil indefinitely. As a result, RAA No. 2 does not achieve Soil RAO #2 ("remediate the subsurface soil at the site to the specified remediation levels"). No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence: Although RAA No. 2 allows an on-going source of groundwater contamination to remain in the subsurface soil, this alternative includes institutional controls that will reduce the exposure risks associated with creosote contaminants. As a result, RAA No. 2 provides long-term effectiveness and permanence with respect to health impacts, but does not reduce potential leaching of contaminants from the subsurface soil to the groundwater.

The land use controls and deed restrictions included under RAA No. 2 will be adequate and reliable controls for preventing exposure to creosote contamination. Regardless, contaminants will be left on site so RAA No. 2 requires 5-year reviews by the lead agency to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: RAA No. 2 does not provide an active means for contaminant treatment. Therefore, there will be no toxicity, mobility, or volume reduction through treatment. This alternative does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: Implementation of the institutional controls associated with RAA No. 2 will not significantly increase risks to the community or to workers. In addition, implementation of RAA No. 2 will not present any significant environmental impacts.

Implementability: RAA No. 2 is an implementable alternative. Ordinance procurement has been easily implemented in the past. In terms of administrative feasibility, this alternative will not require a significant amount of coordination with other agencies. All required services, materials, and/or technologies should be readily available.

Cost: There are negligible capital costs and no O&M costs associated with this alternative. Therefore, the NPW is considered to be $0.

USEPA/State Acceptance: To be assessed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance: To be assessed following the public comment period.

6.2.3 Soil RAA No. 3: Source Removal and Off Site Landfill Disposal

Description

Under Soil RAA No. 3, the soil AOC (see Figure 3-5) will be excavated to an estimated depth of 9 feet bgs. Confirmatory soil sampling in the excavation area will ensure that all contaminated soil above the water table has been removed. Because creosote is a listed hazardous waste, the soil will be transported to a RCRA-permitted Subtitle C facility for landfill disposal.

Assessment

Overall Protection of Human Health and the Environment: Under RAA No. 3, the subsurface soil AOC, which is the source of groundwater contamination, will be removed from the site. Consequently, the AOC will no longer be a source of groundwater contamination and RAA No. 3 will achieve RAO #1 ("prevent the leaching of contaminants from the subsurface soil to the groundwater"). In addition, the soil AOC will no longer be contributing to unacceptable human health risks associated with groundwater (by leaching contaminants into the groundwater). As a result, RAA No. 3 will significantly reduce human health risks and provide a high level of protectiveness.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. Therefore, RAA No. 3 will provide overall protection of the environment.

Compliance With ARARs/TBCs: Under RAA No. 3, soil with contaminant levels that exceed chemical-specific TBCs (i.e., the USEPA Region III SSLs) will be removed from the subsurface and landfilled. Thus, subsurface soil at the site will achieve chemical-specific TBCs and RAA No. 3 will achieve Soil RAO #2 ("remediate subsurface soil at the site to the specified remediation levels"). However, the excavated soil that is landfilled will not achieve the chemical-specific TBCs. Consequently, RAA No. 3 achieves chemical-specific TBCs at the site, but not at the landfill facility.

RAA No. 3 will be designed to meet all of the location-specific and action-specific ARARs that apply to it (see Section 3.0).

Long-Term Effectiveness and Permanence: Under RAA No. 3, the soil AOC, which is considered to be the main source of groundwater contamination, will be removed from the subsurface. As a result, this alternative will significantly reduce human health risks associated with leaching contaminants and provide a high level of long-term effectiveness and permanence.

The subsurface soil at Site 3 will no longer require 5-year reviews by the lead agency. The contaminated groundwater, however, may still require these reviews.

Reduction of Toxicity, Mobility, or Volume Through Treatment: RAA No. 3 does not provide an active means for contaminant treatment. Therefore, there will be no toxicity, mobility, or volume reduction of the soil contaminants through treatment. RAA No. 3 does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: Implementation of RAA No. 3 will temporarily increase risks to the community and to workers during soil excavation, backfilling, and transportation to the disposal facility. The following measures will be taken to provide community and worker protection: proper materials handling procedures, personal protective equipment (PPE), and construction safety fencing.

Although there may be some air emissions (i.e., dust generation) and surface water runoff associated with the excavation and landfilling activities, RAA No. 3 will present minimal environmental impacts. The time in which RAA No. 3 will be implemented is assumed to be less than one month.

Implementability: RAA No. 3 is a technically implementable alternative. Excavation, backfilling, and landfill disposal have been easily implemented in the past. Transportation of contaminated soil, however, will require appropriate materials handling procedures.

In terms of administrative feasibility, RAA No. 3 requires coordination with the Base Public Works/Planning Department for the excavation activities, and the Department of Transportation for off site transport of hazardous materials. In addition, federal and state acceptance of the disposal facility will be required. However, all required services, materials, and/or technologies should be readily available.

Cost: The estimated capital cost associated with RAA No. 3 is $917,000. Since there are no O&M costs, the NPW of this alternative is also $917,000. Table C-1 (Appendix C) presents a cost estimate for Soil RAA No. 3.

USEPA/State Acceptance: To be assessed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance: To be assessed following the public comment period.

6.2.4 Soil RAA No. 4: Source Removal and Off Site Incineration

Description

Under Soil RAA No. 4, the soil AOC (see Figure 3-5) will be excavated to a depth of 9 feet bgs. Confirmatory soil sampling in the excavation area will ensure that all contaminated soil above the water table has been removed. The excavated soil will then be transported to a permitted incineration facility for treatment and disposal.

Assessment

Overall Protection of Human Health and the Environment: Under RAA No. 4, the subsurface soil AOC, which is the source of groundwater contamination, will be removed from the site.

Consequently, this AOC will no longer be a source of groundwater contamination, and RAA No. 4 will achieve RAO #1 ("prevent the leaching of PAH contaminants from the subsurface soil to the groundwater"). In addition, the soil AOC will no longer be contributing to unacceptable human health risks associated with groundwater (by leaching contaminants into the groundwater). As a result, RAA No. 4 will significantly reduce human health risks and provide a high level of protectiveness.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. Therefore, RAA No. 4 will provide overall protection of the environment.

Compliance With ARARs/TBCs: Under RAA No. 4, soil with contaminant levels that exceed chemical-specific TBCs (i.e., the USEPA Region III SSLs) will be removed from the subsurface and treated/disposed at an incineration facility. Thus, subsurface soil at the site will achieve chemical-specific TBCs and RAA No. 4 will achieve Soil RAO #2 ("remediate subsurface soil at the site to the specified remediation levels"). In addition, the contaminated, excavated soil is expected to achieve chemical-specific TBCs via thermal treatment. Incineration is capable of achieving stringent cleanup levels for a wide variety of organic and inorganic contaminants (USEPA, 1992).

RAA No. 4 will be designed to meet all of the location-specific and action-specific ARARs that apply to it (see Section 3.0).

***Long-Term Effectiveness and Permanence*:** Under RAA No. 4, the soil AOC, which is considered to be the main source of groundwater contamination, will be removed from the subsurface. As a result, this alternative will significantly reduce human health risks associated with leaching contaminants and provide a high level of long-term effectiveness and permanence.

The subsurface soil at Site 3 will no longer require 5-year reviews by the lead agency. The contaminated groundwater, however, may still require these reviews.

***Reduction of Toxicity, Mobility, or Volume Through Treatment*:** RAA No. 4 involves direct treatment of the excavated soil, so this alternative will result in toxicity, mobility, and volume reduction of the soil contaminants. Incineration is expected to treat and/or destroy the majority of the soil contaminants. (Incineration is a contaminant destruction technology applicable to a wide range of organic contaminants [USEPA, 1992].) Thus, the majority of the contamination is expected to experience toxicity, mobility, and volume reduction. The time frame for these reductions is estimated to be less than one month. Thus, RAA No. 4 satisfies the statutory preference for treatment.

***Short-Term Effectiveness*:** Implementation of RAA No. 4 will temporarily increase risks to the community and to workers during soil excavation, backfilling, and transportation to the incineration facility. In addition, incinerator off-gases will increase risks to the community. The following measures will be taken to provide community and worker protection: proper materials handling procedures, PPE, construction safety fencing, and off-gas treatment at the incineration facility.

Although there may be some air emissions (i.e., dust generation) associated with the excavation activities, RAA No. 4 will not present any significant environmental impacts. The time in which RAA No. 4 will be implemented is assumed to be less than one month.

***Implementability*:** RAA No. 4 is a technically implementable alternative since excavation, backfilling, and off site incineration have been easily implemented in the past. Transportation of contaminated soil, however, will require appropriate materials handling procedures.

In terms of administrative feasibility, RAA No. 4 requires coordination with the Base Public Works/Planning Department for excavation activities, and the Department of Transportation for off site transport of hazardous materials. In addition, federal and state acceptance of the incineration facility will be required.

Cost: The estimated capital cost associated with RAA No. 4 is $3,150,000. Since there are no O&M costs, the NPW of this alternative is also $3,150,000. Table C-2 (Appendix C) presents a cost estimate for Soil RAA No. 4.

***USEPA/State Acceptance*:** To be assessed following USEPA/NC DEHNR review of the PRAP.

***Community Acceptance*:** To be assessed following the public comment period.

6.2.5 Soil RAA No. 5: Source Removal and Biological Treatment

Description

Under Soil RAA No. 5, the soil AOC (see Figure 3-5) will be excavated to a depth of 9 feet bgs. Confirmatory soil sampling in the excavation area will ensure that all contaminated soil above the water table has been removed. Then the soil will be transported to the existing Lot 203 biocell at MCB, Camp Lejeune. The biocell is a landfarm unit with a 1,000 cubic yard capacity. The excavated soil from Site 3 will undergo landfarming treatment in three batches which will each require approximately three to six months of monthly soil sampling and bimonthly tilling before treatment is complete. Treated soil will be reused on Base as fill material. Prior to treatment, a pilot-scale treatability study will be conducted to further assess the effectiveness of this alternative.

Assessment

***Overall Protection of Human Health and the Environment*:** Under RAA No. 5, the soil AOC, which is the source of groundwater contamination, will be removed from the subsurface and treated at a biological treatment facility. Consequently, the subsurface soil AOC will no longer be a source of groundwater contamination, and RAA No. 5 will achieve RAO #1 ("prevent the leaching of PAH contaminants from the subsurface soil into the groundwater"). In addition, the soil AOC will no longer be contributing to unacceptable human health risks associated with groundwater (by leaching contaminants into the groundwater). As a result, RAA No. 5 will significantly reduce human health risks and provide a high level of protectiveness.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. However, if not properly controlled, the biocell could potentially increase ecological risks to terrestrial receptors that could contact the contaminated soil. The biocell was constructed with a six foot earthen berm and leachate collection system which should provide adequate controls. Therefore, RAA No. 5 is expected to provide overall protection of the environment.

***Compliance With ARARs/TBCs*:** Under RAA No. 5, soil with contaminant levels that exceed chemical-specific TBCs (i.e., the USEPA Region III SSLs) will be removed from the subsurface and treated at a biocell. Thus, subsurface soil at the site will achieve chemical-specific TBCs and RAA No. 5 will achieve Soil RAO #2 ("remediate subsurface soil at the site to the specified remediation levels"). In addition, the contaminated, excavated soil is expected to achieve chemical-specific TBCs via biological treatment.

RAA No. 5 will be designed to meet all of the location-specific and action-specific ARARs that apply to it (see Section 3.0).

***Long-Term Effectiveness and Permanence*:** Under RAA No. 5, the soil AOC, which is considered to be the main source of groundwater contamination, will be removed from the subsurface. As a result, this alternative will significantly reduce human health risks associated with leaching contaminants. Additionally, this alternative will provide a high level of long-term effectiveness and permanence.

The subsurface soil at Site 3 will no longer require 5-year reviews by the lead agency, provided biological treatment does not exceed five years.

***Reduction of Toxicity, Mobility, or Volume Through Treatment*:** RAA No. 5 involves direct treatment of the excavated soil, so this alternative will result in toxicity, mobility, and volume reduction of the soil contaminants. Biological treatment is expected to treat and/or destroy the majority of the soil contaminants. (Biological treatment is a contaminant destruction technology.) Thus, the majority of the contamination is expected to experience toxicity, mobility, and volume reduction. The time frame for these reductions is estimated to be nine months (three months for each of the three biocell batches). However, to be conservative, five years has been assumed for cost estimating purposes. Some compounds may be biodegraded into more toxic or more mobile contaminants, so biological treatment may actually increase contaminant toxicity and mobility to some extent. If the a biocell is properly monitored and controlled, however, the potential for creating more toxic and mobile contaminants can be avoided. Regardless, RAA No. 5 satisfies the statutory preference for treatment

***Short-Term Effectiveness*:** Implementation of RAA No. 5 will temporarily increase risks to the community and to workers during soil excavation, backfilling, transportation, and treatment activities. The following measures will be taken to provide community and worker protection: proper materials handling procedures, PPE, construction safety fencing, and proper maintenance of the liner, berm, and leachate collection system at the biocell.

RAA No. 5 will not present any significant environmental impacts as long as the biocell is adequately controlled and maintained. The time in which RAA No. 5 will be implemented is assumed to be less than one month, with an O&M period of approximately 9 months (although 5 years of O&M have been assumed to develop a conservative cost estimate).

***Implementability*:** RAA No. 5 is a technically implementable alternative since excavation, backfilling, and bioremediation have been easily implemented in the past. The implementability of RAA No. 5 will be better assessed after a pilot-scale treatability study is conducted.

The implementability may be affected by the extensive O&M that the biocell requires. This O&M includes monthly soil sampling, bimonthly tilling, and periodic spraying of collected leachate which will make implementation more difficult. However, the equipment and procedures used for the biocell O&M will be simple and conventional. The biocell must also be available for use during the intended treatment schedule.

The implementability may also be affected by the need to re-permit the Lot 203 biocell. The biocell is currently permitted to treat TPH-contaminated soil. Permit modifications will be required to treat the PAH-contaminated soil from Site 3. In addition, some coordination with the Base Public Works/Planning Department will be required.

Cost: The estimated capital cost associated with RAA No. 5 is $362,000. O&M costs of approximately $35,000 annually are projected for 5 years of biocell O&M. Assuming an annual percentage rate of 5 percent, the NPW of this alternative is $514,000. Table C-3(A) (Appendix C) presents a cost estimate for Soil RAA No. 5.

***USEPA/State Acceptance*:** To be assessed following USEPA/NC DEHNR review of the PRAP.

***Community Acceptance*:** To be assessed following the public comment period.

6.3 Comparative Analysis

This section presents a comparative analysis of the soil alternatives. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each RAA.

6.3.1 Overall Protection of Human Health and the Environment

Under RAA Nos. 1 and 2, no remediation actions will be implemented to address the contaminated soil AOC. Because the soil AOC will be left in place, it will continue to be a source of groundwater contamination by leaching PAH contaminants. As such, the soil will be contributing to the unacceptable future potential human health risks associated with groundwater. RAA No. 1, the no action alternative, provides no means for reducing these human health risks. RAA No. 2, on the other hand, includes institutional controls that will reduce some of the potential human health risks. RAA Nos. 3, 4, and 5 will significantly reduce the risks associated with groundwater by completely removing the main source of this groundwater contamination - the subsurface soil AOC. Thus, RAA No. 1 provides no additional protection of human health, RAA No. 2 provides some additional protection, and RAA Nos. 3, 4, and 5 provide significant protection.

In addition, RAA Nos. 1 and 2 will not achieve Soil RAO #1 ("prevent the leaching of PAH contaminants from the subsurface soil to the groundwater"). RAA Nos. 3, 4, and 5, however, will achieve Soil RAO #1 because the soil AOC will be removed.

Because ecological risks were determined to be minimal, conditions at Site 3 are already protective of the environment. As a result, all five RAAs will provide overall protection of the environment. The biological treatment included under RAA No. 5 could potentially present risks to terrestrial receptors. However, the biocell controls (i.e., the berm and leachate collection system) should provide adequate ecological protection.

6.3.2 Compliance with ARARs/TBCs

Under RAA Nos. 1 and 2, contaminants will remain in the subsurface soil at concentrations that exceed chemical-specific TBCs (i.e., the USEPA Region III SSLs). Thus, soil conditions at the site will not meet chemical-specific TBCs and RAA Nos. 1 and 2 will not achieve Soil RAO #2 ("remediate the subsurface soil at the site to the USEPA Region III SSLs"). Under RAA Nos. 3, 4, and 5, soil contaminants that exceed chemical-specific TBCs will be removed from the subsurface. Thus, soil conditions at the site will meet chemical-specific TBCs and RAA Nos. 3, 4, and 5 will achieve Soil RAO #2.

Although RAO #2 does not require the excavated soil itself to meet chemical-specific TBCs, RAA Nos. 4 and 5 will achieve this effect. Under RAA Nos. 4 and 5, the excavated soil will receive active treatment (via incineration and biological treatment, respectively) so it is expected to meet the chemical-specific ARARs. Under RAA No. 3, however, the excavated soil will be landfilled in an untreated state so it will not meet the chemical-specific TBCs.

RAA Nos. 3, 4, and 5 can be designed to meet all of the location- and action-specific ARARs that apply to them (see Section 3.0). No location- or action-specific ARARs apply to RAA Nos. 1 and 2.

6.3.3 Long-Term Effectiveness and Permanence

RAA No. 1 does not provide long-term effectiveness and permanence. This is because RAA No. 1 allows a source of groundwater contamination, the soil AOC, to remain in the subsurface. In addition, RAA No. 1 does not provide controls to manage the soil contaminants that will be remaining in the subsurface. Like RAA No. 1, RAA No. 2 allows the soil AOC to remain in the subsurface. However, RAA No. 2 includes institutional controls to manage the soil contaminants that will remain in the subsurface. Therefore, RAA No. 2 provides a greater level of long-term effectiveness and permanence than RAA No. 1. The controls should effectively prevent human exposure to the creosote contaminants. However, under RAA No. 2, the contaminants will continue to leach from the subsurface soil to the groundwater. RAA Nos. 3, 4, and 5, on the other hand, provide high levels of long-term effectiveness and permanence. Under all three RAAs, the soil AOC will be completely removed from the subsurface, preventing contaminants from leaching into the groundwater.

RAA Nos. 1 and 2 will require 5-year reviews by the lead agency. RAA No. 5 will not require these reviews provided the treatment time does not exceed 5 years. RAA Nos. 3 and 4 will not require 5-year reviews for soil, but may require these reviews for groundwater.

6.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA Nos. 1, 2, and 3 do not involve treatment processes so these alternatives will not reduce toxicity, mobility, or volume of the soil contaminants through treatment. RAA Nos. 4 and 5, however, involve soil removal and treatment so these alternatives will result in toxicity, mobility, and volume reduction through treatment. Most importantly, RAA Nos. 4 and 5 will eliminate the mobility of PAH contaminants by preventing them from leaching into the groundwater.

RAA Nos. 1, 2, and 3 do not satisfy the statutory preference for treatment. RAA Nos. 4 and 5 do satisfy the statutory preference.

6.3.5 Short-Term Effectiveness

Implementation of RAAs No. 1 and 2 will not increase risks to the community or to workers because no actions will be taken. However, RAA Nos. 3, 4, and 5 will present risks during soil excavation and backfilling activities. In addition, RAA Nos. 3 and 4 will present risks to the community during transportation of the contaminated soil to the treatment/disposal facility. RAA No. 5 will present some transportation risk (during the haul to Lot 203), but less than RAA Nos. 3 and 4. RAA No. 4 will present additional risks to the community by creating incinerator off-gas that may escape to the atmosphere. Air pollution control equipment at the incineration facility, however, should be able to reduce the risks associated with off-gases. RAA No. 5 is the only alternative whose implementation may involve a long-term risk to the community and to the workers. The biocell will present risks during the initial mixing of fertilizer, during placement of the contaminated soil, and during treatment O&M.

6.3.6 Implementability

RAA No. 1 is the most implementable, if not the most effective, alternative. RAA No. 2 is the next most implementable alternative because it only involves ordinance procurement. The remaining RAAs (RAA Nos. 3, 4, and 5) are similar in that they include the excavation of subsurface soil. RAA Nos. 3 and 4 both include transportation of contaminated soil to an off Base treatment/disposal facility. This transportation will require appropriate materials handling procedures. Compared to RAA Nos. 3 and 4, however, RAA No. 5 will require more extensive O&M. In addition, RAA No. 5 will require a pilot-scale treatability study.

6.3.7 Cost

In terms of NPW, the no action alternative (RAA No. 1) and Institutional Controls (RAA No. 2) will be the least expensive RAAs to implement, followed by RAA No. 3, RAA No. 5, and then RAA No. 4. The estimated NPW values, in increasing order, are $0 (RAA No. 1), $0 (RAA No. 2), $514,000 (RAA No. 3), $917,000 (RAA No. 5), and $3,150,000 (RAA No. 4).

6.3.8 USEPA/State Acceptance

To be assessed following USEPA/NC DEHNR review of the PRAP.

6.3.9 Community Acceptance

To be assessed following the public comment period.

SECTION 6.0 TABLES

TABLE 6-1

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Soil RAA No. 1 No Action	Soil RAA No. 2 Institutional Controls	Soil RAA No. 3 Source Removal and Off Site Landfill Disposal	Soil RAA No. 4 Source Removal and Off Site Incineration	Soil RAA No. 5 Source Removal and Biological Treatment
OVERALL PROTECTIVENESS					
• Human Health	If left as is, subsurface soil will continue to be a source of groundwater contamination. As such, the soil will be contributing to unacceptable human health risks associated with groundwater.	If left as is, subsurface soil will continue to be a source of groundwater contamination. As such, the soil will be contributing to unacceptable human health risks associated with groundwater. However, institutional controls will reduce the risks.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.	Eliminates a source of groundwater contamination so human health risks associated with groundwater will be significantly reduced.
• Environmental Protection	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment.	According to the ecological RA, conditions at Site 3 are already protective of the environment. However, terrestrial receptors may be at risk for contacting contaminated soil during treatment.
COMPLIANCE WITH ARARs					
• Chemical-Specific ARARs/TBCs	Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil.	Contaminant levels exceeding chemical-specific TBCs will remain in the subsurface soil.	Subsurface soil at the site will meet chemical-specific TBCs; the landfilled soil will not meet chemical-specific TBCs.	Subsurface soil at the site will meet chemical-specific TBCs; the excavated soil is expected to meet chemical-specific TBCs via thermal treatment.	Subsurface soil at the site will meet chemical-specific TBCs; the excavated soil is expected to meet chemical-specific TBCs via biological treatment.
• Location-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet location-specific ARARs.	Can be designed to meet location-specific ARARs.	Can be designed to meet location-specific ARARs.

TABLE 6-1 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Soil RAA No. 1 No Action	Soil RAA No. 2 Institutional Controls	Soil RAA No. 3 Source Removal and Off Site Landfill Disposal	Soil RAA No. 4 Source Removal and Off Site Incineration	Soil RAA No. 5 Source Removal and Biological Treatment
• Action-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet action-specific ARARs.	Can be designed to meet action-specific ARARs.	Can be designed to meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
• Magnitude of Residual Risk	Risks to contaminated groundwater will remain unchanged.	Institutional controls will reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.	Removal of the contaminant source area will significantly reduce the risks associated with groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Institutional controls will be adequate and reliable controls for preventing exposure to the creosote contaminants.	Construction safety fencing should provide an adequate and reliable control.	Construction safety fencing should provide an adequate and reliable control.	Construction safety fencing and the liner, berm, and leachate collection system should provide adequate controls.
• Need for 5-year Review	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.	Review will not be required.	Review will not be required.	Review will not be required assuming treatment is complete within 5 years.

TABLE 6-1 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Soil RAA No. 1 No Action	Soil RAA No. 2 Institutional Controls	Soil RAA No. 3 Source Removal and Off Site Landfill Disposal	Soil RAA No. 4 Source Removal and Off Site Incineration	Soil RAA No. 5 Source Removal and Biological Treatment
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
• Treatment Process Used	No treatment process.	No treatment process.	No treatment process.	Incineration.	Biological treatment.
• Amount Destroyed or Treated	None.	None.	None.	Expected to treat and/or destroy the majority of the soil contaminants.	Expected to treat and/or destroy the majority of the soil contaminants..
• Reduction of Toxicity, Mobility, or Volume Through Treatment	None.	None.	None.	Reduction in toxicity, mobility, and volume for the majority of the soil contamination.	Reduction in toxicity, mobility, and volume for the majority of the soil contamination.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Not applicable - no treatment.	No treatment residuals will remain on site.	Treatment residuals will include the treated soil which may be beneficially reused as fill material.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Not satisfied.	Satisfied.	Satisfied.

TABLE 6-1 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Soil RAA No. 1 No Action	Soil RAA No. 2 Institutional Controls	Soil RAA No. 3 Source Removal and Off Site Landfill Disposal	Soil RAA No. 4 Source Removal and Off Site Incineration	Soil RAA No. 5 Source Removal and Biological Treatment
SHORT-TERM EFFECTIVENESS					
• Community Protection	Potential risks to the community will not be increased.	Potential risks to the community will not be significantly increased.	Potential risks to the community will be temporarily increased during soil excavation and transportation activities.	Potential risks to the community will be temporarily increased during soil excavation and transportation activities; also, incinerator off-gases will increase risks to the community.	Potential risks to the community will be temporarily increased during soil excavation and transportation activities, and during biocell O&M.
• Worker Protection	No risks to workers.	No significant risks to workers.	Potential risks to workers will be temporarily increased during soil excavation and transportation activities.	Potential risks to workers will be temporarily increased during soil excavation and transportation activities.	Potential risks to workers will be temporarily increased during soil excavation and transportation activities, and during biocell O&M.
• Environmental Impact	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.	No additional environmental impacts.	Terrestrial receptors may potentially contact contaminated soil during treatment.
• Time Until Action is Complete	Not applicable.	Not applicable.	Approximately one month.	Approximately one month.	Amount of time is unknown. 5 years has been assumed for cost estimating purposes.

TABLE 6-1 (Continued)

DETAILED ANALYSIS OF SOIL ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Soil RAA No. 1 No Action	Soil RAA No. 2 Institutional Controls	Soil RAA No. 3 Source Removal and Off Site Landfill Disposal	Soil RAA No. 4 Source Removal and Off Site Incineration	Soil RAA No. 5 Source Removal and Biological Treatment
IMPLEMENTABILITY					
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Easy to implement if excavation remains above the water table; no O&M after soil is disposed; requires appropriate materials handling procedures.	Easy to implement if excavation remains above the water table; no O&M after soil is disposed; requires appropriate materials handling procedures.	Easy to implement if excavation remains above the water table; O&M for an extended period of time; O&M utilizes simple equipment and procedures; Lot 203 biocell must be available for use during the intended treatment schedule.
• Ability to Monitor Effectiveness	No monitoring plan for measuring effectiveness.	No monitoring plan for measuring effectiveness.	No monitoring plan for measuring effectiveness.	No monitoring plan for measuring effectiveness.	No monitoring plan for measuring effectiveness.
• Availability of Services and Capacities; Equipment	No services or equipment required.	No services or equipment required.	Services and equipment should be readily available.	Services and equipment should be readily available.	Services and equipment should be readily available.
• Requirements for Agency Coordination	None required.	No significant requirements.	Coordination with the Base Public Works/Planning Department and the Department of Transportation; federal and state acceptance of off site facility is required.	Coordination with the Base Public Works/Planning Department and the Department of Transportation; federal and state acceptance of off site facility is required.	Coordination with the Base Public Works/Planning Department; permit modification will be required for the Lot 203 biocell.
COST (Net Present Worth)	**$0**	**$0**	**$917,000**	**$3,150,000**	**$514,000**

7.0 DETAILED ANALYSIS OF THE GROUNDWATER ALTERNATIVES

This section contains a detailed analysis of the three Groundwater RAAs that were developed in Section 5.0. The detailed analysis has been conducted using the nine USEPA evaluation criteria defined in Section 6.1. These criteria include:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance (not evaluated at this time)
- Community Acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the ROD by addressing comments received after the TRC has reviewed the FS and the PRAP. The TRC includes participants from the NC DEHNR, USEPA Region IV, and the public.

The detailed analysis has been conducted to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD (USEPA, 1988). The extent to which alternatives are assessed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening (USEPA, 1988). (An initial screening of groundwater alternatives was not conducted.)

Section 7.1 presents an individual analysis of each groundwater alternative, with respect to the evaluation criteria, and Section 7.2 presents a comparative analysis of all the groundwater alternatives. (Please note that the detailed analysis of Soil RAAs was already presented in Section 6.0.)

7.1 <u>Individual Analysis of Alternatives</u>

The following subsections present the detailed analysis of the Groundwater RAAs on an individual basis. This individual analysis includes a brief description of each RAA and an assessment of how well the RAA performs against the evaluation criteria. Table 7-1 summarizes the individual, detailed analysis of groundwater alternatives.

7.1.1 Groundwater RAA No. 1: No Action

Description

Under the no action alternative, groundwater at Site 3 will remain as is. No active remedial actions will be implemented.

Assessment

Overall Protection of Human Health and the Environment: Under RAA No. 1, no remedial actions will be implemented. As a result, there will be no reduction in the human health risks associated with groundwater, and RAA No. 1 will not achieve Groundwater RAO #1 ("prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater"). Based on this information, RAA No. 1 will not provide overall protection of human health and the environment.

Compliance With ARARs: Under RAA No. 1, no active effort will be made to reduce contaminant levels to below chemical-specific ARARs (i.e., the RLs specified in Table 3-11). As a result, RAA No. 1 will not achieve Groundwater RAO #2 ("remediate groundwater in the shallow aquifer to the specified remediation levels"). A waiver of the chemical-specific ARARs may be required before this alternative can be implemented. No action-specific or location-specific ARARs apply to this no action alternative.

Long-Term Effectiveness and Permanence: Under RAA No. 1, contaminated groundwater will be left untreated at the site. However, the risks associated with leaving PAH-contaminated groundwater untreated may not be significant. PAH compounds exhibit low volatility and low water solubility. PAH compounds with increasing molecular weights exhibit decreasing water solubility. Because of their hydrophobic nature, PAHs tend to adsorb onto soils and sediments which makes them relatively immobile contaminants (Mahaffey, et·al.,1991). As a result, the groundwater AOCs are not likely to migrate beyond the limits identified in Figure 3-5. To reinforce this theory, a two-dimensional, horizontal flow model was conducted (see Appendix D). The model was conducted using the maximum concentration of the most mobile PAH contaminant, naphthalene, and the assumption that naphthalene will not biodegrade over time (which is a conservative assumption). The results of the model indicate that over time (up to 100 years), naphthalene from the Site 3 AOCs will not adversely affect the nearest potable water supply well, OW-3. According to the model, which assumes no contaminant biodegradation, naphthalene concentrations at OW-3 will be 0 mg/L in one year, 0.0003 mg/L in 30 years, and 0.012 mg/L in 100 years. None of these concentrations exceed the state standard for naphthalene (0.021 mg/L). In reality, some in situ biodegradation of the PAH contaminants is likely to occur so naphthalene concentrations at OW-3 will be even lower, if not negligible. Based on this information, the untreated PAH-contaminated groundwater will not pose significant risks to the nearest receptors that are currently located on Base. However, future potential receptors located in the vicinity of Site 3 could be affected by the PAH-contaminated groundwater if adequate precautions or controls are not implemented.

RAA No. 1 provides no means for avoiding human exposure (i.e., no controls). Therefore, RAA No. 1 will not provide long-term effectiveness and permanence. 5-year reviews by the lead agency will be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The no action alternative does not provide an active treatment process. Thus, there will be no toxicity, mobility, or volume reduction through treatment, and RAA No. 1 does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: There are no remedial action activities associated with RAA No. 1. As a result, short-term potential risks to the community and workers will not be increased, and there will be no additional environmental impacts.

Implementability: The no action alternative is implementable since no additional construction or operation activities will be conducted. In terms of administrative feasibility, RAA No. 1 should not require additional coordination with other agencies. However, a waiver of the federal and state ARARs may be required since contaminants levels exceeding these ARARs will be left on site. The availability of services, materials, and/or technologies is not applicable to this alternative.

If groundwater quality appears to be deteriorating, additional remedial actions could easily be implemented under RAA No. 1.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the NPW is $0.

7.1.2 Groundwater RAA No. 2: Institutional Controls and Monitoring

Description

Under RAA No. 2, contaminated groundwater at Site 3 will remain as is; no remedial actions involving treatment will be implemented. However, institutional controls (including aquifer use restrictions and deed restrictions) and a long-term groundwater monitoring program will be implemented. Under the proposed monitoring program, samples will be periodically collected from seven existing monitoring wells (03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW07, 03-MW08, and 03-MW11IW) and analyzed for TCL VOCs, TCL SVOCs, and TAL inorganics. For cost estimating purposes, 5 years of quarterly sampling followed by 25 years of semiannual sampling have been assumed. The aquifer use restrictions, implemented via the Base Master Plan, will prohibit future use of the shallow and Castle Hayne aquifers, within the immediate vicinity of Site 3, as potable water sources. The deed restrictions will prevent future placement of wells at the site.

Assessment

Overall Protection of Human Health and the Environment: Under RAA No. 2, institutional controls and long-term groundwater monitoring will reduce the human health risks associated with exposure to contaminated groundwater. The monitoring program will track contaminant concentrations (VOCs and SVOCs) in both the shallow and Castle Hayne aquifers. If the monitoring program indicates that contaminant levels are increasing or migrating toward operating supply wells, appropriate action can be taken before exposure occurs. (However, based on flow model presented in Appendix D, contaminants are not expected to migrate to the nearest supply wells.) Aquifer use and deed restrictions will prohibit use of the shallow and Castle Hayne aquifers, in the immediate vicinity of Site 3, as potable water sources. Consequently, these restrictions will prevent the potential for direct human exposure to contaminated groundwater. Based on this information, RAA No. 2 will achieve Groundwater RAO #1 ("prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater"), and RAA No. 2 will provide overall protection of human health and the environment.

***Compliance With ARARs*:** Under RAA No. 2, no active effort will be made to reduce contaminant levels to below chemical-specific ARARs (i.e., the groundwater RLs specified in Table 3-11). As a result, RAA No. 2 will not achieve Groundwater RAO #2 ("remediate groundwater in the shallow aquifer to the specified remediation levels"). This alternative may require a waiver of the chemical-specific ARARs before it can be implemented. No action-specific or location-specific ARARs apply to this alternative.

***Long-Term Effectiveness and Permanence*:** Under RAA No. 2, contaminated groundwater will be left untreated at the site. However, the risks associated with leaving the PAH-contaminated groundwater untreated may not be significant. PAH compounds exhibit low volatility and low water solubility. PAH compounds with increasing molecular weights exhibit decreasing water solubility. Because of their hydrophobic nature, PAHs tend to adsorb onto soils and sediments which makes them relatively immobile contaminants (Mahaffey, et al.,1991). As a result, the groundwater AOCs are not likely to migrate beyond the limits identified in Figure 3-5. To reinforce this theory, a two-dimensional, horizontal flow model was conducted (see Appendix D). The results of this model indicate that the untreated PAH-contaminated groundwater will not pose significant risks to the nearest receptor (potable water supply well OW-3) that is currently located on Base. (Note: Refer to the Long-Term Effectiveness and Permanence evaluation for RAA No. 1 [Section 7.1.1] for a more comprehensive discussion of the model and its results.) However, future potential receptors located in the vicinity of Site 3 could be affected by the PAH-contaminated groundwater if adequate precautions or controls are not implemented.

RAA No. 2 provides institutional controls (aquifer use restrictions and long-term monitoring) that will effectively prevent future human exposure. Therefore, RAA No. 2 will provide long-term effectiveness and permanence. Regardless, 5-year reviews by the lead agency will be required to ensure that adequate protection of human health and the environment is maintained.

***Reduction of Toxicity, Mobility, or Volume Through Treatment*:** RAA No. 2 does not provide an active treatment process. Thus, there will be no toxicity, mobility, or volume reduction through treatment, and RAA No. 2 does not satisfy the statutory preference for treatment.

***Short-Term Effectiveness*:** Under RAA No. 2, the only activity that may increase risks to the community and to workers is periodic groundwater sampling. However, potential risks to the community and workers will only be slightly increased. RAA No. 2 will not create any additional environmental impacts. The time required for the action to be complete cannot be estimated, but thirty years was assumed for cost estimating purposes.

***Implementability*:** RAA No. 2 is a technically implementable alternative since groundwater sampling and ordinance procurement have been easily implemented in the past. In addition, groundwater monitoring wells have proven to be a reliable technology. If groundwater quality appears to be deteriorating over time, additional remedial actions could easily be implemented along with RAA No. 2.

In terms of administrative feasibility, this alternative will not require additional coordination with other agencies. However, semiannual reports must be submitted to document sampling procedures. In addition, all required services, materials, and/or technologies should be readily available.

Cost: The estimated capital cost associated with RAA No. 2 is $0. The projected annual O&M costs are approximately $63,800 for quarterly sampling in years 1-5, and $33,200 for semiannual sampling in years 6-30. Assuming an annual percentage rate of 5 percent, the NPW of this alternative is $643,000. Table C-4 (Appendix C) presents a cost estimate for Groundwater RAA No. 2.

7.1.3 Groundwater RAA No. 3: Extraction and On Site Carbon Adsorption Treatment

Description

RAA No. 3 involves the installation of two extraction wells (in the shallow aquifer) that will intercept the two groundwater AOCs identified in Figure 3-5. One extraction well will be positioned near existing well 03-MW02, and one extraction well will be positioned near existing well 03-MW06. Groundwater from both wells will be transported to an on site treatment plant where it will undergo pretreatment for oil/water separation and suspended solids/metals removal, then carbon adsorption treatment. The treated groundwater will be discharged into a nearby sanitary sewer line for subsequent discharge to one of the sewage treatment plants located on Base. In addition to groundwater extraction and treatment, RAA No. 3 includes aquifer use restrictions and deed restrictions as institutional controls, and a long-term groundwater monitoring program. Under the monitoring program, wells 03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW07, 03-MW08, and 03-MW11IW will be periodically sampled; samples will be analyzed for TCL VOCs, TCL SVOCs, and TAL inorganics.

Assessment

Overall Protection of Human Health and the Environment: Because RAA No. 3 provides active groundwater remediation, institutional controls, and a long-term groundwater monitoring program, this alternative will reduce potential risks to human health. The pump and treat system will effectively collect and treat the groundwater contaminants. By alleviating some of the groundwater contamination, the pump and treat system will be reducing human health risks associated with groundwater. The long-term monitoring program will track contaminant (VOC and SVOC) concentrations in both the shallow and Castle Hayne aquifers. If the monitoring program indicates that contaminant levels are increasing or migrating toward operating supply wells, appropriate action can be taken before exposure occurs. (However, based on flow model presented in Appendix D, contaminants are not expected to migrate to the nearest supply wells.) Aquifer use and deed restrictions will prohibit use of the shallow and Castle Hayne aquifers, within the immediate vicinity of Site 3, as potable water sources. Thus, these restrictions will prevent the possibility that human receptors may ingest, dermally contact, or inhale contaminated groundwater. Based on this information, RAA No. 3 will achieve Groundwater RAO #1 ("prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater"). In addition, RAA No. 3 provides overall protection of human health and the environment.

Compliance With ARARs: Because RAA No. 3 involves collecting the contaminated groundwater and actively treating it, the contaminants could potentially meet chemical-specific ARARs (i.e., the groundwater RLs specified in Table 3-11). However, there are technical limitations associated with groundwater extraction systems that may affect their ability to achieve stringent ARARs. Groundwater contaminants, especially PAHs, may sorb to solid particles or escape into subsurface pore spaces or fissures where they become difficult to extract. Therefore, RAA No. 3 may not be able to completely remediate the aquifer to the most stringent chemical-specific ARARs; RAA No. 3 will most likely not achieve Groundwater RAO #2 ("remediate groundwater in the shallow aquifer to the specified remediation levels").

RAA No. 3 can be designed to meet the location-specific and action-specific ARARs that apply to it (see Section 3.0).

Long-Term Effectiveness and Permanence: Under RAA No. 3, PAH-contaminated groundwater will be collected and treated at an on site treatment plant. However, the pump and treat system will only be effective to a certain extent. Technologies for completely extracting contaminants from groundwater are not proven. Contaminants, especially PAHs, may sorb to solid particles or escape into subsurface pore spaces or fissures where they become difficult to extract. Also, contaminants may continue to leach from solid particles into the groundwater. As a result, the extraction technologies included under RAA No. 3 may not be effective at completely remediating the aquifer, and RAA No. 3 may not provide a high level of long-term effectiveness and permanence.

The potential for inorganics precipitation to clog well screens also limits the reliability of the extraction well technology. In addition, there is a potential for equipment replacement and/or repairs for both the extraction wells and the treatment plant equipment.

On the other hand, the proposed monitoring program and periodic O&M system checks at the treatment plant will be adequate and reliable controls for determining the effectiveness of RAA No. 3. As long as they are enforced over time, aquifer use and deed restrictions will be adequate and reliable controls for preventing future human exposure to contaminated groundwater. Regardless, 5-year reviews by the lead agency will be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The treatment processes associated with RAA No. 3 include liquid-phase carbon adsorption for VOC removal, neutralization, precipitation, flocculation, sedimentation, and filtration for suspended solids/metals removal, and oil/water separation.

These treatment processes will reduce the toxicity and volume of contaminants collected by the extraction wells. However, the extraction wells will only be able to collect some of the groundwater contamination. Some of the contamination will remain in the aquifer adsorbed to soils and sediments or trapped in pore spaces and fissures. In addition, the extraction wells will reduce the mobility of the majority of the groundwater contamination. The time frame in which these reductions will occur is assumed to be 30 years.

RAA No. 3 satisfies the statutory preference for treatment. Residuals remaining after treatment may include metals sludge, separated oil, exhausted carbon, and treated groundwater.

Short-Term Effectiveness: Dust production during the underground piping and extraction well installation may cause some risk to the community. In addition, workers may require protection during the installation and operation of the pump and treat system. In terms of environmental impacts, RAA No. 3 may cause aquifer drawdown during groundwater extraction.

The exact amount of time required to complete the remedial action is unknown. For costing purposes, 30 years of system operation and groundwater monitoring have been assumed.

Implementability: RAA No. 3 is a technically implementable alternative. Based on past experience and case studies, no major technical difficulties are anticipated under construction and operation of a pump and treat system. All of the associated technologies are conventional and well-demonstrated to be implementable. However, operation of the system will be energy-intensive and frequent maintenance and equipment replacement may be required. In addition, dissolved metals will most likely precipitate out of solution and clog the extraction well screens.

If the long-term monitoring program indicates that groundwater quality is deteriorating, additional remedial actions could easily be implemented under RAA No. 3.

In terms of administrative feasibility, RAA No. 3 will require extensive coordination with the Base Public Works/Planning Department. Also, the substantive requirements of water discharge permits will have to be met. However, all required services, materials, and/or technologies should be readily available.

Cost: The estimated capital cost associated with RAA No. 3 is $422,000. The projected annual O&M costs are $63,800 for quarterly sampling in years 1-5, $33,200 for semiannual sampling in years 6-30, and $84,800 for treatment system O&M in years 1-30. Assuming an annual percentage rate of 5 percent, the NPW of this alternative is $2,369,000. Table C-5 (Appendix C) presents the cost estimate for Groundwater RAA No. 3.

7.2 Comparative Analysis

This section presents a comparative analysis of the groundwater RAAs. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each RAA.

7.2.1 Overall Protection of Human Health and the Environment

RAA No. 1, the no action alternative, will not reduce the human health risks associated with groundwater. On the other hand, RAA Nos. 2 and 3 will reduce human health risks because both alternatives include institutional controls and long-term monitoring. The institutional controls will prevent human receptors from ingesting, dermally contacting, or inhaling groundwater contaminants. Long-term monitoring will provide a warning system against contaminants that have migrated to unsafe locations, and contaminants that have increased to unsafe levels, so that human exposure can be avoided. Thus, RAA Nos. 2 and 3 will achieve Groundwater RAO #1 ("prevent the potential for direct exposure via ingestion, dermal contact, and inhalation, to contaminated groundwater"), but RAA No. 1 will not. In addition, RAA Nos. 2 and 3 will provide overall protection of human health and the environment, but RAA No. 1 will not.

Compared to RAA Nos. 1 and 2, RAA No. 3 provides some additional protection to human health and the environment by collecting the groundwater contaminants and actively treating them at an on site treatment plant. However, this additional protection is not necessary to prevent future human exposure to the groundwater contaminants. PAHs exhibit low volatility and low aqueous solubility; due to their hydrophobic nature, they tend to adsorb onto soils and sediment (Mahaffey, et. al., 1991). As a result, the PAH contaminants at Site 3 will have a low migration potential so it is unlikely that they will horizontally or vertically migrate to the nearest current receptors.

7.2.2 Compliance with ARARs

RAA Nos. 1 and 2 will allow contaminant levels exceeding chemical-specific ARARs (i.e., the groundwater RLs identified in Table 3-11) to remain in groundwater at the site. Therefore, RAA Nos. 1 and 2 will not comply with chemical-specific ARARs and they will not achieve Groundwater

RAO #2 ("remediate groundwater in the shallow aquifer to the specified remediation levels"). RAA Nos. 1 and 2 may also require a waiver of the chemical-specific ARARs before these alternatives can be implemented. RAA No. 3 could potentially remediate the groundwater to chemical-specific ARARs, but most likely this alternative will not achieve such stringent cleanup standards. Groundwater contaminants, especially PAHs, may sorb to solid particles or escape into subsurface pore spaces or fissures where they become difficult to extract. Most likely, extraction wells will only collect a portion of the PAH contamination; the remaining PAH contamination will remain in the groundwater. Therefore, extraction wells may not be able to completely remediate the aquifer to the most stringent chemical-specific ARARs, and RAA No. 3 may not achieve Groundwater RAO #2 ("remediate groundwater in the shallow aquifer to the specified remediation levels").

No location- or action-specific ARARs apply to RAA Nos. 1 and 2. RAA No. 3 can be designed to meet all of the location- and action- specific ARARs that apply to it.

7.2.3 Long-Term Effectiveness and Permanence

RAA No. 3 will provide long-term effectiveness and permanence because it involves collection and treatment of the contaminated groundwater. Although RAA No. 2 will allow groundwater contaminants to remain untreated at the site, this alternative will also provide long-term effectiveness and permanence. Based on the hydrophobic nature of PAH contaminants, and the results of the two-dimensional flow model presented in Appendix D, leaving PAH contaminants untreated at the site will not affect the nearest, current receptors. It may affect future receptors occurring in the vicinity of Site 3, but RAA No. 2 includes institutional controls and long-term monitoring that will effectively prevent future human exposure. RAA No. 1, on the other hand, provides no means for preventing future human exposure so this alternative will not provide long-term effectiveness and permanence.

The pump and treat system included under RAA No. 3 will only be adequate and reliable to a certain extent. Technologies for completely extracting contaminants from groundwater are not proven. Contaminants, especially PAHs, may adsorb to solid particles or escape into subsurface pore spaces or fissures where they become difficult to extract. Also, contaminants may continue to leach from solid particles into the groundwater. As a result, extraction wells may not be completely reliable for removing PAH contaminants from the shallow aquifer.

All three RAAs will require 5-year reviews by the lead agency to ensure that adequate protection of human health and the environment is maintained.

7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA No. 3 will reduce the toxicity, mobility, and volume of contaminated groundwater that is collected by the extraction wells. However, some of the contaminated groundwater will not be collected so it will not receive treatment. This is because PAH contaminants may adsorb to soils and sediments and escape in pore spaces and fissures. Unlike RAA No. 3, RAA Nos. 1 and 2 do not involve active treatment processes. Therefore, RAA Nos. 1 and 2 will not reduce the toxicity, mobility, or volume of groundwater contamination.

Unlike RAA Nos. 1 and 2, RAA No. 3 will create treatment residuals. The residuals associated with RAA 3 (sludge, separated oil, exhausted carbon, and treated groundwater) will be voluminous and must be properly treated and/or disposed.

RAA No. 3 satisfies the statutory preference for treatment; RAA Nos. 1 and 2 do not.

7.2.5 Short-Term Effectiveness

Implementation of RAA Nos. 1 and 2 does not pose substantial risks to the community or to workers. Implementation of RAA No. 3 does pose risks because it involves construction of extraction wells, underground pipelines, and a treatment facility. During pipeline construction, special care must be taken to avoid underground utilities. RAA No. 3 also involves long-term operation and maintenance of an extraction well system and an on site treatment facility. The treatment facility will generate residual waste streams that must be properly treated and/or disposed. Because it creates aquifer drawdown, RAA No. 3 is the only alternative that could potentially create environmental impacts.

Under all three RAAs, the time for the action to be complete is unknown. Thirty years of groundwater monitoring was assumed for RAA No. 2, and 30 years of groundwater monitoring and treatment system O&M was assumed for RAA No. 3.

7.2.6 Implementability

RAA No. 1 is the easiest alternative to implement, if not the most effective. RAA No. 2 is the next most implementable alternative followed by RAA No. 3. RAA No. 1 requires no operation or maintenance. RAA No. 2 requires minimal operation and maintenance (groundwater samples will be collected semiannually and wells will have to be replaced periodically). RAA No. 3, however, requires extensive operation and maintenance. Under all three RAAs, additional remedial actions could easily be implemented.

RAA Nos. 2 and 3 involve conventional equipment and services that should be readily available. Compared to RAA No. 2, RAA No. 3 will all require more extensive coordination with the Base Public Works/Planning department. Unlike RAA No. 1, RAA Nos. 2 and 3 will require semiannual submission of reports that document sampling results. Unlike RAA No. 3, RAA Nos. 1 and 2 may require a waiver of ARARs since groundwater contaminants will be left untreated at the site.

7.2.7 Cost

In terms of NPW, the no action alternative (RAA No. 1) would be the least expensive RAA to implement, followed by RAA No. 2, then RAA No. 3. The estimated NPW values in increasing order are \$0 (RAA No. 1), \$643,000 (RAA No. 2), and \$2,369,000 (RAA No. 3).

SECTION 7.0 TABLES

TABLE 7-1

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Groundwater RAA No. 1 No Action	Groundwater RAA No. 2 Institutional Controls and Monitoring	Groundwater RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
OVERALL PROTECTIVENESS			
• Human Health	No reduction in potential human health risks.	Institutional controls and long-term monitoring will reduce potential human health risks.	Institutional controls, long-term monitoring, and groundwater extraction/treatment will reduce potential human health risks.
• Environmental Protection	No reduction in potential risks to ecological receptors.	No reduction in potential risks to ecological receptors.	No reduction in potential risks to ecological receptors.
COMPLIANCE WITH ARARs			
• Chemical-Specific ARARs	Contaminant levels exceeding chemical-specific ARARs will remain in the groundwater.	Contaminant levels exceeding chemical-specific ARARs will remain in the groundwater.	Contaminant levels exceeding chemical-specific ARARs will most likely remain in the groundwater.
• Location-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Can be designed to meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE			
• Magnitude of Residual Risk	Risks to contaminated groundwater will remain unchanged; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.	Institutional controls and monitoring will reduce the risks associated with contaminated groundwater; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.	Institutional controls and monitoring will reduce the risks associated with contaminated groundwater; these risks will be minimal considering the hydrophobic nature of the PAH contaminants.
• Adequacy and Reliability of Controls	Not applicable - no controls.	The monitoring program is adequate and reliable for determining the alternative's effectiveness. If they are enforced over time, aquifer use and deed restrictions will be adequate and reliable for preventing human exposure to the groundwater.	Once designed/sized in accordance with site-specific characteristics, extraction/treatment should be both adequate and reliable. The monitoring program is adequate and reliable for determining the alternative's effectiveness. If they are enforced over time, aquifer use and deed restrictions will be adequate and reliable for preventing human exposure to the groundwater.

TABLE 7-1 (Continued)

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Groundwater RAA No. 1 No Action	Groundwater RAA No. 2 Institutional Controls and Monitoring	Groundwater RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
LONG-TERM EFFECTIVENESS AND PERMANENCE (continued)			
• Need for 5-year Review	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT			
• Treatment Process Used	No treatment process.	No treatment process.	Extraction wells, liquid-phase carbon adsorption, metals pretreatment, oil/water separation.
• Amount Destroyed or Treated	None.	None.	Some of the contamination will be treated; some will remain adsorbed to subsurface soil particles or trapped in pores spaces and fissures.
• Reduction of Toxicity, Mobility, or Volume Through Treatment	None.	None.	Some.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Treatment residuals will include sludge, separated oil, exhausted carbon, and treated groundwater.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Satisfied.
SHORT-TERM EFFECTIVENESS			
• Community Protection	Potential risks to the community will not be increased during implementation.	Potential risks to the community will not be significantly increased.	Potential risks to the community will be increased during installation of the extraction/treatment system, and during system operation.
• Worker Protection	No risks to workers.	Potential risks to workers will be slightly increased; worker protection is required.	Potential risks to workers will be increased; worker protection is required.
• Environmental Impact	No additional environmental impacts.	No additional environmental impacts.	Potential for aquifer drawdown.
• Time Until Action is Complete	Not applicable.	Not applicable.	Unknown; 30 years has been assumed for cost estimating purposes.

TABLE 7-1 (Continued)

DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	Groundwater RAA No. 1 No Action	Groundwater RAA No. 2 Institutional Controls and Monitoring	Groundwater RAA No. 3 Extraction and On Site Carbon Adsorption Treatment
IMPLEMENTABILITY			
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Based on past experience, a pump and treat system will be easy to construct and operate. Utilities may make pipeline construction challenging. Disposal of treatment residuals (i.e., sludge and oil) and inorganics precipitation on the well screens may also make system operation challenging.
• Reliability of Technology	Not applicable.	Monitoring wells are a reliable technology.	Inorganics may precipitate on the well screens creating the need for well replacement. Also, the long operation time for the system may necessitate equipment replacement. If contaminants migrate into inaccessible regions, the pump and treat system will be less effective at collecting them (MacDonald, 1995).
• Ease of Undertaking Additional Remedial Actions	Additional remedial actions can be easily implemented.	Additional remedial actions can be easily implemented.	Additional remedial actions can be easily implemented.
• Ability to Monitor Effectiveness	No monitoring plan. Failure to detect contamination could result in human/environmental exposure.	Monitoring plan will detect contaminants before significant exposure can occur.	Monitoring plan will detect contaminants before significant exposure can occur.
• Availability of Services and Equipment	No services or equipment required.	Services and equipment are readily available.	Services and equipment are readily available.
• Requirements for Agency Coordination	No requirements.	Must submit semiannual reports to document sampling.	The substantive requirements of water discharge permits must be met; must submit semiannual reports to document sampling.
COST (Net Present Worth)	**$0**	**$643,000**	**$2,369,000**

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APPENDIX A
RISK-BASED RGO CALCULATIONS

Computed by: MDB

Date: 2/96

EXAMPLE GROUNDWATER RGO CALCULATION
OPERABLE UNIT NO. 12 (SITE 3)
CONTRACT TASK ORDER 0274

Purpose: **Estimate groundwater concentration which does not produce carcinogenic risk in excess of 1 x 10-6 or a noncarcinogenic risk in excess of 1.0.**

$$C(mg/L) = \frac{TR \text{ or } THI \times BW \times AT \times DY}{IR \times EF \times ED \times CSF \text{ or } 1/RfD}$$

Where:

TR	=	Target Carcinogenic Risk
THI	=	Target Hazard Index
BW	=	Body Weight (kg)
AT	=	Averaging time (years)
DY	=	Days per year (day/year)
IR	=	Ingestion rate (L/day)
EF	=	Exposure frequency (day/yr)
ED	=	Exposure duration (years)
CSF	=	Carcinogenic Slope Factor $(mg/kg.day)^{-1}$

Example Carcinogen: Benzene

$$C(mg/L) = \frac{1.0x10^{-6} \times 70\ kg \times 70\ yrs \times 365\ days/yr}{2^{L}/day \times 350\ day/yr \times 30 \times 2.9 \times 10^{-2}\ mg/kg.day^{-1}}$$

= 0.0029

Example Noncarcinogen: 1,1-Dichloroethene

$$C(mg/L) = \frac{1.0 \times 70\ kg \times 30\ yrs \times 365\ days/yr}{24\ day \times 350\ days/yr \times 30\ yrs \times 1/9.0E^{-03}\ mg/kg.day}$$

= .3285

INGESTION OF GROUNDWATER REMEDIATION LEVEL
FEASABILITY STUDY CTO-0274
OPERABLE UNIT NO. 12 (SITE 3)
MCB CAMP LEJEUNE
ADULT RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-06
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	2
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	30
BW = body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Benzene	2.937	2	350	30	70	70	365	2.90E-02	1.0E-06
Carbazole	4.258	2	350	30	70	70	365	2.00E-02	1.0E-06
Chloroform	13.962	2	350	30	70	70	365	6.10E-03	1.0E-06
Trichloroethene (3)	7.742	2	350	30	70	70	365	1.10E-02	1.0E-06
1,1-dichloroethene	0.142	2	350	30	70	70	365	6.00E-01	1.0E-06
Benzo(a)anthracene	0.117	2	350	30	70	70	365	7.30E-01	1.0E-06
Benzo(b)fluoranthene	0.117	2	350	30	70	70	365	7.30E-01	1.0E-06
Benzo(k)fluoranthene	1.167	2	350	30	70	70	365	7.30E-02	1.0E-06
Chrysene	11.667	2	350	30	70	70	365	7.30E-03	1.0E-06
Benzo(a)pyrene	0.012	2	350	30	70	70	365	7.30E+00	1.0E-06

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
1,1-dichloroethene	328	2	350	30	70	30	365	9.00E-03	1.00
chloroform	365	2	350	30	70	30	365	1.00E-02	1.00
Trichloroethene (3)	219	2	350	30	70	30	365	6.00E-03	1.00
Toluene (3)	7300	2	350	30	70	30	365	2.00E-01	1.00
Ethylbenzene (3)	3650	2	350	30	70	30	365	1.00E-01	1.00
Xylene (3)	73000	2	350	30	70	30	365	2.00E+00	1.00
Phenol(3)	21900	2	350	30	70	30	365	6.00E-01	1.00
Acenaphthylene (3)	2190	2	350	30	70	30	365	6.00E-02	1.00
Anthracene (3)	10950	2	350	30	70	30	365	3.00E-01	1.00
Fluoranthene (3)	1460	2	350	30	70	30	365	4.00E-02	1.00
Pyrene (3)	1095	2	350	30	70	30	365	3.00E-02	1.00
2-methylphenol	1825	2	350	30	70	30	365	5.00E-02	1.00
4-methylphenol	183	2	350	30	70	30	365	5.00E-03	1.00
2,4-dimethylphenol	730	2	350	30	70	30	365	2.00E-02	1.00
naphthalene	1460	2	350	30	70	30	365	4.00E-02	1.00
acenaphthene	2190	2	350	30	70	30	365	6.00E-02	1.00
dibenzofuran	146	2	350	30	70	30	365	4.00E-03	1.00
fluorene	1460	2	350	30	70	30	365	4.00E-02	1.00
phenanthrene(1)	1095	2	350	30	70	30	365	3.00E-02	1.00
2-methlynaphthalene(2)	1460	2	350	30	70	30	365	4.00E-02	1.00

(1) Pyrene used as a surrogate
(2) Naphthalene used as a surrogate
(3) Not retained as COPCs in the human health risk assessment
Evaluated as criteria-based COPCs in the RI report
File Name: GWIA.WQ1

INGESTION OF GROUNDWATER REMEDIATION LEVEL
FEASABILITY STUDY CTO-0274
OPERABLE UNIT NO. 12 (SITE 3)
MCB CAMP LEJEUNE
CHILD RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-06
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	1
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	6
BW = body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Benzene	6.293	1	350	6	15	70	365	2.90E-02	1.0E-06
Carbazole	9.125	1	350	6	15	70	365	2.00E-02	1.0E-06
Chloroform	29.918	1	350	6	15	70	365	6.10E-03	1.0E-06
Trichloroethene (3)	16.591	1	350	6	15	70	365	1.10E-02	1.0E-06
1,1-dichloroethene	0.304	1	350	6	15	70	365	6.00E-01	1.0E-06
Benzo(a)anthracene	0.250	1	350	6	15	70	365	7.30E-01	1.0E-06
Benzo(b)fluoranthene	0.250	1	350	6	15	70	365	7.30E-01	1.0E-06
Benzo(k)fluoranthene	2.500	1	350	6	15	70	365	7.30E-02	1.0E-06
Chrysene	25.000	1	350	6	15	70	365	7.30E-03	1.0E-06
Benzo(a)pyrene	0.025	1	350	6	15	70	365	7.30E+00	1.0E-06

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
1,1-dichloroethene	141	1	350	6	15	6	365	9.00E-03	1.00
chloroform	156	1	350	6	15	6	365	1.00E-02	1.00
Trichloroethene (3)	94	1	350	6	15	6	365	6.00E-03	1.00
Toluene (3)	3129	1	350	6	15	6	365	2.00E-01	1.00
Ethylbenzene (3)	1564	1	350	6	15	6	365	1.00E-01	1.00
Xylene (3)	31286	1	350	6	15	6	365	2.00E+00	1.00
Phenol(3)	9386	1	350	6	15	6	365	6.00E-01	1.00
Acenaphthylene (3)	939	1	350	6	15	6	365	6.00E-02	1.00
Anthracene (3)	4693	1	350	6	15	6	365	3.00E-01	1.00
Fluoranthene (3)	626	1	350	6	15	6	365	4.00E-02	1.00
Pyrene (3)	469	1	350	6	15	6	365	3.00E-02	1.00
2-methylphenol	782	1	350	6	15	6	365	5.00E-02	1.00
4-methylphenol	78	1	350	6	15	6	365	5.00E-03	1.00
2,4-dimethylphenol	313	1	350	6	15	6	365	2.00E-02	1.00
naphthalene	626	1	350	6	15	6	365	4.00E-02	1.00
acenaphthene	939	1	350	6	15	6	365	6.00E-02	1.00
dibenzofuran	63	1	350	6	15	6	365	4.00E-03	1.00
fluorene	626	1	350	6	15	6	365	4.00E-02	1.00
phenanthrene(1)	469	1	350	6	15	6	365	3.00E-02	1.00
2-methlynaphthalene(2)	626	1	350	6	15	6	365	4.00E-02	1.00

(1) Pyrene used as a surrogate
(2) Naphthalene used as a surrogate
(3) Not retained as COPCs in the human health risk assessment
Evaluated as criteria-based COPCs in the RI report
File Name: GWIC.WQ1

APPENDIX B
RADIUS OF INFLUENCE CALCULATIONS

S.O. No. 62470-274

Subject: SITE 3 – CALCS FOR RECOVERY WELL IN SURFICIAL AQUIFER BASED ON KEELY + TSANG

Sheet No. 1 of 7

Drawing No.

Computed by EJK Checked By [signature]

Date 31 JAN. 1996

Baker

AQUIFER PARAMETERS

TRANSMISSIVITY $(T) = 48\ ft^2/DAY \Longrightarrow 359\ gpd/ft$ (BAKER 1996)

STORATIVITY $(S) = 5.067\ E^{-2}$ (BAKER 1993)

HYDRAULIC CONDUCTIVITY $(K) = 3.2\ ft/DAY$ (BAKER 1996)

GROUNDWATER VELOCITY $(V) = 0.41$ feet/DAY (BAKER 1996)

GRADIENT $(i) = 0.045\ ft/ft$ (BAKER 1996)

SATURATED AQUIFER THICKNESS (b) or $(h) = 15\ ft$ (BAKER 1996)

EFFECTIVE POROSITY $(n) = 35\% \Longrightarrow 0.35$ (BAKER 1996)

INTERCEPTED DISCHARGE LENGTH = L

EQUATION VARIABLES

DISCHARGE $(Q) = TiL/1440$

$L = Q(1440)/Ti$

$r_{(c)} = 720\ Q/\pi Ti$

$r_{(i)} = r_{(c)}/\pi$

$d_{(c)} = 2\ r_{(c)}$

CALCULATIONS

$L = 1\ (1440)/359\ (0.045)$ $\quad$ $L = 5\ (1440)/359\ (0.045)$

$= 89.14\ ft$ $\quad$ $= 445.68\ ft.$

$r_{(c)} = 720\ (1)/\pi\ (359)(0.045)$ $\quad$ $r_{(c)} = 720\ (5)/\pi\ (359)(0.045)$

$= 14.19\ ft.$ $\quad$ $= 70.93\ ft.$

$r_{(i)} = 14.19/\pi$ $\quad$ $r_{(i)} = 70.93/\pi$

$= 4.52\ ft.$ $\quad$ $= 22.58\ ft.$

$d_{(c)} = 2\ (14.19)$ $\quad$ $d_{(c)} = 2\ (70.93)$

$= 28.38\ ft$ $\quad$ $= 141.86\ ft.$

S.O. No. 62470 - 274

Subject: SITE 3 - CALCS. FOR RECOVERY WELL IN SURFICIAL AQUIFER BASED ON KEELY (1983)

Sheet No. 2 of 7

Drawing No.

Computed by EJK Checked By [signature]

Date 31 JAN. 1996
8 FEB. 1996

Baker

SPACING OF EXTRACTION WELLS

EQUATIONS :

$$r = \frac{Q}{2\pi h n V_n} \qquad V_h = \frac{Ti}{bn} \qquad \text{if } h = b, \text{ THEN}$$

$$r = \frac{Q}{2\pi Ti} \Longrightarrow \text{DOWNGRADIENT STAGNANT POINT}$$

$2\pi r$ = INFLOW ZONE

πr = INFLOW ZONE ON ONE SIDE OF WELL OR RADIUS OF INFLUENCE

$$r = \frac{Q}{2\pi Ti} = \frac{1440}{2\pi(359)(0.045)} = 14.19 \text{ ft.}$$

$$r = \frac{Q}{2\pi Ti} = \frac{7200}{2\pi(359)(0.045)} = 70.9 \text{ ft.}$$

$$\pi r = \pi(14.19) = 44.57 \text{ ft.}$$

$$2\pi r = 89.16 \text{ ft}$$

$$\pi r = \pi(70.9) = 222.7 \text{ ft.}$$

$$2\pi r = 445.5 \text{ ft.}$$

CONCLUSIONS

THE RADIUS OF INFLUENCE FOR 1 gpm (89 ft.) AND 5 gpm (223 ft.) APPEAR REALISTIC BASED ON SITE CONDITIONS/CHARACTERISTICS, DETECTED CONTAMINATION AND PAST EXPERIENCE WITH THE ASSUMED DISCHARGE RATES OF 1 gpm AND 5 gpm.

S.O. No. 62470 - 274

Subject: SITE 3 - CALCS FOR RECOVERY WELL IN SURFICIAL AQUIFER THEIS EQUATION

Sheet No. 3 of 7

Drawing No.

Computed by EJK Checked By [signature] Date 31 JAN 1996

Baker

AQUIFER PARAMETERS

TRANSMISSIVITY (T) = 48 ft^2/DAY ⟹ 359 gpd/ft (BAKER 1996)
DRAWDOWN AT BOUNDARY OF INFLUENCE (s) = 0.25 ft (BAKER 1993)

DISCHARGE RATE (Q) = ASSUME 1 gpm, 3 gpm AND 5 gpm

$W_{(u)}$ = "WELL FUNCTION OF U"; EXPONENTIAL INTEGRAL USED IN CONNECTION W/ APPENDIX 9.E TABLE FROM GROUNDWATER AND WELLS (DRISCOLL, 1986)

r = RADIUS IN FT. FROM CENTER OF PUMPED WELL TO A POINT WHERE DRAWDOWN IS MEASURED

STORATIVITY OF AQUIFER (S) = 5.067 E^{-2} (BAKER 1996)

TIME SINCE PUMPING STARTED, IN DAYS (t) = USE 30, 60 + 90

u — OBTAINED FROM APPENDIX 9.E TABLE

EQUATION VARIABLES

$$s\,(\text{DRAWDOWN}) = \frac{114.6\, Q\, W_{(u)}}{T}$$

$$W_{(u)} = \frac{s\,T}{114.6\, Q}$$

$$u = \frac{1.87\, r^2\, S\,(\text{STORATIVITY})}{T\,t}$$

$$r = \sqrt{\frac{u\,T\,t}{1.87\, S}}$$

S.O. No. 62470 - 274

Subject: SITE 3 - CALCS FOR RECOVERY WELL IN SURFICIAL AQUIFER

THEIS EQUATION

Sheet No. 4 of 7

Drawing No.

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CALCULATIONS

$$W_{(u)} = \frac{s\,T}{114.6\,Q}$$

$$= \frac{(0.25)(359)}{114.6\,(1)} \qquad W_{(u)} = \frac{(0.25)(359)}{114.6\,(3)} \qquad W_{(u)} = \frac{(0.25)(359)}{114.6\,(5)}$$

$$= 0.783 \qquad = 0.261 \qquad = 0.157$$

∴ FROM APPENDIX 9.E TABLE

$$u = 3.55\,E^{-1} \qquad u = 8.98\,E^{-1} \qquad u = 1.20$$

$$r = \sqrt{\frac{u\,T\,t}{1.87\,S}}$$

t = 30 DAYS:

$$r = \sqrt{\frac{(3.55\,E^{-1})(359)(30)}{1.87\,(5.067\,E^{-2})}} \qquad r = \sqrt{\frac{(8.98\,E^{-1})(359)(30)}{1.87\,(5.067\,E^{-2})}}$$

$$= 201 \text{ ft.} \qquad = 319 \text{ ft.}$$

$$r = \sqrt{\frac{(1.20)(359)(30)}{1.87\,(5.067\,E^{-2})}}$$

$$= 369 \text{ ft.}$$

S.O. No. 62470-274

Subject: SITE 3 - CALCS. FOR RECOVERY WELL IN SURFICIAL AQUIFER

THEIS EQUATION

Sheet No. 5 of 7

Drawing No.

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Date 31 JAN. 1996

Baker

$$r = \sqrt{\frac{u \cdot T\, t}{1.87\, S}}$$

t = 60 DAYS:

$$r = \sqrt{\frac{(3.55\, E^{-1})(359)(60)}{1.87\,(5.067\, E^{-2})}}$$

$$= 284 \text{ FT.}$$

$$r = \sqrt{\frac{(8.98\, E^{-1})(359)(60)}{1.87\,(5.06\, E^{-2})}}$$

$$= 452 \text{ FT.}$$

$$r = \sqrt{\frac{(1.20)(359)(60)}{1.87\,(5.067\, E^{-2})}}$$

$$= 522 \text{ FT.}$$

t = 90 DAYS:

$$r = \sqrt{\frac{(3.55\, E^{-1})(359)(90)}{1.87\,(5.067\, E^{-2})}}$$

$$= 348 \text{ FT.}$$

$$r = \sqrt{\frac{(8.98\, E^{-1})(359)(90)}{1.87\,(5.067\, E^{-2})}}$$

$$= 553 \text{ FT.}$$

$$r = \sqrt{\frac{(1.20)(359)(90)}{1.87\,(5.067\, E^{-2})}}$$

$$= 640 \text{ FT.}$$

S.O. No. 62470 - 274

Subject: SITE 3 - CALCS. FOR RECOVERY WELL IN SURFICIAL AQUIFER THEIS EQUATION

Sheet No. 6 of 7

Drawing No.

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Date 31 JAN 1996
8 FEB. 1996

Baker

THE TABLE ON SHEET 7 PRESENTS VARIOUS PUMPING RATES AND TIME DURATIONS (30, 60 + 90 DAYS). ALSO INCLUDED IN THE TABLE ARE THE CALCULATED $W_{(u)}$ AND u VALUES, AND THE ASSOCIATED RADIUS OF INFLUENCE DERIVED FROM ASSUMED AND CALCULATED VARIABLES FOR THE THEIS EQUATION.

THE CALCULATED RADII OF INFLUENCE (πr) FROM KEELY (1983) FOR DISCHARGE RATES OF 1, 3 AND 5 gpm ARE PRESENTED IN THE TABLE

* BASED ON EXISTING SITE CONDITIONS, THE SELECTED RADIUS OF INFLUENCE FOR AN EXTRACTION WELL IN THE SURFICIAL AQUIFER AT SITE 3 WILL BE ASSUMED TO BE <u>223 FEET</u> AT A PUMPING RATE OF <u>5 gpm</u> AS CALCULATED USING THE KEELY (1983) METHOD.

THEIS EQUATION					KEELY (1983)
Q (gpm)	W (u)	$u^{(1)}$	t (DAYS)	r (FEET)	πr (RAD. OF INFL.)
1	0.783	3.55 E^{-1}	30	201	45
3	0.261	8.98 E^{-1}	30	319	134
5	0.157	1.20	30	369	223
1	0.783	3.55 E^{-1}	60	284	—
3	0.261	8.98 E^{-1}	60	452	—
5	0.157	1.20	60	522	—
1	0.783	3.55 E^{-1}	90	348	—
3	0.261	8.98 E^{-1}	90	553	—
5	0.157	1.20	90	640	—

APPENDIX C
COST ESTIMATES

TABLE C-1

COST ESTIMATE: SOIL RAA NO. 3 - SOURCE REMOVAL AND OFF SITE LANDFILL DISPOSAL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF THE CONTAMINATED SOIL; TRANSPORTATION OF THE SOIL TO AN OFF SITE HAZARDOUS WASTE LANDFILL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Work, E&S, NPDES, H&S, and Quality Control Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 15,000	$ 15,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Record Drawings, etc.
Subtotal General Costs:					**$ 95,000**		
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	480	$ 2.20	$ 1,056		Eng. Estimate; Means 1996, 028-320-4800	
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Costs:					**$ 11,000**		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	Sample	36	$ 359	$ 12,924		Engineering Estimate	Cost from Baker BOAs; includes TCL SVOC analysis and validation; 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	1	$ 100	$ 100		Engineering Estimate	Assume $100
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors; 20% increase in soil
Subtotal Soil Excavation/Backfill Costs:					**$ 46,700**		
Soil Disposal							
Hauling	LS	1	$ 54,000	$ 54,000		Eng. Estimate; Vendor Quote	Assume 44 CY dump trailers; add 20% to soil volume after excavation 54 truckloads required @ $1,000 per load
Disposal - Landfill	Tons	3240	$ 170	$ 550,800		Eng. Estimate; Vendor Quote	Nearest RCRA-permitted Subtitle C facility is located in Pinewood, S.C.
Subtotal Soil Disposal Costs:					**$ 604,800**		
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 757,500**		

TABLE C-1 (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 3 - SOURCE REMOVAL AND OFF SITE LANDFILL DISPOSAL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 45,450	$ 45,450		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 113,625	$ 113,625		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					**$ 159,100**		
						Revisions: Final FS	
DIRECT AND INDIRECT CAPITAL COSTS					$ 917,000		
TOTAL COST (NPW) - SOIL RAA NO. 3					$ 917,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means have been increased by 20% to account for the small size of the construction project. Means assumes a large project.

TABLE C-2

COST ESTIMATE: SOIL RAA NO. 4 - SOURCE REMOVAL AND OFF SITE INCINERATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF THE CONTAMINATED SOIL; TRANSPORTATION OF THE SOIL TO AN OFF SITE INCINERATION FACILITY

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 15,000	$ 15,000		Engineering Estimate	Includes Mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Operation Manuals, Record Drawings, etc.
Subtotal General Capital Costs:					$ 95,000		
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	480	$ 2.20	$ 1,056		Eng. Estimate; Means 1996, 028-320-4800	
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Capital Costs:					$ 11,000		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	Sample	36	$ 359	$ 12,924		Engineering Estimate	Cost from Baker BOAs; includes TCL SVOC analysis and validation; 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	1	$ 100	$ 100		Engineering Estimate	Assume $100
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors; 20% increase in soil
Subtotal Soil Excavation/Backfill Costs:					$ 46,700		
Incineration							
Hauling to Incineration Facility	LS	1	$ 118,000	$ 118,000		Eng. Estimate; Vendor Quote	Assume 44 CY dump trailers; add 20% to soil volume after excavation (2000 CY x 1.20); 54 truckloads required @ $2,200 per load
Incineration Fees	Tons	3240	$ 720	$ 2,332,800		Eng. Estimate; Vendor Quote	Assume 20% increase in soil volume after excavation; nearest facility is in Calvert City, KY
Subtotal Incineration Costs:					$ 2,450,800		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 2,603,500		

TABLE C-2 (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 4 - SOURCE REMOVAL AND OFF SITE INCINERATION
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 156,210	$ 156,210		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 390,525	$ 390,525		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 546,700		
						Revisions: Final FS	
DIRECT AND INDIRECT CAPITAL COSTS					$ 3,150,000		
TOTAL COST (NPW) - SOIL RAA NO. 4					$ 3,150,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

TABLE C-3 (A)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF CONTAMINATED SOIL; TREATMENT OF THE SOIL AT THE EXISTING LOT 203 BIOCELL IN 2.5 BATCHES

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COSTS							
Treatment Cell Operation (Assume a Total of 5 Years for System Operation)							
Sample Labor	Hours	48	$ 26	$ 1,248		Engineering Estimate	Assume 4 hrs/mo, 12 mos/year, $26/hr
Sample Shipping	Month	12	$ 100	$ 1,200		Engineering Estimate	Assume 1 shipment/month @ $100 each
Sample Analyses							Assume monthly soil sampling (3 composites per event)
TCL Semivolatiles	Sample	36	$ 200	$ 7,200		Engineering Estimate; Baker BOAs	
Total Organic Carbon	Sample	36	$ 100	$ 3,600		Engineering Estimate; Vendor Quote	
Nutrients (Nitrogenn & Phosphorous)	Sample	36	$ 117	$ 4,212		Engineering Estimate; Baker BOAs	
pH	Sample	36	$ 7	$ 252		Engineering Estimate; Vendor Quote	
Mositure Content	Sample	36	$ 15	$ 540		Engineering Estimate; Vendor Quote	
Bacterial Population Density	Sample	36	$ 35	$ 1,260		Engineering Estimate; Vendor Quote	
Soil Mixing/Aeration	Hrs	168	$ 40	$ 6,720		Eng. Estimate; ECHOS (Means) 33 11 0301	Includes labor and dozer with tiller attachment; 7 hrs bimonthly
Water Management	Hrs	24	$ 26	$ 624		Engineering Estimate	Assume 1 hr bimonthly to spray water and pump collected leachate ($26/hr)
Nutrient Addition	LS	1	$ 2,400	$ 2,400		Engineering Estimate	Assume $200 monthly for nutrients
Administration and Records	Hrs	120	$ 50	$ 6,000		Engineering Estimate	Assume 10 hrs/month @ $50/hr
Subtotal Treatment Cell Operation Costs:					$ 35,300		
SUBTOTAL ANNUAL O&M COSTS:					$ 35,300		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 15,000	$ 15,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Miscellaneous Progress Reports
Treatability Study	LS	1	$ 100,000	$ 100,000		Engineering Estimate	Cost estimated for CTO 274 (MOD 02) Final IP/FP; engineering estimate
Subtotal General Costs:					$ 195,000		

TABLE C-3 (A) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	480	$ 2.20	$ 1,056		Eng. Estimate; Means 1996, 028-320-4800	
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Costs:					$ 11,000		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	Sample	36	$ 359	$ 12,924		Engineering Estimate	Cost from Baker BOAs; includes TCL SVOC analysis and validation; 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	1	$ 100	$ 100		Engineering Estimate	Assume $100
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors
Subtotal Soil Excavation/Backfill Costs:					$ 46,700		
Soil Placement/Disposal							
Loading and Hauling Soil to and from Lot 203 (2,000 CY x 120%)	CY	2400	$ 12.84	$ 30,816		Eng. Estimate; Means 1996, A12.1-614-4600	Assume eight 20 CY dump trucks, 4 mile round trip; 20% increase in soil volume after excavation; assume treated soil is used for fill on Base
Initial Characterization Sampling of Biocell Batch	EA	9	$ 474	$ 4,266		Engineering Estimate; Baker BOAs	2.5 batches; 3 samples per batch; all analytical parameters included (see O&M)
Sample Shipping and Labor	LS	1	$ 334	$ 334		Engineering Estimate	1 shipment at $100; 3 hours per batch @ $26/hr
Spreading Soil in the Biocell (2,000 CY x 120%)	CY	2400	$ 2.50	$ 6,000		Eng. Estimate; Means 1996, A12.1-724-1100	
Leachate Disposal	LS	1	$ 5,000	$ 5,000			
Subtotal Soil Placement/Disposal Costs:					$ 46,400		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 299,100		

TABLE C-3 (A) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 17,946	$ 17,946		Engineering Estimate	Assume 6% of Total Direct Capital Costs; includes permit modifications
Contingency Allowance	LS	1	$ 44,865	$ 44,865		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 62,800		
						Revisions: Final FS	
ANNUAL TREATMENT SYSTEM O&M COSTS (over 5 years)					$ 35,000		
DIRECT AND INDIRECT CAPITAL COSTS					$ 362,000		
TOTAL COST (NPW) - SOIL RAA NO. 5					$ 514,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means have been increased by 20% to account for the small size of the construction project. Means assumes a large project.

TABLE C-3 (B)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL (1,340 CY); OFF SITE LANDFILL DISPOSAL (660 CY)
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF CONTAMINATED SOIL; TREATMENT OF THE SOIL FROM 3 TO 9 FEET BGS (APPROX. 1,340 CY) AT THE EXISTING LOT 203 BIOCELL IN 2 BATCHES; DISPOSAL OF THE SOIL FROM 0 TO 3 FEET BGS (APPROX. 660 CY) IN A NON-HAZARDOUS WASTE LANDFILL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COSTS							
Treatment Cell Operation (Assume a Total of 4 Years for System Operation)							
Sample Labor	Hours	48	$ 26	$ 1,248		Engineering Estimate	Assume 4 hrs/mo, 12 mos/year, $26/hr
Sample Shipping	Month	12	$ 100	$ 1,200		Engineering Estimate	Assume 1 shipment/month @ $100 each
Sample Analyses							Assume monthly soil sampling (3 composites per event)
TCL Semivolatiles	Sample	36	$ 200	$ 7,200		Engineering Estimate; Baker BOAs	
Total Organic Carbon	Sample	36	$ 100	$ 3,600		Engineering Estimate; Vendor Quote	
Nutrients (Nitrogenn & Phosphorous)	Sample	36	$ 117	$ 4,212		Engineering Estimate; Baker BOAs	
pH	Sample	36	$ 7	$ 252		Engineering Estimate; Vendor Quote	
Mositure Content	Sample	36	$ 15	$ 540		Engineering Estimate; Vendor Quote	
Bacterial Population Density	Sample	36	$ 35	$ 1,260		Engineering Estimate; Vendor Quote	
Soil Mixing/Aeration	Hrs	168	$ 40	$ 6,720		Eng. Estimate; ECHOS (Means) 33 11 0301	Includes labor and dozer with tiller attachment; 7 hrs bimonthly
Water Management	Hrs	24	$ 26	$ 624		Engineering Estimate	Assume 1 hr bimonthly to spray water and pump collected leachate ($26/hr)
Nutrient Addition	LS	1	$ 2,400	$ 2,400		Engineering Estimate	Assume $200 monthly for nutrients
Administration and Records	Hrs	120	$ 50	$ 6,000		Engineering Estimate	Assume 10 hrs/month @ $50/hr
Subtotal Treatment Cell Operation Costs:					$ 35,300		
SUBTOTAL ANNUAL O&M COSTS:					$ 35,300		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 15,000	$ 15,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Miscellaneous Progress Reports
Treatability Study	LS	1	$ 100,000	$ 100,000		Engineering Estimate	Cost estimated for CTO 274 (MOD 02) Final IP/FP; engineering estimate
Subtotal General Costs:					$ 195,000		

TABLE C-3 (B) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL (1,340 CY); OFF SITE LANDFILL DISPOSAL (660 CY)
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	480	$ 2.20	$ 1,056		Eng. Estimate; Means 1996, 028-320-4800	
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Costs:					$ 11,000		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	Sample	36	$ 359	$ 12,924		Engineering Estimate	Cost from Baker BOAs; includes TCL SVOC analysis and validation; 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	1	$ 100	$ 100		Engineering Estimate	Assume $100
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors
Subtotal Soil Excavation/Backfill Costs:					$ 46,700		
Soil Placement/Disposal							
Loading and Hauling of Soil to & from Lot 203 (1,340 CY x 120%)	CY	1608	$ 12.84	$ 20,647		Eng. Estimate; Means 1996, A12.1-614-4600	Assume eight 20 CY dump trucks, 4 mile round trip; 20% increase in soil volume after excavation; assume treated soil is used for fill on Base
Spreading Soil in the Biocell (1,340 CY x 120%)	CY	1608	$ 2.50	$ 4,020		Eng. Estimate; Means 1996, A12.1-724-1100	
Initial Characterization Sampling of Biocell Batch	EA	6	$ 240	$ 1,440		Engineering Estimate; Baker BOAs	2 batches; 3 samples per batch; all analytical parameters included (see O&M)
Sample Shipping and Labor	LS	1	$ 256	$ 256		Engineering Estimate	1 shipment at $100; 3 hours per batch @ $26/hr
Transportation to Non-Hazardous Landfill (660 CY x 120%)	Load	18	$ 2,800	$ 50,400			Assume $2,800/load; 18 loads
Landfill Disposal Fees (660 CY x 120%)	Tons	1070	$ 170	$ 181,900		Engineering Estimate; Vendor Quote	Listed hazardous waste under RCRA
Leachate Disposal	LS	1	$ 5,000	$ 5,000		Engineering Estimate	Assume $5,000
Subtotal Soil Placement/Disposal Costs:					$ 263,663		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 516,300		

TABLE C-3 (B) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
LOT 203 BIOCELL (1,340 CY); OFF SITE LANDFILL DISPOSAL (660 CY)
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 30,978	$ 30,978		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 77,445	$ 77,445		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 108,400		
						Revisions: Final FS	
ANNUAL TREATMENT SYSTEM O&M COSTS (over 4 years)					$ 35,000		
DIRECT AND INDIRECT CAPITAL COSTS					$ 625,000		
TOTAL COST (NPW) - SOIL RAA NO. 5					$ 749,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means have been increased by 20% to account for the small size of the construction project. Means assumes a large project.

TABLE C-3 (C)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
ON SITE LANDFARM UNIT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF CONTAMINATED SOIL; TREATMENT OF THE SOIL WITH A LANDFARM UNIT CONSTRUCTED AT SITE 3

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COSTS							
Treatment Cell Operation (Assume a Total of 5 Years for System Operation)							
Sample Labor	Hours	48	$ 26	$ 1,248		Engineering Estimate	Assume 4 hrs/mo, 12 mos/year, $26/hr
Sample Shipping	Month	12	$ 100	$ 1,200		Engineering Estimate	Assume 1 shipment/month @ $100 each
Sample Analyses							Assume monthly soil sampling (3 composites per event)
TCL Semivolatiles	Sample	36	$ 200	$ 7,200		Engineering Estimate; Baker BOAs	
Total Organic Carbon	Sample	36	$ 100	$ 3,600		Engineering Estimate; Vendor Quote	
Nutrients (Nitrogenn & Phosphorous)	Sample	36	$ 117	$ 4,212		Engineering Estimate; Baker BOAs	
pH	Sample	36	$ 7	$ 252		Engineering Estimate; Vendor Quote	
Mositure Content	Sample	36	$ 15	$ 540		Engineering Estimate; Vendor Quote	
Bacterial Population Density	Sample	36	$ 35	$ 1,260		Engineering Estimate; Vendor Quote	
Soil Mixing/Aeration	Hrs	168	$ 40	$ 6,720		Eng. Estimate; ECHOS (Means) 33 11 0301	Includes labor and dozer with tiller attachment; 7 hrs bimonthly
Water Management	Hrs	24	$ 26	$ 624		Engineering Estimate	Assume 1 hr bimonthly to spray water and pump collected leachate ($26/hr)
Nutrient Addition	LS	1	$ 2,400	$ 2,400		Engineering Estimate	Assume $200 monthly for nutrients
Administration and Records	Hrs	120	$ 50	$ 6,000		Engineering Estimate	Assume 10 hrs/month @ $50/hr
Subtotal Treatment Cell Operation Costs:					$ 29,300		
SUBTOTAL ANNUAL O&M COSTS:					$ 29,300		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Miscellaneous Progress Reports
Treatability Study	LS	1	$ 100,000	$ 100,000		Engineering Estimate	Cost estimated for CTO 274 (MOD 02) Final IP/FP; engineering estimate
Subtotal General Costs:					$ 220,000		

TABLE C-3 (C) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
ON SITE LANDFARM UNIT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	1000	$ 2.20	$ 2,200		Eng. Estimate; Means 1996, 028-320-4800	Around the excavation area and around the biopile construction area
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Costs:					$ 12,100		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	*Sample*	36	$ 359	$ 12,924		*Engineering Estimate*	*Cost from Baker BOAs; includes TCL SVOC analysis and validation;* 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	*1*	$ 100	$ *100*		Engineering Estimate	Assume *$100*
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors
Subtotal Soil Excavation/Backfill Costs:					$ 46,700		
Landfarm Unit Construction							*Assume a 1,000 cy capacity in a 35,000 square foot area*
Site Preparation - Grading to 1% Slope	SY	3889	$ 1.74	$ 6,767		Eng. Estimate; Means 1996, 025-122-0010	
Liners	SF	35000	$ 2.60	$ 91,000		ECHOS (Means) 33 08 0573	Assume 30 mil HDPE liner with underlying geotextile fabric
Gravel Layer	CY	50	$ 14.50	$ 725		Eng. Estimate; Contract Rate	
Sand Layer	CY	2222	$ 8.20	$ 18,220		ECHOS (Means) 33 31 0103	
Leachate Collection Piping	LF	350	$ 8	$ 2,800		Eng. Estimate; Previous Project	
Leachate Collection Sump	*Each*	*1*	$ 5,000	$ 5,000		*ECHOS (Means) 19 04 0603; Engr. Estimate*	
Leachate Holding Tank	Each	1	$ 1,600	$ 1,600		ECHOS (Means) 19 04 0446	
Equipment Storage Area	Each	1	$ 2,500	$ 2,500		Eng. Estimate	Includes material & installation
Berm	CY	168	$ 30.33	$ 5,095		ECHOS (Means)	Assume 2' x 6' soil berms; no material cost (on Base borrow pit)
Chain Link Fence	LF	754	$ 19.50	$ 14,703		Means 1996 028-308-0500	6' high, 6 ga. wire, galv. steel
Subtotal Landfarm Unit Construction Costs:					$ 148,400		
Soil Placement/Disposal Costs							
Initial Characterization Sampling of Biocell Batch	EA	9	$ 474	$ 4,266		Engineering Estimate; Baker BOAs	2.5 batches; 3 samples per batch; all analytical parameters included (see O&M)
Sample Shipping and Labor	LS	1	$ 334	$ 334		Engineering Estimate	1 shipment at $100; 3 hours per batch @ $26/hr
Initial Fertilizer Mixing	LS	1	$ 3,000	$ 3,000		Engineering Estimate	Assume $3,000 for material, labor, and equipment
Placing Soil in Landfarm Unit	CY	2400	$ 2.50	$ 6,000		Eng. Estimate; Means 1996, A12.1-724-1100	
Hauling Treated Soil	CY	2400	$ 6.42	$ 15,408		*Eng. Estimate; Means 1996, A12.1-614-4600*	*Assume eight 20 CY dump trucks, 4 mile round trip; 20% increase in soil volume after*
Leachate Disposal	LS	1	$ 5,000	$ 5,000		Eng. Estimate; Previous Projects	
Disposal of Treatment Unit	LS	1	$ 5,000	$ 5,000		Engineering Estimate	
Subtotal Soil Placement/Disposal Costs:					$ 39,000		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 466,200		

TABLE C-3 (C) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
ON SITE LANDFARM UNIT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 27,972	$ 27,972		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 69,930	$ 69,930		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 97,900		
						Revisions: Final FS	
ANNUAL TREATMENT SYSTEM O&M COSTS (over 2 years)					$ 29,000		
DIRECT AND INDIRECT CAPITAL COSTS					$ 564,000		
TOTAL COST (NPW) - SOIL RAA NO. 5					$ 690,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means have been increased by 20% to account for the small size of the construction project. Means assumes a large project.

TABLE C-3 (D)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
BIOPILE
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: EXCAVATION OF CONTAMINATED SOIL; TREATMENT OF THE SOIL USING 4 ON-SITE BIOPILES

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COSTS							
Treatment Cell Operation (Assume a Total of 2 Years for System Operation)							
Sample Labor	Hours	72	$ 26	$ 1,872		Engineering Estimate	Assume 6 hrs/mo, 12 mos/year, $26/hr
Sample Shipping	Month	12	$ 100	$ 1,200		Engineering Estimate	Assume 1 shipment/month @ $100 each
Sample Analyses							Assume monthly soil sampling (2 composite samples per biopile per event)
TCL Semivolatiles	Sample	96	$ 200	$ 19,200		Engineering Estimate; Baker BOAs	
Total Organic Carbon	Sample	96	$ 100	$ 9,600		Engineering Estimate; Baker BOAs	
Nutrients (Nitrogenn & Phosphorous)	Sample	96	$ 117	$ 11,232		Engineering Estimate; Baker BOAs	
pH	Sample	96	$ 7	$ 672		Engineering Estimate; Baker BOAs	
Mositure Content	Sample	96	$ 15	$ 1,440		Engineering Estimate; Baker BOAs	
Bacterial Population Density	Sample	96	$ 35	$ 3,360		Engineering Estimate; Baker BOAs	
General Maintenance	Hours	48	$ 26	$ 1,248		Engineering Estimate	Assume 4 hrs/month @ $26/hr
Electricity	Month	12	$ 500	$ 6,000		Engineering Estimate	Assume $500/month
Administration and Records	Hrs	120	$ 50	$ 6,000		Engineering Estimate	Assume 10 hrs/month @ $50/hr
Subtotal Treatment Cell Operation Costs:					$ 61,800		
SUBTOTAL ANNUAL O&M COSTS:					$ 61,800		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Miscellaneous Progress Reports
Treatability Study	LS	1	$ 100,000	$ 100,000		Engineering Estimate	Cost estimated for CTO 274 (MOD 02) Final IP/FP; engineering estimate
Subtotal General Costs:					$ 220,000		

TABLE C-3 (D) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
BIOPILE
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Concrete Removal	SY	180	$ 10	$ 1,800		Eng. Estimate; Means 1996, 020-550-1900	Assume 6" thickness, mesh reinforced
Temporary Safety Fencing	LF	1000	$ 2.20	$ 2,200		Eng. Estimate; Means 1996, 028-320-4800	Around the excavation area and around the biopile construction area
Soil Stockpile Area	SY	576	$ 3.50	$ 2,016		Eng. Estimate; Previous Projects	Assume 72' x 72' area with geomembrane liner
Topsoil Spreading in Cleared Areas	SY	385	$ 3	$ 1,155		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Fine Grading and Seeding (Revegetation)	SY	385	$ 2	$ 770		Eng. Estimate; Means 1996, 022-286	Excludes concrete pad area and access road
Concrete Rehabilitation over Excavation	CY	30	$ 117	$ 3,510		Eng. Estimate; Means 1996, 033-100-4700	Assume 6" thickness
Re-establish Dirt Access Road	CY	317	$ 2.10	$ 666		Eng. Estimate; Means 1996, 022-204-2200	Backfill material from on-Base borrow pit (no cost)
Subtotal Site Work Costs:					$ 12,100		
Soil Excavation/Backfill							
Excavation	CY	2000	$ 6.80	$ 13,600		Eng. Estimate; Means 1996, 022-242-2420	Assume 75 H.P. dozer, 300 foot haul
Confirmatory Sampling of Excavation Area	Sample	36	$ 359	$ 12,924		Engineering Estimate	Cost from Baker BOAs; includes TCL SVOC analysis and validation; 1 sample/500 sf along excavation base (20), 1 sample/ 50 lf along perimeter (8); perimeter samples will be collected twice since excavation will proceed in two stages
Sample Labor	Hrs	9	$ 26	$ 234		Engineering Estimate	Assume 1 hr/4 samples @ $26/hr
Sample Shipping	EA	3	$ 100	$ 300		Engineering Estimate	Assume 3 shipments @ $100 each
Sampling Expendables	LS	1	$ 100	$ 100		Engineering Estimate	Assume $100
Loading and Hauling Backfill	CY	2400	$ 5.10	$ 12,240		Eng. Estimate; Means 1996, A12.1-614-4400	Backfill material from on-Base borrow pit (no cost); assume six 20 CY dump trucks, 2 mile round trip
Spreading and Compacting Backfill	CY	2400	$ 3.04	$ 7,296		Eng. Estimate; Means 1996, A12.1-724-1100	8" lifts, 2 passes, 75 HP dozer & roller compactors
Subtotal Soil Excavation/Backfill Costs:					$ 46,700		
Biopile Construction							
Site Preparation - Grading	SY	1600	$ 1.74	$ 2,784		Eng. Estimate; Means 1996, 025-122-0010	Assume grading across four areas that are 60' x 60' each
Liners	SF	14400	$ 2.60	$ 37,440		ECHOS (Means) 33 08 0573	Assume 4 biopiles, 52' x 52' each; 80 mil HDPE
Gravel Layer	CY	533	$ 14.50	$ 7,729		Eng. Estimate; Contract Rate	
Aeration Piping	LF	924	$ 3.13	$ 2,892		ECHOS (Means) 33 26 0802	Slotted 4" PVC pipe ; 3 rows through each biopile, 75' from each pile to the equipment bldg.
Water Knockout Vessel	Each	2	$ 2,000	$ 4,000		Eng. Estimate; Previous Projects	Assume $2,000 each; includes one for back-up
Blower	Each	2	$ 556	$ 1,112		ECHOS (Means) 33 31 0103	Assume 150 CFM 3/4 HP blower with one for back-up
Nutrient Addition System	Each	1	$ 4,000	$ 4,000		Engineering Estimate	Includes material and equipment
Overhead Sprinkler System	LF	362	$ 25	$ 9,050		ECHOS (Means) 19 06 0101	One overhead line through each biopile, plus connecting lines to equipment building
Vapor-Phase Carbon Adsorption Unit	Each	1	$ 1,000	$ 1,000		Eng. Estimate; Previous Project	
Leachate Collection Sump	Each	1	$ 1,310	$ 1,310		ECHOS (Means) 19 04 0603	
Leachate Holding Tank	Each	1	$ 1,600	$ 1,600		ECHOS (Means) 19 04 0446	
Equipment Building	Each	1	$ 10,000	$ 10,000		Eng. Estimate; Previous Projects	Includes material & installation
Berm	CY	427	$ 5.00	$ 2,135		Eng. Estimate; Means 1996 022-208-4420	Assume 4' x 6' soil berms, 480 LF in length; 300' haul for soil from on-Base borrow pit; no material cost
Chain Link Fence	LF	480	$ 19.50	$ 9,360		Means 1996 028-308-0500	6' high, 6 ga. wire, galv. steel
Subtotal Biopile Construction Costs:					$ 94,400		
Soil Placement/Disposal Costs							
Initial Characterization Sampling of Biocell Batch	EA	9	$ 474	$ 4,266		Engineering Estimate; Baker BOAs	2.5 batches; 3 samples per batch; all analytical parameters included (see O&M)
Sample Shipping and Labor	LS	1	$ 334	$ 334		Engineering Estimate	1 shipment at $100; 3 hours per batch @ $26/hr
Initial Fertilizer Mixing	LS	1	$ 3,000	$ 3,000		Engineering Estimate	Assume $3,000 for material, labor, and equipment
Placing Soil in Biopiles	CY	2400	$ 2.50	$ 6,000		Eng. Estimate; Means 1996, A12.1-724-1100	
Hauling Treated Soil	CY	2400	$ 6.42	$ 15,408		Eng. Estimate; Means 1996, A12.1-614-4600	Assume eight 20 CY dump trucks, 4 mile round trip; 20% increase in soil volume after
Leachate Disposal	LS	1	$ 5,000	$ 5,000		Eng. Estimate; Previous Projects	
Carbon Disposal	LS	1	$ 1,000	$ 1,000		Eng. Estimate; Previous Projects	
Subtotal Soil Placement/Disposal Costs:					$ 35,000		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 408,200		

TABLE C-3 (D) (CONTINUED)

COST ESTIMATE: SOIL RAA NO. 5 - SOURCE REMOVAL AND BIOLOGICAL TREATMENT
BIOPILE
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 24,492	$ 24,492		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 61,230	$ 61,230		Engineering Estimate	Assume 15% of Total Direct Capital Costs
Start-Up Costs	LS	1	$ 61,230	$ 61,230		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 147,000		
						Revisions: Final FS	
ANNUAL TREATMENT SYSTEM O&M COSTS (over 2 years)					$ 62,000		
DIRECT AND INDIRECT CAPITAL COSTS					$ 555,000		
TOTAL COST (NPW) - SOIL RAA NO. 5					$ 670,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means have been increased by 20% to account for the small size of the construction project. Means assumes a large project.

TABLE C-4

COST ESTIMATE: GROUNDWATER RAA NO. 2 - INSTITUTIONAL CONTROLS AND MONITORING
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: LONG-TERM SAMPLING/ANALYSIS OF GROUNDWATER FROM 7 EXISTING MONITORING WELLS (1 DEEP, 2 INTERMEDIATE, AND 4 SHALLOW)

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COST ESTIMATE							
Groundwater Monitoring (Years 1-5: Quarterly Sampling)							
Labor	Hours	240	$ 26	$ 6,240		Engineering Estimate	Quarterly sampling of 7 wells: Assume 3 days per sampling event, incl. travel time 2 geo./eng. samplers @ $26/hr ea, total of 30 hrs/event (10 hrs/day)
Travel	Event	4	$ 1,500	$ 6,000		Engineering Estimate	Cost includes car rental & airfare for 2 people Assume airfare=$600/person, car rental= $300/event
Per Diem	Event	4	$ 396	$ 1,584		Engineering Estimate	Cost includes lodging & meals for 2 people Lodging=$40/day/person, meals= $26/day/person, 3 days/event
TAL Inorganics	Sample	56	$ 219.53	$ 12,294		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
TCL SVOCs	Sample	56	$ 346.77	$ 19,419		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
TCL VOCs	Sample	56	$ 173.34	$ 9,707		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
Misc. Expenses	Event	4	$ 500	$ 2,000		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water, coolers
Report	Event	4	$ 1,000	$ 4,000		Engineering Estimate	1 report per sampling event
Well Maintenance	Year	1	$ 100	$ 100		Engineering Estimate	Includes repainting and miscellaneous repairs
Well Replacement	Year	1	$ 2,500	$ 2,500		Engineering Estimate	Assume $2,500/year
Subtotal Groundwater Monitoring Costs (Years 1-5):					$ 63,800		
Groundwater Monitoring (Years 6-30: Semiannual Sampling)							
Labor	Hours	120	$ 26	$ 3,120		Engineering Estimate	Semiannual sampling of 7 wells: Assume 3 days per sampling event, incl. travel time 2 geo./eng. samplers @ $26/hr ea, total of 30 hrs/event (10 hrs/day)
Travel	Event	2	$ 1,500	$ 3,000		Engineering Estimate	Cost includes car rental & airfare for 2 people Assume airfare=$600/person, car rental= $300/event
Per Diem	Event	2	$ 396	$ 792		Engineering Estimate	Cost includes lodging & meals for 2 people Lodging=$40/day/person, meals= $26/day/person, 3 days/event
TAL Inorganics	Sample	28	$ 219.53	$ 6,147		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
TCL SVOCs	Sample	28	$ 346.77	$ 9,710		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
TCL VOCs	Sample	28	$ 173.34	$ 4,854		Baker Average BOAs (Includes laboratory analysis & data validation costs)	GW samples: 7 from wells, 7 QA/QC = 14 total
Misc. Expenses	Event	2	$ 500	$ 1,000		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water, coolers
Report	Event	2	$ 1,000	$ 2,000		Engineering Estimate	1 report per sampling event
Well Maintenance	Year	1	$ 100	$ 100		Engineering Estimate	Includes repainting and miscellaneous repairs
Well Replacement	Year	1	$ 2,500	$ 2,500		Engineering Estimate	Assume $2,500/year
Subtotal Groundwater Monitoring Costs (Years 6-30):					$ 33,200		
GROUNDWATER MONITORING COSTS (Years 1-5)					$ 63,800	Revisions: Final FS	
GROUNDWATER MONITORING COSTS (Years 6-30)					$ 33,200		
DIRECT CAPITAL COSTS					$ -		
TOTAL COST (NPW) - GROUNDWATER RAA NO. 2					$ 643,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means, but not ECHOS (Means), have been increased by 20% to account for the small project size. Means assumes a large project.

TABLE C-5

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: 2 EXTRACTION WELLS, 10 GPM TREATMENT FACILITY, LIQUID-PHASE CARBON ADSORPTION TREATMENT, LONG-TERM GROUNDWATER MONITORING

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COST ESTIMATE							
Groundwater Monitoring (Years 1-5: Quarterly Sampling)							
Labor	Hours	240	$ 26	$ 6,240		See Table C-4	See Table C-4
Travel	Event	4	$ 1,500	$ 6,000		See Table C-4	See Table C-4
Per Diem	Event	4	$ 396	$ 1,584		See Table C-4	See Table C-4
Laboratory Analyses -							
TAL Inorganics	Sample	56	$ 219.53	$ 12,294		See Table C-4	See Table C-4
TCL SVOCs	Sample	56	$ 346.77	$ 19,419		See Table C-4	See Table C-4
TCL VOCs	Sample	56	$ 173.34	$ 9,707		See Table C-4	See Table C-4
Misc. Expenses	Event	4	$ 500	$ 2,000		See Table C-4	See Table C-4
Report	Event	4	$ 1,000	$ 4,000		See Table C-4	See Table C-4
Well Maintenance	Year	1	$ 100	$ 100		See Table C-4	See Table C-4
Well Replacement	Year	1	$ 2,500	$ 2,500		See Table C-4	See Table C-4
Subtotal Groundwater Monitoring Costs (Years 1-5):					$ 63,800		
Groundwater Monitoring (Years 6-30: Semiannual Sampling)							
Labor	Hours	120	$ 26	$ 3,120		See Table C-4	See Table C-4
Travel	Event	2	$ 1,500	$ 3,000		See Table C-4	See Table C-4
Per Diem	Event	2	$ 396	$ 792		See Table C-4	See Table C-4
Laboratory Analyses -							
TAL Inorganics	Sample	28	$ 219.53	$ 6,147		See Table C-4	See Table C-4
TCL SVOCs	Sample	28	$ 346.77	$ 9,710		See Table C-4	See Table C-4
TCL VOCs	Sample	28	$ 173.34	$ 4,854		See Table C-4	See Table C-4
Misc. Expenses	Event	2	$ 500	$ 1,000		See Table C-4	See Table C-4
Report	Event	2	$ 1,000	$ 2,000		See Table C-4	See Table C-4
Well Maintenance	Year	1	$ 100	$ 100		See Table C-4	See Table C-4
Well Replacement	Year	1	$ 2,500	$ 2,500		See Table C-4	See Table C-4
Subtotal Groundwater Monitoring Costs (Years 6-30):					$ 33,200		
Treatment System O&M (Years 1-30)							
Labor for Plant O&M	Week	52	$ 800	$ 41,600		Engineering Estimate	Assume 16 hrs/wk, 52 wks/year, $50/hr
Labor for Sampling	Month	12	$ 208	$ 2,496		Engineering Estimate	Assume 8 hr/month, 12 month/yr at $26/hr
Chemicals	LS	1	$ 6,900	$ 6,900		Engineering Estimate	Previous Estimates
Effluent Sampling - Analysis	Sample	12	$ 500	$ 6,000		Engineering Estimate	Assume one sample/month @ $500/sample; cost accounts for VOC and SVOC analyses & NPDES permit analyses
Sludge/Oil Disposal	Month	12	$ 75	$ 900		Engineering Estimate	1 drum/2 months at $150/drum for disposal
Carbon Regeneration	EA	0.5	$ 750	$ 375		Engineering Estimate	Assume carbon regeneration every other year @ $750 each
Electricity	LS	1	$ 20,000	$ 20,000		Engineering Estimate	24 hours/day for 365 days/yr operation
Well Maintenance	LS	1	$ 1,500	$ 1,500		Engineering Estimate	Assume 1 well replaced every two years, incl. pump and misc. appurt.
Administration and Records	Hours	100	$ 50	$ 5,000		Engineering Estimate	25 hrs/quarter at $50/hr
Subtotal Treatment System O&M Costs (Years 1-30):					$ 84,800		

TABLE C-5 (CONTINUED)

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 50,000	$ 50,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Miscellaneous Progress Reports
Subtotal General Capital Costs:					$ 170,000		
Site Work							
Trenching for Collection Line	LF	540	$ 15	$ 8,100		Engineering Estimate	Includes excavation, removal, backfill & tamping, utility protection
Trenching for Discharge Line	LF	750	$ 15	$ 11,250		Engineering Estimate	Includes excavation, removal, backfill & tamping, utility protection
Water Connection at Treatment Plant	LF	100	$ 20	$ 2,000		Engineering Estimate	Includes trenching & laying 1" coppper line, utility protection
Sump Discharge	Each	1	$ 2,000	$ 2,000		Engineering Estimate	Includes materials and installation
Topsoil Spreading over Trenching	CY	16	$ 50	$ 800		Engineering Estimate	Includes offsite topsoil & 6" placement
Fine Grading & Seeding over Trenching	SY	96	$ 2	$ 192		Means Site 1994, 022-286	
Electrical to Wells	LF	700	$ 45	$ 31,500		Engineering Estimate	Conduit & wiring, hand holes, pump power
Subtotal Site Work Capital Costs:					$ 55,800		
Extraction Wells							
Extraction Wells & Installation	LF	18	$ 125	$ 2,250		Engineering Estimate	2 Extraction Wells ~ 9' deep each; Scd. 40 6" PVC
Well Development	Each	2	$ 260	$ 520		Engineering Estimate	Assume 4 hrs. at $ 65/hr. (per well)
Extraction Well Pumps	Each	2	$ 1,000	$ 2,000		Vendor Quote	Assume pneumatic pumps; one for each extraction well
Misc. Appurtenances	Each	2	$ 1,500	$ 3,000		Vendor Quote	Assume $1,500
Installation of Pumps & Equipment	LS	1	$ 1,250	$ 1,250		Vendor Quote	Assume 25% of equipment costs
Well House	Each	2	$ 1,810	$ 3,620		Engineering Estimate; Vendor Quote	Watertight closure/vault (4'deep); cost includes material & installation
Subtotal Extraction Wells Capital Costs:					$ 12,600		

TABLE C-5 (CONTINUED)

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Piping Systems							
2" PVC Groundwater Recovery Line	LF	1290	$ 3	$ 4,193		Means Site 1994, 026-678	Pipe length quoted includes down-hole lines
1/2" PE Air Supply Line	LF	1290	$ 2	$ 2,580		Means Site 1994, 026-854	Pipe length quoted includes down-hole lines
4" PVC Conduit to Contain 2" and 1/2" Lines	LF	540	$ 5	$ 2,878		Means Site 1994, 026-678	To provide protection for injection and recovery lines
4" PVC Groundwater Discharge Line	LF	750	$ 5	$ 3,998		Means Site 1994, 026-678	Pipe length quoted includes down-hole lines
Miscellaneous Fittings	LS	1	$ 1,365	$ 2,047		Engineering Estimate	Assume 10% of piping costs
Subtotal Piping Systems Capital Costs:					$ 15,700		
Treatment Plant Equipment							
Packaged Treatment Plant	LS	1	$ 45,000	$ 45,000		Engineering Estimate; Vendor Quote	Includes 2 800-lb liquid-phase carbon adsorption units, flowmeters/ instrumentation control panel, miscellaneous appurtenances, oil/water separator, precipitation system, filtration/sedimentation unit, and pre-fabricated building; 10 gpm facility
Installation of Equipment	LS	1	$ 11,250	$ 11,250		Engineering Estimate	Assume 25% of equipment costs
Subtotal Treatment Plant Equipment Capital Costs:					$ 56,300		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 310,400		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 18,624	$ 18,624		Engineering Estimate	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 46,560	$ 46,560		Engineering Estimate	Assume 15% of Total Direct Capital Costs
Start-Up Costs	LS	1	$ 46,560	$ 46,560		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 111,700		
ANNUAL MONITORING SYSTEM O&M COSTS (Years 1-5)					$ 63,800	Revisions: Final FS	
ANNUAL MONITORING SYSTEM O&M COSTS (Years 6-30)					$ 33,200		
ANNUAL TREATMENT SYSTEM O&M COSTS (Years 1-30)					$ 84,800		
DIRECT AND INDIRECT CAPITAL COSTS					$ 422,100		
TOTAL COST (NPW) - GROUNDWATER RAA NO. 3					$ 2,369,000	By: MSH Chk: TLB	Date Completed: July 22, 1996

Note: Costs obtained from Means, but not ECHOS (Means), have been increased by 20% to account for the small project size. Means assumes a large project.

TABLE C-6

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

ALTERNATIVE SUMMARY: *2 EXTRACTION WELLS, 10 GPM TREATMENT FACILITY, LIQUID-PHASE CARBON ADSORPTION TREATMENT, LONG-TERM GROUNDWATER MONITORING*

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
ANNUAL O&M COST ESTIMATE							
Groundwater Monitoring (Assume Semiannual Sampling for 30 Years)							
Labor	Hours	128	$ 26	$ 3,328		Engineering Estimate	Semiannual sampling of 9 wells: Assume 4 days per sampling event, incl. travel time 2 geo./eng. samplers @ $26/hr ea, total of 64 hrs/event, 2 events/year, 128 total hrs/yr
Travel	Event	2	$ 1,500	$ 3,000		Engineering Estimate	Cost includes car rental & airfare for 2 people Assume airfare=$600/person, car rental= $300/event
Per Diem	Event	2	$ 264	$ 528		Engineering Estimate	Cost includes lodging & meals for 2 people Lodging=$40/day/person, meals= $26/day/person, 4 days/event
Laboratory Analyses - TCL SVOCs	Sample	17	$ 347	$ 5,895		Baker Average 1994 BOAs (Includes laboratory analysis & data validation costs)	GW samples: 9 from wells, 1 duplicate, 1 MS/MSD, 5 rinsates (1/day), 1 field blank = 17 samples/event
TCL VOCs	Sample	22	$ 173	$ 3,813		Baker Average 1994 BOAs (Includes laboratory analysis & data validation costs)	GW samples: 9 from wells, 1 duplicate, 1 MS/MSD, 5 trip blanks (1/day), 5 rinsates (1/day), 1 field blank = 22 samples/event
Misc. Expenses	Event	2	$ 500	$ 1,000		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water, coolers
Report	Event	2	$ 1,000	$ 2,000		Engineering Estimate	1 report per sampling event
Well Maintenance	Year	1	$ 100	$ 100		Engineering Estimate	Includes repainting and miscellaneous repairs
Well Replacement	Year	1	$ 2,500	$ 2,500		Engineering Estimate	Assume $2,500/year
Subtotal GW Monitoring Annual O&M Costs:					$ 22,200		
Treatment System O&M (Assume 30 Years of System Operation)							
Labor for Plant O&M	Week	52	$ 800	$ 41,600		Engineering Estimate	Assume 16 hrs/wk, 52 wks/year, $50/hr
Labor for Sampling	Month	12	$ 208	$ 2,496		Engineering Estimate	Assume 8 hr/month, 12 month/yr at $26/hr
Chemicals	LS	1	$ 6,900	$ 6,900		Engineering Estimate	Previous Estimates
Effluent Sampling - Analysis	Sample	12	$ 500	$ 6,000		Engineering Estimate	Assume one sample/month @ $500/sample; cost accounts for VOC and SVOC analyses & NPDES permit analyses
Sludge Disposal	Month	12	$ 75	$ 900		Engineering Estimate	1 drum/2 months at $150/drum for disposal
Electricity	LS	1	$ 20,000	$ 20,000		Engineering Estimate	24 hours/day for 365 days/yr operation
Well Maintenance	LS	1	$ 1,500	$ 1,500		Engineering Estimate	Assume 1 well replaced every two years, incl. pump and misc. appurt.
Administration and Records	Hours	100	$ 50	$ 5,000		Engineering Estimate	25 hrs/quarter at $50/hr
Subtotal Treatment Annual O&M Costs:					$ 84,396		
SUBTOTAL ANNUAL O&M COSTS:					$ 106,596		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Work, E&S, NPDES, H&S, & QC Plans; Shop Drawings
Mobilization/Demobilization	LS	1	$ 40,000	$ 40,000		Engineering Estimate	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Contract Administration	LS	1	$ 50,000	$ 50,000		Engineering Estimate	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$ 30,000	$ 30,000		Engineering Estimate	Miscellaneous Progress Reports
Subtotal General Capital Costs:					$ 170,000		

TABLE C-6 (CONTINUED)

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Trenching for Collection Line	LF	540	$ 15	$ 8,100		Engineering Estimate	Includes excavation, removal, backfill & tamping, utility protection
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Subtotal Site Work Capital Costs:					$ 55,800		
Extraction Wells							
Extraction Wells & Installation	LF	18	$ 125	$ 2,250		Engineering Estimate	2 Extraction Wells ~ 9' deep each; Scd. 40 6" PVC
Well Development	Each	2	$ 260	$ 520		Engineering Estimate	Assume 4 hrs. at $ 65/hr. (per well)
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Installation of Pumps & Equipment	LS	1	$ 1,250	$ 1,250		Vendor Quote	Assume 25% of equipment costs
Well House	Each	2	$ 1,810	$ 3,620		Engineering Estimate; Vendor Quote	Watertight closure/vault (4'deep); cost includes material & installation
Subtotal Extraction Wells Capital Costs:					$ 12,600		

TABLE C-6 (CONTINUED)

COST ESTIMATE: GROUNDWATER RAA NO. 3 - EXTRACTION AND ONSITE CARBON ADSORPTION TREATMENT
OPERABLE UNIT NO. 12 (SITE 3)
FEASIBILITY STUDY, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

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Treatment Plant Equipment							
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Installation of Equipment	LS	1	$ 11,250	$ 11,250		Engineering Estimate	Assume 25% of equipment costs
Subtotal Traetment Plant Equipment Capital Costs:					$ 56,300		
SUBTOTAL DIRECT CAPITAL COSTS:					$ 310,400		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 18,624	$ 18,624		Engineering Estimate	Assume 6% of Total Direct Capital Costs
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Start-Up Costs	LS	1	$ 46,560	$ 46,560		Engineering Estimate	Assume 15% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 111,700		
ANNUAL MONITORING SYSTEM O&M COSTS					$ 22,200	Revisions:	
ANNUAL TREATMENT SYSTEM O&M COSTS					$ 84,400		
DIRECT AND INDIRECT CAPITAL COSTS					$ 422,100		
TOTAL COST (PW) - GROUNDWATER RAA 3 (See Note 1)					$ 2,061,000	By: MS Chk: TLB	Date Completed: February 14, 1996

Notes:

1. The Present Worth (PW) Value accounts for 30 years of Groundwater Extraction and Treatment and 30 years of Groundwater Monitoring.

APPENDIX D
TWO-DIMENSIONAL HORIZONTAL FLOW MODEL ASSUMING A SLUG SOURCE (WILSON AND MILLER, 1978)

ESTIMATION OF FUTURE NAPHTHALENE CONCENTRATIONS AT SUPPLY WELL NEAR MONITORING WELL LOCATION MW-13, THAT MIGRATE FROM MW-02, USING A TWO "D" HORIZONTAL FLOW MODEL ASSUMING A SLUG SOURCE (WILSON & MILLER, 1978)

ASSUMPTIONS:

- UNIFORM STEADY REGIONAL GROUNDWATER FLOW IN THE x DIRECTION.
- NAPHTHALENE CONCENTRATION IN AQUIFER OVER THE FULL SATURATED THICKNESS.
- y COMPONENT = 0 THROUGHOUT FOR LATERAL SPREAD OF SLUG
- CONTAMINANT SLUG ORIGINATES FROM MW-02. ORIGINAL SLUG DIMENSIONS EXTEND FROM MW-02 TO A POINT THAT IS HALF THE DISTANCE TO MW-04 (LONGITUDINALLY) AND HAS A WIDTH EQUAL TO THE DISTANCE BETWEEN MW-02 AND MW-05. NO DETECTS AT MW-04, 05.

$$C(x,y,t) = \frac{C_0 Q}{b\, 4\pi p\, t (D_x D_y)^{0.5}} * \exp\left[-kt - \frac{(x R_d - v_x t)^2}{4 D_x t R_d} - \cancelto{0}{\frac{(y R_d)^2}{4 D_y t R_d}}\right]$$

WHERE:

C_0 = INITIAL NAPHTHALENE CONCENTRATION = 1.5 mg/L

Q = VOLUME OF CONTAMINANT SLUG AT SOURCE (m^3)
= LENGTH × WIDTH × DEPTH
= 36.6 m × 54.9 m × 4.6 m
= 9,243 m^3

b = AQUIFER THICKNESS = 15 FEET = 4.6 m

p = POROSITY OF AQUIFER MATERIAL (SILTY SAND) = 0.35

t = TIME IN FUTURE FROM PRESENT = 1 yr (365d), 30 yrs. (10,950d), 100 yrs (36,500d)

= DISTANCE TO RECEPTOR WELL = 228.6 m

D_x = LONGITUDINAL DISPERSION COEFFICIENT (m^2/d)
$= 0.1 * x * V_x$
$= 0.1 * 228.6\ m * 0.12\ m/d$
$= 2.7\ m^2/d$

D_y = LATERAL DISPERSION COEFFICIENT (m^2/d)
$= 0.1 * x * 0.333 * V_x$
$= 0.1 * 228.6\ m * 0.333 * 0.12\ m/d$
$= 0.9\ m^2/d$

V_x = SEEPAGE VELOCITY = $0.12\ m/d$

k = FIRST ORDER DECAY COEFFICIENT = $0\ d^{-1}$

ρ_b = BULK DENSITY OF AQUIFER MATERIAL = $1.5\ g/cm^3$

K_{oc} = ORGANIC CARBON PARTITIONING COEFFICIENT = $933\ cm^3/g$

f_{oc} = FRACTION ORGANIC CARBON = 0.005

R_d = RETARDATION COEFFICIENT (UNITLESS)

$$= 1 + \left[\frac{(K_d * \rho_b)}{P}\right]$$

$$= 1 + \left[\frac{((K_{oc} f_{oc}) * \rho_b)}{P}\right]$$

$$= 1 + \left[\frac{((933\ cm^3/g * 0.005) * 1.5\ g/cm^3)}{0.35}\right]$$

$= 21.0$

S.O. No. 66470-274
Subject: Site 3 - Horizontal Flow Model Assuming a Slug Source (2-D)
Computed by RBM Checked By TLB Date 2-15-96
Drawing No.
Sheet No. 3 of 3

Baker

I. CALCULATION OF GROUNDWATER NAPHTHALENE CONCENTRATION AT SUPPLY WELL ONE YEAR (365 d) FROM TODAY.

$$C(229,0,365d) = \frac{(1.5\,mg/L)(9,243\,m^3)}{\left[(4.6\,m)4\pi(0.35)(365d)(2.7\,m^2/d * 0.9\,m^2/d)\right]^{1/2}} * \exp\left[-\frac{(229\,m)(21.0)-(0.12\,m/d)(365d)}{4(2.7\,m^2/d)(365d)(21.0)}\right]$$

$$= 1.2\ mg/L * \exp(-274)$$

$$\approx 0\ mg/L$$

II. SAME AS I, USING THIRTY YEARS (10,950 d)

$$C(229,0,10950d) = \frac{(1.5\,mg/L)(9,243\,m^3)}{\left[(4.6m)4\pi(0.35)(10,950d)(2.7\,m^2/d * 0.9\,m^2/d)\right]^{1/2}} * \exp\left[-\frac{(229m)(21.0)-(0.12\,m/d)(10950d)}{4(2.7\,m^2/d)(365d)(21.0)}\right]$$

$$= 0.04\,mg/L * \exp(-4.9)$$

$$= 0.04\,mg/L * 0.0074$$

$$= 0.00030\,mg/L$$

III SAME AS I, USING ONE HUNDRED YEARS (36,500 d)

$$C(229,0,36500d) = \frac{(1.5\,mg/L)(9243\,m^3)}{\left[(4.6m)4\pi(0.35)(36,500d)(2.7\,m^2/d * 0.9\,m^2/d)\right]^{1/2}} * \exp\left[-\frac{(229)(21.0)-(0.12\,m/d)(36,500d)}{4(2.7\,m^2/d)(365d)(21.0)}\right]$$

$$= 0.012\,mg/L * \exp(-0.022)$$

$$= 0.012\,mg/L * 0.978$$

$$= 0.012\,mg/L$$