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Final

Remedial Investigation Report
Operable Unit No. 12 (Site 3)

Marine Corps Base,
Camp Lejeune, North Carolina

Text and Figures

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	absorption factor
AET	Apparent Effect Threshold Values
AF	adherence factor
AOC	Area of concern
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AT_c	averaging time, carcinogen
AT_{nc}	averaging time, noncarcinogen
AWQC	Ambient Water Quality Criteria
b	saturated thickness
Baker	Baker Environmental, Inc.
Bb	biotransfer factor for beef
BCF	bioconcentration factor
bgs	below ground surface
BI	biotoxic index
Br	biotransfer factor fruit part of plant
BRA	baseline risk assessment
BW	body weight
C	contaminant concentration
CADD	Computer Aided Drafting Design
CDI	chronic daily intake
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
CL	low plasticity clay
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
cm/sec	centimeter/second
CoC	Chain-of-Custody
COPC	contaminant of potential concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Carcinogenic Slope Factor
DDE	dichlorodiphenyldichloroethylene
DDT	diphenyltrichloroethane
DoN	Department of the Navy
DQOs	data quality objectives

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential
ELISA	Enzyme Linked Immunosorbent Assay
EMD	Environmental Management Department
ERA	ecological risk assessment
ESE	Environmental Science and Engineering, Inc.
ET	Exposure Time
ET	Eastern Tributary
FB	Field Blank
FFA	Federal Facilities Agreement
F_i	fraction ingested
FMF	Fleet Marine Force
FSAP	Field Sampling and Analysis Plan
ft	feet
FWQSV	Freshwater Water Quality Screening Values
FWS	Fish and Wildlife Service
GA	Existing or Potential Source of Drinking Water for Humans (<250 mg/L Chloride)
gpm	gallons per minute
H	Species Diversity
H'	Diversity Index
HA	health advisories
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HI	hazard index
HQ	hazard quotient
i	hydraulic gradient
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes
IR	ingestion rate
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	hydraulic conductivity
K_d	soil sorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol water partition coefficient

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	lowest observed adverse effect level
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
MF	modifying factor
mg/kg	milligram per kilogram
mg/L	milligram per liter
mgd	million gallons per day
MI	mobility index
ml	milliliter
msl	mean sea level
MW	monitoring well
NC	North Carolina
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NCMFC	North Carolina Marine Fisheries Commission
NCWP	Near Coastal Waters Program
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission
NEESA	Naval Energy and Environmental Support Activity
NEHC	Navy Environmental Health Center
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAEL or NOEL	No observed adverse effect level
NPL	National Priorities List
NPS	National Park Service
NREA	National Resources and Environmental Affairs
NSW	nutrient sensitive waters
NTU	nephelometric turbidity units
NWI	national wetlands inventory
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PC	permeability constant
PCBs	polychlorinated biphenyls
PEF	particulate emissions factor
PID	photoionization detector
ppb	parts per billion
ppm	parts per million

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RBC	risk based concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	record of decision
SA	estuarine waters not suited for body contact sports or commercial shell fishing
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SC	Estuarine Waters Not Suited for Body Contact Sports or Commercial Shellfishing
Sj	Jaccard Coefficient
SM	silty sand (poorly graded)
SOPs	standard operating procedures
SP	poorly graded sands with little to no fines
SQC	sediment quality criteria
Ss	Sorenson Index
SSSVs	surface soil screening values
SSVs	sediment screening values
S.U.	Standard Unit
SVOCs	semivolatile organic compounds
SW	surface water
T	transmissivity
TAL	target analyte list
TCL	target compound list
TEF	toxicity equivalency factor
TICs	tentatively identified compounds
TOC	total organic carbon or top of casing
TRVs	terrestrial reference values
UCL	upper confidence limit
UF	uncertainty factor
µg/kg	microgram per kilogram
µg/L	micrograms per liter
USCS	Unified Soil Classification System

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
VOCs	volatile organic compounds
VP	vapor pressure
V_x	average seepage velocity
WOE	weight of evidence
WQS	water quality standards
WQSV	water quality screening values
WT	Western Tributary
°C	Degrees Centigrade
°F	Degrees Fahrenheit

EXECUTIVE SUMMARY

INTRODUCTION

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

The Fiscal Year 1996 Site Management Plan for MCB, Camp Lejeune, a primary document identified in the FFA, identifies 17 Operable Units, 33 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. This report documents the Remedial Investigation (RI) completed for Site 3, the Old Creosote Plant. This site comprises Operable Unit (OU) No. 12 at MCB, Camp Lejeune.

The purpose of this remedial investigation is to characterize the nature and extent of contamination, and potential human health and environmental impacts for OU No. 12. This RI has been conducted in accordance with the requirements delineated in the National Oil Hazardous Substance Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 00.430]. The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this document.

SITE DESCRIPTION AND HISTORY

OU No. 12 (Site 3) is referred to as the Old Creosote Plant and is located on the mainside portion of MCB Camp Lejeune, approximately one quarter mile east of Holcomb Boulevard and one mile north of Wallace Creek. Remnants of the former creosote plant including the chimney, concrete pads, and train rails are present in the southern portion of Site 3. The cleared area in the northern portion of the Site 3 was reported to be the location of the former sawmill, which supplied the cut timbers for creosote treatment.

Site 3 area encompasses approximately 5 acres, is generally flat and unpaved, and is intersected by a dirt access road. Access to the site is unrestricted directly from Holcomb Boulevard. The Camp Lejeune Railroad lies approximately 200 feet to the west of Site 3. During periods of heavy rain the western area of the site exhibits several areas of standing water. Surface water runoff from the site flows in both an easterly and westerly direction since runoff ditches flank both the eastern and western edges of the site. To the east is a small drainage way in which ponded water is evident during periods of heavy rain. To the west of the site are drainage areas which parallel the Camp Lejeune Railroad and Holcomb Boulevard. None of these potential drainage areas were under flow conditions during the March 1, 1994 site reconnaissance.

The old creosote plant reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base railroad. Logs were cut into railroad ties at an on-site sawmill, then pressure treated with hot creosote stored in a railroad tank car. There is no indication of creosote disposal on site, and records show that creosote remaining in the pressure chamber at the end of the treatment cycle was stored for future use. Historical information indicates that the on-site sawmill was located to the north of the current dirt access road (Baker, 1994).

Previous investigations conducted under the DoN's IR Program at Site 3 have focused on soil (surficial and subsurface), groundwater, and sediment from standing water at the site. Surface soil exhibited Polyaromatic Hydrocarbon (PAH) contamination at concentrations ranging from 260 µg/kg to 2,200 µg/kg. PAH contaminants detected included: benzo(g,h.i)perylene, benzo(b)fluoranthene, chrysene, benzo(k)fluoranthene, benzo(a)pyrene, pyrene, and indeno(1,2,3-cd)pyrene). PAHs were detected in the subsurface soil (15 to 17 ft bgs) at concentrations greater than 35,000 µg/kg. Several PAHs were detected at concentrations greater than 1,000 µg/L in one of the shallow monitoring wells. No PAHs were reported in the sediment samples.

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

Topography and Surface Features

Site 3 (Old Creosote Plant) is predominantly flat with elevations around 30 feet above msl. The study area is mostly a clear parcel of land bordered on the north, east and south sides by woods. The Camp Lejeune Railroad lies approximately 200 feet to the west of the study area. A gravel road bisects the site from west to east. This road is the only access road from Holcomb Boulevard. Remnants of the former creosote plant including a chimney, concrete pads, and train rails. During periods of heavy rain the western area of the site exhibited several areas of standing water. Surface water runoff from the site flows in both an easterly and westerly direction since runoff ditches flank both the eastern and western edges of the site. The drainage areas on the western side parallel the Camp Lejeune Railroad and Holcomb Boulevard.

Surface Water Hydrology

There are no standing water bodies within the site. Ditches on the eastern and western sides of the site exhibit ponded water during periods of heavy rain. Wallace Creek is located approximately three-quarters of a mile to the south of the site. Surface drainage is towards the east and west, in the directions of the drainage ditches. There is the potential for these ditches to channel site related constituents off site during periods of heavy rainfall.

Site 3 is primarily underlain by sand, and silty sand with occasional discontinuous layers of silt and clay, and clay. These surficial soils represent the Quaternary age "undifferentiated" Formation that characterizes the shallow water table aquifer. Results of the standard penetration tests (ASTM D1586-84) indicate the relative density of the soils range from very loose to dense. Unified Soil Classification System (USCS) classification for the surficial soils identified at the site are SM (silty sand), SP (poorly graded sands with little to no fines), and CL (silty clay and clay). Possible fill material was noted at some borehole locations in the southern portion of the treatment area, ranging in thickness from 1 to 3 feet. This fill material consisted of apparent replaced soil. Two intermediate depth wells (87 feet bgs) and one deep well (140 feet bgs) were installed in the upper and middle portion of the Castle Hayne aquifer. The lithology of the upper Castle Hayne is predominantly a fine grained sand with trace to little silt, and shell and limestone fragments.

Beneath the silty sand is a discontinuous silty clay layer ranging in thickness from 0 to approximately 12 feet thick. This silty clay layer is not evident in the log for well 3-MW03, installed during a previous investigation, in the northern portion of the site. It was also not encountered in wells 3-MW04 and 3-MW06, installed during the 1994 investigation, in the central and southern portion of the site, respectively. Intermediate well 3-MW11IW on the western side of the site exhibited a silty clay layer at a depth of 32 feet. The silty sand above the silty clay unit was damp to wet, indicating that the clay unit may inhibit but not preclude the downward groundwater flow due to its apparent lower permeability. The lithology below the silty clay, as seen in intermediate well 3-MW11IW and deep well 3-MW02DW, indicates the Castle Hayne formation. This unit is comprised of a silty sand with varying amounts of shell fragments, and exhibits a higher density with depth.

Hydrogeology

Groundwater was encountered during drilling during the RI at elevations ranging from 8.13 to 25.56 feet above msl. The shallow groundwater gradient measured from well 3-MW07 to well 3-MW05 in the southwest for December 11, 1994 was 0.046 ft/ft, March 27, 1995 was 0.048 ft/ft, and August 1, 1995 was 0.042 ft/ft. Shallow groundwater may be discharging to Wallace Creek, the nearest surface water body, located approximately three-quarters of a mile south of the site.

The lithology indicates a confining or semiconfining layer between the surficial water table aquifer and the Castle Hayne aquifer. This is substantiated by the difference in groundwater elevations exhibited between the shallow and intermediate wells at locations 3-MW02 and 3-MW11. The differentiation between the two water bearing zones is based on lithology, groundwater parameters as seen from the evaluation of slug test data, and usage (the surficial 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 ft/ft.

Ecological Features

Three general habitat types are present at Site 3. These three include an open area, mixed forest, and pine forest. The open area, which covers most of the site, is dominated by grasses with bare soil present in some places. Scattered trees are found within the open area. A transition zone is present between the open area and the mixed forest southeast of the site. The mixed forest is dominated by loblolly pines, mixed with deciduous trees. Shrubs and herbaceous plants are also found within the mixed forest. The pine forest contains loblolly pine with no other tree species, vines or herbaceous plants present. Birds were identified in the area as was evidence of whitetail deer. The habitat evaluation was conducted in winter so no reptiles or amphibians were observed at Site 3. Site 3 is not within or in close proximity (i.e., one-half mile) to either a natural area or protected area. Protected areas have only been established for the red-cockaded woodpecker.

Land Use Demographics

The Old Creosote Plant is located within the Mainside Supply and Storage areas. Approximately 10.5 percent of all developed land in the Complex is comprised of supply and storage uses, most of which are concentrated in the area east of Paradise Field at Hadnot Point or east of Holcomb

Boulevard in an open storage area. The area of Site 3 is located east of Holcomb Boulevard approximately three-quarters of a mile from the intersection of Brewster and Holcomb Boulevards. This area is currently not being used for open storage.

Water Supply

There are four base supply wells within a one-mile radius of Site 3: HP-613, HP-616, HP-654, and OW-3 (Harnad, et al., 1989).

REMEDIAL INVESTIGATIONS

The first phase of the RI field investigation commenced on September 19 through September 22, 1994. The second phase commenced on October 10, 1994 and continued through December 12, 1994. During the week of January 30, 1995, investigative derived waste (IDW) generated during the first and second phases of the RI investigation was disposed of accordingly. In addition, a third phase of the RI field investigation commenced on June 12 and continued through July 15, 1995. The RI field program at Site 3 consisted of a site survey; a soil investigation and a groundwater investigation which included monitoring well installation and sampling. A summary of the RI field investigation is provided below.

The site survey was performed in four phases: Phase I - initial survey of Enzyme Linked Immunsorbent Assay (ELISA) Sampling Grid was conducted September 19 through September 21, 1994; Phase II - survey of site features and proposed sample locations was completed during the week October 10, 1994; Phase III - post investigation survey of existing sampling locations and monitoring wells was completed during the week of October 10, 1994; and Phase IV - survey of additional soil samples and monitoring wells was completed the week of July 10, 1995. The firm of W. K. Dickson and Associates, Inc. was retained to perform the first three phases of the site survey. Phase IV of the site survey was completed by the surveying firm of Brent A Lanier.

A three-phased soil investigation was conducted to determine the presence or absence of contamination within the study area. The first phase of the soil investigation involved utilizing ELISA field screening technology on surface soils only, and the second phase involved the installation of soil borings and groundwater monitoring wells for the collection of surface and subsurface soils with a drill rig. The third phase of the soil investigation involved the installation of additional soil borings and groundwater monitoring wells.

Site 3 was broken down into four areas of concern. These areas include the Rail Spur Area, Concrete Pad Area, Treatment Area, and North Area. From these four areas of concern a total of 84 surface soils (i.e., samples collected from 0 to 1 foot bgs) were collected during the first phase of the investigation, to evaluate the presence or absence of PAH contamination within the study area. All of the soil samples were analyzed in the field utilizing test kits, produced by ENSYS, Inc. (ENSYS). These test kits were for the specific detection/analysis of Polyaromatic Hydrocarbons (PAHs). In addition, three surface soil samples were also collected from background locations, not known or suspected to be contaminated. These background locations were sampled during the second phase of the soil investigation. Each soil sampling location was identified with a unique descriptive abbreviation (e.g., surface soil location 3-RS-SB01 refers to Site 3, the Rail Spur Area, and soil boring number one). The following provides a summary of the number of surface soil soils collected for PAH RISC ® soil test and the area in which they were collected:

- Ten surface soils, Rail Spur Area (RS)
- Ten surface soils, Concrete Pad Area (CP)
- Forty-four surface soils, Treatment Area (TA)
- Seventeen surface soils, North Area (NA)
- Three surface soils, Background Locations (BB)

In addition to being analyzed in the field, 37 out of the 84 surface soil samples were sent to the laboratory for confirmatory analysis.

A total of 9 surface soils were collected within the study area during the second phase of the investigation to evaluate the presence of PAH contamination that was detected during the EnSys investigation. Three out of the nine surface soils were collected from background locations, not known or suspected to be contaminated. The remaining six surface soils were collected from soil borings that were converted into groundwater monitoring wells.

A total of 16 surface soils were collected during the third phase of the investigation to further delineate the extent of contamination detected during the second phase of the soil investigation. Nine out of the 16 surface soils were collected from soil borings. From these nine soil borings, six surface soil samples were collected within the Treatment Area, and three samples were collected within the North Area. The remaining seven surface soils were collected from soil borings that were converted into groundwater monitoring wells. The following provides a summary of the number of surface soil samples collected during both the second and third phases of the soil investigation and the area in which they were collected:

- Six surface soils, Treatment Area (TA)
- Three surface soils, North Area (NA)
- Thirteen surface soils, Monitoring Well Locations (MW)
- Three surface soils, Background Locations (BB)

During the third phase of the surface soil investigation, 16 surface soils were collected. Of the 16 surface soil samples 6 were collected from soil borings within the Treatment Area, 3 samples were collected from soil borings within the North Area, and remaining 7 were collected from soil borings converted into monitoring wells.

A total of 34 subsurface soils (i.e., samples collected from 1 foot bgs to just above the groundwater table) were collected from Site 3 during the second phase of the soil investigation to evaluate the presence or absence of contamination within the vadose zone. All of the subsurface soil samples were collected via split-spoon sampling. Twenty-seven out of the 34 subsurface soils were collected from soil borings based on ENSYS field screening and confirmatory results. Fifteen out of the 27 samples were collected within the Treatment Area. Six out of the 27 samples were collected within the Rail Spur Area. Three out of the 27 samples were collected within the North Area. The remaining three samples were collected from background locations not known or suspected to be contaminated. Additionally, seven subsurface soils were collected from soil borings that were converted into groundwater monitoring wells. It should be noted that monitoring well 3-MW02IW was the only well to have two subsurface samples collected from the boring. This additional sample was obtained from 17 to 19 feet bgs due to apparent creosote contamination within the split-spoon.

An additional 16 subsurface soil samples were collected during the third phase of the soil investigation. This phase was conducted to further define PAH contamination that was detected during the second phase of the soil investigation. Nine out of the 16 subsurface soils were collected from soil borings. From these nine subsurface samples, six were collected within the Treatment Area, and three were collected within the North Area. The remaining seven subsurface soil samples were collected form soil borings that were converted to monitoring wells. The following provides a summary of the number of subsurface soil samples collected during both the second and third phases of the soil investigation and the areas in which they were collected:

- Six subsurface soils, Rail Spur Area (RS)
- Twenty-one subsurface soils, Treatment Area (TA)
- Six subsurface soils, North Area (NA)
- Fourteen subsurface soils, Monitoring Well Locations (MW)
- Three subsurface soils, Background Locations (BB)

A groundwater investigation was conducted at Site 3 to determine the presence or absence of contamination in both the surficial aquifer and the deeper Castle Hayne aquifer, which may have resulted from past operational activities. During the second phase of the soil investigation five permanent shallow groundwater monitoring wells (3-MW04, 3-MW05, 3-MW06, 3-MW07, and 3-MW08) were installed, then sampled during December 1 through December 3, 1994. In addition, one intermediate groundwater monitoring well 3-MW02IW (i.e., installed to the top of the Castle Hayne aquifer) was installed and sampled as part of this investigation. Two of the three existing on-site shallow monitoring wells (3-MW02, and 3-MW03) were also sampled during the groundwater investigation. Shallow monitoring well 3-MW01 was not sampled since this well had less than 0.5 feet of standing water within it, and did not respond to development and purging procedures.

Existing monitoring well 3-MW03 and newly installed monitoring well 3-MW08 are located within the North Area. Monitoring well 3-MW08 was placed in an upgradient (i.e., background) location to assess off-site groundwater quality. Existing monitoring wells 3-MW01, and 3-MW02, and newly-installed monitoring wells 3-MW02IW, 3-MW04, 3-MW05, and 3-MW07 are located within the Treatment Area of Site 3. Newly-installed monitoring well 3-MW06 is located within the Rail Spur Area.

Monitoring wells 3-MW02IW, 3-MW07, and 3-MW08 were the only monitoring wells at Site 3 that were sampled for full TCL organics, and TAL total metals and dissolved metals. The remaining six shallow monitoring wells were only sampled for TCL semivolatiles.

Due to volatile and PAH contamination detected within the groundwater during the first round of sampling, an additional seven groundwater monitoring wells were installed to further define the vertical and horizontal extent. These wells were installed during the period June 12 through June 29, 1995. Five additional shallow wells (3-MW09, 3-MW10, 3-MW11, 3-MW12, and 3-MW13), one intermediate well (3-MW11IW), and one deep well (3-MW02DW) were installed during the Phase III soil investigation. Shallow monitoring well 3-MW09 is located in the North Area of Site 3. Shallow monitoring wells 3-MW12 and 3-MW13 are located to the west of Site 3. Monitoring well 3-MW12 is located on the western edge of the railroad line and 3-MW13 is located on the western side of Holcomb Boulevard. Monitoring wells 3-MW11 and 3-MW11IW are located on the southwestern side of the site on the western side of the railroad tracks. Monitoring well 3-MW10 is located on the eastern edge of Site 3. The deep monitoring well, 3-MW02DW, is located alongside monitoring wells 3-MW02 and 3-MW02IW near the center of Site 3.

All new and existing monitoring wells were sampled for TCL volatiles and semivolatiles analysis. Monitoring wells 3-MW02, 3-MW02DW, 3-MW08 were also sampled for Engineering Parameters (i.e., {Biological Oxygen Demand [BOD]}, {Chemical Oxygen Demand [COD]}, {Total Dissolved Solids [TDS]}, {Total Suspended Solids [TSS]}, and TOC). In addition, monitoring well 3-MW01, which was not sampled during round 1 of the groundwater investigation conducted in December 1994, was sampled during this investigation.

In order to confirm the presence or absence of contamination detected in monitoring wells 3-MW02DW during the Round 2 sampling, and determine the need for additional deep wells to characterize deep groundwater flow, a third round of groundwater samples were collected from all the wells.

Samples collected during the RI were submitted for laboratory analysis to Quantera Environmental, Inc. Field QA/QC samples were collected during the investigation in order to: (1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); (2) evaluate field methodologies (e.g., field duplicate samples); (3) establish field background conditions (e.g., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (e.g., trip blanks). Data Quality Objectives (DQOs) for the samples were implemented in accordance with DQO Level IV, as defined in the Environmental Compliance Branch standard operating procedures (SOPs) and Quality Assurance Manual, (USEPA Region IV, 1991). The DQO Level IV is equivalent to Naval Facilities Engineering Service Center (NFESC) DQO Level D, as specified in the Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs document (NEESA, 1988).

A habitat evaluation was performed at Site 3 during December 4 to 6, 1994. The evaluation focussed on the determination of terrestrial and aquatic ecosystems, along with the identification of plant and animal species site. During the reconnaissance, particular species (botanical and/or animal) identified on site were documented in a field logbook. Also, unknown botanical species were collected for further identification. In addition, sketches of the site were also produced to show the different areas of varying species or zones (i.e., the general locations of a deciduous forest, hardwood forest, shrub, industrial, swamp, wetland, and water body areas).

EXTENT OF CONTAMINATION

ENSYS

The ENSYS field screening provided an accurate preliminary assessment of the surface contamination at the site. It identified areas of concern, which was confirmed with fix-based laboratory analyses defining specific areas which exhibited contamination and may require remediation.

ENSYS results were comparable to laboratory results approximately 39 percent of the time. Four of the ENSYS tests (15 percent) indicated levels >1 part per million (ppm) and <10 ppm where the normalized laboratory results were undetected. Eleven (42 percent) of the remaining laboratory results were <1 ppm where as the ENSYS results indicated concentrations >1 <10 ppm. Only one ENSYS result (4 percent) indicated a concentration >10 ppm, with the corresponding laboratory result was <1 ppm. The majority of the laboratory concentrations are presented as estimated values ("J" qualifier). Estimated values may bias the normalized laboratory results when comparing them to ENSYS results. The six laboratory samples which exhibited the fewest estimated values for compounds showed the best correlation to the ENSYS field results. These were also the samples exhibiting the highest concentrations of the individual compounds. This may indicate that the ENSYS testing is more accurate or reliable at concentrations greater than 10 ppm.

Soil

PAH constituents were the most frequently detected organics and exhibited the greatest concentrations in the soil. These constituents are believed to be associated with past wood treating activities at the site. The highest concentrations of PAHs in soils occurred in the Treatment Area in the central portion of the site. Fuel constituents, such as ethylbenzene and xylene, were also detected in surface and subsurface soils at Site 3, primarily at the former treatment area in the central portion of the site. The following is a summary of the soil investigation findings.

Surface Soil

"Fuel-related" constituents were the only volatile organics detected in the surface soil samples. Toluene was detected in the samples from intermediate well 3-MW02IW (2J µg/kg) and shallow well 3-MW13 (2J µg/kg). Ethylbenzene and xylenes (total) were detected in the surface sample from location 3-TA-SB50 at concentrations of 2J µg/kg and 6J µg/kg, respectively.

Polynuclear aromatic hydrocarbons (PAHs) were the predominant semivolatiles detected in the surface soil samples. Total PAH concentrations ranged from nondetect to 93,750 µg/kg (location 3-NA-SB03). The PAH constituent with the highest concentration was pyrene (14,000 µg/kg) at location 3-NA-SB03. Phenanthrene and pyrene were detected at low levels in the surface soil at background boring location 3-BB-SB01, located at the northern end of the North Area. Phthalate esters [di-n-butylphthalate and/or bis(2-ethylhexyl)phthalate] were detected at low levels in 37 of 58 samples. Di-n-butylphthalate concentrations ranged from 37J (3-NA-SB18) to 340J µg/kg (3-TA-SB13). Bis(2-ethylhexyl)phthalate was detected at concentrations ranging from 36J µg/kg (3-TA-SB21) to 91J µg/kg (3-NA-SB01). Di-n-butylphthalate and bis(2-ethylhexyl)phthalate were detected in surface soil at background boring 3-BB-SB03 in the Rail Spur Area. Phenol and dibenzofuran were each detected in one sample at concentrations of 38J µg/kg (3-RS-SB03) and 370J µg/kg (3-NA-SB05), respectively. No semivolatile organics were detected in QA/QC blanks.

No pesticides or PCBs were detected in the limited number of surface soil samples submitted for full TCL organics.

Eleven of 23 inorganics were detected in the surface soil at borings 3-MW05 and 3-MW02IW. Calcium, chromium, magnesium, sodium, and zinc were detected above base background levels (by an order of magnitude or less) at boring 3-MW02IW.

Subsurface Soil

Low levels of volatile organics were generally detected above the 7 to 9 foot depth, except for chloroform which was detected in well 3-MW11IW at a concentration of 3J µg/kg at a depth of 15 to 17 feet. "Fuel-related" constituents were the most frequently detected volatile organics. These constituents were only detected in the central portion of the Treatment Area. Total concentrations ranged from 18 µg/kg (3-MW02IW, 5 to 7 feet) to 423 µg/kg (3-TA-SB49, 7 to 9 feet). Sample 3-MW12 (3 to 5 feet) exhibited a carbon disulfide concentration of 1J µg/kg.

Boring 3-TA-SB48 exhibited the highest semivolatile organic concentrations in the subsurface soil. Semivolatile organic contaminants consisted predominantly of PAH constituents. The highest concentrations of semivolatile organics were observed in 7 to 9 foot depth samples. The total PAH concentration at 3-TA-SB48 was 402,300 µg/kg (7 to 9 feet). The higher PAH concentrations were detected in the central portion of the Treatment Area. Di-n-butylphthalate, the only detected phthalate ester, was detected in 18 of 47 subsurface soil samples at concentrations ranging from 39J µg/kg (3-MW11IW, 15 to 17 feet) to 170J µg/kg (samples 3-TA-SB18, 5 to 7 feet, and 3-TA-SB43, 5 to 7 feet).

No pesticides or PCBs were detected in the subsurface soil samples submitted for full TCL organics.

Nine of 23 inorganics were detected in the two subsurface soil submitted for TAL inorganics analysis. None of the inorganics were detected above base background levels.

Groundwater

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. Naphthalene was the only PAH constituent detected above State and/or Federal standards in the shallow groundwater. This contaminant was detected in the Treatment Area and in the Rail Spur Area, but the detections were not consistent for the three rounds of sampling for location and concentrations.

Volatiles (fuel constituents) and semivolatiles (PAH constituents and phenols) were detected in the Castle Hayne aquifer during the three rounds of groundwater sampling. Benzene, phenols, and PAH constituents were the only organics detected in the Castle Hayne above State and/or Federal standards. Benzene was detected in intermediate well 3-MW02IW during the first sampling round. Benzene, phenols, and PAH constituents were detected during the second round of groundwater sampling in deep well 3-MW02DW in the Treatment Area. No contaminants were detected above State and Federal standards during the third groundwater sampling round. The following is a summary of the groundwater investigation findings.

Shallow Groundwater - Round One

Two shallow well samples were analyzed for volatile organics. The detected volatiles included carbon disulfide (location 3-MW07, 1J µg/L) and "fuel-related" constituents. Total fuel concentrations ranged from 24 µg/L (3-MW07) to 59 µg/L (3-MW08). These contaminants were not detected in QA/QC blanks.

PAHs were the prevalent semivolatile organics detected in the shallow groundwater. Total PAH concentrations ranged from 5J µg/L (3-MW07, naphtahlene only) to 1,287 µg/L (3-MW02). Monitoring well 3-MW06 exhibited low levels of naphthalene, acenaphthene and fluorene. Wells 3-MW02 and 3-MW06 exhibited dibenzofuran concentrations of 230 µg/L and 2 µg/L, respectively. Phenol was detected in QA/QC blanks at a maximum concentration of 7J µg/L. Phenol was detected in groundwater at a concentration less than 5 times the maximum concentration detected in QA/QC blanks.

No pesticides or PCBs were detected in the two shallow groundwater samples submitted from wells 3-MW07 and 3-MW08 for full TCL organics.

Two shallow wells were sampled for TAL metals. Twelve of 23 total metals were detected, with well 3-MW08 exhibiting the maximum concentration of ten of the twelve metals. Fewer dissolved metals were detected than total metals. Total metal concentrations were the same order of magnitude or less as base background concentrations:

Castle Hayne Aquifer - Round One

The only volatile organics detected in intermediate well 3-MW02IW were "fuel-related" constituents. Concentrations of fuel constituents were benzene (11J µg/L), toluene (4J µg/L) and xylenes (total) (7J µg/L).

PAH constituents were the prevalent semivolatile organics detected in well 3-MW02IW. The total PAH concentration in well 3-MW02IW was 167 µg/L. Dibenzofuran was detected at a concentration of 57 µg/L.

No pesticides or PCBs were detected in well 3-MW02IW.

Seven of 23 total metals were detected in well 3-MW02IW. Fewer dissolved metals were detected than total metals. Detected total metals included aluminum barium, calcium, iron, magnesium, manganese, potassium and sodium. Only aluminum and iron were detected above State and/or Federal standards.

Shallow Groundwater - Round Two

No volatile organics were detected during this sampling round. Semivolatiles were detected in well 3-MW06 in the rail spur area in the southern portion of the site. These semivolatiles consisted of PAHs and dibenzofuran. Total PAH concentration was 194 µg/L and dibenzofuran was detected at a concentration of 25 µg/L.

Castle Hayne Aquifer - Round Two

Intermediate well 3-MW02IW (85 foot depth) exhibited concentrations of volatiles and semivolatiles. Volatiles were limited to 1,1-dichloroethene (1J µg/L) and trichloroethene (1J µg/L). PAH constituents and dibenzofuran were the semivolatiles detected in the upper portion of the Castle Hayne aquifer. Total PAH concentration was 48J µg/L, consisting of acenaphthene (34 µg/L), anthracene (3J µg/L) and pyrene (11 µg/L). Dibenzofuran was detected at a concentration of 17 µg/L.

Deep well 3-MW02DW (125 foot depth) exhibited volatiles and semivolatiles. Volatiles consisted of BTEX constituents. Total BTEX concentration was 64J µg/L. Detected semivolatiles included phenols, dibenzofuran and PAH constituents. Phenols consisted of phenol (420 µg/L), 2-methylphenol (300 µg/L), 4-methylphenol (690 µg/L) and 2,4-dimetylphenol (170 µg/L). Dibenzofuran was detected at a concentration of 140 µg/L. Total PAH concentration was 3,895 µg/L. Naphthalene was detected at a concentration of 2,400 µg/L.

Shallow Groundwater - Round Three

"Fuel-related" constituents were detected in shallow wells 3-MW06 (9J µg/L) and 3-MW02 (44J µg/L). These constituents were not detected in QA/QC blanks.

PAHs were the prevalent semivolatile organics detected in the shallow groundwater. Total PAH concentrations ranged from 497 µg/L (3-MW06) to 1,923 µg/L (3-MW02). Wells 3-MW02 and 3-MW06 exhibited concentrations of dibenzofuran, 120 µg/L and 24 µg/L, respectively. Phenol was detected in well 3-MW02 at a concentration greater than five times the maximum concentration detected in QA/QC blanks.

Castle Hayne Aquifer - Round Three

No volatile organics were detected in the intermediate wells at Site 3.

PAH constituents were only detected in intermediate well 3-MW02IW. Total PAH concentration was 244 µg/L. Phenol was detected in well 3-MW11IW at a concentration of 1 µg/L. Dibenzofuran was detected in well 3-MW02IW at a concentration of 29 µg/L.

No volatile or semivolatile organics were detected in deep well 3-MW02DW.

HUMAN HEALTH RISK ASSESSMENT

Future Residential Children (with Round 2 Groundwater Contamination)

Total ICR for future residential children, (1.9E-05) is within the USEPA's acceptable cancer risk range. However, total HI, (1.7) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk (100 percent contribution). Groundwater ingestion contributes 56 percent to the total groundwater HI, and dermal contact with groundwater contributes 44 percent to the total groundwater HI.

Future Residential Children (with Worst Case Groundwater Contamination)

Total ICR for future residential children (7.6E-04) exceeds the USEPA acceptable cancer risk range. The risk from groundwater exposure drives the total cancer risk (100 percent contribution to risk). Groundwater ingestion contributes 4 percent to the total groundwater ICR, and dermal contact with groundwater contributes 95 percent to the total groundwater ICR.

Total HI (2.3) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk for future residential children (100 percent contribution to risks). Groundwater ingestion contributes 93 percent to the total groundwater HI, and dermal contact with groundwater contributes 7 percent to the total groundwater HI.

Future Residential Adults (with Round 2 Groundwater Contamination)

Total ICR for future residential adults (1.7E-05) is within the USEPA acceptable cancer risk range. However, total HI (0.7) falls below the USEPA acceptable noncarcinogenic risk value of 1.0. Therefore, no systemic risks are likely to occur from exposure to groundwater.

Castle Hayne Aquifer - Round Three

No volatile or semivolatile organics were detected in deep well 3-MW02DW.

Future Residential Adults (with Worst Case Groundwater Contamination)

Total ICR for future residential adults (1.8E-03) exceeds the USEPA acceptable cancer risk range. The risk from groundwater exposure drives the total carcinogenic risk (100 percent contribution). Groundwater ingestion contributes 4 percent to the total groundwater ICR, and dermal contact with groundwater contributes 96 percent to the total groundwater ICR.

Total HI, (3.7) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk (100 percent contribution). Groundwater ingestion contributes 91 percent to the total groundwater HI, and dermal contact with groundwater contributes 9 percent to the total groundwater HI.

Current Military Personnel

Total ICR for current military personnel (1.7E-06) is within the USEPA acceptable risk range. Total HI was not calculated (is not applicable), because there are no noncarcinogens retained as COPCs in surface soil.

Future Construction Workers

Total ICR for future construction workers (1.0E-07) is below the USEPA acceptable risk range. Total HI (less than 0.01) is less than 1.0.

ECOLOGICAL RISK ASSESSMENT

Terrestrial Receptors

Several of the contaminants at Site 3 exceeded the SSSVs. Many of the exceedences were located in open grass areas or along the tree line. Therefore, there is the potential for a decrease in population of terrestrial invertebrates in these areas.

None of the CDI to TRV QIs for any of the species exceeded "1". Therefore, potential impacts to terrestrial mammals or birds are not expected.

Threatened and Endangered Species

No threatened or endangered species are known to occur at Site 3, therefore no adverse impacts to these species from contaminants at Site 3 are expected.

Wetlands

No wetlands have been identified at Site 3, therefore no adverse impacts to wetlands from contaminants at Site 3 are expected.

1.0 INTRODUCTION

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). Subsequent to this listing, 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) and Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at MCB, Camp Lejeune were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect the public health, welfare, and the environment (FFA, 1989). The Fiscal Year 1996 Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 33 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 33 sites have been divided into 17 Operable Units (OUs) to simplify proceeding with RI/FS activities. This report describes the RI conducted by Baker Environmental Inc. (Baker) at OU No. 12, which is comprised of Site 3. Figure 1-1 depicts the MCB Camp Lejeune location along with the location of Site 3. [Note that all tables and figures are provided in the back of each section.]

The purpose of the RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. The RI investigation was conducted through the sampling of several media (surficial and subsurface soil and groundwater) at Site 3, evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. Furthermore, the RI report provides information to support the FS and Record of Decision (ROD) for a final remedial action.

This RI Report has been prepared by Baker for submittal to the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), MCB, Camp Lejeune Environmental Management Division (EMD), USEPA Region IV, the NC DEHNR, and the Navy Environmental Health Center (NEHC), for their review.

The following subsections describe the characteristics and histories of OU No. 12 (Site 3). In addition, the organization of this report is provided in Section 1.1.

1.1 Report Organization

This RI Report for Site 3 is comprised of the following sections:

- Section 1.0 - Introduction (includes OU and site description, and site history)
- Section 2.0 - Field Investigation
- Section 3.0 - Regional and Site Characteristics
- Section 4.0 - Nature and Extent of Contamination
- Section 5.0 - Contaminant Fate and Transport
- Section 6.0 - Baseline Human Health Risk Assessment
- Section 7.0 - Ecological Risk Assessment
- Section 8.0 - Conclusions and Recommendations

Appendices that are referenced in this RI Report for Site 3 are provided in a separate volume.

1.2 Operable Unit Description

Operable Units are formed as an incremental step toward addressing individual site concerns and to simplify the specific problems associated with a site or a group of sites. There are currently 33 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune which have been grouped into 17 operable units. Site 3 is the only site within OU No. 12, due to its previous history of being a creosote plant. The creosote plant operated from 1951 to 1952, supplying treated timbers for the construction of the Base railroad. Figure 1-2 depicts the locations of all 17 OUs and 33 sites at MCB, Camp Lejeune.

OU No. 12 (Site 3) is referred to as the Old Creosote Plant and is located on the mainside portion of MCB Camp Lejeune, approximately one quarter mile east of Holcomb Boulevard and one mile north of Wallace Creek. Remnants of the former creosote plant including the chimney, concrete pads, and train rails are present in the southern portion of OU No. 12. The cleared area in the northern portion of the OU No. 12 was reported to be the location of the former sawmill, which supplied the cut timbers for creosote treatment.

1.3 Site Description and History

Site 3 area encompasses approximately 5 acres, is generally flat and unpaved, and is intersected by a dirt access road. Access to the site is unrestricted directly from Holcomb Boulevard. The Camp Lejeune Railroad lies approximately 200 feet to the west of Site 3. During periods of heavy rain the western area of the site exhibits several areas of standing water. Surface water runoff from the site flows in both an easterly and westerly direction since runoff ditches flank both the eastern and western edges of the site. To the east is a small drainage way in which ponded water is evident during periods of heavy rain. To the west of the site are drainage areas which parallel the Camp Lejeune Railroad and Holcomb Boulevard. None of these potential drainage areas were under flow conditions during the March 1, 1994 site reconnaissance. Figure 1-3 depicts the location of Site 3 and the bordering areas.

The old creosote plant reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base railroad. Logs were cut into railroad ties at an on-site sawmill, then pressure treated with hot creosote stored in a railroad tank car. There is no indication of creosote disposal on site, and records show that creosote remaining in the pressure chamber at the end of the treatment cycle was stored for future use. Historical information indicates that the on-site sawmill was located to the north of the current dirt access road (Baker, 1994).

1.4 Previous Investigations

A Site Inspection (SI) was conducted by Halliburton/NUS in June of 1991. This investigation encompassed the collection of surface and subsurface soil samples, the installation of three groundwater monitoring wells, and the collection of two sediment samples from standing water at the site. The following subsections present a description of the investigation along with the results. Information regarding procedures and methodologies can be obtained in the Site Inspection Report (Halliburton/NUS,1991).

1.4.1 Soil Investigation

Eight surface soil samples (0 to 2 feet below ground surface [bgs]) and 8 subsurface soil samples (3 to 17 feet bgs) were collected. All samples were analyzed for TCL semivolatile compounds. Analytical findings are summarized on Table 1-1.

The surficial soil samples from locations SB04 and 3MW02 (0 to 2 feet bgs) exhibited Polyaromatic Hydrocarbon (PAH) contamination 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. Other PAHs detected at concentrations greater than 1,000 µg/kg include chrysene, benzo(k)fluoranthene, benzo(a)pyrene, fluoranthene, pyrene, and indeno(1,2,3-cd)pyrene.

PAH contamination was not detected in the shallow subsurface soil (3 to 5 feet bgs). However, in the deep subsurface soil sample collected from boring 3MW02 (15 to 17 feet bgs), PAHs were detected at elevated concentrations. Several contaminants were detected at concentrations greater than 35,000 µg/kg, such as acenaphthene, fluoranthene, fluorene, naphthalene, and phenanthrene. In addition, dibenzofuran was detected at a concentration of 35,000 µg/kg.

1.4.2 Groundwater Investigation

Three shallow monitoring wells (3MW01, 3MW02, and 3MW03) were installed in June 1991 to a depth of 17 to 25 feet bgs. One round of groundwater samples were collected from each monitoring well and analyzed for full TCL semivolatile organic compounds. Analytical findings for groundwater samples are summarized on Table 1-2. Monitoring well locations are shown on Figure 1-4.

Of the three monitoring wells, only well 3MW02 was found to contain semivolatile compounds. Several PAHs were detected in this well at concentrations greater than 1,000 microgram per liter (µg/L) (acenaphthene, 2-methylnaphthalene, napthalene, and phenanthrene). Other PAHs detected included anthracene (260 µg/L), chrysene (96 µg/L), fluoranthene (640 µg/L), fluorene (890 µg/L), and pyrene (460 µg/L). Dibenzofuran was also detected in this sample at a concentration of 1,100 µg/L.

1.4.3 Sediment Investigation

Two sediment samples were collected from the low lying areas of the site that collect runoff water. Both samples were analyzed for TCL semivolatile compounds. Bis(2-ethylhexyl)phthalate was detected at a concentration of 750 µg/kg in sample SD01, which was collected in the far eastern side of the study area. Sediment sampling locations are provided on Figure 1-4.

1.5 Data Limitations

Upon review of the SI data, it was determined that there were possible soil and groundwater data limitations. Contamination was detected in some soil and groundwater samples, however, the extent to which the contamination was present on-site was not sufficient to characterize human health or ecological risks, or to characterize the extent of contamination.

Upon review of the SI data limitations were generated for soil and groundwater as described below.

The data limitations for the soil include the following:

- Presence or absence of soil contamination in the northern portion of the site.
- Presence or absence of soil contamination around the concrete pads in the southern portion of the site.
- Extent of soil contamination at the former creosote treatment facility.
- Assess human health and ecological risks associated with exposure to surface soils at the site.

The data limitations for the groundwater include the following:

- Extent (if any) of the health risks posed by the potential future usage of the shallow groundwater.
- Vertical and horizontal extent of shallow groundwater contamination.
- Presence or absence of shallow groundwater contamination migrating to deeper zones.
- Definitizing the hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation.

Upon review of the above data limitations, site-specific data requirements were generated and are listed below:

- The nature of surface soil contamination in the former sawmill area at the northern portion of the site.
- The nature of surface soil contamination at the former creosote treatment area and the concrete pads in the southern portion of the site.
- The impact of the former creosote operation on soil and groundwater.
- The presence or absence of site-related contaminants in the surface and subsurface soil in order to conduct a human health risk assessment.
- The hydrogeologic parameters of the shallow and intermediate aquifers.
- The information to support the assessment of risks to human health posed by future potential exposure to the groundwater.

From these site-specific data requirements, RI objectives were established to meet the data deficiencies for Site 3. RI objectives are discussed in detail in the following section.

1.6 Remedial Investigation Objectives

The purpose of this section is to: (1) define the RI objectives aimed at characterizing past operational activities at Site 3, (2) assess potential impacts to public health and environment; and (3) provide feasible alternatives for consideration during preparation of the ROD. The remedial objectives presented in this section have been identified through review and evaluation of existing background information, assessment of potential risks to public health and environment, and consideration of feasible remediation technologies and alternatives. Table 1-4 presents both the RI objectives identified for Site 3 and the criteria necessary to meet those objectives. In addition, this table provides a general description of the study or investigation efforts required to obtain the necessary information. The different media investigations conducted at Site 3 are described in Section 2.0 of this report.

1.7 References

Baker Environmental, Inc. 1994. Remedial Investigation/Feasibility Study Project Plans for Operable Units Numbers 8, 11, and 12 (Sites 16, 7, 80, and 3). Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk Virginia.

Haliburton/NUS, 1991. Preliminary Draft Site Inspection Report for Site 3 Old Creosote Plant. Marine Corps Base, Camp Lejeune, North Carolina.

SECTION 1.0 TABLES

TABLE 1-1

DETECTED CONTAMINANTS IN SOIL - 1991 SITE INSPECTION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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

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

TABLE 1-2

DETECTED CONTAMINANTS IN GROUNDWATER - 1991 SITE INSPECTION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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	21	--	2/3	9-4,400	3MW02
Phenanthrene	210	--	1/3	1,600	3MW02
Pyrene	210	--	1/3	460	3MW02
Dibenzofuran	--	--	1/3	1,100	3MW02

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

TABLE 1-3

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent, if any, of soil contamination in the northern portion of the study area.	Characterize semivolatile levels in surface soils.	Soil Investigation - ENSYS Screening
	1b. Assess the extent, if any, of soil contamination around the concrete pads in the southern portion of the study area.	Characterize semivolatile levels in surface soils.	Soil Investigation - ENSYS Screening
	1c. Assess the extent of soil contamination at the former creosote treatment facility.	Characterize semivolatile and creosote levels in surface soil	Soil Investigation - ENSYS Screening
	1d. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize organic and inorganic contaminant levels in surface and subsurface soils.	Soil Investigation Risk Assessment
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to Applicable or Relevant and Appropriate Requirements (ARARs) and health-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess the horizontal and vertical extent of shallow groundwater contamination.	Characterize downgradient groundwater quality. Identify the presence or absence of contamination in deep groundwater.	Groundwater Investigation
	2c. Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation

SECTION 1.0 FIGURES

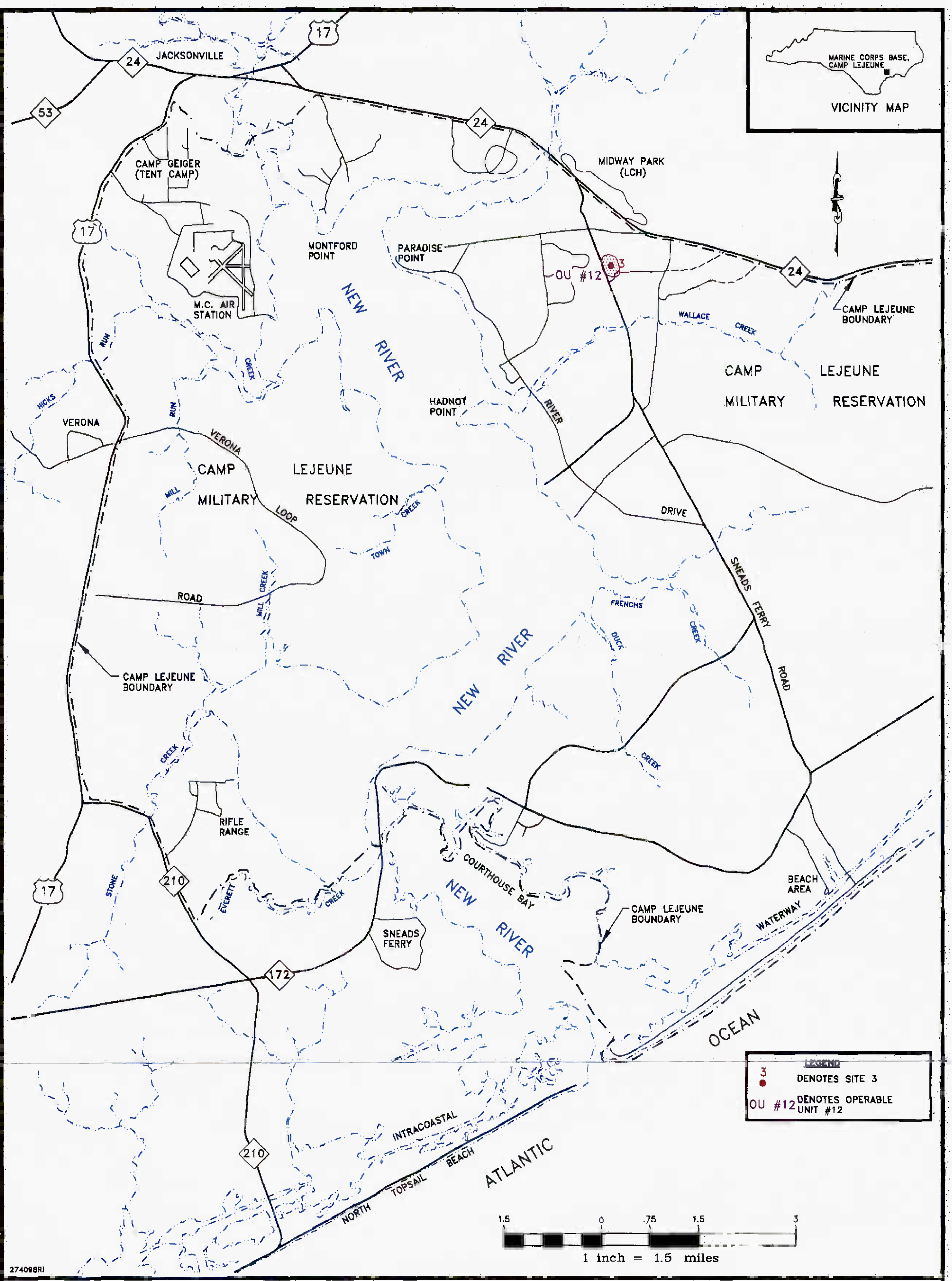


FIGURE 1-1
OPERABLE UNIT AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

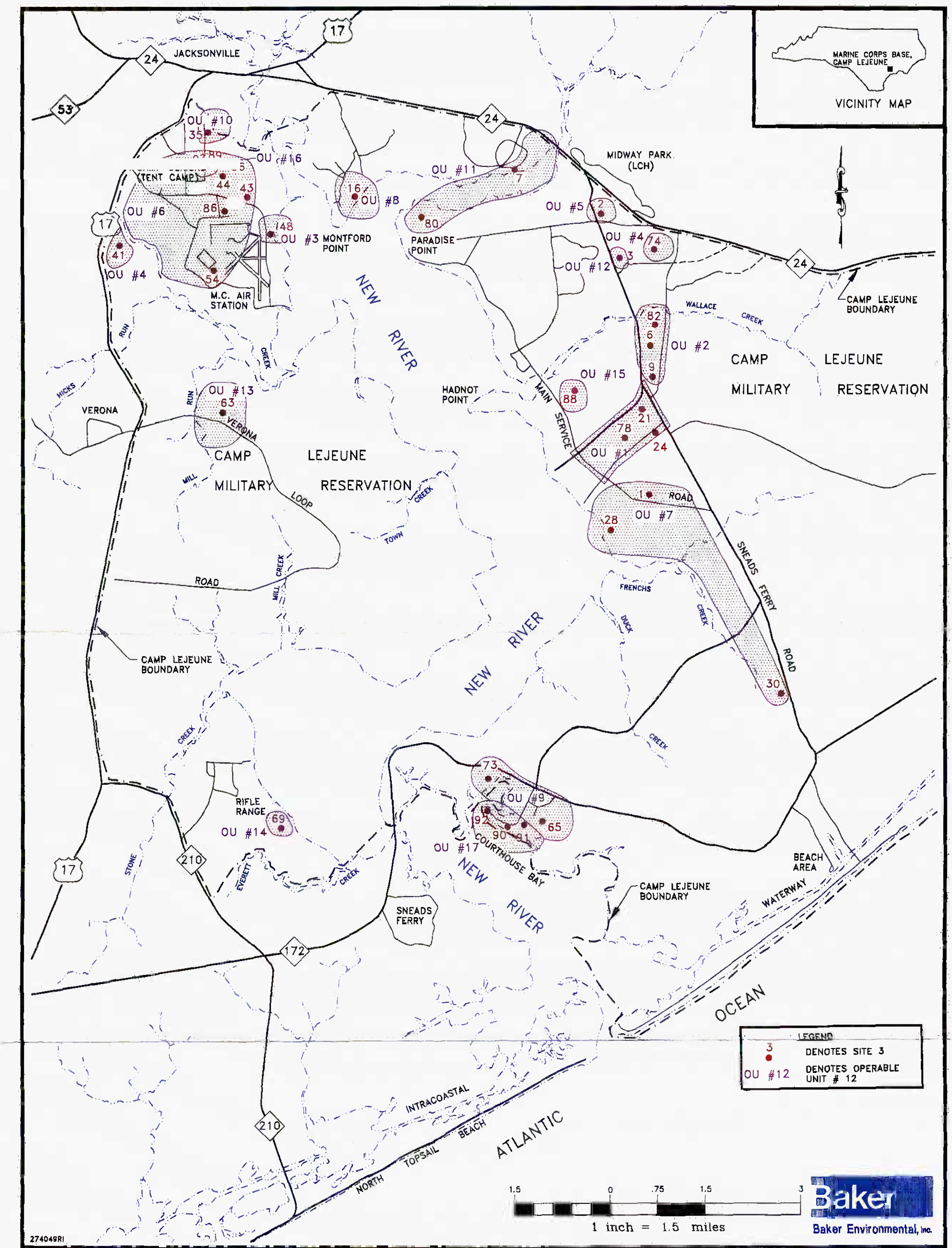
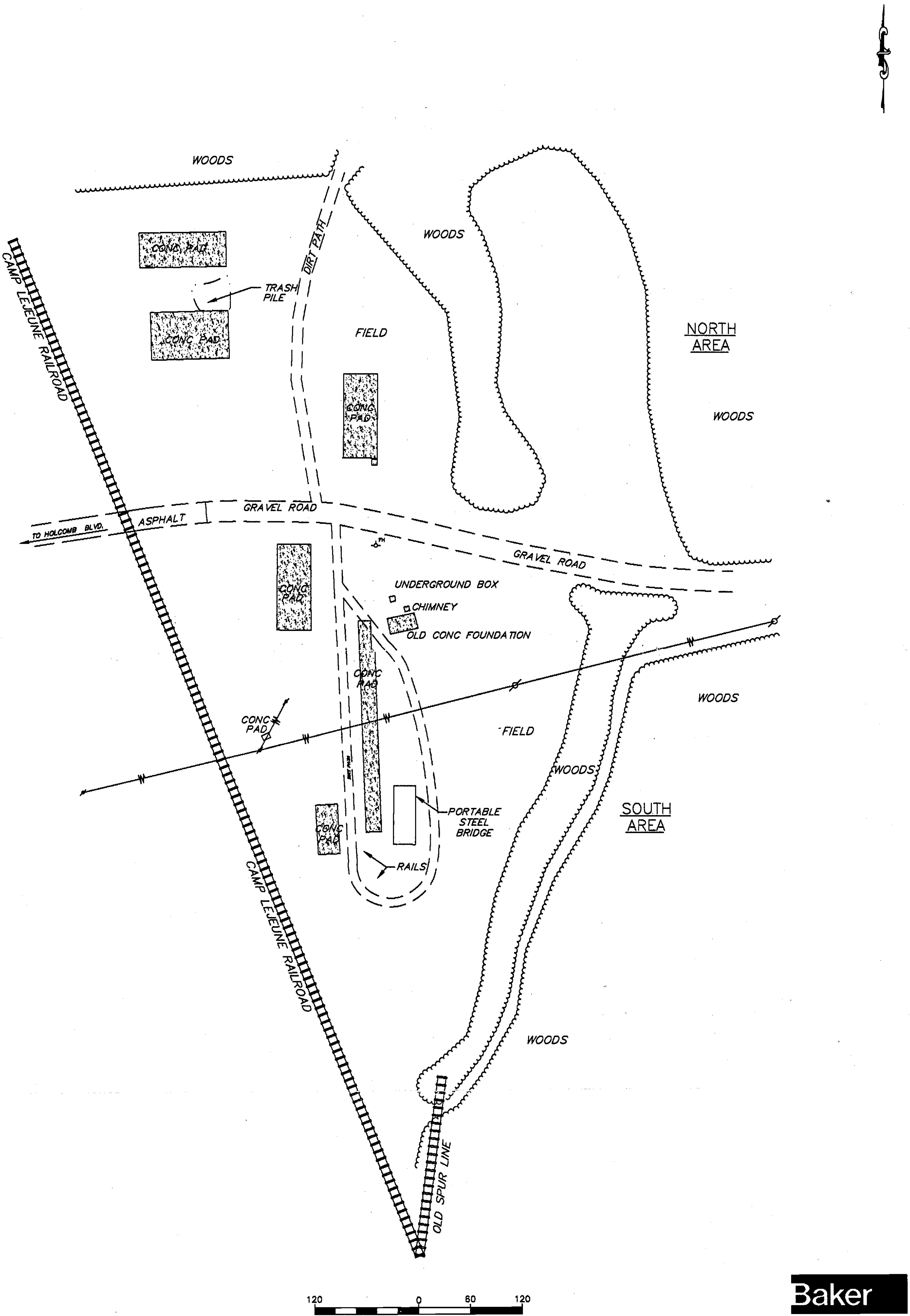


FIGURE 1-2
OPERABLE UNITS AND SITE LOCATIONS AT MARINE CORPS BASE CAMP LEJEUNE REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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Baker Environmental, Inc.

274051RI

FIGURE 1-3
SITE LOCATION MAP
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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

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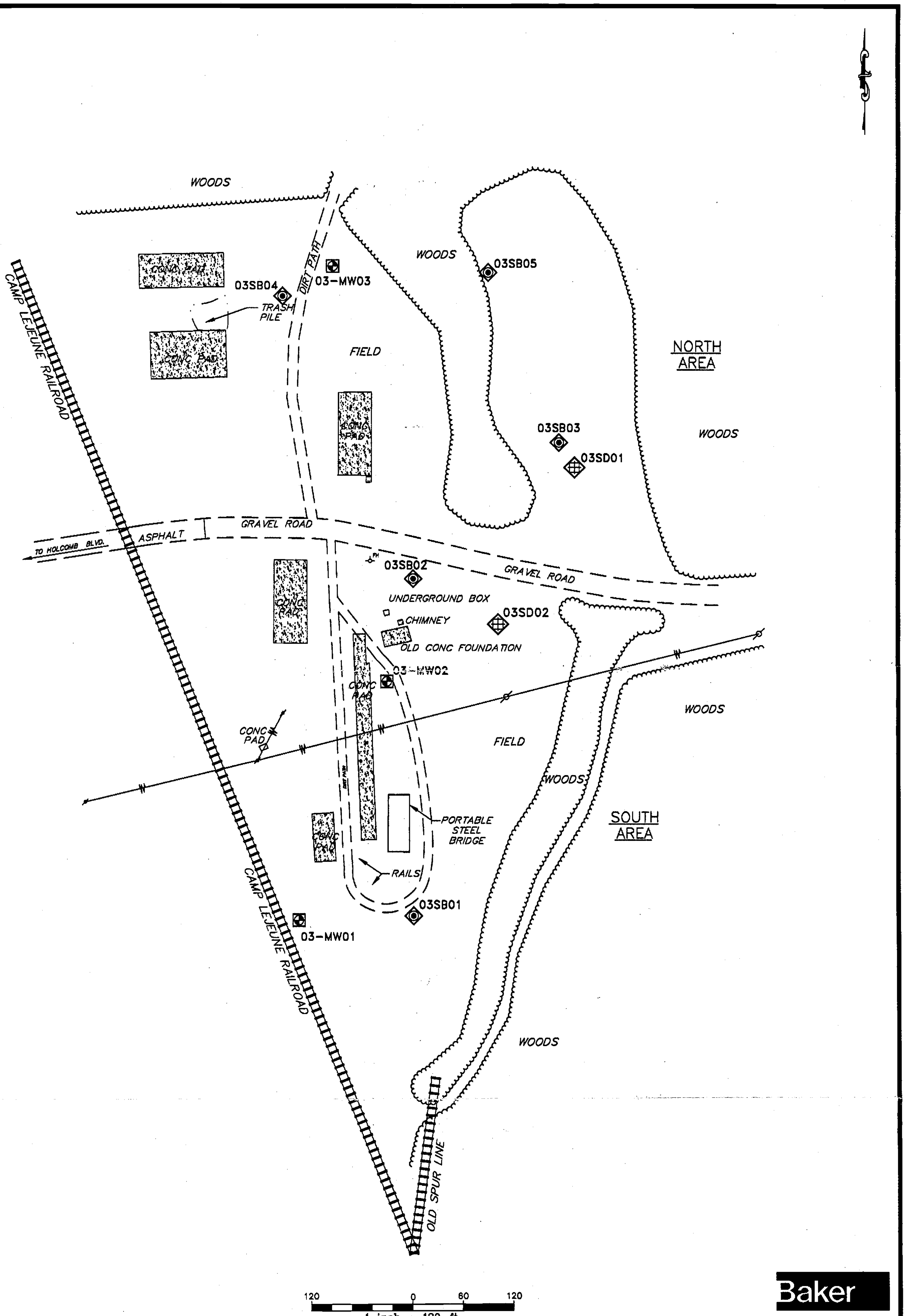

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Baker Environmental, Inc.

LEGEND

03-MW01	MONITORING WELL INSTALLED BY HALLIBURTON NUS, NOVEMBER 1991
03SB03	SOIL BORING INSTALLED BY HALLIBURTON NUS, NOVEMBER 1991
03SD01	SEDIMENT SAMPLE INSTALLED BY HALLIBURTON NUS, NOVEMBER 1991

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

FIGURE 1-4
PREVIOUS SAMPLING LOCATIONS
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 FIELD INVESTIGATION

This section discusses the site-specific RI field investigation activities that were conducted to fulfill the objectives identified in Section 1.6. The first phase of the RI field investigation commenced on September 19 through September 22, 1994. This soil investigation involved the use of Enzyme Linked Immunosorbent Assay (ELISA) field screening technology. The second phase commenced on October 10, 1994 and continued through December 12, 1994. This phase involved the collection of soil and groundwater samples. During the week of January 30, 1995, investigative derived waste (IDW) generated during the first and second phases of the RI investigation was disposed of accordingly. In addition, a third phase of the RI field investigation commenced on June 12 and continued through July 15, 1995. During this phase, additional soil and groundwater samples were also collected. The RI field program at Site 3 consisted of a site survey; a soil investigation which included an ELISA investigation, drilling and soil sampling; and a groundwater investigation which included monitoring well installation and sampling. The following sections detail the various investigation activities which were implemented during the RI.

Investigative procedures and methodologies for the RI conducted at Site 3 have been previously discussed in detail within Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for OU No. 12, (Baker, 1994).

2.1 Site Survey

The site survey was performed in four phases: Phase I - initial survey of ELISA Sampling Grid; Phase II - survey of site features and proposed sample locations; Phase III - post investigation survey of existing sampling locations and monitoring wells; and Phase IV - survey of additional soil samples and monitoring wells. The firm of W. K. Dickson and Associates, Inc. was retained to perform the first three phases of the site survey. Phase I of the survey task was conducted at Site 3 September 19 through September 21, 1994.

The proposed soil borings and monitoring well locations, provided in the Final RI/FS Work Plan for OU No. 12 (Baker, 1994), were also surveyed and then marked with wooden stakes during Phase II. Each sample location was assigned a specific identification number that corresponded to the site and sampling media. The Phase II task was completed during the week of October 10, 1994.

Phase III of the site survey task was completed at Site 3 during the week of November 28, 1994. During Phase III, all soil borings and monitoring wells were surveyed. In addition, any supplemental or relocated soil borings completed during the investigation were surveyed. For each soil boring and monitoring well, the latitude, longitude, and elevation in feet above mean sea level (msl) were recorded.

Phase IV of the site survey task was completed during the week of July 10, 1995. The surveying firm of Brent A. Lanier was retained to perform the additional phase of the site survey. The latitude, longitude, and the elevation in feet above msl were recorded for each of the additional soil borings and monitoring wells.

2.2 Soil Investigation

A three-phased soil investigation was conducted to determine the presence or absence of contamination within the study area. The first phase of the soil investigation involved utilizing ELISA field screening technology on surface soils only, and the second phase involved the installation of soil borings and groundwater monitoring wells for the collection of surface and subsurface soils with a drill rig. The third phase of the soil investigation involved the installation of additional soil borings and groundwater monitoring wells. For discussion purposes, the sections detailing the second and third phases of the soil investigation have been combined.

Investigative procedures and methodologies for the RI conducted at Site 3 are provided within Section 6.0 of the Final FSAP (Baker, 1994). The following subsections describe both the surface and subsurface soil investigations conducted at Site 3.

2.2.1 ELISA Surface Soil Investigation

A total of 84 surface soils (i.e., samples collected from 0 to 1 foot bgs) were collected at Site 3 to evaluate the presence or absence of Polyaromatic Hydrocarbon (PAH)contamination within the study area. All of the samples were analyzed in the field by utilizing the EnSys Polyaromatic Hydrocarbon (PAH RISC ® Draft Method USEPA 4035) soil test. Results of this test are presented in Section 4.0 of this report. This phase of the surface soil investigation was conducted during September 19 through September 22, 1994. Before the field screening was conducted, Site 3 was broken down into four areas of concern. These areas include the Rail Spur Area, Concrete Pad Area, Treatment Area, and North Area. In addition, three surface soil samples were also collected from background locations, not known or suspected to be contaminated. In addition, these background locations were sampled during the second phase of the soil investigation. These areas along with the sample locations and background locations are identified on Figures 2-1, 2-2, and 2-3. Note, (Figure 2-1 depicts the North Area of Site 3, Figure 2-2 depicts the Treatment and Concrete Pad Areas of Site 3, and Figure 2-3 depicts the Rail Spur Area of Site 3). Each soil sampling location was identified with a unique descriptive abbreviation (e.g., surface soil location 3-RS-SB01 refers to Site 3, the Rail Spur Area, and soil boring number one). The following provides a summary of the number of surface soil soils collected for PAH RISC ® soil test and the area in which they were collected:

- Ten surface soils, Rail Spur Area (RS)
- Ten surface soils, Concrete Pad Area (CP)
- Forty-four surface soils, Treatment Area (TA)
- Seventeen surface soils, North Area (NA)
- Three surface soils, Background Locations (BB)

Table 2-1 identifies all surfical soil samples collected during this part of soil investigation at Site 3. In addition to sample identification, Table 2-1 also lists the depth interval of the sample, depth of borehole, and chemical analysis performed.

In addition to being analyzed in the field, 37 out of the 84 surface soil samples were also sent to the laboratory for confirmatory analysis. The correlation between EnSys PAH RISC ® soil test and the confirmatory results is described in Section 4.0. The firm of Quanterra Environmental Services

(Quanterra) was retained to provide confirmatory analytical laboratory services throughout this phase of the surface soil investigation. All confirmatory samples were analyzed for TCL semivolatiles.

2.2.2 Surface Soil Investigation

A total of 9 surface soils were collected within the study area during the second phase of the investigation to evaluate the presence of PAH contamination that was detected during the EnSys investigation. Three out of the nine surface soils were collected from background locations, not known or suspected to be contaminated. The remaining six surface soils were collected from soil borings that were converted into groundwater monitoring wells (i.e., 3-MW02IW, 3-MW04, 3-MW05, 3-MW06, 3-MW07, and 3-MW08). This investigation was conducted between November 15 through November 21, 1994. Surface soil sample locations are provided on Figures 2-1, 2-2, and 2-3.

A total of 16 surface soils were collected at Site 3 during the third phase of the investigation to further delineate the extent of contamination detected during the second phase of the soil investigation. Nine out of the 16 surface soils were collected from soil borings. From these nine soil borings, six surface soil samples were collected within the Treatment Area, and three samples were collected within the North Area. The remaining seven surface soils were collected from soil borings that were converted into groundwater monitoring wells (i.e., 3-MW02DW, 3-MW09, 3-MW10, 3-MW11, 3-MW11IW, 3-MW12, and 3-MW13). This investigation was conducted between June 12 through June 29, 1995. Figures 2-1, 2-2, and 2-3 provide all of the on-site, monitoring well, and background locations where surface soil samples were collected. The following provides a summary of the number of surface soil samples collected during both the second and third phases of the soil investigation and the area in which they were collected:

- Six surface soils, Treatment Area (TA)
- Three surface soils, North Area (NA)
- Thirteen surface soils, Monitoring Well Locations (MW)
- Three surface soils, Background Locations (BB)

Table 2-1 identifies all surficial soil samples collected at Site 3. In addition to sample identification, Table 2-1 also lists the depth interval of the sample, depth of the borehole, and analytical parameters requested.

All surface soils were classified in the field by a geologist. Soils were classified using the United Soil Classification System (USCS) by the visual-manual methods described in American Society for Testing and Materials (ASTM) D-2488. Lithologic descriptions were recorded in a field logbook and later transposed onto boring log records. Soil classification included characterization of soil type, grain size, color, moisture content, relative density, plasticity, and other pertinent information such as indications of contamination. Lithologic descriptions of the site soils are provided on Test Boring Records and on Test Boring and Well Construction Records in Appendix A.

Laboratory services for the soil investigation where provided by Quanterra. During the second phase of the soil investigation, nine surface soils were collected. Three out of the nine surface soil samples were collected from background locations and were analyzed for TCL semivolatiles. The remaining six surface soil samples were collected from soil borings that were converted into monitoring wells. Surface soils collected from monitoring well locations 3-MW02IW and 3-MW05 were analyzed for full TCL organics (volatiles, semivolatiles, pesticides, PCBs) and TAL metals. Surface soils collected from monitoring well locations 3-MW04, 3-MW06, 3-MW07, and 3-MW08 were analyzed for TCL semivolatiles.

During the third phase of the surface soil investigation, 16 surface soils were collected. Six out of the 16 surface soil samples were collected from soil borings within the Treatment Area, and were analyzed for TCL volatiles and semivolatiles. Three out of the 16 samples were collected from soil borings within the North Area, and were analyzed for TCL volatiles and semivolatiles. The remaining seven samples were collected from soil borings converted into monitoring wells. All seven samples were analyzed for TCL volatiles and semivolatiles. Surface soil sample collected from monitoring well location 3-MW05, was analyzed for engineering parameters (i.e., Particle Size, Atterberg limits, and Total Organic Carbon [TOC]). Table 2-1 provides a summary of the analytical parameters requested for surface soils collected during phases one and two of the surface soil investigation conducted at Site 3.

Results of the surface soil investigation conducted at Site 3 are discussed in detail within Section 4.0 of this report. Chain-of-Custody (CoC) documentation, provided in Appendix B, accompanied the samples to the laboratory. Information such as sample number, collection date, analytical parameters requested, and time of sampling were included on the CoCs. Internal sample and analytical tracking forms for Site 3 are also provided in Appendix B. Samples were shipped overnight via Federal Express to Quanterra for analysis.

2.2.1.1 Quality Assurance and Quality Control

Field QA/QC samples were collected during the surface soil investigation in order to: (1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); (2) evaluate field methodologies (e.g., field duplicate samples); (3) establish field background conditions (e.g., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (e.g., trip blanks). Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DQO Level IV, as defined in the Environmental Compliance Branch standard operating procedures (SOPs) and Quality Assurance Manual, (USEPA Region IV, 1991). The DQO Level IV is equivalent to Naval Facilities Engineering Service Center (NFESC) DQO Level D, as specified in the Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs document (NEESA, 1988).

Field duplicate samples are identified on Table 2-1. In addition to field duplicates, the remaining QA/QC samples which were collected during the surface soil investigation are provided on Table 2-2.

Four types of field QA/QC samples were collected and analyzed including: duplicate samples; equipment rinsate samples; field blanks; and trip blanks. Definitions for the different field QA/QC samples are provided below (USEPA, 1991):

- Field Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under the identical conditions. Field duplicate samples were collected at a frequency of 10 percent of the environmental samples.

- Equipment Blanks: Equipment field blanks (or rinsate blanks) are defined as samples which are obtained by running organic free water over/through sample collection equipment after it has been cleaned. These samples are used to determine if decontamination procedures are adequate. Equipment blanks were collected daily but only samples collected on every other day were analyzed.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at designated locations. This is done to determine if contaminants present in the area may have an affect on the sample integrity. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled. Two field blanks were collected to test both the potable and distilled water used in drilling and decontamination investigative operations.

- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they return to the laboratory. Field sampling teams utilize volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided for each shipment but not necessarily for each cooler(i.e., coolers with samples for Volatile Organic Contaminants [VOC] analysis only). One set of trip blanks accompanied each cooler that contained samples with requested VOC analysis.

2.2.1.2 Air Monitoring and Field Screening

Two air monitoring and field screening procedures were implemented during drilling and sampling activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a Photoionizing Detector (PID) to monitor for airborne contaminants. Also, a Lower Explosive Limit/Oxygen meter (LEL/O_2) was used to monitor the borehole during drilling activities. Moreover, samples (i.e., surface and split-spoon samples) were screened with a PID to measure for volatile organic vapor. Readings obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records and the Test Boring and Well Construction Records which are provided in Appendix A. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.2.3 Subsurface Soil Investigation

A total of 34 subsurface soils (i.e., samples collected from 1 foot bgs to just above the groundwater table) were collected from Site 3 during the second phase of the soil investigation to evaluate the presence or absence of contamination within the vadose zone. All of the subsurface soil samples were collected via split-spoon sampling. Twenty-seven out of the 34 subsurface soils were collected from soil borings based on ENSYS field screening and confirmatory results. Fifteen out of the 27 samples were collected within the Treatment Area. Six out of the 27 samples were collected within the Rail Spur Area. Three out of the 27 samples were collected within the North Area. The remaining three samples were collected from background locations not known or suspected to be contaminated. Additionally, seven subsurface soils were collected from soil borings that were converted into groundwater monitoring wells. It should be noted that monitoring well 3-MW02IW was the only well to have two subsurface samples collected from the boring. This additional sample was obtained from 17 to 19 feet bgs due to apparent creosote contamination within the split-spoon. This investigation was conducted between November 15 and November 22, 1994. Subsurface soil sample locations are provided on Figures 2-1, 2-2, and 2-3.

An additional 16 subsurface soil samples were collected during the third phase of the soil investigation. This phase was conducted to further define PAH contamination that was detected during the second phase of the soil investigation. Nine out of the 16 subsurface soils were collected from soil borings. From these nine subsurface samples, six were collected within the Treatment Area, and three were collected within the North Area. The remaining seven subsurface soil samples were collected form soil borings that were converted to monitoring wells. This investigation was conducted between June 13 through June 29, 1995. Figures 2-1, 2-2, and 2-3 provide all of the on-site, monitoring well, and background locations where subsurface soil samples were collected. The following provides a summary of the number of subsurface soil samples collected during both the second and third phases of the soil investigation and the areas in which they were collected:

- Six subsurface soils, Rail Spur Area (RS)
- Twenty-one subsurface soils, Treatment Area (TA)
- Six subsurface soils, North Area (NA)
- Fourteen subsurface soils, Monitoring Well Locations (MW)
- Three subsurface soils, Background Locations (BB)

Table 2-1 identifies all subsurface soil samples collected during both the second and third phases of the soil investigation at Site 3, In addition to sample identification, Table 2-1 also lists the depth interval of the sample, depth of the borehole, and analytical parameters requested.

All subsurface soils were classified according to procedures and guidelines described in Section 2.2.2. Lithologic descriptions of the site soils are provided on Test Boring Records and on Test Boring and Well Construction Records in Appendix A.

During the second phase of the soil investigation, 26 out of the 34 subsurface samples that were collected from soil borings, were analyzed for TCL semivolatiles. One out of the 34 subsurface samples was collected from a soil boring within the Treatment Area, and was analyzed for TCL semivolatiles, pesticides, PCBs and TAL metals. Additionally, seven subsurface soils were collected from soil borings that were converted into groundwater monitoring wells. Five of the seven subsurface samples collected from monitoring well soil borings were analyzed for TCL semivolatiles. The two remaining samples from monitoring wells (3-MW02IW and 3-MW05) were analyzed for full TCL organics and TAL metals. The subsurface soil sample collected from monitoring well location 3-MW05, was also analyzed for engineering parameters (i.e., Particle Size, Atterberg limits, and TOC).

Subsurface soil samples collected during the third phase of this investigation (16 total) were analyzed for TCL volatiles and semivolatiles. Table 2-1 identifies all subsurface soil samples collected during both the second and third phases of the soil investigation at Site 3, In addition to sample identification, Table 2-1 also lists the depth interval of the sample, depth of the borehole, and chemical analysis performed.

Results of the subsurface soil investigation conducted at Site 3 are provided within Section 4.0 of this report. Internal sample and analytical tracking forms and CoCs for Site 3 are provided in Appendix B. Subsurface samples were shipped overnight via Federal Express to Quanterra for analysis.

2.2.2.1 Quality Assurance and Quality Control

Field QA/QC samples were also collected during both phases of the subsurface soil investigation. These samples were obtained according to procedures and guidelines addressed in Section 2.2.1.1.

Field duplicate samples collected at Site 3 are identified on Table 2-1. In addition to field duplicates, additional QA/QC samples that were collected during the subsurface soil investigation are provided on Table 2-2.

2.2.2.2 Air Monitoring and Field Screening

Two air monitoring and field screening procedures were implemented during drilling and sampling activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a Photoionizing Detector (PID) to monitor for airborne contaminants. Also, a Lower Explosive Limit/Oxygen meter (LEL/O_2) was used to monitor the borehole during drilling activities. Moreover, samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Readings obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records and the Test Boring and Well Construction Records which are provided in Appendix A. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.3 Groundwater Investigation

A groundwater investigation was conducted at Site 3 to determine the presence or absence of contamination in both the surficial aquifer and the deeper Castle Hayne aquifer, which may have resulted from past operational activities. During the second phase of the soil investigation five permanent shallow groundwater monitoring wells (3-MW04, 3-MW05, 3-MW06, 3-MW07, and 3-MW08) were installed, then sampled during December 1 through December 3, 1994. In addition, one intermediate groundwater monitoring well 3-MW02IW (i.e., installed to the top of the Castle Hayne aquifer) was installed and sampled as part of this investigation. Two of the three existing on-site shallow monitoring wells (3-MW02, and 3-MW03) were also sampled during the groundwater investigation. Shallow monitoring well 3-MW01 was not sampled since this well had less than 0.5 feet of standing water within it, and did not respond to development and purging procedures. All newly-installed and existing monitoring well locations are provided on Figure 2-4.

Existing monitoring well 3-MW03 and newly installed monitoring well 3-MW08 are located within the North Area. Monitoring well 3-MW08 was placed in an upgradient (i.e., background) location to assess off-site groundwater quality. Existing monitoring wells 3-MW01, and 3-MW02, and newly-installed monitoring wells 3-MW02IW, 3-MW04, 3-MW05, and 3-MW07 are located within the Treatment Area of Site 3. Newly-installed monitoring well 3-MW06 is located within the Rail Spur Area. Depths of the newly installed wells ranged from 14.0 to 86.5 feet bgs. All permanent monitoring wells were constructed with 2 inch I.D. PVC pipe, with 15 feet of 0.01-inch slotted well screen. One exception to this is that monitoring well 3-MW07 was constructed with only ten feet of slotted screen. A summary of monitoring well construction details (i.e., well casing and ground surface elevations, boring depth, well depth, screen interval depth, sand pack depth, bentonite depth, and PVC stick-up) is provided on Table 2-3.

Groundwater samples were obtained using USEPA Region IV's low flow purging and sampling technique. Although this technique has not yet been finalized, the Technical Compliance Branch of the USEPA Region IV, located in Athens Georgia, has set up procedures and guidelines. Procedurally this technique requires that the groundwater be purged at less than 0.33 gallons per minute, by means of either a submersible or peristaltic pump. In this case Baker utilized a 2-inch submersible pump system. While the well was being purged, pH, conductivity, temperature, and turbidity measurements were obtained. Water quality data is provided within Section 4.0 of this report. Once water quality readings had stabilized, a groundwater sample was collected. One round of groundwater sampling was conducted at Site 3. Groundwater sampling was conducted during the period December 1 through December 3, 1994. Monitoring wells 3-MW02IW, 3-MW07, and 3-MW08 were the only monitoring wells at Site 3 that were sampled for full TCL organics, and TAL total metals and dissolved metals. The remaining six shallow monitoring wells were only sampled for TCL semivolatiles.

Due to volatile and PAH contamination detected within the groundwater during the first round of sampling, an additional seven groundwater monitoring wells were installed to further define the vertical and horizontal extent. These wells were installed during the period June 12 through June 29, 1995. Five additional shallow wells (3-MW09, 3-MW10, 3-MW11, 3-MW12, and 3-MW13), one intermediate well (3-MW11IW), and one deep well (3-MW02DW) were installed during the Phase III soil investigation. The locations for the monitoring wells installed during the additional groundwater investigation are provided on Figure 2-4. Shallow monitoring well 3-MW09 is located in the North Area of Site 3. Shallow monitoring wells 3-MW12 and 3-MW13 are located to the west of Site 3. Monitoring well 3-MW12 is located on the western edge of the railroad line and 3-MW13 is located on the western side of Holcomb Boulevard. Monitoring wells 3-MW11 and 3-MW11IW are located on the southwestern side of the site on the western side of the railroad tracks. Monitoring well 3-MW10 is located on the eastern edge of Site 3. The deep monitoring well, 3-MW02DW, is located alongside monitoring wells 3-MW02 and 3-MW02IW near the center of Site 3. Depths of the newly installed wells ranged from 19.0 to 140 feet bgs. All permanent monitoring wells were constructed with 2 inch I.D. PVC pipe, with 15 feet of 0.01-inch slotted well screen. A summary of monitoring well construction details (i.e., well casing and ground surface elevations, boring depth, well depth, screen interval depth, sand pack depth, bentonite depth, and PVC stick-up) is provided on Table 2-3.

All permanent monitoring wells including the existing monitoring wells were developed prior to sampling. During well development operations water quality readings and turbidity comments were recorded on monitoring well development records. These records are provided in Appendix C.

Groundwater sampling procedures followed the same as the initial sampling round, with one exception; a peristaltic pump instead of the 2-inch submersible was used to purge and sample the monitoring wells. Groundwater samples were collected once the water quality readings stabilized. The seven additional monitoring wells (3-MW09, 3-MW10, 3-MW11, 3-MW12, 3-MW13, 3-MW11IW, and 3-MW02DW) were sampled, along with a second round of groundwater samples that were collected from the previously installed (3-MW04, 3-MW05, 3-MW06, 3-MW07, 3-MW08, and 3-MW02IW) and existing monitoring wells (3-MW02 and 3-MW03). Groundwater sampling activities were conducted during July 12 through July 15, 1995. All monitoring wells were sampled for TCL volatiles and semivolatiles analysis. Monitoring wells 3-MW02, 3-MW02DW, 3-MW08 were also sampled for Engineering Parameters (i.e., {Biological Oxygen Demand [BOD]}, {Chemical Oxygen Demand [COD]}, {Total Dissolved Solids [TDS]}, {Total Suspended Solids [TSS]}, and TOC). In addition, monitoring well 3-MW01, which was not sampled during round 1 of the groundwater investigation conducted in December 1994, was sampled during this investigation.

On September 28 and 29, 1995 a third round of groundwater samples were collected from wells that were installed during the second phase of the soil investigation and previously existing (3-MW01 through 3-MW08 and 3-MW02IW). Additionally, a second round of samples were collected from wells 3-MW09, 3-MW10, 3-MW11, 3-MW12, 3-MW13, and 3-MW11IW. Groundwater from these monitoring wells was sampled utilizing a peristaltic pump with dedicated polyethylene tubing. The low flow purging and sampling technique used in the initial sampling rounds was not employed during this round since metals were not being analyzed for. Groundwater that was purged from the monitoring wells during this round was done so at a rate of less than or equal to 1.0 gallon per minute (gpm). In addition, water quality readings (i.e., pH, temperature, and specific conductivity) were collected during purging activities. Groundwater samples were collected once water quality readings stabilized over three well volumes. All sixteen monitoring wells at Site 3 were sampled for TCL volatiles and semivolatiles.

Due to inconsistencies in the contaminant levels detected in the deep well, 3-MW02DW, an additional groundwater sample was collected on January 29, 1996. This sample was collected utilizing a peristaltic pump with dedicated polyethylene tubing. Groundwater was purged at a rate less than or equal to 1.0 gpm. The groundwater sample was collected once water quality readings stabilized over three well volumes. This sample was submitted for TCL volatiles and semivolatiles.

Table 2-4 provides a summary of groundwater analyses for each of the monitoring wells for all three rounds at Site 3.

2.3.1 Water Level Measurements

Static water level measurements were collected on three separate occasions. Measurements were recorded from top-of-casing reference points, marked on the PVC at each monitoring well. A complete round of static water level measurements was collected on December 11, 1994, March 27, 1995, August 1, 1995 and January 29, 1996. Groundwater measurements were recorded using an electric measuring tape (i.e., M-scope). Measurements were recorded to the nearest 0.01 foot from the top-of-PVC casing. Water level data are presented in Section 3.0 of this report.

2.3.2 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the groundwater investigations. These samples included trip blanks, equipment rinsates, and field duplicates. Equipment rinsates were collected from the submersible pump and peristaltic pump line prior to and during daily usage. Table 2-5 summarizes the QA/QC sampling program employed for the groundwater investigations conducted at Site 3.

2.3.3 Field Screening and Air Monitoring

Air monitoring and field screening procedures were implemented during the groundwater sampling activities for health and safety and initial contaminant monitoring. Air monitoring and field screening procedures implemented at Site 3 include the screening of well heads and purged groundwater with a PID for volatile organic vapors. Measurements obtained during air monitoring and field sçreening were recorded in a field logbook. Prior to daily monitoring, field instruments were calibrated and readings were recorded in a field logbook and on calibration forms.

2.4 Habitat Evaluation

A habitat evaluation was performed at Site 3 during December 4 to 6, 1994. The evaluation focussed on the determination of terrestrial and aquatic ecosystems, along with the identification of plant and animal species. The evaluation was conducted by performing a thorough site reconnaissance. During the reconnaissance, particular species (botanical and/or animal) identified on site were documented in a field logbook. Also, unknown botanical species were collected for further identification. In addition, sketches of the site were also produced to show the different areas of varying species or zones (i.e., the general locations of a deciduous forest, hardwood forest, shrub, industrial, swamp, wetland, and water body areas). These sketches were later transferred onto a biohabitat map with each area identified by a unique color and pattern legend. In addition, information from the National Wetlands Inventory (NWI) maps and from base-specific endangered species surveys were transferred to the biohabitat map, if applicable. A detailed discussion of the habitat evaluation is provided within Section 3.0 of this report.

2.5 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV SOPs. Sampling and drilling equipment were divided into two decontamination groups, heavy equipment and routine sample collection equipment. Heavy equipment included drill rigs, hollow-stem augers, drill and sampling rods. Routine sample collection equipment included split spoons, stainless steel spoons, and bowls.

For heavy equipment, the following procedures were implemented:

- Removal of caked-on soil with a brush
- Steam clean with high pressure steam
- Air dry

For routine sample collection equipment, the following procedures were implemented:

- Clean with distilled water and laboratory detergent (Liquinox soap solution).

- Rinse thoroughly with distilled water.

- Rinse with isopropyl alcohol.

- Air dry and/or bake off through the use of heaters (latter dependent upon air temperature).

- Wrap in aluminum foil, if appropriate.

Temporary decontamination pads, constructed of wood and plastic, were used to minimize spillage onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 2.6.

2.6 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 3 resulted in the generation of various IDW. This IDW included well development and purge water, solutions used to decontaminate non-disposable sampling equipment, and mud cuttings from intermediate and deep monitoring well installation. The general management techniques utilized for the IDW were:

- Collection and containerization of IDW material (i.e., development water, and decontamination fluids).
- Temporary storage of IDW while awaiting confirmatory analytical data.
- Final disposal of aqueous and solid IDW material.

The management of the IDW was performed in accordance with guidelines developed by the USEPA Office of Emergency and Remedial Response, Hazardous Site Control Division.

The development and purge water along with the decontamination fluids, and mud cuttings generated during all phases of the investigation was containerized, however analytical results did not show contamination at a concentration that would classify the IDW as being hazardous. Therefore the water, decontamination fluids, and mud cuttings were deposited back onto Site 3. Based on the non-hazardous analytical concentrations present in the groundwater during rounds 1 and 2, purge water generated during the rounds 3 and 4 was deposited on-site. Appendix D provides information regarding the management, results, and disposal of the IDW.

2.7 References

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SECTION 2.0 TABLES

TABLE 2-1

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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	

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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-SB04	00	1.0	0.0 - 1.0	X							
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)					

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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-SB15	00	1.0	0.0 - 1.0	X							
3-TA-SB16	00	1.0	0.0 - 1.0	X							
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)					

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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-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							
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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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							

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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-SB17	00	1.0	0.0 - 1.0	X		X (2)					
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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 2-2

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM FOR THE SURFACE AND SUBSURFACE SOIL INVESTIGATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (2)
Trip Blanks (3)	One per Cooler	8	TCL Volatiles
Field Blanks (4)	One per Event	2	TCL Volatiles/Semivolatiles
Equipment Rinsates (5)	One per Day	3	TCL Organics/TAL Metals
		4	TCL Volatiles/Semivolatiles
Number of Environmental Samples		84	EnSys (PAH RISC ®) Draft Method USEPA (4035) (6)
		4	TCL Semivolatiles TCL Pesticides/PCBs/TAL Metals (7)
		4	TCL Organics/TAL Metals (1)
		71	TCL Semivolatiles (7)
		32	TCL Volatiles/Semivolatiles (8)
Field Duplicates (9) (10)	10% of Sample Frequency	13	EnSys (PAH RISC ®) Draft Method USEPA (4035)
		2	TCL Organics/TAL Metals
		3	TCL Semivolatiles
		2	TCL Volatiles/Semivolatiles

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Parameters analyzed according to CLP Protocol.
(3) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(4) Field blanks collected during Site 3 soil and groundwater investigation (June 12 through July 15, 1995).
(5) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, and groundwater sampling pumps). Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.
(6) Soil samples collected during the first phase of the surface soil investigation (Septebmer 19 through September 22, 1994).
(7) Soil samples collected during the second phase of the surface and subsurface soil investigation (November 15, through November 21, 1994).
(8) Soil samples collected during the third phase of the surface and subsurface soil investigation (June 12 through June 29, 1995).
(9) Refer to Table 2-1 for duplicate sample identification.
(10) Field duplicates were segregated into four areas (Rail Spur Area, Concrete Pad Area, Treatment Area, and North Area).

TABLE 2-3

SUMMARY OF WELL CONSTRUCTION DETAILS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring Well No.	Date Installed	Top of PVC Casing Elevation (feet,above msl)(1)	Ground Surface Elevation (feet,above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)	Stick-Up (feet, above ground surface)
Shallow Monitoring Wells									
3-MW04	11/17/94	33.43	30.91	27.0	25.0	25.0 - 10.0	27.0 - 7.5	7.5 - 6.0	2.52
3-MW05	11/19/94	34.0	31.85	33.0	33.0	33.0 - 18.0	33.0 - 16.0	16.0 - 14.0	2.15
3-MW06	11/19/94	30.55	27.93	23.0	22.0	22.0 - 7.0	23.0 - 5.0	5.0 - 3.5	2.62
3-MW07	11/19/94	33.51	31.05	15.0	14.0	14.0 - 4.0	15.0 - 3.0	3.0 - 1.5	2.46
3-MW08	11/20/94	32.62	30.13	18.0	18.0	18.0 - 3.0	18.0 - 2.0	2.0 - 1.0	2.49
3-MW09	6/13/95	33.29	31.5	20.0	19.0	19.0 - 4.0	20.0 - 2.0	2.0 - 0.5	1.79
3-MW10	6/14/95	33.85	32.4	20.0	18.5	18.5 - 3.5	20.0 - 1.5	1.5 - 0.5	1.45
3-MW11	6/15/95	32.69	30.69	32.0	31.5	31.5 - 16.5	32.0 - 14.0	14.0 - 11.5	2.0
3-MW12	6/13/95	29.55	27.7	21.0	20.0	20.0 - 5.0	21.0 - 3.0	3.0 - 1.0	1.85
3-MW13	6/14/95	22.93	20.80	22.0	21.5	21.5 - 6.5	22.0 - 4.0	4.0 - 2.0	2.13
Intermediate and Deep Monitoring Wells									
3-MW02IW	11/19/94	35.19	32.5	87.0	86.5	86.5 - 71.5	87.0 - 66.5	66.5 - 61.0	2.69
3-MW02DW	6/28/95	34.06	32.19	140.5	140.0	140.0- 125.0	140.5 - 122.0	122.0 - 119.0	1.87
3-MW11IW	6/29/95	32.55	30.30	88.0	87.0	87.0 - 72.0	88.0 - 69.0	69.0 - 66.0	2.25

Note: (1) msl - mean sea level

TABLE 2-4

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

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pest.icides/ 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						
3-MW02-02	7/11/95	X	X				X		

TABLE 2-4 (Continued)

MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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-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)

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

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pest.icides/ 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)

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

Sample Location	Date of Sampling	TCL Volatiles	TCL Semivolatiles	TCL Pest.icides/ 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						
3-MW02DW-03	1/29/96	X	X						

Note: [1] Engineering Parameters include (BOD, COD, TDS, TSS, and TOC)

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM FOR ROUNDS 1, 2, AND 3 OF THE GROUNDWATER INVESTIGATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (2)
Trip Blanks (3)	One per Cooler	7	TCL Volatiles
Field Blanks (4)	One per Event	1	TCL Volatiles/Semivolatiles
Equipment Rinsates (5)	One per Day	1	TCL Organics/TAL Total Metals/Dissolved Metals
		5	TCL Volatiles/Semivolatiles
Number of Environmental Samples		3	TCL Organics/TAL Total Metals/Dissolved Metals (6)
		6	TCL Semivolatiles (6)
		16	TCL Volatiles/Semivolatiles (7)
		16	TCL Volatiles/Semivolatiles (8)
Field Duplicates (9) (10)	10% of Sample Frequency	1	TCL Organics/TAL Total Metals/Dissolved Metals
		1	TCL Volatiles/Semivolatiles

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Parameters analyzed according to CLP Protocol.
(3) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(4) Field blanks were collected during rounds 1 and 2 of the groundwater investigation.
(5) Equipment rinsates collected from various sampling equipment (e.g., submersible pump, and pump discharge hose. Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.
(6) Groundwater samples collected during the first round of sampling conducted (December 1, through December 3, 1994).
(7) Eight out of the 16 groundwater samples were collected from existing monitoring wells during the second round of sampling conducted (June 12 through July 15, 1995). Seven out of the 16 groundwater samples were collected from newly installed wells during the second round. The last groundwater sample was collected from 3-MW01, which was unable to be sampled during the first round.
(8) Groundwater samples collected during the third round of sampling conducted (September 28 through September 29, 1995).
(9) Refer to Table 2-4 for duplicate sample identification.
(10) Additional field duplicates were not collected during the second and third rounds of groundwater sampling.

SECTION 2.0 FIGURES

274100RI

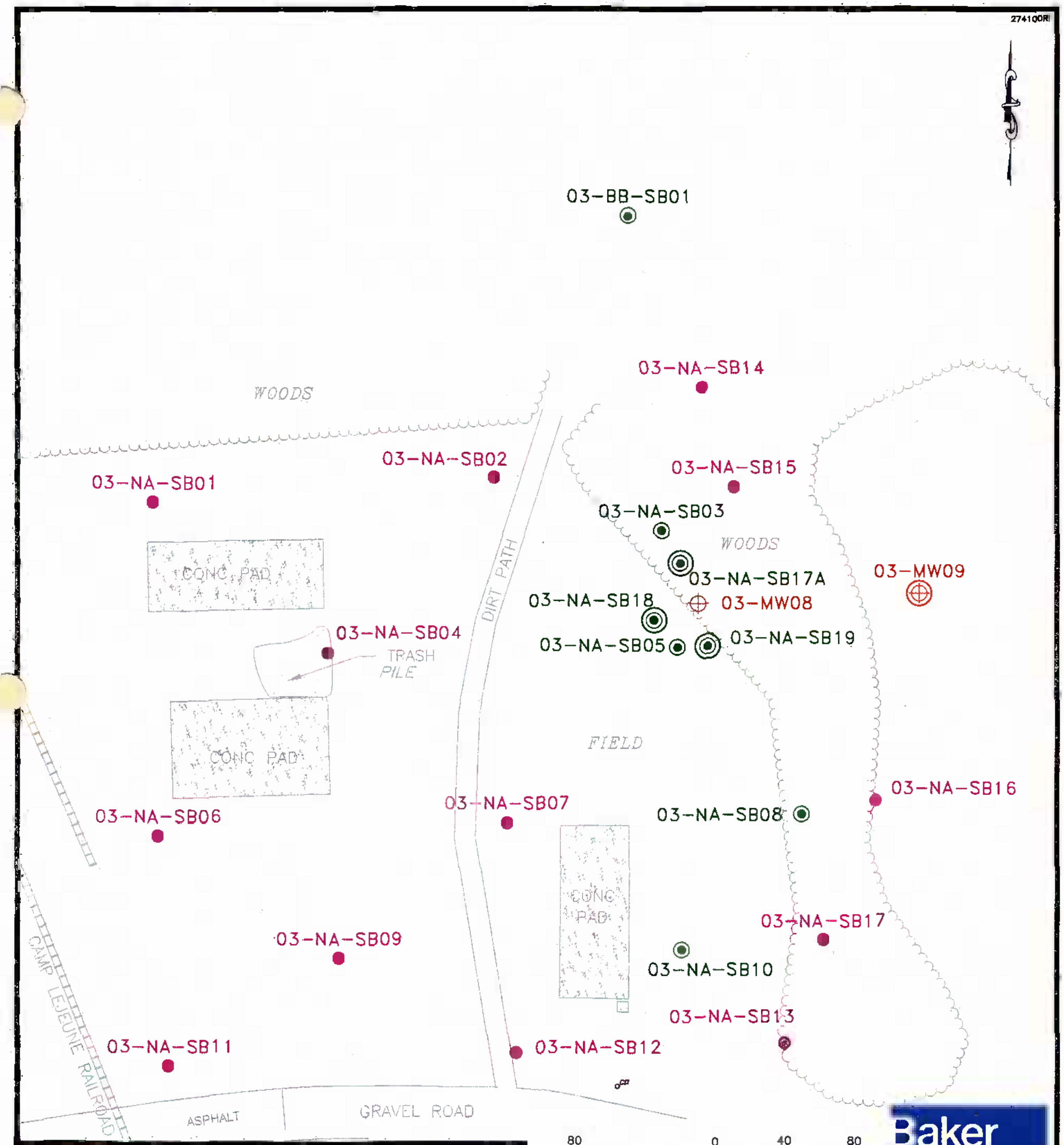

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FIGURE 2-1
SOIL SAMPLE LOCATIONS
SITE 3 – OLD CREOSOTE PLANT
(NORTHERN AREA)
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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

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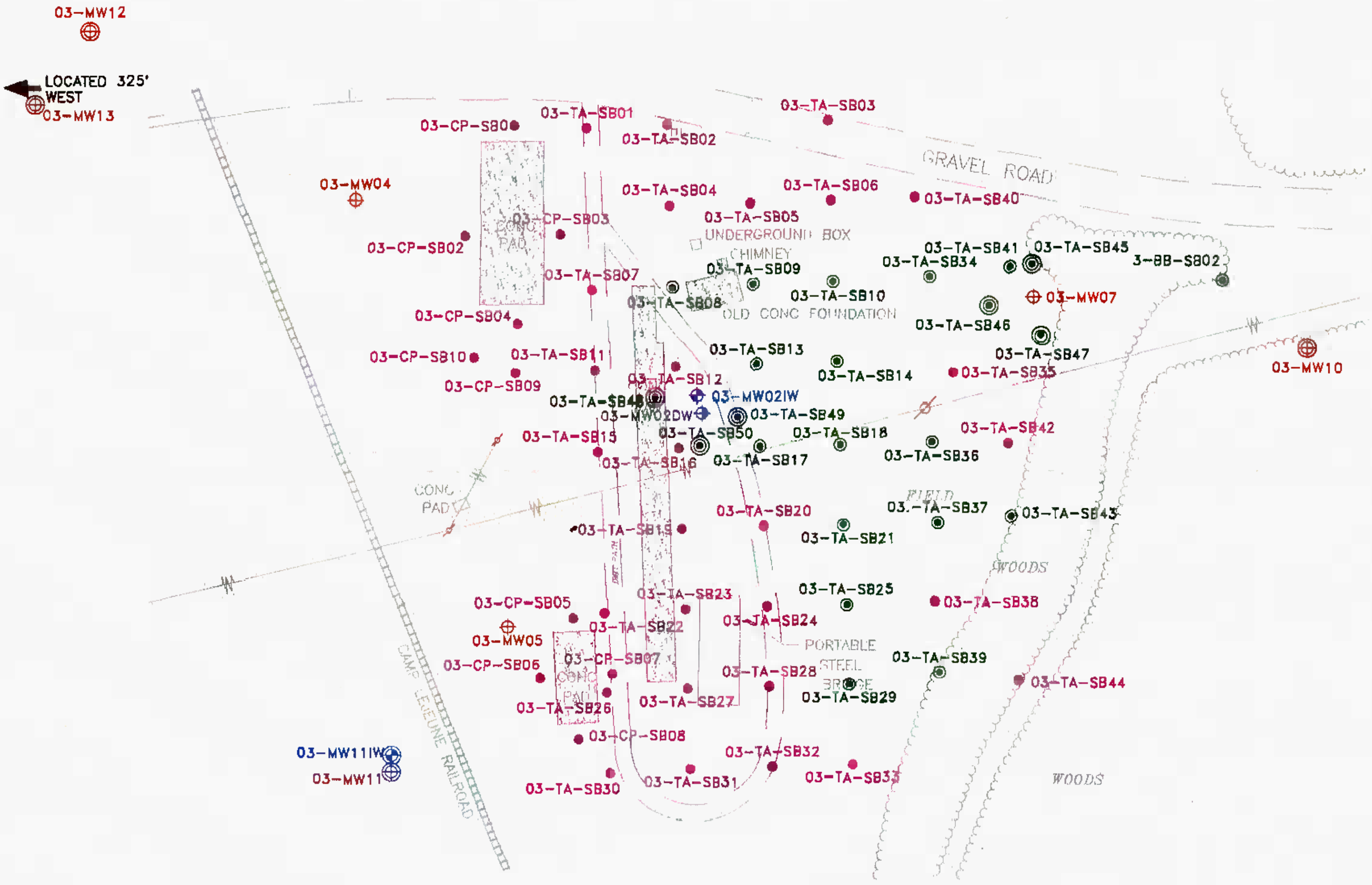

274099R1

100 0 50 100
1 inch = 100 ft.

LEGEND

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-TA-SB08 ●	SOIL BORING LOCATION (INSTALLED DURING THE SECOND PHASE OF THE SOIL INVESTIGATION NOVEMBER 15 THROUGH NOVEMBER 22, 1994).
03-TA-SB01 ●	ENSYS SURFACE SOIL BORING (INSTALLED DURING THE FIRST PHASE OF THE SOIL INVESTIGATION SEPTEMBER 19 THROUGH SEPTEMBER 22, 1994).
03-MW10 ⊕	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-MW02IW ⊕	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 THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).
03-TA-SB45 ◉	SOIL BORING LOCATION (INSTALLED DURING THE THIRD PHASE OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 29, 1995).

SOURCE: LANTDIV, OCT. 1991

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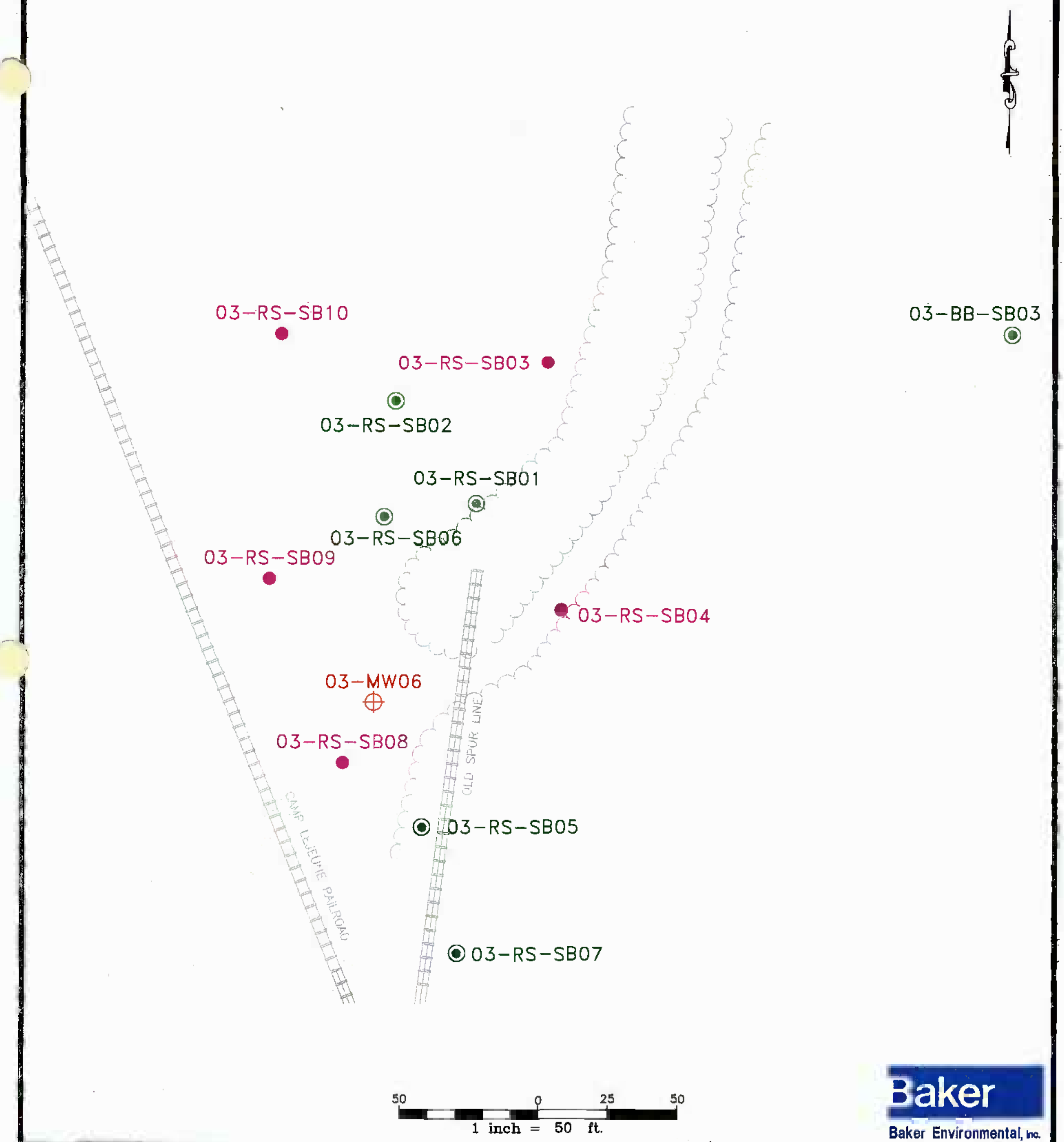
FIGURE 2-2
SOIL SAMPLE LOCATIONS
SITE 3 – OLD CREOSOTE PLANT
(TREATMENT AND CONCRETE PAD AREAS)
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

374101RI



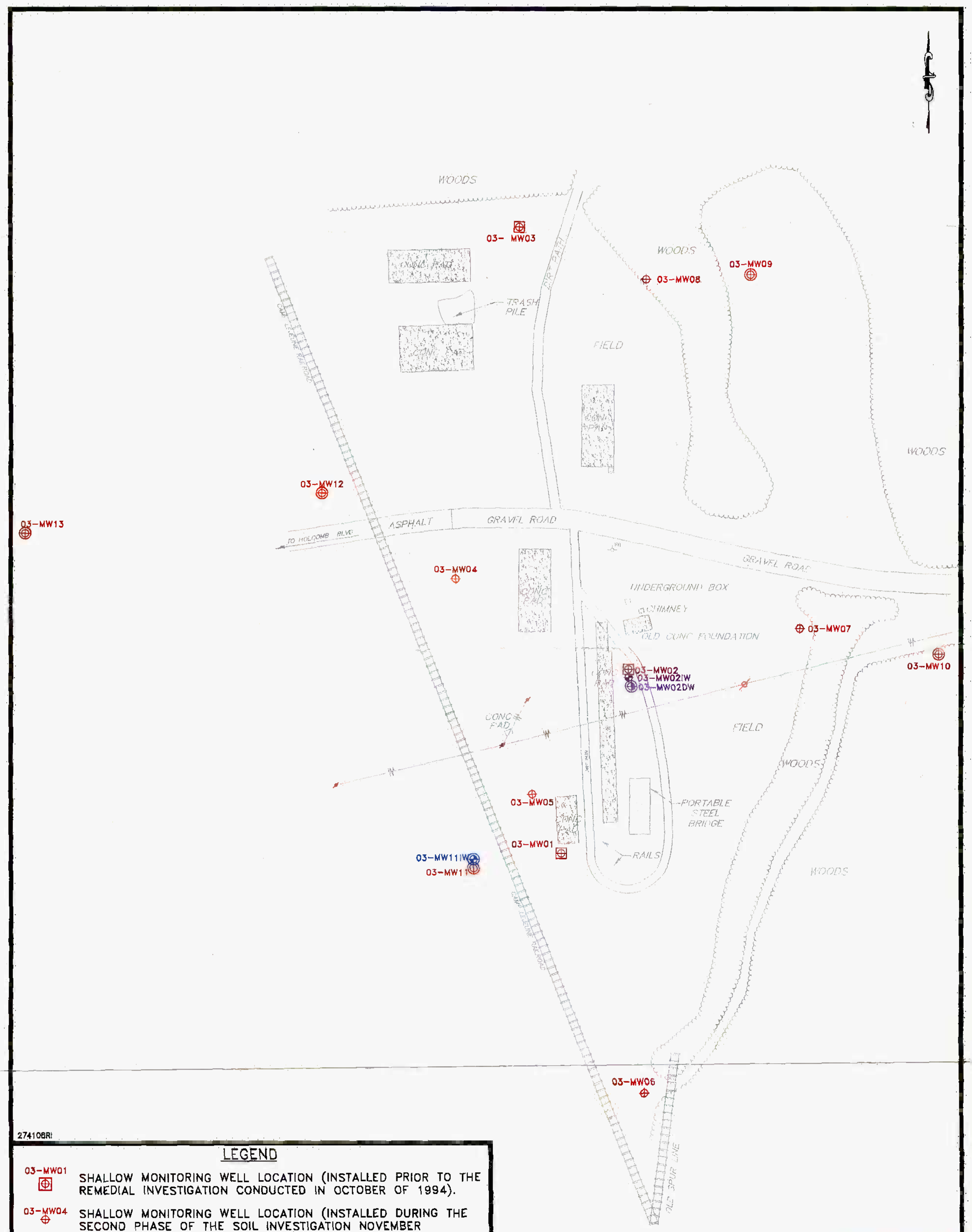
Baker Environmental, Inc.

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 2-3
SOIL SAMPLING LOCATIONS
SITE 3 - OLD CREOSOTE PLANT
(RAIL SPUR AREA)
REMEDIAL INVESTIGATION 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 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.

Baker Environmental, Inc.

FIGURE 2-4
MONITORING WELL SAMPLING LOCATIONS
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 REGIONAL AND SITE CHARACTERISTICS

This section describes the regional and site-specific environmental settings. A discussion of topography, surface hydrology and drainage, geology, hydrogeology, ecology, land use and demographics, climate/meteorology, and water supplies is presented for Marine Corps Base (MCB), Camp Lejeune and Operable Unit (OU) No. 12 (Site 3). The tables and figures for Section 3.0 are contained at the back of the section.

3.1 Topography and Surface Features

The generally flat topography of MCB, Camp Lejeune is typical of the seaward portions of the North Carolina coastal plain. Elevations at the base vary from sea level to 72 feet above mean sea level (msl); however, the elevation of most of MCB, Camp Lejeune is between 20 and 40 feet above msl.

Site 3 (Old Creosote Plant) is predominantly flat with elevations around 30 feet above msl. The study area is mostly a clear parcel of land bordered on the north, east and south sides by woods. The Camp Lejeune Railroad lies approximately 200 feet to the west of the study area. A gravel road bisects the site from west to east. This road is the only access road from Holcomb Boulevard. Remnants of the former creosote plant including a chimney, concrete pads, and train rails. During periods of heavy rain the western area of the site exhibited several areas of standing water. Surface water runoff from the site flows in both an easterly and westerly direction since runoff ditches flank both the eastern and western edges of the site. The drainage areas on the western side parallel the Camp Lejeune Railroad and Holcomb Boulevard. Figure 3-1 presents the topography and surface features identified at Site 3.

3.2 Surface Water Hydrology

3.2.1 Regional

The following summary of surface water hydrology was originally presented in the IAS report (Water and Air Research, 1983).

The dominant surface water feature of MCB, Camp Lejeune is the New River, which receives drainage from most of the base. The New River is short with a course of approximately 50 miles on the central coastal plain of North Carolina. Over most of its length, the New River is confined to a relatively narrow channel entrenched in the Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB, Camp Lejeune that are not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet. The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15A of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body contact sports or commercial shell fishing) and SA (estuarine waters suited for commercial shell fishing). The northern area of the New River near Montford Point at MCB, Camp Lejeune falls into the SA classification.

Drainage at MCB, Camp Lejeune is generally towards the New River, except in areas near the coast, where flow is into the Intracoastal Waterway. In developed areas, natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of MCB, Camp Lejeune is situated in broad, flat interstream areas. Drainage is poor in these areas.

The U.S. Corps of Engineers has mapped the limits of the 100-year floodplain at 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.

3.2.2 Site-Specific

There are no standing water bodies within the site. Ditches on the eastern and western sides of the site exhibit ponded water during periods of heavy rain. Wallace Creek is located approximately three-quarters of a mile to the south of the site. Surface drainage is towards the east and west, in the directions of the drainage ditches. There is the potential for these ditches to channel site related constituents off site during periods of heavy rainfall.

3.3 Geology and Soil

3.3.1 Regional

MCB, Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone. These sediments lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1990). These sediments were deposited in marine and near-marine environments and range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic basement rocks of pre-Cretaceous age. Table 3-1 presents a generalized stratigraphic column for this area (ESE, 1990).

3.3.2 Site-Specific

Site 3 is primarily underlain by sand, and silty sand with occasional discontinuous layers of silt and clay, and clay. These surficial soils represent the Quaternary age "undifferentiated" Formation that characterizes the shallow water table aquifer. Results of the standard penetration tests (ASTM D1586-84) indicate the relative density of the soils range from very loose to dense. Unified Soil Classification System (USCS) classification for the surficial soils identified at the site are SM (silty sand), SP (poorly graded sands with little to no fines), and CL (silty clay and clay). Possible fill material was noted at some borehole locations in the southern portion of the treatment area, ranging in thickness from 1 to 3 feet. This fill material consisted of apparent replaced soil. Two intermediate depth wells (87 feet bgs) and one deep well (140 feet bgs) were installed in the upper and middle portion of the Castle Hayne aquifer. The lithology of the upper Castle Hayne is predominantly a fine grained sand with trace to little silt, and shell and limestone fragments.

Geologic cross-sections were developed for the surficial and upper Castle Hayne sediments based on samples collected during the RI. As shown on Figure 3-2, two cross-sections were developed using groundwater monitoring well boreholes. Cross-section A-A' (Figure 3-3) depicts the site lithology from north to south and cross-section B-B' (Figure 3-4) depicts the lithology from west to east of the site soils.

As shown on cross-sections A-A' and B-B' (see Figures 3-3 and 3-4), the surficial soils are comprised of fine grained sand with varying amounts of silt between 11 and 32 feet thick. Beneath the silty sand is a discontinuous silty clay layer ranging in thickness from 0 to approximately 12 feet thick. This silty clay layer is not evident in the log for well 3-MW03, installed during a previous investigation, in the northern portion of the site. It was also not encountered in wells 3-MW04 and 3-MW06, installed during the 1994 investigation, in the central and southern portion of the site, respectively. Intermediate well 3-MW11IW on the western side of the site exhibited a silty clay layer at a depth of 32 feet. The silty sand above the silty clay unit was damp to wet, indicating that the clay unit may inhibit but not preclude the downward groundwater flow due to its apparent lower permeability. The lithology below the silty clay, as seen in intermediate well 3-MW11IW and deep well 3-MW02DW, indicates the Castle Hayne formation. This unit is comprised of a silty sand with varying amounts of shell fragments, and exhibits a higher density with depth.

3.4 Hydrogeology

3.4.1 Regional

The following summary of regional hydrogeology was originally presented in Harned, et al. (1989) and reevaluated by Cardinell, et al. (1993), and in Environmental Science and Engineering, Inc. (ESE) Site Summary Report (1988).

The aquifers of interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne aquifer. Aquifers below the Castle Hayne include the Beaufort, Peedee, Black Creek, and the upper and lower Cape Fear aquifers. The combined thickness of the seven aquifers underlying MCB, Camp Lejeune is approximately 1500 feet. The following summary is a compilation of information which pertains to aquifer characteristics within MCB, Camp Lejeune area. A generalized cross-section illustrating the relationship between aquifers in this area is presented on Figures 3-5 and 3-6.

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB, Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is cut by the New River and its tributaries. The beds are thin and discontinuous, and have a limited lateral continuity. This aquifer is not used as a water supply at MCB, Camp Lejeune.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of relatively high vertical conductivity within the aquifer. The estimated lateral hydraulic conductivity of the surficial aquifer in the MCB, Camp Lejeune area is 50 feet per day, and is based on a general composition of fine sand mixed with some silt and clay. However, data collected from a number of slug tests conducted by Baker at MCB, Camp Lejeune indicate much lower lateral hydraulic conductivity values. These values range from 8.0×10^{-4} feet per day to 79.24 feet per day. Table 3-2 presents a summary of hydraulic properties compiled during investigations at sites located within Mainside of MCB, Camp Lejeune.

Between the surficial and the Castle Hayne aquifers is the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places. The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet where present. There is no discernable trend in the thickness of the confining unit seen in these or related investigations, nor is there any information in the USGS literature regarding any trend of the depth of the confining unit.

Previously recorded data indicate that vertical hydraulic conductivity of the confining unit ranged from 0.0014 to 0.41 feet per day (Cardinell et al., 1993). Data obtained from a pump test conducted by ESE indicated a vertical hydraulic conductivity for this unit ranging from 1.4×10^{-3} to 5.1×10^{-2} feet per day (ESE, 1988). Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the downward movement of groundwater from the surficial aquifer.

The Castle Hayne aquifer lies below the surficial aquifer and consists primarily of unconsolidated sand, shell fragments, and fossiliferous limestone. Clay, silt, silty and sandy clay, and indurated limestone also occur within the aquifer. The upper part of the aquifer consists primarily of calcareous sand with some continuous and discontinuous thin clay and silt beds. The calcareous sand becomes more limey with depth. The lower part of the aquifer consists of consolidated or poorly consolidated limestone and sandy limestone interbedded with clay and sand.

The Castle Hayne aquifer is about 150 to 350 feet thick, increasing in thickness towards the ocean. The top of the aquifer lies approximately 20 to 73 feet below ground surface. The top of the aquifer dips southward and is deepest near the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet per day. Table 3-3 presents estimates of the Castle Hayne aquifer and confining unit hydraulic properties in the vicinity of MCB, Camp Lejeune.

Onslow County and MCB, Camp Lejeune lie in an area where the Castle Hayne aquifer contains freshwater, although the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per liter (mg/L) chloride (State criteria for classification of saltwater) throughout the base, except for one USGS well in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a sample collected in 1989 from this well.

Rainfall in the MCB, Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the surficial aquifer. Recharge areas at Camp Lejeune are mainly comprised of interstream areas. In the surficial aquifer, groundwater flows in the direction of low hydraulic head until it reaches discharge points or fronts. These discharge areas include the New River and its tributaries, and the ocean. Though most of the rainfall entering the surficial aquifer discharges to local streams, a relatively small amount infiltrates to the Castle Hayne. The surficial aquifer supplies the primary recharge to the Castle Hayne aquifer. Like the surficial aquifer, the Castle Hayne naturally discharges to the New River and major tributaries; however, pumping of the Castle Hayne may locally influence flow directions.

The potentiometric surface of the surficial aquifer varies seasonally, as seen through observation of water levels in monitoring wells. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. As a result, the potentiometric surface is generally highest in winter months and lowest in the summer or early fall.

Water levels from wells placed in deeper aquifers, such as the Castle Hayne, were also used to establish potentiometric surfaces. Because the Castle Hayne is at least partially confined from the surficial aquifer and is not influenced by rainfall as strongly as the surficial aquifer, the seasonal variations tend to be slower and smaller than in the surficial aquifer.

3.4.2 Site-Specific

Groundwater was encountered during drilling during the RI at elevations ranging from 8.13 to 25.56 feet above msl. Groundwater elevation measurements from December 11, 1994, March 27, 1995 and August 1, 1995 for Site 3 are presented in Table 3-4. Groundwater elevation contour maps for the shallow aquifer on December 11, 1994, March 27, 1995 and August 1, 1995 are presented on Figures 3-7, 3-8 and 3-9, respectively. The contour maps indicate a linear flow toward the southwest. Based on the groundwater contour maps, recharge for this area is from the northeast. The shallow groundwater gradient measured from well 3-MW07 to well 3-MW05 in the southwest for December 11, 1994 was 0.046 ft/ft, March 27, 1995 was 0.048 ft/ft, and August 1, 1995 was 0.042 ft/ft. Shallow groundwater may be discharging to Wallace Creek, the nearest surface water body, located approximately three-quarters of a mile south of the site.

The hydraulic properties of the surficial aquifer were characterized by performing in situ rising and falling head slug tests in five of the thirteen newly installed monitoring wells. The tests were performed on December 9 and 10, 1994. An electronic data logger (In Situ Hermit Model SE2000) and pressure transducer assembly were used to record the recovery of groundwater in the monitoring wells to static level. All data were recorded on logarithmic scale to more closely monitor the initial changes in groundwater elevation. The data resulting from the slug tests were converted into time (in minutes) and the corresponding change in water level displacement (in feet). Results from the rising head tests were analyzed using Geraghty & Miller's AQTESOLV (ver. 1.1) computer program for performing quantitative groundwater assessments. No data from falling head tests were analyzed as the groundwater levels in the shallow wells were below the top of the sand pack, making the falling head tests invalid. The Bouwer and Rice solution for slug tests in unconfined aquifers was used to evaluate all test data. The input parameters and plots generated from the slug tests are contained in Appendix E.

Table 3-5 lists the hydraulic conductivity values (K) obtained from the data analysis, the average hydraulic gradient from the three shallow groundwater elevation contour maps, the assumed effective porosity, and the calculated value for groundwater velocity. The average estimated K value from the five shallow wells was 3.2 feet/day (1.1 x 10^{-3} cm/sec), which is within the typical range for silty sands (Freeze/Cherry, 1979). The average hydraulic gradient from groundwater measurements between wells 3-MW07 and 3-MW05 on December 11, 1994, March 27, 1995 and August 1, 1995 was 0.045 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sands and silts (Freeze/Cherry, 1979). Due to the silty nature of the sand, a value of 35 percent was used for effective porosity. The estimated average linear groundwater velocity was calculated by using a variation of Darcy's equation:

$$V=Ki/n_e$$

Where: V = groundwater velocity (feet/day)
K = hydraulic conductivity (feet/day)
i = hydraulic gradient (feet/feet)
n_e = effective porosity (dimension less)

Using these variables, the groundwater velocity (V) is estimated to be 0.41 feet/day (149.7 feet/year). This is a conservatively low estimate because of the nature of the silty sand and the variability in the estimated K values from the slug tests. An approximate transmissivity value (T) can be obtained from multiplying the hydraulic conductivity by the saturated thickness (b) of the aquifer. Using a saturated thickness of 15 feet, which corresponds to the distance above the top of the Castle Hayne (24 foot depth) to the water table surface (average depth of 9 feet), an approximate T value for the shallow aquifer in this direction is 48 feet^2/day (359 gallons/day/ft). A recent hydrogeologic investigation conducted by Baker in the Camp Geiger area (1994), which included an aquifer pump test within the shallow water-bearing zone (approximately 25 foot depth), indicated T and K values of 94 ft^2/day (7.1 x 10 gallons/day/ft) and 6.3 feet/day (2.2 x^3 10 cm/sec), respectively. Values for T determined from a pump test performed at Hadnot Point on the opposite side of the New River from Camp Geiger were 75 feet^2/day (5 x 10^2 gallons/day/ft). The average transmissivity value from these two pump tests is 85 feet^2/day (6 x 10 gallons/day/ft). The calculated transmissivity value of 48 feet^2/day from the slug tests is approximately equal to the average pump test value.

Two intermediate depth wells (87 feet) have been installed in the upper portion and one deep well (140 feet) has been installed in the middle portion of the Castle Hayne aquifer. Groundwater levels for these wells are presented in Table 3-4. Groundwater elevations for the intermediate wells were 5.78 and 5.23 feet above msl on August 1, 1995. The deep well exhibited a groundwater elevation of 4.31 feet above msl on August 1, 1995. Groundwater contours can not be prepared from just two wells. There is a groundwater elevation difference between monitoring wells installed in the surficial aquifer and the upper portion of the Castle Hayne aquifer. This elevation difference produces a potential vertical gradient ranging from 0.3 ft/ft (at well location 3-MW02) to 0.08 ft/ft (at well location 3-MW11) downward from the shallow water-bearing zone to the upper Castle Hayne. The recharge area for the upper Castle Hayne aquifer may be to the northeast with the Castle Hayne potentially discharging to the New River where the Castle Hayne formation is near surface.

In situ rising and falling slug tests were performed in well 3-MW02IW on December 10, 1994. Both the falling head and rising head test data was analyzed using Geraghty & Miller's AQTESOLV (ver. 1.1) program, as with the shallow wells. The input parameters and plots generated are contained in Appendix E. Table 3-5 lists the K values obtained from the data analysis, the hydraulic gradient, the assumed effective porosity, and the calculated value for groundwater velocity. The average hydraulic conductivity value for the Castle Hayne aquifer was 4 feet/day (1.4 x 10^{-3} cm/sec). USGS Water Resources report (Harned et al., 1989) lists a hydraulic conductivity range of 14 - 82 feet/day for the Castle Hayne aquifer. Calculated K values for Site 3 are lower than those reported in the USGS report. Assuming a linear groundwater flow in the upper portion of the Castle Hayne, the measured hydraulic gradient between intermediate wells 3-MW02IW and 3-MW11IW on August 1, 1995 is 0.002 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sand and silt (Freeze/Cherry, 1979). Due to the silty nature of the sand, a value of 35 percent was used for effective porosity. The estimated average linear velocity was calculated using the variation of Darcy's equation.

Using the variables stated in the previous paragraph, the groundwater velocity (V) for the upper portion of the Castle Hayne is estimated to be 0.02 feet/day (7.3 feet/year). This is a conservatively low estimate because of the nature of the silty sand and the assumed hydraulic gradient of the aquifer at the site. Using an estimated saturated aquifer thickness of 200 feet, an estimated T value of 800 feet^2/day (6 x 10 gpd/ft) was obtained. A Wellhead Management Program Engineering Study (Geophex, Ltd, 1992) was conducted in 1991 at Camp Lejeune which states a transmissivity value of 15,000 ft^2/day (1.1 x 10 gpd/ft) for the Holcomb Boulevard and Hadnot Point areas. This document also reports a transmissivity value of 8,000 ft^2/day (6 x 10^4 gpd/ft) for the Marine Corps Air Station (MCAS) on the opposite side of the New River. The estimated transmissivity value from the slug tests at Site 3 is one to two orders of magnitude less than the values stated in the Geophex study. The estimated T value calculated from the slug test data is representative of the 85 to 90 foot depth in the area of Site 3, as opposed to the deeper water supply zones (100 to 200 feet) studied under the Wellhead Management Program.

The lithology indicates a confining or semiconfining layer between the surficial water table aquifer and the Castle Hayne aquifer. This is substantiated by the difference in groundwater elevations exhibited between the shallow and intermediate wells at locations 3-MW02 and 3-MW11. The differentiation between the two water bearing zones is based on lithology, groundwater parameters as seen from the evaluation of slug test data, and usage (the surficial 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 ft/ft.

3.5 Ecological Features

3.5.1 Regional

The following summary of natural resources and ecological features was obtained from the IAS Report (Water and Air Research, 1983).

The Camp Lejeune Complex is predominantly tree-covered with large amounts of softwood including shortleaf, longleaf, pond, and pines (primarily loblolly), and substantial stands of hardwood species. Approximately 60,000 of the 112,000 acres of MCB, Camp Lejeune are under forestry management. Timber producing areas are under even-aged management with the exception of those areas along streams and swamps. These areas are managed to provide both wildlife habitat and erosion control. Forestry management provides wood production, increased wildlife populations, enhancement of natural beauty, soil protection, prevention of stream pollution, and protection of endangered species.

Upland game species including black bear, whitetail deer, gray squirrel, fox squirrel, quail, turkey, and migratory waterfowl are abundant and are considered in the wildlife management programs.

Aquatic ecosystems on MCB, Camp Lejeune consist of small lakes, the New River estuary, numerous tributaries, creeks, and part of the Intracoastal Waterway. A wide variety of freshwater and saltwater fish species exist here. Freshwater ponds are under management to produce optimum yields and ensure continued harvest of desirable fish species (Water and Air Research, 1983). Freshwater fish in streams and ponds include largemouth bass, redear sunfish, bluegill, chain pickerel, and catfish. Reptiles include alligators, turtles, and snakes, including venomous. Both recreational and commercial fishing are practiced in the waterways of the New River and its tributaries.

Wetland ecosystems of MCB, Camp Lejeune can be categorized into five habitat types: (1) pond pine or pocosin; (2) sweet gum, water oak, cypress, and tupelo; (3) sweet bay, swamp black gum, and red maple; (4) tidal marshes; and, (5) coastal beaches. Pocosins provide excellent habitat for bear and deer because these areas are seldom disturbed by humans. The presence of pocosin-type habitat at MCB, Camp Lejeune is primarily responsible for the continued existence of black bear in the area. Many of the pocosins are overgrown with brush and pine species that would not be profitable to harvest. Sweet gum, water oak, cypress, and tupelo habitat is found in the rich, moist bottom lands along streams and rivers. This habitat extends to the marine shorelines. Deer, bear, turkey, and waterfowl are commonly found in this type of habitat. Sweet bay, sweet black gum, and red maple habitat exist in the floodplain areas of MCB, Camp Lejeune. Fauna including waterfowl, mink, otter, raccoon, deer, bear, and gray squirrel frequent this habitat. The tidal marsh at the mouth of the New River is one of the few remaining North Carolina coastal areas relatively free from filling or other manmade changes. This habitat, which consists of marsh and aquatic plants such as algae, cattails, saltgrass, cordgrass, bulrush, and spikerush, provides wildlife with food and cover. Migratory waterfowl, alligators, raccoons, and river otter exist in this habitat. Coastal beaches along the Intracoastal Waterway and along the outer banks of MCB, Camp Lejeune are used for recreation and to house a small military command unit. Basic assault training maneuvers are also conducted along these beaches. Training regulations presently restrict activities that would impact ecologically sensitive coastal barrier dunes. The coastal beaches provide habitat for many shorebirds (Water and Air Research, 1983).

The Natural Resources and Environmental Affairs (NREA) Division of MCB, Camp Lejeune, the U.S. Fish and Wildlife Service, and the North Carolina Wildlife Resource Commission have entered into an agreement for the protection of endangered and threatened species that might inhabit MCB, Camp Lejeune. Habitats are maintained at MCB, Camp Lejeune for the preservation and protection of rare and endangered species through the base's forest and wildlife management programs. Full protection is provided to such species, and critical habitat is designated in management plans to prevent or mitigate adverse effects of base activities. Special emphasis is placed on habitat and sightings of alligators, osprey, bald eagles, cougars, dusky seaside sparrows, and red-cockaded woodpeckers (Water and Air Research, 1983).

Within 15 miles of MCB, Camp Lejeune are three publicly owned forests: Croatan National Forest; Hofmann Forest; and Camp Davis Forest. The remaining land surrounding MCB, Camp Lejeune is primarily used for agriculture. Typical crops include soybeans, small grains, and tobacco (Water and Air Research, 1983).

3.5.2 Site-Specific

Three general habitat types are present at Site 3. These three include an open area, mixed forest, and pine forest. The open area, which covers most of the site, is dominated by grasses with bare soil present in some places. Scattered trees are found within the open area. A transition zone is present between the open area and the mixed forest southeast of the site. The mixed forest is dominated by loblolly pines, mixed with deciduous trees. Shrubs and herbaceous plants are also found within the mixed forest. The pine forest contains loblolly pine with no other tree species, vines or herbaceous plants present. Birds were identified in the area as was evidence of whitetail deer. The habitat evaluation was conducted in winter so no reptiles or amphibians were observed at Site 3. Site 3 is not within or in close proximity (i.e., one-half mile) to either a natural area or protected area. Protected areas have only been established for the red-cockaded woodpecker. Section 7 presents the ecological features in detail and Figure 7-1 presents the habitat map of the site area.

3.6 Land Use Demographics

3.6.1 Base-Wide

MCB, Camp Lejeune presently covers approximately 236 square miles. Present military population of MCB, Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in base housing units. The remaining personnel and dependents live off base and have dramatic effects on the surrounding area. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350 (Master Plan, Camp Lejeune Complex, North Carolina, 1988). During World War II, MCB, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the recent Gulf War (i.e., Desert Storm). Toward the end of World War II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

3.6.2 Site-Specific

The Old Creosote Plant is located within the Mainside Supply and Storage areas. Approximately 10.5 percent of all developed land in the Complex is comprised of supply and storage uses, most of which are concentrated in the area east of Paradise Field at Hadnot Point or east of Holcomb Boulevard in an open storage area. The area of Site 3 is located east of Holcomb Boulevard approximately three-quarters of a mile from the intersection of Brewster and Holcomb Boulevards. This area is currently not being used for open storage.

The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-6. In addition, the number of acres comprising each land use category has been estimated and provided on the table. Site 3 is located in the northern region of Mainside of MCB, Camp Lejeune.

3.7 Climate and Meteorology

MCB, Camp Lejeune experiences mild winters, and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 34 to 54 degrees Fahrenheit (°F) in the winter (i.e., January) and 72 to 89 °F in the summer (i.e., July). Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983). Table 3-7 presents a summary of climatic data readings from the MCAS at New River. These measurements were collected between January 1955 and December 1990.

3.8 Water Supply

MCB, Camp Lejeune water is supplied entirely from groundwater. Groundwater is obtained from approximately 90 water supply wells, and treated. There are eight water treatment plants with a total capacity of 15.821 million gallons per day (mgd). Groundwater usage is estimated at over seven mgd (Harned, et al., 1989).

All of the water supply wells utilize the Castle Hayne aquifer. The Castle Hayne aquifer is a highly permeable, semiconfined aquifer that is capable of yielding several hundred to 1,000 gallons per minute (gpm) in municipal and industrial wells in the MCB, Camp Lejeune Area. The water retrieved is typically hard, calcium bicarbonate type.

There are four base supply wells within a one-mile radius of Site 3: HP-613, HP-616, HP-654, and OW-3 (Harnad, et al., 1989). Table 3-8 presents a summary of the water supply wells within a one-mile radius of Site 3. The location of these base water supply wells are shown on Figure 3-10.

3.9 References

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SECTION 3.0 TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Geologic Units			Hydrogeologic Units
System	Series	Formation	Aquifer and Confining Unit
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial aquifer
Tertiary	Pliocene	Yorktown Formation(1)	Yorktown confining unit
	Miocene		Yorktown Aquifer
		Eastover Formation(1)	Pungo River confining unit
		Pungo River Formation(1)	Pungo River Aquifer
		Belgrade Formation(2)	Castle Hayne confining unit
	Oligocene	River Bend Formation	Castle Hayne Aquifer
	Eocene	Castle Hayne Formation	Beaufort confining unit(3)
	Paleocene	Beaufort Formation	Beaufort Aquifer
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee confining unit
			Peedee Aquifer
		Black Creek and Middendorf Formations	Black Creek confining unit
			Black Creek Aquifer
		Cape Fear Formation	Upper Cape Fear confining unit
			Upper Cape Fear Aquifer
			Lower Cape Fear confining unit
			Lower Cape Fear Aquifer
	Lower Cretaceous(1)	Unnamed deposits(1)	Lower Cretaceous confining unit
			Lower Cretaceous Aquifer(1)
Pre-Cretaceous basement rocks		--	--

(1) Geologic and hydrologic units probably not present beneath MCB,. Camp Lejeune.
(2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
(3) Estimated to be confined to deposits of Paleocene age in the study area.

Source: Harned et al., 1989.

TABLE 3-2

SUMMARY OF HYDRAULIC PROPERTIES
UNRELATED SITE INVESTIGATIONS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Hydraulic Conductivity Falling Head Test		Hydraulic Conductivity Rising Head Test		Transmissivity
Well No.	ft/day	cm/sec	ft/day	cm/sec	gal/day/ft
Site 74 - Mess Hall (Mainside)					
74-GW03A	--	--	0.5907	2.09E-4	70.7
74-GW06	--	--	6.3302	2.23E-3	758
74-GW08	--	--	3.5496	1.25E-3	425
Site 80 - Paradise Point Golf Course					
80-MW04	1.71	6.04E-4	51.11	1.80E-2	486/14529⁽¹⁾
80-MW05	--	--	79.24	2.80E-2	22526
80-MW06	--	--	3.92	1.38E-3	1114
80-MW07	--	--	7.84	2.77E-3	2229
Building 21 - Residential Area Hadnot Point					
110MW-07	--	--	0.01	3.50E-6	0.67
110MW-09	--	--	0.16	5.64E-5	11.34
110DW-03	--	--	1.07	3.78E-4	176
Building H-28 - Housing Area Hadnot Point					
111-MW05	0.57	2.00E-4	2.60E-3	9.00E-7	--
111-MW03	2.26	8.00E-4	8.22E-4	2.00E-7	--

Notes:

All data compiled from unrelated Baker Investigations within Mainside, MCB, Camp Lejeune

(1) First value is for falling head test, second value is for rising head test

TABLE 3-3

HYDRAULIC PROPERTY ESTIMATES OF THE CASTLE HAYNE AQUIFER
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Hydraulic Properties	USGS Phase I Study(1)	USGS Aquifer Test(2)	ESE, Inc. (3)	DEHNR Aquifer Test(4)	RASA Estimate(5)
Aquifer transmissivity (cubic foot per day per square foot times foot of aquifer thickness)	4,300 to 24,500 average 9,500	1,140 to 1,325	820 to 1,740 average 1,280	900	10,140 to 26,000
Aquifer hydraulic conductivity (foot per day)	14 to 82 average 35	20 to 60	--	18 to 91 average 54	45 to 80 average 65
Aquifer storage coefficient (dimensionless)	--	0.0002 to 0.00022	0.0005 to 0.001 average 0.0008	0.0019	--
Confining-unit vertical hydraulic conductivity (foot per day)	--	0.03 to 0.41	0.0014 to 0.051 average 0.0035	--	--

Note:

(1) Analysis of specific capacity data from Harned and others (1989).
(2) Aquifer test at well HP-708.
(3) Aquifer test at Hadnot Point well HP-462 from Environmental Sciences and Engineering, Inc. (1988).
(4) Unpublished aquifer test data at well X24s2x, from DEHNR well records (1985).
(5) Transmissivities based on range of aquifer thickness and average hydraulic conductivity from Winner and Coble (1989).

Source: Cardinell, et al., 1993.

TABLE 3-4

SUMMARY OF WATER LEVEL MEASUREMENTS FROM MONITORING WELLS ON DECEMBER 11, 1994, MARCH 27, 1995, AUGUST 1, 1995 AND JANUARY 29, 1996
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation(1) (feet, above msl)	Depth to Groundwater (feet, below top of casing) (12/11/94)	Groundwater Elevation (feet, above msl) (12/11/94)	Depth to Groundwater (feet, below top of casing) (03/27/95)	Groundwater Elevation (feet, above msl) (03/27/95)	Depth to Groundwater (feet, below top of casing) (08/01/95)	Groundwater Elevation (feet, above msl) (08/01/95)	Depth to Groundwater (feet, below top of casing) (01/29/96)	Groundwater Elevation (feet, above msl) (01/29/96)
Shallow Wells									
3-MW01	35.36	27.23	8.13	24.71	10.65	25.51	9.85	NA	NA
3-MW02	35.85	11.65	24.20	8.55	27.30	9.25	26.60	NA	NA
3-MW03	32.60	12.12	20.48	8.74	23.86	10.24	22.36	NA	NA
3-MW04	33.43	22.35	11.08	17.44	15.99	19.13	14.30	NA	NA
3-MW05	34.00	25.86	8.14	23.24	10.76	23.87	10.13	NA	NA
3-MW06	30.55	12.50	18.05	9.55	21.00	11.52	19.03	NA	NA
3-MW07	33.51	7.95	25.56	4.66	28.85	7.25	26.26	NA	NA
3-MW08	32.62	9.51	23.11	6.04	26.58	7.91	24.71	NA	NA
3-MW09	33.29	NA	NA	NA	NA	7.38	25.91	NA	NA
3-MW10	33.85	NA	NA	NA	NA	6.92	26.93	NA	NA
3-MW11	32.69	NA	NA	NA	NA	22.84	9.85	NA	NA
3-MW12	29.55	NA	NA	NA	NA	20.20	9.35	NA	NA
3-MW13	22.93	NA	NA	NA	NA	16.88	6.05	NA	NA
Intermediate Wells									
3-MW02IW	35.19	31.04	4.15	29.75	5.44	29.41	5.78	NA	NA
3-MW11IW	32.55	NA	NA	NA	NA	27.32	5.23	NA	NA
Deep Well									
3-MW02DW	34.06	NA	NA	NA	NA	29.75	4.31	30.25	3.81

Notes:

(1) Mean Sea Level (msl)
NA - Not Applicable

TABLE 3-5

AQUIFER CHARACTERISTICS - MONITORING WELLS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity (K) (feet/day)	Hydraulic Gradient (i) (feet/feet)	Effective Porosity[1] (n_e)	Groundwater Velocity (V) (feet/day)
Shallow Wells				
3-MW04	0.043	0.045	0.35	0.01
3-MW05	6.13	0.045	0.35	0.79
3-MW06	0.65	0.045	0.35	0.08
3-MW07	6.14	0.045	0.35	0.79
3-MW08	2.97	0.045	0.35	0.38
Average	3.2	0.045	0.35	0.41
Intermediate Wells				
3-MW02IW Rising Head	4.15	0.002	0.35	0.02
3-MW02IW Falling Head	4.03	0.002	0.35	0.02
Average	4	0.002	0.35	0.02

(1) Freeze/Cherry, 1979

TAB 6

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Geographic Area	Oper.	Training (Instruc.)	Maint.	Supply/ Storage	Medical	Admin.	Family Housing	Troop Housing	CM	CO	Recreat.	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins Village							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						57 (100)
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		73 (28.6)	28 (10.9)	14 (5.5)		12 (4.7)	12 (4.7)	43 (16.9)	15 (5.9)	4 (1.6)	43 (16.9)	11 (4.3)	255 (100)
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	**57 (1.1)**	**155 (3.1)**	**287 (5.7)**	**590 (11.7)**	**17 (0.38)**	**186 (3.7)**	**1,523 (30.2)**	**548 (10.8)**	**370 (7.4)**	**65 (1.3)**	**1.116 (22.2)**	**119 (2.4)**	**5,033 (100)**

Notes:

CM = Community Development
CO = Commercial Development

TABLE 3-7

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Precipitation (Inches)			Relative Humidity (Percent)	Temperature (Fahrenheit)			Mean Number of Days With				
								Precipitation		Temperature		
	Maximum	Minimum	Average		Maximum	Minimum	Average	>=0.01"	>=0.5"	>=90F	>=75F	<=32F
January	7.5	1.4	4.0	79	54	34	44	11	2	0	1	16
February	9.1	.9	3.9	78	57	36	47	10	3	0	2	11
March	8	.8	3.9	80	64	43	54	10	3	*	5	5
April	8.8	.5	3.1	79	73	51	62	8	2	1	13	*
May	8.4	.6	4.0	83	80	60	70	10	3	2	25	0
June	11.8	2.2	5.2	84	86	67	77	10	4	7	29	0
July	14.3	4.0	7.7	86	89	72	80	14	5	13	31	0
August	12.6	1.7	6.2	89	88	71	80	12	4	11	31	0
September	12.8	.8	4.6	89	83	66	75	9	3	4	27	0
October	8.9	.6	2.9	86	75	54	65	7	2	*	17	*
November	6.7	.6	3.2	83	67	45	56	8	2	0	7	3
December	6.6	.4	3.7	81	58	37	48	9	2	0	2	12
Annual	65.9	38.2	52.4	83	73	53	63	118	35	39	189	48

* = Mean no. of days less than 0.5 days

Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1990.

TABLE 3-8

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS OF SITE 3(1)
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	USGS Identification Number	Total Depth (feet)	Screened Intervals (feet)	In/Out of Service (2)	Analytical Data(2)	Approximate Distance/ Direction from Site(3) (feet)
Site 3: HP-613	3442290772020.1	150	60-70 90-95 115-120 130-135 145-150	In	No Organics Detected	990/southwest
HP-616	3442470772028.1	170	95-115 130-140 160-170	In	No Organics Detected	2380/northwest
HP-654	3442270771953.1	250	--	In	No Organics Detected	1190/southeast
OW-3	3442280772018.1	75	--	Out	NA	660/west

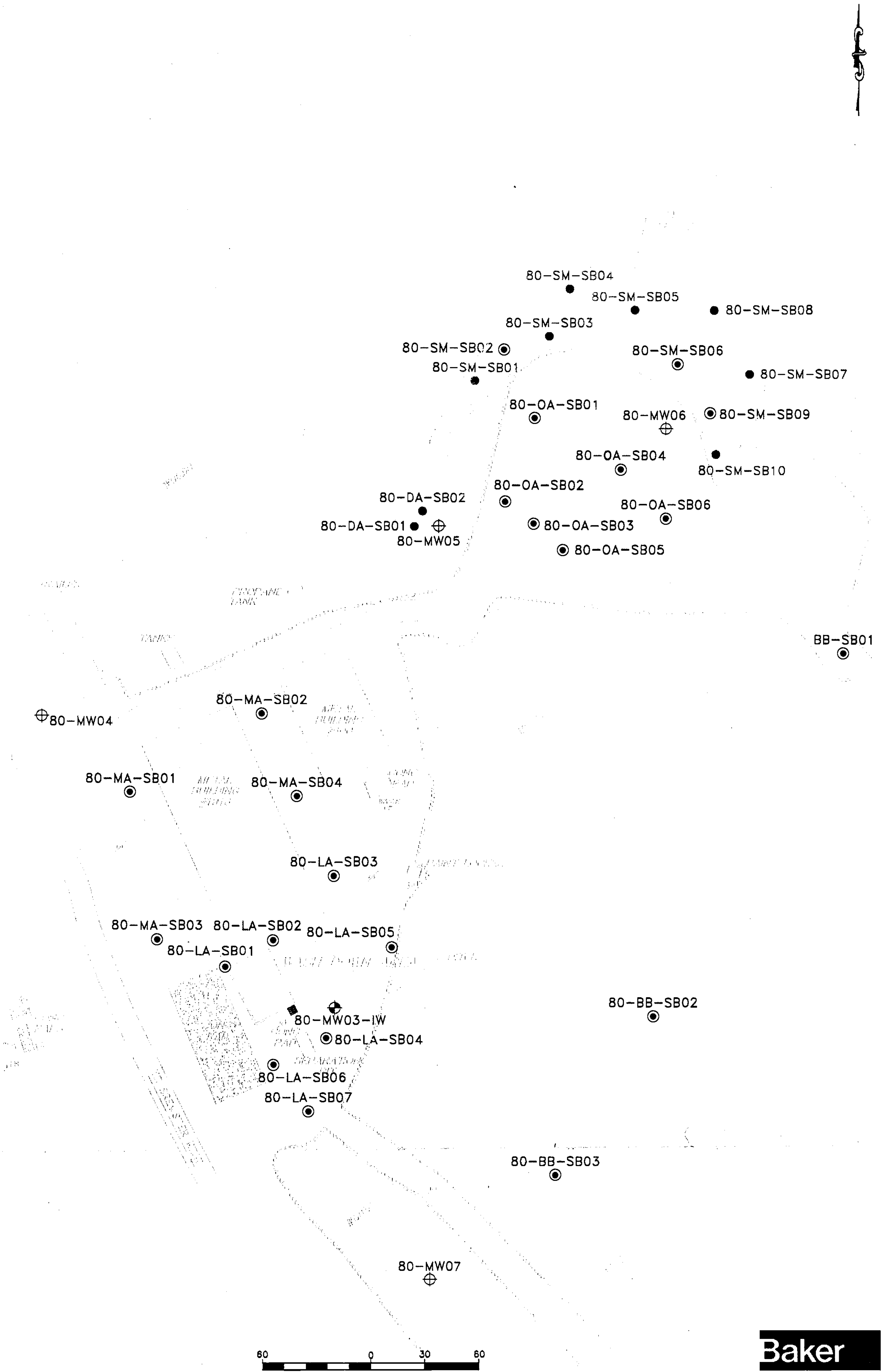
Notes: (1) Information obtained from "Assessment of Hydrogeologic and Hydraulic Data at Camp Lejeune Marine Corps Base, North Carolina," 1989.

(2) As per Greenehorne & O'Mara, Inc. Draft Report Wellhead Monitoring Study, December, 1992

(3) Distance measured from site location mark on Figure 3-10.

NA = Not Applicable

SECTION 3.0 FIGURES



274074RI

Baker

Baker Environmental, Inc.

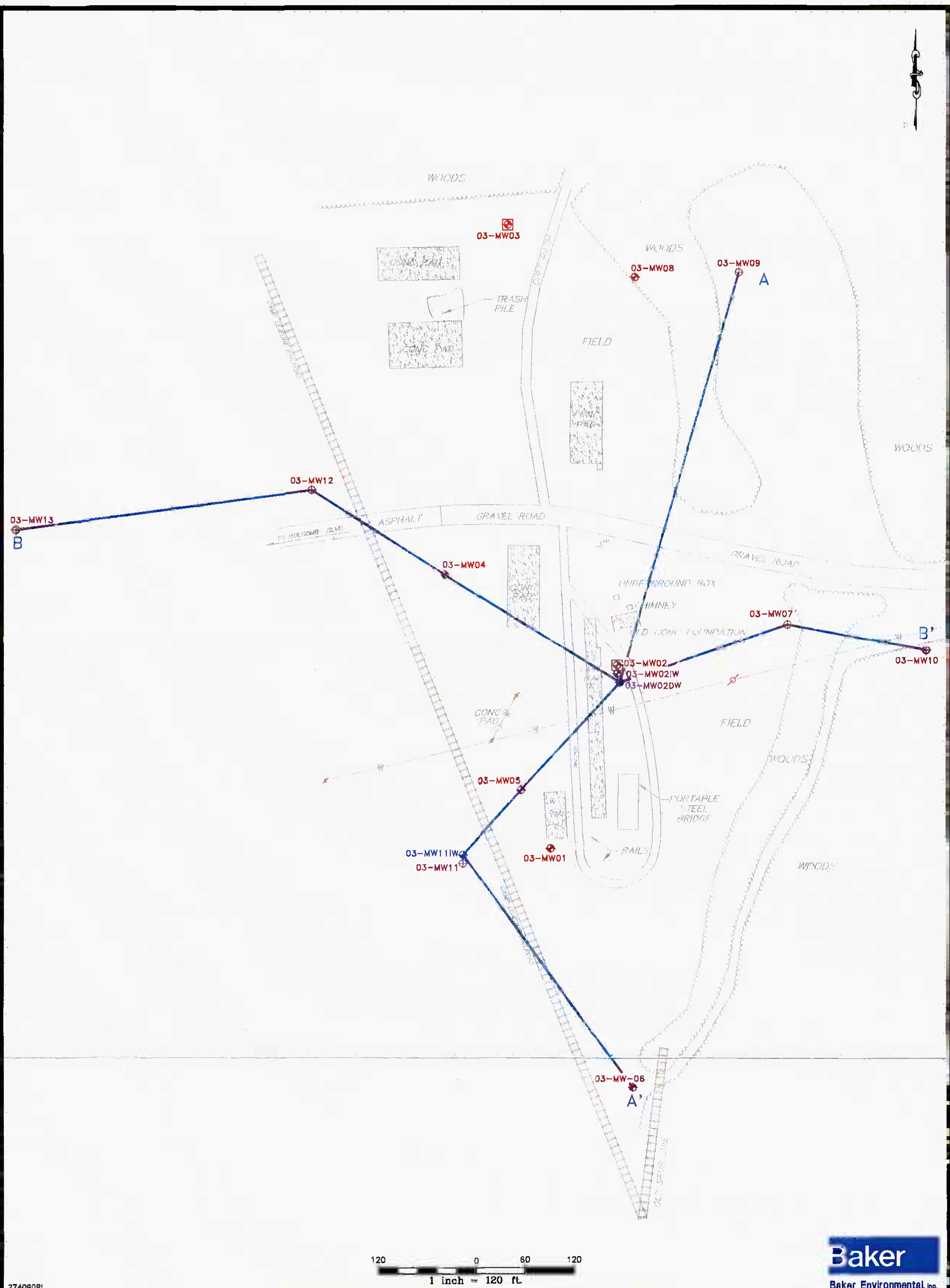
LEGEND

80-MW04 ⊖	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MW03IW ⊕	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MA-SB01 ◉	SOIL BORING LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-DA-SB01 ●	SURFACE SOIL BORING LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).

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

FIGURE 2-1
SOIL SAMPLING LOCATIONS
SITE 80 - PARADISE POINT
GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

01697X012



274090RI

Baker
Baker Environmental, Inc.

LEGEND

03-MW02 ⊕ EXISTING MONITORING WELL LOCATION

03-MW04 ⊕ NEWLY INSTALLED MONITORING WELL LOCATION

A-A' CROSS-SECTION TRAVERSE

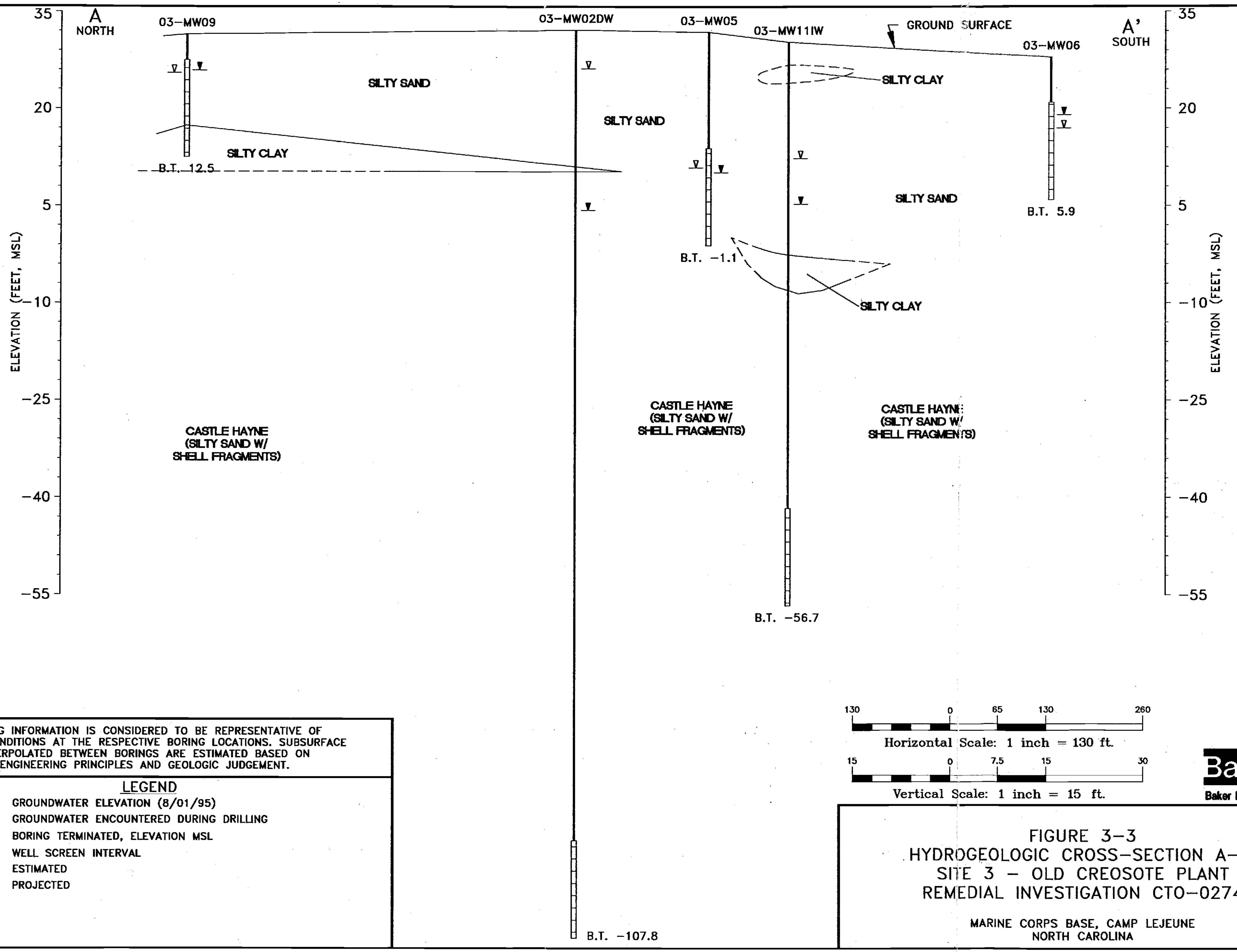
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 3-2
CROSS-SECTION LOCATION MAP
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699X02Y

274091RI



THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

LEGEND

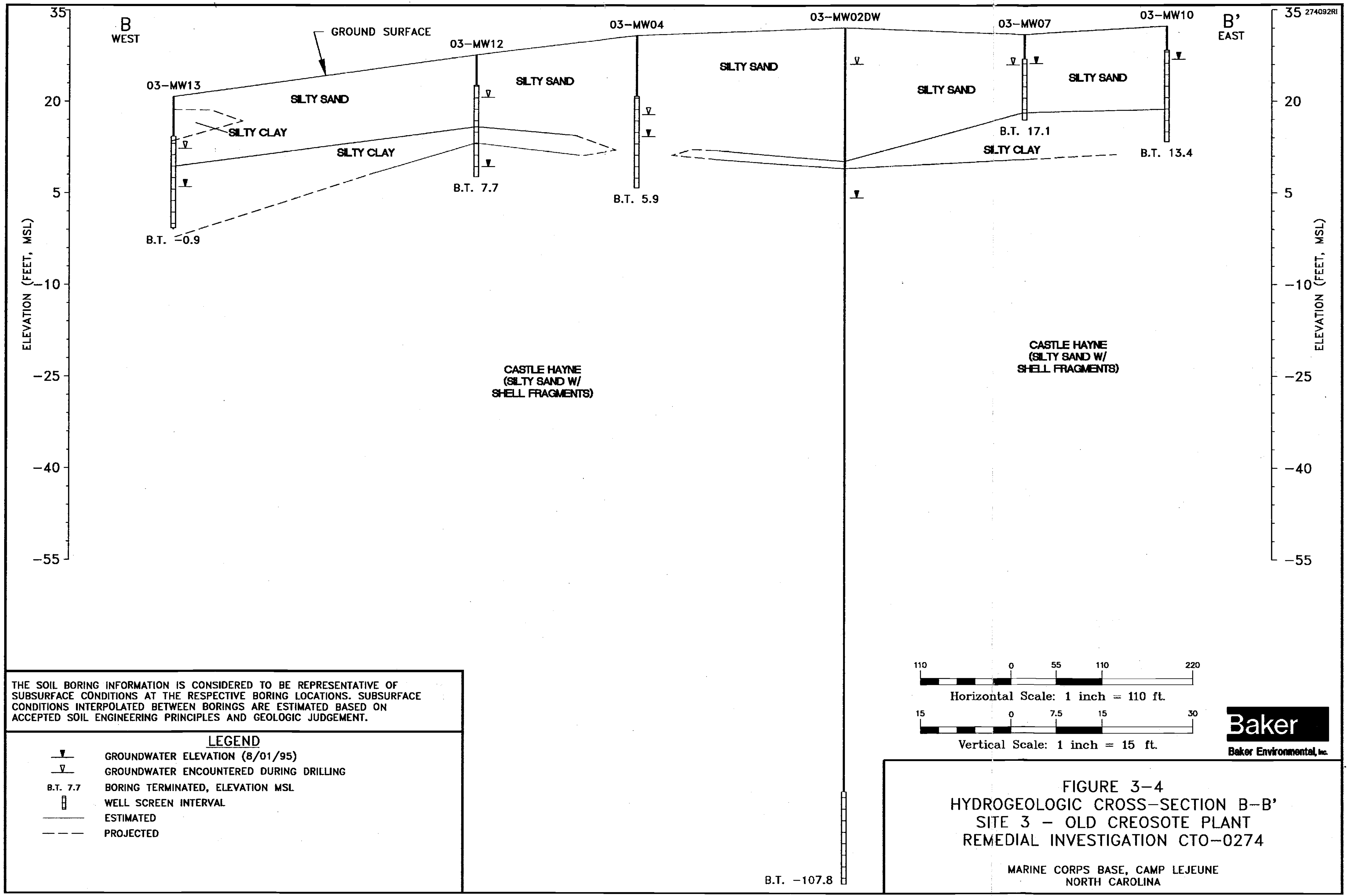
▼	GROUNDWATER ELEVATION (8/01/95)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 12.1	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
——	ESTIMATED
– – –	PROJECTED

Baker
Baker Environmental, Inc.

FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699XB42



THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

LEGEND

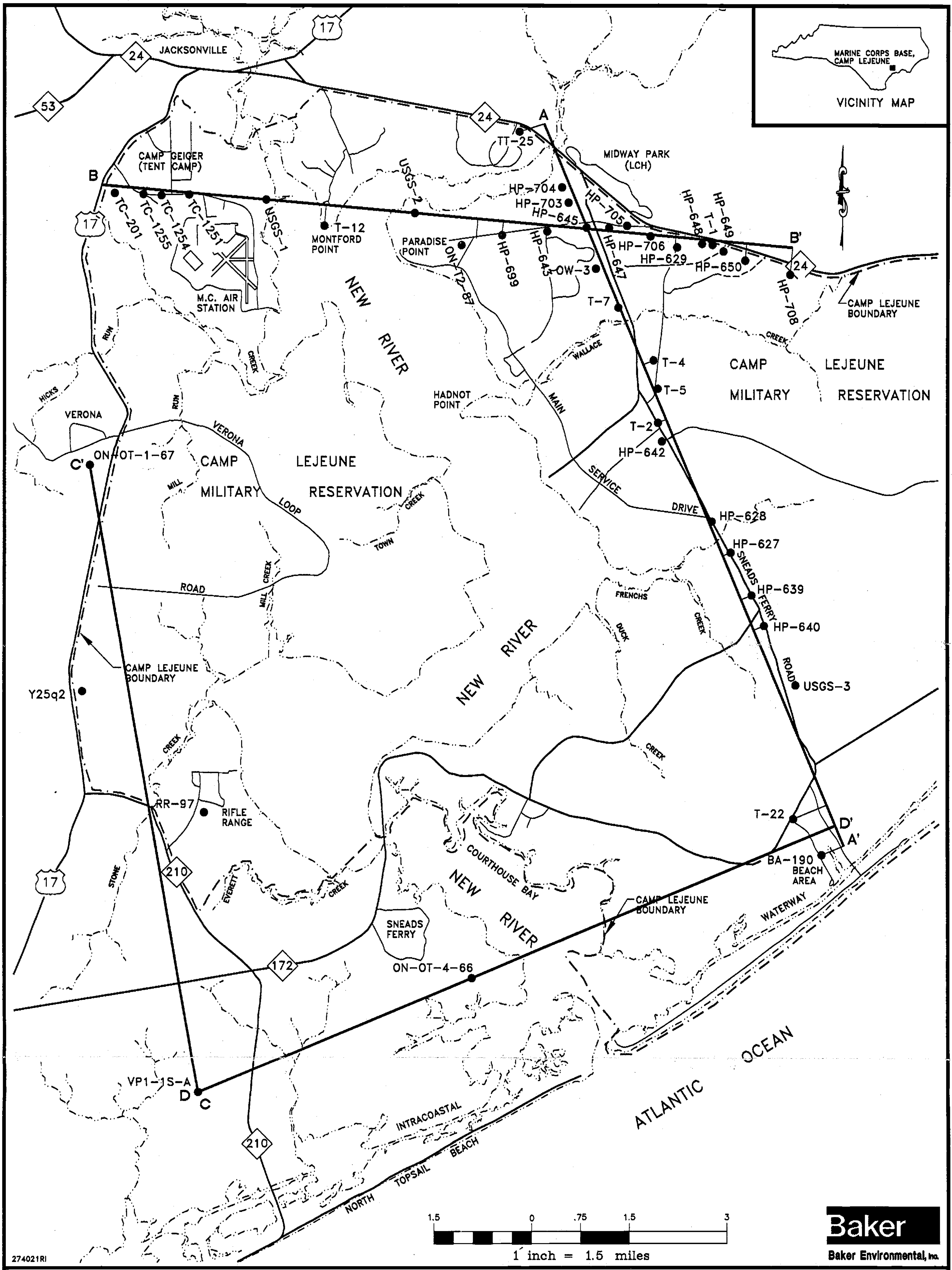
▼	GROUNDWATER ELEVATION (8/01/95)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 7.7	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

Baker

Baker Environmental, Inc.

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

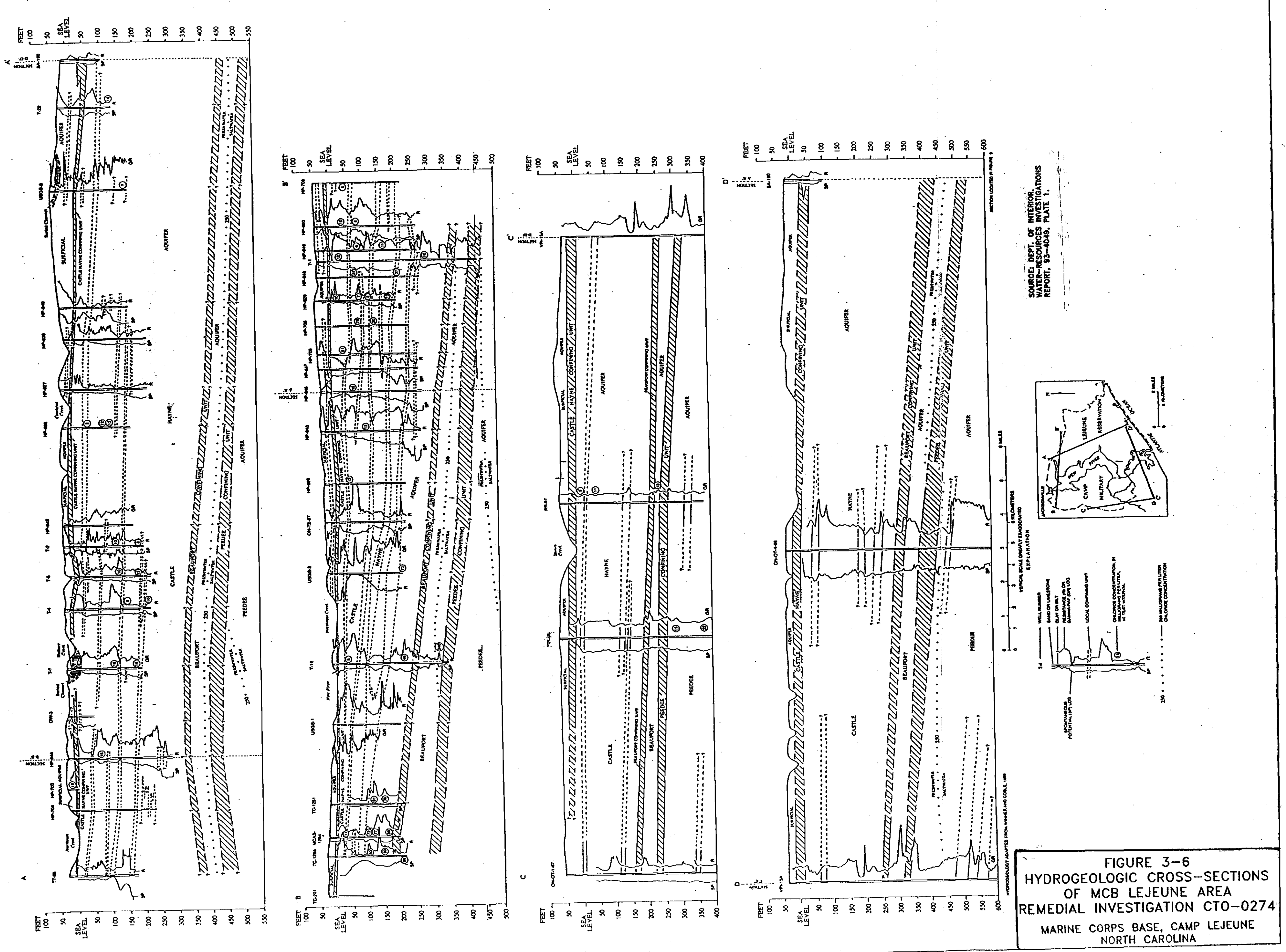
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SOURCE: DEPT. OF INTERIOR,
WATER-RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 3-5
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

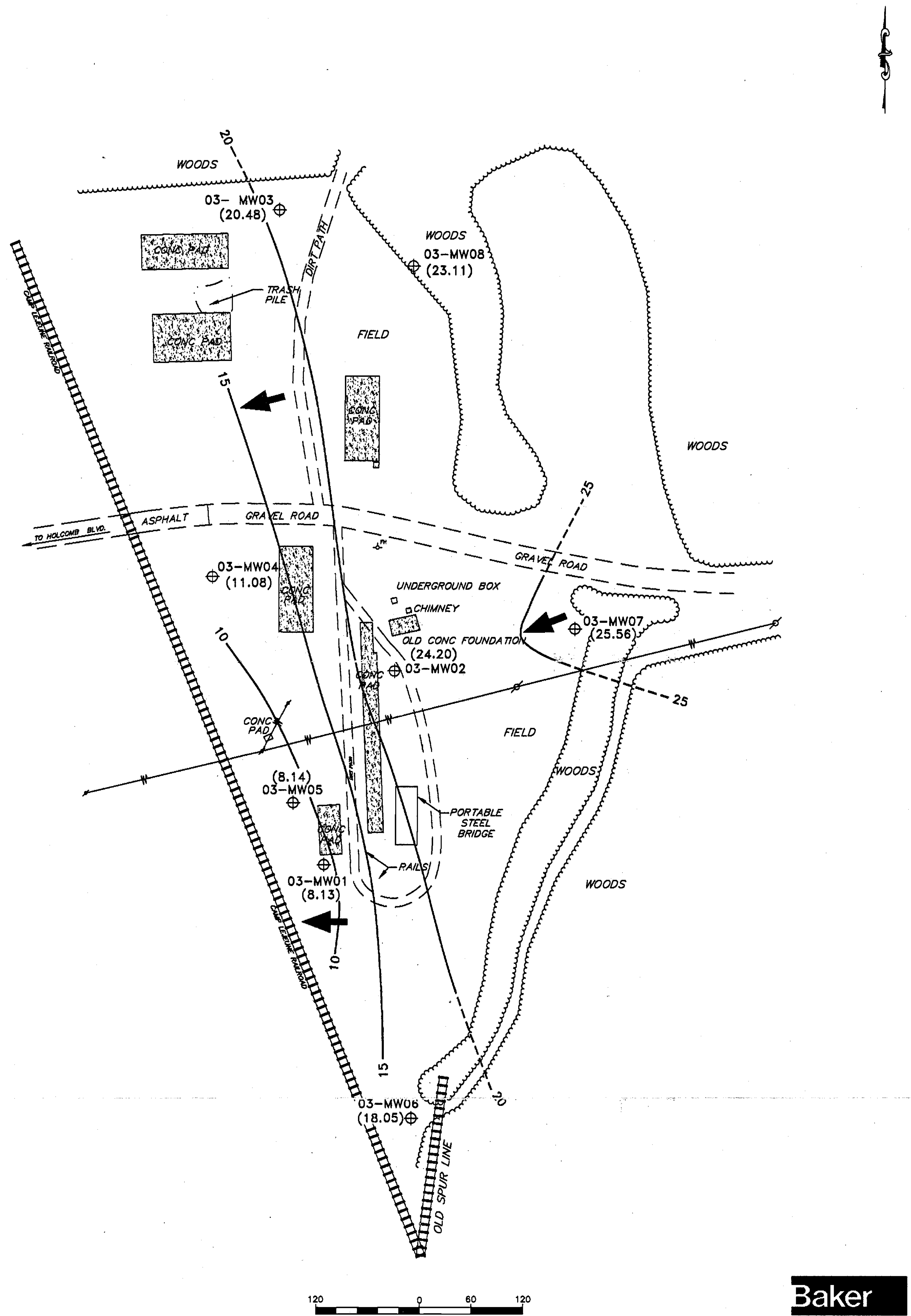
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SOURCE: DEPT. OF INTERIOR, WATER-RESOURCES INVESTIGATIONS REPORT, 93-4049, PLATE 1.

FIGURE 3-6
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB LEJEUNE AREA
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



274004RI

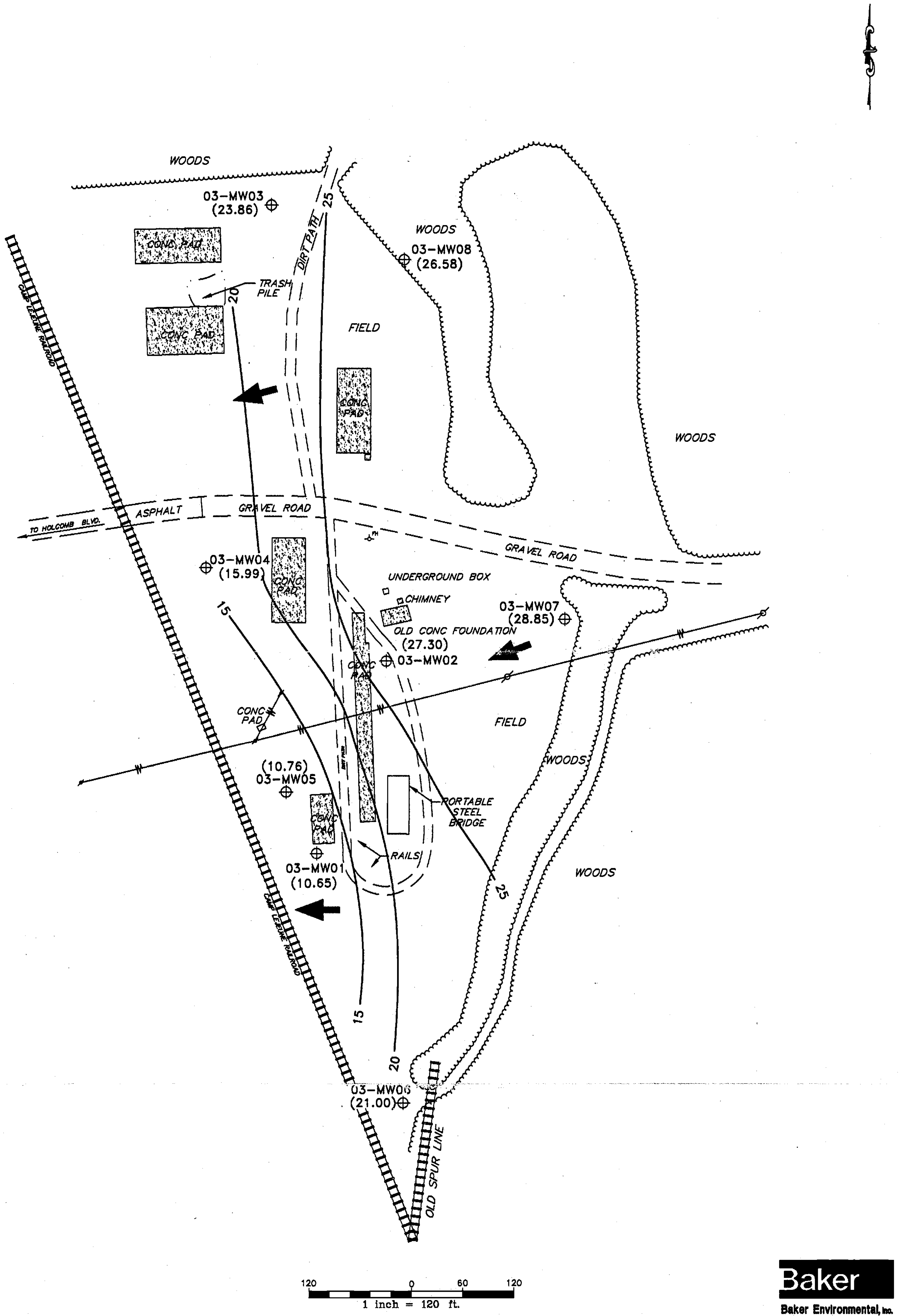
Baker

Baker Environmental, Inc.

	LEGEND
03-MW01 ⊕	EXISTING SHALLOW MONITORING WELL
(8.13)	GROUNDWATER ELEVATION
———	GROUNDWATER ELEVATION CONTOUR
- - -	GROUNDWATER ELEVATION CONTOUR - INFERRED
➡	GROUNDWATER FLOW DIRECTION

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

FIGURE 3-7
SHALLOW GROUNDWATER ELEVATION CONTOUR
MAP - DECEMBER 11, 1994
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



274008RI

Baker

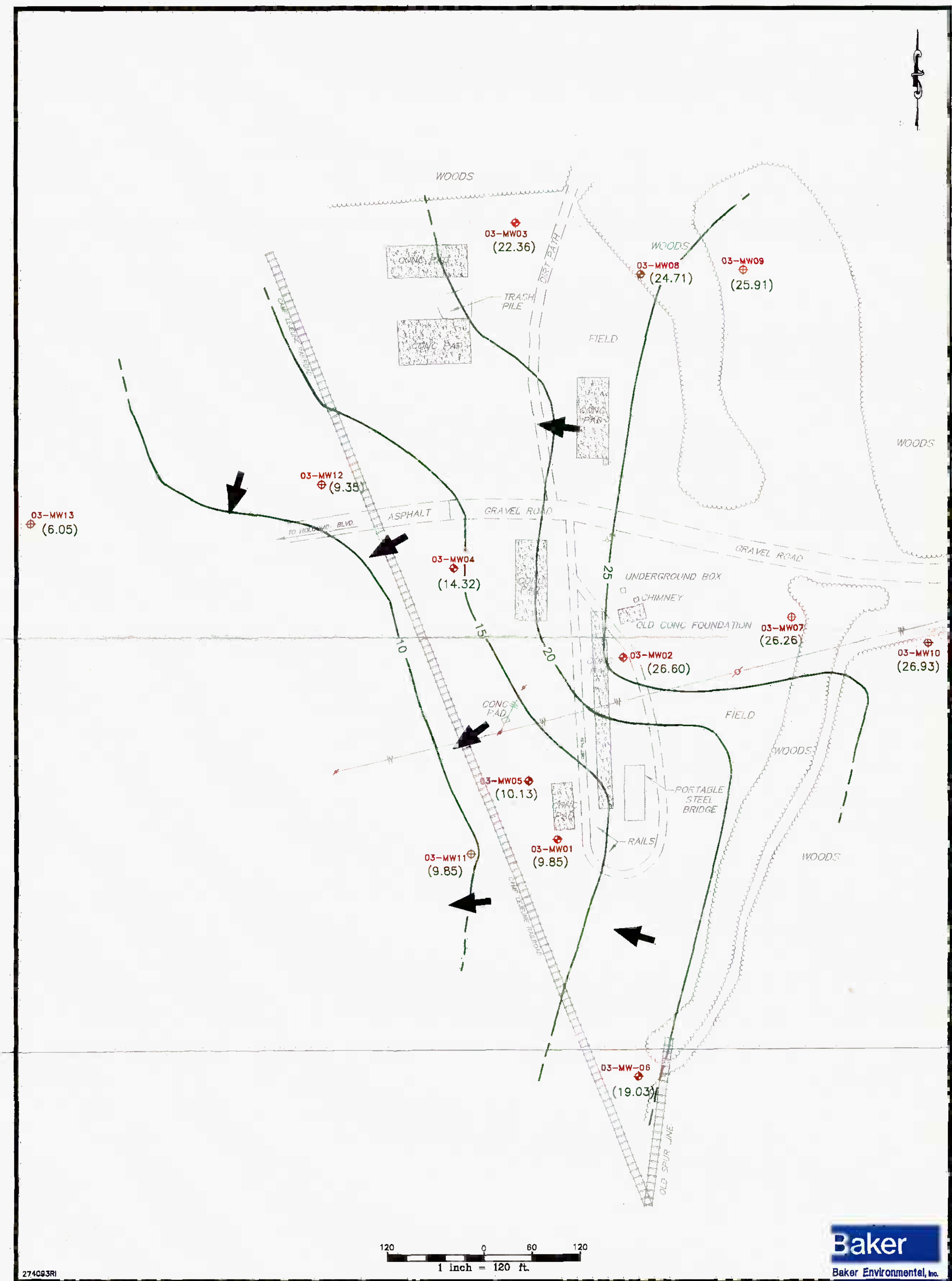
Baker Environmental, Inc.

LEGEND

03-MW01 ⊕	EXISTING SHALLOW MONITORING WELL
(10.65)	GROUNDWATER ELEVATION
———	GROUNDWATER ELEVATION CONTOUR
– – –	GROUNDWATER ELEVATION CONTOUR – INFERRED
➔	GROUNDWATER FLOW DIRECTION

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

FIGURE 3-8
SHALLOW GROUNDWATER ELEVATION CONTOUR
MAP – MARCH 27, 1995
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
Baker Environmental, Inc.

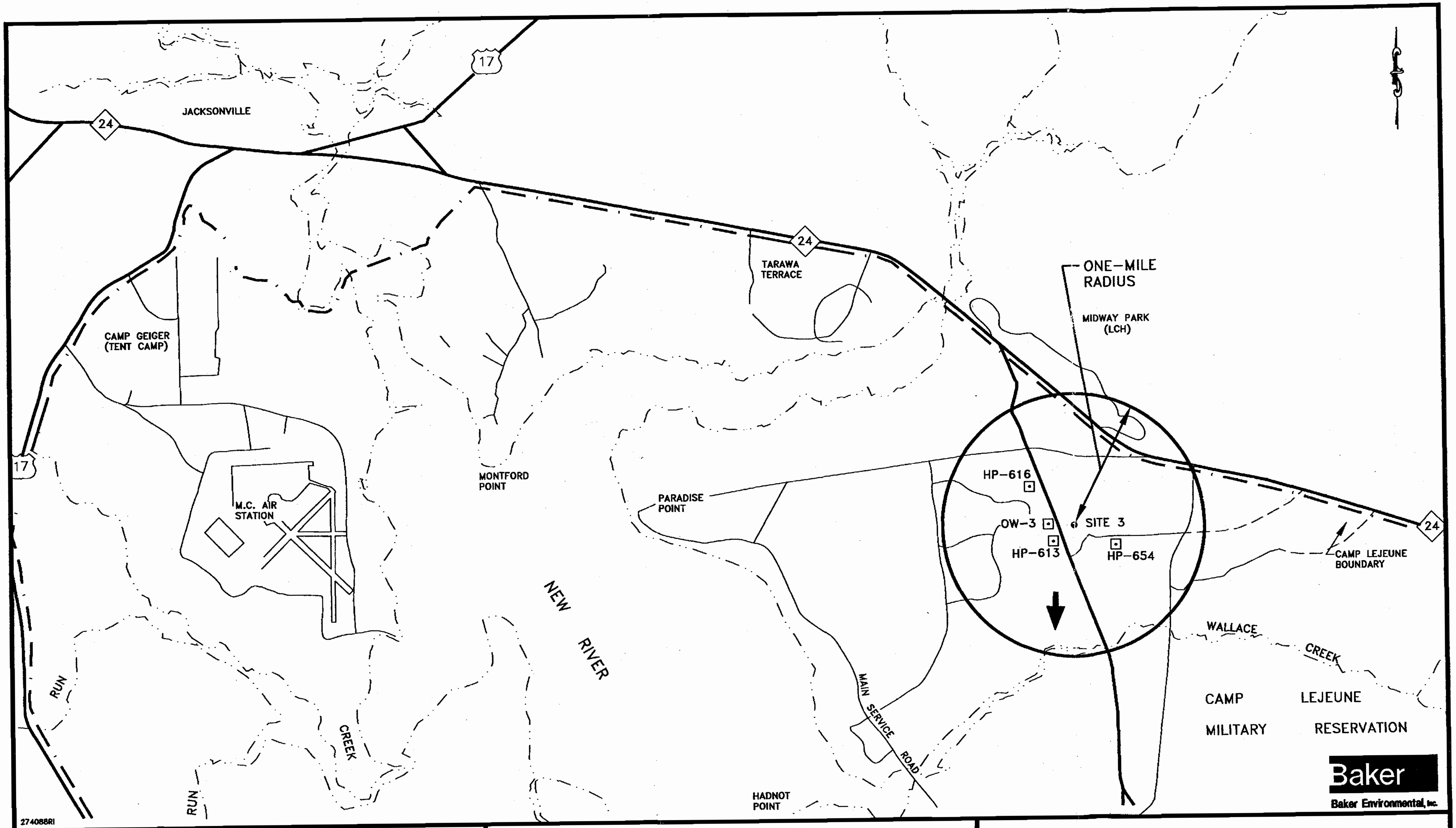
LEGEND

03-MW02 ⊕	EXISTING SHALLOW MONITORING WELL LOCATION
(26.60)	GROUNDWATER ELEVATION (FEET, MSL)
—10—	GROUNDWATER ELEVATION CONTOUR
— — —	GROUNDWATER ELEVATION CONTOUR – INFERRED
➔	GROUNDWATER FLOW DIRECTION

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

FIGURE 3-9
SHALLOW GROUNDWATER ELEVATION
CONTOUR MAP – AUGUST 1, 1995
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699X03V



LEGEND

T-12 ⊡ WATER SUPPLY WELL

➡ GROUNDWATER FLOW DIRECTION IN SURFICIAL AQUIFER

.75 0 .375 .75

1 INCH = .75 MILES

FIGURE 3-10
WATER SUPPLY WELL LOCATIONS - SITE 3
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699X042

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the analytical results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 12 (Site 3). The objectives of the section are to characterize the nature and extent of contamination at Site 3. This characterization was accomplished through environmental sample collection and laboratory analysis of soil and groundwater. The summary tables and figures referenced in the text are presented at the end of Section 4.0.

4.1 Data Management and Tracking

Analytical data generated during the RI were submitted for third-party validation to Chester Engineers, Inc. Procedures established by the National Functional Guidelines for Organic (USEPA, 1991) and Inorganic (USEPA, 1988) Analyses were adhered to during the validation process. Validation of the analytical data, through established procedures, served to reduce the inherent uncertainties associated with its usability. Data qualified as "J" were retained as estimated. Estimated analytical results within a data set are common and considered usable by the USEPA. Data may be qualified as estimated for several reasons, including an exceedance of holding times, high or low surrogate recovery, or intra-sample variability. In addition, values may be assigned an estimated "J" qualifier if the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL).

Analyses for over 5,000 separate contaminants were included in the Site 3 RI. No data were rejected as unusable.

Additional data qualifiers were employed during the validation of data. The "NJ" qualifier denotes that a compound was tentatively identified, but the reported value may not be accurate or precise. Compounds which were not detected and had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier.

The management and tracking of data from the time of field collection to receipt of the validated electronic analytical results is of primary importance and reflects the overall quality of the analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, which are included as Appendix B. The chain-of-custody forms were checked against the Field Sampling and Analysis Plan (Baker, 1994) to determine if all designated samples were collected for the appropriate parameters. Upon receipt of the laboratory results, a comparison to the field information was made to determine if each sample received by the laboratory was analyzed for the correct parameters. Similarly, the validated information was compared to laboratory information as a final check. In summary, the tracking information was used to identify the following items:

- Identify sample discrepancies between the analysis plan and the field investigation
- Verify that the laboratory received all samples, and analyzed for the correct parameters
- Verify that the data validator received a complete data set
- Ensure that a complete data set was available for each media of concern prior to entering results into the database

4.2 Non-Related Analytical Results

Many of the organic and inorganic constituents detected in soil and groundwater at Site 3 are attributable to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally-occurring inorganic elements. In addition, non-site related operational activities and conditions may contribute to "on-site" contamination. A discussion of non-site related analytical results for Site 3 is provided in the following subsections.

4.2.1 Laboratory Contaminants

Blank samples (i.e., rinsate and trip) provide a measure of contamination that has been introduced into a sample set during the collection, transportation, preparation, and/or analysis of samples. To remove non-site related contaminants from further consideration, the concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in environmental samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, chloroform, methylene chloride, toluene, and phthalate esters) were considered as positive results only when observed concentrations exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989a). The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

acetone	720J µg/L
methylene chloride	7J µg/L
2-butanone	17 µg/L
2-hexanone	1J µg/L
butyl benzyl phthalate	4J µg/L
bis(2-ethylhexyl)phthalate	4J µg/L

Organic constituents contained in blanks that were not considered common laboratory contaminants [i.e., all other Target Compound List (TCL) organics] were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds of less than five times the maximum level of contamination noted in any blank were considered to be not detected in that sample. The maximum concentrations of all other detected blank contaminants were as follows:

chloromethane	2J µg/L
1,2-dichloroethane	3J µg/L
tetrachloroethene	1J µg/L
phenol	7J µg/L

A limited number of solid environmental samples that exhibited high concentrations of tentatively identified compounds (TICs) underwent an additional sample preparation. Medium level sample preparation provides a corrected Contract Required Quantitation Limit (CRQL) based on the volume of sample used for analysis. The corrected CRQL produces higher detection limits than the low level sample preparation. A comparison to laboratory blanks used in the medium level preparation was used to evaluate the relative amount of contamination within these samples.

4.2.2 Naturally-Occurring Inorganic Elements

In order to differentiate inorganic contamination due to site operations from naturally-occurring inorganic elements in site media, the results of the sample analyses were compared to information regarding background conditions at MCB, Camp Lejeune. The following criteria were used for each media:

Soil:	MCB, Camp Lejeune Background Soil Samples
Groundwater:	MCB, Camp Lejeune Background Groundwater Samples

The following subsections address the various comparison criteria used to evaluate the analytical results from soil and groundwater samples collected at Site 3.

4.2.2.1 Soil

In general, chemical-specific standards and criteria are not available for soil. As a result, base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to evaluate background levels of inorganic elements in the surface and subsurface soil. Organic contaminants, unlike inorganic elements, are not naturally-occurring. It is probable that organic contaminants, except for those organics associated with laboratory and/or field procedures (i.e., acetone, methylene chloride or phthalates), detected in the surface and subsurface soil are attributable to activities which have or are currently taking place within or surrounding the study area.

Typical background concentration values for inorganic elements in surface and subsurface soil at MCB, Camp Lejeune are presented in Tables 4-1 and 4-2, respectively. The base background ranges are based on analytical results of background samples collected in areas known to be unimpacted by site operations or disposal activities at MCB, Camp Lejeune. In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding these ranges will be considered as possible site-related constituents. Appendix F contains the base soil background database for inorganics.

4.2.2.2 Groundwater

Monitoring well (3-MW10) was installed in an apparent upgradient direction to assess background groundwater conditions at Site 3. Surficial groundwater flow is towards the southwest as seen on the groundwater contour maps (refer to Section 3.4.2).

Background wells are often installed to assess the natural state and quality of groundwater. Natural in this sense implies that the groundwater has not been altered due to human activity. In some cases, these monitoring wells provide data that is representative of naturally occurring conditions. In other cases, these wells may not be representative of naturally occurring conditions if base-related activities have altered the natural state of groundwater. In the latter cases, the well samples would be classified as "control" samples. Control samples are samples which may not represent background conditions (i.e., unimpacted by human activities), but represent the current state of groundwater quality upgradient of the site. During the past four years, a number of background wells have been installed throughout the base as part of individual site investigations. Most of the background wells installed throughout the base actually serve as "control" points. The data collected from these wells have generated data that is representative of "base-wide" groundwater quality.

Chemical-specific standards and criteria are available for evaluation of groundwater analytical results. In the subsequent sections, which address the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable Federal and/or State regulations will be discussed. In order to supplement comparison criteria, a number of base-specific background (i.e., upgradient) samples were compiled as part of a study to evaluate levels of inorganic elements in groundwater at MCB, Camp Lejeune. Appendix G presents Baker's Draft Report Evaluation of Metals in Groundwater, June 1994, prepared for the Department of the Navy, Atlantic Division Naval Facilities Engineering Command.

Only a limited number of groundwater samples were analyzed for total and dissolved (i.e., "unfiltered" and "filtered", respectively) inorganic parameters. Concentrations of dissolved inorganics were found to be generally lower than total inorganics for each sample, particularly for metals such as chromium, iron, lead and manganese. For dissolved metal samples, a 0.45-micron filter was used in the field to remove small particles of silt and clay that would otherwise be dissolved during sample preservation and generate an unrealistically high apparent value of metals in groundwater. The total metals, or unfiltered samples, thus reflect the concentrations of inorganics in the natural lithology and inorganic elements dissolved in the groundwater.

To more accurately represent total metals in groundwater, a "low-flow" purging technique has been adopted at MCB, Camp Lejeune. This technique allows for the purging of groundwater monitoring wells at a low rate prior to sampling. This reduces the amount of suspended solids in the groundwater sample which contributes to the overall concentration of metals. This "low-flow" purging allows for the collection of a much more representative sample. The procedures followed for this purging were based on discussions with the USEPA Region IV research office in Athens, Georgia. The USEPA is currently researching the use of "low-flow" purging and sampling, and anticipates issuing Standard Operating Procedures (SOPs) later this year.

Relatively high concentrations of metals in unfiltered groundwater are not considered abnormal, based on experience gained from several other studies at MCB, Camp Lejeune (see Appendix G). The difference between the two analytical results (i.e., unfiltered and filtered) is important in terms of understanding and separating naturally-occurring elements (e.g. lead) from contamination by site operations (e.g., lead in gasoline).

USEPA Region IV requires that unfiltered inorganic concentrations be used in evaluating ARARs and risk to human health and the environment. In the subsequent sections, which discuss the groundwater sample analytical results, both total and dissolved inorganics (which exceed applicable Federal and/or State standards) will be presented and discussed.

Groundwater in the MCB, Camp Lejeune area is naturally rich in iron and manganese. Iron and manganese concentrations (i.e., total and dissolved) in groundwater at MCB, Camp Lejeune often exceed the MCLs and NCWQS of 300 and 50 µg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCLs and NCWQS, were reported in samples collected from a number of base potable water supply wells which were installed at depths greater than 162 feet bgs (Greenhorne and O'Mara, 1992). Iron concentrations in two of the sampled monitoring wells at Site 3 exceeded the MCLs and NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. A potential concern with comparing the results of the base evaluation of metals in groundwater with new site results obtained from the "low-flow" purging and sampling is the difference in techniques. An intrinsic high bias in the base background levels exists because the bailed samples will have a high suspended solids content. The "low-flow" technique has shown consistently lower solids content with the associated lower total metals concentrations. Comparison between recent analytical results and the base background levels from the 1994 report should not necessarily be taken as conclusive because of the difference in sampling techniques. The results in the 1994 report does illustrate the effects of suspended solids in groundwater samples on total inorganic analyses. There is no record of any historical use of iron at Site 3. In light of this, it is assumed that iron is a naturally-occurring inorganic element in groundwater, and its presence is not attributable to site operations.

4.3 State and Federal Criteria and Standards

Contaminant concentrations can be compared to contaminant-specific established Federal and State criteria and standards such as Maximum Contaminant Levels (MCLs) or North Carolina Water Quality Standards (NCWQS).

The only enforceable Federal regulatory standards for water are the Federal MCLs. In addition to the Federal standards, the State of North Carolina has developed the North Carolina Water Quality Standards (NCWQS) for groundwater. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary.

Mandatory chemical-specific criteria and/or standards for soils are not available for soils. There are tools which can be used to evaluate concentrations in soil. Risk-based concentrations (RBCs) for residential soil ingestion developed by USEPA (Region III) were used as a guidance criteria to evaluate soil concentrations. Soil Screening Levels (SSLs) were developed by the Office of Solid Waste and Emergency Response (OSWER) for the exposure to soil contaminants via migration to groundwater. The RBCs and SSLs were used as benchmarks for evaluating site investigation data and to assist in predicting single-contaminant health risks. These values were used in conjunction with other criteria in the selection of COPCs. Base-specific background concentrations were compiled to evaluate background levels of inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within Site 3, are attributable to the practices which have or are currently taking place within the areas of concern.

A brief explanation of the criteria and standards used for the comparison of site analytical results is presented below.

Risk-Based Concentrations (Soil) - RBCs are used for comparison purposes of organics and inorganics in soil. The concentrations correspond to a systemic hazard quotient of 0.1 or a lifetime cancer risk of 10^{-6}. The risk-based concentrations were developed using protective default exposure scenarios suggested by USEPA (1991) and the best available reference doses and carcinogenic potency slopes, and represent relatively protective environmental concentrations at which USEPA would typically not take action. The use of RBCs allow analytical results for soil, for which there are no specific criteria and standards, to be compared to accepted values to determine the nature and extent of contamination. The RBCs used in the evaluation of data for this report were from USEPA Region III Risk-Based Concentrations - October 20, 1995.

Soil Screening Levels (Migration to Groundwater) - SSLs are used for comparison purposes of organics and inorganics in subsurface soil. The concentrations correspond to levels below which further study or action would not be warranted under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The site screening levels were developed from standardized equations to model exposures to soil contaminants via ingestion, inhalation and migration to groundwater by OSWER (EPA/540/R-94/105). The use of SSLs allow analytical results for soil, for which there are no mandatory specific criteria and standards, to be compared to accepted values to determine the nature and extent of contamination.

North Carolina Water Quality Standards (Groundwater) - NCWQSs are the maximum allowable concentrations resulting from any discharge of contaminants to the land or waters of the state, which may be tolerated without creating a threat to human health or which otherwise render the groundwater unsuitable for its intended purpose.

Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act 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. They 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.

4.4 Analytical Results

The analytical results of the soil and groundwater sampling performed at Site 3 are presented in the following sections. A summary of site contamination, by media, is provided in Tables 4-3 through 4-5. The data and frequency summaries for all media at Site 3 are presented in Appendix H.

4.4.1 Soil Investigation

The initial set of surface soil samples were collected from various areas of concern and analyzed in the field using ENSYS PAH RIS$^{\underline{C}}$ Soil Test Kits to detect PAHs. These analyses were for screening the areas of concern to define the limits of surficial contamination and to determine the most appropriate locations for performance of soil borings to collect subsurface soil samples for analysis.

Based on the screening results, selected surface soil samples and all subsurface soil samples (collected from the boreholes) were submitted for analysis of TCL semivolatile organics. Surface and subsurface soil samples collected from the five shallow, one intermediate and one deep wells installed during June 1995 were also analyzed for TCL volatile organics. The surface and subsurface soil samples collected from shallow monitoring well 3-MW05 and intermediate monitoring well 3-MW02IW were analyzed for full Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. All samples were analyzed using CLP protocols and Level III data quality.

A comparison of the ENSYS screening results and laboratory analysis of confirmatory samples is presented in Table 4-6. Results for the confirmatory samples are also included with the surface soil positive detection summary for organics (refer to Table 4-7). Positive detection summary for surface soil inorganics is presented in Table 4-8. Positive detection summary tables for organics and inorganics in subsurface soils are presented in Tables 4-9 and 4-10, respectively.

4.4.1.1 Surface Soil

PAH Field Screening Testing

A total of eighty-four surface soil samples were collected and analyzed using an Enzyme Linked Immunosorbent Assay (ELISA) field test kit for PAHs in soil. The ENSYS PAH RIS$^{\underline{C}}$ soil test kits (USEPA SW-846 Draft Method 4035) was utilized to test the soil samples for PAHs. Seventeen samples were from the North Area, 10 samples from the Rail Spur, 10 samples from around the concrete pads in the south area, 44 samples from the Treatment Area, and 3 background locations. Thirty-seven confirmatory samples were submitted to the laboratory for semivolatile analysis using CLP procedures. These results are presented with the soil boring results. These samples were submitted from locations where the ENSYS screening indicated levels of PAHs above 1 part per million (ppm). Elevated levels of PAHs were detected in the northwest corner of the North Area, the western side of the treatment area, and the rail spur area in the south..

Table 4-6 presents the field screening and laboratory results for the confirmatory samples. The laboratory results for each compound have been normalized by dividing by a factor specific to each compound. This factor is the concentration of the compound at which point it is detectable by the ENSYS screening test. Since the ENSYS testing is for total PAHs, normalizing the laboratory results provides a more accurate comparative base to the ENSYS results.

As shown on Table 4-6, ENSYS results were comparable to laboratory results approximately 39 percent of the time. Four of the ENSYS tests (15 percent) indicated levels >1 part per million (ppm) and <10 ppm where the normalized laboratory results were undetected. Eleven (42 percent) of the remaining laboratory results were <1 ppm where as the ENSYS results indicated concentrations >1 <10 ppm. Only one ENSYS result (4 percent) indicated a concentration >10 ppm, with the corresponding laboratory result was <1 ppm. The majority of the laboratory concentrations are presented as estimated values ("J" qualifier). Estimated values may bias the normalized laboratory results when comparing them to ENSYS results. The six laboratory samples which exhibited the fewest estimated values for compounds showed the best correlation to the ENSYS field results. These were also the samples exhibiting the highest concentrations of the individual compounds. This may indicate that the ENSYS testing is more accurate or reliable at concentrations greater than 10 ppm.

Soil Borings

Surface soil samples were submitted from well locations 3-MW05 and 3-MW02IW (installed in November 1994), and from nine soil borings, five shallow monitoring wells, two intermediate monitoring wells and one deep monitoring well (installed in June 1995 to further characterize the site) for volatile and semivolatile organics analyses.

"Fuel-related" constituents were the only volatile organics detected in the surface soil samples. Toluene was detected in the samples from intermediate well 3-MW02IW (2J µg/kg) and shallow well 3-MW13 (2J µg/kg). Ethylbenzene and xylenes (total) were detected in the surface sample from location 3-TA-SB50 at concentrations of 2J µg/kg and 6J µg/kg, respectively. These constituents were not detected in QA/QC blanks.

Polynuclear aromatic hydrocarbons (PAHs) were the predominant semivolatiles detected in the surface soil samples. Total PAH concentrations ranged from nondetect to 93,750 µg/kg (location

3-NA-SB03). The PAH constituent with the highest concentration was pyrene (14,000 µg/kg) at location 3-NA-SB03. Phenanthrene and pyrene were detected at low levels in the surface soil at background boring location 3-BB-SB01, located at the northern end of the North Area. Phthalate esters [di-n-butylphthalate and/or bis(2-ethylhexyl)phthalate] were detected at low levels in 37 of 58 samples. Di-n-butylphthalate concentrations ranged from 37J (3-NA-SB18) to 340J µg/kg (3-TA-SB13). Bis(2-ethylhexyl)phthalate was detected at concentrations ranging from 36J µg/kg (3-TA-SB21) to 91J µg/kg (3-NA-SB01). Di-n-butylphthalate and bis(2-ethylhexyl)phthalate were detected in surface soil at background boring 3-BB-SB03 in the Rail Spur Area. Phenol and dibenzofuran were each detected in one sample at concentrations of 38J µg/kg (3-RS-SB03) and 370J µg/kg (3-NA-SB05), respectively. No semivolatile organics were detected in QA/QC blanks.

As expected, no pesticides or PCBs were detected in the limited number of surface soil samples submitted for full TCL organics.

Eleven of 23 inorganics were detected in the surface soil at borings 3-MW05 and 3-MW02IW. Calcium, chromium, magnesium, sodium, and zinc were detected above base background levels (by an order of magnitude or less) at boring 3-MW02IW.

4.4.1.2 Subsurface Soil

A total of forty-seven subsurface soil samples were submitted for analysis. Eighteen of these samples were submitted for volatile analyses. Low levels of volatile organics were generally detected above the 7 to 9 foot depth, except for chloroform which was detected in well 3-MW11IW at a concentration of 3J µg/kg at a depth of 15 to 17 feet. "Fuel-related" constituents were the most frequently detected volatile organics. These constituents were only detected in the central portion of the Treatment Area. Total concentrations ranged from 18 µg/kg (3-MW02IW, 5 to 7 feet) to 423 µg/kg (3-TA-SB49, 7 to 9 feet). Acetone was detected in sample 3-NA-SB17A (3 to 5 feet) at a concentration of 120 µg/kg. Sample 3-MW12 (3 to 5 feet) exhibited a carbon disulfide concentration of 1J µg/kg. Of these volatile constituents, only acetone was detected in the QA/QC blanks.

Boring 3-TA-SB48 exhibited the highest semivolatile organic concentrations in the subsurface soil. Semivolatile organic contaminants consisted predominantly of PAH constituents. The highest concentrations of semivolatile organics were observed in 7 to 9 foot depth samples. The total PAH concentration at 3-TA-SB48 was 402,300 µg/kg (7 to 9 feet). The higher PAH concentrations were detected in the central portion of the Treatment Area. Di-n-butylphthalate, the only detected phthalate ester, was detected in 18 of 47 subsurface soil samples at concentrations ranging from 39J µg/kg (3-MW11IW, 15 to 17 feet) to 170J µg/kg (samples 3-TA-SB18, 5 to 7 feet, and 3-TA-SB43, 5 to 7 feet).

No pesticides or PCBs were detected in the subsurface soil samples submitted for full TCL organics.

Nine of 23 inorganics were detected in the two subsurface soil submitted for TAL inorganics analysis. None of the inorganics were detected above base background levels.

4.4.2 Groundwater Investigation

Groundwater samples for Round One were collected from 7 shallow wells and 1 intermediate well (upper portion of the Castle Hayne aquifer) at Site 3. Monitoring well 3-MW01 did not have enough water to purge and sample for the first sampling round. The first round of samples were collected on December 1-3, 1994. Monitoring wells 3-MW08, 3-MW07 and 3-MW02IW were analyzed for Full TCL organics and TAL inorganics, the remaining five shallow wells were analyzed for TCL semivolatiles. Thirteen shallow wells, two intermediate wells, and one deep monitoring well have been installed at Site 3. All wells were purged and sampled for the second and third sampling rounds. Analysis consisted of TCL volatiles and semivolatiles. The second round of samples were collected on July 11 through 13, 1995. The third round of groundwater samples were collected on September 28 through 29, 1995.

4.4.2.1 Round One

Positive detection summaries for Round One TCL organics and TAL metals (total and dissolved) are presented in Tables 4-11, 4-12 and 4-13, respectively.

Shallow Groundwater

Two shallow well samples were analyzed for volatile organics. The detected volatiles included carbon disulfide (location 3-MW07, 1J µg/L) and "fuel-related" constituents. Total fuel concentrations ranged from 24 µg/L (3-MW07) to 59 µg/L (3-MW08). These contaminants were not detected in QA/QC blanks.

PAHs were the prevalent semivolatile organics detected in the shallow groundwater. Total PAH concentrations ranged from 5J µg/L (3-MW07, naphtahlene only) to 1,287 µg/L (3-MW02). Monitoring well 3-MW06 exhibited low levels of naphthalene, acenaphthene and fluorene. Phenols were also detected at low levels in well 3-MW02. Wells 3-MW02 and 3-MW06 exhibited dibenzofuran concentrations of 230 µg/L and 2µg/L, respectively. PAH constituents and dibenzofuran were not detected in QA/QC blanks. Phenol was detected in QA/QC blanks at a maximum concentration of 7J µg/L. Phenol was detected in groundwater at a concentration less than 5 times the maximum concentration detected in QA/QC blanks.

No pesticides or PCBs were detected in the two shallow groundwater samples submitted from wells 3-MW07 and 3-MW08 for full TCL organics.

Two shallow wells were sampled for TAL metals. Twelve of 23 total metals were detected, with well 3-MW08 exhibiting the maximum concentration of ten of the twelve metals. Fewer dissolved metals were detected than total metals. Total metal concentrations were the same order of magnitude or less as base background concentrations.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-14. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 3.95 to 5.83 s.u., specific conductance values ranged from 69 to 221 micromhos/cm, and temperature values ranged from 17.9 to 28.5° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). A turbidity reading of less than 5 NTU is considered to be non-visible to the human eye. The USEPA Region IV research into low-flow purging considers a reading of 10 NTU as satisfactory for well stabilization criteria. Specific conductance values are well within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). All values for pH are below the range of Federal Secondary Drinking Water

MCLs (6.5 to 8.5 s.u.). There is no known specific source for the generally low pH values in the shallow groundwater. The area around Site 3 is undeveloped with no current activities that would explain the observed pH values. The surficial soil in Site 3 area is classified as Baymeade fine sand (USDA, 1992). This soil is strongly to medium acidic throughout its profile. This may be contributing to the low pH values observed in the surficial aquifer at the site. The pH values reported for Site 3 shallow groundwater are comparable to values reported for Sites 74 and 80, which are located on Mainside at MCB, Camp Lejeune.

Castle Hayne Aquifer

The only volatile organics detected in intermediate well 3-MW02IW were "fuel-related" constituents. Concentrations of fuel constituents were benzene (11J µg/L), toluene (4J µg/L) and xylenes (total) (7J µg/L).

PAH constituents were the prevalent semivolatile organics detected in well 3-MW02IW. The total PAH concentration in well 3-MW02IW was 167 µg/L. Dibenzofuran was detected at a concentration of 57 µg/L.

No pesticides or PCBs were detected in well 3-MW02IW.

Seven of 23 total metals were detected in well 3-MW02IW. Fewer dissolved metals were detected than total metals. Detected total metals included aluminum barium, calcium, iron, magnesium, manganese, potassium and sodium. Only aluminum and iron were detected above State and/or Federal standards.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-14. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last reading obtained for intermediate well 3-MW02IW, which is representative of groundwater conditions following purging, the pH value was 8.03 s.u., specific conductance value was 322 micromhos/cm, and temperature value was 25.0° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). Specific conductance value was within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). The pH value is within the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). The reported pH value was comparable to values measured in the Castle Hayne aquifer in other areas of MCB, Camp Lejeune.

4.4.2.2 Round Two

Positive detection summaries for Round Two groundwater samples are presented as Table 4-15 for TCL volatiles and semivolatiles.

Shallow Groundwater

No volatile organics were detected during this sampling round. Semivolatiles were detected in well 3-MW06 in the rail spur area in the southern portion of the site. These semivolatiles consisted of PAHs and dibenzofuran. Total PAH concentration was 194 µg/L and dibenzofuran was detected at a concentration of 25 µg/L.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-16. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 4.64 to 6.21 s.u., specific conductance values ranged from 76 to 434 micromhos/cm, and temperature values ranged from 19.5 to 27.1° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). Specific conductance values are well within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). All values for pH are below the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). There is no known specific source for the generally low pH values in the shallow groundwater. The area around Site 3 is undeveloped with no current activities that would explain the observed pH values. The surficial soil in the Site 3 area is classified as Baymeade fine sand (USDA, 1992). This soil is strongly to medium acidic throughout its profile. This may be contributing to the low pH values observed in the surficial aquifer at the site. Measured values of pH were similar to Round One values, and comparable to values reported for Sites 74 and 80. There is no indication of a problem with well construction as a source for the elevated pH values detected in the Castle Hayne monitoring wells. The depth of the wells is such that salt water intrusion is not a factor. Published information [Harned, et al (1989) and Cardinell, et al (1993)] states that salt water intrusion has not been observed in the Castle Hayne except in the southern portion of the Base at a depth greater than 200 feet. There does not seem to be an apparent reason for the higher pH values observed in the Castle Hayne aquifer at Site 3.

Castle Hayne Aquifer

Intermediate well 3-MW02IW (85 foot depth) exhibited concentrations of volatiles and semivolatiles. Volatiles were limited to 1,1-dichloroethene (1J µg/L) and trichloroethene (1J µg/L). PAH constituents and dibenzofuran were the semivolatiles detected in the upper portion of the Castle Hayne aquifer. Total PAH concentration was 48J µg/L, consisting of acenaphthene (34 µg/L), anthracene (3J µg/L) and pyrene (11 µg/L). Dibenzofuran was detected at a concentration of 17 µg/L.

Deep well 3-MW02DW (125 foot depth) exhibited volatiles and semivolatiles. Volatiles consisted of BTEX constituents. Total BTEX concentration was 64J µg/L. Detected semivolatiles included phenols, dibenzofuran and PAH constituents. Phenols consisted of phenol (420 µg/L), 2-methylphenol (300 µg/L), 4-methylphenol (690 µg/L) and 2,4-dimetylphenol (170 µg/L). Dibenzofuran was detected at a concentration of 140 µg/L. Total PAH concentration was 3,895 µg/L. Naphthalene was detected at a concentration of 2,400 µg/L.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-16. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 7.70 to 11.96 s.u., specific conductance values ranged from 2593 to 1061 micromhos/cm, and temperature values ranged from 22.6 to 26.6° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). Specific conductance values are above the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). The pH values for intermediate well 3-MW11IW and deep well 3-MW02DW were above the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). There is no known specific source for the high pH values in the Castle Hayne aquifer. The area around Site 3 is undeveloped with no current activities that would explain the observed pH values. The limestone and shell fragment observed in the Castle Hayne formation may be contributing to the more basic pH values measured in the upper portions of the Castle Hayne aquifer at the site.

4.4.2.3 Round Three

Positive detection summary for Round Three groundwater samples is presented as Table 4-17 for TCL volatiles and semivolatiles.

Shallow Groundwater

"Fuel-related" constituents were detected in shallow wells 3-MW06 (9J µg/L) and 3-MW02 (44J µg/L). These constituents were not detected in QA/QC blanks.

PAHs were the prevalent semivolatile organics detected in the shallow groundwater. Total PAH concentrations ranged from 497 µg/L (3-MW06) to 1,923 µg/L (3-MW02). Wells 3-MW02 and 3-MW06 exhibited concentrations of dibenzofuran, 120 µg/L and 24 µg/L, respectively. PAH constituents and dibenzofuran were not detected in QA/QC blanks. Phenols were also detected at low levels in well 3-MW02. Bis(2-ethylhexyl)phthalate was detected in well 3-MW09 at a concentration of 1J µg/L. Phenol and bis(2-ethylhexyl)phthalate were detected in QA/QC blanks at maximum concentrations of 7J µg/L and 4J µg/L, respectively. Phenol was detected in well 3-MW02 at a concentration greater than five times the maximum concentration detected in QA/QC blanks.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-18. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 4.85 to 6.79 s.u., specific conductance values ranged from 53 to 711 micromhos/cm, and temperature values ranged from 20.0 to 25.0° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). Specific conductance values are within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978), except for wells 3-MW01 and 3-MW05. All values for pH are below the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.), except for well 3-MW04. There is no known specific source for the generally low pH values in the shallow groundwater. The area around Site 3 is undeveloped with no current activities that would explain the observed pH values. The surficial soil in the Site 3 area is classified as Baymeade fine sand (USDA, 1992). This soil is strongly to medium acidic throughout its profile. This may be contributing to the low pH values observed in the surficial aquifer at the site. As stated for Round Two, pH values were comparable to previous sampling rounds and other sites at MCB, Camp Lejeune.

Castle Hayne Aquifer

No volatile organics were detected in the intermediate wells at Site 3.

PAH constituents were only detected in intermediate well 3-MW02IW. Total PAH concentration was 244 µg/L. Phenol was detected in well 3-MW11IW at a concentration of 1 µg/L. Dibenzofuran was detected in well 3-MW02IW at a concentration of 29 µg/L. Phenol was detected in QA/QC blanks, but was detected in sample 3-MW02IW at less than five times the maximum concentration detected in QA/QC blanks.

No volatile or semivolatile organics were detected in deep well 3-MW02DW.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-18. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 7.61 to 10.57 s.u., specific conductance values ranged from 304 to 375 micromhos/cm, and temperature values ranged from 19.1 to 19.9° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). Specific conductance values are well within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). The pH value for well 3-MW11IW was above the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). There is no known specific source for the high pH values in the Castle Hayne aquifer. The area around Site 3 is undeveloped with no current activities that would explain the observed pH values. The limestone and shell fragments observed in the Castle Hayne formation may be contributing to the more basic pH values measured in the upper portions of the Castle Hayne aquifer at the site. Values of pH were comparable with Rounds One and Two, and with others sited at MCB, Camp Lejeune.

4.4.3 Engineering Parameter Results

Engineering parameters were analyzed for selected soil and groundwater samples collected at Site 3. One soil sample was analyzed from well location 3-MW05. Soil engineering parameters included moisture content, particle-size analysis, and cation exchange capacity. Groundwater samples were collected from shallow wells 3-MW02 and 3-MW08, and deep well 3-MW02DW and submitted for analyses which included Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Total Organic Carbon (TOC). Engineering parameter results for soil and groundwater are summarized in Appendix I.

Results indicated the following average analysis data for soils from 3-MW05:

- Moisture Content - 12.7%
- Sand - 83.4%; silt - 7.2%; and clay - 9.4%
- Cation Exchange Capacity - 5.15 MEQ/100 grams

Results indicated the following concentration levels in shallow (3-MW02) groundwater:

- COD 25 mg/L
- BOD 10.3 mg/L
- TOC 2 mg/L

Results indicated the following concentration levels in shallow (3-MW08) groundwater:

- COD not detected
- TSS <4 mg/L
- TDS 42 mg/L
- TOC 3 mg/L

Results indicated the following concentration levels in deep (3-MW02DW) groundwater:

BOD	not detected
TSS	12 mg/L
TDS	1800 mg/L

4.4.4 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) samples were collected during the soil, groundwater, surface water and sediment investigations. These samples included trip blanks, field blanks, equipment rinsate blanks, and duplicate samples. Analytical results of the field duplicates are provided in Appendix J and other field QA/QC (e.g. rinsate blanks, trip blanks, etc.) results are provided in Appendix K.

Organics detected in QA/QC samples include acetone, methylene chloride, chloroform, 2-butanone, bis(2-ethylhexyl)phthalate, chloromethane, 1,2-dichloroethane, bromodichloromethane, and dibromochloromethane. Acetone was detected in 10 of 15 samples at concentrations ranging from 5J µg/L to 720 µg/L. Methylene chloride was detected in 13 of 15 QA/QC samples with concentrations ranging from 1J µg/L to 10J µg/L. Eight of 23 TAL metals were detected in QA/QC samples, with zinc being quantified with J qualifiers.

4.5 Extent of Contamination

4.5.1 Soil Investigation

4.5.1.1 Surface Soil

Figure 4-1 presents the positive detections of semivolatiles in the surface soils in the North Area of Site 3. Volatiles and semivolatiles detected in the surface soil in the Treatment Area are shown on Figure 4-2. Detected semivolatile concentrations in the surface soil are shown on Figure 4-3 for the Rail Spur area.

"Fuel-related" constituents were the only volatiles detected in the surface soil at Site 3, and were confined to the treatment area. Ethylbenzene and xylenes (total) were detected at location 3-TA-SB50, in the central portion of the treatment area. Toluene was detected in the surface soil sample at well location 3-MW13 on the western side of Holcomb Boulevard, opposite Site 3. The fuel constituents detected in the treatment area may be due to the past activities at the site, due to the fact that fuels may have been used in the treatment process as a carrier for creosote. The source of the toluene on the western side of Holcomb Boulevard is unknown. All volatiles were detected at low levels. No concentrations in surface soil samples were detected above the risk-based concentrations for residential soils. No fuel constituents were detected in the QA/QC blanks.

PAH constituents were the primary semivolatiles detected in the surface soil at Site 3. No PAHs were detected in the QA/QC blanks. PAHs were detected throughout Site 3, with the highest concentrations exhibited in the treatment area. The phthalate esters di-n-butylphthalate and bis(2-ethylhexyl)phthalate were also detected in the surface soil. Bis(2-ethylhexyl)phthalate was detected in QA/QC blanks, with 29 samples exhibiting concentrations greater than ten times the maximum concentration detected in QA/QC blanks. The source of the bis(2-ethylhexyl)phthalate is unknown. Di-n-Butylphthalate exhibited the highest phthalate concentrations and was not detected in QA/QC blanks. Phenol was detected in one sample in the rail spur area. Dibenzofuran was detected in the north area at one sample location. No specific sources for these two contaminants have been identified. Concentrations of benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and dibenzo(g,h,i)perylene were detected above risk-based concentrations for residential soils.

No pesticides or PCBs were detected in the two surface soil samples submitted for full TCL organics analysis.

Inorganic analysis was limited to two surface soil samples from well locations 3-MW05 and 3-MW02IW. No inorganic concentrations in surface soil samples were detected above the risk-based concentrations for residential soils. Figure 4-4 presents the inorganic concentrations detected above base background levels.

4.5.1.2 Subsurface Soil

Figure 4-5 presents the positive detections of volatiles and semivolatiles in subsurface soil at Site 3.

"Fuel-related" constituents were the predominant volatile organics detected in the subsurface soil at Site 3; however, these constituents were only detected at three of the 18 locations sampled, and were concentrated around the central portion of the Treatment Area. Concentrations were higher in the subsurface soil than in the surface soil. No fuel constituents were detected in the QA/QC blanks. Acetone, 2-butanone, chloroform and carbon disulfide were detected at isolated locations across Site 3. Acetone and 2-butanone were also detected in QA/QC blanks, but the detected sample concentrations of acetone (120 µg/kg) and 2-butanone (3J µg/kg) were less than ten times the maximum concentrations detected in the QA/QC blanks. Carbon disulfide and chloroform were detected at low levels; however, no source for these constituents has been identified. No fuel constituent concentrations were detected above the risk-based concentrations for residential soils.

PAH constituents were the predominant semivolatiles detected in the subsurface soil. Semivolatiles were detected over the entire site with the highest concentrations found in the central portion of the treatment area. PAH concentrations were higher in the subsurface soil than in the surface soil. Phthalate esters, consisting of di-n-butylphthalate and bis(2-ethylhexyl)phthalate, were detected over much of the site. Di-n-butylphthalate was detected in 18 of 47 samples, predominantly in the north area and the rail spur area. Bis(2-ethylhexyl)phthalate was only detected in two samples, with the maximum concentration exhibited at well location 3-MW11IW on the western side of the railroad tracks. Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene concentrations were detected above risk-based concentrations for residential soils. The bis(2-ethylhexyl)phthalate concentrations were greater than ten times the maximum concentration detected in the QA/QC blanks. Di-n-butylphthalate was not detected in the QA/QC blanks. Phenols were detected in one sample in the central portion of the treatment area. The detected phenols may be associated with the former activities/processes at the site.

No pesticides were detected in the subsurface soil at Site 3.

Nine inorganics were detected in the two subsurface soil samples submitted for TAL metals analyses. No inorganic concentrations were above risk-based concentrations for residential soils or base background levels.

4.5.2 Groundwater Investigation

4.5.2.1 Round One

Shallow Groundwater

Figure 4-6 presents the positive detections of volatiles, semivolatiles and total metals above State and/or Federal standards in the shallow groundwater for Round One.

Benzene was the only volatile detected in the shallow groundwater above State and/or Federal standards. The highest concentration of benzene was exhibited by well 3-MW08 in the North Area of the site. Benzene was not detected in the surface or subsurface soils in this area. No specific source for the detected benzene is known. The surrounding area is wooded with no known activities in the upgradient direction. The area around well 3-MW08 is cleared with only light brush and the detected benzene may be just a localized occurrence from past activities. The remaining detections of benzene were in the central portion of the Treatment Area.

Shallow well 3-MW02 in the Treatment Area exhibited the only semivolatile concentrations above State and/or Federal standards. The semivolatiles were naphthalene, phenanthrene, benzo(a)anthracene, chrysene, and benzo(a)pyrene, which are PAH constituents.

No pesticides or PCBs were detected above State and/or Federal standards.

Total aluminum and iron were the only metals detected above State and/or Federal standards (refer to Figure 4-6) in wells 3-MW07 and 3-MW08. Iron is a naturally occurring inorganic in groundwater at MCB, Camp Lejeune and is not likely associated with past creosote treating operations.

Castle Hayne Aquifer

Benzene was the only organic detected above State and/or Federal standards in the Castle Hayne aquifer during Round One sampling (refer to Figure 4-7).

4.5.2.2 Round Two

Shallow Groundwater

The positive detections of volatiles and semivolatiles above State and/or Federal standards in shallow groundwater for Round Two are presented on Figure 4-8.

Chloroform was the only volatile organic detected above the MCL and/or NCWQS standards. Chloroform was detected in well 3-MW02 in the central portion of the Treatment Area.

Well location 3-MW06 in the Rail Spur Area exhibited the only PAH constituent (naphthalene) concentration above State and/or Federal standards. Bis(2-ethylhexyl)phthalate was detected in wells 3-MW09 (North Area) and 3-MW11(southwest of Treatment Area) above State and/or Federal standards.

Castle Hayne Aquifer

Volatiles and semivolatiles were detected above State and/or Federal standards in the deep well (3-MW02DW) at Site 3. Figure 4-9 presents the positive detections of volatiles and semivolatiles above State and/or Federal standards.

Benzene was detected above North Carolina Water Quality Standards (NCWQS) in deep well 3-MW02DW. Chloroform was detected in well 3-MW11IW above State and/or Federal standards. Phenol and naphthalene were the only semivolatiles detected above State and/or Federal standards. No BTEX or PAHs were detected in the intermediate well at location 3-MW02 above State and/or Federal standards.

4.5.2.3 Round Three

Shallow Groundwater

Figure 4-10 presents the positive detections of volatile and semivolatile organics above State and/or Federal standards.

Well 3-MW02 in the Treatment Area exhibited the only volatile organic (benzene) detected above State and/or Federal standards. Naphthalene was the only semivolatile detected above State and/or Federal standards. It was detected in well 3-MW02 (Treatment Area) and 3-MW06 (Rail Spur Area).

Castle Hayne Aquifer

No volatile or semivolatile organics were detected in the Castle Hayne aquifer above State and/or Federal standards during Round Three groundwater sampling.

4.5.2.4 Round FourU

Castle Hayne Aquifer

No volatile or semivolatile organics were detected in the Castle Hayne aquifer above State and/or Federal standards during Round Four groundwater sampling.

4.6 Summary

The ENSYS field screening provided an accurate preliminary assessment of the surface contamination at the site. It identified areas of concern, which was confirmed with fix-based laboratory analyses defining specific areas which exhibited contamination and may require remediation.

PAH constituents were the most frequently detected organics and exhibited the greatest concentrations in both soil and groundwater. These constituents are believed to be associated with past wood treating activities at the site. The highest concentrations of PAHs in soils occurred in the Treatment Area in the central portion of the site. Fuel constituents, such as ethylbenzene and xylene, were also detected in surface and subsurface soils at Site 3, primarily at the former treatment area in the central portion of the site.

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. Naphthalene was the only PAH constituent detected above State and/or Federal standards in the shallow groundwater. This contaminant was detected in the Treatment Area and in the Rail Spur Area, but the detections were not consistent for the three rounds of sampling for location and concentrations.

Volatiles (fuel constituents) and semivolatiles (PAH constituents and phenols) were detected in the Castle Hayne aquifer during the three rounds of groundwater sampling. Benzene, phenols, and PAH constituents were the only organics detected in the Castle Hayne above State and/or Federal standards. Benzene was detected in intermediate well 3-MW02IW during the first sampling round. Benzene, phenols, and PAH constituents were detected during the second round of groundwater sampling in deep well 3-MW02DW in the Treatment Area. No contaminants were detected above State and Federal standards during the third groundwater sampling round.

4.7 References

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SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF BASE BACKGROUND INORGANIC LEVELS IN SURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO - 0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Base Background (mg/kg)
Aluminum	17.7 - 9,570
Antimony	0.33 - 8
Arsenic	0.065 - 3.9
Barium	0.65 - 20.8
Beryllium	0.02 - 0.26
Cadmium	0.04 - 0.6
Calcium	4.25 - 10,700
Chromium	0.33 - 12.5
Cobalt	0.185 - 2.355
Copper	0.5 - 87.2
Iron	69.7 - 9,640
Lead	0.47 - 142
Magnesium	2.55 - 610
Manganese	0.87 - 66
Mercury	0.01 - 0.08
Nickel	0.6 - 3.55
Potassium	1 - 416
Selenium	0.075 - 1.3
Silver	0.0435 - 4.3
Sodium	4.7 - 126
Vanadium	0.305 - 18.2
Zinc	0.3 - 28.3

TABLE 4-2

SUMMARY OF BASE BACKGROUND
INORGANIC LEVELS IN SUBSURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO - 0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Base Background (mg/kg)
Aluminum	16.9 - 11,000
Antimony	0.355 - 6.9
Arsenic	0.033 - 15.4
Barium	0.65 - 22.6
Beryllium	0.01 - 0.31
Cadmium	0.155 - 1.2
Calcium	4.75 - 4,410
Chromium	0.65 - 66.4
Cobalt	0.175 - 7
Copper	0.47 - 9.5
Iron	63.3 - 90,500
Lead	0.465 - 21.4
Magnesium	2.85 - 852
Manganese	0.395 - 19.9
Mercury	0.01 - 0.68
Nickel	0.45 - 4.7
Potassium	1.05 - 1,250
Selenium	0.085 - 2.4
Silver	0.175 - 1
Sodium	5.4 - 141
Vanadium	0.34 - 69.4
Zinc	0.32 - 26.6

TABLE 4-3

SUMMARY OF SURFACE SOIL CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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		
Surface Soils	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-Methylnaphthalene	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
		Phenanthrene	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 4-3 (Continued)

SUMMARY OF SURFACE SOILS CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 (mg/kg)	Base Background (mg/kg)	(mg/kg)	(mg/kg)			RBC Residential Soils	Base Background	
Surface Soils (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	18.2	3.3	5.2	3-MW05-00	2/2	0	0	--
		Zinc	2,300	28.3	16.6	16.6	3-MW02IW-00	1/2	0	0	--

(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 4-4

SUMMARY OF SUBSURFACE SOIL CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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)	Soil Screening Level (µg/kg)	(µg/kg)	(µg/kg)			RBC Residential Soils	Soil Screening Level	
Subsurface Soils	Volatile Organic Compounds	Acetone	780,000	8,000	120	120	3-NA-SB17A-02	1/18	0	NA	North Area
		Carbon Disulfide	780,000	19,000	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	49,000	7,200J	7,200J	3-TA-SB48-08	1/47	0	0	Treatment Area
		2-Methylphenol	390,000	6,000	2,000J	2,000J	3-TA-SB48-08	1/47	0	0	Treatment Area
		4-Methylphenol	39,000	NE	5,900J	5,900J	3-TA-SB48-08	1/47	0	NA	Treatment Area
		Naphthalene	310,000	30,000	55J	95,000	3-TA-SB48-08	9/47	0	2	Treatment Area
		2-Methylnaphthalene	310,000	30,000	100J	31,000	3-TA-SB48-08	6/47	0	1	Treatment Area
		Acenaphthylene	230,000	200,000	190J	190J	3-MW02IW-09	1/47	0	0	Treatment Area
		Acenaphthene	470,000	200,000	560	47,000	3-TA-SB48-08	6/47	0	0	Treatment Area
		4-Nitrophenol	480,000	NE	570J	570J	3-TA-SB50-04	1/47	0	NA	Treatment Area
		Dibenzofuran	31,000	120,000	440	36,000J	3-TA-SB48-08	6/47	0	0	Treatment Area
		Fluorene	310,000	160,000	710	35,000J	3-TA-SB48-08	6/47	0	0	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	4,300,000	42J	12,000J	3-TA-SB48-08	7/47	0	0	Treatment Area
		Carbazole	32,000	500	200J	4,900	3-TA-SB50-04	6/47	0	4	Treatment Area
		di-n-Butyl-phthalate	780,000	120,000	39J	170J	3-TA-SB43-03	18/47	0	0	Scattered
		Fluoranthene	310,000	980,000	51J	66,000	3-TA-SB50-04	7/47	0	0	Treatment Area

TABLE 4-4 (Continued)

SUMMARY OF SUBSURFACE SOIL CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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)	Soil Screening Level (µg/kg)	(µg/kg)	(µg/kg)			RBC Residential Soils	Siol Screening Level	
Subsurface Soils (Cont.)		Pyrene	230,000	1,400,000	43J	38,000J	3-TA-SB48-08	10/47	0	0	Treatment Area, North Area, Rail Spur
		Benzo(a)anthracene	880	700	77J	8,000	3-TA-SB50-04	7/47	5(1)	4	Treatment Area
		Chrysene	88,000	1,000	86J	8,400J	3-TA-SB48-08	7/47	0	5	Treatment Area
		Bis(2-ethylhexyl)phthalate	46,000	11,000	53J	240J	3-MW11IW-08	2/47	0	0	West of Treatment Area
		Benzo(b)fluoranthene	880	4,000	96J	3,500J	3-TA-SB48-08	7/47	4	0	Treatment Area
		Benzo(k)fluoranthene	8,800	4,000	79J	3,300J	3-TA-SB50-04	6/47	0	0	Treatment Area
		Benzo(a)pyrene	88	4,000	55J	3,300J	3-TA-SB48-08	7/47	6	0	Treatment Area
		Indeno(1,2,3-cd)pyrene	880	35,000	46J	3,100J	3-TA-SB48-08	5/47	1	0	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 4-4 (Continued)

SUMMARY OF SUBSURFACE SOIL CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 (USEPA, May 30, 1996)
Soil Screening Level (USEPA, May 30, 1996)
µg/kg - microgram per kilogram (ppb)
mg/kg - milligram per kilogram (ppm)

TABLE 4-5

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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
			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 4-5 (Continued)

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria MCL (µg/L)	Comparison Criteria NCWQS (µg/L)	Site Contamination Min. (µg/L)	Max. (µg/L)	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria MCL	Number of Detections Above Comparison Criteria NCWQS	Distribution
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(2)	300	840	2,190	3-MW08-01	2/2	2	2	--
		Lead	15(2)	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	5,000(2)	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 4-5 (Continued)

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 4-5 (Continued)

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 4-5 (Continued)

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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 4-5 (Continued)

SUMMARY OF GROUNDWATER CONTAMINATION
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, 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
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.
(2) SMCL = Secondary Maximum Contaminant Level
(3) Action Level

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

TABLE 4-6

COMPARISON OF ENSYS RESULTS WITH
LABORATORY ANALYSIS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Analytical Results					Normalized Results				
Compound	Normalizing Factor	TA-SB08 µg/kg	TA-SB09 µg/kg	TA-SB10 µg/kg	TA-SB13 µg/kg	TA-SB14 µg/kg	TA-SB08 µg/kg	TA-SB09 µg/kg	TA-SB10 µg/kg	TA-SB13 µg/kg	TA-SB14 µg/kg
Acenaphthene	8.1	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Anthracene	0.81	99 J	U	130 J	U	250 J	122.22	0.00	160.49	0.00	308.64
Benzo(a)pyrene	8.3	75 J	U	140 J	120 J	110 J	9.04	0.00	16.87	14.46	13.25
Benzo(b)fluoranthene	4.6	130 J	U	350 J	230 J	310 J	28.26	0.00	76.09	50.00	67.39
Benzo(k)fluoranthene	9.4	90 J	U	180 J	140 J	150 J	9.57	0.00	19.15	14.89	15.96
Benzo(a)anthracene	1.6	57 J	U	81 J	56 J	110 J	35.63	0.00	50.63	35.00	68.75
Chrysene	1.2	63 J	U	240 J	120 J	180 J	52.50	0.00	200.00	100.00	150.00
Dibenz(a,h)anthracene	200	44 J	U	63 J	U	64 J	0.22	0.00	0.32	0.00	0.32
Fluoranthene	1.4	250 J	U	120 J	71 J	380 J	178.57	0.00	85.71	50.71	271.43
Fluorene	1.5	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Ideno(1,2,3-cd)pyrene	11	98 J	U	180 J	U	140 J	8.91	0.00	16.36	0.00	12.73
Naphthalene	200	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Pyrene	3.5	350 J	U	160 J	100 J	330 J	100.00	0.00	45.71	28.57	94.29
Total ppb		1256.00 J	0 J	1644.00 J	837.00 J	2024.00 J	544.92	0.00	671.33	293.64	1002.76
Total ppm		1.26 J	0 J	1.64 J	0.84 J	2.02 J	0.54	0.00	0.67	0.29	1.00
EnSys Result		>1 <10ppm	>10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm

Notes:

µg/kg - micrograms per kilogram
ppm - parts per million
U - nondetected
J - value is estimated

TABLE 4-6 (Continued)

COMPARISON OF ENSYS RESULTS WITH LABORATORY ANALYSIS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Analytical Results					Normalized Results				
Compound	Normalizing Factor	TA-SB17 µg/kg	TA-SB18 µg/kg	TA-SB21 µg/kg	TA-SB25 µg/kg	TA-SB29 µg/kg	TA-SB17 µg/kg	TA-SB18 µg/kg	TA-SB21 µg/kg	TA-SB25 µg/kg	TA-SB29 µg/kg
Acenaphthene	8.1	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Anthracene	0.81	63 J	2600	190 J	160 J	120 J	77.78	3209.88	234.57	197.53	148.15
Benzo(a)pyrene	8.3	U	U	89 J	230 J	150 J	0.00	0.00	10.72	27.71	18.07
Benzo(b)fluoranthene	4.6	97 J	160 J	350	430	300 J	21.09	34.78	76.09	93.48	65.22
Benzo(k)fluoranthene	9.4	80 J	130 J	200 J	270 J	180 J	8.51	13.83	21.28	28.72	19.15
Benzo(a)anthracene	1.6	U	71 J	120 J	160 J	72 J	0.00	44.38	75.00	100.00	45.00
Chrysene	1.2	40 J	150 J	230 J	230 J	140 J	33.33	125.00	191.67	191.67	116.67
Dibenz(a,h)anthracene	200	U	44 J	968 J	91 J	72 J	0.00	0.22	4.84	0.46	0.36
Fluoranthene	1.4	42 J	110 J	410	310 J	130 J	30.00	78.57	292.86	221.43	92.86
Fluorene	1.5	U	39 J	U	U	U	0.00	26.00	0.00	0.00	0.00
Ideno(1,2,3-cd)pyrene	11	U	40 J	130 J	230 J	210 J	0.00	3.64	11.82	20.91	19.09
Naphthalene	200	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Pyrene	3.5	U	49 J	320 J	360 J	160 J	0.00	14.00	91.43	102.86	45.71
Total ppb		322.00 J	3393.00 J	3007.00 J	2471.00 J	1534.00 J	170.71	3550.29	1010.26	984.76	570.28
Total ppm		0.32 J	3.39 J	3.01 J	2.47 J	1.53 J	0.17	3.55	1.01	0.98	0.57
EnSys Result		>1 <10ppm	>1 <10ppm	>1 <10ppm	>10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>10ppm	>1 <10ppm

TABLE 4-6 (Continued)

COMPARISON OF ENSYS RESULTS WITH LABORATORY ANALYSIS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Analytical Results					Normalized Results				
Compound	Normalizing Factor	TA-SB34 µg/kg	TA-SB36 µg/kg	TA-SB37 µg/kg	TA-SB39 µg/kg	TA-SB41 µg/kg	TA-SB34 µg/kg	TA-SB36 µg/kg	TA-SB37 µg/kg	TA-SB39 µg/kg	TA-SB41 µg/kg
Acenaphthene	8.1	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Anthracene	0.81	46 J	70 J	100 J	U	U	56.79	0.00	123.46	0.00	0.00
Benzo(a)pyrene	8.3	66 J	72 J	510	130 J	97 J	7.95	0.00	61.45	15.66	11.69
Benzo(b)fluoranthene	4.6	120 J	120 J	1000	250 J	200 J	26.09	0.00	217.39	54.35	43.48
Benzo(k)fluoranthene	9.4	57 J	100 J	670	210 J	130 J	6.06	0.00	71.28	22.34	13.83
Benzo(a)anthracene	1.6	U	U	800	94 J	U	0.00	0.00	500.00	58.75	0.00
Chrysene	1.2	50 J	74 J	880	170 J	92 J	41.67	0.00	733.33	141.67	76.67
Dibenz(a,h)anthracene	200	U	40 J	U	U	U	0.00	0.00	0.00	0.00	0.00
Fluoranthene	1.4	42 J	74 J	760	200 J	75 J	30.00	0.00	542.86	142.86	53.57
Fluorene	1.5	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Ideno(1,2,3-cd)pyrene	11	68 J	88 J	U	U	96 J	6.18	0.00	0.00	0.00	8.73
Naphthalene	200	U	U	U	U	U	0.00	0.00	0.00	0.00	0.00
Pyrene	3.5	58 J	91 J	1200	280 J	110 J	16.57	0.00	342.86	80.00	31.43
Total ppb		507.00 J	729.00 J	5920.00 J	1334.00 J	800.00 J	191.31	0.00	2592.62	515.62	239.39
Total ppm		0.51 J	0.73 J	5.92 J	1.33 J	0.80 J	0.19	0.00	2.59	0.52	0.24
EnSys Result		>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm

TABLE 4-6 (Continued)

COMPARISON OF ENSYS RESULTS WITH LABORATORY ANALYSIS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Analytical Results					Normalized Results				
Compound	Normalizing Factor	TA-SB43 µg/kg	RS-SB01 µg/kg	RS-SB02 µg/kg	RS-SB05 µg/kg	RS-SB06 µg/kg	TA-SB43 µg/kg	RS-SB01 µg/kg	RS-SB02 µg/kg	RS-SB05 µg/kg	RS-SB06 µg/kg
Acenaphthene	8.1	U	U	44 J	U	U	0.00	0.00	5.43	0.00	0.00
Anthracene	0.81	80 J	U	690	320 J	U	98.77	0.00	851.85	395.06	0.00
Benzo(a)pyrene	8.3	280 J	44 J	560	190 J	110 J	33.73	5.30	67.47	22.89	13.25
Benzo(b)fluoranthene	4.6	860	63 J	630	280 J	350 J	186.96	13.70	136.96	60.87	76.09
Benzo(k)fluoranthene	9.4	U	47 J	690	290 J	U	0.00	5.00	73.40	30.85	0.00
Benzo(a)anthracene	1.6	260 J	U	240 J	130 J	100 J	162.50	0.00	150.00	81.25	62.50
Chrysene	1.2	540	U	460	190 J	180 J	450.00	0.00	383.33	158.33	150.00
Dibenz(a,h)anthracene	200	150 J	U	270 J	85 J	U	0.75	0.00	1.35	0.43	0.00
Fluoranthene	1.4	350 J	U	220 J	170 J	190 J	250.00	0.00	157.14	121.43	135.71
Fluorene	1.5	U	U	57 J	U	U	0.00	0.00	38.00	0.00	0.00
Ideno(1,2,3-cd)pyrene	11	280 J	U	650	240 J	140 J	25.45	0.00	59.09	21.82	12.73
Naphthalene	200	U	U	38 J	U	U	0.00	0.00	0.19	0.00	0.00
Pyrene	3.5	670	U	320 J	210 J	330 J	191.43	0.00	91.43	60.00	94.29
Total ppb		3470.00 J	154.00 J	4869.00 J	2105.00 J	1400.00 J	1399.59	24.00	2015.65	952.93	544.57
Total ppm		3.47 J	0.15 J	4.87 J	2.11 J	1.40 J	1.40	0.02	2.02	0.95	0.54
EnSys Result		>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm	>1 <10ppm

TABLE 4-6 (Continued)

COMPARISON OF ENSYS RESULTS WITH LABORATORY ANALYSIS OPERABLE UNIT NO. 12 (SITE 3) REMEDIAL INVESTIGATION, CTO-0274 MCB, CAMP LEJEUNE, NORTH CAROLINA

		Analytical Results						Normalized Results					
Compound	Normalizing Factor	RS-SB07 µg/kg	NA-SB03 µg/kg	NA-SB05 µg/kg	NA-SB08 µg/kg	NA-SB10 µg/kg	CP-SB04 µg/kg	RS-SB07 µg/kg	NA-SB03 µg/kg	NA-SB05 µg/kg	NA-SB08 µg/kg	NA-SB10 µg/kg	CP-SB04 µg/kg
Acenaphthene	8.1	U	U	460 J	U	U	U	0.00	0.00	56.79	0.00	0.00	0.00
Anthracene	0.81	470	7700	1300 J	1100 J	U	U	580.25	9506.17	1604.94	1358.02	0.00	0.00
Benzo(a)pyrene	8.3	910	8700	4500	3200	U	U	109.64	1048.19	542.17	385.54	0.00	0.00
Benzo(b)fluoranthene	4.6	1600	13000	7200	4300	U	U	347.83	2826.09	1565.22	934.78	0.00	0.00
Benzo(k)fluoranthene	9.4	1300	9000	6700	4200	U	U	138.30	957.45	712.77	446.81	0.00	0.00
Benzo(a)anthracene	1.6	1000	8300	4500	3000	U	U	625.00	5187.50	2812.50	1875.00	0.00	0.00
Chrysene	1.2	1200	12000	6900	4400	U	U	1000.00	10000.00	5750.00	3666.67	0.00	0.00
Dibenz(a,h)anthracene	200	290 J	2900	U	U	U	U	1.45	14.50	0.00	0.00	0.00	0.00
Fluoranthene	1.4	1400	11000	9400	U	U	U	1000.00	7857.14	6714.29	0.00	0.00	0.00
Fluorene	1.5	U	350 J	620 J	240 J	U	U	0.00	233.33	413.33	160.00	0.00	0.00
Ideno(1,2,3-cd)pyrene	11	590	6800	3600	2300	U	U	53.64	618.18	327.27	209.09	0.00	0.00
Naphthalene	200	U	U	200 J	U	U	U	0.00	0.00	1.00	0.00	0.00	0.00
Pyrene	3.5	3200 E	14000	12000	7200	U	U	914.29	4000.00	3428.57	2057.14	0.00	0.00
Total ppb		11960.00 J	93750.00 J	57380.00 J	29940.00 J	0.00 J	0.00 J	4770.38	42248.56	23928.84	11093.06	0.00	0.00
Total ppm		11.96 J	93.75 J	57.38 J	29.94 J	0.00 J	0.00 J	4.77	42.25	23.93	11.09	0.00	0.00
EnSys Result		>10ppm	>10ppm	>10ppm	>10ppm	>1 <10ppm	>1 <10ppm	>10ppm	>10ppm	>10ppm	>10ppm	>1 <10ppm	>1 <10ppm

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-CP-SB02-00	3-CP-SB04-00	3-CP-SB05-00	3-CP-SB09-00	3-MW02DW-00
Laboratory Sample ID:		AC0948	AC0950	AC0928	AC0927	AF7367
Date Sampled:		9/20/94	9/20/94	9/20/94	9/21/94	06/20/95
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	ND
Ethylbenzene	ug/kg	NA	NA	NA	NA	ND
Xylenes (total)	ug/kg	NA	NA	NA	NA	ND
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND
Anthracene	ug/kg	ND	ND	ND	ND	ND
Carbazole	ug/kg	ND	ND	ND	ND	ND
di-n-Butylphthalate	ug/kg	170 J	64 J	92 J	70 J	ND
Fluoranthene	ug/kg	ND	ND	ND	ND	ND
Pyrene	ug/kg	ND	ND	ND	ND	ND
Benzo[a]anthracene	ug/kg	ND	ND	ND	ND	ND
Chrysene	ug/kg	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	43 J	65 J	43 J	42 J	ND
Benzo[b]fluoranthene	ug/kg	ND	ND	ND	ND	210 J
Benzo[k]fluoranthene	ug/kg	ND	ND	ND	ND	ND
Benzo[a]pyrene	ug/kg	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW02IW-00	3-MW04-00	3-MW06-00	3-MW07-00	3-MW08-00
Laboratory Sample ID:		AC9747	AD0036	AD0551	AD0553	AD0549
Date Sampled:		11/16/94	11/17/94	11/19/94	11/19/94	11/20/94
VOLATILES	**UNITS**					
Toluene	ug/kg	2 J	NA	NA	NA	NA
Ethylbenzene	ug/kg	ND	NA	NA	NA	NA
Xylenes (total)	ug/kg	ND	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND
Anthracene	ug/kg	49 J	ND	ND	110 J	ND
Carbazole	ug/kg	ND	ND	ND	45 J	ND
di-n-Butylphthalate	ug/kg	110 J	ND	ND	ND	ND
Fluoranthene	ug/kg	55 J	46 J	49 J	91 J	62 J
Pyrene	ug/kg	86 J	64 J	73 J	100 J	60 J
Benzo[a]anthracene	ug/kg	32 J	ND	ND	42 J	ND
Chrysene	ug/kg	64 J	54 J	49 J	81 J	47 J
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	ug/kg	120 J	96 J	74 J	100 J	39 J
Benzo[k]fluoranthene	ug/kg	83 J	ND	48 J	120 J	39 J
Benzo[a]pyrene	ug/kg	59 J	ND	38 J	57 J	ND
Indeno[1,2,3-cd]pyrene	ug/kg	65 J	ND	ND	68 J	ND
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	52 J	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW11-00	3-MW12-00	3-MW13-00	3-NA-SB01-00	3-NA-SB03-00
Laboratory Sample ID:		AF6976	AF6645	AF6981	AC0962	AC0964
Date Sampled:		06/15/95	06/13/95	06/14/95	9/20/94	9/20/94
VOLATILES	**UNITS**					
Toluene	ug/kg	ND	ND	2 J	NA	NA
Ethylbenzene	ug/kg	ND	ND	ND	NA	NA
Xylenes (total)	ug/kg	ND	ND	ND	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	290 J	ND	ND	ND	2700
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	350 J
Phenanthrene	ug/kg	ND	ND	ND	ND	970 J
Anthracene	ug/kg	290 J	ND	ND	ND	7700
Carbazole	ug/kg	ND	ND	ND	ND	830 J
di-n-Butylphthalate	ug/kg	ND	50 J	ND	130 J	220 J
Fluoranthene	ug/kg	530 J	ND	ND	ND	11000
Pyrene	ug/kg	1700 J	ND	ND	ND	14000
Benzo[a]anthracene	ug/kg	1800 J	ND	ND	ND	8300
Chrysene	ug/kg	3300	ND	ND	ND	12000
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	91 J	ND
Benzo[b]fluoranthene	ug/kg	3800	ND	ND	ND	13000
Benzo[k]fluoranthene	ug/kg	2000	ND	ND	ND	9000
Benzo[a]pyrene	ug/kg	2000	ND	ND	ND	8700
Indeno[1,2,3-cd]pyrene	ug/kg	940 J	ND	ND	ND	6800
Dibenz[a,h]anthracene	ug/kg	390 J	ND	ND	ND	2900
Benzo[g,h,i]perylene	ug/kg	690 J	ND	ND	ND	4700

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-NA-SB05-00	3-NA-SB07-00	3-NA-SB08-00	3-NA-SB17-00	3-NA-SB17A-00
Laboratory Sample ID:		AC0932	AC0923	AC0933	AC0924	AF6990
Date Sampled:		9/20/94	9/20/94	9/20/94	9/21/94	06/15/95
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	ND
Ethylbenzene	ug/kg	NA	NA	NA	NA	ND
Xylenes (total)	ug/kg	NA	NA	NA	NA	ND
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	200 J	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	590 J	ND	470 J	ND	ND
Acenaphthene	ug/kg	460 J	ND	ND	ND	ND
Dibenzofuran	ug/kg	370 J	ND	ND	ND	ND
Fluorene	ug/kg	620 J	ND	240 J	ND	ND
Phenanthrene	ug/kg	2900	ND	1300 J	ND	ND
Anthracene	ug/kg	1300 J	ND	1100 J	ND	ND
Carbazole	ug/kg	350 J	ND	210 J	ND	ND
di-n-Butylphthalate	ug/kg	ND	170 J	ND	230 J	ND
Fluoranthene	ug/kg	9400	ND	5100	ND	ND
Pyrene	ug/kg	12000	ND	7200	ND	45 J
Benzo[a]anthracene	ug/kg	4500	ND	3000	ND	ND
Chrysene	ug/kg	6900	ND	4400	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	54 J	ND	57 J	ND
Benzo[b]fluoranthene	ug/kg	7200	ND	4300	ND	46 J
Benzo[k]fluoranthene	ug/kg	6700	ND	4200	ND	ND
Benzo[a]pyrene	ug/kg	4500	ND	3200	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	3600	ND	2300	ND	ND
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	3000	ND	2200	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-NA-SB18-00	3-NA-SB19-00	3-RS-SB01-00	3-RS-SB02-00	3-RS-SB03-00
Laboratory Sample ID:		AF6995	AF6999	AC0938	AC0939	AC0925
Date Sampled:		06/15/95	06/15/95	9/20/94	9/20/94	9/21/94
VOLATILES	**UNITS**					
Toluene	ug/kg	ND	ND	NA	NA	NA
Ethylbenzene	ug/kg	ND	ND	NA	NA	NA
Xylenes (total)	ug/kg	ND	ND	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	38 J
Naphthalene	ug/kg	ND	ND	ND	38 J	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	41 J	ND
Acenaphthylene	ug/kg	ND	ND	ND	480	44 J
Acenaphthene	ug/kg	ND	ND	ND	44 J	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	57 J	ND
Phenanthrene	ug/kg	ND	ND	ND	95 J	ND
Anthracene	ug/kg	ND	ND	ND	690	88 J
Carbazole	ug/kg	ND	ND	ND	83 J	ND
di-n-Butylphthalate	ug/kg	37 J	ND	62 J	85 J	180 J
Fluoranthene	ug/kg	ND	ND	ND	220 J	110 J
Pyrene	ug/kg	ND	39 J	ND	320 J	140 J
Benzo[a]anthracene	ug/kg	ND	ND	ND	240 J	62 J
Chrysene	ug/kg	ND	ND	ND	460	100 J
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	48 J	64 J	48 J
Benzo[b]fluoranthene	ug/kg	ND	40 J	63 J	630	170 J
Benzo[k]fluoranthene	ug/kg	ND	44 J	47 J	690	160 J
Benzo[a]pyrene	ug/kg	ND	ND	44 J	560	93 J
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	650	120 J
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	270 J	42 J
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	770	77 J

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-RS-SB05-00	3-RS-SB06-00	3-RS-SB07-00	3-TA-SB08-00	3-TA-SB10-00
Laboratory Sample ID:		AC0940	AC0937	AC0941	AC0942	AC0944
Date Sampled:		9/21/94	9/21/94	9/22/94	9/19/94	9/19/94
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	NA	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	190 J	ND	200 J	ND	64 J
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND
Anthracene	ug/kg	320 J	ND	470	99 J	130 J
Carbazole	ug/kg	93 J	ND	110 J	ND	45 J
di-n-Butylphthalate	ug/kg	53 J	170 J	75 J	140 J	190 J
Fluoranthene	ug/kg	170 J	190 J	1400	250 J	120 J
Pyrene	ug/kg	210 J	330 J	3200 J	350 J	160 J
Benzo[a]anthracene	ug/kg	130 J	100 J	1000	57 J	81 J
Chrysene	ug/kg	190 J	180 J	1200	63 J	240 J
bis(2-Ethylhexyl)phthalate	ug/kg	90 J	58 J	84 J	47 J	42 J
Benzo[b]fluoranthene	ug/kg	280 J	350 J	1600	130 J	350 J
Benzo[k]fluoranthene	ug/kg	290 J	ND	1300	90 J	180 J
Benzo[a]pyrene	ug/kg	190 J	110 J	910	75 J	140 J
Indeno[1,2,3-cd]pyrene	ug/kg	240 J	140 J	590	98 J	180 J
Dibenz[a,h]anthracene	ug/kg	85 J	ND	290 J	44 J	63 J
Benzo[g,h,i]perylene	ug/kg	280 J	170 J	410	110 J	160 J

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB12-00	3-TA-SB13-00	3-TA-SB14-00	3-TA-SB17-00	3-TA-SB18-00
Laboratory Sample ID:		AC0931	AC0945	AC0946	AC0947	AC0951
Date Sampled:		9/19/94	9/19/94	9/19/94	9/19/94	9/19/94
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	NA	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	61 J	ND	58 J
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	39 J
Phenanthrene	ug/kg	ND	ND	130 J	ND	67 J
Anthracene	ug/kg	40 J	75 J	250 J	63 J	2600
Carbazole	ug/kg	ND	ND	66 J	ND	220 J
di-n-Butylphthalate	ug/kg	54 J	340 J	160 J	210 J	90 J
Fluoranthene	ug/kg	48 J	71 J	380	42 J	110 J
Pyrene	ug/kg	48 J	100 J	330 J	ND	49 J
Benzo[a]anthracene	ug/kg	ND	56 J	110 J	ND	71 J
Chrysene	ug/kg	48 J	120 J	180 J	40 J	150 J
bis(2-Ethylhexyl)phthalate	ug/kg	41 J	47 J	51 J	50 J	66 J
Benzo[b]fluoranthene	ug/kg	89 J	230 J	310 J	97 J	160 J
Benzo[k]fluoranthene	ug/kg	56 J	140 J	150 J	80 J	130 J
Benzo[a]pyrene	ug/kg	55 J	120 J	110 J	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	47 J	ND	140 J	ND	40 J
Dibenz[a,h]anthracene	ug/kg	ND	ND	64 J	ND	44 J
Benzo[g,h,i]perylene	ug/kg	51 J	ND	39 J	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB21-00	3-TA-SB25-00	3-TA-SB29-00	3-TA-SB34-00	3-TA-SB36-00
Laboratory Sample ID:		AC0952	AC0954	AC0955	AC0956	AC0957
Date Sampled:		9/20/94	9/19/94	9/20/94	9/21/94	9/21/94
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	NA	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	58 J	70 J	68 J	ND	40 J
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	55 J	ND	ND	ND	ND
Anthracene	ug/kg	190 J	160 J	120 J	46 J	70 J
Carbazole	ug/kg	63 J	47 J	40 J	ND	ND
di-n-Butylphthalate	ug/kg	96 J	100 J	210 J	150 J	77 J
Fluoranthene	ug/kg	410 J	310 J	130 J	42 J	74 J
Pyrene	ug/kg	320 J	360 J	160 J	58 J	91 J
Benzo[a]anthracene	ug/kg	120 J	160 J	72 J	ND	ND
Chrysene	ug/kg	230 J	230 J	140 J	50 J	74 J
bis(2-Ethylhexyl)phthalate	ug/kg	36 J	41 J	47 J	46 J	58 J
Benzo[b]fluoranthene	ug/kg	350 J	430	300 J	120 J	120 J
Benzo[k]fluoranthene	ug/kg	200 J	270 J	180 J	57 J	100 J
Benzo[a]pyrene	ug/kg	89 J	230 J	150 J	66 J	72 J
Indeno[1,2,3-cd]pyrene	ug/kg	130 J	230 J	210 J	68 J	88 J
Dibenz[a,h]anthracene	ug/kg	68 J	91 J	72 J	ND	40 J
Benzo[g,h,i]perylene	ug/kg	ND	250 J	200 J	77 J	90 J

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB37-00	3-TA-SB39-00	3-TA-SB40-00	3-TA-SB41-00	3-TA-SB43-00
Laboratory Sample ID:		AC0958	AC0959	AC0929	AC0960	AC0961
Date Sampled:		9/21/94	9/21/94	9/22/94	9/22/94	9/22/94
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	NA	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	41 J	ND	ND	37 J
Anthracene	ug/kg	100 J	ND	ND	ND	80 J
Carbazole	ug/kg	ND	ND	ND	ND	ND
di-n-Butylphthalate	ug/kg	170 J	160 J	140 J	270 J	130 J
Fluoranthene	ug/kg	760	200 J	ND	75 J	350 J
Pyrene	ug/kg	1200	280 J	ND	110 J	670
Benzo[a]anthracene	ug/kg	800	94 J	ND	ND	260 J
Chrysene	ug/kg	880	170 J	ND	92 J	540
bis(2-Ethylhexyl)phthalate	ug/kg	ND	52 J	44 J	51 J	51 J
Benzo[b]fluoranthene	ug/kg	1000	250 J	ND	200 J	860
Benzo[k]fluoranthene	ug/kg	670	210 J	37 J	130 J	ND
Benzo[a]pyrene	ug/kg	510	130 J	ND	97 J	280 J
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	96 J	280 J
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	ND	150 J
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	94 J	200 J

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB44-00	3-TA-SB45-00	3-TA-SB47-00	3-TA-SB48-00	3-TA-SB49-00
Laboratory Sample ID:		AC0930	AF7156	AF7160	AF7003	AF7007
Date Sampled:		9/22/94	06/15/95	06/15/95	06/15/95	06/15/95
VOLATILES	**UNITS**					
Toluene	ug/kg	NA	ND	ND	ND	ND
Ethylbenzene	ug/kg	NA	ND	ND	ND	ND
Xylenes (total)	ug/kg	NA	ND	ND	ND	ND
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	46 J	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND
Anthracene	ug/kg	ND	48 J	ND	85 J	ND
Carbazole	ug/kg	ND	ND	ND	56 J	ND
di-n-Butylphthalate	ug/kg	190 J	ND	ND	44 J	38 J
Fluoranthene	ug/kg	ND	54 J	ND	190 J	ND
Pyrene	ug/kg	ND	93 J	ND	270 J	41 J
Benzo[a]anthracene	ug/kg	ND	47 J	ND	230 J	ND
Chrysene	ug/kg	ND	80 J	ND	380	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	63 J	ND	ND
Benzo[b]fluoranthene	ug/kg	ND	130 J	ND	400	60 J
Benzo[k]fluoranthene	ug/kg	ND	160 J	46 J	460	64 J
Benzo[a]pyrene	ug/kg	ND	70 J	ND	220 J	57 J
Indeno[1,2,3-cd]pyrene	ug/kg	ND	74 J	ND	180 J	43 J
Dibenz[a,h]anthracene	ug/kg	ND	ND	ND	67 J	ND
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	180 J	48 J

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB50-00
Laboratory Sample ID:		AF7011
Date Sampled:		06/15/95
VOLATILES	**UNITS**	
Toluene	ug/kg	ND
Ethylbenzene	ug/kg	2 J
Xylenes (total)	ug/kg	6 J
SEMIVOLATILES		
Phenol	ug/kg	ND
Naphthalene	ug/kg	ND
2-Methylnaphthalene	ug/kg	ND
Acenaphthylene	ug/kg	ND
Acenaphthene	ug/kg	ND
Dibenzofuran	ug/kg	ND
Fluorene	ug/kg	ND
Phenanthrene	ug/kg	ND
Anthracene	ug/kg	ND
Carbazole	ug/kg	ND
di-n-Butylphthalate	ug/kg	ND
Fluoranthene	ug/kg	ND
Pyrene	ug/kg	ND
Benzo[a]anthracene	ug/kg	ND
Chrysene	ug/kg	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND
Benzo[b]fluoranthene	ug/kg	ND
Benzo[k]fluoranthene	ug/kg	ND
Benzo[a]pyrene	ug/kg	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND
Dibenz[a,h]anthracene	ug/kg	ND
Benzo[g,h,i]perylene	ug/kg	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		3-MW02IW-00	3-MW05-00
Laboratory Sample ID:		AC9747	AD0556
Date Sampled:		11/16/94	11/19/94
	UNITS		
Aluminum	mg/kg	1740	4240
Barium	mg/kg	6.4 J	7.8 J
Calcium	mg/kg	67700	4020
Chromium	mg/kg	7.1	2.7
Iron	mg/kg	1390	1970
Lead	mg/kg	4.4 J	ND
Magnesium	mg/kg	1020	150
Manganese	mg/kg	11.7	13.1
Sodium	mg/kg	112	ND
Vanadium	mg/kg	3.3	5.2
Zinc	mg/kg	16.6	ND
Moisture	%	0.44	9.69

mg/kg - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-MW02DW-02	3-MW02IW-03	3-MW02IW-09	3-MW08-02	03-MW09-02	03-MW11IW-08
Laboratory Sample ID:		AF7371	AC9764	AD0022	AD0550	AF6809	AF7152
Date Sampled:		06/20/95	11/16/94	11/17/94	11/20/94	06/13/95	06/16/95
VOLATILES	**UNITS**						
Acetone	ug/kg	ND	ND	NA	NA	ND	ND
Carbon Disulfide	ug/kg	ND	ND	NA	NA	ND	ND
Chloroform	ug/kg	ND	ND	NA	NA	ND	3 J
2-Butanone	ug/kg	ND	ND	NA	NA	ND	ND
Benzene	ug/kg	ND	2 J	NA	NA	ND	ND
Toluene	ug/kg	ND	6 J	NA	NA	ND	ND
Ethylbenzene	ug/kg	ND	3 J	NA	NA	ND	ND
Styrene	ug/kg	ND	ND	NA	NA	5 J	ND
Xylenes (total)	ug/kg	ND	7 J	NA	NA	ND	ND
SEMIVOLATILES							
Phenol	ug/kg	ND	ND	ND	ND	ND	ND
2-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
4-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
Naphthalene	ug/kg	530 J	110 J	17000	ND	ND	ND
2-Methylnaphthalene	ug/kg	290 J	100 J	7200	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	190 J	ND	ND	ND
Acenaphthene	ug/kg	1000 J	560	13000	ND	ND	ND
4-Nitrophenol	ug/kg	ND	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	660 J	440	9000	ND	ND	ND
Fluorene	ug/kg	870 J	710	9100	ND	ND	ND
N-nitrosodiphenylamine	ug/kg	ND	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	1800 J	2700	24000	ND	ND	ND
Anthracene	ug/kg	370 J	530	2400	ND	ND	ND
Carbazole	ug/kg	270 J	200 J	1600	ND	ND	ND
di-n-Butylphthalate	ug/kg	ND	110 J	ND	ND	ND	39 J
Fluoranthene	ug/kg	4800 J	1900	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-MW02DW-02	3-MW02IW-03	3-MW02IW-09	3-MW08-02	03-MW09-02	03-MW11IW-08
Laboratory Sample ID:		AF7371	AC9764	AD0022	AD0550	AF6809	AF7152
Date Sampled:		06/20/95	11/16/94	11/17/94	11/20/94	06/13/95	06/16/95
SEMIVOLATILES cont'	**UNITS**						
Pyrene	ug/kg	3500 J	1300	9400	43 J	ND	ND
Benzo[a]anthracene	ug/kg	1100 J	270 J	2100	ND	ND	ND
Chrysene	ug/kg	1700 J	310 J	1700	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	ND	ND	240 J
Benzo[b]fluoranthene	ug/kg	780 J	140 J	1200	ND	ND	ND
Benzo[k]fluoranthene	ug/kg	740 J	150 J	ND	ND	ND	ND
Benzo[a]pyrene	ug/kg	450 J	120 J	700	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND	54 J	200 J	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	240 J	ND	71 J	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-MW12-02	03-MW13-04	3-NA-SB03-03	3-NA-SB05-03	3-NA-SB08-03	03-NA-SB17A-02
Laboratory Sample ID:		AF6650	AF6984	AC9737	AC9736	AC9740	AF6993
Date Sampled:		06/13/95	06/14/95	11/16/94	11/16/94	11/16/94	06/15/95
VOLATILES	**UNITS**						
Acetone	ug/kg	ND	ND	NA	NA	NA	120
Carbon Disulfide	ug/kg	1 J	ND	NA	NA	NA	ND
Chloroform	ug/kg	ND	ND	NA	NA	NA	ND
2-Butanone	ug/kg	ND	ND	NA	NA	NA	ND
Benzene	ug/kg	ND	ND	NA	NA	NA	ND
Toluene	ug/kg	ND	ND	NA	NA	NA	ND
Ethylbenzene	ug/kg	ND	ND	NA	NA	NA	ND
Styrene	ug/kg	ND	ND	NA	NA	NA	ND
Xylenes (total)	ug/kg	ND	ND	NA	NA	NA	ND
SEMIVOLATILES							
Phenol	ug/kg	ND	ND	ND	ND	ND	ND
2-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
4-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
Naphthalene	ug/kg	80 J	55 J	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND	ND
4-Nitrophenol	ug/kg	ND	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND	ND
N-nitrosodiphenylamine	ug/kg	ND	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	66 J	61 J	ND	ND	ND	ND
Anthracene	ug/kg	ND	ND	ND	ND	ND	ND
Carbazole	ug/kg	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	ug/kg	43 J	ND	140 J	120 J	110 J	40 J
Fluoranthene	ug/kg	51 J	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-MW12-02	03-MW13-04	3-NA-SB03-03	3-NA-SB05-03	3-NA-SB08-03	03-NA-SB17A-02
Laboratory Sample ID:		AF6650	AF6984	AC9737	AC9736	AC9740	AF6993
Date Sampled:		06/13/95	06/14/95	11/16/94	11/16/94	11/16/94	06/15/95
SEMIVOLATILES cont'	**UNITS**						
Pyrene	ug/kg	ND	43 J	ND	ND	ND	ND
Benzo[a]anthracene	ug/kg	ND	ND	ND	ND	ND	ND
Chrysene	ug/kg	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	ug/kg	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	ND	71 J	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-NA-SB19-02	3-RS-SB01-03	3-RS-SB02-04	3-RS-SB05-03	3-RS-SB05-04	3-RS-SB06-04
Laboratory Sample ID:		AF7001	AC9732	AC9733	AC9734	AC9735	AC9731
Date Sampled:		06/15/95	11/15/94	11/15/94	11/15/94	11/16/94	11/15/94
VOLATILES	**UNITS**						
Acetone	ug/kg	ND	NA	NA	NA	NA	NA
Carbon Disulfide	ug/kg	ND	NA	NA	NA	NA	NA
Chloroform	ug/kg	ND	NA	NA	NA	NA	NA
2-Butanone	ug/kg	3 J	NA	NA	NA	NA	NA
Benzene	ug/kg	ND	NA	NA	NA	NA	NA
Toluene	ug/kg	ND	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	ND	NA	NA	NA	NA	NA
Styrene	ug/kg	ND	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	ND	NA	NA	NA	NA	NA
SEMIVOLATILES							
Phenol	ug/kg	ND	ND	ND	ND	ND	ND
2-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
4-Methylphenol	ug/kg	ND	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND	ND
4-Nitrophenol	ug/kg	ND	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND	ND
N-nitrosodiphenylamine	ug/kg	ND	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND	ND
Anthracene	ug/kg	ND	ND	ND	ND	ND	ND
Carbazole	ug/kg	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	ug/kg	41 J	110 J	150 J	97 J	130 J	92 J
Fluoranthene	ug/kg	ND	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		03-NA-SB19-02	3-RS-SB01-03	3-RS-SB02-04	3-RS-SB05-03	3-RS-SB05-04	3-RS-SB06-04
Laboratory Sample ID:		AF7001	AC9732	AC9733	AC9734	AC9735	AC9731
Date Sampled:		06/15/95	11/15/94	11/15/94	11/15/94	11/16/94	11/15/94
SEMIVOLATILES cont'	**UNITS**						
Pyrene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	ug/kg	ND	ND	ND	ND	ND	ND
Chrysene	ug/kg	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	ug/kg	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-RS-SB07-04	3-TA-SB17-04	3-TA-SB18-03	3-TA-SB37-02	3-TA-SB41-02
Laboratory Sample ID:		AD0031	AC9729	AC9738	AC9724	AC9728
Date Sampled:		11/17/94	11/15/94	11/16/94	11/15/94	11/15/94
VOLATILES	**UNITS**					
Acetone	ug/kg	NA	NA	NA	NA	NA
Carbon Disulfide	ug/kg	NA	NA	NA	NA	NA
Chloroform	ug/kg	NA	NA	NA	NA	NA
2-Butanone	ug/kg	NA	NA	NA	NA	NA
Benzene	ug/kg	NA	NA	NA	NA	NA
Toluene	ug/kg	NA	NA	NA	NA	NA
Ethylbenzene	ug/kg	NA	NA	NA	NA	NA
Styrene	ug/kg	NA	NA	NA	NA	NA
Xylenes (total)	ug/kg	NA	NA	NA	NA	NA
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	ND	ND	ND
2-Methylphenol	ug/kg	ND	ND	ND	ND	ND
4-Methylphenol	ug/kg	ND	ND	ND	ND	ND
Naphthalene	ug/kg	ND	320 J	ND	ND	ND
2-Methylnaphthalene	ug/kg	ND	ND	ND	ND	ND
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	ND	ND	ND
4-Nitrophenol	ug/kg	ND	ND	ND	ND	ND
Dibenzofuran	ug/kg	ND	ND	ND	ND	ND
Fluorene	ug/kg	ND	ND	ND	ND	ND
N-nitrosodiphenylamine	ug/kg	ND	ND	ND	ND	ND
Phenanthrene	ug/kg	ND	ND	ND	ND	ND
Anthracene	ug/kg	ND	ND	ND	ND	ND
Carbazole	ug/kg	ND	ND	ND	ND	ND
di-n-Butylphthalate	ug/kg	ND	110 J	170 J	140 J	110 J
Fluoranthene	ug/kg	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-RS-SB07-04	3-TA-SB17-04	3-TA-SB18-03	3-TA-SB37-02	3-TA-SB41-02
Laboratory Sample ID:		AD0031	AC9729	AC9738	AC9724	AC9728
Date Sampled:		11/17/94	11/15/94	11/16/94	11/15/94	11/15/94
SEMIVOLATILES cont'	**UNITS**					
Pyrene	ug/kg	61 J	ND	ND	ND	ND
Benzo[a]anthracene	ug/kg	ND	ND	ND	ND	ND
Chrysene	ug/kg	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/kg	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	ug/kg	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	ug/kg	ND	ND	ND	ND	ND
Benzo[a]pyrene	ug/kg	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ug/kg	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ug/kg	ND	ND	ND	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB43-03	03-TA-SB47-02	03-TA-SB48-04	03-TA-SB49-04	03-TA-SB50-04
Laboratory Sample ID:		AC9727	AF7162	AF7005	AF7009	AF7013
Date Sampled:		11/15/94	06/15/95	06/15/95	06/15/95	06/15/95
VOLATILES	**UNITS**					
Acetone	ug/kg	NA	ND	ND	ND	ND
Carbon Disulfide	ug/kg	NA	ND	ND	ND	ND
Chloroform	ug/kg	NA	ND	ND	ND	ND
2-Butanone	ug/kg	NA	ND	ND	ND	ND
Benzene	ug/kg	NA	ND	2 J	ND	ND
Toluene	ug/kg	NA	ND	11 J	13	3 J
Ethylbenzene	ug/kg	NA	ND	15	110	9 J
Styrene	ug/kg	NA	ND	4 J	ND	ND
Xylenes (total)	ug/kg	NA	ND	40	300	22
SEMIVOLATILES						
Phenol	ug/kg	ND	ND	7200 J	ND	ND
2-Methylphenol	ug/kg	ND	ND	2000 J	ND	ND
4-Methylphenol	ug/kg	ND	ND	5900 J	ND	ND
Naphthalene	ug/kg	ND	ND	95000 J	24000	62000
2-Methylnaphthalene	ug/kg	ND	ND	31000 J	8300	10000
Acenaphthylene	ug/kg	ND	ND	ND	ND	ND
Acenaphthene	ug/kg	ND	ND	47000 J	17000	32000
4-Nitrophenol	ug/kg	ND	ND	ND	ND	570 J
Dibenzofuran	ug/kg	ND	ND	36000 J	11000	19000
Fluorene	ug/kg	ND	ND	35000 J	13000	20000
N-nitrosodiphenylamine	ug/kg	ND	ND	1100 J	ND	400 J
Phenanthrene	ug/kg	ND	ND	110000 J	42000	110000
Anthracene	ug/kg	42 J	ND	12000 J	3300 J	7000
Carbazole	ug/kg	ND	ND	4200 J	3300 J	4900
di-n-Butylphthalate	ug/kg	170 J	ND	ND	ND	ND
Fluoranthene	ug/kg	86 J	ND	53000 J	17000	66000

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-TA-SB43-03	03-TA-SB47-02	03-TA-SB48-04	03-TA-SB49-04	03-TA-SB50-04
Laboratory Sample ID:		AC9727	AF7162	AF7005	AF7009	AF7013
Date Sampled:		11/15/94	06/15/95	06/15/95	06/15/95	06/15/95
SEMIVOLATILES cont'	**UNITS**					
Pyrene	ug/kg	110 J	ND	38000 J	12000	30000
Benzo[a]anthracene	ug/kg	77 J	ND	7500 J	2900 J	8000
Chrysene	ug/kg	86 J	ND	8400 J	2800 J	5700
bis(2-Ethylhexyl)phthalate	ug/kg	ND	53 J	ND	ND	ND
Benzo[b]fluoranthene	ug/kg	96 J	ND	3500 J	1000 J	3000 J
Benzo[k]fluoranthene	ug/kg	79 J	ND	3100 J	1400 J	3300 J
Benzo[a]pyrene	ug/kg	55 J	ND	3300 J	1100 J	2600 J
Indeno[1,2,3-cd]pyrene	ug/kg	46 J	ND	3100 J	ND	770 J
Benzo[g,h,i]perylene	ug/kg	ND	ND	1200 J	ND	ND

ug/kg - micrograms per kilogram
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		3-MW02IW-03	3-MW05-10
Laboratory Sample ID:		AC9764	AD0558
Date Sampled:		11/16/94	11/19/94
	UNITS		
Aluminum	mg/kg	6570	3950
Barium	mg/kg	6.6 J	4.6 J
Calcium	mg/kg	638	77.4
Chromium	mg/kg	7.5	3.7
Iron	mg/kg	1030	734
Lead	mg/kg	5.7 J	ND
Magnesium	mg/kg	112	104
Manganese	mg/kg	2.8 J	ND
Vanadium	mg/kg	5	3.7
Moisture	%	13.92	14.09

mg/kg - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 1
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW02-01	3-MW02IW-01	3-MW06-01	3-MW07-01	3-MW08-01
Laboratory Sample ID:		AD1965	AD2155	AD1968	AD1647	AD1650
Date Sampled:		12/02/94	12/03/94	12/01/94	12/01/94	12/01/94
VOLATILES	**UNITS**					
Carbon Disulfide	ug/L	NA	ND	NA	1 J	ND
Benzene	ug/L	NA	11 J	NA	13 J	40 J
Toluene	ug/L	NA	4 J	NA	5 J	10 J
Xylenes (total)	ug/L	NA	7 J	NA	6 J	9 J
SEMIVOLATILES						
Phenol	ug/L	3 J	ND	ND	ND	ND
2-Methylphenol	ug/L	1 J	ND	ND	ND	ND
4-Methylphenol	ug/L	3 J	ND	ND	ND	ND
2-Nitrophenol	ug/L	ND	ND	ND	ND	2 J
2,4-Dimethylphenol	ug/L	2 J	ND	ND	ND	ND
Naphthalene	ug/L	64	3 J	6 J	5 J	8 J
2-Methylnaphthalene	ug/L	65	ND	ND	ND	ND
Acenaphthylene	ug/L	3 J	3 J	ND	ND	ND
Acenaphthene	ug/L	280	95	2 J	ND	ND
Dibenzofuran	ug/L	230	57	2 J	ND	ND
Fluorene	ug/L	210	59	1 J	ND	ND
Phenanthrene	ug/L	410	75	ND	ND	ND
Anthracene	ug/L	33	5 J	ND	ND	ND
Carbazole	ug/L	39 J	ND	ND	ND	ND
di-n-Butylphthalate	ug/L	1 J	ND	ND	ND	ND
Fluoranthene	ug/L	100	10	ND	ND	ND
Pyrene	ug/L	58	7 J	ND	ND	ND
Benzo[a]anthracene	ug/L	8 J	ND	ND	ND	ND
Chrysene	ug/L	8 J	ND	ND	ND	ND
Benzo[b]fluoranthene	ug/L	3 J	ND	ND	ND	ND
Benzo[k]fluoranthene	ug/L	3 J	ND	ND	ND	ND
Benzo[a]pyrene	ug/L	3 J	ND	ND	ND	ND

ug/L - microgram per liter
J - value is estimated
ND - not detected
NA - not analyzed

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 1
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL TOTAL METALS

Client Sample ID:		3-MW02IW-01	3-MW07-01	3-MW08-01
Laboratory Sample ID:		AD2156	AD2282	AD1651
Date Sampled:		12/03/94	12/01/94	12/01/94
	UNITS			
Aluminum	ug/L	ND	447	4030
Barium	ug/L	31.8 J	120	88.8
Calcium	ug/L	43600	2870	3870
Chromium	ug/L	ND	ND	31.6
Iron	ug/L	43.2	840	2190
Lead	ug/L	ND	ND	3.2 J
Magnesium	ug/L	1410	4200	2080
Manganese	ug/L	4.5 J	17.1 J	21.7 J
Nickel	ug/L	ND	ND	34.1
Potassium	ug/L	1300	1490	1900
Sodium	ug/L	15300	4750	8890
Zinc	ug/L	ND	ND	114

ug/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-13
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 1
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL DISSOLVED METALS

Client Sample ID:		3-MW02IWD-01	3-MW07D-01	3-MW08D-01
Laboratory Sample ID:		AD2166	AD2281	AD1660
Date Sampled:		12/03/94	12/01/94	12/01/94
	UNITS			
Aluminum	ug/L	ND	381	ND
Barium	ug/L	29 J	129	68.1
Calcium	ug/L	42200	3550	3390
Iron	ug/L	24.4	930	1220
Magnesium	ug/L	1370	4730	1730
Manganese	ug/L	4.9 J	20.7 J	16.2 J
Potassium	ug/L	ND	1420	ND
Sodium	ug/L	13900 J	5450	8310

ug/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-14

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
3-MW01	27.16	-	Well had insufficient water for sampling.					
12/2/94								
3-MW02	16.75	0.87	1.1	237	19	5.59	20.6	-
12/2/94			2.3	237	18	5.47	21.7	-
			3.4	232	20	5.36	21.5	-
			4.6	238	20	5.38	22.2	-
			5.7	221	20	5.27	22.5	-
3-MW03	18.16	1.1	1.4	130	21	5.61	30.3	-
12/2/94			2.7	108	21	5.16	23.9	-
			4.1	122	20	5.11	24.2	-
			5.5	130	21	5.06	23.8	-
			6.8	130	21	5.16	23.3	-
			8.2	128	21	5.10	22.0	-
3-MW04	22.26	0.86	1.2	153	17	-	-	-
12/2/94			2.3	185	15	-	-	-
			3.5	198	15	-	-	-
			4.7	189	17	5.64	17.8	-
			5.8	185	18	5.74	18.8	-
			7	189	17	5.83	17.9	-
3-MW05	25.75	1.5	1	104	18	4.49	18.9	-
12/2/94			2	106	18	4.07	20.6	-
			3	109	17	4.11	27.3	-
			4	108	18.5	4.18	23.6	-
			5	107	19	3.95	21.4	-
3-MW06	22.00	1.9	1	70	17.5	5.27	20.8	>200
12/1/94			2.1	69	18	5.36	23.9	144.2
			3.1	71	19	5.32	30.6	12.2
			4.2	68	19	5.29	31.1	3.12
			5.2	70	19	5.31	26.3	1.23
			6.3	69	18.5	5.34	28.5	0.85

TABLE 4-14 (Continued)

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (feet)[1]	Purge Volume (gallons)	Field Parameters: Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)[2]
3-MW07	14.00	1.4	1.4	135	19	5.18	22	66.2
12/1/94			2.8	128	21	5.13	21.4	3.5
			4.2	130	21	5.22	24.1	1.3
			5.6	127	22	5.12	22.3	0.64
3-MW08	18.00	1.8	1.1	37	8	6.40	15	38.5
12/1/94			2.3	51	14	5.95	16	34.6
			3.4	32	21	5.31	22.3	8.4
			4.5	29	24	5.11	24.2	1.81
			5.7	73	23	5.19	24	1.27
3-MW02IW	87.00	9.47	1.1	323	21	8.70	23.1	17.8
12/3/94			2.1	318	22	8.43	24.4	5.13
			3.2	310	25	8.14	25.7	2.98
			4.2	322	23	8.03	25.0	1.75

Notes:

(1) Measurements taken from top of PVC casing.
(2) NTU - nephelometric turbidity unit
" - " not measured

TABLE 4-15
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 2
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW02-02	3-MW02DW-01	3-MW02IW-02	3-MW04-02	3-MW06-02
Laboratory Sample ID:		AG0132	AG0126	AF6617	AF9815	AG0120
Date Sampled:		07/13/95	07/13/95	06/12/95	07/11/95	07/12/95
VOLATILES	**UNITS**					
1,1-Dichloroethene	ug/L	ND	ND	1 J	ND	ND
Chloroform	ug/L	1 J	ND	ND	ND	ND
Trichloroethene	ug/L	ND	ND	1 J	1 J	ND
Benzene	ug/L	ND	3 J	ND	ND	ND
Toluene	ug/L	ND	15 J	2 J	ND	ND
Ethylbenzene	ug/L	ND	14 J	ND	ND	ND
Xylenes (total)	ug/L	ND	32 J	ND	ND	ND
SEMIVOLATILES						
Phenol	ug/L	ND	420 J	ND	ND	ND
2-Methylphenol	ug/L	ND	300 J	ND	ND	ND
4-Methylphenol	ug/L	ND	690 J	ND	ND	ND
2,4-Dimethylphenol	ug/L	ND	170 J	ND	ND	ND
Naphthalene	ug/L	ND	2400 J	ND	ND	110
2-Methylnaphthalene	ug/L	ND	250 J	ND	ND	10
Acenaphthylene	ug/L	ND	ND	1 J	ND	ND
Acenaphthene	ug/L	ND	320 J	34	ND	24
Dibenzofuran	ug/L	ND	140 J	17	ND	25
Fluorene	ug/L	ND	160 J	23	ND	28
Phenanthrene	ug/L	ND	130 J	ND	ND	21
Anthracene	ug/L	ND	13 J	3 J	ND	1 J
Carbazole	ug/L	ND	87 J	3 J	ND	10
Fluoranthene	ug/L	ND	21 J	17	ND	2 J
Pyrene	ug/L	ND	14 J	11	ND	ND
bis(2-Ethylhexyl)phthalate	ug/L	2 J	ND	ND	ND	2 J

ug/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-15
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 2
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW07-02	3-MW09-01	3-MW11-01	3-MW11IW-01	3-MW12-01
Laboratory Sample ID:		AG0129	AG0122	AG0140	AF9801	AF9813
Date Sampled:		07/12/95	07/13/95	07/12/95	07/12/95	07/12/95
VOLATILES	**UNITS**					
1,1-Dichloroethene	ug/L	ND	ND	ND	ND	ND
Chloroform	ug/L	ND	ND	ND	1 J	ND
Trichloroethene	ug/L	ND	ND	ND	ND	1 J
Benzene	ug/L	ND	ND	ND	ND	ND
Toluene	ug/L	ND	ND	ND	ND	ND
Ethylbenzene	ug/L	ND	ND	ND	ND	ND
Xylenes (total)	ug/L	ND	ND	ND	ND	ND
SEMIVOLATILES						
Phenol	ug/L	ND	ND	ND	ND	ND
2-Methylphenol	ug/L	ND	ND	ND	ND	ND
4-Methylphenol	ug/L	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ug/L	ND	ND	ND	ND	ND
Naphthalene	ug/L	4 J	ND	ND	ND	ND
2-Methylnaphthalene	ug/L	ND	ND	ND	ND	ND
Acenaphthylene	ug/L	ND	ND	ND	ND	ND
Acenaphthene	ug/L	ND	ND	ND	ND	ND
Dibenzofuran	ug/L	ND	ND	ND	ND	ND
Fluorene	ug/L	ND	ND	ND	ND	ND
Phenanthrene	ug/L	ND	ND	ND	ND	ND
Anthracene	ug/L	ND	ND	ND	ND	ND
Carbazole	ug/L	ND	ND	ND	ND	ND
Fluoranthene	ug/L	ND	ND	ND	ND	ND
Pyrene	ug/L	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ug/L	ND	11	4 J	ND	ND

ug/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-16

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
Shallow Wells								
3-MW01	27.16	0.5	1	99	21.4	4.52	-	18.81
7/13/95			4	97	20.5	4.61	-	1.03
			5	95	20.6	4.62	-	0.30
			6	95	20.6	4.62	-	0.15
			7	96	20.3	4.64	-	0.20
3-MW02	16.75	1.2	0.8	174	23.1	4.87	-	2.60
7/13/94			1.7	182	22.9	5.35	-	2.40
			2.5	181	23.0	5.57	-	2.40
			3.3	181	23.1	5.57	-	1.90
3-MW03	18.16	1.5	1	194	23.4	6.27	-	3.40
7/13/94			1.3	185	23.5	5.95	-	3.50
			2	182	23.9	6.14	-	3.10
			3	180	23.7	6.20	-	2.60
			3.3	175	23.8	5.97	-	2.40
			3.7	179	23.0	6.00	-	2.70
3-MW04	22.26	1.1	0.9	411	25	(3)	(3)	106
7/11/95			1.4	427	21.9			83.1
			1.8	428	21.8			12.0
			2.3	431	21.4			8.3
			2.7	435	21.1			5.8
			3.2	435	21.1			2.6
			3.6	427	21.7			1.1
			4.1	432	21.1			0.8
			4.5	427	21.4			0.6
			5	434	21.2			0.4

TABLE 4-16 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
3-MW05	25.75	1.5	0.7	11	29.1	(3)	(3)	0.45
7/11/95			1.3	77	27.9			34.8
			2	84	25.5			22.3
			3	86	25.2			7.6
			3.3	85	25.1			5.1
			3.7	86	25.0			4.4
			4	87	25.1			3.6
3-MW06	22.00	1.87	0.5	87	21.0	5.67	21.9	3.91
7/12/94			1.1	83	20.5	5.85	21.2	2.14
			1.6	82	20.3	5.88	20.8	1.26
			2.1	83	20.0	5.91	20.5	2.78
			2.7	84	20.1	5.91	20.1	2.94
			3.7	84	19.8	5.86	19.9	-
			5.3	84	19.7	5.83	19.9	-
3-MW07	14.00	1.38	0.4	2059	23	5.25	24.3	0.45
7/11/95			0.7	153	21.5	5.31	22	42.7
			1.4	154	21.3	5.34	21.3	5.64
			2.2	155	20.7	5.37	20.9	2.43
			2.9	151	21.2	5.42	21.8	1.55
			3.6	149	21.3	5.44	22.4	0.95
			4.3	148	21.5	5.46	21.9	0.75
3-MW08	18.00	1.76	1	122	22.6	(3)	(3)	0.9
7/11/95			2	114	21.8			0.7
			3	114	21.5			1.0
			4	102	-			0.8
			5	110	21.4			1.0

TABLE 4-16 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No. Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Field Parameters Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
3-MW09	19.73	2.35	0.4	146	20.2	4.60	-	175.3
7/13/95			0.9	154	18.9	5.43	-	199.0
			1.3	152	19.1	5.44	-	122.2
			1.7	149	18.9	5.08	-	90.3
			2.1	144	19.1	5.25	-	82.2
			2.6	138	19.2	5.15	-	62.3
			3	135	19.2	5.40	-	50.9
			3.4	130	19.2	5.26	-	50.2
			3.8	124	19.4	5.24	-	37.2
			4.3	119	19.3	5.35	-	34.7
			4.7	117	19.6	5.40	-	37.8
			5.1	113	19.7	5.35	-	45.6
			5.5	108	21.1	5.30	-	28.7
			6.4	106	20	5.35	-	54.2
			6.8	106	19.7	5.30	-	55.2
3-MW10	20.59	2.3	0.4	82	21.2	5.01	21.4	7.0
7/12/95			0.9	79	20.3	5.07	20.1	4.6
			1.3	78	20.3	5.09	19.9	4.2
			1.7	78	20.3	5.10	19.3	3.5
			2.2	77	20.3	5.08	19.4	3.8
			2.6	77	20.2	5.12	19.3	3.4
			3	76	20.3	5.09	19.3	3.3

TABLE 4-16 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No. Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Field Parameters					
			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
3-MW11	33.28	1.7	1.2	74	30.5	7.07	30.7	147
7/12/95			1.7	82	27.4	6.45	28.1	>200
			2.4	72	27.2	6.35	27.1	>200
			2.9	68	27.8	6.26	28.8	97
			3.5	68	28.0	6.21	28.7	106
			4.1	68	28.4	6.27	28.1	179
			4.7	67	28.8	6.19	28.6	>200
			5.3	66	29.4	6.06	28.9	179
			5.9	68	28.4	6.01	28.9	>200
			6.5	68	27.7	6.05	28.1	>200
			7.1	70	27.4	6.08	28.1	50
			7.6	71	27.2	6.18	27.1	26
			8.2	72	27.2	6.19	26.9	13
			8.8	74	27.1	6.25	26.8	8
			9.4	76	27.1	6.21	26.9	5
3-MW12	21.90	1.7	0.3	100	22.4	6.49	23.1	66
7/12/95			0.6	110	22.2	6.28	23.5	5.5
			0.9	106	22.7	6.25	23.7	7.4
			1.2	102	23.1	6.18	23.4	4.5
3-MW13	23.27	1.1	0.9	280	20.5	5.05	-	2.1
7/13/95			1.4	280	20.5	5.14	-	2.1
			1.8	275	22.0	5.66	-	2.4
			2.3	284	20.5	5.66	-	2.0
			2.7	290	20.0	5.65	-	2.0
			3.2	280	22.0	5.41	-	2.6

TABLE 4-16 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
Intermediate Wells								
3-MW02IW	87.0	8.96	1	348	24.4	7.46	24.4	-
6/12/95			1.7	351	25.8	7.77	26.4	-
			2.2	359	24.6	7.82	25.2	-
			2.8	346	23.4	7.83	23.5	-
			3	343	22.4	7.70	22.6	-
03-MW11IW	87.0	9.4	0.5	Recharging				
7/12/95			1.0	673	31.8	10.24	33.4	11.94
			1.0	894	31.2	11.26	32.4	15.22
			1.2	1095	28.9	11.28	30.5	16.00
			1.3	936	27.5	11.5	28.5	13.20
			1.4	1068	28.7	11.57	30	6.64
			1.5	1227	28.4	11.73	29.5	5.02
			1.7	934	28.6	11.83	29.5	3.95
			1.9	1237	27.5	11.76	28.5	4.25
			2.2	1178	26	11.89	26.6	1
			2.6	1169	25.1	11.88	26.9	1.65
			2.8	1173	25.3	11.94	25.8	1.54
			3.0	1097	24.5	11.92	25.6	2.34
			3.2	1096	26.2	11.93	26.5	1
			3.4	1081	26.2	11.93	26.5	1.89
			3.6	1061	26.1	11.96	26.6	1.67

TABLE 4-16 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Depth of Well (feet)(1)	Purge Volume (gallons)	Field Parameters					
Date of Measurement			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
Deep Well								
03-MW02DW	142.50	17.9	0.3	267	26.1	10.74	24.2	11.3
7/13/95			0.6	283	26.7	10.82	25.2	14.5
			0.8	212	26.2	10.18	25.1	36.1
			1	198	26.3	9.87	26.1	42.0
			1.3	235	25.9	9.49	25.8	25.1
			1.6	245	25.5	9.36	25.1	17.6
			1.8	251	26.1	9.29	26.3	13.8
			2	253	26.0	9.15	26.5	12.3
			2.3	260	24.8	9.08	25.2	10.7
			2.6	267	24.7	9.06	24.6	9.9
			2.8	268	24.8	9.01	25.0	9.4
			3	261	26.3	8.96	26.3	8.4
			3.3	260	25.8	8.85	25.8	8.3
			3.6	259	26.0	8.83	26.1	8.7
3-MW02DW	142.5	17	0	285	15.3	7.34	--	2.38
1/29/95			1	297	14.5	7.44	--	1.50
			2	296	14.6	7.70	--	1.20
			3	294.5	14.8	7.66	--	0.75

(1) Measurements taken from top of PVC casing.
(2) NTU - nephelometric turbidity unit
(3) pH meter malfunctioning
" - " not measured

TABLE 4-17
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 12 (SITE 3)
GROUNDWATER - ROUND 3
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		3-MW02-03	3-MW02IW-03	3-MW06-03	3-MW09-02	3-MW11IW-02
Laboratory Sample ID:		AG9865	AG9889	AG9873	AG9879	AG9893
Date Sampled:		09/28/95	09/29/95	09/29/95	09/29/95	09/28/95
VOLATILES	**UNITS**					
Benzene	ug/L	3 J	ND	ND	ND	ND
Toluene	ug/L	11	ND	8 J	ND	ND
Ethylbenzene	ug/L	10	ND	1 J	ND	ND
Xylenes (total)	ug/L	20	ND	ND	ND	ND
SEMIVOLATILES						
Phenol	ug/L	68	ND	ND	ND	1 J
2-Methylphenol	ug/L	160 J	ND	ND	ND	ND
4-Methylphenol	ug/L	200 J	ND	ND	ND	ND
2,4-Dimethylphenol	ug/L	64 J	ND	ND	ND	ND
Naphthalene	ug/L	1500	4 J	360	ND	ND
2-Methylnaphthalene	ug/L	94	1 J	23	ND	ND
Acenaphthylene	ug/L	2 J	ND	ND	ND	ND
Acenaphthene	ug/L	45 J	25	55	ND	ND
Dibenzofuran	ug/L	120 J	29	24	ND	ND
Fluorene	ug/L	80	35	20	ND	ND
Phenanthrene	ug/L	97 J	120	23	ND	ND
Anthracene	ug/L	5 NJ	11 NJ	ND	ND	ND
Carbazole	ug/L	82	4 J	11 J	ND	ND
Fluoranthene	ug/L	10 J	28	3 J	ND	ND
Pyrene	ug/L	8 J	16	2 J	ND	ND
bis(2-Ethylhexyl)phthalate	ug/L	ND	ND	1 J	1 J	ND

ug/L - micrograms perliter
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-18
SUMMARY OF ROUND THREE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
Shallow Wells								
3-MW01	27.85	0.33	1	714	22.5	5.80	-	1.54
9/28/95			2	690	22.0	5.58	-	NA
			3	670	21.5	5.23	-	NA
3-MW02	16.45	1.0	1	174	23.1	5.92	-	42.8
9/28/94			2	182	22.9	5.98	-	39.5
			3	181	23.0	5.97	-	20.7
3-MW03	18.09	1.0	1	149	24.5	6.40	-	12.98
9/28/94			2	162	24.5	6.48	-	7.65
			3	160	24.5	6.45	-	5.92
3-MW04	25.00	1.0	1	339	20.5	6.55	-	120.6
9/28/95			2	345	20.5	6.76	-	128.7
			3	321	20.0	6.79	-	113.4
3-MW05	25.75	1.4	1	661	21.0	5.10	-	2.08
9/28/95			2	667	20.5	4.92	-	NA
			3	711	20.5	4.91	-	NA
3-MW06	22.00	1.0	1	76	21.0	6.08	-	119.0
9/29/94			2	65	21.0	5.72	-	43.5
			3	70	21.0	5.55	-	23.4
3-MW07	14.00	1.0	1	111	22.0	5.12	-	0.45
9/29/95			2	111	22.0	4.90	-	NA
			3	111	22.0	4.87	-	NA
3-MW08	18.00	1.0	1	100	25.0	5.10	-	1.64
9/29/95			2	95	24.8	4.90	-	NA
			3	90	25.0	4.85	-	NA
3-MW09	20.70	2.0	1	194	24.0	4.37	-	8.66
9/29/95			2	178	24.0	4.67	-	3.86
			3	161	24.0	4.90	-	NA

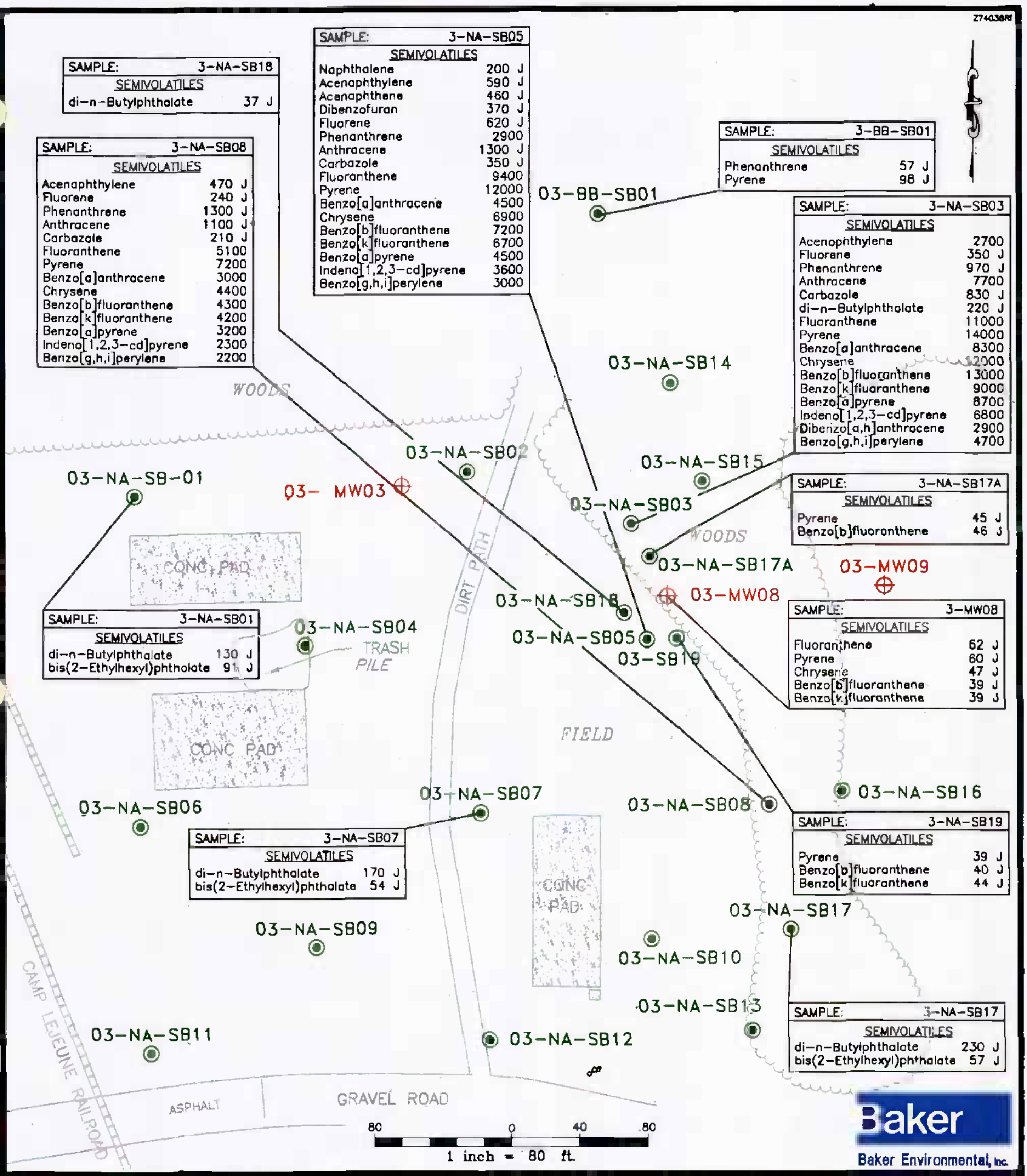
TABLE 4-18 (Continued)

SUMMARY OF ROUND THREE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)(2)
3-MW10	20.6	2.0	1	172	21.0	4.85	-	13.99
9/29/95			2	154	21.0	5.02	-	1.70
			3	141	21.0	5.11	-	NA
3-MW11	33.30	1.0	1	53	22.0	5.29	-	82.8
9/29/95			2	53	21.0	5.32	-	14.8
			3	53	21.0	5.22	-	7.68
3-MW12	21.90	0.5	1	73	24.0	5.19	-	74.3
9/29/95			2	71	24.0	5.14	-	139.5
			3	72	23.5	5.11	-	174.5
3-MW13	23.30	1.0	1	265	22.0	5.81	-	7.25
9/29/95			2	284	22.0	5.96	-	1.25
			3	307	21.2	5.96	-	NA
Intermediate Wells								
3-MW02IW	87.0	9.2	1	395	18.7	7.45	-	0.10
9/29/95			2	375	19.3	7.55	-	0.06
			3	375	19.8	7.79	-	0.07
3-MW11IW	88.26	10.0	1	691	19.6	11.29	-	5.43
9/29/95			2	478	19.1	11.13	-	3.85
			3	344	19.1	10.57	-	NA
Deep Well								
3-MW02DW	141.50	18.0	1	306	20.2	7.48	-	13.6
9/29/95			2	303	20.3	7.55	-	3.1
			3	304	19.9	7.61	-	2.9

(1) Measurements taken from top of PVC casing.
(2) NTU - nephelometric turbidity unit
(3) pH meter malfunctioning
" - " not measured

SECTION 4.0 FIGURES



SAMPLE:	3-NA-SB18
SEMIVOLATILES	
di-n-Butylphthalate	37 J

SAMPLE:	3-NA-SB05
SEMIVOLATILES	
Naphthalene	200 J
Acenaphthylene	590 J
Acenaphthene	460 J
Dibenzofuran	370 J
Fluorene	620 J
Phenanthrene	2900
Anthracene	1300 J
Carbazole	350 J
Fluoranthene	9400
Pyrene	12000
Benzo[a]anthracene	4500
Chrysene	6900
Benzo[b]fluoranthene	7200
Benzo[k]fluoranthene	6700
Benzo[a]pyrene	4500
Indeno[1,2,3-cd]pyrene	3600
Benzo[g,h,i]perylene	3000

SAMPLE:	3-BB-SB01
SEMIVOLATILES	
Phenanthrene	57 J
Pyrene	98 J

SAMPLE:	3-NA-SB08
SEMIVOLATILES	
Acenaphthylene	470 J
Fluorene	240 J
Phenanthrene	1300 J
Anthracene	1100 J
Carbazole	210 J
Fluoranthene	5100
Pyrene	7200
Benzo[a]anthracene	3000
Chrysene	4400
Benzo[b]fluoranthene	4300
Benzo[k]fluoranthene	4200
Benzo[a]pyrene	3200
Indeno[1,2,3-cd]pyrene	2300
Benzo[g,h,i]perylene	2200

SAMPLE:	3-NA-SB03
SEMIVOLATILES	
Acenaphthylene	2700
Fluorene	350 J
Phenanthrene	970 J
Anthracene	7700
Carbazole	830 J
di-n-Butylphthalate	220 J
Fluoranthene	11000
Pyrene	14000
Benzo[a]anthracene	8300
Chrysene	12000
Benzo[b]fluoranthene	13000
Benzo[k]fluoranthene	9000
Benzo[a]pyrene	8700
Indeno[1,2,3-cd]pyrene	6800
Dibenzo[a,h]anthracene	2900
Benzo[g,h,i]perylene	4700

SAMPLE:	3-NA-SB17A
SEMIVOLATILES	
Pyrene	45 J
Benzo[b]fluoranthene	46 J

SAMPLE:	3-NA-SB01
SEMIVOLATILES	
di-n-Butylphthalate	130 J
bis(2-Ethylhexyl)phthalate	91 J

SAMPLE:	3-MW08
SEMIVOLATILES	
Fluoranthene	62 J
Pyrene	60 J
Chrysene	47 J
Benzo[b]fluoranthene	39 J
Benzo[k]fluoranthene	39 J

SAMPLE:	3-NA-SB07
SEMIVOLATILES	
di-n-Butylphthalate	170 J
bis(2-Ethylhexyl)phthalate	54 J

SAMPLE:	3-NA-SB19
SEMIVOLATILES	
Pyrene	39 J
Benzo[b]fluoranthene	40 J
Benzo[k]fluoranthene	44 J

SAMPLE:	3-NA-SB17
SEMIVOLATILES	
di-n-Butylphthalate	230 J
bis(2-Ethylhexyl)phthalate	57 J

LEGEND

03-MW09 ⊕	SHALLOW MONITORING WELL/ BORING LOCATION
03-NA-SB-01 ●	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER KILOGRAM (ug/kg).

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

FIGURE 4-1
POSITIVE DETECTIONS OF SEMIVOLATILES
IN SURFACE SOILS AT SITE 3 – OLD
CREOSOTE PLANT (NORTHERN AREA)
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SAMPLE: 3-MW04

SEMIVOLATILES

Fluoranthene	46	J
Pyrene	64	J
Chrysene	54	J
Benzo[b]fluoranthene	96	J

SAMPLE: 3-TA-SB13

SEMIVOLATILES

Anthracene	75	J
di-n-Butylphthalate	340	J
Fluoranthene	71	J
Pyrene	100	J
Benzo[a]anthracene	56	J
Chrysene	120	J
bis(2-Ethylhexyl)phthalate	47	J
Benzo[b]fluoranthene	230	J
Benzo[k]fluoranthene	140	J
Benzo[a]pyrene	120	J

SAMPLE: 3-TA-SB08

SEMIVOLATILES

Anthracene	99	J
di-n-Butylphthalate	140	J
Fluoranthene	250	J
Pyrene	350	J
Benzo[a]anthracene	57	J
Chrysene	63	J
bis(2-Ethylhexyl)phthalate	47	J
Benzo[b]fluoranthene	130	J
Benzo[k]fluoranthene	90	J
Benzo[a]pyrene	75	J
Indeno[1,2,3-cd]pyrene	98	J
Dibenzo[a,h]anthracene	44	J
Benzo[g,h,i]perylene	110	J

SAMPLE: 3-TA-SB14

SEMIVOLATILES

Acenaphthylene	61	J
Phenanthrene	130	J
Anthracene	250	J
Carbazole	66	J
di-n-Butylphthalate	160	J
Fluoranthene	380	
Pyrene	330	J
Benzo[a]anthracene	110	J
Chrysene	180	J
bis(2-Ethylhexyl)phthalate	51	J
Benzo[b]fluoranthene	310	J
Benzo[k]fluoranthene	150	J
Benzo[a]pyrene	110	J
Indeno[1,2,3-cd]pyrene	140	J
Dibenzo[a,h]anthracene	64	J
Benzo[g,h,i]perylene	39	J

SAMPLE: 3-TA-SB40

SEMIVOLATILES

di-n-Butylphthalate	140	J
bis(2-Ethylhexyl)phthalate	44	J
Benzo[k]fluoranthene	37	J

SAMPLE: 3-CP-SB04

SEMIVOLATILES

di-n-Butylphthalate	64	J
bis(2-Ethylhexyl)phthalate	65	J

SAMPLE: 3-TA-SB34

SEMIVOLATILES

Anthracene	46	J
di-n-Butylphthalate	150	J
Fluoranthene	42	J
Pyrene	58	J
Chrysene	50	J
bis(2-Ethylhexyl)phthalate	46	J
Benzo[b]fluoranthene	120	J
Benzo[k]fluoranthene	57	J
Benzo[a]pyrene	66	J
Indeno[1,2,3-cd]pyrene	68	J
Benzo[g,h,i]perylene	77	J

SAMPLE: 3-CP-SB09

SEMIVOLATILES

di-n-Butylphthalate	70	J
bis(2-Ethylhexyl)phthalate	42	J

SAMPLE: 3-TA-SB12

SEMIVOLATILES

Anthracene	40	J
di-n-Butylphthalate	54	J
Fluoranthene	48	J
Pyrene	48	J
Chrysene	48	J
bis(2-Ethylhexyl)phthalate	41	J
Benzo[b]fluoranthene	89	J
Benzo[k]fluoranthene	56	J
Benzo[a]pyrene	55	J
Indeno[1,2,3-cd]pyrene	47	J
Benzo[g,h,i]perylene	51	J

SAMPLE: 3-TA-SB10

SEMIVOLATILES

Acenaphthylene	64	J
Anthracene	130	J
Carbazole	45	J
di-n-Butylphthalate	190	J
Fluoranthene	120	J
Pyrene	160	J
Benzo[a]anthracene	81	J
Chrysene	240	J
bis(2-Ethylhexyl)phthalate	42	J
Benzo[b]fluoranthene	350	J
Benzo[k]fluoranthene	180	J
Benzo[a]pyrene	140	J
Indeno[1,2,3-cd]pyrene	180	J
Dibenzo[a,h]anthracene	63	J
Benzo[g,h,i]perylene	160	J

SAMPLE: 3-TA-SB18

SEMIVOLATILES

Acenaphthylene	58	J
Fluorene	39	J
Phenanthrene	67	J
Anthracene	2600	
Carbazole	220	J
di-n-Butylphthalate	90	J
Fluoranthene	110	J
Pyrene	49	J
Benzo[a]anthracene	71	J
Chrysene	150	J
bis(2-Ethylhexyl)phthalate	66	J
Benzo[b]fluoranthene	160	J
Benzo[k]fluoranthene	130	J
Indeno[1,2,3-cd]pyrene	40	J
Dibenzo[a,h]anthracene	44	J

SAMPLE: 3-TA-SB41

SEMIVOLATILES

di-n-Butylphthalate	270	J
Fluoranthene	75	J
Pyrene	110	J
Chrysene	92	J
bis(2-Ethylhexyl)phthalate	51	J
Benzo[b]fluoranthene	200	J
Benzo[k]fluoranthene	130	J
Benzo[a]pyrene	97	J
Indeno[1,2,3-cd]pyrene	96	J
Benzo[g,h,i]perylene	94	J

Sample: 3-MW12

SEMIVOLATILES

di-n-Butylphthalate	50	J

SAMPLE: 3-CP-SB02

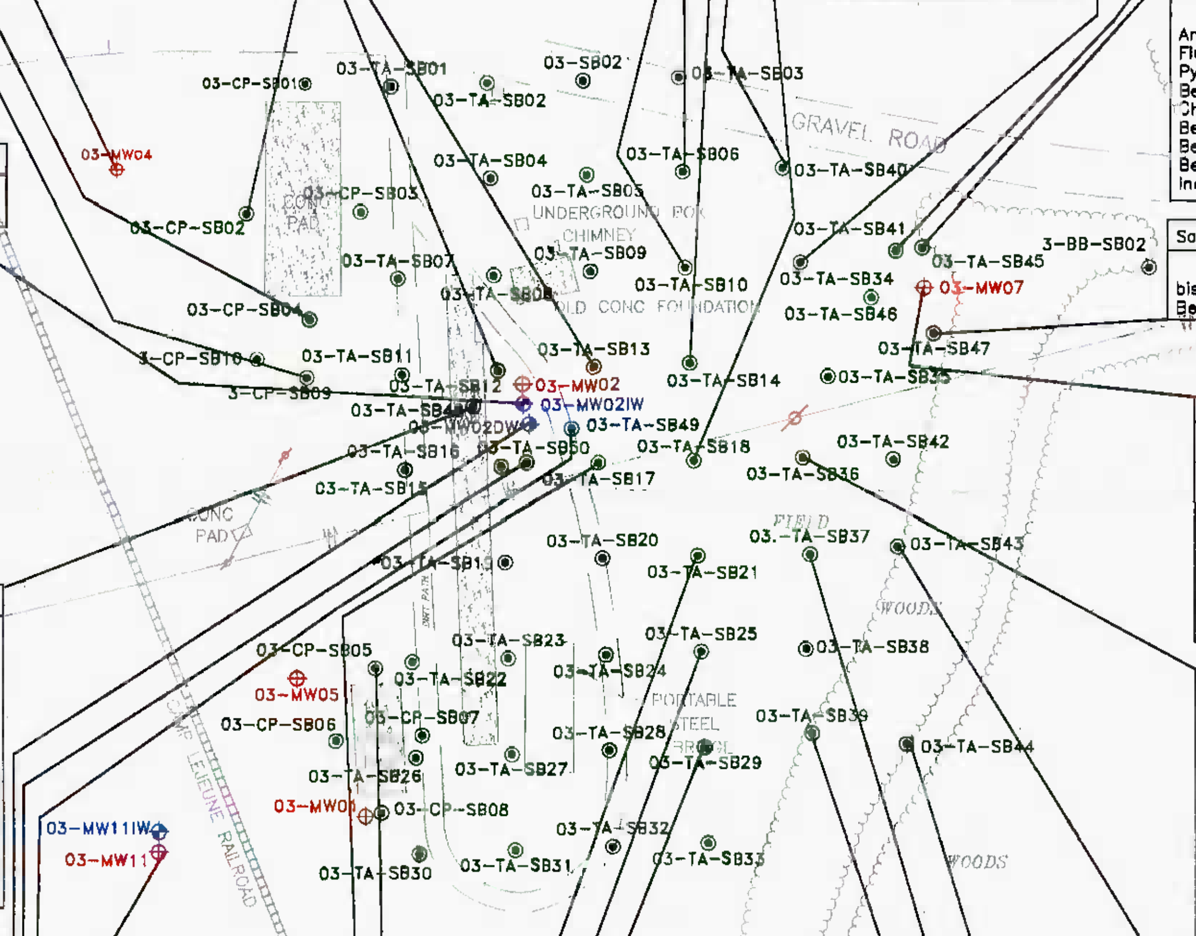
SEMIVOLATILES

di-n-Butylphthalate	170	J
bis(2-Ethylhexyl)phthalate	43	J

Sample: 3-TA-SB45

SEMIVOLATILES

Anthracene	48	J
Fluoranthene	54	J
Pyrene	93	J
Benzo[a]anthracene	47	J
Chrysene	80	J
Benzo[b]fluoranthene	130	J
Benzo[k]fluoranthene	160	J
Benzo[a]pyrene	70	J
Indeno[1,2,3-cd]pyrene	74	J



Sample: 3-MW13

VOLATILES

Toluene	2	J

Sample: 3-TA-SB47

SEMIVOLATILES

bis(2-Ethylhexyl)phthalate	63	J
Benzo[k]fluoranthene	46	J

SAMPLE: 3-MW02IW

VOLATILES

Toluene	2	J

SEMIVOLATILES

Anthracene	49	J
di-n-Butylphthalate	110	J
Fluoranthene	55	J
Pyrene	86	J
Benzo[a]anthracene	32	J
Chrysene	64	J
Benzo[b]fluoranthene	120	J
Benzo[k]fluoranthene	83	J
Benzo[a]pyrene	59	J
Indeno[1,2,3-cd]pyrene	65	J
Benzo[g,h,i]perylene	52	J

SAMPLE: 3-MW07

SEMIVOLATILES

Anthracene	110	J
Carbazole	45	J
Fluoranthene	91	J
Pyrene	100	J
Benzo[a]anthracene	42	J
Chrysene	81	J
Benzo[b]fluoranthene	100	J
Benzo[k]fluoranthene	120	J
Benzo[a]pyrene	57	J
Indeno[1,2,3-cd]pyrene	68	J

Sample: 3-TA-SB48

SEMIVOLATILES

Acenaphthylene	46	J
Anthracene	85	J
Carbazole	56	J
di-n-Butylphthalate	44	J
Fluoranthene	190	J
Pyrene	270	J
Benzo[a]anthracene	230	J
Chrysene	380	
Benzo[b]fluoranthene	400	
Benzo[k]fluoranthene	460	
Benzo[a]pyrene	220	J
Indeno[1,2,3-cd]pyrene	180	J
Dibenz[a,h]anthracene	67	J
Benzo[g,h,i]perylene	180	J

SAMPLE: 3-TA-SB36

SEMIVOLATILES

Acenaphthylene	40	J
Anthracene	70	J
di-n-Butylphthalate	77	J
Fluoranthene	74	J
Pyrene	91	J
Chrysene	74	J
bis(2-Ethylhexyl)phthalate	58	J
Benzo[b]fluoranthene	120	J
Benzo[k]fluoranthene	100	J
Benzo[a]pyrene	72	J
Indeno[1,2,3-cd]pyrene	88	J
Dibenzo[a,h]anthracene	40	J
Benzo[g,h,i]perylene	90	J

Sample: 3-MW02DW

SEMIVOLATILES

Benzo[b]fluoranthene	210	J

SAMPLE: 3-TA-SB43

SEMIVOLATILES

Phenanthrene	37	J
Anthracene	80	J
di-n-Butylphthalate	130	J
Fluoranthene	350	J
Pyrene	670	
Benzo[a]anthracene	260	J
Chrysene	540	
bis(2-Ethylhexyl)phthalate	51	J
Benzo[b]fluoranthene	860	
Benzo[a]pyrene	280	J
Indeno[1,2,3-cd]pyrene	280	J
Dibenzo[a,h]anthracene	150	J
Benzo[g,h,i]perylene	200	J

SAMPLE: 3-TA-SB29

SEMIVOLATILES

Acenaphthylene	68	J
Anthracene	120	J
Carbazole	40	J
di-n-Butylphthalate	210	J
Fluoranthene	130	J
Pyrene	160	J
Benzo[a]anthracene	72	J
Chrysene	140	J
bis(2-Ethylhexyl)phthalate	47	J
Benzo[b]fluoranthene	300	J
Benzo[k]fluoranthene	180	J
Benzo[a]pyrene	150	J
Indeno[1,2,3-cd]pyrene	210	J
Dibenzo[a,h]anthracene	72	J
Benzo[g,h,i]perylene	200	J

SAMPLE: 3-TA-SB17

SEMIVOLATILES

Anthracene	63	J
di-n-Butylphthalate	210	J
Fluoranthene	42	J
Chrysene	40	J
bis(2-Ethylhexyl)phthalate	50	J
Benzo[b]fluoranthene	97	J
Benzo[k]fluoranthene	80	J

Sample: 3-TA-SB50

VOLATILES

Ethylbenzene	2	J
Xylenes (total)	6	J

Sample: 3-TA-SB49

SEMIVOLATILES

di-n-Butylphthalate	38	J
Pyrene	41	J
Benzo[b]fluoranthene	60	J
Benzo[k]fluoranthene	64	J
Benzo[a]pyrene	57	J
Indeno[1,2,3-cd]pyrene	43	J
Benzo[g,h,i]perylene	48	J

SAMPLE: 3-CP-SB05

SEMIVOLATILES

di-n-Butylphthalate	92	J
bis(2-Ethylhexyl)phthalate	43	J

SAMPLE: 3-TA-SB44

SEMIVOLATILES

di-n-Butylphthalate	190	J

Sample: 3-MW11

SEMIVOLATILES

Acenaphthylene	290	J
Anthracene	290	J
Fluoranthene	530	J
Pyrene	1700	J
Benzo[a]anthracene	1800	J
Chrysene	3300	
Benzo[b]fluoranthene	3800	
Benzo[k]fluoranthene	2000	
Benzo[a]pyrene	2000	
Indeno[1,2,3-cd]pyrene	940	J
Dibenz[c,h]anthracene	390	J
Benzo[g,h,i]perylene	690	J

SAMPLE: 3-TA-SB21

SEMIVOLATILES

Acenaphthylene	58	J
Phenanthrene	55	J
Anthracene	190	J
Carbazole	63	J
di-n-Butylphthalate	96	J
Fluoranthene	410	J
Pyrene	320	J
Benzo[a]anthracene	120	J
Chrysene	230	J
bis(2-Ethylhexyl)phthalate	36	J
Benzo[b]fluoranthene	350	J
Benzo[k]fluoranthene	200	J
Benzo[a]pyrene	89	J
Indeno[1,2,3-cd]pyrene	130	J
Dibenzo[a,h]anthracene	68	J

SAMPLE: 3-TA-SB25

SEMIVOLATILES

Acenaphthylene	70	J
Anthracene	160	J
Carbazole	47	J
di-n-Butylphthalate	100	J
Fluoranthene	310	J
Pyrene	360	J
Benzo[a]anthracene	160	J
Chrysene	230	J
bis(2-Ethylhexyl)phthalate	41	J
Benzo[b]fluoranthene	430	
Benzo[k]fluoranthene	270	J
Benzo[a]pyrene	230	J
Indeno[1,2,3-cd]pyrene	230	J
Dibenzo[a,h]anthracene	91	J
Benzo[g,h,i]perylene	250	J

SAMPLE: 3-TA-SB39

SEMIVOLATILES

Phenanthrene	41	J
di-n-Butylphthalate	160	J
Fluoranthene	200	J
Pyrene	280	J
Benzo[a]anthracene	94	J
Chrysene	170	J
bis(2-Ethylhexyl)phthalate	52	J
Benzo[b]fluoranthene	250	J
Benzo[k]fluoranthene	210	J
Benzo[a]pyrene	130	J

SAMPLE: 3-TA-SB37

SEMIVOLATILES

Anthracene	100	J
di-n-Butylphthalate	170	J
Fluoranthene	760	
Pyrene	1200	
Benzo[a]anthracene	800	
Chrysene	880	
Benzo[b]fluoranthene	1000	
Benzo[k]fluoranthene	670	
Benzo[a]pyrene	510	

100 0 50 100

1 inch = 100 ft.

274037RI

LEGEND

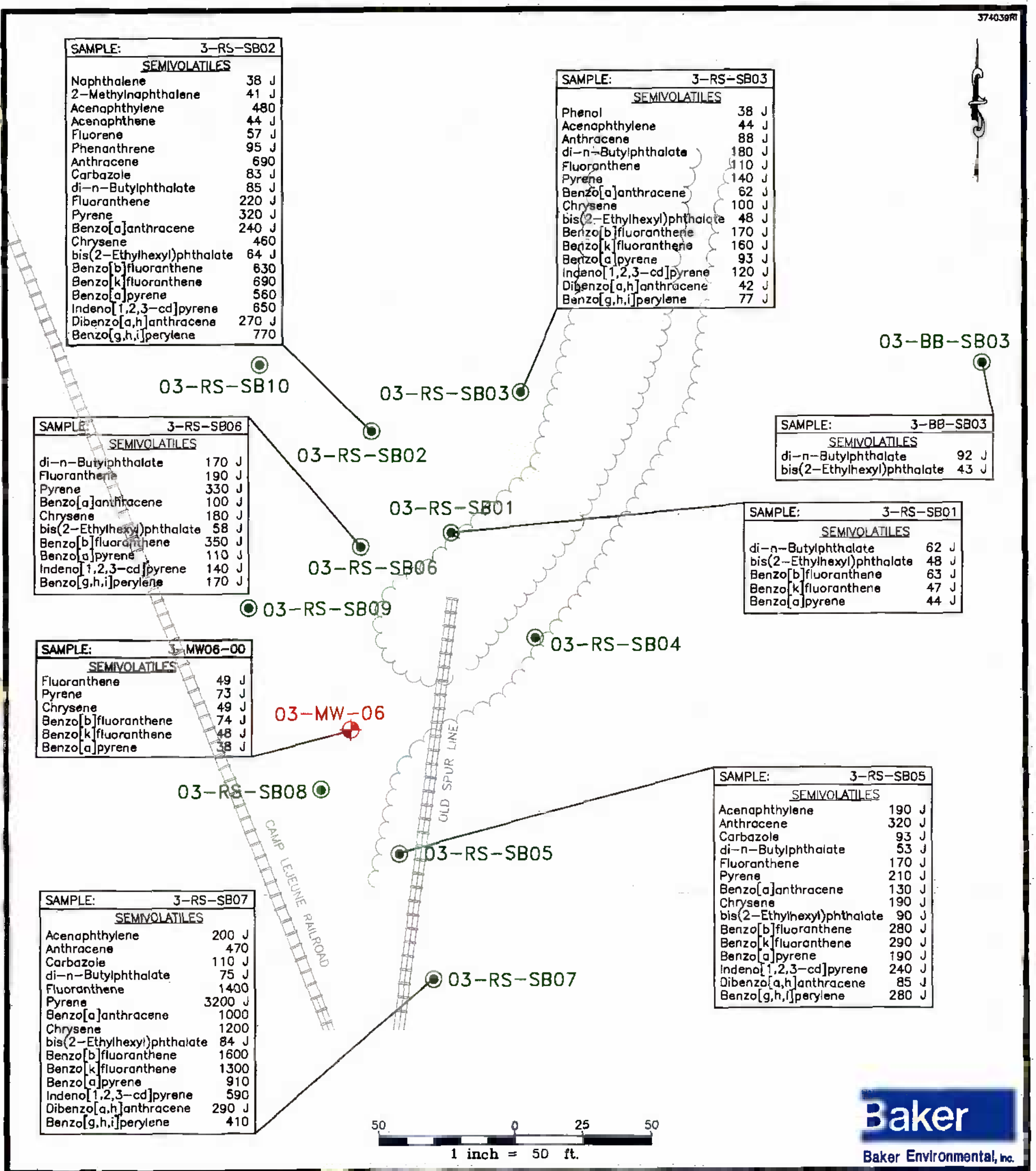
03-MW02	SHALLOW MONITORING WELL/BORING LOCATION
03-MW02IW	INTERMEDIATE MONITORING WELL/BORING LOCATION
03-MW02DW	DEEP MONITORING WELL/BORING LOCATION
03-CP-SB01	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER KILOGRAM (ug/kg)

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-2
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES IN SURFACE SOILS AT SITE 3 - OLD CREOSOTE PLANT (TREATMENT AREA)
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

374039RI



SAMPLE: 3-RS-SB02

SEMIVOLATILES

Naphthalene	38	J
2-Methylnaphthalene	41	J
Acenaphthylene	480	
Acenaphthene	44	J
Fluorene	57	J
Phenanthrene	95	J
Anthracene	690	
Carbazole	83	J
di-n-Butylphthalate	85	J
Fluoranthene	220	J
Pyrene	320	J
Benzo[a]anthracene	240	J
Chrysene	460	
bis(2-Ethylhexyl)phthalate	64	J
Benzo[b]fluoranthene	630	
Benzo[k]fluoranthene	690	
Benzo[a]pyrene	560	
Indeno[1,2,3-cd]pyrene	650	
Dibenzo[a,h]anthracene	270	J
Benzo[g,h,i]perylene	770	

SAMPLE: 3-RS-SB03

SEMIVOLATILES

Phenol	38	J
Acenaphthylene	44	J
Anthracene	88	J
di-n-Butylphthalate	180	J
Fluoranthene	110	J
Pyrene	140	J
Benzo[a]anthracene	62	J
Chrysene	100	J
bis(2-Ethylhexyl)phthalate	48	J
Benzo[b]fluoranthene	170	J
Benzo[k]fluoranthene	160	J
Benzo[a]pyrene	93	J
Indeno[1,2,3-cd]pyrene	120	J
Dibenzo[a,h]anthracene	42	J
Benzo[g,h,i]perylene	77	J

SAMPLE: 3-BB-SB03

SEMIVOLATILES

di-n-Butylphthalate	92	J
bis(2-Ethylhexyl)phthalate	43	J

SAMPLE: 3-RS-SB06

SEMIVOLATILES

di-n-Butylphthalate	170	J
Fluoranthene	190	J
Pyrene	330	J
Benzo[a]anthracene	100	J
Chrysene	180	J
bis(2-Ethylhexyl)phthalate	58	J
Benzo[b]fluoranthene	350	J
Benzo[a]pyrene	110	J
Indeno[1,2,3-cd]pyrene	140	J
Benzo[g,h,i]perylene	170	J

SAMPLE: 3-RS-SB01

SEMIVOLATILES

di-n-Butylphthalate	62	J
bis(2-Ethylhexyl)phthalate	48	J
Benzo[b]fluoranthene	63	J
Benzo[k]fluoranthene	47	J
Benzo[a]pyrene	44	J

SAMPLE: 3-MW06-00

SEMIVOLATILES

Fluoranthene	49	J
Pyrene	73	J
Chrysene	49	J
Benzo[b]fluoranthene	74	J
Benzo[k]fluoranthene	48	J
Benzo[a]pyrene	38	J

SAMPLE: 3-RS-SB05

SEMIVOLATILES

Acenaphthylene	190	J
Anthracene	320	J
Carbazole	93	J
di-n-Butylphthalate	53	J
Fluoranthene	170	J
Pyrene	210	J
Benzo[a]anthracene	130	J
Chrysene	190	J
bis(2-Ethylhexyl)phthalate	90	J
Benzo[b]fluoranthene	280	J
Benzo[k]fluoranthene	290	J
Benzo[a]pyrene	190	J
Indeno[1,2,3-cd]pyrene	240	J
Dibenzo[a,h]anthracene	85	J
Benzo[g,h,i]perylene	280	J

SAMPLE: 3-RS-SB07

SEMIVOLATILES

Acenaphthylene	200	J
Anthracene	470	
Carbazole	110	J
di-n-Butylphthalate	75	J
Fluoranthene	1400	
Pyrene	3200	J
Benzo[a]anthracene	1000	
Chrysene	1200	
bis(2-Ethylhexyl)phthalate	84	J
Benzo[b]fluoranthene	1600	
Benzo[k]fluoranthene	1300	
Benzo[a]pyrene	910	
Indeno[1,2,3-cd]pyrene	590	
Dibenzo[a,h]anthracene	290	J
Benzo[g,h,i]perylene	410	

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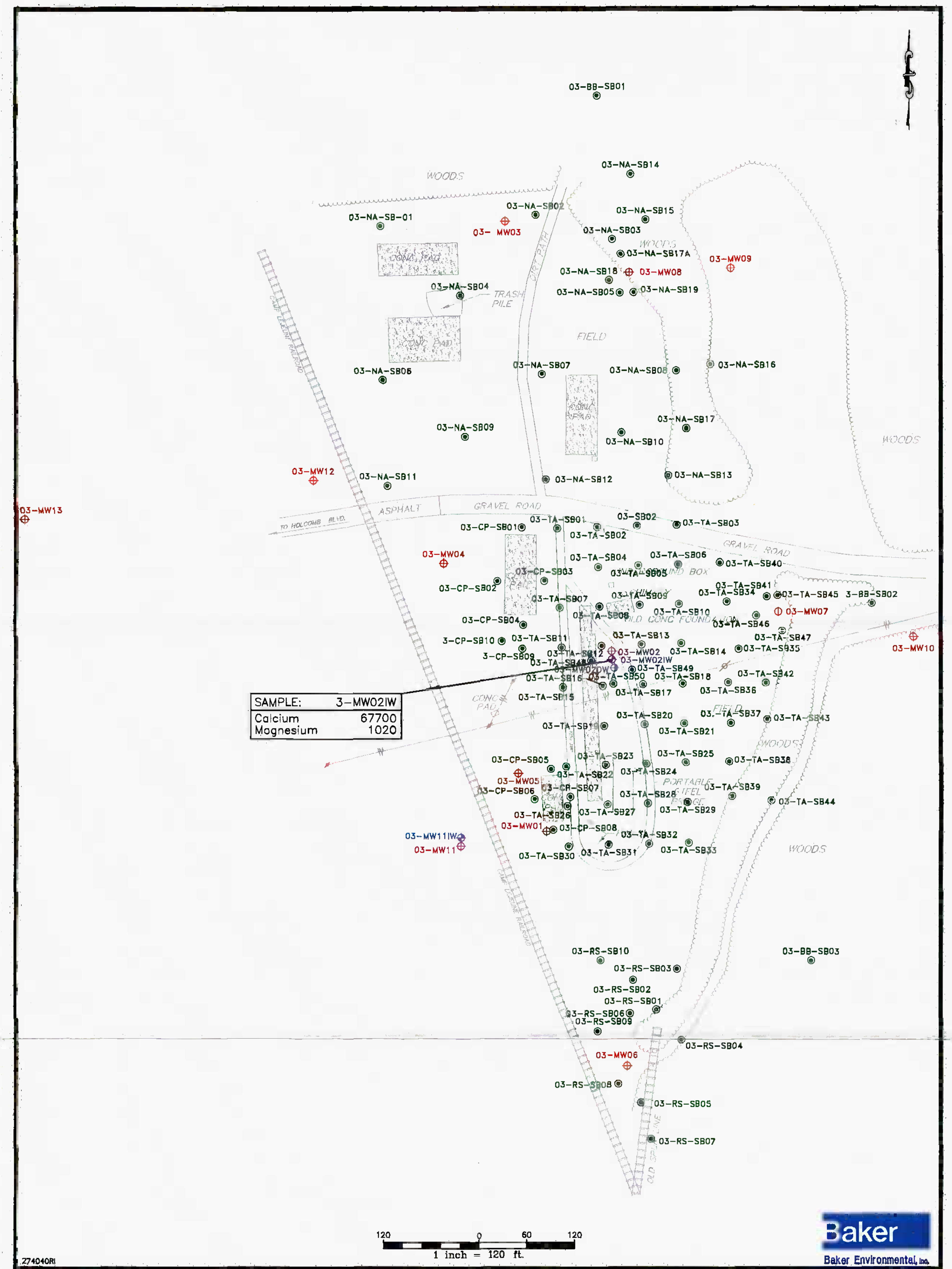
LEGEND

03-MW-06	MONITORING WELL LOCATION
03-RS-SB01	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-3
POSITIVE DETECTIONS OF SEMIVOLATILES IN SURFACE SOILS AT SITE 3 – OLD CREOSOTE PLANT (RAIL SPUR AREA)
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SAMPLE:	3-MW02IW
Calcium	67700
Magnesium	1020

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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

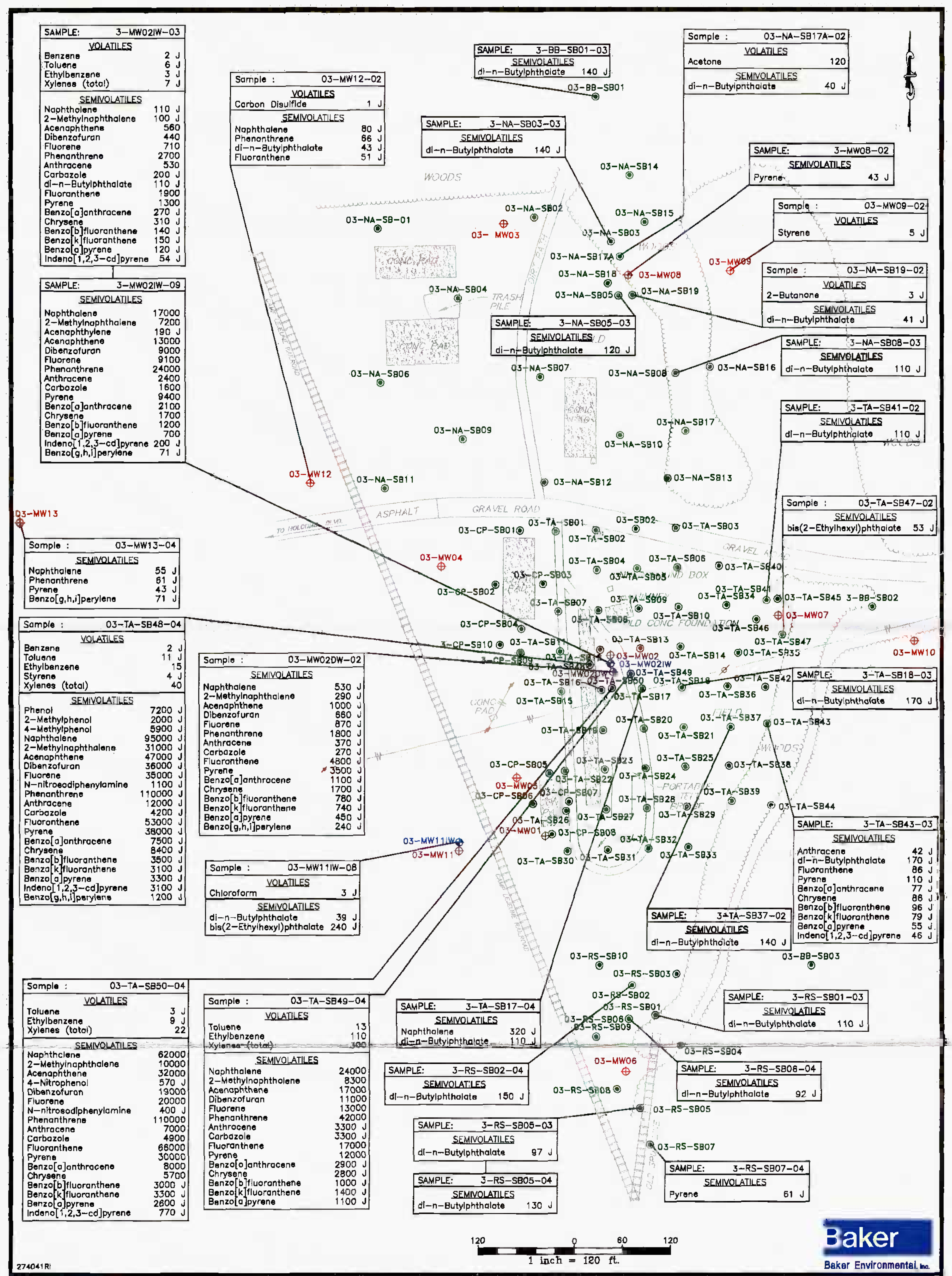
NOTE:

-SAMPLE CONCENTRATIONS SHOWN IN MILLIGRAMS PER KILOGRAM (mg/kg).

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

FIGURE 4-4

POSITIVE DETECTIONS OF INORGANICS IN SURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SAMPLE:	3-MW02IW-03
VOLATILES	
Benzene	2 J
Toluene	6 J
Ethylbenzene	3 J
Xylenes (total)	7 J
SEMIVOLATILES	
Naphthalene	110 J
2-Methylnaphthalene	100 J
Acenaphthene	560
Dibenzofuran	440
Fluorene	710
Phenanthrene	2700
Anthracene	530
Carbazole	200 J
di-n-Butylphthalate	110 J
Fluoranthene	1900
Pyrene	1300
Benzo[a]anthracene	270 J
Chrysene	310 J
Benzo[b]fluoranthene	140 J
Benzo[k]fluoranthene	150 J
Benzo[a]pyrene	120 J
Indeno[1,2,3-cd]pyrene	54 J

SAMPLE:	3-MW02IW-09
SEMIVOLATILES	
Naphthalene	17000
2-Methylnaphthalene	7200
Acenaphthylene	190 J
Acenaphthene	13000
Dibenzofuran	9000
Fluorene	9100
Phenanthrene	24000
Anthracene	2400
Carbazole	1600
Pyrene	9400
Benzo[a]anthracene	2100
Chrysene	1700
Benzo[b]fluoranthene	1200
Benzo[a]pyrene	700
Indeno[1,2,3-cd]pyrene	200 J
Benzo[g,h,i]perylene	71 J

Sample :	03-MW12-02
VOLATILES	
Carbon Disulfide	1 J
SEMIVOLATILES	
Naphthalene	80 J
Phenanthrene	66 J
di-n-Butylphthalate	43 J
Fluoranthene	51 J

SAMPLE:	3-BB-SB01-03
SEMIVOLATILES	
di-n-Butylphthalate	140 J

SAMPLE:	3-NA-SB03-03
SEMIVOLATILES	
di-n-Butylphthalate	140 J

Sample :	03-NA-SB17A-02
VOLATILES	
Acetone	120
SEMIVOLATILES	
di-n-Butylphthalate	40 J

SAMPLE:	3-MW08-02
SEMIVOLATILES	
Pyrene	43 J

Sample :	03-MW09-02
VOLATILES	
Styrene	5 J

Sample :	03-NA-SB19-02
VOLATILES	
2-Butanone	3 J
SEMIVOLATILES	
di-n-Butylphthalate	41 J

SAMPLE:	3-NA-SB05-03
SEMIVOLATILES	
di-n-Butylphthalate	120 J

SAMPLE:	3-NA-SB08-03
SEMIVOLATILES	
di-n-Butylphthalate	110 J

SAMPLE:	3-TA-SB41-02
SEMIVOLATILES	
di-n-Butylphthalate	110 J

Sample :	03-TA-SB47-02
SEMIVOLATILES	
bis(2-Ethylhexyl)phthalate	53 J

Sample :	03-MW13-04
SEMIVOLATILES	
Naphthalene	55 J
Phenanthrene	61 J
Pyrene	43 J
Benzo[g,h,i]perylene	71 J

Sample :	03-TA-SB48-04
VOLATILES	
Benzene	2 J
Toluene	11 J
Ethylbenzene	15
Styrene	4 J
Xylenes (total)	40
SEMIVOLATILES	
Phenol	7200 J
2-Methylphenol	2000 J
4-Methylphenol	5900 J
Naphthalene	95000 J
2-Methylnaphthalene	31000 J
Acenaphthene	47000 J
Dibenzofuran	36000 J
Fluorene	35000 J
N-nitroeodiphenylamine	1100 J
Phenanthrene	110000 J
Anthracene	12000 J
Carbazole	4200 J
Fluoranthene	53000 J
Pyrene	38000 J
Benzo[a]anthracene	7500 J
Chrysene	8400 J
Benzo[b]fluoranthene	3500 J
Benzo[k]fluoranthene	3100 J
Benzo[a]pyrene	3300 J
Indeno[1,2,3-cd]pyrene	3100 J
Benzo[g,h,i]perylene	1200 J

Sample :	03-MW02DW-02
SEMIVOLATILES	
Naphthalene	530 J
2-Methylnaphthalene	290 J
Acenaphthene	1000 J
Dibenzofuran	660 J
Fluorene	870 J
Phenanthrene	1800 J
Anthracene	370 J
Carbazole	270 J
Fluoranthene	4800 J
Pyrene	3500 J
Benzo[a]anthracene	1100 J
Chrysene	1700 J
Benzo[b]fluoranthene	780 J
Benzo[k]fluoranthene	740 J
Benzo[a]pyrene	450 J
Benzo[g,h,i]perylene	240 J

Sample :	03-MW11IW-08
VOLATILES	
Chloroform	3 J
SEMIVOLATILES	
di-n-Butylphthalate	39 J
bis(2-Ethylhexyl)phthalate	240 J

Sample :	03-TA-SB50-04
VOLATILES	
Toluene	3 J
Ethylbenzene	9 J
Xylenes (total)	22
SEMIVOLATILES	
Naphthalene	62000
2-Methylnaphthalene	10000
Acenaphthene	32000
4-Nitrophenol	570 J
Dibenzofuran	19000
Fluorene	20000
N-nitrosodiphenylamine	400 J
Phenanthrene	110000
Anthracene	7000
Carbazole	4900
Fluoranthene	66000
Pyrene	30000
Benzo[a]anthracene	8000
Chrysene	5700
Benzo[b]fluoranthene	3000 J
Benzo[k]fluoranthene	3300 J
Benzo[a]pyrene	2600 J
Indeno[1,2,3-cd]pyrene	770 J

Sample :	03-TA-SB49-04
VOLATILES	
Toluene	13
Ethylbenzene	110
Xylenes (total)	300
SEMIVOLATILES	
Naphthalene	24000
2-Methylnaphthalene	8300
Acenaphthene	17000
Dibenzofuran	11000
Fluorene	13000
Phenanthrene	42000
Anthracene	3300 J
Carbazole	3300 J
Fluoranthene	17000
Pyrene	12000
Benzo[a]anthracene	2900 J
Chrysene	2800 J
Benzo[b]fluoranthene	1000 J
Benzo[k]fluoranthene	1400 J
Benzo[a]pyrene	1100 J

SAMPLE:	3-TA-SB18-03
SEMIVOLATILES	
di-n-Butylphthalate	170 J

SAMPLE:	3-TA-SB43-03
SEMIVOLATILES	
Anthracene	42 J
di-n-Butylphthalate	170 J
Fluoranthene	86 J
Pyrene	110 J
Benzo[a]anthracene	77 J
Chrysene	88 J
Benzo[b]fluoranthene	96 J
Benzo[k]fluoranthene	79 J
Benzo[a]pyrene	55 J
Indeno[1,2,3-cd]pyrene	46 J

SAMPLE:	3-TA-SB37-02
SEMIVOLATILES	
di-n-Butylphthalate	140 J

SAMPLE:	3-TA-SB17-04
SEMIVOLATILES	
Naphthalene	320 J
di-n-Butylphthalate	110 J

SAMPLE:	3-RS-SB01-03
SEMIVOLATILES	
di-n-Butylphthalate	110 J

SAMPLE:	3-RS-SB02-04
SEMIVOLATILES	
di-n-Butylphthalate	150 J

SAMPLE:	3-RS-SB06-04
SEMIVOLATILES	
di-n-Butylphthalate	92 J

SAMPLE:	3-RS-SB05-03
SEMIVOLATILES	
di-n-Butylphthalate	97 J

SAMPLE:	3-RS-SB05-04
SEMIVOLATILES	
di-n-Butylphthalate	130 J

SAMPLE:	3-RS-SB07-04
SEMIVOLATILES	
Pyrene	61 J

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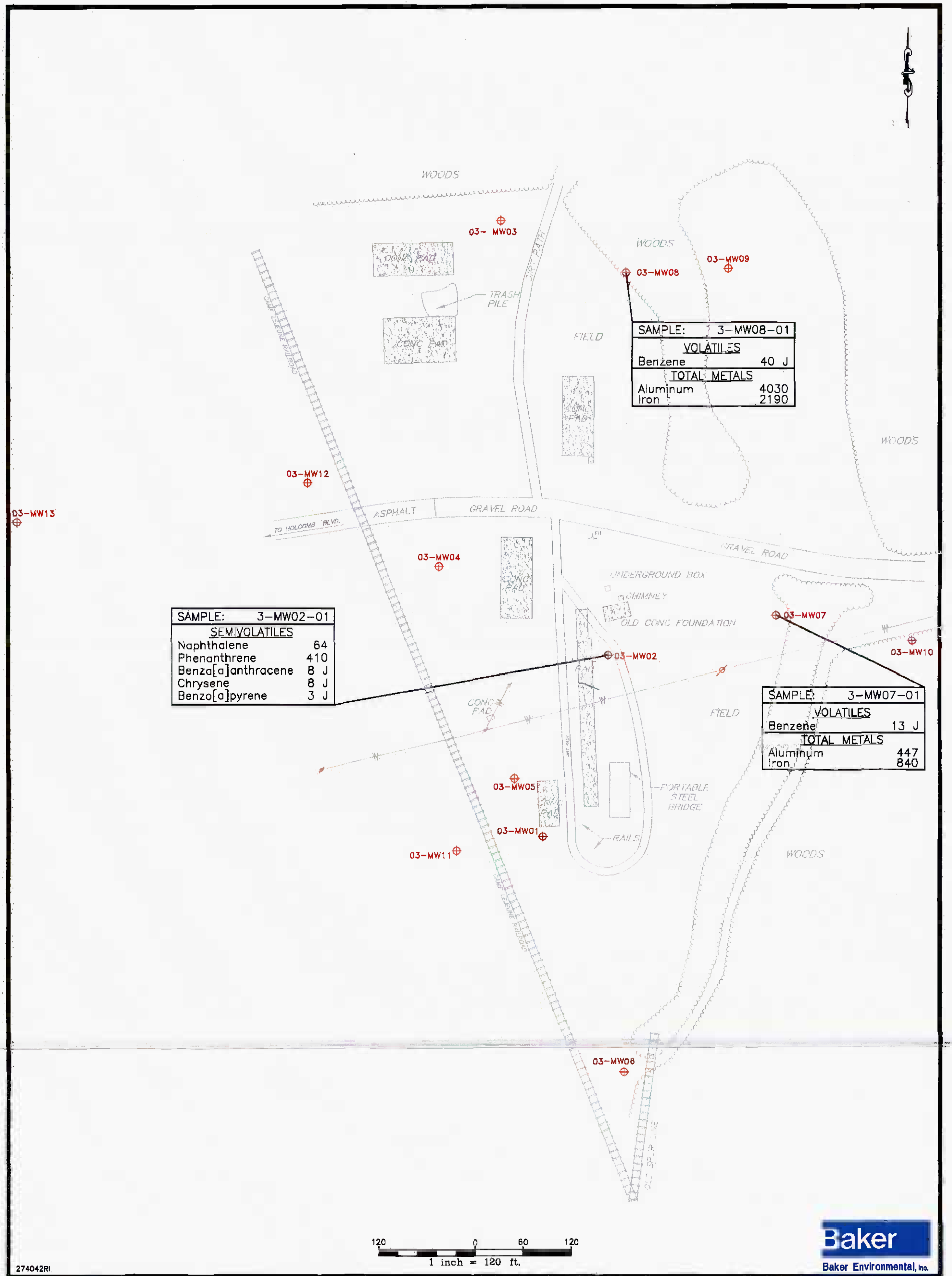
LEGEND

03-MW01 ⊕	SHALLOW MONITORING WELL LOCATION
03-MW02IW ⊕	INTERMEDIATE MONITORING WELL LOCATION
03-MW02DW ⊕	DEEP MONITORING WELL LOCATION
03-RS-SB01 ◉	SOIL BORING LOCATION

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

FIGURE 4-5
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES IN SUBSURFACE SOILS AT SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SAMPLE:	3-MW08-01
VOLATILES	
Benzene	40 J
TOTAL METALS	
Aluminum	4030
Iron	2190

SAMPLE:	3-MW02-01
SEMIVOLATILES	
Naphthalene	64
Phenanthrene	410
Benza[a]anthracene	8 J
Chrysene	8 J
Benzo[a]pyrene	3 J

SAMPLE:	3-MW07-01
VOLATILES	
Benzene	13 J
TOTAL METALS	
Aluminum	447
Iron	840

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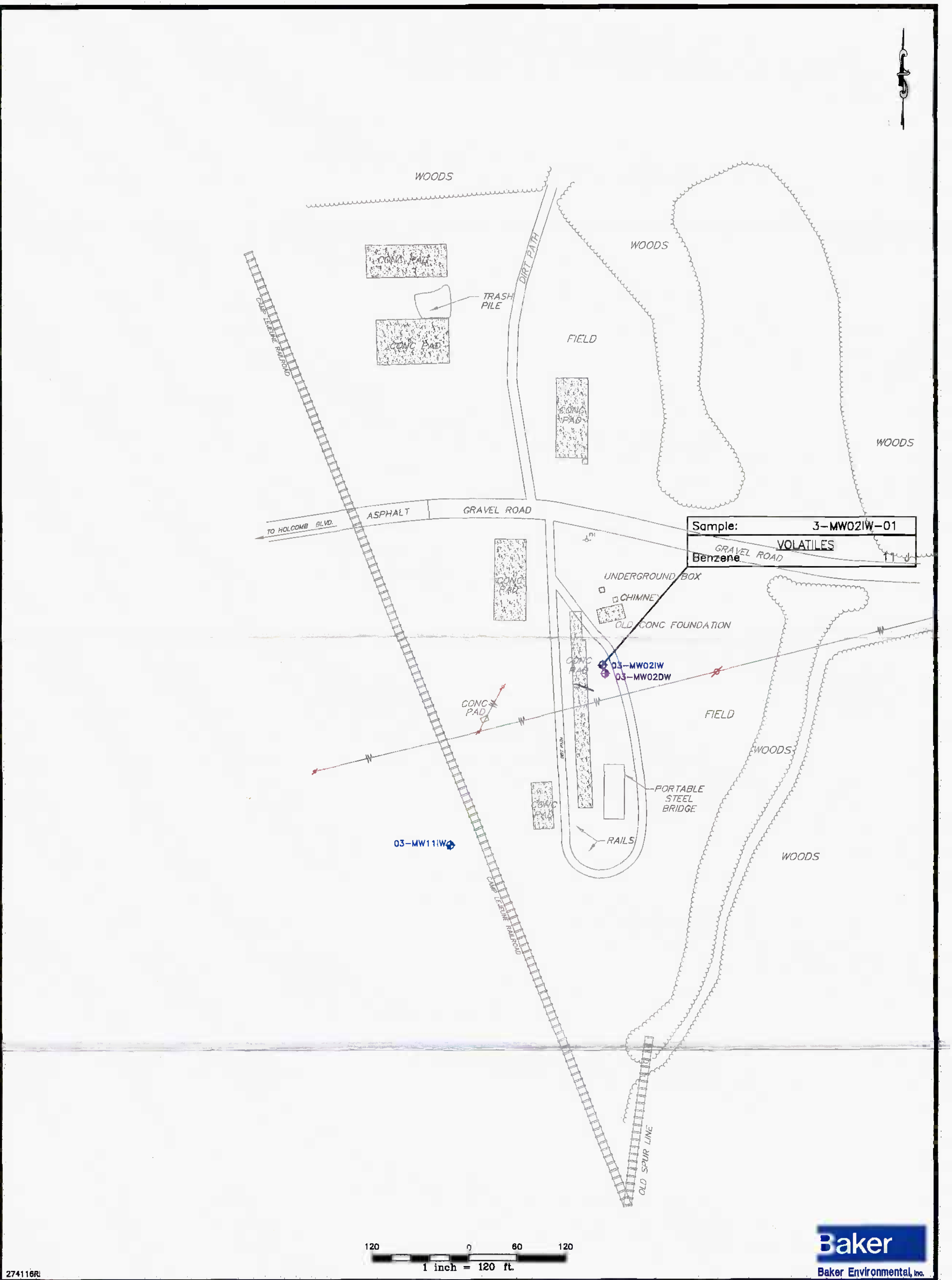
LEGEND

03-MW01 ⊕	SHALLOW MONITORING WELL LOCATION

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

FIGURE 4-6
POSITIVE DETECTIONS OF VOLATILES, SEMIVOLATILES, AND TOTAL METALS FOR ROUND ONE ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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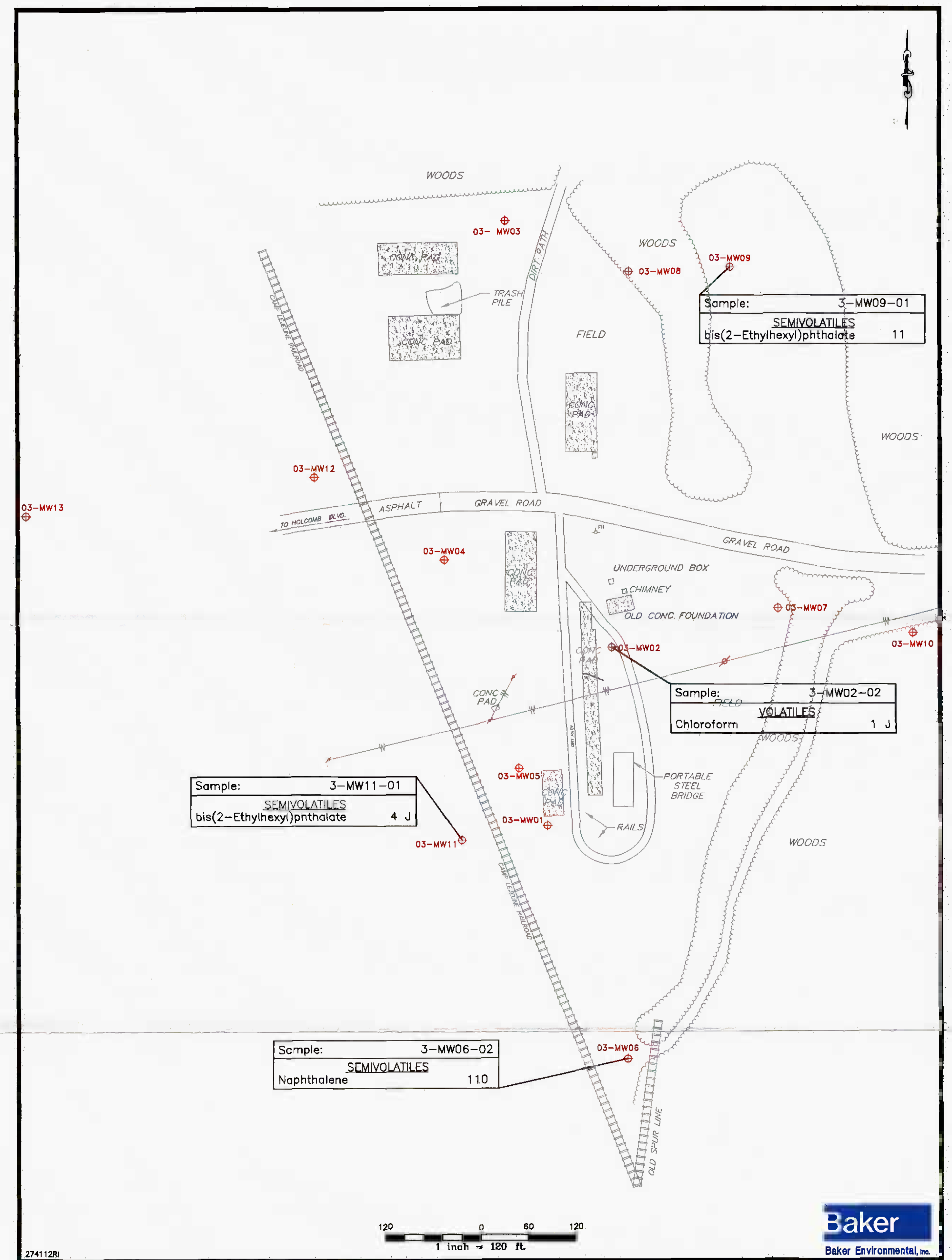
LEGEND

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

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

FIGURE 4-7
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES FOR ROUND ONE ABOVE FEDERAL MCLs AND/OR NCWQS IN CASTLE HAYNE AQUIFER
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Sample:	3–MW09–01
SEMIVOLATILES	
bis(2–Ethylhexyl)phthalate	11

Sample:	3–MW02–02
VOLATILES	
Chloroform	1 J

Sample:	3–MW11–01
SEMIVOLATILES	
bis(2–Ethylhexyl)phthalate	4 J

Sample:	3–MW06–02
SEMIVOLATILES	
Naphthalene	110

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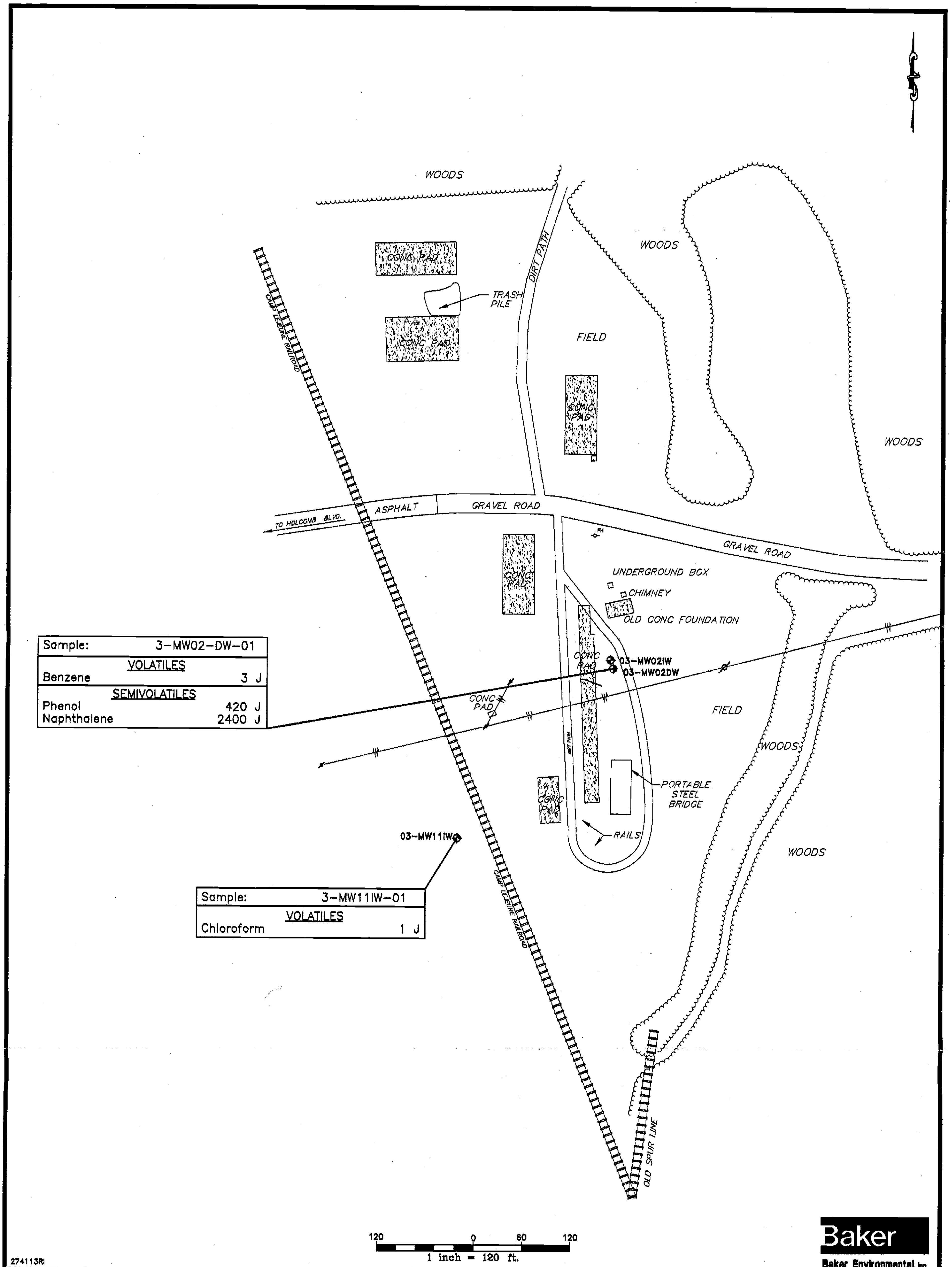
LEGEND

03–MW01 ⊕ SHALLOW MONITORING WELL LOCATION

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

FIGURE 4–8
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES FOR ROUND TWO ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 3 – OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO–0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Sample:	3-MW02-DW-01
VOLATILES	
Benzene	3 J
SEMIVOLATILES	
Phenol	420 J
Naphthalene	2400 J

Sample:	3-MW11IW-01
VOLATILES	
Chloroform	1 J

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LEGEND

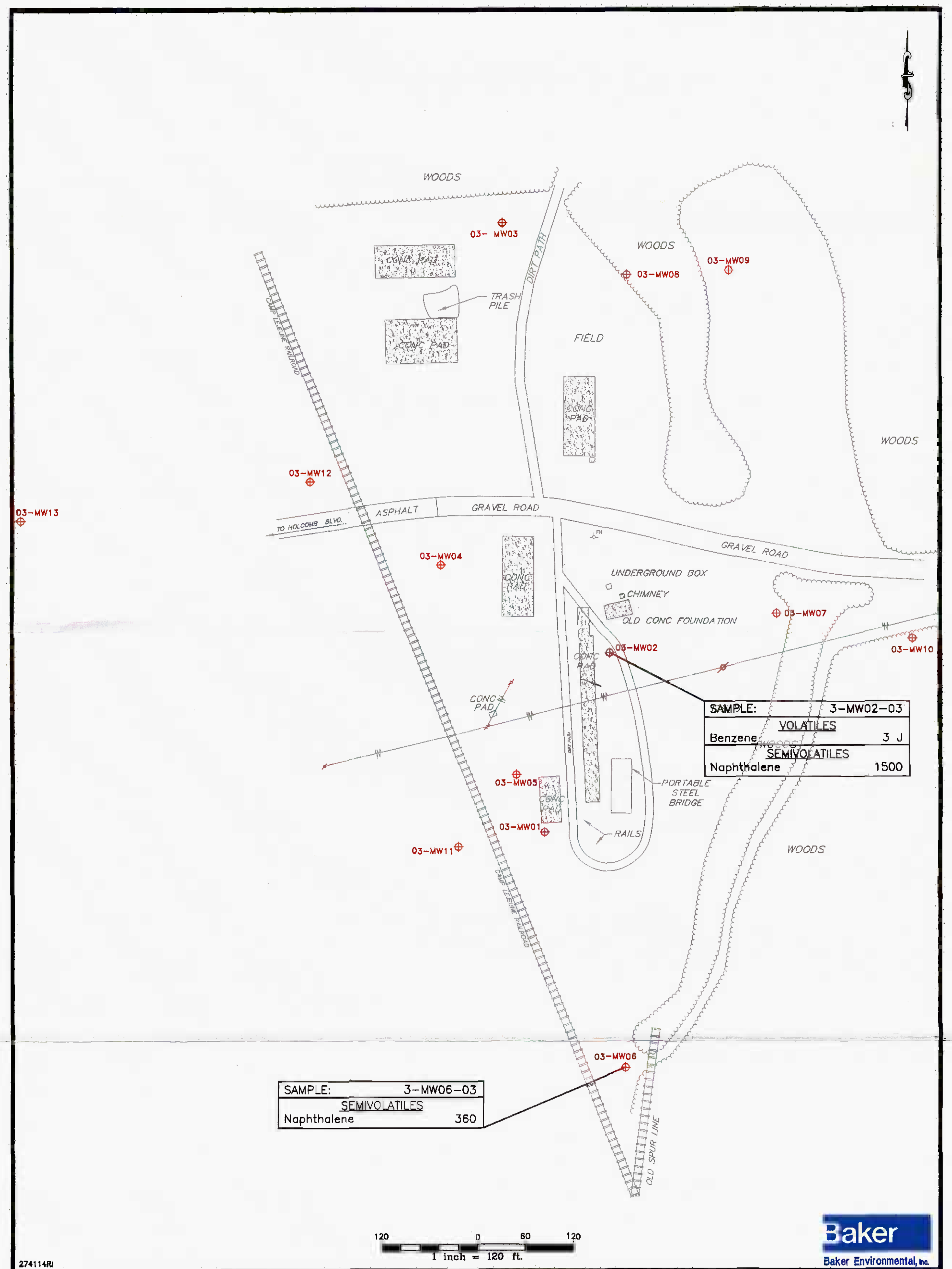
03-MW02IW ⊕ INTERMEDIATE MONITORING WELL LOCATION

03-MW02DW ⊕ DEEP MONITORING WELL LOCATION

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

FIGURE 4-9
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES FOR ROUND TWO ABOVE FEDERAL MCLs AND/OR NCWQS IN CASTLE HAYNE AQUIFER
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699X052



SAMPLE:	3-MW02-03
VOLATILES	
Benzene	3 J
SEMIVOLATILES	
Naphthalene	1500

SAMPLE:	3-MW06-03
SEMIVOLATILES	
Naphthalene	360

LEGEND

03-MW01 ⊕ SHALLOW MONITORING WELL LOCATION

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

FIGURE 4-10
POSITIVE DETECTIONS OF VOLATILES AND SEMI-VOLATILES FOR ROUND THREE ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01699X06Y

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section presents a discussion of the various physical and chemical properties of contaminants detected at Operable Unit No. 12, Site 3, and their fate and transport through the environment.

5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with the organic contaminants detected during this investigation. These properties determine the inherent environmental mobility and fate of a contaminant. These properties include:

- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Organic carbon adsorption coefficient (sediment partition)
- Specific gravity
- Henry's Law constant
- Mobility index

A discussion of the environmental significance of each of these properties follows.

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization can be important when evaluating groundwater and subsurface soils, particularly when selecting remedial technologies. Vapor pressure for monocyclic aromatics are generally higher than vapor pressures for polyaromatic hydrocarbons (PAHs). Contaminants with higher vapor pressures (e.g., volatile organic compounds [VOCs]) will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures (e.g., inorganics).

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants (e.g., VOCs) are usually more readily leached than less soluble contaminants (e.g., inorganics). The water solubilities indicate that the volatile organic contaminants including monocyclic aromatics are usually several orders-of-magnitude more soluble than PAHs. Consequently, highly soluble compounds such as the chlorinated VOCs will migrate at a faster rate than less water soluble compounds.

The octanol/water partition coefficient (K_{ow}) is the ratio of the chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. Specifically, a linear relationship between octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available.

The organic carbon adsorption coefficient (K_{oc}) indicates the tendency of a chemical to adhere to soil particles organic carbon. The solubility of a chemical in water is inversely proportional to the K_{oc}. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities. For example, contaminants such as PAHs are relatively immobile in the environment and are preferentially bound to the soil. These compounds are not subject to aqueous transport to the extent of compounds with higher water solubilities. Erosional properties of surface soils may, however, enhance the mobility of these bound soils contaminants.

Specific gravity is the ratio of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to "float" or "sink" (as an immiscible liquid) in water if it exceeds its corresponding water solubility.

Vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This can be expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}) (Laskowski, 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI is presented by Ford and Gurba (1984):

Relative MI	**Mobility Description**
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

The relative mobilities of many inorganic constituents is presented in Table 5-1.

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 3, the following potential contaminant transport pathways have been identified.

- On-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants off site.
- Migration of contaminants in surface water.
- Surface soil run-off from Site 3.

Contaminants released to the environment could also undergo the following during transportation:

- Physical transformations: volatilization, precipitation
- Chemical transformations: photolysis, hydrolysis, oxidation, reduction
- Biological transformation: biodegradation
- Accumulation in one or more media

The following paragraphs describe the potential transport pathways listed above.

5.2.1 On-Site Deposition of Windblown Dust

Wind can act as a contaminant transport pathway agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the soil or sediment. Wind also may have acted as a transport agent during station-wide pesticide spraying.

The Site 3 area is generally flat, unpaved, mostly barron parcel of land. The remainder of the area is surrounded by woods. Therefore, this transport pathway will be of concern.

5.2.2 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can disassociate from the sediment particle into surface water. Hydrophobic contaminants present in the surface water also can be removed from the water column by sediment. Typically, an equilibrium between sediment concentrations and surface water concentrations is established in an aquatic system over time. This is primarily influenced by the physical and chemical properties of the contaminant, (i.e., water solubility, K_{oc}) and the physical and chemical properties of the sediment particle (i.e., grain size, f_{oc}).

There are no surface water bodies that traverse this site, therefore, this transport pathway will not be of concern.

5.2.3 Leaching of Soil Contaminants to Groundwater

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to the groundwater due to precipitation. The rate and extent of this migration is influenced by the depth to the water table, amount of precipitation, rate of infiltration, the physical and chemical properties of the soil, and the physical and chemical properties of the contaminant.

Groundwater samples were collected from shallow, intermediate, and deep monitoring wells at Site 3. The groundwater analytical results can be compared to soil sample analytical results to determine if contaminants detected in soil have migrated or may migrate in the future, to underlying groundwater. These soil and groundwater analytical results in Section 4.0, Nature and Extent of Contamination indicate that water soluble soil contaminants (i.e., PAHs and phenolic compounds) are migrating (leaching) into the groundwater.

5.2.4 Migration of Groundwater Contaminants

Contaminants leaching from soils to underlying groundwater can migrate as dissolved constituents in groundwater in the direction of groundwater flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) advection, movement caused by flow of groundwater; (2) dispersion, movement caused by irregular mixing of waters during advection; and (3) retardation, principally chemical mechanisms which occur during advection. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants.

Advection

Advection is the process which most strongly influences the migration of dissolved organic solutes. Groundwater, under water table aquifer conditions (i.e., unconfined aquifer), generally flows from regions of the subsurface where the water table is under a higher head (i.e., recharge areas) to regions of where the water table is under a lower head (i.e., discharge areas). Hydraulic gradient is the term used to describe the magnitude of this force (i.e., the slope of the water table). The gradient typically follows the topography for shallow, uniform sandy aquifers which are commonly found in coastal regions. In general, groundwater flow velocities, in sandy aquifers, under natural gradient conditions are probably between 10 meters/year to 100 meters/year (32.8 to 328 feet/year) (Lyman, et al., 1982).

Thus, when monitoring wells or small supply wells in silty sand aquifers are located hundreds of thousands of meters downgradient of a contaminated source, the average travel time for the groundwater to flow from the source to the well point is typically on the order of decades. Based on the general topography of the site it is likely that local groundwater flows to the west in the direction of Holcomb Boulevard. Based on regional topography, however, and the site's close proximity to Wallace Creek, it is believed that at some distance away from the railroad, groundwater may flow south in the direction of Wallace Creek.

Dispersion

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes results in diffusion of solutes from a zone of high concentration to a lower concentration. Dispersion and spreading during transport result in the dilution of contaminants (maximum concentration of contaminant decreases with distance from the source). For simple hydrogeological systems, the spreading is reported to be proportional to the flow rate. Spreading is largely scale dependent. Furthermore, dispersion in the direction of flow is often observed to be markedly greater than dispersion in the directions transverse (perpendicular) to the flow. Because detailed studies to determine dispersive characteristics at the site were not conducted, longitudinal and transverse dispersivities are estimated based on similar hydrogeological systems (Mackay, et al., 1985).

Chemical Mechanisms

Some dissolved contaminants in groundwater may interact with saturated soils encountered along the flow path through adsorption, partitioning, ion exchange, and other processes. The interactions result in the contaminant distribution between the aqueous phase and aquifer solids, diminution of concentrations in the aqueous phase, and retardation of the movement of the contaminant relative to groundwater flow. The higher the fraction of the contaminant sorbed, the more retarded its transport. Certain halogenated organic solvents sorption is affected by hydrophobility (antipathy for dissolving in water) and the fraction of solid organic matter in the saturated soils (organic carbon content). If the aquifer is homogeneous, sorption of hydrophobic organic solute should be constant in space and time. If the sorptive interaction is at equilibrium and completely reversible, the solute should move at a constant average velocity equal to the groundwater average velocity divided by the retardation factor.

Organic contaminants can be transformed into other organic compounds by a complex set of chemical and biological mechanisms. The principal classes of chemical reactions that can affect organic contaminants in water are hydrolysis and oxidation. However, it is believed that most chemical reactions occurring in the groundwater zone are likely to be slow compared with transformations mediated by microorganisms. Certain organic groundwater contaminants can be biologically transformed by microorganisms attached to solid surfaces within the aquifer. Factors which affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, and presence of microbial toxicants and nutrients, and the availability of electron acceptors. Transformation of a toxic organic solute is no assurance that it has been converted to harmless or even less harmless hazardous products. Biotransformation of common groundwater contaminants, such as trichloroethene (TCE), 1,1,1-trichloroethane (TCA), and tetrachloroethene (PCE), can result in the formation of such intermediates as vinyl chloride (Mackay, et al., 1985).

The interaction of non-ionic organic compounds with solid phases can also be used to predict the fate of the highly nonpolar organic contaminants (i.e., 4,4'-DDT, PCBs). Sorptive binding is proportional to the organic content of the sorbent. Sorption of non-ionic organic pesticides can be attributed to an active fraction of the soil organic matter (Lyman et al., 1982). The uptake of neutral organics by soils results from their partitioning to the solutes aqueous solubility and to its liquid-liquid (e.g., octanol-water) partition coefficient (Chiou, 1979). Currently, literature information is available on the interrelation of soil organic properties to the binding of pesticides, herbicides, and high molecular weight pollutants such as PCBs. Organic matrices in natural systems that have varying origins, degrees of humification, and degrees of association with inorganic matrices exhibit dissimilarities in their ability to sorb non-ionic organic contaminants.

The soils and sediments formed or deposited on the land surface can act as a reservoir for inorganic contaminants. Soils contain surface-active mineral and humic constituents involved in reactions that affect metal retention. The surfaces of fine-grained soil particles are very chemically active. The surface soils can be negatively charged, positively charged or electronically neutral.

Opposite charged metallic counterions from solutions in soils (i.e., groundwater) are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depends on the degree of acidity or alkalinity of the soil, on its mineralogical composition, and on its content of organic matter. The extent of adsorption depends on either the respective charges on the adsorbing surface and the metallic cation.

In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates, and sulfides. The precipitation of hydroxide minerals is important for metals such as iron and aluminum, the precipitation of carbonate minerals is significant for calcium and barium, and the precipitation of sulfide minerals dominates the soil chemistry of zinc, cadmium, and mercury. A number of precipitates may form if metals are added to soils the concentration of metal in solution will be controlled, at equilibrium, by the solid phase that results in the lowest value of the activity of the metallic ion in solution (Evans, 1989).

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at Site 3, these processes include: sorption, volatilization, biodegradation, photolysis, hydrolysis, and bioaccumulation. For organic priority pollutants, consulting the rates contained in this table concerning the relative importance of aquatic processes for the fate of each compound, may aid in the elimination of unimportant processes.

5.2.5 Migration of Contaminants in Surface Water

Contaminants leaching from soils to surface water can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) movement caused by the flow of surface water, (2) movement caused by irregular mixing of water, and (3) chemical mechanisms occurring during the movement of surface water. As stated earlier, sediment particles can disassociate from the sediment particle into surface water and migrate in one of the aforementioned methods. Although surface runoff flows into ditches, these ditches are intermittent and do not flow into any surface water body. Therefore, this transport pathway will not be of concern.

5.2.6 Surface Soil Run-Off

Water can erode exposed soil and sediment particles during precipitation events. This is influenced by site topography, amount of precipitation, soil/sediment particle size/density and cohesion, and vegetative cover.

The study area is relatively flat, mostly cleared parcel of land. During periods of heavy rain the western area of the site exhibited several areas of standing water. Surface water runoff from the site flows in both an easterly and westerly direction since runoff ditches flank both the eastern and western edges of the site. To the east is a small drainageway in which ponded water is evident during periods of heavy rain. To the west of the site are drainage areas which parallel the Camp Lejeune Railroad and Holcomb Boulevard. These surface runoff flows into ditches that are intermittent and do not flow into any surface water body. Therefore, this transport pathway will not be of concern.

The following paragraphs summarize the site-specific fate and transport data for some contaminants of potential concern at Site 3.

5.3 <u>Fate and Transport Summary</u>

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at Site 3.

5.3.1 Volatile Organic Compounds

VOCs (i.e., benzene, chloroform and 1,1-dichloroethene) tend to be mobile in environmental media as indicated by their presence in groundwater and their corresponding MI values. Their environmental mobility is a function of high water solubilities, high vapor pressures, low K_{ow} and K_{oc} values, and high mobility indices.

Without a continuing source, VOCs do not generally tend to persist in environmental media because photolysis, oxidation, and biodegradation figure significantly in their removal.

5.3.2 Polycyclic Aromatic Hydrocarbons

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, pyrene, is probably the best marker compound, since it is consistently the most abundant of the PAHs measured and provides the strongest correlation with total PAH values. Other PAH are acenaphthene, fluorene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and phenanthrene. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exception is naphthalene, which is considered only slightly immobile because of somewhat higher water solubility (Jones, et al., 1989).

PAHs generally lack adequate vapor pressures to be transmitted via vaporization and subsequent airborne transport. However, surface and shallow surface soil particles containing PAHs could potentially be subject to airborne transport and subsequent deposition, especially during mechanical disturbances such as vehicle traffic or digging (Jones, et al., 1989).

PAHs are somewhat persistent in the environment. In general their persistence increases with increasing ring numbers. Photolysis and oxidation may be important removal mechanisms in surface waters and surficial soils, while biodegradation could be an important fate process in groundwater, surface soils or deeper soils. PAHs are ubiquitous in nature.

5.3.3 Inorganics

Inorganics can be found as solid complexes at ambient temperature and pressure in soils at the site. Inorganic ions exist in pure solutions as hydrated ions. Groundwater, as opposed to a pure solution, is a highly complex chemical system which is heavily influenced by the mineralogy of the substrate. Factors affecting the transport of inorganics in saturated soils are interactive and far more complex and numerous than those affecting the transport of organic contaminants.

The most complicated pathway for inorganic contaminants is migration in subsurface soils and groundwaters, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-3 presents an assessment of relative inorganic environmental mobilities as a function of Eh and pH. Soils at MCB Camp Lejeune are relatively neutral, therefore, inorganics in the subsurface soil should be relatively immobile.

Transport of inorganic species in groundwater is mainly a function of the inorganic's solubility in solution under the chemical conditions of the soil-solution matrix. The inorganic must be dissolved (i.e. in solution) for leaching and transport by advection with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such process include precipitation/dissolution, adsorption/desorption, and ion exchange.

Inorganics could be sorbed onto colloidal materials, theoretically increasing their inherent mobility in saturated porous media. It is important to note, however, that colloids themselves are not mobile in most soil/water systems.

Inorganics such as arsenic and chromium depend upon speciation to influence their mobility. Speciation varies with the chemistry of the environmental medium and temporal factors. These variables make the site-specific mobility of an inorganic constituent difficult to assess.

5.4 References

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SECTION 5.0 TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
OLD CREOSOTE PLANT
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Volatiles: Benzene	9.5 x $10^{+01(1)}$	1.8 x $10^{+03(1)}$	1.92$^{(2)}$	2.1$^{(1)}$	0.879$^{(7)}$	5.6 x $10^{-03(1)}$	3.3
Chloroform	1.6 x $10^{+02(5)}$	8.0 x $10^{+03(5)}$	1.97$^{(5)}$	1.64$^{(5)}$	--	2.9 x $10^{-03(5)}$	4.1
1,1-Dichloroethene	6.0 x $10^{+02(1)}$	2.3 x $10^{+03(1)}$	1.81$^{(8)}$	2.1$^{(1)}$	--	2.6 x $10^{-02(1)}$	4.3
Semivolatiles: 2-Methylphenol	2.4 x $10^{-01(5)}$	2.5 x $10^{+04(5)}$	1.34$^{(5)}$	1.93$^{(5)}$	--	1.23 x $10^{-06(5)}$	2.4
4-Methylphenol	1 x $10^{+02(7)}$	4.4 x $10^{+03(7)}$	2.17$^{(7)}$	2.56$^{(7)}$	1.035$^{(7)}$	--	3.5
2-Nitrophenol	2.0 x $10^{-01(5)}$	2.1 x $10^{+03(5)}$	1.57$^{(5)}$	1.78$^{(5)}$	--	3.5 x $10^{-06(5)}$	1.1
2,4-Dimethylphenol	9.8 x $10^{-02(1)}$	7.9x$10^{+03(1)}$	2.07$^{(5)}$	2.5$^{(1)}$	--	2.0 x $10^{-06(1)}$	0.8
Naphthalene	8.5 x $10^{-02(1)}$	3.1 x $10^{+01(1)}$	2.97$^{(6)}$	3.6$^{(1)}$	1.152$^{(7)}$	4.8 x $10^{-04(1)}$	-2.5
2-Methylnaphthalene	--	insoluble	3.03	3.6	1.0058$^{(7)}$	--	--
Acenaphthene	1.5 x $10^{-03(3)}$	3.47$^{(3)}$	1.25$^{(3)}$	3.97$^{(3)}$	0.994$^{(7)}$	1.5 x $10^{-04(3)}$	2.5
Dibenzofuran	--	10$^{(5)}$	3.9-4.1$^{(5)}$	4.12-4.31$^{(5)}$	1.0886$^{(5)}$	--	--
Fluorene	1 x $10^{-02(3)}$	1.69$^{(3)}$	3.65$^{(3)}$	4.18$^{(3)}$	--	1.29 x $10^{-03(3)}$	-5.4
Phenanthrene	9.6 x $10^{-04(3)}$	1.0$^{(3)}$	4.2$^{(3)}$	4.46$^{(3)}$	1.025$^{(7)}$	2.25 x $10^{-04(3)}$	-7.2
Carbazole	7.0 x $10^{-04(4)}$	1.2$^{(4)}$	--	3.72$^{(4)}$	1.1$^{(4)}$	--	--
Benzo(a)anthracene	2.2 x $10^{-08(3)}$	5.7 x $10^{-03(3)}$	5.34$^{(3)}$	5.61$^{(3)}$	--	7.34 x $10^{-07(3)}$	-15.2
Benzo(b)fluoranthene	5 x $10^{-07(3)}$	1 x $10^{-03(3)}$	--	6.08$^{(3)}$	--	1.66 x $10^{-04(3)}$	--

TABLE 5-1 (continued)

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF POTENTIAL CONCERN
OLD CREOSOTE PLANT
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Benzo(k)fluoranthene	5×10^{-07}(3)	5.5×10^{-04}(3)	--	6.08(3)	--	3.02×10^{-04}(3)	--
Benzo(a)pyrene	5.6×10^{-09}(3)	3.8×10^{-03}(3)	--	6.08(3)	1.274(7)	4.89×10^{-07}(3)	--
Indeno(1,2,3-cd)pyrene	1×10^{-10}(3)	5×10^{-04}(3)	--	6.51(3)	--	6.0×10^{-10}(3)	--
Dibenz(a,h)anthracene	1.0×10^{-10}(5)	5.0×10^{-04}(5)	6.22(5)	6.36(5)	--	7.33×10^{-09}(5)	-2.0

Notes:

-- = Value not available.
(1) SCDM, 1992
(2) SPHEM, 1986.
(3) USEPA, 1985.
(4) USEPA, 1986.
(5) Montgomery, 1980.
(6) ATSDR, 1990.
(7) Verscheuren, 1983.
(8) ATSDR, 1989

TABLE 5-2

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
OLD CREOSOTE PLANT
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Volatiles:						
Benzene	+	+	--	--	--	--
Chloroform	NA	NA	NA	NA	NA	NA
1,1-Dichloroethene	?	+	?	--	--	?
Semivolatiles:						
2-Methylphenol	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA
2-Nitrophenol	--	--	--	++(c)	--	--
2,4-Dimethylphenol	--	--	?	+	--	--
Naphthalene	+	--	+	+	--	--
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
Acenaphthene(b)	+	--	+	+	--	--
Dibenzofuran	NA	NA	NA	NA	NA	NA
Fluorene(b)	+	--	+	+	--	--
Phenanthrene(b)	+	+	+	+	--	--
Carbazole	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	+	+	+	+	--	--
Benzo(b)fluoranthene(b)	+	--	+	+	--	--

TABLE 5-2 (Continued)

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
OLD CREOSOTE PLANT
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Benzo(k)fluoranthene(b)	+	--	+	+	--	--
Benzo(a)pyrene	+	+	+	+	--	--
Indeno(1,2,3-cd)pyrene(b)	+	--	+	+	--	--
Dibenz(a,h)anthracene(c)	+	--	+	+	--	--

Key to Symbols:

+	=	Could be an important fate process
-	=	Not likely to be an important process
?	=	Importance of process uncertain or not known
NA	=	Information not avialable

Notes:

(a) Biodegradation is the only process known to transform polychlorinated biphenyls under environmental conditions, and only the lighter compounds are measurably biodegraded. There is experimental evidence that the heavier polychlorinated biphenyls (five chlorine atoms or more per molecule) can be photolyzed by ultraviolet light, but there are no data to indicate that this process is operative in the environment.
(b) Based on information for PAH's as a group. Little or no information for these compounds exists.
(c) Based on information for 4-Nitrophenol.

Source: U.S. Environmental Protection Agency. September 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Part I. EPA/600-6-85/022a.

TABLE 5-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
OLD CREOSOTE PLANT
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Relative Mobility	Environmental Conditions			
	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very High			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Cr, Se, Zn, Cu, Ni, Hg, Pb, Ba, Be, Ag

Notes:

As = Arsenic
Ag = Silver
Ba = Barium
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
Ni = Nickel
Pb = Lead
Se = Selenium
Zn = Zinc

Source: Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December 1992.

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

This Baseline Risk Assessment (BRA) evaluates the projected impact of contaminants of potential concern (COPCs) on human health and/or the environment, now and in the future, in a "no further remedial action scenario". The BRA process examines the data generated during the sampling and analytical phase of the RI, identifying areas of concern (AOCs) and COPCs with respect to geographical, demographic, physical and biological characteristics of the study area. These factors are combined with an understanding of physical and chemical properties of site-associated constituents, (relative to environmental fate and transport processes) and are then used to estimate contaminant concentrations at logical exposure pathway endpoints. Finally, contaminant intake levels are calculated for hypothetical receptors. Toxicological properties are applied in order to estimate potential public health threats posed by detected contaminants.

The BRA for Operable Unit (OU) No. 12, (Site 3) has been conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991a) and USEPA Region IV Supplemental Risk Guidance (USEPA, 1991b).

The components of the BRA include:

- Identification of contaminants of potential concern
- The exposure assessment
- The toxicity assessment
- Risk characterization
- Uncertainty analysis
- Conclusions of the BRA and potential site risk

The BRA is divided into eight sections, including the introduction. Section 6.2 presents criteria for selecting COPCs. COPCs are chosen, for each environmental medium at each site, from an overall list of detected contaminants. Section 6.3 lists site characteristics, identifies potential exposure pathways, and describes current and future exposure scenarios. In section 6.4, potential exposure is calculated by estimating daily intakes, incremental cancer risks and hazard indices. In addition, advisory criteria for evaluating human health risk is presented. Section 6.5 addresses risk characterization. Section 6.6 addresses sources of uncertainty in the BRA. Section 6.7 provides conclusions regarding potential human health impacts, in terms of total site risk. Section 6.8 lists references sited in the BRA text. Referenced tables and figures are presented after the text portion of this section.

6.2 Contaminants of Potential Concern

COPCs are site-related contaminants used to quantitatively estimate human exposures and associated health effects. Three environmental media were investigated during this RI: surface soil, subsurface soil and groundwater. This section presents COPC selection for these media.

6.2.1 Criteria for Selecting Contaminants of Potential Concern

Following is a list of criteria used to select COPCs, with respect to human health risk. COPCs are selected from the list of constituents detected during the field sampling and analytical phase of the RI. Criteria are listed in hierarchical order:

- Historical information
- Comparison to Risk-Based Concentrations (RBCs)
- Comparison to background or naturally occurring levels
- Comparison to field and laboratory blank data
- Prevalence
- Persistence
- Mobility
- Comparison to anthropogenic levels
- Toxicity

Federal and state criteria and standards are not used to select human health risk-based COPCs. They are, however, used to select COPCs to be employed in the Feasibility Study (FS) portion of the investigation, only. In other words, COPCs selected as a result of a comparison to criteria and standards are not risk-based COPCs, and are not used as such to evaluate human health risk. They are used in the FS to evaluate remediation levels. An explanation of the federal and state criteria and standards used for qualitative evaluation of contaminants is presented in Section 6.2.1.10.

USEPA's Risk Assessment Guidance for Superfund provides the criteria used to establish COPCs (USEPA, 1989a). COPC selection also involves comparing detection levels to additional contaminant-specific criteria. A brief description of the selection criteria used in choosing final COPCs is presented below. A contaminant must not necessarily fit into all of these categories to be retained as a COPC.

6.2.1.1 Historical Information

Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps determine contaminant retention or elimination.

6.2.1.2 Risk-Based Concentrations

Risk-Based Concentrations (RBCs) were developed by USEPA Region III as benchmark concentrations for evaluating site investigation data. RBCs are not established as stand-alone decision-making tools, but as screening tools to be used in conjunction with other information to help select COPCs. Selecting COPCs using RBCs is accomplished by comparing the maximum concentration of each contaminant detected in each medium to its corresponding RBC. RBCs were developed using conservative default exposure scenarios suggested by the USEPA and the latest available toxicity indices for carcinogenic and systemic chemicals. The RBC corresponds to a Hazard Quotient of 1.0 and a lifetime cancer risk of 1E-6. RBCs represent protective environmental concentrations at which the USEPA would not typically take action (USEPA, 1995a).

RBC values listed in the 1995 Region III Risk-Based Concentration table have been multiplied by a factor of 0.1, in order to generate more conservative values to be used in selecting noncarcinogenic COPCs for this risk assessment. This approach is explained in Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening (USEPA, 1993).

6.2.1.3 Background or Naturally Occurring Levels

Naturally occurring levels of chemicals are present under ambient conditions. Generally, a comparison to naturally occurring levels applies only to inorganic analytes, because the majority of organic contaminants are not naturally occurring. Background samples are collected from areas that are known to be uninfluenced by site contamination. An inorganic concentration is considered site-related only if it exceeds two times the mean concentration estimated for the site-specific background samples. The mean for surface soil inorganics is estimated using results from 51 sample locations. The mean for subsurface soil inorganics is estimated using results from 45 sample locations.

Background soil data is presented in Appendix F.

6.2.1.4 Contaminant Concentrations in Blanks

Associating contaminants detected in field related QA/QC samples (i.e., trip blanks, equipment rinsates and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated; however, due to the comprehensive nature of data sets, it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate contaminant levels, maximum contaminant concentrations reported in a given set of blanks are applied to an entire data set for a given medium.

In accordance with the National Functional Guidelines for Organics, common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding five times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991).

When evaluating contaminant concentrations in soil, Contract Required Quantitation Limits (CRQLs) and percent moisture are employed, in order to correlate solid and aqueous quantitation limits. The CRQL for semivolatiles (SVOCs) in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess SVOC contaminant levels in soil using aqueous blanks, blank concentrations must be multiplied by 33 or 66 to account for variances in the CRQL. The final value is divided by the sample percent moisture, in order to account for the aqueous-to-solid blank medium adjustment.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

Maximum concentrations of common laboratory contaminants detected in blanks are presented in Table 6-1.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) are regarded as positive results only when observed concentrations exceed five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds at concentrations less than five times the maximum level of contamination noted in any blank are considered not detected in that sample.

Maximum concentrations of other contaminants detected in blanks are presented in Table 6-1.

QA/QC data summaries are presented in Appendix J.

6.2.1.5 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. The judicious use of data sets limits for including infrequently detected contaminants. Chemical occurrence must be evaluated with respect to the number of samples taken in order to determine frequency criteria warranting the inclusion of a chemical as a COPC. Contaminants that are infrequently detected, (i.e., less than 5 percent when at least 20 samples of a medium are available) do not necessarily indicate contamination. Such detections may result from certain sampling or analytical practices.

A contaminant may not be retained for quantitative evaluation in the BRA if: (1) it is detected infrequently in an environmental medium, (2) it is absent or detected at low concentrations in other media, or (3) site history does not provide evidence to suggest that the contaminant should be present.

6.2.1.6 Persistence

Contaminant persistence in the environment varies in accordance with factors such as microbial content in soil and water, organic carbon content, contaminant concentration, climate and potential for microbes to degrade a contaminant under site conditions. In addition, chemical degradation, (i.e., hydrolysis) photochemical degradation and certain fate processes such as absorption may contribute to the elimination or retention of a particular compound in a given medium.

6.2.1.7 Mobility

A contaminant's physical and chemical properties are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will have a greater tendency to volatilize into the air, out of surface soils or surface waters, or to relocate via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also determine tendency for contaminant adsorption onto soil/sediment particles. In summary, environmental mobility factors can increase or decrease contaminant effects on human health and/or the environment.

6.2.1.8 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from sources of contamination not related to the site, such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. Polynuclear aromatic hydrocarbons (PAHs) are examples of ubiquitous, anthropogenic chemicals. Sometimes it is difficult to determine whether contamination is actually site-incurred, or caused by contaminant-producing activities that are not site-related (i.e., anthropogenic). It then follows that systematically omitting anthropogenic background chemicals from the risk assessment may produce false negative results. For this reason, anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria.

The remaining sections apply the aforementioned selection criteria, beginning with prevalence of detected analytical results in each medium of interest, in order to establish a preliminary list of COPCs for Site 3. Once this task is completed, a final list of media-specific COPCs is selected using the remaining criteria (persistence, mobility, toxicity, ARARs, RBCs, blank concentrations, background concentrations, and anthropogenic concentrations).

6.2.1.9 Toxicity

Contaminant toxicity assessment must be incorporated when selecting COPCs with respect to human health risk. Toxic properties to be considered in COPC selection include weight-of-evidence classification, carcinogenicity, mutagenicity, teratogenicity, systemic effects and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of toxic response in an organism and/or subsequent receptors; these additional properties are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic contaminants are essential nutrients (eg., calcium, sodium). As such, these contaminants need not be considered in a quantitative risk assessment, if one of the following conditions applies: (1) they are detected at relatively low concentrations, (i.e., below two times average base-specific background levels or slightly elevated above naturally occurring levels) or (2) the contaminant is toxic at doses much higher than those which can be assimilated through exposures at the site.

6.2.1.10 State and Federal Criteria and Standards

Contaminant concentrations in aqueous media can be compared to contaminant-specific state and federal criteria. This risk assessment utilizes North Carolina Water Quality Standards (NCWQS) for groundwater and surface water. The only enforceable federal regulatory standards for water are Federal Maximum Contaminant Levels (MCLs).

Regulatory guidelines are used, when necessary, to infer potential health risks and environmental impacts. Health Advisories (HA) are relevant regulatory guidelines.

Chemical-specific criteria and standards for soil are generally not available; however, base-specific background concentrations have been compiled in order to evaluate background levels of organic and inorganic constituents in surface and subsurface soil at MCB Camp Lejeune.

Tables 6-2 through 6-6 present data compared to applicable standards and criteria.

An explanation of the federal and state criteria and standards used for qualitative evaluation of contaminants is presented below.

North Carolina Water Quality Standards (Groundwater) - NCWQSs are the maximum allowable concentrations, resulting from any discharge of contaminants to the lands or waters of the state, that may be tolerated without threatening human health or otherwise rendering the groundwater unsuitable for its intended purposes.

Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies, designed to protect human health and promulgated under the Safe Drinking Water Act. MCLs also account for the technical feasibility of removing contamination from a public water supply. MCLs are based on laboratory or epidemiological studies and are applied to analyses of drinking water supplies consumed by a minimum of 25 persons. MCLs establish limits under which 70 kg adults, drinking 2 liters of water a day for 70 years, can avoid detrimental health effects.

Health Advisories - HAs are guidelines developed by the USEPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight 10 kg) who consume 1 liter of water per day or in adults (assumed body weight 70 kg) who consume 2 liters of water per day. HAs are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for potential human carcinogens.

6.2.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each environmental medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria.

6.2.2.1 Surface Soil

Seventeen surface soil samples were analyzed for volatile organic contaminants (VOCs). Toluene, ethylbenzene and xylenes were detected at maximum concentrations less than respective residential soil RBC values. For this reason, these contaminants are not retained as COPCs. Although chrysene was detected at a maximum concentration below its residential soil RBC, it was retained as a COPC since carcinogenic PAHs do not occur alone.

None of the VOCs detected in surface soil are retained as COPCs.

Thirty-four surface soil samples were analyzed for semivolatile organic contaminants SVOCs. The following contaminants were detected at concentrations less than respective residential soil RBC values: phenol, naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, dibenzofuran, fluorene, phenanthrene, anthracene, carbazole, di-n-butylphthalate, fluoranthene, pyrene, chrysene, bis(2-ethylhexyl)phthalate and benzo(g,h,i)perylene. For this reason, these SVOCs are not retained as COPCs.

Benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were detected frequently in surface soil (i.e., greater than 5 percent). These contaminants were detected at maximum concentrations exceeding respective residential soil RBC values. Consequently, these SVOCs are retained as COPCs.

There were no pesticides or PCBs detected in surface soil.

Two surface soil samples were analyzed for inorganic contaminants. The following contaminants were detected at maximum concentrations less than respective residential soil RBCs: aluminum, barium, chromium, iron, lead, manganese, vanadium and zinc. In addition, iron was detected at a maximum concentration less than the background level. Consequently, these inorganics are not retained as COPCs. Calcium, magnesium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients. In addition, sodium was detected in at a maximum concentration less than the level detected in blanks. Consequently, these contaminants are not retained as COPCs.

None of the inorganics detected in surface soil are retained as COPCs.

6.2.2.2 Subsurface Soil

Eighteen subsurface soil samples were analyzed for VOCs. The following contaminants were detected at maximum concentrations less than respective residential soil RBCs: acetone, carbon disulfide, chloroform, 2-butanone, benzene, toluene, ethylbenzene, styrene and xylenes. In addition, acetone and 2-butanone were detected at maximum concentrations less than the levels detected in blanks. Consequently, these contaminants are not retained as COPCs.

None of the VOCs detected in subsurface soil are retained as COPCs.

Forty-seven subsurface soil samples were analyzed for SVOCs. The following contaminants were detected at maximum concentrations less than respective residential soil RBC values: phenol, 2-methylphenol, 4-methylphenol, naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, 4-nitrophenol, fluorene, n-nitrosodiphenylamine, phenanthrene, anthracene, carbazole, di-n-butylphthalate, fluoranthene, pyrene, bis(2-ethylhexyl)phthalate, and benzo(g,h,i)perylene. For this reason, these contaminants are not retained at COPCs.

Dibenzofuran, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene were detected frequently in subsurface soil samples (i.e., greater than 5 percent). These contaminants were detected at concentrations exceeding respective residential soil RBC values. Consequently, these SVOCs are retained as COPCs in subsurface soil. Although chrysene and benzo(k)fluoranthene were detected at maximum concentrations less than respective residential soil RBC values, they were retained as COPCs since carcinogenic PAHs do not occur alone.

There were no pesticides or PCBs detected in subsurface soil.

Thirty-two subsurface soil samples were analyzed for inorganic contaminants. The following inorganics were detected at maximum concentrations less than respective residential soil RBCs: aluminum, barium, chromium, iron, lead, manganese and vanadium. Iron and magnesium were detected at maximum concentrations less than respective background levels. Consequently, none of these contaminants are retained as COPCs. Calcium is not retained as a COPC, because it is considered an essential nutrient.

None of the inorganics detected in subsurface soil are retained as COPCs.

6.2.2.3 Groundwater - Round 1 Only

Three Round 1 groundwater samples were analyzed for VOCs. Carbon disulfide, toluene and xylenes were detected at maximum concentrations less than respective tap water RBC values. For this reason, these contaminants are not retained as COPCs.

Benzene was detected at a maximum concentration exceeding the tap water RBC value. It was detected at a frequency greater than 5 percent, and it was not detected in Round 1 groundwater blanks. Consequently, benzene is retained as a COPC.

Eight Round 1 groundwater samples were analyzed for SVOCs. The following contaminants were detected at maximum concentrations less than respective tap water RBC values: phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, acenaphthylene, anthracene, di-n-butylphthalate, fluoranthene, pyrene and chrysene.

The following SVOCs were detected in Round 1 groundwater samples at respective frequencies greater than 5 percent: 2-nitrophenol, acenaphthene, dibenzofuran, fluorene, phenanthrene, carbazole, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene. These contaminants were detected at maximum concentrations exceeding respective tap water RBC values, and were not detected in Round 1 blanks. Consequently, these SVOCs are retained as COPCs.

There were no pesticides or PCBs detected in Round 1 groundwater samples.

Three Round 1 groundwater samples were analyzed for inorganic contaminants. The following contaminants were detected at maximum concentrations less than respective tap water RBC values: barium, manganese, nickel and zinc. For this reason, these inorganics are not retained as COPCs. Lead is not retained as a COPC, because its maximum concentration is less than the concentration detected in blanks. Calcium, iron, magnesium, potassium and sodium are not retained as COPCs, because these contaminants are considered essential nutrients.

Chromium was detected in Round 1 groundwater samples at a maximum concentration exceeding the tap water RBC value and the concentration detected in blanks. Consequently, chromium is retained as a COPC.

6.2.2.4 Groundwater - Round 2 Only

Three rounds of groundwater data were collected at Site 3. Health risk from groundwater is evaluated using COPCs from one sampling round and also from a worst case contamination scenario, using COPCs from all 3 sampling rounds, combined. Round 2 groundwater results exhibited the highest levels of contamination, relative to the results from Round 1 and Round 3. Consequently, Round 2 groundwater data are used to evaluate the groundwater risk from a single round of data.

Sixteen Round 2 groundwater samples were analyzed for VOCs. The following contaminants were detected at maximum concentrations less than respective tap water RBC values: trichloroethene, toluene, ethylbenzene and xylenes. For this reason, these contaminants are not retained as COPCs.

1,1-Dichloroethene, chloroform and benzene were detected at frequencies greater than 5 percent. In addition, these contaminants were detected at maximum concentrations exceeding respective tap water RBC values. Consequently, these contaminants are retained as COPCs.

Sixteen Round 2 groundwater samples were analyzed for SVOCs. The following contaminants were detected at maximum concentrations less than respective tap water RBC values: phenol, acenaphthylene, anthracene, fluoranthene and pyrene. For this reason, these contaminants are not retained as COPCs. Bis(2-ethylhexyl)phthalate is not retained as a COPC, because it was detected at a maximum concentration less than the level detected in blanks.

The following SVOCs were detected frequently in groundwater samples (i.e., greater than 5 percent): 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene and carbazole. These contaminants were detected at concentrations exceeding respective tap water RBC values. For this reason, these SVOCs are retained as COPCs. Although chrysene was detected at a maximum concentration less than its tap water RBC, it was retained as a COPC since carcinogenic PAHs do not occur alone.

There were no pesticides or PCBs detected in Round 2 groundwater samples.

Round 2 groundwater samples were not analyzed for inorganic contaminants.

6.2.2.5 Groundwater - Round 3 Only

Sixteen Round 3 groundwater samples were analyzed for VOCs. Toluene, ethylbenzene and xylenes were detected at maximum concentrations less than respective tap water RBC values. For this reason, these contaminants are not retained as COPCs.

Benzene was detected at a maximum concentration exceeding the tap water RBC value. It was not detected in Round 3 groundwater blanks. Consequently, benzene is retained as a COPC.

Sixteen Round 3 groundwater samples were analyzed for SVOCs. The following contaminants were detected at maximum concentrations less than respective tap water RBC values: phenol, 2-methylphenol, 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, fluoranthene, pyrene and bis(2-ethylhexyl)phthalate. For this reason, these SVOCs are not retained as COPCs.

4-Methylphenol, dibenzofuran, phenanthrene and carbazole were detected at maximum concentrations exceeding respective tap water RBC values. These contaminants were not detected in Round 3 groundwater blanks. Consequently, these SVOCs are retained as COPCs.

There were no pesticides or PCBs detected in Round 3 groundwater samples.

Round 3 groundwater samples were not analyzed for inorganic contaminants.

6.2.2.6 Groundwater - Combined Rounds (i.e., worst case contamination scenario)

In order to evaluate groundwater risk in a worst case contamination scenario, COPCs selected using data from sampling rounds 1, 2, and 3 were combined. If a particular COPC was detected in data from all 3 sampling rounds, the maximum concentration of that contaminant is used in the worst case contamination scenario. In other words, the list of COPCs for the worst case groundwater contamination scenario is a compilation of the COPCs selected from each of 3 individual data sets, using the maximum detected concentration for each COPC. Following is a list of COPCs used in this scenario.

VOCs - 1,1-dichloroethene, chloroform and benzene.

SVOCs - 2-nitrophenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene, carbazole, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene.

Inorganics - aluminum and chromium.

6.2.2.5 Summary of COPCs

Table 6-7 presents a detailed summary of COPCs identified in each environmental medium sampled at Site 3. Worksheets used for COPC selection are presented in Appendix L.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Site 3 and presents the rationale for their evaluation. Potential source areas and potential migration routes, in conjunction with contaminant fate and transport information, are combined to produce a site conceptual model. Exposure pathways to be retained for quantitative evaluation are subsequently selected, based on the conceptual site model.

6.3.1 Site Conceptual Model of Potential Exposure

A site conceptual model of potential sources, migration pathways and human receptors is developed to encompass all current and future routes for potential exposure at Site 3. Figure 6-1 presents the Site 3 conceptual model. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of Site 3. All available analytical data and meteorological data are considered, in conjunction with a general understanding of surrounding habitat demographics. The following list of receptors is developed for a quantitative health risk analysis:

- Future on-site residents (child and adult)
- Current military personnel
- Future construction workers

Contaminants detected in surface and subsurface soils are discussed in Section 4.0 (Nature and Extent of Contamination) and in section 6.2.2, Selection of COPCs. Migration of COPCs from these sources can occur in the following ways:

- Vertical migration of contaminants from surface soil to subsurface soil.
- Leaching of contaminants from subsurface soil to water-bearing zones.
- Vertical migration from shallow water-bearing zones to deeper flow systems.
- Horizontal migration in groundwater in the direction of groundwater flow.
- Wind erosion and subsequent deposition of windblown dust.

The potential for a contaminant to migrate spatially and persist in environmental media is important in estimating exposure.

6.3.2 Exposure Pathways

This section presents exposure pathways, shown in Figure 6-1, associated with each environmental medium and each human receptor group. It then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-8 presents the matrix of human exposure at Site 3.

6.3.2.1 Surface Soil

Potential exposure to surface soil may occur by incidental soil ingestion, contaminant absorption through the skin and inhalation of airborne particulates. Surface soil exposure is evaluated for future residential children and adults and for current military personnel.

6.3.2.2 Subsurface Soil

Subsurface soil is available for contact only during excavation activities, so potential exposure to subsurface soil is limited to future construction workers. Exposure pathways involving ingestion and dermal contact are evaluated for future construction workers only.

6.3.2.3 Groundwater

Currently, shallow groundwater at Site 3 is not used as a potable supply for residents or base personnel. However, in the future, (albeit unlikely due to poor transmissivity and insufficient flow) shallow groundwater may be tapped for potable water. Groundwater exposure is evaluated for future residential children and adults. Potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering.

6.3.2.4 Surface Water/Sediment

There is no surface water body in the proximity of Site 3. For this reason, surface water/sediment samples were not collected as part of the RI. Consequently, exposure to surface water/sediment is not evaluated.

6.3.3 Quantification of Exposure

The concentrations used to estimate chronic daily intakes (CDIs) must represent the type of exposure evaluated.

Exposure to groundwater can occur distinctly, at one sampling location, or collectively, from various locations. These media are transitory in that their contaminant concentrations change over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points than those existing at Site 3. Consequently, the most complete groundwater contaminant concentrations, from an exposure standpoint, are representative exposure concentrations.

Soils are less transitory than groundwater, and in most cases, soil exposure occurs over a wider area (eg., residential exposure). For this reason, upper confidence intervals are used to represent soil contaminant concentrations.

The human health risk assessment for future groundwater use incorporates groundwater data collected from all monitoring wells at a given site.

Because all data sets originate from a skewed underlying distribution, lognormal distribution is used to represent all relevant media. This ensures conservative CDI calculations.

Ninety-five percent upper confidence levels, (95 percent U.C.L.) derived for lognormal data sets, produce concentrations in excess of the 95 percent confidence interval derived assuming normality. The 95 percent U.C.L. for lognormal distribution is used for each contaminant in a given data set, in order to quantify conservative exposure values. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent U.C.L. can be greater than the maximum detected concentration. In such cases, the maximum concentration is used instead. The true mean, however, may still be higher than this maximum value. In other words, the 95 percent U.C.L. indicates that a higher mean is possible, especially if the most contaminated portion of the site, by chance, has not been sampled (USEPA, 1992c).

Statistical summaries are presented in Appendix M.

6.3.4 Calculation of Chronic Daily Intakes (CDI)

In order to numerically calculate risks for current and future human receptors at Site 3, a CDI must be computed for each COPC, in each relevant exposure pathway.

The following paragraphs present the general equations and input parameters used to calculate CDIs. Input parameters are taken from USEPA's default exposure factors guidelines. All inputs not defined by this source are derived either from other USEPA exposure documents or by using best professional judgment. All exposure assessments incorporate representative contaminant concentrations; only one exposure scenario is developed for each exposure route/receptor combination.

Exposure assessment summaries are presented in Tables 6-9 through 6-14.

Carcinogenic risk is calculated as an incremental lifetime risk, and thereby involves exposure duration (years) over the course of a lifetime (70 years, or 25,550 days).

Noncarcinogenic risk, on the other hand, involves average annual exposure. Exposure time and frequency represent the number of hours of exposure per day, and days of exposure per year, respectively. Generally, noncarcinogenic risk for certain exposure routes (e.g., soil ingestion) is greater for children, as the combination of a lower body weight and an exposure frequency equal to that of an adult increases their ingestion rates.

Future residential exposure scenarios address 1 to 6-year old children weighing 15 kg, and adults weighing 70 kg, on average. An exposure duration of 4 years is used to estimate military residential exposure duration. A one year duration is used for future construction workers.

6.3.4.1 Incidental Ingestion of Soil

The equation for CDI, calculated for all human receptors potentially experiencing incidental soil ingestion, is as follows:

$$CDI = \frac{C \times IR \times CF \times Fi \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1E-6 kg/mg)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in incidental soil ingestion.

In each exposure scenario, the Fi value, indicating the portion of exposure from soils actually containing COPCs, is 100 percent.

Future On-Site Residents

Future on-site residents may be exposed to COPCs in surface soil, during outdoor activities around their homes. In addition, children and adults may be exposed to COPCs by incidental ingestion of surface soil through hand-to-mouth contact.

Ingestion rates (IR) for adults and children in this scenario are assumed to be 100 mg/day and 200 mg/day, respectively. The EF for both receptor groups is 350 days per year. Residential exposure duration (ED) is divided into two parts. First, a six-year ED, used for young children, represents the period of highest soil ingestion (200 mg/day). Second, a 24-year ED, used for older children and adults, represents a period of lower soil ingestion (100 mg/day) (USEPA, 1991a).

The BW of future residential children (age 1 to 6 years) is assumed to be 15 kg, and 70 kg is used as the BW for future residential adults.

AT values of 25,550 days (70 years x 365 days/year) and 8,760 days (24 years x 365 days/year) are assigned to potentially carcinogenic and noncarcinogenic constituents, respectively, to estimate adult CDIs. The AT used for children exposed to noncarcinogens is 2,190 days (6 years x 365 days/year).

Military Personnel

During the course of daily activities at Site 3, civilian base personnel may be exposed to COPCs by ingesting surface soil.

The IR for military personnel exposed to surficial soils is assumed to be 100 mg/day. An EF of 350 days per year is used in conjunction with a 4-year ED (USEPA, 1989a).

Carcinogenic compounds have an AT 25,550 days (70 years x 365 days/year), and the AT for noncarcinogenic compounds is 1,460 days (4 years ED x 365 days/year). Adult average body weight BW is 70 kg (USEPA, 1989a).

Future Construction Worker

Construction workers may be exposed to COPCs through incidental ingestion of subsurface soil, during the course of excavation activities.

An IR of 480 mg/day is assigned to future construction workers. A 90-day per year EF is used in conjunction with a 1-year ED, representing the estimated length of a typical construction job (USEPA, 1991). AT_{nc} is 365 days (USEPA, 1989a).

CF, Fi, BW and AT_c values are the same as those used for adults in the residential exposure scenarios.

A summary of incidental soil ingestion exposure assessment input parameters is presented in Table 6-9.

6.3.4.2 Dermal Contact with Soil

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with soil, is as follows:

$$CDI = \frac{C \ x \ CF \ x \ SA \ x \ AF \ x \ ABS \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with soil.

Future On-Site Residents

Future on-site residents may be exposed to COPCs through dermal contact with surface soil during outdoor activities near their homes.

The SA values represent reasonable worst case scenarios for an individual wearing a short-sleeved shirt, shorts, and shoes. The exposed skin surface area is limited to the head, hands, forearms and lower legs. Twenty-five percent of the upper-bound total body surface area yields a default SA of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) is estimated using an average of the 50th (0.866 m^2) and the 95th (1.06 m^2) percentile body surface for a six year old child, multiplied by 25 percent (USEPA, 1992a).

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992c).

Military Personnel

During work-related activities, base personnel may be exposed to COPCs through dermal contact with surface soil.

It is assumed that civilian base personnel have approximately 5,800 cm^2 of skin surface (SA) available for contact with COPCs (USEPA, 1992a). Exposed body parts include the hands, head, forearms and lower legs, and represent 25 percent of total body surface area (23,000 cm^2). Taking 25 percent of the upper-bound total body surface area gives the default value 5,800 cm^2 for military personnel.

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992c).

Future Construction Worker

Construction workers may be exposed to COPCs through dermal contact with subsurface soil, experienced during excavation activities.

It is assumed that a construction worker wears a short-sleeved shirt, long pants and boots. Exposed skin surface area is then limited to the head, (1,180 cm^2) arms (2,280 cm^2) and hands (840 cm^2) (USEPA, 1992a). Total SA for the construction worker is 4,300cm^2.

ED and EF values are the same as those used in the incidental soil ingestion scenario.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992b).

A summary of dermal contact with soil exposure assessment input parameters is presented in Table 6-10.

6.3.4.3 Inhalation of Fugitive Particulates

The Cowherd model for inhalation of soil particulates is used to evaluate this risk scenario (USEPA, 1989a).

The equation for CDI, calculated for future residents and base personnel potentially inhaling particulates, is as follows:

$$CDI = \frac{C \times IR \times ET \times EF \times ED \times 1/PEF}{BW \times AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
1/PEF = Particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (days)

PEF relates contaminant concentrations in soil to concentrations of respirable particles in air, from surface soil fugitive dust emissions. A default PEF is used in this assessment (USEPA 1995). Particulate emissions at contaminated sites occur vis-a-vis wind erosion, and thereby vary according to irritability of the surface material (Cowherd et al. 1985). A PEF of 6.79E08m^3/kg is used for all receptors in this scenario (USEPA 1995).

The following paragraphs explain the exposure assumptions used to evaluate COPC impact in particulate inhalation.

Future On-Site Residents

Future on-site residents may be exposed to COPCs by inhaling fugitive dust during outdoor activities near their homes.

Due to the absence of a derived IR value for residential exposure scenarios, 20 m^3/day is used for adults (USEPA 1991), and 15 m^3/day is used for children (USEPA 1995b).

ED, EF, BW and AT values are the same as those used the incidental soil ingestion scenario.

Military Personnel

During work-related activities, base personnel may inhale COPCs emitted as fugitive dust. An inhalation rate of 20 m^3/day is used in this scenario (USEPA 1991).

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Future Construction Worker

The inputs for the Cowherd model for particulate inhalation are surface soil specific (e.g., wind erosion factor, vegetation cover and level of soil-disturbing activity). In other words, the Cowherd model for particulate inhalation specifically addresses surface soil exposure. For this reason, it is not used to evaluate subsurface soil particulate inhalation for construction workers.

A summary of particulate inhalation exposure assessment input parameters is presented in Table 6-11.

6.3.4.4 Ingestion of Groundwater

Currently at Site 3, deep groundwater provides the potable water supply. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies.

The equation for CDI, calculated for all human receptors potentially ingesting groundwater, is as follows:

$$CDI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

here:

C = Contaminant concentration is groundwater (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to calculate the impact of COPCs in groundwater ingestion.

Future On-Site Residents

Future children and adult residents may be exposed to COPCs through groundwater ingestion.

A 6-year-old child weighing 15kg has an IR of 1.0 L/day (USEPA 1991). This rate provides a conservative exposure estimate, in terms of systemic health effects. This value assumes that children obtain all the tap water they drink from the same source, for 350 days/year (EF). AT is 2,190 days (6 years x 365 days/year) for noncarcinogenic compound exposure (USEPA 1989a).

IR for adults is 2 L/day (USEPA 1989a). ED is 30 years, the national upper-bound (90th percentile) length of time spent at one residence (USEPA 1991). AT for noncarcinogens is 10,950 days. An AT of 25,550 days (70 years x 365 days/year) is used to evaluate exposure to potential carcinogenic compounds, for children and adults (USEPA 1989a).

A summary of groundwater ingestion exposure assessment input parameters is presented in Table 6-12.

6.3.4.5 Dermal Contact with Groundwater

As stated previously, deep groundwater currently provides the potable water supply at Site 3. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies.

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with groundwater, is as follows:

$$CDI = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

C = Contaminant concentration is groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (1 L/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with groundwater.

Future On-Site Residents

Children and adults may be exposed to COPCs through dermal contact with groundwater while bathing or showering.

It is assumed that bathing takes place 350 days/year (EF) (USEPA 1991). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992a).

PC is used to evaluate the movement of a chemical through the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose; however, many compounds do not have published PC values. PC is calculated for COPCs that do not have published PC values. The equation used to calculate PC is provided in Section 6.6.7. The default PC for water, 1.6E-04, is used for any organics without published parameters required to calculate PC (USEPA 1992a).

ET for bathing or showering is 0.25 hours/day, a conservative estimate (USEPA 1992a).

ED, BW and AT values are the same as those used in the groundwater ingestion scenario.

A summary of dermal contact with groundwater exposure assessment input parameters is presented in Table 6-13.

6.3.4.6 Inhalation of Volatile Organics While Showering

The Andelman (1983) inhalation model is applied in a qualitative assessment of inhaling volatile organics released from shower water. Contaminant (VOC) concentrations in air while showering are estimated by determining the following: the rate of chemical releases into air, (generation rate) the buildup of VOCs in the shower room air when the shower is on, the decay of VOCs in the shower room after the shower is turned off and the quantity of airborne VOCs inhaled while the shower is on and off.

The equation for CDI, calculated for all human receptors potentially inhaling volatile organics while showering, is as follows:

$$CDI = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

Future On-Site Residents

The potential to inhale vaporized volatile organic COPCs while showering is considered for both children and adults.

It is assumed that showering takes place 350 days/year (EF). IR for children and adults is 0.6 m^3/hr. ET is 0.25 hrs/day for both receptors (USEPA, 1989a).

ED, BW and AT values are the same as those used in the groundwater ingestion scenario.

A summary of groundwater inhalation exposure assessment input parameters is presented in Table 6-14.

Appendix N contains CDI calculation spreadsheets for specific exposure scenarios.

6.4 Toxicity Assessment

This section reviews toxicological information available for COPCs identified in Section 6.2.

6.4.1 Toxicological Evaluation

Toxicological evaluation addresses the inherent toxicity of chemical compounds. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with exposure to various contaminants.

Because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies, human data from occupational exposures are often insufficient for determining quantitative indices of toxicity. For this reason, animal bioassays are conducted under controlled conditions, and results are extrapolated to humans. There are several stages in this extrapolation. First, to account for species differences, conversion factors are used to apply test animal data to human studies. Second, high dosage administered to test animals must be translated into lower dosage, more typical of human exposure. When developing acceptable human doses of noncarcinogenic contaminants, safety factors and modifying factors are applied to animal test results. When studying carcinogens, mathematical models are used to convert high dosage effects to effects at lower dosages. Epidemiological data can then be used to determine credibility of these experimentally derived indices.

Reference dose (RfD) is an experimentally derived exposure index for noncarcinogenic contaminants, and carcinogenic slope factor (CSF) is an experimentally derived exposure index for carcinogens. These values are addressed, within the context of dose-response evaluation, in the next section.

Available toxicological information indicates that many COPCs have both carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although COPCs may cause adverse health and environmental effects, dose-response relationships and exposure must be evaluated before receptor risk can be determined. Dose-response relationships correlate dose magnitude with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component in risk assessment is the relationship between the dose of a compound and the potential for adverse health effects resulting from the exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of exposure to develop an estimate of risk.

6.4.2.1 Carcinogenic Slope Factor

CSFs are used to estimate upper-bound lifetime probability of developing cancer as a result of exposure to a particular dose of a potential carcinogen (USEPA, 1989a). This factor is generally reported in $(\text{mg/kg/day})^{-1}$ CSF is derived by converting high dose-response values produced by animal studies to low dose-response values, and by using an assumed low-dosage linear multistage model. The value used in reporting the slope factor is the upper 95th percent confidence limit.

USEPA WOE classifications accompany CSFs. They provide the weight of evidence according to which particular contaminants are defined as potential human carcinogens.

The USEPA's Human Health Assessment Group (HHAG) classifies carcinogenic potential by placing chemicals into one of the following groups, according to weight of evidence from epidemiological and animal studies:

Group A - Human Carcinogen (sufficient evidence of carcinogenicity in humans)

Group B - Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)

Group C	-	Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
Group D	-	Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
Group E	-	Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies)

6.4.2.2 Reference Dose

RfD is developed for chronic and/or subchronic chemical exposure and is based solely on noncarcinogenic effects of chemical substances. It is defined as an estimate of the daily exposure level for a human population that is not likely to produce an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect, by the appropriate "uncertainty factor (UF)". Effect levels are determined by laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989a):

- A UF of 10 is to account for variation in the general population and is intended to protect sensitive populations (e.g., elderly; children).
- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.
- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.
- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UFs, a modifying factor (MF) is applied to each reference dose and is defined as:

- An MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA WOE classifications are presented in Table 6-15. The hierarchy for choosing these values is as follows (USEPA, 1989a):

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)
- USEPA Environmental Criterion Assessment Office (EPA-ECAO) (USEPA, 1995)

The IRIS database is updated monthly and contains both verified CSFs and RfDs. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and to validate toxicity values used in developing CSFs. Once the slope factors have been verified with extensive peer review, they appear in the IRIS database. Like the CSF Workgroup, an RfD Workgroup has been formed by the USEPA to review existing data used to derive RfDs. Once RfDs have been verified, they also appear in IRIS.

HEAST, on the other hand, provides both interim (unverified) and verified CSFs and RfDs. This document is published quarterly and incorporates any applicable changes to its database.

6.5 Risk Characterization

This section presents estimated incremental lifetime cancer risks (ICRs) and hazard indices (HIs) for identified receptor groups possibly exposed to COPCs by the exposure pathways presented in Section 6.3.

Quantitative risk calculations for carcinogenic compounds estimate ICR levels for individuals in a given population. An ICR of 1E-06, for example, indicates that, within a lifetime of exposure to site-specific contamination, one additional case of cancer may occur per one million exposed individuals.

The following represents an individual's ICR:

$$ICR = \sum_{i=1}^{n} CDI_i \ x \ CSF_i$$

Where CDI_i is the chronic daily intake (mg/kg/day) for compound i, and CSF_i is the compound's carcinogenic slope factor [(mg/kg/day)-1]. The CSF is defined as an upper 95th percentile confidence limit of the probability of a carcinogenic response, based on experimental animal data. The CDI defines exposure, expressed as a mass of a substance contracted per unit body weight per unit time, averaged over a period of time (i.e., six years to a lifetime). The above equation is derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

Quantitative noncarcinogenic risk calculations assume that noncarcinogenic compounds have threshold values for toxicological effects. Noncarcinogenic effect weighs CDI against threshold levels (RfDs). Noncarcinogenic effect is estimated by calculating the hazard index (HI), defined by the following equation:

$$HI = HQ_1 + HQ_2 + ...HQ_n$$

$$= \sum_{i=1}^{n} HQ_i$$

$$\gamma \text{ where } HQ_i = CDI_i / RfD_i$$

Where HQi is the hazard quotient for contaminant i, CDI_i is chronic daily intake (mg/kg/day) and RfD_i is the reference dose (mg/kg/day) for contaminant i, over a prolonged period of exposure.

6.5.1 Human Health Risks

ICR and HI values associated with exposure to environmental media at Site 3, soil and groundwater, are presented in Tables 6-16 and 6-17, respectively. Total carcinogenic and noncarcinogenic risks, per medium, for all relevant receptor groups, are provided in these tables. ICR and HI are also broken down to show risks from specific exposure pathways: ingestion, dermal contact and inhalation (where applicable).

The text in this section explains the calculated risk results for Site 3, presented in Tables 6-16 and 6-17.

A cancer risk range of 1E-04 to 1E-06 is used to evaluate calculated ICR levels. Any ICR value within this range is considered "acceptable"; an ICR greater than 1E-04 denotes an existing cancer risk. A noncarcinogenic risk of 1.0 is used as an upper limit to which calculated HI values are compared. Any HI exceeding 1.0 indicates an existing noncarcinogenic risk (USEPA 1989a).

6.5.1.1 Surface Soil

ICR values calculated for future residential children and adults and military personnel fall within the USEPA acceptable risk range. In other words, carcinogens in Site 3 soil generate no risks beyond acceptable levels.

HI values calculated for future residential children and adults and military personnel are less than 1.0, below the acceptable risk level. In other words, noncarcinogens in Site 3 soil generate no risks beyond acceptable levels.

6.5.1.2 Subsurface Soil

ICR values calculated for future construction workers fall within the USEPA acceptable risk range. In other words, carcinogens in Site 3 soil generate no risks beyond acceptable levels.

HI values calculated for future construction workers are less than 1.0, below the acceptable risk level. In other words, noncarcinogens in Site 3 soil generate no risks beyond acceptable levels.

6.5.1.3 Groundwater, Round 2 Only

ICR values calculated for future residential children and adults fall within the USEPA acceptable risk range. In other words, carcinogenic COPCs from Round 2 groundwater data generate no risks beyond acceptable levels.

The HI value calculated for future residential adults is less than 1.0. The HI value calculated for future residential children is greater than 1.0 (Child HI = 1.7). This indicates that future children may experience adverse systemic health effects from noncarcinogenic COPCs from Round 2 groundwater data. Groundwater ingestion and dermal contact drive these total risks. 4-Methylphenol (35 %), dibenzofuran (25 %), and naphthalene (22 %) drive the groundwater ingestion risks for children. Naphthalene (39 %), phenanthrene (19 %) and 4-methylphenol (17 %) drive the groundwater dermal contact risks for both children and adults.

6.5.1.4 Groundwater, Worst Case Contamination Scenario

ICR values calculated for future residential children and adults exceed the USEPA acceptable risk range (Child ICR = 7.5E-04; Adult ICR = 1.8E-03). This indicates that carcinogenic COPCs in a worst case groundwater contamination scenario may generate risks beyond acceptable levels. Groundwater ingestion and dermal contact drive these total risks. Benzo(a)pyrene (71 %) and benzo(a)anthracene (14 %) drive the groundwater ingestion risks for both children and adults. Benzo(a)pyrene (93 %) drives the groundwater dermal contact risks for both children and adults.

HI values calculated for future residential children and adults are greater than 1.0 (Child HI = 2.3; Adult HI = 3.7). This indicates that future residents may experience adverse systemic health effects from noncarcinogenic COPCs from Site 3 groundwater, in a worst case contamination scenario. Groundwater ingestion and dermal contact drive these total risks. Dibenzofuran (54 %) and phenanthrene (13 %) drive the groundwater ingestion risks for both children and adults. Phenanthrene (73 %) and acenaphthene (14 %) drive the groundwater dermal contact risks for both children and adults.

6.6 Sources of Uncertainty

Uncertainties may arise during the risk assessment process. This section presents site specific sources of uncertainty in the risk assessment:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Qualitatively Evaluated
- Surrogates Substituted for Contaminants Without Toxicity Information
- Permeability Constant (Kp)
- Approach to Groundwater Evaluation for Site 3

6.6.1 Analytical Data

The credibility of the BRA relies on the quality of the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. In addition, the statistical methods used to compile and analyze data (mean concentration, standard deviation, and detection frequencies) are subject to uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in risk estimation. Data can be qualified as "J" (estimated) for many reasons, including a slight exceedance of holding times, high or low surrogate recovery, or intra-sample variability.

Data qualified with "J" were retained for risk assessment. Organic data qualified with "B" (detected in blank) or "R" (rejected/unreliable) were not applied to risk analysis. Because the sampling and analytical program at Site 3 was so comprehensive, dismissing data points qualified with "B" or "R" did not significantly increase uncertainty in the risk assessment.

6.6.2 Exposure Assessment

When performing exposure assessments, uncertainties can arise from two main sources. First, the chemical concentration to which a receptor may be exposed must be estimated for every medium of interest. Second, uncertainties can arise in estimating contaminant intakes resulting from contact with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor may be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a given data set. More complex methods for deriving contaminant concentration are necessary when exposure to COPCs in a given medium occurs subsequent to contaminant release from another medium, or when analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate potential human exposure.

Potential inhalation of fugitive dusts from affected soils is estimated by using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination (Cowherd et al., 1985). The Cowherd model employs the use of a site-specific PEF for wind erosion based on source area and vegetative cover. A conservative PEF estimate was derived for Site 3 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential.

Groundwater samples were analyzed for total (unfiltered) and dissolved (filtered) inorganic contaminants. These samples were obtained from wells which were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells cannot be considered representative of potable groundwater, or groundwater which is obtained from a domestic well at the tap. The use of total inorganic analytical results overestimates the potential human health risks associated with potable use scenarios. However, in order to produce the most conservative risk estimates, total organic results were used to calculate the potential intake associated with groundwater use.

As stated previously, the shallow groundwater at Camp Lejeune is currently not used as a potable source. Receptors are only exposed to groundwater drawn from the deep zone. For this reason, exposure to shallow groundwater is not evaluated for current receptors. Groundwater exposure is evaluated for future residents only, as there is a possibility that shallow groundwater may be tapped someday.

To estimate receptor intake, certain assumptions must be made about exposure events, exposure durations and the corresponding assimilation of contaminants by the receptor. Exposure factors have been created from a range of values generated by studies conducted by the scientific community, and have been reviewed by the USEPA. Conservative assumption for daily intakes are employed throughout the BRA when values are not available; they are designed to produce low error, to protect human health and to yield reasonable clean-up goals. In all instances, the values, conservative scientific judgments and conservative assumptions used in the risk assessment concur with USEPA guidelines.

6.6.3 Sampling Strategy

As an environmental medium, soil is available for direct contact exposure, and it is often the main source of contamination released to other media. Soil sampling intervals should be appropriate for the exposure pathways and contaminant transport routes of concern. Surface soil exposure assessment is based on samples collected from the shallowest depth, 0 to 1 foot below the ground surface. Subsurface soil samples are necessary to generate data for exposure assessment when soil excavation is possible, or if leaching of chemicals to groundwater is likely. Subsurface soil samples are collected at depths greater than 1 foot below the ground surface.

6.6.4 Toxicity Assessment

In making quantitative estimates about the toxicity of varying chemical doses, uncertainties arise from two sources. First, existing data usually provide insufficient information about toxic exposure and subsequent effects. Human exposure data display inherent temporal variability and often lack adequate concentration estimates. Animal studies are often used to subsidize available human data. In the process of extrapolating animal results to humans; however, more uncertainties can arise. Second, in order to obtain visible toxic effects in experimental animals, high chemical doses are employed over short periods of time. Doses typical of human exposure, however, are much lower, relative to those doses administered to experimental animals. In order to apply animal test results to human exposure assessments, then, data must be adjusted to extrapolate from high dose effects to low dose effects.

In extrapolating effects from animal receptors to human receptors, and from high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose response calculations, the following factors are considered:

- Studies are preferred in which the animal closely mimics human pharmacokinetics
- Studies are preferred in which dose intake most closely mimics intake route and duration for humans
- Studies are preferred in which the most sensitive responses to the compound in question is demonstrated

In order to evaluate compounds that cause threshold effects, (i.e., noncarcinogens) safety factors are taken into account when experimental results are extrapolated from animals to humans, and from high to low doses.

Employing conservative assumptions yields quantitative toxicity indices that are not expected to underestimate potential toxic effects, but may overestimate these effects by some magnitude.

6.6.5 Compounds Not Quantitatively Evaluated

The following contaminants detected at Site 3 were not quantitatively evaluated in the BRA, as there is no toxicity information promulgated by the USEPA, and no appropriate surrogates to substitute for them:

- 2-nitrophenol

6.6.6 Surrogates Substituted for Contaminants Without Toxicity Information

In the event that the list of COPCs contains contaminants with no toxicity information, other contaminants are substituted as surrogates for them. Toxicity values (i.e., RBC, CSF and RfD) for the surrogate contaminants are used in CDI calculations. Following is a list of COPCs from Site 3 without toxicity values, and their corresponding chemical surrogates:

phenanthrene: pyrene
2-methylnaphthalene: naphthalene

6.6.7 Permeability Constant (Kp)

In order to calculate CDI for dermal contact with groundwater, Kp must be calculated for COPCs that do not have published Kp values. The following equation is used to calculate Kp (USEPA, 1992a):

$$\log Kp = -2.72 + 0.71 \log Ko/w - 0.0061\ MW$$

The default Kp for water, 1.6E-04 is used for any organics without a published logKo/w (USEPA, 1992a). Kp calculations are presented with the CDI spreadsheets for dermal contact with groundwater in Appendix N.

6.6.8 Approach to Groundwater Evaluation for Site 3

Three rounds of groundwater samples were collected for the Site 3 RI. Each round of data 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.

These are the 2 approaches that have been taken to evaluate groundwater exposure at Site 3. ICRs and HIs have been calculated for receptors using both of these approaches.

6.7 BRA Conclusions

The BRA evaluates environmental media at Site 3, in terms of human health risk. Potential receptors at the site include future residential children and adults, current military personnel and future construction workers. Total site ICR and HI per receptor group are estimated by combining ICRs and HIs associated with specific exposure pathways. The following algorithms define total site risk:

1. Future Residents (Children and Adults)
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of COPCs in particulates

b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs

2. Current Military Personnel

a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs

3. Future Construction Worker

a. Incidental ingestion of COPCs subsurface soil + dermal contact with COPCs in subsurface soil

6.7.1 Total Site Risk

The text below addresses total site risks by receptor group.

6.7.1.1 Future Residential Children (with Round 2 Groundwater Contamination)

Total ICR for future residential children (1.9E-05) is within the USEPA acceptable cancer risk range. However, total HI (1.7) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk (100 percent contribution). Groundwater ingestion contributes 56 percent to the total groundwater HI, and dermal contact with groundwater contributes 44 percent to the total groundwater HI.

6.7.1.2 Future Residential Children (with Worst Case Groundwater Contamination)

Total ICR for future residential children (7.67E-04) exceeds the USEPA acceptable cancer risk range. The risk from groundwater exposure drives the total cancer risk (100 percent contribution to risk). Groundwater ingestion contributes 4 percent to the total groundwater ICR, and dermal contact with groundwater contributes 95 percent to the total groundwater ICR.

Total HI (2.3) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk for future residential children (100 percent contribution to risks). Groundwater ingestion contributes 93 percent to the total groundwater HI, and dermal contact with groundwater contributes 7 percent to the total groundwater HI.

6.7.1.3 Future Residential Adults (with Round 2 Groundwater Contamination)

Total ICR for future residential adults (1.7E-05) is within the USEPA acceptable cancer risk range. Total HI (0.7) falls below the USEPA acceptable noncarcinogenic risk value of 1.0. Therefore, no systemic risks are likely to occur from exposure to groundwater.

6.7.1.4 Future Residential Adults (with Worst Case Groundwater Contamination)

Total ICR for future residential adults (1.8E-03) exceeds the USEPA acceptable cancer risk range. The risk from groundwater exposure drives the total carcinogenic risk (100 percent contribution). Groundwater ingestion contributes 4 percent to the total groundwater ICR, and dermal contact with groundwater contributes 96 percent to the total groundwater ICR.

Total HI, (3.7) is greater than 1.0. The risk from groundwater exposure drives the total noncarcinogenic risk (100 percent contribution). Groundwater ingestion contributes 91 percent to the total groundwater HI, and dermal contact with groundwater contributes 9 percent to the total groundwater HI.

6.7.1.5 Current Military Personnel

Total ICR for current military personnel (1.7E-06) is within the USEPA acceptable risk range. Total HI was not calculated (is not applicable), because there are no noncarcinogens retained as COPCs in surface soil.

6.7.1.6 Future Construction Workers

Total ICR for future construction workers (1.0E-07) is below the USEPA acceptable risk range. Total HI (less than 0.01) is less than 1.0.

Total site ICR and HI values are presented in Table 6-18.

6.8 References

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SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blanks (µg/L)	Medium Associated with Blanks	Concentration for Comparison(1) (Aqueous - µg/L)	Concentration for Comparison(2) (Solid - µg/kg)
Methylene Chloride	7J	Soil	70	70
Acetone	720J	Soil	7200	7200
1,2-Dichloroethane	3J	Soil	30	30
2-Butanone	10J	Soil	100	100
2-Hexanone	1J	Soil	10	10
Phenol	7J	Soil	35	1155(3)
Butyl benzyl phthalate	4J	Soil	40	1320(3)
bis(2-Ethylhexyl)phthalate	4J	Soil	40	1320(3)
Calcium	44.8	Soil	44.8	44.8
Iron	24.3	Soil	24.3	24.3
Lead	4.2	Soil	4.2	4.2
Sodium	145	Soil	145	145
Zinc	50.1	Soil	50.1	50.1
Chloromethane	2J	GW1	20	NA
Methylene Chloride	2J	GW1	20	NA
Acetone	19	GW1	190	NA
1,2-Dichloroethane	3J	GW1	30	NA
2-Butanone	17	GW1	170	NA
Tetrachloroethane	1J	GW1	10	NA
Aluminum	52.2	GW1	261	NA
Calcium	62.6	GW1	313	NA
Iron	28.3	GW1	141.5	NA
Lead	5.8	GW1	290	NA
Sodium	128	GW1	640	NA
Zinc	53.8	GW1	269	NA
Methylene chloride	6J	GW2	60	NA
Acetone	160J	GW2	1600	NA
4-Methyl-2-pentanone	10	GW2	100	NA
Xylenes	1J	GW2	10	NA
Phenol	16	GW2	160	NA
Methylene Chloride	2J	GW3	20	NA
Acetone	35J	GW3	350	NA

TABLE 6-1 (Continued)

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blanks (µg/L)	Medium Associated with Blanks	Concentration for Comparison⁽¹⁾ (Aqueous - µg/L)	Concentration for Comparison⁽²⁾ (Solid - µg/kg)
2-Butanone	6J	GW3	60	NA
Toluene	1J	GW3	10	NA
di-n-Butylphthalate	1J	GW3	10	NA

Notes: (1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum concentration detected in a blank.

(2) Concentration is five or ten times the maximum concentration detected in a blank; converted to µg/kg.

(3) Semivolatile blank concentrations are multiplied by 33 to account for matrix difference.

GW1 - Groundwater Round 1
GW2 - Groundwater Round 2
GW3 - Groundwater Round 3
NA - Not applicable

TABLE 6-2

SURFACE SOIL ORGANIC DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Residential Soil RBC[1]	Surface Soil Range of Positive Detections	Surface Soil No. of Positive Detections/ No. of Samples	No. of Detections Exceeding RBC
Volatiles				
Toluene	1,600,000	2J - 2J	2/17	0
Ethylbenzene	780,000	2J	1/17	0
Xylenes (Total)	16,000,000	6J	1/17	0
Semivolatiles				
Phenol	4,700,000	38J	1/58	0
Naphthalene	310,000	38J - 200J	2/58	0
2-Methylnaphthalene	310,000	41J	1/58	0
Acenaphthylene	230,000	40J - 2,700	16/58	0
Acenaphthene	470,000	44J - 460J	2/58	0
Dibenzofuran	31,000	370J	1/58	0
Fluorene	310,000	39J - 620J	5/58	0
Phenanthrene	230,000	37J - 2,900	9/58	0
Anthracene	2,300,000	40J - 7,700	26/58	0
Carbazole	32,000	40J - 830J	14/58	0
Di-n-butylphthalate	780,000	37J - 340J	37/58	0
Fluoranthene	310,000	42J - 11,000	32/58	0
Pyrene	230,000	39J - 14,000	34/58	0
Benzo(a)anthracene	880	32J - 8,300	24/58	5
Chrysene	88,000	40J - 12,000	32/58	0
bis(2-Ethylhexyl)phthalate	46,000	36J - 91J	30/58	0
Benzo(b)fluoranthene	880	39J - 13,000	37/58	6
Benzo(k)fluoranthene	8,800	37J - 9,000	34/58	1
Benzo(a)pyrene	88	38J - 8,700	30/58	20
Indeno(1,2,3-cd)pyrene	880	40J - 6,800	26/58	4
Dibenz(a,h)anthracene	88	40J - 2,900	16/58	6
Benzo(g,h,i)perylene	230,000	39J - 4,700	22/58	0

Notes: (1) USEPA Region III Risk-Based Concentration (RBC) Table (USEPA, 1995b).
Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-3

SURFACE SOIL INORGANIC DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil			
	Twice the Average Base Specific Background[1] Concentration.	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	5151.959	1,740 - 4,240	2/2	0
Antimony	5.835	ND	0/2	0
Arsenic	1.302	ND	0/2	0
Barium	15.229	6.4J - 7.8J	2/2	0
Beryllium	0.222	ND	0/2	0
Cadmium	0.706	ND	0/2	0
Calcium	957.712	4,020 - 67,700	2/2	2
Chromium	5.857	2.7 - 7.1	2/2	1
Cobalt	2.233	ND	0/2	0
Copper	7.291	ND	0/2	0
Iron	3260.2	1,390 - 1,970	2/2	0
Lead	21.798	4.4J	1/2	0
Magnesium	177.212	150 - 1,020	2/2	1
Manganese	17.642	11.7 - 13.1	2/2	0
Mercury	0.087	ND	0/2	0
Nickel	3.377	ND	0/2	0
Potassium	186.724	ND	0/2	0
Selenium	0.831	ND	0/2	0
Silver	0.945	ND	0/2	0
Sodium	67.556	112	1/2	1
Thallium	1.076	ND	0/2	0
Vanadium	8.498	3.3 - 5.2	2/2	0
Zinc	12.124	16.6	1/2	1

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

ND - Not Detected

J - Estimated Value

TABLE 6-4

SUBSURFACE SOIL ORGANIC DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Residential Soil RBC(1)	Subsurface Soil		No. of Detections Exceeding RBC
		Range of Positive Detections	No. of Positive Detections/ No. of Samples	
Volatiles				
Acetone	780,000	120	1/18	0
Carbon Disulfide	780,000	1J	1/18	0
Chloroform	100,000	3J	1/18	0
2-Butanone	4,700,000	3J	1/18	0
Benzene	22,000	2J	2/18	0
Toluene	1,600,000	3J - 13	4/18	0
Ethylbenzene	780,000	3J - 110	4/18	0
Styrene	1,600,000	4J - 5J	2/18	0
Xylenes (Total)	16,000,000	7J - 300	4/18	0
Semivolatiles				
Phenol	4,700,000	7,200J	1/47	0
2-Methylphenol	390,000	2,000J	1/47	0
4-Methylphenol	39,000	5,900J	1/47	0
Naphthalene	310,000	55J - 95,000J	9/47	0
2-Methylnaphthalene	310,000	100J - 31,000J	6/47	0
Acenaphthylene	230,000	190J	1/47	0
Acenaphthene	470,000	560 - 47,000J	6/47	0
4-Nitrophenol	480,000	570J	1/47	0
Dibenzofuran	31,000	440 - 36,000J	6/47	1
Fluorene	310,000	710 - 35,000J	6/47	0
N-nitrosodiphenylamine	13,000	400J - 1,100J	2/47	0
Phenanthrene	230,000	61J - 110,000J	8/47	0
Anthracene	2,300,000	42J - 12,000J	7/47	0
Carbazole	32,000	200J - 4,900	6/47	0
Di-n-butylphthalate	780,000	39J - 170J	18/47	0
Fluoranthene	310,000	51J - 66,000	7/47	0
Pyrene	230,000	43J - 38,000J	10/47	0
Benzo(a)anthracene	880	77J - 8,000	7/47	5
Chrysene	88,000	86J - 8,400J	7/47	0
bis(2-Ethylhexyl)phthalate	46,000	53J - 240J	2/47	0
Benzo(b)fluoranthene	880	96J - 3,500J	7/47	4
Benzo(k)fluoranthene	8,800	79J - 3,300J	6/47	0
Benzo(a)pyrene	88	55J - 3,300J	7/47	6
Indeno(1,2,3-cd)pyrene	880	46J - 3,100J	5/47	1
Benzo(g,h,i)perylene	230,000	71J - 1,200J	4/47	0

Notes: (1) USEPA Region III Risk-Based Concentration (RBC) Table (USEPA, 1995b).
Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-5

SUBSURFACE SOIL INORGANIC DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Subsurface Soil			
Inorganic	Twice the Average Base Specific Background[(1)] Concentration.	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	7229.446	3,950 - 6,570	2/2	0
Antimony	7.315	ND	0/2	0
Arsenic	2.32	ND	0/2	0
Barium	14.126	4.6J - 6.6J	2/2	0
Beryllium	0.207	ND	0/2	0
Cadmium	0.745	ND	0/2	0
Calcium	449.1	77.4 - 638	2/2	1
Chromium	13.503	3.7 - 7.5	2/2	0
Cobalt	1.761	ND	0/2	0
Copper	2.868	ND	0/2	0
Iron	8202.497	734 - 1,030	2/2	0
Lead	8.672	5.7J	1/2	0
Magnesium	273.731	104 - 112	2/2	0
Manganese	8.673	2.8J	1/2	0
Mercury	0.135	ND	0/2	0
Nickel	2.875	ND	0/2	0
Potassium	394.894	ND	0/2	0
Selenium	0.939	ND	0/2	0
Silver	0.95	ND	0/2	0
Sodium	56.731	ND	0/2	0
Thallium	1.176	ND	0/2	0
Vanadium	14.078	3.7 - 5	2/2	0
Zinc	7.763	ND	0/2	0

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

NA - Not Applicable

ND - Not Detected

J - Estimated Value

TABLE 6-6

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
			Federal Health Advisories(3)						No. of Detects Above Health Advisories	
Contaminant	NCWQS(1)	MCL(2)	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
ROUND 1										
Volatiles:										
Carbon Disulfide	700	NA	NE	NE	1/3	1J	0	NA	NA	NA
Benzene	1	5	NE	NE	3/3	13J-40J	3	3	NA	NA
Toluene	1,000	1,000	NE	NE	3/3	5J-10J	0	0	NA	NA
Xylenes (Total)	530	10,000	NE	NE	3/3	6J-9J	0	0	NA	NA
Semivolatiles:										
Phenol	300	NA	NE	NE	1/8	3J	0	NA	NA	NA
2-Methylphenol	NE	NE	NE	NE	1/8	1J	NA	NA	NA	NA
4-Methylphenol	NE	NE	NE	NE	1/8	3J	NA	NA	NA	NA
2-Nitrophenol	NE	NE	NE	NE	1/8	2J	NA	NA	NA	NA
2,4-Dimethylphenol	NE	NE	NE	NE	1/8	2J	NA	NA	NA	NA
Naphthalene	21	NE	400	100	5/8	3J-64	1	NA	0	0
2-Methylnaphthalene	NE	NE	NE	NE	1/8	65	NA	NA	NA	NA
Acenaphthylene	210	NE	NE	NE	1/8	3J	0	NA	NA	NA
Acenaphthene	800	NE	NE	NE	3/8	2J-280	0	NA	NA	NA
Dibenzofuran	NE	NE	NE	NE	3/8	2J-230	NA	NA	NA	NA
Fluorene	280	NE	NE	NE	3/8	1J-210	0	NA	NA	NA
Phenanthrene	210	NE	NE	NE	2/8	75-410	1	NA	NA	NA
Anthracene	2,100	NE	NE	NE	2/8	5J-33	0	NA	NA	NA
Carbazole	NE	NE	NE	NE	1/8	39J	NA	NA	NA	NA
di-n-Butylphthalate	700	NE	NE	NE	1/8	1J	0	NA	NA	NA

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
			Federal Health Advisories(3)						No. of Detects Above Health Advisories	
Contaminant	NCWQS(1)	MCL(2)	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
ROUND 1 (Continued)										
Fluoranthene	280	NE	NE	NE	2/8	10-100	0	NA	NA	NA
Pyrene	210	NE	NE	NE	2/8	7J-58	0	NA	NA	NA
Benzo(a)anthracene	0.05	NE	NE	NE	1/8	8J	1	NA	NA	NA
Chrysene	5	NE	NE	NE	1/8	8J	1	NA	NA	NA
Benzo(b)fluoranthene	NE	NE	NE	NE	1/8	3J	NA	NA	NA	NA
Benzo(k)fluoranthene	NE	NE	NE	NE	1/8	3J	NA	NA	NA	NA
Benzo(a)pyrene	NE	2	NE	NE	1/8	3J	NA	1	NA	NA
Inorganics:										
Aluminum	NE	NE	NE	NE	2/3	447-4,030	NA	NA	NA	NA
Barium	2,000	2,000	NE	NE	3/3	88.1-120	0	0	NA	NA
Calcium	NE	NE	NE	NE	3/3	2,870-43,600	NA	NA	NA	NA
Chromium	50	100	200	800	1/3	31.6	0	0	0	0
Iron	300	NE	NE	NE	3/3	43.2-2,190	2	NA	NA	NA
Lead	15	15	NE	NE	1/3	3.2J	0	0	NA	NA
Magnesium	NE	NE	NE	NE	3/3	1,410-4,200	NA	NA	NA	NA
Manganese	50	NE	NE	NE	3/3	4.5J-21.7J	0	NA	NA	NA
Nickel	100	100	500	1,700	1/3	34.1	0	0	0	0
Potassium	NE	NE	NE	NE	3/3	1,300-1,900	NA	NA	NA	NA
Sodium	NE	NE	NE	NE	3/3	4,750-15,300	NA	NA	NA	NA
Zinc	2,100	NE	3,000	10,000	1/3	114	0	NA	0	0

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	NCWQS(1)	MCL(2)	Federal Health Advisories(3)		No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above Health Advisories	
			10 kg Child	70 kg Adult					10 kg Child	70 kg Adult
ROUND 2										
Volatiles:										
1,1-Dichloroethene	7	7	NE	NE	1/16	1J	0	0	NA	NA
Chloroform	0.19	100	100	400	2/16	1J - 1J	2	0	0	0
Trichloroethene	NE	5	NE	NE	3/16	1J - 1J	NA	0	NA	NA
Benzene	1	5	NE	NE	1/16	3J	1	0	NA	NA
Toluene	1,000	1,000	NE	NE	2/16	2J - 15J	0	0	NA	NA
Ethylbenzene	29	700	1,000	3,000	1/16	14J	0	0	0	0
Xylenes (Total)	530	10,000	NE	NE	1/16	32J	0	0	NA	NA
Semivolatiles:										
Phenol	300	NE	NE	NE	1/16	420J	1	NA	NA	NA
2-Methylphenol	NE	NE	NE	NE	1/16	300J	NA	NA	NA	NA
4-Methylphenol	NE	NE	NE	NE	1/16	690J	NA	NA	NA	NA
2,4-Dimethylphenol	NE	NE	NE	NE	1/16	170J	NA	NA	NA	NA
Naphthalene	21	NE	400	100	3/16	4J - 2,400J	2	NA	1	2
2-Methylnaphthalene	NE	NE	NE	NE	2/16	10 - 250J	NA	NA	NA	NA
Acenaphthylene	210	NE	NE	NE	1/16	1J	0	NA	NA	NA
Acenaphthene	800	NE	NE	NE	3/16	24 - 320J	0	NA	NA	NA
Dibenzofuran	NE	NE	NE	NE	3/16	17 - 140J	NA	NA	NA	NA
Fluorene	280	NE	NE	NE	3/16	23 - 160J	0	NA	NA	NA
Phenanthrene	210	NE	NE	NE	2/16	21 - 130J	0	NA	NA	NA
Anthracene	2,100	NE	NE	NE	3/16	1J - 13J	0	NA	NA	NA

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
			Federal Health Advisories$^{(3)}$						No. of Detects Above Health Advisories	
Contaminant	NCWQS$^{(1)}$	MCL$^{(2)}$	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
ROUND 2 (Continued)										
Carbazole	NE	NE	NE	NE	3/16	3J - 87J	NA	NA	NA	NA
Fluoranthene	280	NE	NE	NE	3/16	2J - 21J	0	NA	NA	NA
Pyrene	210	NE	NE	NE	2/16	11 - 14J	0	NA	NA	NA
Bis(2-ethylhexyl)phthalate	3	6	NE	NE	4/16	2J - 11	2	1	NA	NA
ROUND 3										
Volatiles:										
Benzene	1	5	NE	NE	1/16	3J	1	0	NA	NA
Toluene	1,000	1,000	NE	NE	2/16	8J-11	0	0	NA	NA
Ethylbenzene	29	700	1,000	3,000	2/16	1J-10	0	0	NA	NA
Xylenes (Total)	530	10,000	NE	NE	1/16	20	0	0	NA	NA
Semivolatiles:										
Phenol	300	NE	NE	NE	2/16	1J-68	0	NA	NA	NA
2-Methylphenol	NE	NE	NE	NE	1/16	160J	NA	NA	NA	NA
4-Methylphenol	NE	NE	NE	NE	1/16	200J	NA	NA	NA	NA
2,4-Dimethylphenol	NE	NE	NE	NE	1/16	64J	NA	NA	NA	NA
Naphthalene	21	NE	400	100	3/16	4J-1,500	2	NA	1	2
2-Methylnaphthalene	NE	NE	NE	NE	3/16	1J-94	NA	NA	NA	NA
Acenaphthylene	210	NE	NE	NE	1/16	2J	0	NA	NA	NA
Acenaphthene	800	NE	NE	NE	3/16	25-55	0	NA	NA	NA
Dibenzofuran	NE	NE	NE	NE	3/16	24-120J	NA	NA	NA	NA
Fluorene	280	NE	NE	NE	3/16	20-80	0	NA	NA	NA

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	NCWQS[1]	MCL[2]	Federal Health Advisories[3]		No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above Health Advisories	
			10 kg Child	70 kg Adult					10 kg Child	70 kg Adult
ROUND 3 (Continued)										
Phenanthrene	210	NE	NE	NE	3/16	23-120	0	NA	NA	NA
Anthracene	2,100	NE	NE	NE	2/16	5NJ-11NJ	0	NA	NA	NA
Carbazole	NE	NE	NE	NE	3/16	4J-82	NA	NA	NA	NA
Fluoranthene	280	NE	NE	NE	3/16	3J-28	0	NA	NA	NA
Pyrene	210	NE	NE	NE	3/16	2J-16	0	NA	NA	NA
Bis(2-ethylhexyl)phthalate	3	6	NE	NE	2/16	1J	0	0	NA	NA

Notes: Concentrations expressed in microgram per liter (µg/L).

[1] NCWQS = North Carolina Water Quality Standards for Groundwater

[2] MCL = Safe Drinking Water Act Maximum Contaminant Level

[3] Longer Term Health Advisories for a 10 kg Child and 70 kg Adult

NE - No Criteria Established
NA - Not Applicable
J - Estimated value

TABLE 6-7

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	Subsurface Soil	Round 2 Groundwater		Combined Rounds Groundwater
Volatiles:					
1,1-Dichloroethene			●	X	X
Chloroform			●	X	X
Trichloroethene			●		
Benzene			●	X	X
Toluene			●		
Ethylbenzene			●		
Xylenes (total)			●		
Semivolatiles:					
Phenol			●		
2-Methylphenol			●	X	X
4-Methylphenol			●	X	X
2,4-Dimethylphenol			●	X	X
Naphthalene			●	X	X
2-Methylnaphthalene			●	X	X
Acenaphthene			●	X	X
Acenaphthylene			●		
Dibenzofuran		X	●	X	X
Fluorene			●	X	X
Phenanthrene			●	X	X
Anthracene			●		
Carbazole			●	X	X
Fluoranthene			●		
Pyrene			●		
Bis(2-ethylhexyl)phthalate			●		
Benzo(a)anthracene	X	X			X
Chrysene	X	X			X
Benzo(b)fluoranthene	X	X			X
Benzo(k)fluoranthene	X	X			X
Benzo(a)pyrene	X	X			X
Indeno(1,2,3-cd)pyrene	X	X			
Dibenz(a,h)anthracene	X				
2-Nitrophenol					X
Inorganics:					
Aluminum					X
Chromium					X

● = Detected in media; compared to relevant criteria and standards.
X = Selected as a COPC for human health risk assessment.

TABLE 6-8

MATRIX OF POTENTIAL HUMAN EXPOSURE
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Future Residential Population
Soil Incidental Ingestion	M	W	A,C
Dermal Contact	M	W	A,C
Groundwater Ingestion	NE	NE	A,C
Dermal Contact	NE	NE	A,C
Surface Water$^{(1)}$ Ingestion	NA	NA	NA
Dermal Contact	NA	NA	NA
Sediment$^{(1)}$ Incidental Ingestion	NA	NA	NA
Dermal Contact	NA	NA	NA
Air Inhalation of Vapor Phase Chemicals Indoor	NE	NE	A,C
Inhalation of Particulates Outdoor	M	NA	A,C

Note:

(1) Surface water/sediment exposure is not evaluated since there is no surface water body in the proximity of Site 3.

A = Residential exposure for adults
C = Residential exposure for children
M = Military lifetime exposure
W = Construction duration exposure
NE = Not Exposed
NA = Not Applicable.

TABLE 6-9

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Military Personnel, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
IR	Ingestion Rate	Child Adult Military Personnel Construction Worker	200 mg/day 100 mg/day 100 mg/day 480 mg/day	USEPA, December 1989a USEPA, March 1991
CF	Conversion Factor	1E-6 kg/mg		USEPA, December 1989a
Fi	Fraction Ingested from Contaminated Source	100%		Conservative Professional Judgement
EF	Exposure Frequency	Child Adult Military Personnel Construction Worker	350 days/yr 350 days/yr 350 days/yr 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child Adult Military Personnel Construction Worker	6 years 24 years 4 years 1 year	USEPA, December 1989a USEPA, March 1991
BW	Body Weight	Child Adult Military Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult Military Personnel Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, December 1989a

TABLE 6-10

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Military Personnel, Future Construction Worker

Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992d
CF	Conversion Factor	1E-6 kg/mg		USEPA, December 1989a
SA	Exposed Surface Area of Skin Available for Contact	Child Adult Military Personnel Construction Worker	2,300 cm^2 5,800 cm^2 5,800 cm^2 4,300 cm^2	USEPA, January 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs and feet
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2		USEPA, Region IV, 1992c
ABS	Fraction Absorbed (unitless)	Organics Inorganics	1.0% 0.1%	USEPA, Region IV, 1992c
EF	Exposure Frequency	Child Adult Military Personnel Construction Worker	350 days/yr 350 days/yr 350 days/yr 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child Adult Military Personnel Construction Worker	6 years 24 years 4 years 1 year	USEPA, December 1989a USEPA, March 1991
BW	Body Weight	Child Adult Military Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult Military Personnel Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, December 1989a

TABLE 6-11

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Military Personnel, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
EF	Exposure Frequency	Child Adult Military Personnel	350 days/yr 350 days/yr 350 days/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult Military Personnel	6 years 24 years 4 years	USEPA, March 1991
IR	Inhalation Rate	Child Adult Military Personnel	15 m^3 20 m^3 20 m^3	USEPA, November, 1995 USEPA, May 1989b
BW	Body Weight	Child Adult Military Personnel	15 kg 70 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult Military Personnel	2,190 days 8,760 days 1,460 days	USEPA, December 1989a
PEF	Site-Specific Particulate Emission Factor	All	6.79E08 m^3/kg	USEPA, 1995

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, May 1992d
IR	Ingestion Rate	Child Adult	1 L/day 2 L/day	USEPA, March 1991 USEPA, December 1989a
EF	Exposure Frequency	Child Adult	350 days/yr 350 days/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, March 1991
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, December 1989a

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, May 1992d
SA	Exposed Surface Area of Skin Available for Contact	Child 10,000 cm^2 Adult 23,000 cm^2	USEPA, January 1992a
PC	Permeability Constant	Chemical Specific	USEPA, January 1992a
ET	Exposure Time	All 0.25 hr/day	USEPA, January 1992a
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, March, 1991
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989a
CF	Conversion Factor	1 L/1000 cm^3	USEPA, December 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989a

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF VOLATILE ORGANICS IN GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, May 1992d
IR	Inhalation Rate	Child Adult	0.6 m^3/hr 0.6 m^3/hr	USEPA, December 1989a
ET	Exposure Time	All	0.25 hr/day	USEPA, January 1992a
EF	Exposure Frequency	All	350 day/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, December 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, December 1989a

TABLE 6-15

TOXICITY FACTORS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	Dermally Adjusted RfD*	RfC	CSF	Dermally Adjusted CSF*	CSFI	Oral Absorption Factors(1)	WOE	Reference
Volatiles:									
1,1-Dichloroethene	9.0E-03	7.2E-03	ND	6.0E-01	7.5E-01	1.75E-01	80%	C	IRIS
Chloroform	1.0E-02	8E-03	ND	6.1E-03	7.6E-03	8.05E-02	80%	B2	IRIS
Benzene	ND	ND	1.71E-03	2.9E-02	3.6E-02	2.9E-02	80%	A	IRIS
Semivolatiles:									
Benzo(a)anthracene	ND	ND	ND	7.3E-01	1.46	6.1E-01	50%	B2	EPA-NCEA
Benzo(b)fluoranthene	ND	ND	ND	7.3E-01	1.46	6.1E-01	50%	B2	EPA-NCEA
Benzo(k)fluoranthene	ND	ND	ND	7.3E-02	1.46E-01	6.1E-02	50%	B2	EPA-NCEA
Benzo(a)pyrene	ND	ND	ND	7.3E+00	1.46E+01	6.1E+00	50%	B2	IRIS
Indeno(1,2,3-cd)pyrene	ND	ND	ND	7.3E-01	1.46	6.1E-01	50%	B2	EPA-NCEA
Dibenz(a,h)anthracene	ND	ND	ND	7.3E+00	1.46E+01	6.1E+00	50%	B2	EPA-NCEA
Chrysene	ND	ND	ND	7.3E-03	1.46E-02	6.1E-03	50%	B2	EPA-NCEA
Dibenzofuran	4.0E-03	2.0E-03	ND	ND	ND	ND	50%	D	EPA-NCEA
Carbazole	ND	ND	ND	2.0E-02	4.0E-02	ND	50%	B2	HEAST
2-Nitrophenol	ND	ND	ND	ND	ND	ND	50%	ND	IRIS
2-Methylphenol	5.0E-02	2.5E-02	ND	ND	ND	ND	50%	C	IRIS
4-Methylphenol	5.0E-03	2.5E-03	ND	ND	ND	ND	50%	ND	IRIS
2,4-Dimethylphenol	2.0E-02	1.0E-01	ND	ND	ND	ND	50%	ND	IRIS
Naphthalene	4.0E-02	2.0E-02	ND	ND	ND	ND	50%	D	IRIS
Acenaphthene	6.0E-02	3.0E-02	ND	ND	ND	ND	50%	ND	IRIS
Fluorene	4.0E-02	2.0E-02	ND	ND	ND	ND	50%	D	IRIS
Phenanthrene(2)	3.0E-02	1.5E-02	ND	ND	ND	ND	50%	D	IRIS
2-Methylnaphthalene(3)	4.0E-02	2.0E-02	ND	ND	ND	ND	50%	D	IRIS

TABLE 6-15 (Continued)

TOXICITY FACTORS
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	Dermally Adjusted RfD*	RfC	CSF	Dermally Adjusted CSF*	CSFI	Oral Absorption Factors(1)	WOE	Reference
Inorganics:									
Aluminum	1.0E+00	2.0E-01	ND	ND	ND	ND	20%	ND	EPA-NCEA
Chromium(4)	5.0E-03	1.0E-03	ND	ND	ND	4.2E+01	20%	D	IRIS

Notes:

RfD	Oral Reference Dose (mg/kg - day)
RfC	Inhalation Reference Concentration (mg/cu m)
CSF	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
CSFI	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
WOE	Weight of Evidence
IRIS	Integrated Risk Information System
HEAST	Health Effects Assessment Summary Tables
EPA-ECAO	Environmental Protection Agency - Environmental Criterion Assessment Office
ND	Not Determined
A	Human Carcinogen
B1	Probable Human Carcinogen - Limited Evidence
B2	Probable Human Carcinogen - Sufficient Evidence
C	Possible Human Carcinogen
D	Not Classifiable as to Human Carcinogenicity
*	Only oral toxicity values were dermally adjusted; inhalation toxicity values were not adjusted. Dermally-adjusted RfD = oral RfD*oral absorption factor Dermally-adjusted CSF = oral CSF/oral absorption factor
(1)	Region IV recommended values (i.e., 80% for VOCs, 50% for SVOCs/Pesticides, and 20% for Inorganics).
(2)	Pyrene is used as a surrogate
(3)	Naphthalene is used as a surrogate
(4)	Chromium VI

TABLE 6-16

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult		Current Military Personnel		Future Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Soil	1.1E-05	NA	4.8E-06	NA	8.0E-07	NA	8.5E-08	<0.01
Dermal Contact with Soil	2.6E-06	NA	8.2E-07	NA	9.3E-07	NA	1.5E-08	<0.01
Inhalation of Soil Particulates	5.3E-10	NA	6.1E-10	NA	1.0E-10	NA	NE	NE
Total	1.4E-05	NA	5.7E-06	NA	1.7E-06	NA	1.0E-07	<0.01

Notes:

NA - Not Applicable (no noncarcinogenic contaminants selected as COPCs in surface soil).
NE - Not Exposed (model for inhalation of surface soil particulates does not apply).

TABLE 6-17

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH GROUNDWATER
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Round 2 Future Residential Child		Round 2 Future Residential Adult		Worst Case Future Residential Child		Worst Case Future Residential Adult	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Groundwater	5.2E-06	1.4	1.11E-05	0.58	1.7E-04	6.7	3.63E-04	2.9
Dermal Contact with Groundwater	5.8E-08	0.26	1.4E-07	0.13	5.8E-04	1.6	1.4E-03	0.8
Inhalation - Shower	5.25E-09	<0.01	5.62E-09	<0.01	6.16E-09	<0.01	6.60E-09	<0.01
Total	5.3E-06	1.7	1.1E-05	0.7	7.5E-04	2.3	1.8E-03	3.7

TABLE 6-18

TOTAL SITE RISK
OPERABLE UNIT NO. 12 (SITE 3)
OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

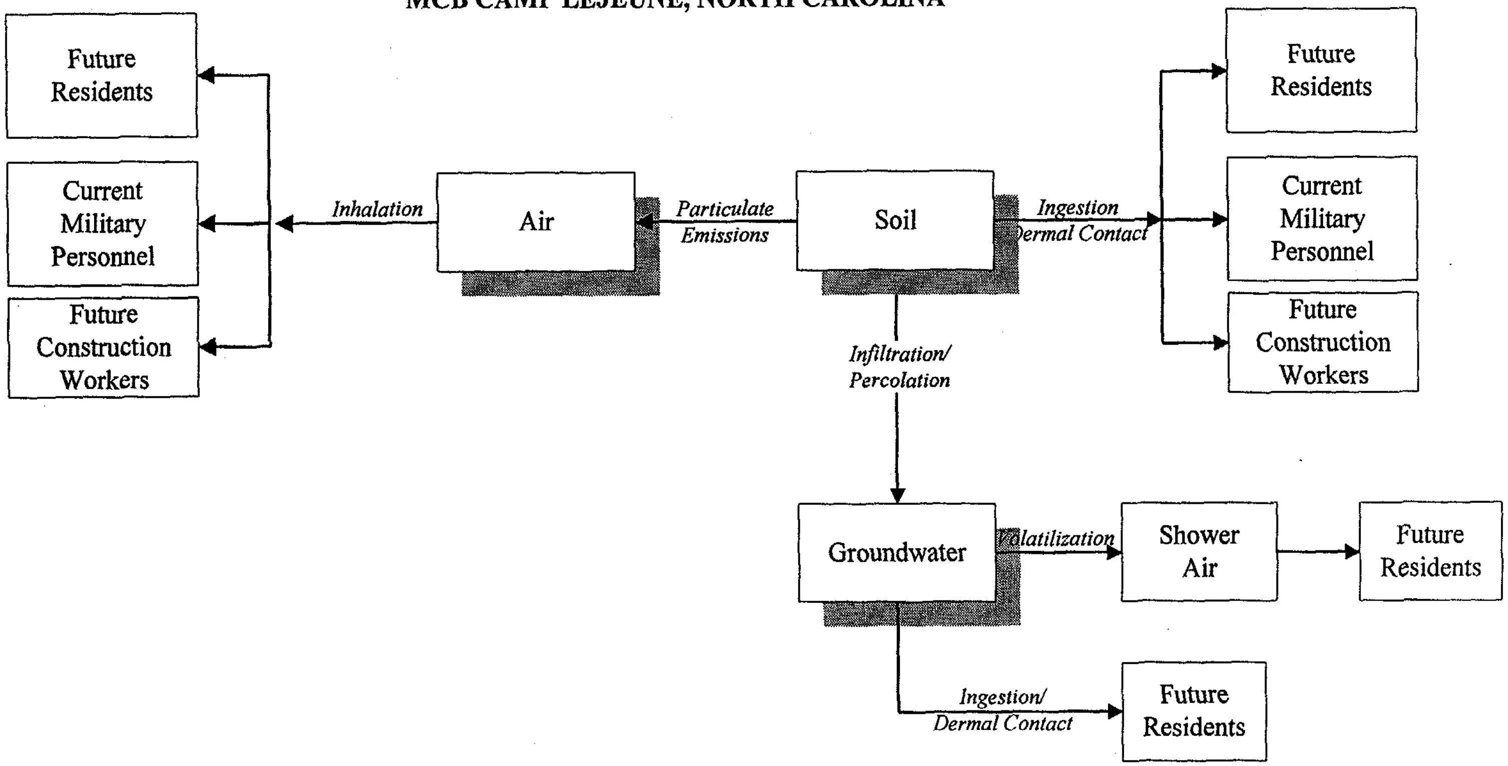
	Soil		Round 2 Groundwater		Worst Case Groundwater		Total with Round 2 Groundwater Contamination		Total with Worst Case Groundwater Contamination	
Receptors	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Military Personnel	1.7E-06 (100)	NA	NE	NE	NE	NE	1.7E-06	NA	1.7E-06	NA
Future Child Resident	1.4E-05 (74)/(<1)	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)

SECTION 6.0 FIGURES

FIGURE 6-1

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



7.0 ECOLOGICAL RISK ASSESSMENT

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, directs USEPA to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989a). This section of the report presents the ecological risk assessment (ERA) conducted at Operable Unit No. 12 (Site 3) and assesses the potential impacts to ecological receptors from contaminants detected at the site.

7.1 Objectives, Scope, and Organization of the Ecological Risk Assessment

The objective of this ERA is to evaluate if past reported disposal practices at Site 3 are potentially adversely impacting the terrestrial communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants at Site 3 on sensitive environments including wetlands and protected species. Information used to evaluate sensitive environments is obtained from historical data and previous studies obtained in the literature, or through conversations with appropriate state, federal, and local personnel.

This ERA evaluates and analyzes the results from the Remedial Investigation (RI) including chemical analysis of the surface soil. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted. The conclusions of the ERA are used in conjunction with the human health risk assessment to evaluate the appropriate remedial action for this site for the overall protection of public health and the environment.

The risk assessment methodologies used in this evaluation are consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1994), and Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information in the following documents was used to supplement the USEPA guidance document:

- USEPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989b)

- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989c)

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: 1) Problem Formulation; 2) Analysis; and, 3) Risk Characterization (USEPA, 1992a). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data is evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section also evaluates the potential impact to the ecological receptors at the site from the contaminants detected in the media. This ERA is organized to parallel these three components.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects (USEPA, 1992a). Chemical analyses were performed on soil and groundwater samples to evaluate the presence, concentrations, and variabilities of the contaminants. A habitat characterization also was conducted as part of the field activities. Based on these observations, potential ecological receptors are identified. Finally, toxicological information for the contaminants detected in the media was obtained from available references and literature and used to evaluate the potential adverse effects to the ecological receptors.

The components of the problem formulation include identifying the stressors and their potential ecological effects, identifying ecosystems potentially at risk, defining ecological endpoints and presenting a conceptual model. The following sections present each of these components, and how they are evaluated in this ERA.

7.3 Contaminants of Potential Concern

One of the initial steps in the problem formulation stage of an ERA is identifying the stressors and their potential ecological effects. For this ERA, the stressors that are evaluated include contaminants detected in the surface soil. Contaminants in the subsurface soil and groundwater are not evaluated in this ERA. Some terrestrial species burrow in the subsurface soil, and microorganisms most likely exist in the groundwater. However, current guidance does not provide sufficient information to evaluate risk to these receptors.

The nature and extent of contamination detected in the environmental media at Site 3 are presented in Section 4.0 of this report. Sample locations were based on available historical site information and a site visit to evaluate potential ecosystems and ecological receptors.

7.3.1 Criteria for Selecting of Contaminants of Potential Concern

Quantifying risk for all positively identified contaminants may distract from the dominant risk-driving contaminants at the site. Therefore, that data set is reduced to a list of contaminants of potential concern (COPCs). COPCs are site-related contaminants used to quantitatively estimate ecological exposures and associated potential ecological effects.

The criteria that are used in selecting the COPCs from the contaminants detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Prevalence
- Toxicity
- Comparison to federal and state criteria and standards
- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels
- Comparison to anthropogenic levels

7.3.1.1 Historical Information

Historical information that associates contaminants with site activities, when combined with the following selection procedures, is used to determine contaminant retention or elimination. To be conservative, contaminants that may not have been historically used at a site are retained as COPCs to evaluate risk, but may be eliminated in the ecological significance section as not being site-related.

7.3.1.2 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. Contaminants that are detected infrequently are not retained as COPCs.

7.3.1.3 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the ERA. Several contaminants detected in the media at Site 3 are prevalent, however, their inherent toxicity to terrestrial receptors is low (e.g., calcium, magnesium, potassium, and sodium). Therefore, they are not retained as COPCs. In addition, several contaminants have not been adequately studied to develop published toxicity values, or even accepted toxicological data that can be used to assess the contaminants. Contaminants that fall into this category are retained as COPCs (if they are not eliminated due to other criteria), however, they are not quantitatively evaluated in the ERA.

7.3.1.4 State and Federal Criteria and Standards

There are no State or Federal soil criteria or standards to evaluate potential ecological risks to terrestrial receptors. There are some screening levels and benchmark values to evaluate potential impacts to terrestrial invertebrates, microorganisms, and plants, however, their values do not account for terrestrial vertebrates. Therefore, State and federal criteria or standards are not used to select COPCs in the surface soil.

7.3.1.5 Field and Laboratory Blank Data

Associating contaminants detected in field related blanks (i.e., trip blanks, equipment rinsates and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated. However, for this data set, it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate detection levels, maximum contaminant concentrations reported in a given set of blanks are applied to a corresponding set of samples.

In accordance with the National Functional Guidelines for Organics, common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding 5 times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991a).

Contract Required Quantitation Limits (CRQLs) and percent moisture are employed when evaluating contaminant concentrations in soil, in order to correlate solid and aqueous detection limits. For example, the CRQL for semivolatiles in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess semivolatile contaminant levels in soil using aqueous blanks, the blank concentration must then also be multiplied by 33 or 66 to account for variance from the CRQL (common lab contaminants must first be multiplied by 5 or 10, as explained in the paragraph above). The final value is divided by the sample percent moisture.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than 5 percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

Maximum concentrations of common laboratory contaminants detected in blanks are presented in Section 6.0, Table 6-1. Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other Target Compound List (TCL) compounds) are regarded as positive results only when observed concentrations exceed 5 times the maximum concentration detected in any blank (USEPA, 1989a). All TCL compounds at less than 5 times the maximum level of contamination noted in any blank are considered not detected in that sample.

7.3.1.6 Background or Naturally Occurring Levels

Contaminants that were detected in the surface soil at concentrations less than two-times the average Base background concentration are not retained as COPCs.

7.3.1.7 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from non-site related sources such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. Examples of ubiquitous, anthropogenic chemicals are polycyclic aromatic hydrocarbons (PAHs). Anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria. It is difficult to determine that such chemicals are present at the site due to operations not related to the site or the surrounding area. Omitting anthropogenic background chemicals from the risk assessment may result in the loss of important information for those potentially exposed.

The following sections apply the aforementioned selection criteria beginning with the prevalence of detected analytical results in each medium of interest to establish a preliminary list of COPCs for Site 3. Once this task is completed, a final list of media-specific COPCs is selected based on the remaining criteria.

7.3.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for the surface soil during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria.

A summary of the COPCs in the surface soil is presented in Table 7-1. Of the fifty-eight surface soil samples collected at Site 3, two were analyzed for TCL pesticides/PCBs and Target Analyte List

(TAL) inorganics, seventeen were analyzed for TCL volatile organic compounds (VOCs), and fifty-eight samples were analyzed for TCL semivolatile organic compounds (SVOCs).

7.3.2.1 Surface Soil

Eleven inorganics were detected in the surface soil. The following inorganics are not retained as COPCs because they are common naturally occurring chemicals, are not related to the site, and no published toxicity data was identified to assess potential impacts to terrestrial life: calcium, magnesium, and sodium. Aluminum, barium, iron, lead, manganese, and vanadium are not retained as COPCs because they were detected at a concentration less than two times the base background concentration. The remaining two inorganics (chromium and zinc) are retained as COPCs because they were detected at concentrations greater than two times the background concentration.

Twenty-two SVOCs were detected in the surface soils. The following contaminants are not retained as COPC because they were detected infrequently (1/58 or 2/58): acenaphthene, dibenzofurane, 2-methylnaphthalene, naphthalene, and phenol. The following seventeen SVOCs are retained as COPCs because they were detected frequently: acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, carbazole, chrysene, dibenzo(a,h)anthracene, di-n-butylphthalate, fluorene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene.

Three VOCs (ethylbenzene, toluene, and xylenes) were detected in the surface soil. All three VOCs are retained as COPCs, because they were detected frequently

7.3.3 Physical/Chemical Characteristics of COPCs

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), organic carbon partition coefficient (Koc), octanol water partition coefficient (Kow), and biotransfer factors (Bv, Bb, Br). Table 7-2 presents these values for the COPCs detected in the surface soil samples. Information from these tables is used to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs present the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in biota. Bioconcentration factors are important for ecological receptors because chemicals with high BCFs can accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain.

The organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between soil particles containing organic carbon and water. This coefficient is important in the ecological environment because it determines how strongly an organic chemical will be bound to the organic portion in the soil.

The octanol/water partition coefficient (Kow) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors and with adsorption to soil. The Kow is used to calculate the plant biotransfer factors that are used to estimate the COPC concentration in plants that would potentially be ingested by the terrestrial receptors in the intake model.

The plant biotransfer factors (Bv or Br) measure the potential for a chemical to accumulate in a plant. These factors are used to calculate the concentration of the COPCs in either the leafy part of the plant (Bv) or the fruit of the plant (Br). The factors for inorganics are obtained from Baes et.al., (1984), while the factors for organics are calculated according to Travis and Arms, (1988). The Bv and Br values for the organics are assumed to be same value.

Finally, the beef biotransfer factor (Bb) measures the potential for a chemical to accumulate in an animal. This factor is used to calculate the concentration of the COPCs in the small mammal that was being ingested by the red fox. The factors for inorganics are obtained from Baes et.al., (1984), while the factors for organics are calculated according to Travis and Arms, (1988).

7.4 Ecosystems Potentially at Risk

Ecological receptors that might be potentially at risk from contaminants at Site 3 were identified during the field investigations and the habitat evaluation. Potential receptors of contaminants in soil include the following: deer, rabbits, foxes, birds and other terrestrial flora and fauna.

7.4.1 Regional Ecology

MCB, Camp Lejeune is located on North Carolina's coastal plain. A number of natural ecological communities are present within this region. In addition, variations of natural communities have occurred in response to disturbance and intervention (e.g., forest clearing, urbanization). The natural communities found in the area are summarized as follows:

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech, white oak, tulip, sweetgum, and holly are indicator species.
- Southeastern Evergreen Forest - Dominated by pines, especially longleaf pine.
- Loblolly Pine/Hardwoods Community - Second growth forest that includes loblolly pine with a mix of hardwoods (i.e., oak, hickory, sweetgum, sour gum, red maple, and holly).
- Southern Floodplain Forest - Occurs on the floodplains of rivers. Hardwoods dominate with a variety of species present. Composition of species varies with the amount of moisture.
- Maritime Forest - Develops on the lee side of stable sand dunes protected from the ocean. Live oak is an indicator species along with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.
- Pocosins - Lowland forest community that develops on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and acidic soils low in nutrients. Pond pine is the dominant tree with dense layers of evergreen shrubs. Strongly influenced by fire.
- Cypress Tupelo Swamp Forest - Occurs in the lowest and wettest areas of floodplains. Dominated by bald cypress and tupelo.

- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present.

- Salt Marsh - Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide.

- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. Subjected to salt spray and periodic saltwater flooding. Dominated by salt resistant shrubs.

- Dunes/Beaches - Zones from the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water.

- Ponds and Lakes - Low depressional areas where water table reaches the surface or where ground is impermeable. In ponds rooted plants can grow across the bottom. Fish populations in these ponds include redear sunfish, bluegill, largemouth bass, and channel catfish.

- Open Water - Marine and estuarine waters as well as all underlying bottoms below the intertidal zone.

MCB, Camp Lejeune covers approximately 111,000 acres or 234 square miles. Marine and estuarine open water account for 26,000 acres and terrestrial and palustrine land account for 85,000 acres. Forests are predominant as terrestrial cover and pine forest is the dominant habitat type. A total of 21,000 acres of the pine forest is loblolly pine, 7700 acres are dominated by longleaf pine forest, and 3600 acres are dominated by pond pine forest. These pine forests include natural subcommunities that are maintained by fire.

In addition to the pine forest, mixed pine\hardwood forest is present on MCB, Camp Lejeune and accounts for 15,900 acres. An additional 12,100 acres are covered by hardwood forest. Of the wetlands present, estuarine marsh accounts for 700 acres; open freshwater accounts for 200 acres; and dune, beach, and brackish marsh account for 2200 acres. Industrial, infrastructure, and administrative areas make up 10,000 acres and artillery impact areas and buffer zones account for 11,000 acres (LeBlond, 1994). The base contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds. The soil types range from sandy loams to fine sand and muck, with the dominant series being sandy loam (USMC,1987).

The base drains primarily to the New River via its tributaries. These tributaries include Northeast Creek, Southwest Creek, Cogdels Creek, Wallace Creek, Frenchs Creek, Bear Head Creek, Brinson Creek, Edwards Creek, and Duck Creek. Site-specific information regarding surface water and drainage features is presented in Section 3.0 of this report.

Forested areas within the military reservation are actively managed for timber. Game species are also managed for hunting and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, raccoons, and wood ducks. About 150 acres are maintained for wildlife food plots.

7.4.2 Site-Specific Ecology

During December 1994, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 3. **Appendix O** includes data sheets that provide more detailed information than is presented in the following paragraphs.

Three general habitat types are found at Site 3 (see Figure 7-1). Most of the actual site area is open. This open area is surrounded by mixed forest and by pine forest.

The open area is dominated by grasses with exposed soil present in some places. Scattered conifers are found within the grassy areas. Two species of grass, broom sedge (Andropogon virginicus) and bushy beardgrass (Andropogon glomeratus), are dominant. These two species are mixed with other grasses and with annual and perennial herbs. The herbaceous plants include the following:

- Narrow-leaved Plantain- Plantago lanceolata
- Sweet White Clover- Melilotus alba
- Dandelion- Taraxacum officinalis
- Slender Bush Clover- Lezpedeza virginica

- Pussytoes- Antennaria sp.
- Dog Fennel- Eupatorium capillifolium
- Aster- Aster sp.
- Verbena- Verbena brasiliensis
- Lemon Mint- Monarda punctata
- Grass- Eremochloa ophiuroides

Scattered trees are found within the grassy, open area. They include loblolly pine (Pinus taeda), juniper (Juniperus virginiana), black cherry (Prunus serotina), and tulip poplar (Liriodendron tulipifera). Many of these trees are saplings and are mixed with sweet myrtle (Myrica cerifera).

The trees that are present in the open area have probably seeded from the two forested areas surrounding the site. A transition zone several hundred feet wide is present between the open area and the mixed forest that is located southeast of the site. This transition zone contains a mix of species from both the open area and the mixed forest.

The mixed forest is dominated by trees with loblolly pine (Pinus taeda) dominant in some areas. This loblolly pine is mixed with the following deciduous trees:

- Tulip Poplar- Liriodendron tulipifera
- Black Cherry- Prunus serotina
- Water Oak- Quercus nigra
- Sassafras- Sassafras albidum
- Willow Oak- Quercus phellos
- Sweetgum- Liquidambar styraciflua
- Southern Red Oak- Quercus falcata
- Holly- Ilex opaca
- Sweetbay- Magnolia virginiana

The understory of the mixed forest contains shrubs, among them privit (Ligustrum vulgare), juniper (Juniperus virginiana), blueberry (Vaccinum sp.), and sweet myrtle (Myrica cerifera). No vines are present in the understory. Herbaceous plants include switch cane (Arundinaria tecta), braken fern

(Pteridium aquilinum), and broom sedge (Andropogon americana), and hydrocotyl (Hydrocotyl americana) is present in damp areas.

A pine forest is found to the north, northeast, and west of Site 3. Loblolly pine (Pinus taeda) is clearly dominant in this forest, which may be a planted pine plantation. No other tree species are present, although sweet myrtle (Myrica cerifera) is growing in the understory of the pine forest. No vines or herbaceous plants are found in this pine forest because the canopy of pine trees emits little light.

During the habitat evaluation, large flocks of bluebirds (Sialia sialis) and myrtle warblers (Dendroica coronata) were identified at Site 3. A Bachmans sparrow, which is a protected specie, also was observed during the study, although it is unlikely that the bird breeds at the site. Other birds identified during the habitat study include the following:

- Robin- Turdus migratorius
- Carolina Wren- Thyrothorus ludovicianus
- Song Sparrow- Melospiza melodia
- Towhee- Pipilo erythrophthalmus
- Common Crow- Corvus brachyrhynchos

Because the habitat evaluation was conducted in the winter, no reptiles or amphibians were observed at Site 3. However, signs of whitetail deer (Odocoileus virginianus) were noted.

7.4.3 Sensitive Environments

Two areas on MCB, Camp Lejeune have been registered as designated natural areas within the North Carolina Natural Heritage Program. These two areas, which encompass 141 acres, are the Longleaf Pine Natural Area and the Wallace Creek Swamp Natural Area. In addition, 12 other Natural Areas have been recommended for inclusion in the registry. Appendix P contains a listing of the Natural Areas at MCB, Camp Lejeune.

These Natural Areas contain some of the finest examples of natural communities in North Carolina and support many rare species. A few of these community types are globally rare. The Calcareous

Coastal Fringe Forest on the 100-acre midden at Corn Landing is the only known extant example of this community type. Camp Lejeune has some of the best examples of the following globally-rare, natural community types: Cypress Savanna, Depression Meadow, and Small Depression Pond. The Maritime Evergreen Forest hammocks between Cedar Point and Shell Point are connected by shell tombolos and appear to be a very rare geological formation. Several areas of natural interest were identified southeast of Site 3 in the headwaters of Wallace Creek in the same general area as the red-cockaded woodpecker colony (see below). These areas are described as "depression meadows" and shelter grasses and bog plants.

7.4.3.1 Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992). In addition, certain activities affecting wetlands are also regulated by the U.S. Corps of Engineers.

The U.S. Fish and Wildlife Service (FWS) has prepared National Wetlands Inventory (NWI) maps for the MCB, Camp Lejeune area. Through stereoscopic analysis of high altitude aerial photographs, wetlands were identified based upon vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et al., 1979). The NWI maps are intended for an initial identification of wetland areas and are not meant to replace an actual wetland delineation survey that may be required by Federal, state and local regulatory agencies. No wetlands were present on or near Site 3.

7.4.3.2 Threatened and Endangered Species

Certain species have been granted protection by the FWS under the Federal Endangered Species Act (16 U.S.C. 1531-1543), and by the North Carolina Wildlife Resources Commission, under the North Carolina Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: federal or state endangered, threatened or candidate species; state special concern; state significantly rare; or state watch list. While only the federal or state threatened or endangered and state special concern species are protected from certain actions, the other classified species may have protection in the future.

Surveys have been conducted to identify threatened and endangered species at MCB, Camp Lejeune and several programs are underway to manage and protect them. Table 7-3 lists federally protected species present at the base and their protected classification. Appendix P contains a list and locations of the protected species at MCB, Camp Lejeune. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are protected by specific regulatory programs.

The red-cockaded woodpecker requires a mature, living longleaf or loblolly pine environment. The birds live in family groups and young are raised cooperatively. At MCB, Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Approximately 3,300 acres are in actively managed red-cockaded woodpecker colonies. Research on the bird at MCB, Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered a state special concern specie. It is found in freshwater, estuarine, and saltwater wetlands in MCB, Camp Lejeune. Base wetlands are maintained and protected for alligators; signs have been posted where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles, the Atlantic loggerhead and Atlantic green turtle, nest on Onslow Beach at MCB, Camp Lejeune. The green turtle was found nesting in 1980; this sighting was the first time the species had been observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

Three bird species, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at MCB, Camp Lejeune. The piping plover is a shore bird. Piping plovers prefer beaches with broad open sandy flats above the high tide line and feed along the edge of incoming waves. Like the piping plover, Bachmans sparrows have very specific habitat requirements. The sparrows live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern portion MCB, Camp Lejeune.

In addition to the protected species that breed or forage at MCB, Camp Lejeune, several protected whales migrate through the coastal waters off the base during spring and fall. These include the Atlantic right whale, finback whale, sei whale, and sperm whale. Before artillery or bombing practice is conducted in the area, aerial surveys are made to assure that whales are not present in the impact areas.

A natural heritage resource study was conducted at MCB, Camp Lejeune (LeBlond, 1994) to identify threatened or endangered plants and areas of significant natural interest. During the resource study, 55 rare plant species were documented from Camp Lejeune. These include one specie that is classified as Federally Endangered, one specie that is classified as Federally Threatened, nine species that are candidates for federal listing as Endangered or Threatened, four species that are listed as Endangered or Threatened in the State of North Carolina, and 27 species that are State Rare or State Special Concern. These species are summarized on Table 7-3. In addition, species that are candidates for state listing or are on the North Carolina state watch list were noted.

During the habitat evaluation, a small flock of sparrows, tentatively identified as Bachmans sparrows, was observed at Site 3. However, the habitat at Site 3 is not conducive for the sparrows to breed. In addition, a colony of red-cockaded woodpeckers is located 6,000 feet southeast of the site. A woodpecker foraging area is located the same distance away to the northeast.

7.4.3.3 Other Sensitive Environments

In addition to wetlands and protected species, other sensitive environments, including those listed in 40 CFR Part 300, were evaluated during Hazard Ranking System evaluations. These sensitive environments and their presence or absence at Site 3 are discussed below.

- Marine Sanctuary - Site 3 is not located within a Marine Sanctuary (NCMFC, 1994).
- National Park - Site 3 is not located within a National Park (NPS, 1993a).

- Designated Federal Wilderness Area - Site 3 is not located within a Designated Federal Wilderness Area (WS, 1989).

- Areas Identified under the Coastal Zone Management Act - The North Carolina Coastal Area Management Act (CAMA) regulates various types of Areas of Environmental Concern including estuarine waters, coastal wetlands, public trust areas, and estuarine shoreline through the establishment of unified policies, criteria, standards, methods, and processes (CAMA, 1974).

- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 3 is not located within a Sensitive Area identified under the NEP or NCWP (NCMFC, 1994).

- Critical Areas Identified under the Clean Lakes Program - Site 3 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1993a).

- National Monument - Site 3 is not located near a National Monument (NPS, 1993a).

- National Seashore Recreational Area - Site 3 is not located within a National Seashore Recreational Area (NPS, 1993a).

- National Lakeshore Recreational Area - Site 3 is not located within a National Lakeshore Recreational Area (NPS, 1993a).

- National Preserve - Site 3 is not located within a National Preserve (NPS, 1993a).

- National or State Wildlife Refuge - Site 3 is not located within a National or State Wildlife Refuge (NCWRC, 1994).

- Unit of the Coastal Barrier Resource Program - Site 3 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 3 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - No surface water is present at Site 3.

- Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which fish spend extended periods of time - No surface water is associated with Site 3 (USMC, 1993).

- National river reach designated as Recreational - No surface water is present at Site 3.

- Federal designated Scenic or Wild River - No surface water is present at Site 3.

- State land designated for wildlife or game management - Site 3 is not located within a State game land (NC WRC, 1992).

- State designated Scenic or Wild River - No surface water is present at Site 3.

- State designated Natural Area - Site 3 is not located within a State designated Natural Area or Area of Significant Value (LeBlond et.al., 1994).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of Site 3 are designated as primary nursery areas or are unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses (NC DEHNR, 1994).

- Areas of Significant Value - Site 3 is not located within a State Area of Significant Value (LeBlond et.al., 1994).

- State Registered Natural Resource Area - Site 3 is located within a State Registered Natural Resource Area (LeBlond et.al., 1994).

7.5 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics and ecosystems potentially at risk) is used to select the ecological endpoints for this ERA. The following section contains a description of the ecological endpoints selected for this ERA, and the reasons they are selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they are found to be significantly affected, would indicate a need for remediation (e.g., decrease in sports/fisheries). Measurement endpoints are quantitative expressions of an observed or measured effect of the contamination of concern. Measurement endpoints may be identical to assessment endpoints (e.g., measurement of abundance of fish), or they may be used as surrogates for assessment endpoints (e.g., toxicity test endpoints). Both types of endpoints are used in the ecological risk evaluation and are discussed in the following sections.

A measurement endpoint, or "ecological effects indicator" as it is sometimes referred, is used to evaluate the assessment endpoint. Therefore, the measurement endpoint must correspond to, or be predictive of, assessment endpoints. In addition, they must be readily measurable, preferably quickly and inexpensively, using existing techniques. Measurement endpoints must take into consideration the magnitude of the contamination and the exposure pathway. The measurement endpoint should be an indicator of effects that are temporally distributed. Low natural variability in the endpoint is preferred to aid in attributing the variability in the endpoint to the contaminant. Measurement endpoints should be diagnostic of the pollutants of interest, as well as broadly applicable to allow comparison between sites and regions. Also, measurement endpoints should be standardized (e.g., standard procedures for toxicity tests). Finally, it is desirable to use endpoints that already are being measured (if they exist) to determine baseline conditions.

The assessment endpoint for this ERA is the potential reduction of the terrestrial receptor population or subpopulation that is attributable to contaminants from Site 3. The measurement endpoints include exceedances of contaminant-specific soil effect concentrations (i.e., Surface Soil Screening Values (SSSVs)) and contaminant-specific effect doses (i.e., Terrestrial Reference Values (TRVs)).

7.6 Conceptual Model

This section of the ERA presents each potential exposure pathway via soil, groundwater, and air, and the likelihood that an exposure will occur through these pathways. Figure 7-2 presents the conceptual exposure model for ecological receptors.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis is conducted including the identification and characterization of the exposure pathways. The following four elements are examined to determine if a complete exposure pathway is present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

7.6.1 Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soil are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soil.

COPCs were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around surface soil in the areas of detected COPCs include the following: deer, fox, rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soil through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soil. In addition, terrestrial species may ingest organisms that have bioconcentrated contaminants from the soil. This exposure pathway is likely to occur at Site 3 and is retained for further analysis. Some terrestrial species burrow in the subsurface soil. However, this pathway is not evaluated because current guidance does not provide sufficient information to evaluate risk to these receptors.

7.6.2 Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soil. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration. However, no groundwater discharges were observed and no surface water is associated with Site 3. Therefore, this pathway is incomplete and it will not be evaluated in the ERA.

Sub-surface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. These biota are not assessed in this ERA because current guidance does not provide sufficient information to evaluate risk.

7.6.3 Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil and groundwater. The potential exposure points for receptors are areas at/or adjacent to the site. The air exposure pathway is not evaluated in this ERA because air sampling was not conducted, and current guidance does not provide sufficient information to evaluate risk

7.7 Exposure Assessment

The next phase after the problem formulation is the exposure assessment that consists of quantifying the potential exposure of the stressors (i.e., COPCs) to the ecological receptors. The RI included collecting samples for analytical analysis from two media; soil and groundwater. The analytical results for the data used in ERA are presented in Section 4.0 of this report. As presented above, contaminants in the subsurface soil and groundwater are not evaluated in the ERA.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 3 are presented in Section 7.4 of this report. Information on sensitive environments and endangered species also is included in this section.

Exposure of contaminants in the surface soil to terrestrial flora and fauna (invertebrates and microorganisms) is assumed to be equal to the contaminant concentration in the surface soil. However, it is noted in the uncertainty section of this ERA that all the contaminants in the surface soil may not be bioavailable to the terrestrial flora or fauna. Exposure of contaminants in the surface soil to other terrestrial fauna (mammals, birds) is estimated using the chronic daily intake models.

7.8 Ecological Effects Characterization

The ecological effects data used to assess potential risks to terrestrial receptors in this ERA are presented in the following sections.

7.8.1 Surface Soil

Although promulgated standards do not exist, Surface Soil Screening Values (SSSVs) that can be used to evaluate potential ecological risks to terrestrial flora and fauna have been developed by USEPA Region III (USEPA, 1995b) and Oak Ridge National Laboratory (ORNL) (Will and Suter, 1994a, 1994b). The contaminant concentrations in the surface soils are compared to the SSSVs to determine if potential impacts to terrestrial flora and fauna (invertebrates) may be expected (see Table 7-4).

Chromium was the only inorganic COPC that exceeded a SSSV. SVOCs were detected in several samples at concentrations that exceeded the SSSVs. The majority of these samples were collected in the open grass areas, and a few were collected along the tree line.

7.8.4 Terrestrial Chronic Daily Intake Model

In addition to comparing the soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial Chronic Daily Intake (CDI) model is used to estimate the exposure of the COPCs to terrestrial receptors. The following sections present the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 3 by both direct and indirect exposure to COPCs via surface soil, and foodchain transfer. Because surface water was not present at Site 3, this portion of the model was deleted from the equations presented below.

Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis are the white-tailed deer, cottontail rabbit, red fox, and the bobwhite quail. The exposure points for these receptors are the surface soil. The routes for terrestrial exposure to the COPCs in the soil are incidental soil ingestion, and ingestion of vegetation and small mammals.

7.8.4.1 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry Toxicological Profiles, mineral tolerance levels of domestic animals (NAS, 1992), or other toxicological data in the literature. **Appendix Q** presents the methodology used in deriving the TRVs and which animals were used to derive each TRV.

7.8.4.2 Calculation of Chronic Daily Intake

Total exposure of the terrestrial receptors to the COPCs in the surface soil is determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The estimated CDI dose of the bobwhite quail, cottontail rabbit, white-tailed deer and small mammal to surface soil and vegetation is determined using the following equation:

$$CDI = \frac{[(Cs)(Bv)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI = Chronic Daily Intake, mg/kg/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

To calculate the contaminant concentration in the small mammal, the resulting CDI dose from the above equation is multiplied by the biotransfer factor for beef (Bb) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984).

The estimated CDI dose of the red fox is determined using the following equation:

$$CDI = \frac{[(Cs)(Bv)(Iv)+(Cs)(Is)+(Cm)(Im)][H]}{BW}$$

Where:

CDI = Chronic Daily Intake, mg/kg/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
Cm = Contaminant concentrations in small mammals, mg/kg
Im = Rate of small mammal ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

Bioconcentration of the COPCs to plants is calculated using the soil to plant transfer coefficient (Bv) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984). The concentrations of the COPCs used in the models are the upper 95 percent confidence limit or the maximum concentration detected of each COPC. The exposure parameters used in the CDI calculations are presented in Table 7-5.

7.9 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section evaluates the potential decrease in terrestrial populations at Site 3 from contaminants identified at the site.

A Quotient Index (QI) approach is used to characterize the risk to terrestrial receptors from exposure to contaminants in the surface soil. This approach characterizes the potential effects by comparing the CDI to the TRV. The QI is calculated as follows:

$$QI = \frac{CDI}{TRV}$$

Where: QI = Quotient Index
CDI = Chronic Daily Intake, mg/kg/day
TRV = Terrestrial Reference Value, mg/kg-day

A QI of greater than "unity" is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. However, it is important to determine which contaminants are posing the highest risks, in order to evaluate the significance of those contaminants to the site. The evaluation of the significance of the QI has been judged as follows: (Menzie et.al., 1993)

- QI exceeds "1" but less than "10": some small potential for environmental effects;

- QI exceeds "10": significant potential that greater exposures could result in effects based on experimental evidence;

- QI exceeds "100": effects may be expected since this represents an exposure level at which effects have been observed in other species.

The risks characterized above provide insight into general effects upon animals and plants in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

Table 7-6 presents the CDI to TRV QIs for each contaminant for each species. None of these QIs exceeded "1" for any of the species.

7.10 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses impacts to the ecological integrity at Site 3 from the COPCs detected in the media and determines which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health risk assessment, supports the selection of remedial action(s) for Site 3 that are protective of public health and the environment.

7.10.1 Terrestrial Receptors

Several of the contaminants at Site 3 exceeded the SSSVs. As presented in the Ecological Effects Section of this report, many of the exceedences were located in open grass areas or along the tree line. Therefore, there is the potential for a decrease in population of terrestrial invertebrates in these areas. It should be noted, however, and it is presented in more detail in the Uncertainty Analysis section of this ERA, that the SSSVs are not well established, and have a high degree of uncertainty.

None of the CDI to TRV QIs for any of the species exceeded "1". Therefore, potential impacts to terrestrial mammals or birds are not expected.

7.10.2 Threatened and Endangered Species

No threatened or endangered species are known to occur at Site 3, therefore no adverse impacts to these species from contaminants at Site 3 are expected.

7.10.3 Wetlands

No wetlands have been identified at Site 3, therefore no adverse impacts to wetlands from contaminants at Site 3 are expected.

7.11 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following paragraphs present some of the uncertainty in this ERA.

There is uncertainty in the ecological endpoint comparison. Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. 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. For example, soil with high organic carbon content will tend to sorb many of the organic COPCs, thus making them less bioavailable to terrestrial receptors. In addition, most of the SSSVs are based on one or two studies, which greatly adds to their uncertainty.

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent actual site conditions, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk, however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et.al., 1993).

There are several sources of uncertainty when using these models. First, most of the terrestrial reference values are based on toxicity data from another species, which is then extrapolated to the species of concern using a body-size scaling equation. Since the toxicity of all contaminants may not be proportional to body size, the calculated TRVs may not accurately predict risk to the species of concern. Another source of uncertainty with the models is that many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent the actual values of the parameters. Also, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site.

There is uncertainty in use of the biotransfer factors. Biotransfer factors can vary widely from species to species. The species used in the calculation of the biotransfer factors probably are different that the species that actually occur at the site. Therefore, use of the factors will tend to either overestimate or underestimate actual bioaccumulation of contaminants.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species that were used to develop the toxicity data may not be present at the site, or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site use of the toxicity values may overestimate of underestimate risk. Many chemicals are not acutely toxic, however, they have the potential to bioaccumulate in ecological receptors through food chain transfer. This bioaccumulation potential typically is not taken into account when comparing contaminant concentrations to screening values.

Finally, toxicological data for several of the COPCs were limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to receptors from these contaminants

7.12 Conclusions

Several of the COPCs detected in the surface soils at Site 3 exceeded the SSSVs. Therefore, there may be a reduction in the soil flora or fauna population in the contaminated areas. However, the COPCs at Site 3 are not expected to cause a significant adverse risk to terrestrial mammals or birds.

7.13 References

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SECTION 7.0 TABLES

TABLE 7-1

CONTAMINANTS OF CONCERN IN THE SURFACE SOIL
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Surface Soil
Inorganics	
Chromium	X
Zinc	X
Semivolatiles	
Acenaphthylene	X
Anthracene	X
Benzo(a)anthracene	X
Benzo(b)fluoranthene	X
Benzo(k)fluoranthene	X
Benzo(g,h,i)perylene	X
Benzo(a)pyrene	X
Bis(2-ethylhexyl)phthalate	X
Carbazole	X
Chrysene	X
Dibenz(a,h)anthracene	X
Di-n-butylphthalate	X
Fluoranthene	X
Fluorene	X
Indeno(1,2,3-cd)pyrene	X
Phenanthrene	X
Pyren e	X
Volatiles	
Ethylbenzene	X
Toluene	X
Xylenes	X

TABLE 7-2
PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv(1)(2)	Br(1)(2)	Bb(1)(2)
Inorganics						
Chromium	16(3)	ND	ND	7.50e-03	4.50e-03	5.50e-03
Zinc	47(3)	ND	ND	1.50e+00	9.00e-01	1.00e-01
Semivolatiles						
Acenaphthylene	30(3)	2,500(5)	4.1(6)	1.65e-01	1.65e-01	3.16e-04
Anthracene	30(3)	14,000(5)	4.5(6)	9.70e-02	9.70e-02	7.94e-04
Benzo(a)anthracene	30(3)	1,380,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
Benzo(a)pyrene	30(3)	5,500,000(5)	6.0(6)	1.30e-02	1.30e-02	2.51e-02
Benzo(b)fluoranthene	30(3)	550,000(5)	6.6(6)	6.00e-03	6.00e-03	1.00e-01
Benzo(k)fluoranthene	30(3)	550,000(5)	6.1(5)	1.20e-02	1.20e-02	3.16e-02
Benzo(g,h,i)perylene	30(3)	1,600,000(5)	6.5(5)	7.00e-03	7.00e-03	7.94e-02
Bis(2-ethylhexyl)phthalate	130(3)	100,000(7)	5.1(6)	4.40e-02	4.40e-02	3.16e-03
Carbazole	ND	ND	6(6)	5.50e-01	5.50e-01	2.51e-02
Chrysene	30(3)	200,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
Dibenz(a,h)anthracene	30(3)	3,300,000(5)	6.5(6)	7.00e-03	7.00e-03	7.94e-02
Di-n-butylphthalate	89(3)	170,000(5)	5.2(6)	3.80e-02	3.80e-02	3.98e-03
Fluoranthene	1,150(3)	38,000(8)	4.9(5)	5.70e-02	5.70e-02	2.00e-03
Fluorene	30(3)	38,000(5)	5.3(6)	3.30e-02	3.30e-02	5.01e-03
Indeno(1,2,3-cd)pyrene	30(3)	1,600,000(5)	6.5(5)	7.00e-03	7.00e-03	8.13e-02
Phenanthrene	30(3)	28,840(9)	4.5(5)	9.70e-02	9.70e-02	7.94e-04
Pyrene	30(3)	38,000(5)	5.3(6)	3.30e-02	3.30e-02	5.01e-03
Volatiles						
Ethylbenzene	37.5(3)	1,100(5)	3.2(6)	5.48e-01	5.48e-01	3.98e-05
Toluene	10.70(3)	300(5)	2.70(6)	1.07e+00	1.07e+00	1.26e-05
Xylenes	2.20(4)	240(5)	3.20(6)	5.48e-01	5.48e-01	3.98e-05

BCF = Bioconcentration Factor
ND = No Data
Bv = Biotransfer factor for vegetation (stems, leaves)
Br = Biotransfer factor for vegetation (berries, fruits)

TABLE 7-2 (Continued)
PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Bb = Biotransfer factor for beef

(1) Baes, et.al., 1984 for the inorganics
(2) Travis and Arms, 1988 for the organics
(3) USEPA, 1995a (Region IV)
(4) USEPA, 1995b (Region III)
(5) USEPA, 1986.
(6) SCDM, 1991.
(7) Montgomery, 1990.
(8) USEPA, 1993a (Sediment Quality Criteria for Fluoranthene)
(9) USEPA, 1993b (Sediment Quality Criteria for Phenanthrene)

TABLE 7-3

PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Animals:	
American alligator (Alligator mississippienis)	SC
Bachmans sparrow (Aimophilia aestivalis)	FCan, SC
Green (Atlantic) turtle (Chelonia m. mydas)	T(f), T(s)
Loggerhead turtle (Caretta caretta)	T(f), T(s)
Peregrine falcon (Falco peregrinus)	E(f), (E(s)
Piping plover (Charadrius melodus)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)	E(f), E(s)
Southern Hognose Snake (Heterodon simus)	FCan, SR
Diamondback Terrapin (Malaclemys terrapin)	FCan, SC
Carolina Gopher Frog (Rana capito capito)	FCan, SC
Cooper's Hawk (Accipiter cooperii)	SC
Eastern Diamondback Rattlesnake (Crotalus adamanteus)	SR
Eastern Coral Snake (Micrurus fulvius)	SR
Pigmy Rattlesnake (Sistrurus miliarius)	SR
Black Bear (Ursus americanus)	SR
Plants:	
Rough-leaf loosestrife (Lysimachia asperulifolia)	E(f), E(s)
Seabeach Amaranth (Amaranthus pumilus)	T(f). T(s)
Chapman's Sedge (Carex chapmanii)	FCan
Hirst's Witchgrass (Dichanthelium sp.)	FCan
Pondspice (Litsea aestivalis)	FCan
Boykin's Lobelia (Lobelia boykinii)	FCan
Loose Watermilfoil (Myriophyllum laxum)	FCan,T(s)
Awned Meadowbeauty (Rhexia aristosa)	FCan,T(s)
Carolina Goldenrod (Solidago pulchra)	FCan, E(s)
Carolina Asphodel (Tofieldia glabra)	FCan
Venus Flytrap (Dionaea muscipula)	FCan
Flaxleaf Gerardia (Agalinis linifolia)	SR
Pinebarrens Goober Grass (Amphicarpum purshii)	SR
Longleaf Three-awn (Aristida palustris)	SR
Pinebarrens Sandreed (Calamovilfa brevipilis)	E(s)
Warty Sedge (Carex verrucosa)	SR
Smooth Sawgrass (Cladium mariscoides)	SR
Leconte's Flatsedge (Cyperus lecontei)	SR
Erectleaf Witchgrass (Dichanthelium erectifolium)	SR
Horsetail Spikerush (Eleocharis equisetoides)	SR
Sand Spikerush (Eleocharis montevidensis)	SR

TABLE 7-3 (Continued)

PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Flaxleaf Seedbox (Ludwigia linifolia)	SR
Torrey's Muhley (Muhlenbergia torreyana)	E(s)
Southeastern Panic Grass (Panicum tenerum)	SR
Spoonflower (Peltandra sagittifolia)	SR
Shadow-witch (Ponthieva racemosa)	SR
West Indies Meadowbeauty (Rhexia cubensis)	SR
Pale Beakrush (Rhynchospora pallida)	SR
Longbeak Baldsedge (Rhynchospora scirpoides)	SR
Tracy's Beakrush (Rhynchospora tracyi)	SR
Canby's Bulrush (Scirpus etuberculatus)	SR
Slender Nutrush (Scleria minor)	SR
Lejeune Goldenrod (Solidago sp.)	SR
Dwarf Bladderwort (Utricularia olivacea)	T(s)
Elliott's Yellow-eyed Grass (Xyris elliottii)	SR
Carolina Dropseed (Sporobolus sp.)	T(s)

Legend:
E(f) = Federal Endangered
T(f) = Federal Threatened
Fcan = Candidate for Federal Listing
E(s) = State Endangered
T(s) = State Threatened
SC = State Special Concern
SR = Significantly Rare
Source: LeBlond et.al., 1994

TABLE 7-4

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range		
Contaminant	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Lowest Screening Value
Inorganics (mg/kg)							
Chromium	1	0.4	0.0075(2)	10	2/2	2.7-7.1	2
Zinc	50	200	500	100	1/2	16.6	0
Semivolatiles (µg/kg)							
Acenaphthylene	NE	100(2)	100(2)	NE	16/58	40J-2,700	7
Anthracene	NE	100(2)	100(2)	NE	26/58	40J-7,700	14
Benzo(a)anthracene	NE	100(2)	100(2)	NE	24/58	32J-8,300	13
Benzo(b)fluoranthene	NE	100(2)	100(2)	NE	37/58	39J-13,000	27
Benzo(k)fluoranthene	NE	100(2)	100(2)	NE	34/58	37J-9,000	21
Benzo(g,h,i)perylene	NE	100(2)	100(2)	NE	22/58	39J-4,700	14
Benzo(a)pyrene	NE	20,000(2)	25,000	NE	30/58	38J-8,700	0
Bis(2-ethylhexyl)phthalate	NE	NE	NE	NE	30/58	36J-91J	NA
Carbazole	NE	NE	NE	NE	14/58	40J-830J	NA
Chrysene	NE	100(2)	100(2)	NE	32/58	40J-12,000	19
Dibenzo(a,h)anthracene	NE	100(2)	100(2)	NE	16/58	40J-2,900	5

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES OPERABLE UNIT NO. 12 (SITE 3) MCB CAMP LEJEUNE, NORTH CAROLINA REMEDIAL INVESTIGATION CTO-0274

	Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range		
Contaminant	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Lowest Screening Value
Di-n-butylphthalate	NE	1,000(3)	NE	NE	37/58	37J-340J	0
Fluoranthene	NE	100(2)	100(2)	NE	32/58	42J-11,000	20
Fluorene	NE	30,000	100(2)	NE	5/58	39J-620J	3
Indeno(1,2,3-cd)pyrene	NE	100(2)	100(2)	NE	26/58	40J-6,800	16
Phenanthrene	NE	100(2)	100(2)	NE	9/58	37J-2,900	4
Pyrene	NE	100(2)	100(2)	NE	34/58	39J-14,000	19
Volatiles (µg/kg)							
Ethylbenzene	NE	100(2)	100(2)	NE	1/17	2J	0
Toluene	200,000	100(2)	100(2)	NE	2/17	2J	0
Xylenes	>1000(3)	NE	NE	NE	1/17	6J	0

(1) Will and Suter, 1994a and 1994b unless indicated otherwise (Values presented for plants, earthworms, and microorganisms and microbial processes are benchmarks below which adverse impacts to these species are not expected. Values for invertebrates are No Observed Effects Concentrations, however, they are based on less data than the benchmarks)

(2) USEPA, 1995b (Region III BTAG Soil Screening Values for Soil Fauna)

(3) Hulzebos et. al., 1993 (EC50)

TABLE 7-5
EXPOSURE FACTORS FOR TERRESTRIAL CHRONIC DAILY INTAKE MODEL
OPERABLE UNIT NO. 11 (SITE 3)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Small Mammal (Meadow Vole)
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 100%
Feeding Rate	kg/d	1.6(2)	0.237(4)	0.0135(3)	0.601(3)	0.112(3)
Incident Soil Ingestion	kg/d	0.0185(1)	0.0057(5)	0.0011(5)	0.0168(5)	0.00269(5)
Rate of Drinking Water Ingestion	L/d	1.1(2)	0.119(3)	0.0191(3)	0.385(3)	0.0652(3)
Rate of Vegetation Ingestion	kg/d	1.6	0.237	0.0135	0.12	0.112
Body Weight	kg	45.4(2)	1.229(3)	0.174(3)	4.54(3)	0.3725(3)
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.48	NA
Home Range Size	acres	454(2)	9.30(3)	26.24(3)	1,245(3)	0.032(3)

NA - Not Applicable

(1) Arthur and Alldridge, 1979

(2) Dee, 1991

(3) USEPA, 1993c

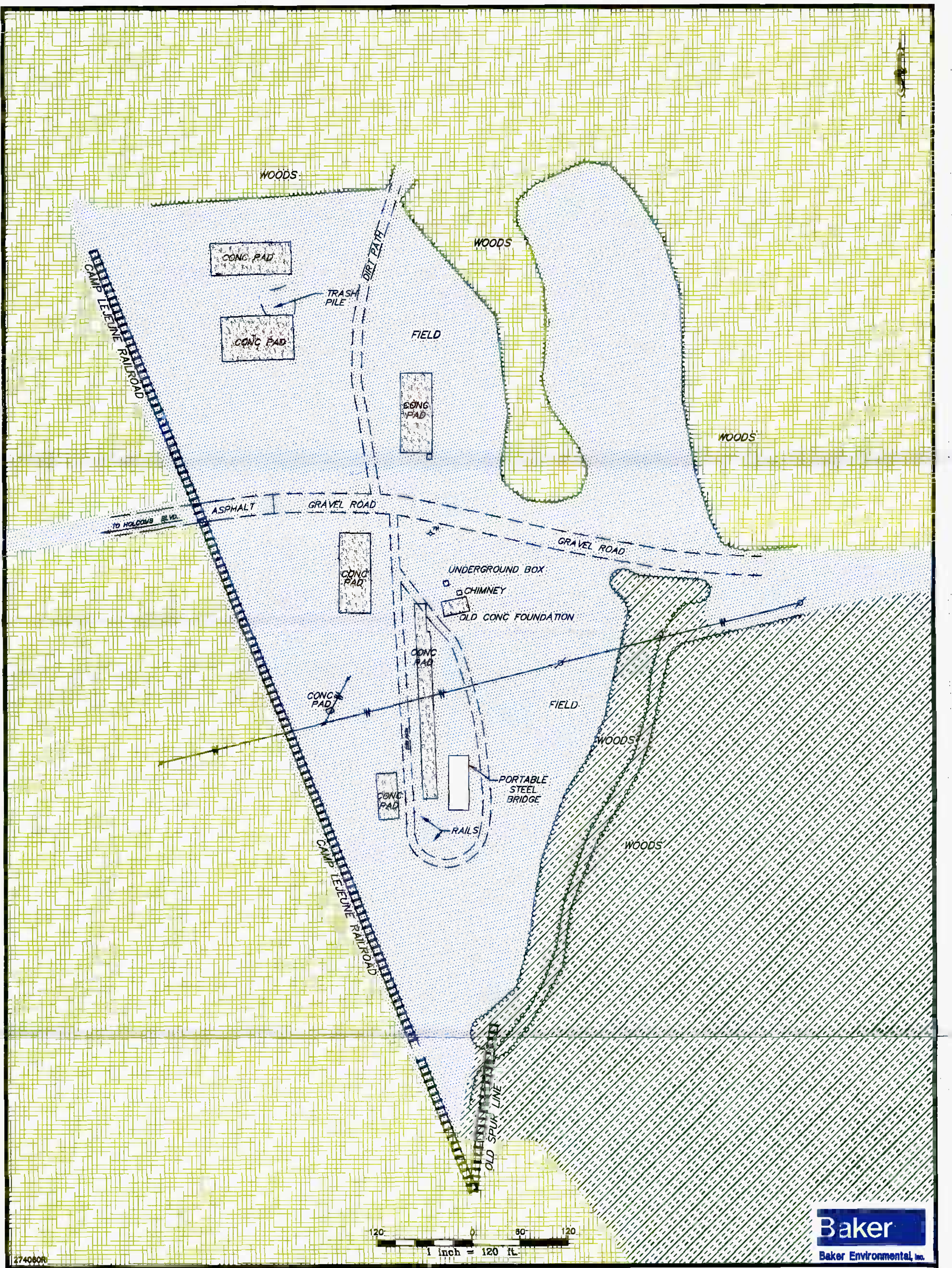
(4) Opresko, et.al., 1994

(5) Beyer, 1993

TABLE 7-6
TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
OPERABLE UNIT NO. 12 (SITE 3)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Whitetail Deer
Chromium	1.09e-04	6.15e-05	4.00e-04	8.07e-06
Zinc	2.47e-03	2.54e-03	9.04e-02	2.99e-03
Acenaphthylene	1.85e-06	3.26e-05	7.23e-04	8.41e-06
Anthracene	8.07e-07	1.33e-05	2.60e-04	2.91e-06
Benzo(a)anthracene	6.50e-05	8.99e-04	1.12e-02	9.95e-05
Benzo(b)fluoranthene	8.52e-05	1.09e-03	1.08e-02	7.84e-05
Benzo(k)fluoranthene	7.57e-05	1.01e-03	1.11e-02	9.00e-05
Benzo(ghi)perylene	4.96e-05	6.41e-04	6.43e-03	4.78e-05
Benzo(a)pyrene	6.29e-05	8.46e-04	9.56e-03	7.93e-05
Bis(2-ethylhexyl)phthalate	1.69e-05	7.36e-05	3.93e-03	3.99e-05
Carbazole	1.52e-04	2.97e-03	7.80e-02	9.51e-04
Chrysene	8.50e-05	1.18e-03	1.46e-02	1.30e-04
Dibenz(a,h)anthracene	3.77e-05	4.88e-04	4.89e-03	3.63e-05
Di-n-butylphthalate	1.21e-07	2.66e-03	2.67e-05	2.66e-07
Fluoranthene	7.81e-06	1.20e-04	2.02e-03	2.13e-05
Fluorene	2.11e-06	3.67e-05	7.90e-04	9.12e-06
Indeno(1,2,3-cd)pyrene	5.30e-05	6.85e-04	6.86e-03	5.08e-05
Phenanthrene	6.71e-07	1.10e-05	2.16e-04	2.42e-06
Pyrene	1.48e-05	2.15e-04	3.09e-03	3.02e-05
Ethylbenzene	3.54e-08	7.06e-07	1.86e-05	2.26e-07
Toluene	2.70e-08	5.60e-07	1.54e-05	1.90e-07
Xylenes	5.66e-09	1.13e-07	2.97e-06	3.62e-08
Total Quotient Index	**3.30e-03**	**1.56e-02**	**2.55e-01**	**4.68e-03**

SECTION 7.0 FIGURES



LEGEND

▥	PINE FOREST
▨	MIXED FOREST
░	OPEN AREA

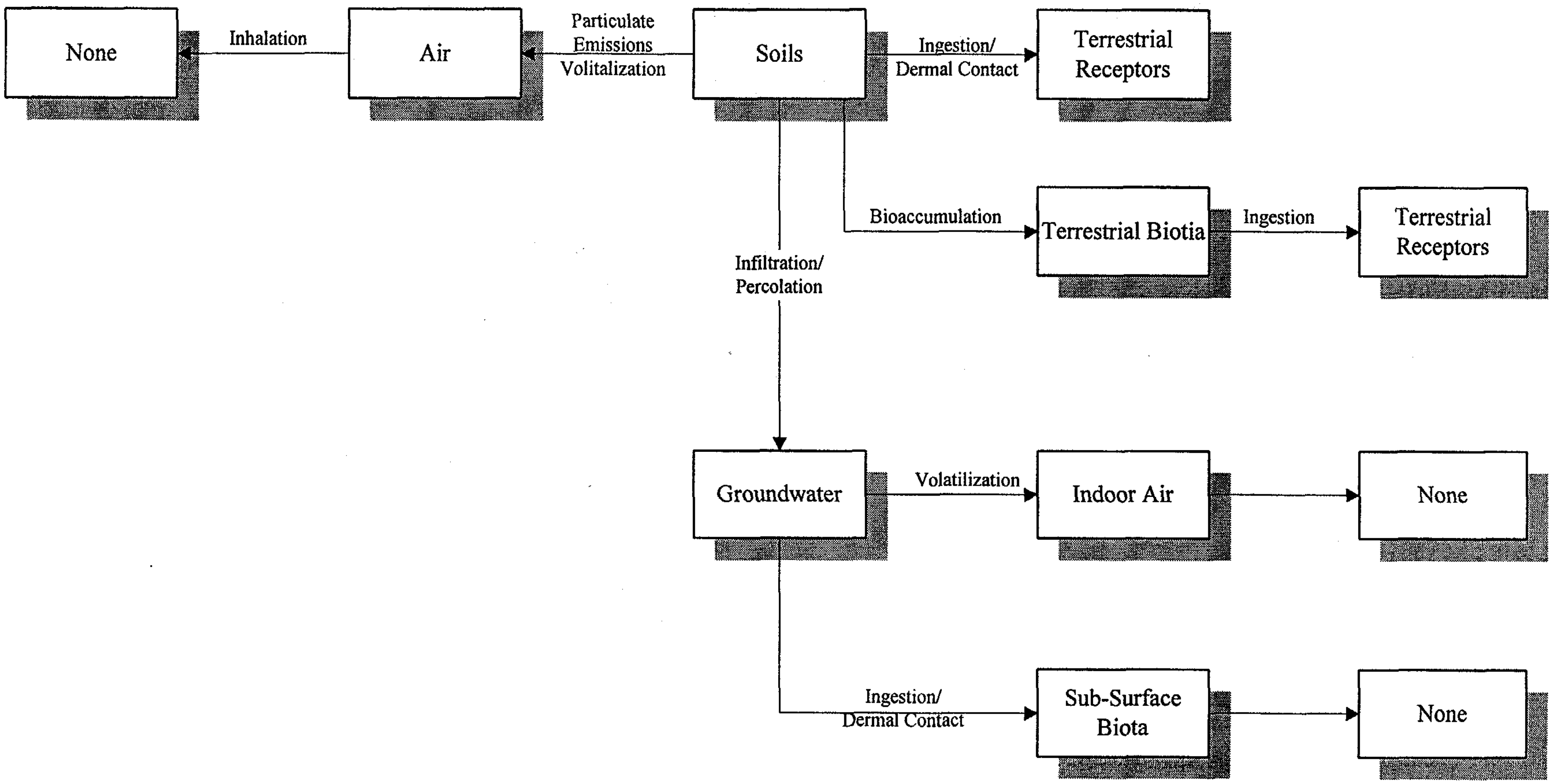
SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 7-1
BIOHABITAT MAP
SITE 3 - OLD CREOSOTE PLANT
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

FIGURE 7-2

CONCEPTUAL EXPOSURE MODEL FOR ECOLOGICAL RECEPTORS
SITE 3



8.0 CONCLUSIONS

The following conclusions for Operable Unit (OU) No. 12 (Site 3) are based on the results of the Remedial Investigation, and the human and ecological risk assessment.

1. Shallow and deep groundwater has been impacted with volatile contaminants from former creosote operations. The volatile contamination in the shallow and the upper Castle Hayne Aquifer was dominated by benzene, toluene, and xylenes. Benzene was detected above State and Federal standards in the central portion of the treatment area (well 3-MW02) during the first and third rounds of groundwater sampling, but not during the second round of sampling. Volatiles were detected in the Castle Hayne Aquifer during all rounds of sampling. Benzene was detected in intermediate well (3-MW02IW) above State and Federal standards during the first sampling round. Benzene was detected in the deep well (3-MW02DW) above State and Federal standards during the second round of sampling. No volatile contaminants were detected above standards during the third round of sampling.

2. Shallow and deep groundwater has been impacted by semivolatile contaminants from former creosote operations. In round one PAH constituents naphthalene, phenanthrene, benzo(a)pyrene, chrysene, and benzo(a)anthracene were detected in monitoring well 3-MW02 above State and/or Federal criteria. In the second round of sampling naphthalene was detected in shallow well 3-MW06 above the State and/or Federal standard. Phenol and naphthalene were the only semivolatiles detected above State and/or Federal standards during the second round of sampling in deep well 3-MW02DW. Naphthalene was detected above the State and/or Federal standard in shallow well 3-MW02 and 3-MW06 during the third round of sampling. No semivolatile organics were detected in the Castle Hayne Aquifer above State and/or Federal criteria during round three.

3. Although volatiles and semivolatiles area present in the both the shallow and Castle Hayne Aquifers, the vertical and horizontal extent of contamination is limited in area. No off-site supply wells or down gradient intermediate wells (3-MW11IW) exhibited contamination. Based on existing data, the plume is estimated to cover approximately two to three acres.

4. Semivolatiles (PAH) were the predominant organic contaminants in the soil. These contaminants are believed to be associated with past wood treating activities at the site. The highest PAH concentrations occurred in the Treatment Area in the central portion of the site. Fuel constituents, such as ethylbenzene and xylene, were also detected in surface and subsurface soils at Site 3, primarily at the former treatment area in the central portion of the site.

5. The source of contamination is associated with the past creosote treatment practices. It is possible that the contaminated soil may continue to impact groundwater quality; however; given the nature of the contaminants migration vertically and horizontally can be monitored.

6. Under current human health exposure scenarios, there are no adverse human health risks mainly because groundwater is not utilized at the for potable supply, and because the site is not within several miles of a residential area.

7. Under future potential human health exposure scenarios involving residential use of the area, adverse risks would result due to groundwater exposure. Future residential use of the area is unlikely due to the proximity of the area to the Lejeune Rail Road and Holcomb Boulevard.

8. There are no significant ecological risks to terrestrial receptors associated with Site 3. Several contaminants detected in the surface soil exceeded the SSSVs which may result in the reduction in the flora or fauna population. However, the contaminants are not expected to cause a significant adverse risk to terrestrial mammals or birds.

9. Based on human health risk and ecological risk assessments, groundwater is the only medium of concern at Site 3. However, examination of the analytical data indicates that contamination in the surface and subsurface soil may be a continuing source of contamination in the groundwater. Although, there is no current groundwater exposure pathway that would result in adverse human health risks, contaminants are migrating to the Castle Hayne Aquifer. The Castle Hayne Aquifer is utilized extensively throughout MCB Camp Lejeune and the surrounding communities for water.