03.13-02/01/96-01701

Final

Remedial Investigation Report
Operable Unit No. 11 (Site 7)

Marine Corps Base,
Camp Lejeune, North Carolina

Text and Figures

Reference:
Contract
N62470-89-D-4814

CTO-0274

February 1996

Prepared For:

Department of the Navy
Atlantic Division
Naval Facilities
Engineering Command
Norfolk, Virginia

Under the

LANTDIV CLEAN Program

Comprehensive Long-Term
Environmental Action Navy

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF FIGURES

LIST OF APPENDICES

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
DD	Drainage Ditch
DDE	dichlorodiphenyldichloroethylene

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

DDT	diphenyltrichloroethane
DoN	Department of the Navy
DQOs	data quality objectives
EA	East Area
ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential
EMD	Environmental Management Department
ER-L	Effects Range - Low
ER-M	Effects Range-Median
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

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

K	hydraulic conductivity
K_d	soil sorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol water partition coefficient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	lowest observed adverse effect level
MA	Swamp Area
MBI	Macroinvertebrate Biotic Index
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
NA	North Area
NC	North Carolina
NC	Northeast Creek
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

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

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
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
SD	sediment
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
SWA	Southwest Area
SWQSVs	surface water quality screening values
SWSVs	surface water screening value

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

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
TP	Test Pit
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
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 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 14 operable units, 27 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. This report documents the Remedial Investigation (RI) completed for Site 7 Tarawa Terrace Dump. This site along with Site 80 comprise Operable Unit (OU) No. 11 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 Operable Unit (OU) No. 11. 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) 300.430]. 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

MCB Camp Lejeune is located within the Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The eastern border of MCB Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB Camp Lejeune to the north.

Site 7, the Tarawa Terrace Dump, is located northeast of the wastewater treatment plant and south of the community center between Tarawa Boulevard and Northeast Creek. The study area is approximately 5 acres in size, and public access is not restricted. A marsh area is encountered in the southern portion of the study area in the vicinity of Northeast Creek. The entire study area is dense with wooded areas and ground cover. Northeast Creek flows to the west in the direction of the New River. Two unnamed surface water bodies, within the site boundaries, flow southerly in the direction of Northeast Creek. Northeast Creek and the surface water bodies are influenced by tides. During high tide much of the marsh area is covered with ponded water.

During a March 1994 site reconnaissance, four areas of concern were apparent. Aerial photos from 1973 and 1978 indicated a potential dump area east of a utility right-of-way. Additionally, a smaller cleared area was shown on the western side of the utility right-of-way. The area south of the community center is a concern based on elevated levels of pesticides/PCBs reported in a previous investigation. Visual debris (i.e., paint cans, motor oil cans, and other rusted cans) were observed in the wooded area east of the water treatment plant. What appeared to be a cleared area, where past dumping may have occurred was observed due east of the water treatment plant adjacent to the smaller surface water body.

Site 7 is a former dump that was used during the construction of the base housing located in Tarawa Terrace. Precise years of operation are unknown, but it has been reported that the dump was closed in 1972. Historical records do not indicate that hazardous materials were disposed of at this facility; only construction debris, water treatment plant filter media, and household trash are known to have been disposed. Aerial photos from the 1970s indicate a cleared area east of the right-of-way, and a smaller cleared area west of the right-of-way.

REMEDIAL INVESTIGATION ACTIVITIES

The RI field program at Site 7 consisted of a site survey; a soil investigation which included drilling and sampling; a groundwater investigation which included monitoring well installation and sampling; a surface water and sediment investigation; a habitat evaluation; and an earthworm bioaccumulation study. The surface water, sediment, and ecological investigation was conducted from June 22 to June 27, 1994, due to fish migration and benthic macronivertebrate life cycles. The soil and groundwater phase of the RI field program commenced on October 10, 1994 and continued through December 12, 1994. Baker returned to the site from January 30 through February 5, 1995 to coordinate the disposal of investigative derived waste (IDW). Due to DEHNR concerns over PCBs in the soil, confirmatory surface and subsurface soils were collected during October 6 through 7, 1995. The following details the various investigation activities which were implemented at the during the RI.

The site survey task was performed in two phases: Phase I - initial survey of site features and proposed sample locations; and Phase II - post investigation survey of existing sampling locations and monitoring wells. The firm W.K. Dickson and Associates, Inc. was retained to perform both phases of the site survey.

The soil investigation was conducted at Site 7 to characterize soil quality at the site and to determine the presence or absence of contamination within the site boundary. For the soil investigation, Site 7 was separated into four areas of concern: Community Center Area, East Area, North Area, and South West Area. A total of 35, including background samples, surface soil [0 to 1 foot below ground surface (bgs)] samples were collected from Site 7. A total of 28 subsurface soil samples, including background, (1 foot bgs to just above the water table) were collected at Site 7. In addition to the soil investigation, five trenches were performed. All surface and subsurface soil samples were analyzed for full TCL organics and TAL metals.

The groundwater investigation was conducted at Site 7 to determine the presence or absence of contamination in the surficial aquifer resulting from past activities. Two shallow groundwater monitoring wells were drilled and installed as part of this investigation, in addition to the three existing monitoring wells. Additionally, three temporary wells were installed. Static water level

measurements were collected on two separate occasions. Measurements were recorded from top-of-casing reference points, marked on the PVC casing at each monitoring well.

Surface water and sediment were collected from the west tributary to Northwest Creek, in the drainage ditch to the west tributary, the east tributary to Northeast Creek, and in Northeast Creek. Sediment samples were also collected in the marsh area. At each sediment sampling station in the marsh area and in Northeast Creek, samples were collected at a depth of 0 to 6 inches and/or 6 to 12 inches. Sediment samples in the drainage ditch and east and west tributaries were collected from a depth of only 6 inches.

Field QA/QC samples were submitted during the investigation. These samples included trip blanks, equipment rinsates, and field duplicates.

Samples collected during the RI were submitted for laboratory analysis to Quanterra Environmental, Inc. A majority of the samples were analyzed by Contract Laboratory Program (CLP) methods using Level IV Data Quality Objectives (DQOs). Additionally Chester Environmental, Inc. performed data validation, frequency of detection, and statistical analyses on the laboratory data.

A habitat evaluation was performed at Site 7 from December 4 through December 6, 1994. The evaluation focussed on the determination of terrestrial and aquatic ecosystems, along with the identification of plant and animal species.

Benthic macroinvertebrates were collected as part of the ecological investigation, which included sampling along the west tributary and Northeast Creek.

The earthworm bioaccumulation study was conducted at Site 7 to determine if earthworms were bioaccumulating PCBs, pesticides, and metals from the soil.

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

Topography and Surface Features

The topography at Site 7 is variable with elevations ranging from 20 feet msl to the north to 5 feet msl to the south. The slope of the site is to the south in the direction of Northeast Creek. Several surface water bodies (i.e., eastern tributary and western tributary) and the drainage ditch are within the boundaries of the site. Surface water and runoff from the site flow in a southerly direction into Northeast Creek. Northeast Creek flows in a southwesterly direction along the southern edge of the site and into the New River, approximately 3 miles downstream. Northeast Creek and the surface water bodies are influenced by tides. During high tides, much of the southern portion of the site is covered with ponded water.

Surface Water Hydrology and Drainage Features

There are three surface water bodies identified within the site. These have been identified as the "eastern tributary", "western tributary", and a "drainage ditch" which flows into the western tributary. There is also a minor drainage ditch on the eastern side of the site, which only appears to have water flowing in it during periods of heavy rain and/or high water table. Approximately one-half of the site, the southern portion, is classified as a swamp. Northeast Creek is located at the

southern edge of the site. The surface water bodies and the surface water runoff flow in a south/southeast direction toward Northeast Creek.

Geology and Soil

The site is primarily underlain by sands and silty sands. These sands are generally overlain by thin layers of silt and silty clay. Occasional lenses and/or discontinuous layers of sand and clay, and clay are present at depth. The relative density of the soils range from loose/soft to very dense/very stiff. Fill material was identified in the southwest area of the study area. Most notably, the fill material contained roofing shingles, ranging in thickness from 1 to 6 feet.

HYDROGEOLOGY

Groundwater was encountered during the RI at depths ranging from 3.63 to 19.81 feet below ground surface (bgs). Linear groundwater flow is in the south/southeast direction toward Northeast Creek. Recharge for this area is from the north/northwest. The shallow groundwater gradient measured from 7-MW04 to 7-MW03 to the southwest for December 11, 1994 was 0.07 ft/ft and for March 27, 1995 was 0.01 ft/ft. Shallow groundwater discharges to Northeast Creek.

A tidal study was conducted to determine the influence of tidal effects on the shallow groundwater within the site boundaries. A staff gauge was installed in Northeast Creek near the confluence of the western tributary, approximately 50 feet from shore. The staff gage in Northeast Creek indicated fluctuations in the water surface from 0.2 to 0.3 feet. The data indicates that there is a tidal effect on the shallow groundwater, but there is a delay between the highest elevations of groundwater and the creek.

Potable Water Supply Wells

Potable supply wells within a one-mile radius of the site were identified. Based on information obtained from United States Geological Society (USGS) publication (Harned, et al., 1989) there are six supply wells within a one-mile radius of Site 7. Currently, none of these wells are operational and have been scheduled for demolition.

EXTENT OF CONTAMINATION

A total of 35 surface soils and 28 subsurface soil samples were collected from the community center, east area, north area, southwest area, background locations, and from monitoring well locations at Site 7. Additionally, due to DEHNR concerns over previous PCB findings an additional 18 surface and 16 subsurface confirmatory soil samples were collected from the east area and north area.

The pesticides dieldrin, 4,4'-DDE, 4,4'-DDT, and 4,4'-DDD are the most prevalent pesticide contaminants in the surface and subsurface soil. Of these, dieldrin and 4,4'-DDE are the most prevalent in the surface and subsurface soil. The maximum pesticide level reported in the surface soil is for 4,4'-DDT (280 µg/kg), and in the subsurface soil the maximum concentration level is for alpha-chlordane (120 µg/kg).

Surface and subsurface contamination also consists of trace levels of PCBs (Aroclor 1254 and 1260). The maximum surface soil concentration of Aroclor 1260 (80 µg/kg) was found in soil boring location 7-NA-SB04. The maximum soil concentration of Aroclor 1260, detected in the subsurface

soil, is 91 µg/kg. This concentration was reported for soil boring 7-SWA-SB04. PCBs were detected in one surface soil boring (7-EPCB-SB09) collected as part of the confirmatory sampling. PCBs were found to be absent in the subsurface samples collected as part of the confirmatory sampling.

Semivolatile contamination was detected in the north and eastern portions of the study area. Semivolatile compounds are detected more frequently in the surface rather than subsurface. Semivolatile compounds fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(k)fluoranthene are the most prevalent. These contaminants were detected in 4 out of 32 surface soil samples. Semivolatile compounds were not detected in more than one subsurface sample.

For the exception of one detection of trichloroethene, detected at 1 µg/kg in the surface soil, surface and subsurface soil are absent of volatile contamination.

The concentration of several inorganic constituents exceed twice the average base-specific background concentration. A continuing soil background database is being developed for MCB Camp Lejeune to support the RI/FS efforts. Comparing the results for surface and subsurface soil, it appears that there is correlation between elevated metals concentrations in the surface and subsurface soil. Aluminum, barium, beryllium, calcium, nickel, and zinc exceed the base-specific background concentrations for both surface and subsurface soil. However, the surface soil concentrations more frequently exceeded the background values.

Groundwater

One round of groundwater samples were collected from eight wells (five monitoring wells and three temporary wells) at Site 7.

Metals are the most prevalent and widely distributed contaminants in the groundwater. Elevated levels of total (unfiltered) metals above state and/or federal standards included aluminum (maximum concentration 888,000 µg/L), chromium (maximum concentration 104 µg/L), iron (maximum concentration 25,400 µg/L), and lead (maximum concentration (67.5 µg/L).

For the exception of phenol (maximum concentration 4 µg/L), 4-Methylphenol (10 µg/L), and dieldrin (maximum concentration 0.41 µg/L) semivolatile and pesticide/PCB contamination is not in the groundwater.

Volatile organic contaminants chloroform, 2-hexanone, and toluene were infrequently detected at low concentrations in the groundwater.

Surface Water

A total of 13 surface water samples were collected from Northeast Creek, eastern tributary, western tributary, and drainage ditch.

The pesticide dieldrin was detected in two surface water samples at concentrations of 0.4 µg/L and 0.5 µg/L. Endrin ketone was detected in two samples at concentrations of 0.12 µg/L and 0.13 µg/L.

Arsenic, iron, and manganese are the only inorganics detected above applicable federal and state surface water criteria.

Sediment

Twenty-seven sediment samples were collected from Northeast Creek, eastern tributary, western tributary, drainage ditch, and the swamp area.

Polynuclear Aromatic Hydrocarbons (PAHs) were the most prevalent semivolatile organics in the sediment. Anthracene and pyrene were detected at concentrations above NOAA criteria.

Pesticide and PCB contaminants were detected in the sediment. The pesticide 4,4'-DDE was the most prevalent pesticide. Dieldrin, 4,4'-DDD, 4,4'-DDT and 4,4'-DDE exhibited concentrations exceeding NOAA criteria. Additional pesticides aldrin, endrin ketone, alpha chlordane, and gamma chlordane were also detected in the sediment, but at levels below the NOAA criteria. Aroclor 1260 was detected in one sediment sample collected in the marsh area at a concentration of 450 µg/kg.

Inorganics copper, lead, mercury, and zinc were detected at concentrations greater than NOAA criteria.

HUMAN HEALTH RISK ASSESSMENT

There are no potential noncarcinogenic or carcinogenic risks associated with exposure to surface soil, subsurface soil, surface water, or sediment. Due to the presence of beryllium the carcinogenic risk associated with exposure to groundwater slightly exceeds the USEPAs acceptable risk range of 1E-04 to 1E-06. There are; however, noncarcinogenic risks to future residents (children and adults) associated with combined exposure (ingestion and dermal contact) to groundwater. The Hazard Index (HI) 8.8 and 3.8 estimated for children and adults, respectively exceeds the acceptable risk level 1.0. Both of the exceedences are primarily due to the ingestion of aluminum in the groundwater.

On comparison with contaminant concentrations with state and federal criteria, only aluminum, chromium, lead, and iron exceed either federal or state groundwater criteria.

ECOLOGICAL RISK ASSESSMENT

Aquatic Ecosystem

Based on the results of the surface water, sediment, and benthic macroinvertebrate sampling at the west tributary freshwater stations, it appears that there is a reduction of the benthic macroinvertebrate population. However, it is not known if this reduction is from site-related inorganics in the surface water, or from non site-related pesticides in the sediment. Other possible sources for the low and poorly diversified benthic macroinvertebrate population is washout of the tributary that occurs as a result of high rainfall events, or periodic high tidal events that would stress the resident benthic population with high saline water. The benthic macroinvertebrate population appears to recover by the downstream saltwater station. The benthic macroinvertebrate population is consistent with the population at the off-site reference stations with respect to species density and diversity. In addition, there are no site-related contaminants at this station that exceed either the SWSVs of the SSVs at this station.

Based on the results of the surface water, sediment, and benthic macroinvertebrate sampling at the Northeast Creek stations, there does not appear to be a significant reduction, or potential reduction of the benthic macroinvertebrate population from site-related contaminants. Lead was the only site-related contaminant that exceeded a screening value. In addition, the benthic macroinvertebrate population is consistent with the population at off-site reference stations with respect to species density and diversity.

The benthic community in either the drainage ditch or the east tributary were not determined; however, based on the exceedences of the Surface Water Screening Values (SWSVs) and Sediment Screening Values (SSVs), potential impacts are expected. Some of the inorganics in the surface water are considered site-related, the pesticides in the sediment are not considered site-related.

Terrestrial Ecosystem

Based on the comparisons of contaminants in the surface soils to Surface Soil Screening Values (SSSVs), there is a potential for the reduction of the terrestrial floral and faunal population. However, the earthworm bioaccumulation study indicated that the SSVs appear to overestimate potential risk to earthworms. In addition, this was further reinforced by the observations of worms in soils containing contaminant levels greater than the SSSVs, and no visible signs of stressed or dead vegetation were observed.

The results of the Chronic Daily Intake (CDI) model indicated that the cottontail rabbit, raccoon, and short-tailed shrew may be potentially at risk from contaminants in the surface water and surface soil. The risk to the rabbit does not appear to be significant because the QI barely exceeded "1". Aluminum caused the majority of the risk in the raccoon and the shrew. However, based on the conservative nature of the models, and the assumption that aluminum is most likely not site related, the potential for a decrease in the raccoon and shrew population from site-related Contaminants of Potential Concern (COPCs) is expected to be low.

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), 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 1995 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 to simplify proceeding with RI/FS activities. This report describes the RI conducted at Operable Unit (OU) No. 11, which is comprised of Sites 7 and 80. However, this report will only focus on Site 7.

[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. This RI investigation was conducted through the sampling of several media (soil both surficial and subsurface, groundwater, surface water, sediment, and benthic macroinvertebrates) at Site 7, evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. Furthermore, the RI report provides information in support of the FS and record of decision (ROD).

This RI Report is 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 physical characteristic and history of OU No. 11 (Site 7). In addition, Section 1.1 provides an overview of the RI Report's Organization.

1.1 Report Organization

This RI Report for Site 7 is comprised of the following sections:

- Section 1.0 - Introduction (includes OU and site descriptions, and site histories)
- 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 7 are provided in separate volumes.

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. Sites 7 and 80 were grouped together as OU No. 11 due to their proximity to each other. Site 7 is located on the northern bank of Northeast Creek and Site 80 is located on the southern bank of Northeast Creek. In addition to their proximity, previous investigations at both sites have detected the presence of pesticides and PCBs in soils. Figure 1-2 depicts the locations of all 17 OUs at MCB, Camp Lejeune.

Site 7, the Tarawa Terrace Dump, is located northeast of the Tarawa Terrace Wastewater Treatment Plant and south of the Community Center between Tarawa Boulevard and Northeast Creek. The study area is approximately 5 acres in size and is not in a restricted area. A marsh/swamp borders the southern portion of the study area along Northeast Creek (Baker, 1994).

1.3 Site Description and History

The entire study area is densely wooded with large areas and ground cover. Northeast Creek flows west in the direction of the New River at Site 7. Two unnamed surface water bodies (referred to is this report as the Eastern and Western Tributaries), within the site boundaries, flow in a southerly direction toward Northeast Creek. Northeast Creek and the two surface water bodies are tidally influenced. During high tide much of the marsh/swamp area is covered with ponded water. Figure 1-3 depicts the location of Site 7 and bordering areas.

During a review of historic information and based on site reconnaissance conducted in March 1994, four areas of concern were identified. Aerial photos from 1973 and 1978 depict a potential dump area to the east of the utility right-of-way. Additionally, a smaller cleared area was noted on the western side of the utility right-of-way. The area south of the community center was also determined to be of concern, based on elevated levels of pesticides/PCBs reported in a previous investigation. Visual debris (i.e., paint cans, motor oil cans, and other rusted cans) were observed in the wooded area east of the Tarawa Terrace Wastewater Treatment Plant and adjacent to the drainage ditch (Baker, 1994).

Site 7, is known to be a former dump that was used during the construction of the Tarawa Terrace housing complex. Precise years of operation are unknown, but is has been reported that the dump was closed in 1972. Historical records do not indicate that hazardous materials were disposed at this location. However, construction debris, wastewater treatment plant filter media, and household trash are known to have been disposed (Baker, 1994).

1.4 Previous Investigations

An investigation was conducted by Halliburton NUS at Site 7 in June of 1991. This investigation entailed the collection of surface and subsurface soil samples, and the installation of three groundwater monitoring wells. A surface water and sediment investigation was not performed during this investigation. The following subsections present the results of those investigations.

1.4 Previous Investigations

An investigation was conducted by Halliburton NUS at Site 7 in June of 1991. This investigation entailed the collection of surface and subsurface soil samples, and the installation of three groundwater monitoring wells. A surface water and sediment investigation was not performed during this investigation. The following subsections present the results of those investigations. Information regarding procedures and methodologies of the previous investigation can be obtained in the Haliburton/NUS Site Inspection Draft Report, 1991.

1.4.1 Soil Investigation

Eight surface soil samples (i.e., samples collected from 0 to 2 feet below ground surface [bgs]) and five subsurface soil samples (i.e., samples collected from 3 to 12 feet bgs) were collected in June of 1991. All samples were analyzed for Target Compound List (TCL) organics, Target Analyte List (TAL) metals and cyanide. Analytical findings for soil samples are summerized on Table 1-1. Soil sampling locations are shown on Figure 1-4.

Soil sample location from monitoring well 7-MW02 exhibited pesticides and PCBs. Pesticides and PCBs were also reported in soil samples from soil borings SB01 and SB02. The maximum concentration of dieldrin (2,500 µg/kg) and endrin (1,300 µg/kg) were reported at location 7-MW02 (7.5 to 9.5 feet bgs) and the maximum concentration of endosulfan II (2,000 µg/kg) was found in the 7 to 9 foot bgs sample from location SB02. The contaminant PCB-1260 was detected in seven surface and subsurface soil samples. Concentrations of PCB-1260 ranged from 108 µg/kg at location SB05 from a depth of 0 to 2 feet bgs to 25,000 µg/kg at location 7-MW02 at a depth 7.5 to 9.5 feet bgs.

1.4.2 Groundwater Investigation

Three shallow monitoring wells (7-MW01, 7-MW02, and 7-MW03) were installed in June 1991. These wells were installed to depths of 5.71 to 14.27 feet bgs. One round of groundwater samples were collected and analyzed for full TCL organics, TAL total metals and cyanide. Analytical findings from groundwater samples are summerized on Table 1-2. Monitoring well locations are shown on Figure 1-4.

Two pesticides, dieldrin and endrin ketone, were reported at low levels (0.63 µg/L and 0.09 µg/L respectively) in monitoring well 7-MW02. Manganese, chromium, lead, and iron were the only metals which exceeded either the North Carolina Water Quality Standard (NCWQS) or the Federal Maximum Contaminant Level (MCL).

1.5 Data Limitations

Upon review of the previous investigation and the subsequent analytical findings, it was determined that possible data limitations existed for soils, groundwater, surface water, and sediment, at Site 7. Contamination was detected in some soil and groundwater samples, however, the extent to which the contamination was present on-site was unknown. Listed below are the media types that were identified to determine the presence or absence, and extent of potential site related contamination:

- Surficial soil
- Subsurface soil

- Surficial groundwater
- Surface water
- Sediment

[Note, surface water and sediments were included in the media types to be studied, due to the proximity of Northeast Creek to the site.]

Upon review of previous investigation results, the following data limitations for each sample media were identified:

The soil data limitations include:

- Assessment of the extent of pesticide and PCB contamination
- Assessment of human health and ecological risks associated with surface soil contamination
- Determination of whether organic and/or inorganic contamination is migrating from the soil to the groundwater

The ground water data limitations include:

- Assessment of the health risks posed by the potential future usage of the shallow groundwater
- Assessment of the extent of shallow groundwater contamination
- Definitizing the hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation

The surface water data limitations include:

- Assessment of the presence or absence of surface water contamination in the east and west tributaries, drainage ditch, and Northeast Creek
- Assessment of the potential impact of water quality to aquatic organisms

The sediment data limitations include:

- Assessment of potential human health and ecological risks associated with exposure to sediments in the east and west tributaries, drainage ditch, and Northeast Creek
- Determine extent of potentially contaminated sediment for the purposes of identifying areas requiring remediation

Upon review of the limitations for the soil, grounwater, surface water, and sediment, site-specific data requirements were generated. These requirements are listed below:

- The nature of soil, shallow groundwater, surface water, and sediment contamination at Site 7.
- The vertical and horizontal extent of contamination in the soil along the northern boundary of the site.
- The presence or absence of surface and subsurface soil contamination in the southeast corner of the site.
- The presence or absence of contamination in the marsh/swamp area in the southern portion of the site.
- The presence or absence of buried material or waste.
- The hazardous or nonhazardous nature of potential buried metal.
- 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 nature of the shallow aquifer.
- Information to support the assessment of risks to human health presented by potential exposure to the shallow groundwater.
- The effects of natural discharge from the shallow aquifer to local surface water.
- The risks to human health and the environment associated with current or future surface water use or exposure.
- The migration of contaminants to sediments in Northeast Creek from runoff and groundwater discharge.
- The risk to human health and the environment associated with exposure to sediments in local water bodies.

From these data requirements, RI objectives were established to meet the data deficiencies for Site 7. The RI objectives are discussed in detail in the following section.

1.6 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives aimed at characterizing past waste disposal activities at Site 7, assessing potential impacts to public health and environment, and providing 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 1-3 presents both the RI objectives identified for Site 7 and the criteria necessary to meet those objectives. In addition, Table 1-3 provides a general description of the study or investigation efforts required to obtain the necessary

information. The different media investigations conducted at Site 7 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 7 Tarawa Terrace Dump. Marine Corps Base, Camp Lejeune, North Carolina.

SECTION 1.0 TABLES

TABLE 1-1

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil (0-2 feet)		Subsurface Soil (3-12 feet)	
	No. of Positive Detections/ No. of Samples	Range of Positive Detections	No. of Positive Detections/ No. of Samples	Range of Positive Detections
Organics [1]				
Bis(2-ethylhexyl)phthalate	1/8	1,000	0/5	ND
Fluoranthene	2/8	220-290	0/5	ND
Benzoic acid	2/8	6,300-15,000	1/5	7,900
Aldrin	1/8	4.3	0/5	ND
4,4'-DDD	3/8	12-20	2/5	58-190
4,4'-DDE	1/8	240	0/5	ND
Dieldrin	3/8	12-540	3/5	400-2,500
Endosulfan II	3/8	7.6-1,400	3/5	73-2,000
Endrin	2/8	91-140	4/5	14-1,300
PCB-1260	3/8	108-12,000	4/5	660-25,000
Inorganics [2]				
Aluminum	8/8	3,690-9,700	5/5	1,030-5,030
Arsenic	3/8	1.1-1.7	3/5	1.1-1.5
Barium	8/8	9.1-223	5/5	6.6-72.8
Beryllium	4/8	0.26-2.1	3/5	0.29-3.6
Cadmium	8/8	1.1-5.0	5/5	1.2-4.5
Calcium	7/8	190-58,200	3/5	3,660-9,990
Chromium (Total)	8/8	4.2-10.6	5/5	5.2-12.5
Cobalt	8/8	1.7-8.1	5/5	1.9-10.2
Iron	8/8	876-5,330	5/5	981-5,490
Lead	8/8	3.0-114	5/5	2.4-17.0
Magnesium	8/8	104-1,150	4/5	99.9-541
Manganese	8/8	3.2-69.0	5/5	3.0-47.7
Mercury	8/8	0.11-0.53	5/5	0.12-0.45

TABLE 1-1 (Continued)

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil (0-2 feet)		Subsurface Soil (3-12 feet)	
	No. of positive Detections/ No. of Samples	Range of Positive Detections	No. of positive Detections/ No. of Samples	Range of Positive Detections
Nickel	8/8	2.8-13.1	5/5	3.1-11.7
Potassium	6/8	110-507	4/5	120-452
Selenium	1/8	0.54	0/5	ND
Silver	8/8	0.66-3.0	5/5	0.72-2.7
Sodium	1/8	754	1/5	1,020
Thallium	8/8	0.44-2.0	5/5	0.47-1.8
Vanadium	8/8	4.5-18.1	5/5	4.5-9.8
Zinc	2/8	1.1-44.5	3/5	1.2-4.5
Cyanide	8/8	0.54-2.5	5/5	0.60-2.3

(1) - Organic concentrations expressed in μg/kg (microgram per kilogram).
(2) - Inorganic concentrations expressed mg/kg (milligram per kilogram).
ND - Not detected.
Reference: Halliburton NUS, 1991

TABLE 1-2

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN GROUNDWATER
OPERABLE UNIT NO. 11 (SITE 7)
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 Detections	Location of Maximum Concentration
Benzoic Acid	--	--	2/3	9-12	7MW03
Dieldrin	--	--	1/3	0.63	7MW02
Endrin Ketone	2.0	2.0	1/3	0.09	7MW02
Aluminum	--	--	3/3	29,000-137,000	7MW02
Antimony	--	6	1/3	4.75	7MW02
Barium	2,000	2,000	3/3	427-706	7MW02
Beryllium	--	4	2/3	3.1-9.4	7MW02
Chromium (Total)	50	100	3/3	47.8-251	7MW02
Cobalt	--	--	2/3	9.6-21.7	7MW01
Copper	1,000	1,300	3/3	17.7-41.6	7MW02
Iron	300	300[1]	3/3	26,400-228,000	7MW02
Lead	15	15	3/3	30.3-37.3	7MW01
Magnesium	--	--	1/3	13,500	7MW01
Manganese	50	50[1]	3/3	56.9-220	7MW01
Mercury	1.1	2	2/3	0.24-0.36	7MW03
Potassium	--	--	1/3	5,240	7MW02
Selenium	50	50	1/3	3.4	7MW01
Sodium	--	--	1/3	156,000	7MW01
Vanadium	--	--	3/3	37.8-442	7MW02
Zinc	2,100	500[1]	3/3	83.6-151	7MW02

[1] Secondary Maximum Contaminant Level
-- = 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. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination at the former dump area.	Characterize contaminant levels in surface and subsurface soils at the former dump area.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface and subsurface soils at the site.	Soil Investigation Risk Assessment
	1c. Determine whether organic or inorganic contamination from soils is migrating to groundwater.	Characterize groundwater quality in the former dump area.	Groundwater Investigation
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to ARARs and health-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess the extent of shallow groundwater contamination.	Determine the horizontal extent of shallow groundwater contamination.	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
3. Sediment	3a. Assess human health and ecological risks associated with exposure to sediments in the east and west tributaries and Northeast Creek.	Characterize nature and extent of contamination in sediment	Sediment Investigation in the east and west tributaries and Northeast Creek Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments in the east and west tributaries and Northeast Creek.	Qualitatively evaluate stress to benthic and fish communities.	Evaluation of Surface Water and Sediment Investigation
	3c. Determine extent of sediment contamination for purposes of identifying areas potentially requiring remediation.	Identify extent of sediment contamination where contaminant levels exceed risk-based action levels or EPA Region IV TBCs for sediment.	Sediment Investigation in the east and west tributaries and Northeast Creek Risk Assessment
4. Surface Water	4a. Assess the presence or absence of surface water contamination in the east and west tributaries and Northeast Creek.	Determine surface water quality in the east and west tributaries and Northeast Creek.	Surface Water Investigation

SECTION 1.0 FIGURES

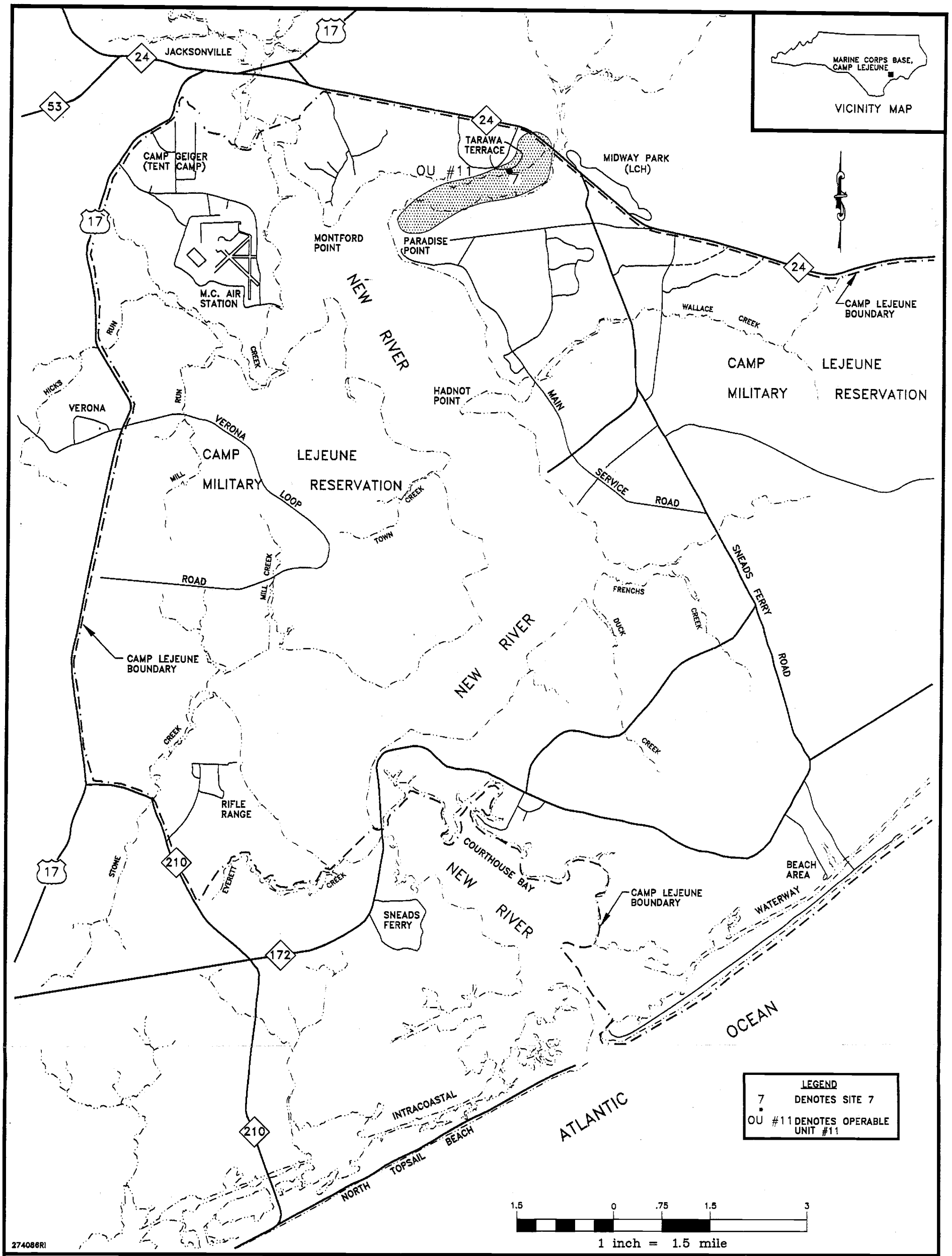


FIGURE 1–1
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO–0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701VB1Z

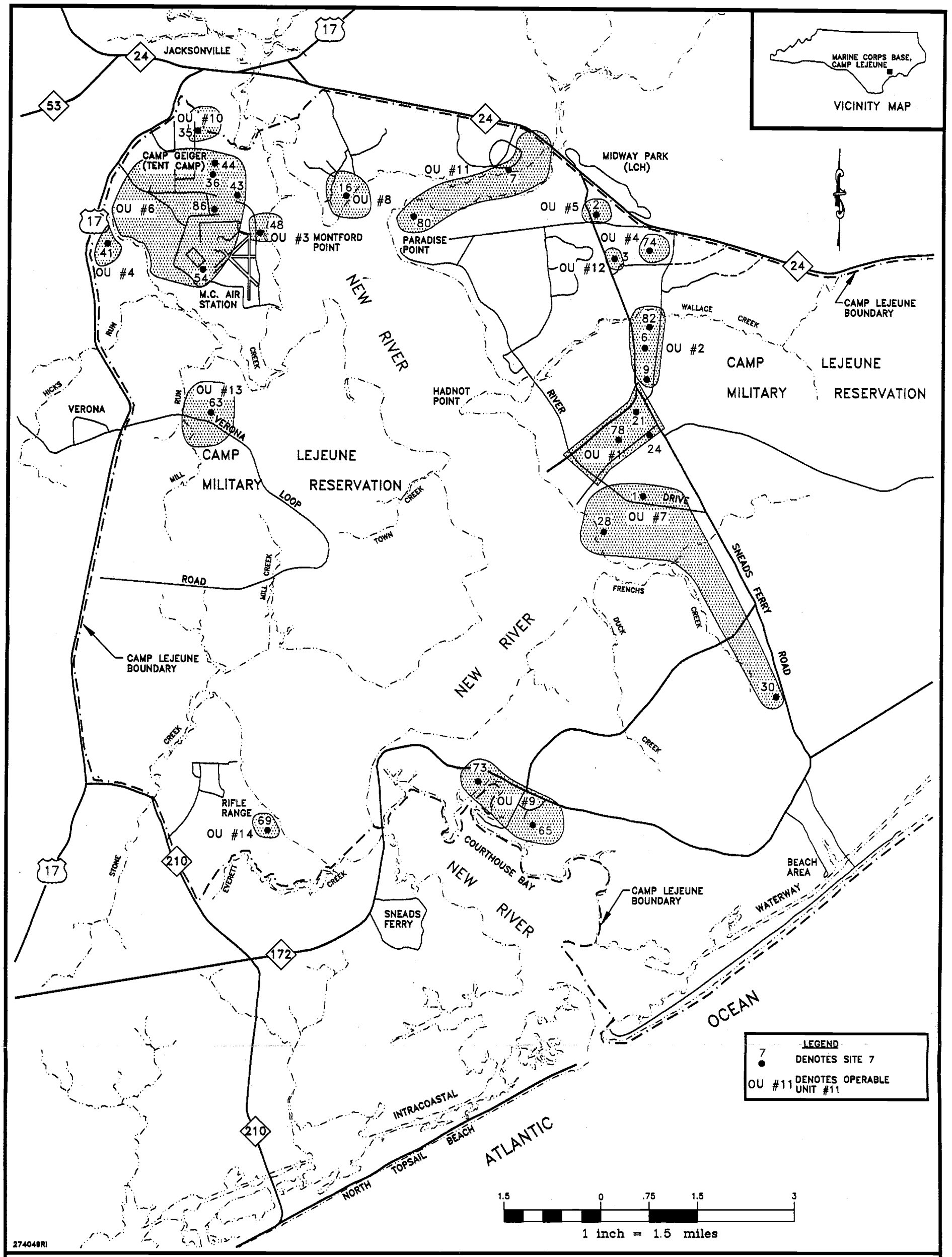
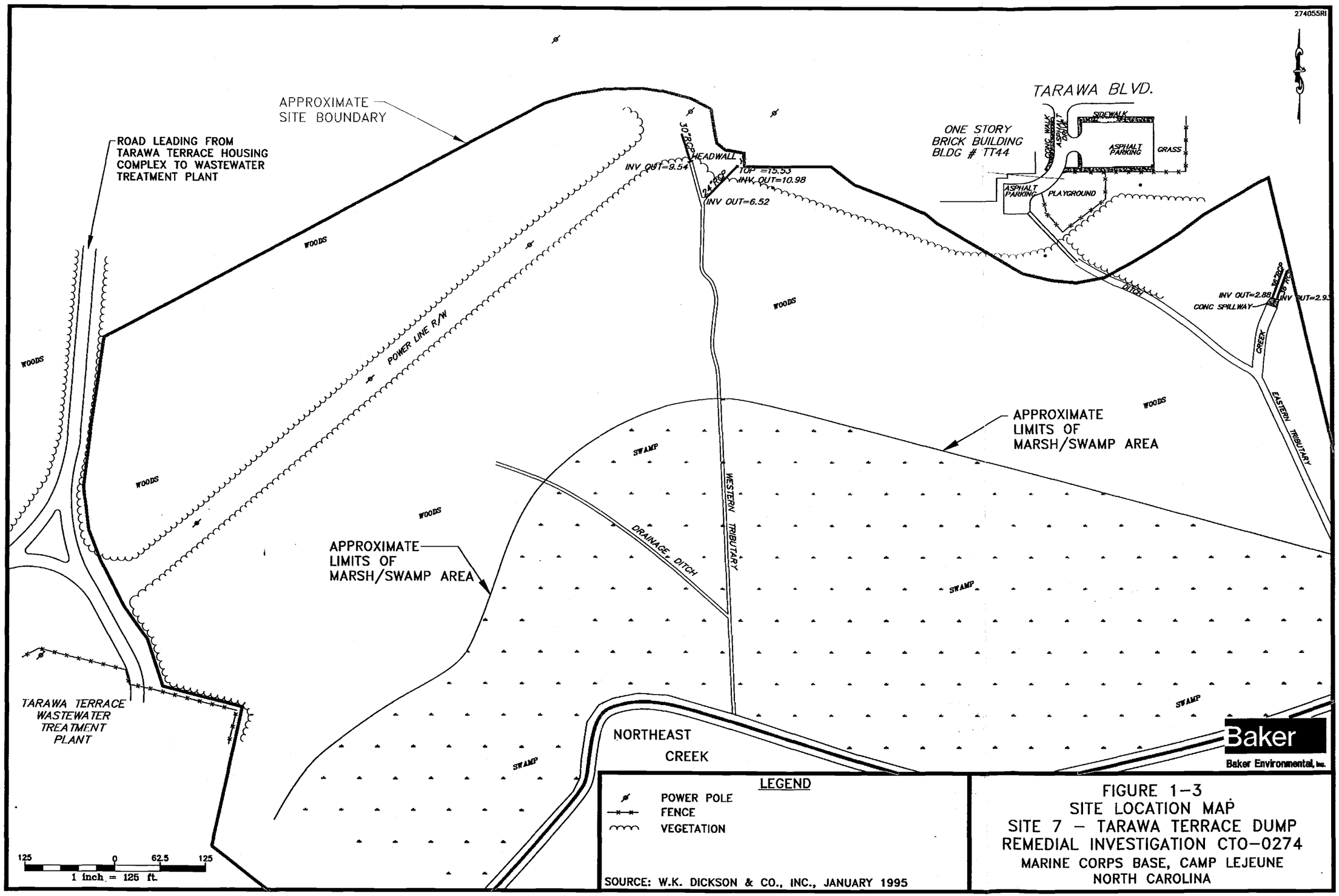


FIGURE 1–2
OPERABLE UNIT LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO–0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274055RI



Baker
Baker Environmental, Inc.

LEGEND

- POWER POLE
- FENCE
- VEGETATION

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

FIGURE 1-3
SITE LOCATION MAP
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274056RI

APPROXIMATE SITE BOUNDARY

ROAD LEADING FROM TARAWA TERRACE HOUSING COMPLEX TO WASTEWATER TREATMENT PLANT

TARAWA BLVD.

ONE STORY BRICK BUILDING BLDG # TT44

SIDEWALK

CONC WALK

ASPHALT DRIVE

ASPHALT PARKING

GRASS

ASPHALT PARKING

PLAYGROUND

30" RCP

HEADWALL

INV OUT=9.54

24" RCP

TOP =15.53

INV OUT=10.98

INV OUT=6.52

07-SB02

07-SB01

DITCH

INV OUT=2.88

INV OUT=2.93

CONC SPILLWAY

15" RCP

CREEK

EASTERN TRIBUTARY

WOODS

POWER LINE R/W

07-MW02

07-SB05

07-SB04

APPROXIMATE LIMITS OF MARSH/SWAMP AREA

07-MW01

SWAMP

WESTERN TRIBUTARY

DRAINAGE DITCH

07-SB03

07-MW03

TARAWA TERRACE WASTEWATER TREATMENT PLANT

NORTHEAST CREEK

125 0 62.5 125

1 inch = 125 ft.

Baker

Baker Environmental, Inc.

LEGEND

07-MW01 MONITORING WELL INSTALLED BY HALLIBURTON NUS, NOV. 1991

07-SB01 BOIL BORING INSTALLED BY HALLIBURTON NUS, NOV. 1991

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

FIGURE 1-4
PREVIOUS INVESTIGATION SAMPLING LOCATIONS
SITE 7 - TARAWA TERRACE DUMP
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 initial phase of the RI field investigation commenced on October 10, 1994 and continued through December 12, 1994. The earthworm bioaccumulation study was conducted during the initial phase of the RI. The surface water, sediment, and ecological investigation was conducted from June 22 to 27, 1994, due to fish migration and benthic macroinvertebrate life cycles. In addition, data obtained from the surface water, sediment, and ecological investigation was compared to background data (White Oak River Basin Study, provided in Appendix H) which was collected during the summer of 1994. During the week of January 30, 1995, investigative derived waste (IDW) generated during the RI was disposed of. In response to DEHNR, an additional 18 soil borings were installed at Site 7. This investigation took place on October 6 through 7, 1995. The RI field program at Site 7 consisted of a site survey; a soil investigation which included drilling and sampling; a groundwater investigation which included monitoring well installation and sampling; and a surface water and sediment sampling investigation. The following sections detail the various investigation activities which were implemented during the RI.

Investigative procedures and methodologies for the RI conducted at Site 7 have been previously discussed in detail within Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for OU No. 8, (Baker, 1994).

2.1 Site Survey

The site survey task was performed in two phases: Phase I - initial survey of site features and proposed sample locations; and Phase II - post investigation survey of existing sampling locations and monitoring wells. The firm of W. K. Dickson and Associates, Inc. was retained to perform both phases of the site survey. Phase I of the survey task was conducted at Site 7 during the week of October 10, 1994. The proposed soil borings and monitoring well locations, provided in the Final RI/FS Work Plan for OU No. 11 (Baker, 1994), were also surveyed and then marked with wooden stakes. Each sample location was assigned a specific identification number that corresponded to the site and sampling media.

Phase II of the site survey task was completed at Site 7 during the week of November 28, 1994. During Phase II, all soil borings and monitoring wells were surveyed at Site 7. In addition, any supplemental or relocated soil borings completed during the investigation were also surveyed. For each soil boring and monitoring well, the latitude, longitude, and elevation in feet above mean sea level (msl) were recorded.

2.2 Soil Investigation

A soil investigation was conducted at Site 7 to determine the presence or absence of contamination within the study area. Site 7 was segregated into four areas of concern: Community Center Area, East Area, North Area, and South West Area. Soil samples were collected at Site 7 from the following: soil borings, monitoring wells, test pits, and off-site background borings. A majority of the soil samples collected at Site 7 were done so by hand augers due to drill rig accessibility problems. In areas where drill rig accessibility was not an issue, soil samples were collected from drill rig split-spoons. The remaining soil samples were obtained from five test pits and represent composite samples collected with a stainless steel sampling spoon.

Investigative procedures and methodologies for the RI conducted at Site 7 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 7.

2.2.1 Surface Soil Investigation

A total of 35 surface soils (i.e., samples collected from 0 to 1 foot bgs) were collected at Site 7 to evaluate the presence or absence of contamination within the study area. Two of the 53 surface soils were obtained from soil borings that were converted to monitoring wells. In addition to the 48 on-site sample locations, three surface soil samples were also collected from background locations, not known or suspected to be contaminated. These background samples were located to the north, north east, and north west of Site 7. This investigation was conducted between October 21 and November 2, 1994. In addition to the 35 surface soil samples, 9 surface soil samples were collected from each of two sampling grids. The sampling grids were demarcated in the east and north areas where three positive detections of Aroclor-1260 had been reported during the Halliburton/NUS investigation in 1991. These samples were collected due to DEHNR concerns that previous soil sampling locations were not sufficient in the areas where PCBs had been reported. This investigation was conducted during October 6 through 7, 1995. Figure 2-1 provides all of the on-site surface soil sampling, monitoring well, and background locations. Each soil sampling location was identified with a unique descriptive abbreviation (e.g., soil sample location 7-CC-SB01 refers to Site 7, the Community Center Area, and Soil Boring number one). The following list provides the number of surface soil samples collected and the area in which they were collected:

- Two surface soils, Community Center Area (CC)
- Eleven surface soils, East Area (EA)
- Twelve surface soils, North Area (NA)
- Five surface soils, South West Area (SWA)
- Two surface soils, Monitoring Well Locations (MW)
- Three surface soils, Background Locations (BB)
- Nine surface soils, East PCB Area (EPCB)
- None surface soils, North PCB Area (NPCB)

Table 2-1 identifies all surficial soil samples collected at Site 7. In addition to sample identification, Table 2-1 also lists the depth interval of the sample, depth of 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 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.

The firm of Quanterra Environmental Services (Quanterra) was retained to provide analytical laboratory services throughout the project. All of the surface soil samples collected between October 21 and November 2, 1994 were sent to the laboratory and analyzed for full TCL organics and TAL total metals. The eighteen surface soil samples collected in October, 1995 were screened onsite with a gas chromatograph. Based on the field screening findings, 10 of 18 soil samples were

confirmed with fix-based laboratory confirmation. Table 2-1 provides a summary of the analytical parameters requested for surface soils collected at Site 7. Results of the surface soil investigation conducted at Site 7 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 was included on the CoCs. Internal sample and analytical tracking forms for Site 7 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 also collected during the surface soil investigation. These samples were obtained 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 1 out of 10 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. A Lower Explosive Limit/Oxygen (LEL/O_2) meter was also utilized to monitor the borehole for explosive gases during drilling operations. Moreover, samples (i.e., surface and split-spoon samples) were screened with a PID to measure for volatile organic vapor. Measurements 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.

2.2.2 Subsurface Soil Investigation

A total of 28 subsurface soils (i.e., samples collected from 1 foot bgs to just above the groundwater table) were collected from Site 7 to evaluate the presence or absence of contamination within the study area. Two of the 28 subsurface soils were obtained from soil borings that were converted to monitoring wells. In addition to the on-site subsurface soil samples, three subsurface soil samples were also collected from background locations not known or suspected to be contaminated. The background samples were located to the north, north east, and north west of Site 7. These samples were collected during October 21 through November 2, 1994. In addition to the 28 subsurface soil samples, a total of 16 subsurface soil samples were collected from two sampling grids. The sampling grids were demarcated in the east and north areas where PCBs had been detected during the Halliburton/NUS investigation in 1991. The samples were collected due to DEHNR concerns that previous soil sampling were not sufficient in the areas where PCBs had been reported. The remaining 16 subsurface soil samples were collected during October 6 and 7, 1995. Samples 7-EPCB-SB08 and 7-EPCB-SB09 were the only locations where subsurface soil samples could not be collected due to encountering the groundwater table. Figure 2-1 provides all of the on-site soil sampling, monitoring well, and background locations. The following list provides the number of subsurface soil samples collected and the area in which they were collected:

- Seven subsurface soils, East Area (EA)
- Twelve subsurface soils, North Area (NA)

- Four subsurface soils, South West Area (SWA)
- Two subsurface soils, Monitoring Well Locations (MW)
- Three subsurface soils, Background Locations (BB)
- Seven subsurface soils, East PCB Area (EPCB)
- Nine subsurface soils, North PCB Area (NPCB)

Table 2-1 identifies all subsurface soil samples collected at Site 7, the depth interval of the sample, depth of borehole, and analytical parameters requested.

Five test pit excavations were also completed at Site 7 as part of the subsurface soil investigation. These test pits were excavated within the South West Area to investigate surface debris (i.e., rusted cans, concrete, and construction debris) which was observed during the initial site visit. Each test pit was at least 20 feet in length, 10 feet in depth or to the top of the groundwater table (whichever was encountered first), and 3 feet in width. The content and lithology of each test pit was described and photographs were taken as supplemental documentation. Test pit lithologic descriptions were recorded in a field logbook and later transposed onto Test Pit Records, which are provided in Appendix A. Test pit locations are provided on Figure 2-2. Test pit 7-SWA- TP02 was the only test pit that had evidence of debris. Test pit 7-SWA-TP02 had two separate layers of roofing shingles running parallel to the test pit from a southwest to a northeast direction. Composite samples were collected from the spoils pile at each of the test pits. No elevated PID readings were recorded during test pitting operations. The test pit investigation was conducted on December 2, 1994.

All subsurface soils were classified according to procedures and guidelines described in Section 2.2.1. Lithologic descriptions of the site soils are provided on Test Boring Records and on Test Boring and Well Construction Records in Appendix A.

All of the subsurface soil samples collected October 21 through November 2, 1994 were sent to the laboratory and analyzed for full TCL organics and TAL total metals. Samples collected in October 1995 were screened onsite using a gas chromatograph. Based on these findings, 8 of the 16 soil samples were confirmed by fix-based laboratory confirmation. Provided on Table 2-1, are the sample identifications and the analytical parameters requested for the test pit samples collected at Site 7. Results of the subsurface soil investigation conducted at Site 7 are provided within Section 4.0 of this report. Internal sample and analytical tracking forms and CoCs for Site 7 are provided in Appendix B. Subsurface samples were shipped overnight via Federal Express to the laboratory for analysis.

2.2.2.1 Quality Assurance and Quality Control

Field QA/QC samples were also collected during 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 7 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, sampling, and test pitting activities for health and safety and initial contaminant monitoring. During drilling,

ambient air monitoring in the vicinity of the borehole was performed with a PID to monitor for airborne contaminants. A LEL/O_2 meter was also utilized to monitor for explosive gases during drilling operations. Samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Lastly, soils excavated during test pitting activities were also screened with a PID. Measurements obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records, Test Boring and Well Construction Records, and Test Pit 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 7 to determine the presence or absence of contamination in the surficial aquifer which may have resulted from past disposal activities. Two permanent shallow groundwater monitoring wells (7-MW04, and 7-MW05) were installed and sampled as part of this investigation. Three on-site existing monitoring wells (7-MW01, 7-MW02, and 7-MW03) were also sampled during the ground water investigation. In addition, three temporary monitoring wells (7-TW01, 7-TW02, and 7-TW03) were installed using hand augers due to drill rig inaccessibility. These temporary wells were also sampled during the ground water investigation. Monitoring well (7-MW04) was placed in an upgradient (i.e., background) location to assess off-site groundwater quality. Monitoring well (7-MW05) was installed downgradient of Site 7 in the South West Area to assess on-site groundwater quality. Two of the three temporary monitoring wells (7-TW01, and 7-TW02) were installed in the South West Area to assess the quality of groundwater that may have migrated from the study area. The third temporary monitoring well (7-TW03) was installed in the East Area to assess on-site groundwater quality. Newly installed temporary and existing monitoring wells at Site 7 are provided on Figure 2-3. These monitoring wells were installed during the period from October 21 to November 2, 1994. Depths of both the permanent and temporary monitoring wells ranged from 4.5 to 31 feet bgs. All permanent monitoring wells were constructed with 2 inch ID PVC pipe, with 15 feet of 0.01-inch slotted well screen. Temporary monitoring wells were constructed with 2 inch ID PVC pipe, with 5 feet of 0.01-inch slotted well screen. A summary of monitoring well construction details (i.e., boring depth, well depth, and screen interval depth) are provided on Table 2-3.

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

Monitoring well installation and development procedures may be found in Section 6.0 of the Final FSAP, for OU No. 8 (Site 7). In addition, groundwater sampling procedures are also discussed within Section 6.0 of the FSAP (Baker, 1994).

Groundwater from permanent monitoring wells at Site 7 was sampled 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, water quality readings were collected. The water quality readings collected were: pH, conductivity, temperature, and turbidity. The temporary monitoring wells were purged and sampled with Teflon™ bailers. Water quality readings were also collected while the temporary wells were being purged. Water

quality data is provided within Section 4.0 of this report. Once water quality readings had stabilized, the groundwater sample was collected. One round of groundwater sampling was conducted at Site 7. Groundwater sampling of the temporary monitoring wells was conducted on November 7, 1994. Groundwater sampling of the newly installed and existing permanent monitoring wells was conducted during December 1, and 2, 1994. All monitoring wells (i.e., newly installed, existing, and temporary monitoring wells) were sampled for full TCL organics, TAL total metals, and dissolved metals. Internal sample and analytical tracking forms and CoCs for Site 7 are provided in Appendix B. Table 2-4 provides a summary of groundwater analyses for each of the monitoring wells at Site 7. Results from the groundwater sampling round are provided and discussed in Section 4.0 of this report. All samples were shipped via Federal Express overnight to Quanterra for laboratory analysis.

2.3.1 Water Level Measurements

Static water level measurements were collected on two 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 both December 11, 1994 and March 27, 1995. 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-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 investigation. These samples included trip blanks, equipment rinsates, and field duplicates. Equipment rinsates were collected from the submersible pump prior to and during daily usage. Table 2-5 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 7.

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 7 include the screening of well heads and purged groundwater with a PID for volatile organic vapors. Measurements obtained during air monitoring and field screening 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 Surface Water Investigation

A surface water investigation was conducted at Site 7 to assess the possible impact of the waste disposal practices. Surface water samples were collected from four different water bodies located within the immediate vicinity of the study area. Figure 2-4 depicts the locations of the following water bodies: drainage ditch discharging into the Western Tributary, Western Tributary to Northeast Creek, Eastern Tributary to Northeast Creek, and Northeast Creek. A total of thirteen surface water samples were collected from the four surface water bodies. Figure 2-4 also provides the surface water sampling locations. Flow direction from the Eastern and Western Tributaries is primarily to the south and is intercepted by Northeast Creek. Flow direction of the drainage ditch is to the southeast and is intercepted by the Western Tributary.

Two surface water samples were collected from the drainage ditch on June 22, 1994. Surface water sample 7-DD-SW01 was collected in the upper portion of the drainage ditch, while 7-DD-SW02 was collected approximately 50 feet upstream of its confluence with the Western Tributary.

Three surface water samples were collected from the Western Tributary during June 23, and 24, 1994. Surface water sample 7-WT-SW01 was collected in the headwaters of the Western Tributary, approximately 75 to 100 feet downstream of Tarawa Boulevard. Sample 7-WT-SW02 was collected in the Western Tributary just upstream of its confluence with the drainage ditch. Finally, sample 7-WT-SW03 was collected approximately 20 to 30 feet upstream of its confluence with Northeast Creek.

Two surface water samples were collected from the Eastern Tributary during June 23, and 24, 1994. Surface water sample 7-ET-SW01 was collected in the headwaters of the Eastern Tributary, approximately 50 feet downstream from the culvert pipe. Sample 7-ET-SW02 was collected approximately 20 feet upstream from its confluence with Northeast Creek.

Six surface water samples were collected from Northeast Creek during June 24, to 26, 1994. Surface water sample 7-NC-SW01 was collected to the east and upstream of Site 7. Sample 7-NC-SW02 was collected approximately 20 feet downstream of an unnamed tributary to Northeast Creek. Sample 7-NC-SW03 was collected approximately 20 feet downstream of the Eastern Tributary. Sample 7-NC-SW04 was collected approximately 20 feet downstream from the Western Tributary. Finally, samples 7-NC-SW05, and 7-NC-SW06 were collected downstream of Site 7, with sample 7-NC-SW06 being the furthest downstream sample.

Surface water sample collection procedures are provided Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994).

The thirteen surface water samples collected at Site 7 were submitted to the laboratory for TCL organics and TAL total metals analyses. Table 2-6 provides the sample identification, the corresponding requested analyses, and QA/QC sample identification. After sample collection, the following water quality measurements were obtained; temperature, pH, dissolved oxygen, salinity, and specific conductance. These water quality measurements were then recorded in a field logbook.

Surface water sampling locations were marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The stake was marked with indelible ink. In addition, the distance from the shore and the approximate sampling location was estimated and recorded in the field logbook. Photographs were also taken to document the physical and biological characteristics of the sampling location.

Internal sample and analytical tracking forms and CoCs for Site 7 are provided in Appendix B. Results of the surface water sampling are provided and discussed in Section 4.0 of this report. All surface water samples were shipped via Federal Express overnight to Quanterra for laboratory analysis.

2.4.1 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the surface water investigation. These samples included trip blanks, equipment rinsates, and field duplicates. Trip blanks were placed into all shipping coolers containing sample jars with requested volatile analyses. Equipment rinsates were

collected from the sediment corer during the sediment investigation, which was conducted during the same time period as the surface water investigations. The sample locations at which field duplicate samples were collected is provided on Table 2-6. Table 2-7 summarizes the QA/QC sampling program employed during the surface water investigation conducted at Site 7.

2.5 Sediment Investigation

A sediment investigation was conducted at Site 7 to assess the possible impact to aquatic environments of past disposal practices. Sediment samples were collected from four different water bodies located within the immediate vicinity of the study area, and adjacent marsh/swamp area. Figure 2-4 depicts the locations of the following water bodies: drainage ditch discharging into the Western Tributary, Western Tributary to Northeast Creek, Eastern Tributary to Northeast Creek, Northeast Creek. A total of 27 sediment samples were collected as part of the sediment investigation at Site 7. Figure 2-4 also provides the sediment sampling locations.

Seven sediment samples were collected from the same locations as the surface water samples, within the drainage ditch, Western Tributary, and Eastern Tributary. These sediment samples were also collected from a depth of 0 to 6 inches. In addition, 20 sediment samples were collected on Northeast Creek and the marsh/swamp area at two depths (0 to 6 inches, and 6 inches to 1-foot). The 20 sediment samples are comprised of 10 sediment sampling stations, six of these stations are located on Northeast Creek, and four stations are located in the marsh/swamp area. The sediment investigation was conducted during June 22, to June 26, 1994.

Sediment sample collection procedures are provided Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994).

The 27 sediment samples collected at Site 7 were submitted to the laboratory for TCL organics and TAL total metals analyses. Additionally, select sediment samples from the 0 to 6 inch sampling interval where also analyzed for Total Organic Carbon (TOC), and grain size. Table 2-8 provides the sediment sampling identifications, sampling depths (i.e., 06 and/or 612), and the requested analyses.

The sampling location was marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The stake was marked with indelible ink. In addition the distance from the shore and the approximate sampling location was estimated and recorded in the field logbook. Photographs were also taken to document the physical and biological characteristics of the sampling location.

Internal sample and analytical tracking forms and CoCs for Site 7 are provided in Appendix B. Results of the sediment sampling are provided in Section 4.0 of this report. All sediment samples were shipped via Federal Express overnight to Quanterra for laboratory analysis.

2.5.1 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the sediment investigation. These samples included trip blanks, equipment rinsates, and field duplicates. Trip blanks were placed into all shipping coolers containing sample jars with requested volatile analyses. Equipment rinsates were collected from the sediment corer. The sample locations at which field duplicate samples were

collected is provided on Table 2-8. Table 2-9 summarizes the QA/QC sampling program employed during the sediment investigation conducted at Site 7.

2.6 Ecological Investigation

An ecological investigation was conducted at Site 7, which included sampling along the Western Tributary and Northeast Creek. Biological samples collected as part of this investigation included benthic macroinvertebrates and fish. In addition, an earthworm bioaccumulation study was also conducted at Site 7. The biological samples were collected to obtain population data for the benthic macroinvertebrates, and to determine if large fish were entering the Western Tributary.

2.6.1 Benthic Macroinvertebrate Investigation

Benthic macroinvertebrates were collected at three stations in the Western Tributary. These sampling stations correspond with the surface water and sediment sampling stations from the western tributary (i.e., 7-WT-BN01 was collected by 7-SW/SD01). Benthic macroinvertebrates were collected from four sampling stations in Northeast Creek. Benthic sampling station 7-NC-BN01 was collected by 7-NC-SW/SD01, 7-NC-BN02 was collected by 7-NC-SW/SD03, 7-NC-BN03 was collected by 7-NC-SW/SD04, and 7-NC-BN04 was collected by 7-NC-SW/SD06. Three replicate benthic samples were collected at each station, each sample was moved slightly to prevent sampling of the same area. Prior to initiating the sampling event at each station, the following information which pertains to the sample site was recorded in the field logbook:

- Average width, depth, and velocity of the water body.
- Description of substrate.
- Description of abiotic characteristics of the reach such as pools, riffles, runs, channel shape, degree of bank erosion, and shade/sun exposure.
- Description of biotic characteristics of the reach including aquatic and riparian vegetation and wetlands.

In addition to the above mentioned information, water quality readings were also recorded prior to benthic macroinvertebrate sampling. Water quality readings consisted of the following: temperature, pH, specific conductance, salinity and dissolved oxygen. Benthic macroinvertebrate sampling station locations are provided on Figure 2-4. This investigation was conducted during June 22, to 26, 1994.

Benthic macroinvertebrate sample collection procedures are provided within Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994).

The seven benthic macroinvertebrate samples collected at Site 7 were submitted to RMC Environmental Services, Inc. for sample sorting and taxonomic identification. Table 2-8 provides the benthic sampling identifications along with the requested analysis.

2.6.2 Fish Investigation

Fish collection was attempted at the mouth of the Western Tributary at Northeast Creek, using hoop nets, to see if larger fish were entering the Western Tributary. The hoop nets were three to four feet in diameter and fourteen to sixteen feet in length. Twenty five foot wings were attached to the nets to help direct fish into the net. The nets were deployed in the middle of the channel with the wings stretched across the creek at a 45 degree angle. The end of the net and the wings were secured using 6.5-foot wooden posts. The nets were checked at least once daily, as the fish usually survive when captured in these nets. Although, the nets were deployed for five days, larger fish were not captured within the net. As a result samples were not sent to the laboratory.

2.6.3 Earthworm Bioaccumulation Study

The earthworm bioaccumulation study was conducted at Site 7 from October 17, to November 14, 1994. The study sought to determine if earthworms were bioaccumulating pesticides, PCBs, and metals from the surface soils.

Canadian nightcrawlers were purchased three days prior to deployment. On the morning of deployment, 20 sets of ten adult, fully clitellated earthworms were weighed to the nearest tenth of a gram. Lethargic or damaged earthworms were not deployed.

Test chambers were used to house the earthworms for the duration of the study. The test chambers were constructed from 8-inch sections of 4-inch PVC pipe. The ends of the pipe were covered with a 30 mesh (600 micron openings) polyester monofilament screen of 0.76 mm thickness. The screens were fastened to the pipe with 2-inch sections of 4.5-inch diameter PVC couplings.

Holes, approximately seven inches in depth, were dug with a clean shovel. The soil was placed into the test chamber with the same vertical distribution as it occurred in the ground. Any extra soil was used to fill in the hole surrounding the pipe. There was evidence of animals disturbing the test chambers prior to introduction of the earthworms. In response, a wood frame covered with plastic-coated one-inch mesh size wire was placed on top of the chambers to prevent disturbances.

Each station consisted of three replicate samples, one control sample, and two instrument samples (i.e., one for the replicates and one for the controls). Each of the two replicate samples and the control sample consisted of two chambers containing ten earthworms. A minimum of 60 grams of earthworm tissue was needed by the laboratory for chemical analysis. One off-site reference station also was used in this study. This station consisted of two replicate samples and one instrument sample. A control sample was not included at this station since it was a background station. The approximate locations for all three stations are provided on Figure 2-4.

The soil moisture was measured using a Model "P" irrometer™. The irrometer works on the principal of soil suction which is measured in centibars. The correlation between centibars and percent moisture depends on the soil type. Therefore the site soil was used to "calibrate" the irrometer by adding varying amounts of water to soil samples, measuring them with the irrometer, and then sending them to Quanterra for percent moisture analysis. The irrometer reading in the site soils dropped to zero when the percent moisture was approximately 31 percent, and 29 percent at an irrometer reading of 4. Water was added when the irrometer reading was above ten in either the site or control soils, to keep the soils moisture around 30 percent or higher. The soil moisture was

checked daily using the irrometer, unless it was raining, at which point the soil would be saturated. Temperature was also collected from the chambers daily.

At the end of the 28 days, the chambers were removed from the stations. The chambers were opened one at a time, and the earthworms were removed, observed for mobility, tumors, and other malformations. The earthworms from each chamber were then washed in distilled water and weighed. The earthworms from each of the two chambers for each replicate were combined, wrapped in aluminum foil, and frozen. Earthworm tissue was sent to Quanterra for TCL pesticides and PCBs, and TAL metals analysis. In addition, soil samples from each station were collected for TCL pesticides and PCBs, TAL metals, TOC, pH, percent moisture, and Cation Exchange Capacity (CEC). Table 2-10 provides a listing of the soil and earthworm tissue sample identifications along with the requested analysis. Both the earthworm and soil samples were shipped overnight to Quanterra via Federal Express.

Results of the earthworm bioaccumulation study are presented in Section 7.0 of this report.

2.7 Habitat Evaluation

A habitat evaluation was performed at Site 7 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.

2.8 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 2.8.

2.9 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 7 resulted in the generation of various IDW. This IDW included well development and purge water, and solutions used to decontaminate non-disposable sampling equipment. 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, did not show contamination at a concentration that would make them hazardous. Therefore the water and decontamination fluids were deposited back onto Site 7. Appendix D provides information regarding the management, results, and disposal of the IDW.

2.10 References

Baker Environmental Inc. 1994. Remedial Investigation, Feasibility Study Project Plans for Operable Units 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.

USEPA. 1991. United States Environmental Protection Agency Region IV. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Environmental Services Division. Atlanta, Georgia. February, 1991.

U.S. Navy, NEESA. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. Prepared by Martin Marietta Energy Systems, Inc. for U.S. Department of Energy, Contract No. DE-AC05-840R21400. Neesa 20.2-047B. June 1988.

SECTION 2.0 TABLES

TABLE 2-1

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
Community Center Area									
7-CC-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
7-CC-SB02	00	1.0	0.0 - 1.0	X	X	X	X	X	
East Area									
7-EA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
7-EA-SB02	00	1.0	0.0 - 1.0	X	X	X	X	X	X
	02	5.0	3.0 - 5.0	X	X	X	X	X	X
7-EA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	08	17.0	15.0 - 17.0	X	X	X	X		
7-EA-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	01	3.0	1.0 - 3.0	X	X	X	X		
7-EA-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
7-EA-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	01	3.0	1.0 - 3.0	X	X	X	X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
7-EA-SB07	00	1.0	0.0 - 1.0	X	X	X	X		
7-EA-SB08	00	1.0	0.0 - 1.0	X	X	X	X		
7-EA-SB09	00	1.0	0.0 - 1.0	X	X	X	X		
7-EA-SB10	00	1.0	0.0 - 1.0	X	X	X	X		
7-EA-SB11	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
7-EPCB-SB01[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[2]			
7-EPCB-SB02[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[2]			
7-EPCB-SB03[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[2]			
7-EPCB-SB04[1]	00	1.0	0.0 - 1.0			X[3]			
	02	5.0	3.0 - 5.0			X[3]			
7-EPCB-SB05[1]	00	1.0	0.0 - 1.0			X[2]			
	02	3.0	1.0 - 3.0			X[2]			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
7-EPCB-SB06[1]	00	1.0	0.0 - 1.0			X[3]			
	02	3.0	1.0 - 3.0			X[3]			
7-EPCB-SB07[1]	00	1.0	0.0 - 1.0			X[3]			
	02	3.0	1.0 - 3.0			X[3]			
7-EPCB-SB08[1]	00	1.0	0.0 - 1.0			X[3]			
7-EPCB-SB09[1]	00	1.0	0.0 - 1.0			X[2]			
North Area									
7-NA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
7-NA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	08	17.0	15.0 - 17.0	X	X	X	X		
7-NA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
7-NA-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
7-NA-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
7-NA-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
7-NA-SB07	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
7-NA-SB08	00	1.0	0.0 - 1.0	X	X	X	X		
	09	19.0	17.0 - 19.0	X	X	X	X	X	X
7-NA-SB09	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
7-NA-SB10	00	1.0	0.0 - 1.0	X	X	X	X		
7-NA-SB11	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
7-NA-SB12	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
7-NPCB-SB01[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[3]			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
7-NPCB-SB02[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[3]			
7-NPCB-SB03[1]	00	1.0	0.0 - 1.0			X[3]			
	01	3.0	1.0 - 3.0			X[3]			
7-NPCB-SB04[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[2]			
7-NPCB-SB05[1]	00	1.0	0.0 - 1.0			X[2]			
	02	5.0	3.0 - 5.0			X[2]			
7-NPCB-SB06[1]	00	1.0	0.0 - 1.0			X[3]			
	02	5.0	3.0 - 5.0			X[3]			
7-NPCB-SB07[1]	00	1.0	0.0 - 1.0			X[3]			
	02	5.0	3.0 - 5.0			X[3]			
7-NPCB-SB08[1]	00	1.0	0.0 - 1.0			X[2]			
	01	3.0	1.0 - 3.0			X[2]			
7-NPCB-SB09[1]	00	1.0	0.0 - 1.0			X[3]			
	01	5.0	3.0 - 5.0			X[2]			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
South West Area									
7-SWA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X	X	X
7-SWA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
7-SWA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
7-SWA-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	01	3.0	1.0 - 3.0	X	X	X	X		
7-SWA-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
Test Pits									
7-SWA-TP01	Composite	9.0	0.0 - 9.0	X	X	X	X		
7-SWA-TP02	Composite	6.5	0.0 - 6.5	X	X	X	X		
7-SWA-TP03	Composite	7.0	0.0 - 7.0	X	X	X	X		
7-SWA-TP04	Composite	9.0	0.0 - 9.0	X	X	X	X		
7-SWA-TP05	Composite	8.0	0.0 - 8.0	X	X	X	X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole/ Test Pit (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matix Spike/Matrix Spike Duplicate
Background Borings									
7-BB-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
7-BB-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
7-BB-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	09	19.0	17.0 - 19.0	X	X	X	X		
Monitoring Wells									
7-MW04	00	1.0	0.0 - 1.0	X	X	X	X		
	08	17.0	15.0 - 17.0	X	X	X	X		
7-MW05	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		

Notes:

(1) Soil boring locations installed and sampled during October 6 and 7, 1995.
(2) Samples were only analyzed for TCL PCBs.
(3) Samples subjected to field screening for PCBs only.

TABLE 2-2

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE AND SUBSURFACE SOIL INVESTIGATION OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	7	TCL Volatiles
Field Blanks[4]	One per Event	1	TCL Organics/TAL Inorganics
Equipment Rinsates[5]	One per Day	3	TCL Organics/TAL Inorganics
Number of Environmental Samples [6]		68	TCL Organics/TAL Inorganics
		34	TCL PCBs
Field Duplicates [7]	10% of Sample Frequency	5	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blanks collected during Site 7 soil and groundwater investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, and stainless steel bowls. 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) Refer to Table 2-1 for duplicate sample identification.
(7) Field duplicates were segregated into five areas (Community Center Area, East Area, North Area, South West Area, and the Monitoring Well Area), actual field duplicates collected are not indicative of the total frequency of surface and subsurface samples.

TABLE 2-3

SUMMARY OF WELL CONSTRUCTION DETAILS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

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)
7-MW04	10/24/94	25.9	23.47	31.5	31.0	31.0 - 16.0	31.5 - 14.0	14.0 - 12.0	2.43
7-MW05	11/2/94	6.29	3.75	21.0	20.5	20.5 - 5.5	21.5 - 4.0	4.0 - 1.0	2.54

Notes: [1]msl - mean sea level

MONITORING WELL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Monitoring Well (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Total Metals	TAL Dissolved Metals	Duplicate	Matrix Spike/Matrix Spike Duplicate
Temporary Wells								
7-TW01-01	4.50	X	X	X	X	X		
7-TW02-01	10.00	X	X	X	X	X		
7-TW03-01	4.50	X	X	X	X	X		
Permanent Monitoring Wells								
7-MW01-01	13.72	X	X	X	X	X		
7-MW02-01	14.27	X	X	X	X	X		
7-MW03-01	5.71	X	X	X	X	X		
7-MW04-01	31.0	X	X	X	X	X		
7-MW05-01	20.5	X	X	X	X	X	X	X

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	3	TCL Volatiles
Field Blanks[4]	One per Event	1	TCL Organics/TAL Inorganics
Equipment Rinsates[5]	One per Day	2	TCL Organics/TAL Inorganics
Number of Environmental Samples[6]		8	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blanks collected during Site 7 soil and groundwater investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., submersible pump, and pump discarge 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) Refer to Table 2-4 for duplicate sample identification.

TABLE 2-6

SURFACE WATER SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/Matrix Spike Duplicate
Drainage Ditch Area						
7-DD-SW01	X	X	X	X		
7-DD-SW02	X	X	X	X		
East Tributary Area						
7-ET-SW01	X	X	X	X		
7-ET-SW02	X	X	X	X	X	X
West Tributary Area						
7-WT-SW01	X	X	X	X		
7-WT-SW02	X	X	X	X	X	X
7-WT-SW03	X	X	X	X		
Northeast Creek Area						
7-NC-SW01	X	X	X	X		
7-NC-SW02	X	X	X	X		
7-NC-SW03	X	X	X	X		
7-NC-SW04	X	X	X	X	X	X
7-NC-SW05	X	X	X	X		
7-NC-SW06	X	X	X	X		

TABLE 2-7

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER INVESTIGATION OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	3	TCL Volatiles
Field Blanks[4]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates [5]	One per Day	0	TCL Organics/TAL Inorganics
Number of Environmental Samples [6]		13	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	3	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blanks collected during Site 7 soil and groundwater investigation (October 17 through December 4, 1994).
(5) Equipment rinsates were not collected during the surface water investigation due to surface water sample collection involving dipping laboratory bottles directly into the surface water and then transferring the contents into bottles with preservative. However, equipment rinsates were collected from sediment sampling equipment, which was conducted during the same time period as the surface water investigation.
(6) Refer to Table 2-6 for duplicate sample identification.

TABLE 2-8

SEDIMENT AND BENTHIC MACROINVERTEBRATE SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identifiction	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Grain Size	TOC	Benthic Macroinvertebrate Identification	Duplicate	Matrix Spike/Matrix Spike Duplicate
Drainage Ditch Area											
7-DD-SD01	06	0.0 - 0.5	X	X	X	X	X	X		X	
7-DD-SD02	06	0.0 - 0.5	X	X	X	X	X	X			
East Tributary Area											
7-ET-SD01	06	0.0 - 0.5	X	X	X	X	X	X			
7-ET-SD02	06	0.0 - 0.5	X	X	X	X	X	X		X	X
West Tributary Area											
7-WT-SD01	06	0.0 - 0.5	X	X	X	X	X	X			
7-WT-SD02	06	0.0 - 0.5	X	X	X	X	X	X		X	X
7-WT-SD03	06	0.0 - 0.5	X	X	X	X		X			
West Tributary Benthic Macroinvertebrate Samples											
7-WT-BN01	NA	0.0 - 0.5							X		
7-WT-BN02	NA	0.0 - 0.5							X		
7-WT-BN03	NA	0.0 - 0.5							X		

TABLE 2-8 (Continued)

SEDIMENT AND BENTHIC MACROINVERTEBRATE SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identifiction	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Grain Size	TOC	Benthic Macroinvertebrate Identification	Duplicate	Matrix Spike/Matrix Spike Duplicate
Northeast Creek Area											
7-NC-SD01	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
7-NC-SD02	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
7-NC-SD03	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
7-NC-SD04	06	0.0 - 0.5	X	X	X	X	X	X		X	
	612	0.5 - 1.0	X	X	X	X					
7-NC-SD05	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
7-NC-SD06	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
Northeast Creek Benthic Macroinvertebrate Samples											
7-NC-BN01	NA	0.0 - 0.5							X		
7-NC-BN02	NA	0.0 - 0.5							X		
7-NC-BN03	NA	0.0 - 0.5							X		
7-NC-BN04	NA	0.0 - 0.5							X		

TABLE 2-8 (Continued)

SEDIMENT AND BENTHIC MACROINVERTEBRATE SAMPLING SUMMARY
SITE 7
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identifiction	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Grain Size	TOC	Benthic Macroinvertebrate Identification	Duplicate	Matrix Spike/Matrix Spike Duplicate
Marsh Area											
7-MA-SD01	06	0.0 - 0.5	X	X	X	X	X	X			
	612	0.5 - 1.0	X	X	X	X					
7-MA-SD02	06	0.0 - 0.5	X	X	X	X				X	
	612	0.5 - 1.0	X	X	X	X					
7-MA-SD03	06	0.0 - 0.5	X	X	X	X					
	612	0.5 - 1.0	X	X	X	X					
7-MA-SD04	06	0.0 - 0.5	X	X	X	X					
	612	0.5 - 1.0	X	X	X	X					

Notes: NA - Non Applicable

TABLE 2-9

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SEDIMENT INVESTIGATION OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	5	TCL Volatiles
Field Blanks[4]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates[5]	One per Day	3	TCL Organics/TAL Inorganics
Number of Environmental Samples[6]		27	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	3	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blanks collected during Site 7 soil and groundwater investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., sediment sleeve, and brass sediment extruder. 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) Refer to Table 2-8 for duplicate sample identification.

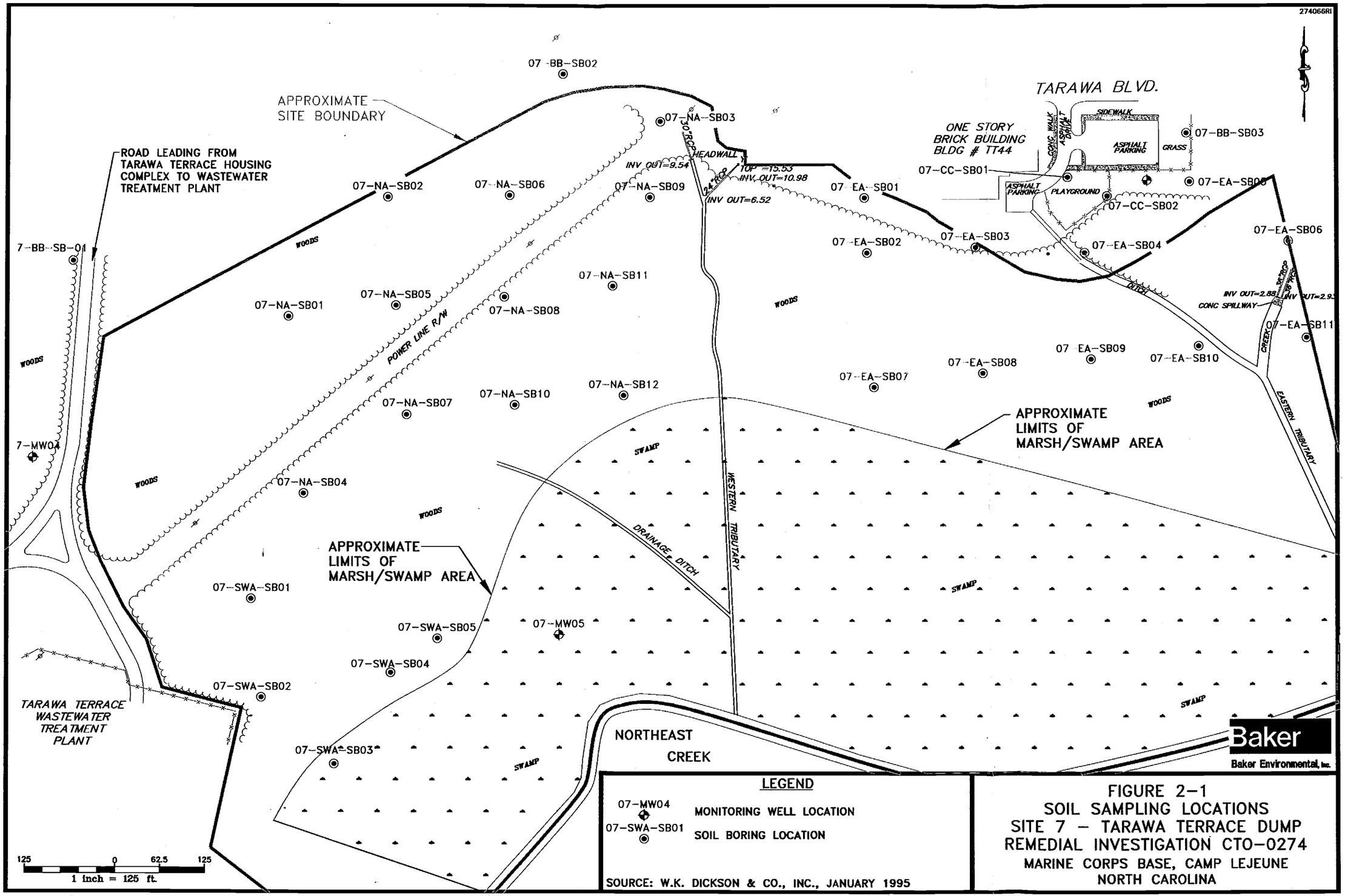
TABLE 2-10

EARTHWORM (BIOACCUMULATION STUDY) AND SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	TCL Pest./PCBs	TAL Metals	Grain Size	TOC	pH	Percent Moisture	Cation Exchange Capacity (CEC)
Earthworm Station Soil Samples							
7-WM-SB01	X	X	X	X	X	X	X
7-WM-SB02	X	X	X	X	X	X	X
7-WM-SBO3	X	X	X	X	X	X	X
Earthworm Samples							
7-EW-02	X	X					
7-EW-03	X	X					
7-EW-04	X	X					
7-EW-05	X	X					
7-EW-06	X	X					
7-EW-07	X	X					
7-EW-08	X	X					

SECTION 2.0 FIGURES

274066RI



Baker
Baker Environmental, Inc.

LEGEND

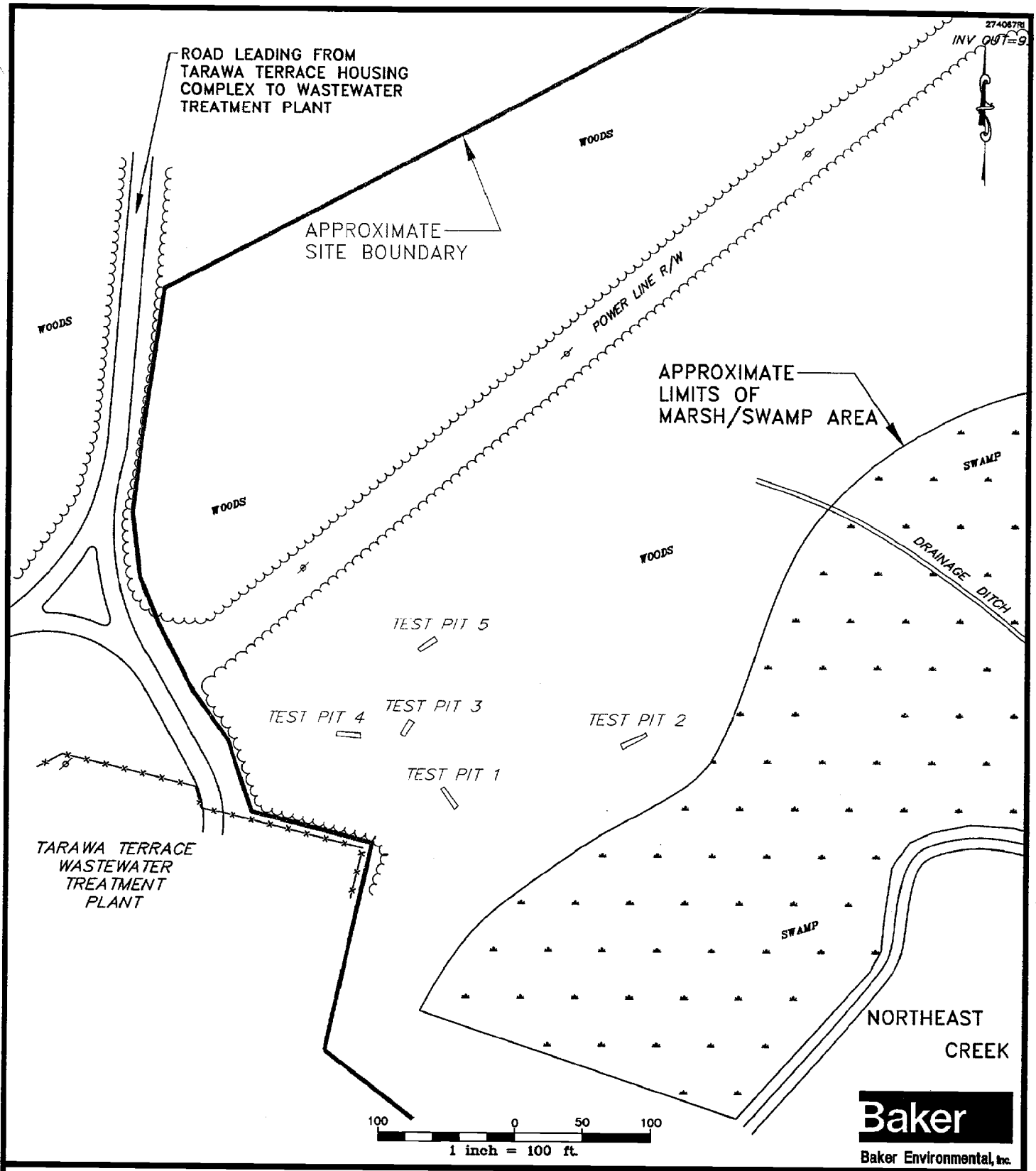
07-MW04 MONITORING WELL LOCATION

07-SWA-SB01 SOIL BORING LOCATION

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

FIGURE 2-1
SOIL SAMPLING LOCATIONS
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701V01Z



Baker

Baker Environmental, Inc.

LEGEND

TEST PIT 1 — TEST PIT LOCATION

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

FIGURE 2-2
TEST PIT LOCATIONS
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274068RI

APPROXIMATE SITE BOUNDARY

ROAD LEADING FROM TARAWA TERRACE HOUSING COMPLEX TO WASTEWATER TREATMENT PLANT

TARAWA BLVD.

ONE STORY BRICK BUILDING BLDG # TT44

SIDEWALK

CONC. WALK

ASPHALT

ASPHALT PARKING

GRASS

ASPHALT PARKING

PLAYGROUND

30" RCP

HEADWALL

INV OUT=9.54

TOP =15.53

INV. OUT=10.98

24" RCP

INV OUT=6.52

07-TW03

DITCH

INV OUT=2.88

CONC SPILLWAY

18" RCP

INV OUT=2.9

GREEK

EASTERN TRIBUTARY

WOODS

POWER LINE R/W

07-MW02

APPROXIMATE LIMITS OF MARSH/SWAMP AREA

07-MW01

7-MW04

SWAMP

WESTERN TRIBUTARY

DRAINAGE DITCH

APPROXIMATE LIMITS OF MARSH/SWAMP AREA

07-MW05

07-TW02

TARAWA TERRACE WASTEWATER TREATMENT PLANT

07-MW03

07-TW01

NORTHEAST CREEK

125 0 62.5 125

1 inch = 125 ft.

Baker

Baker Environmental, Inc.

LEGEND

07-MW01 EXISTING MONITORING WELL LOCATION

07-MW04 NEWLY INSTALLED MONITORING WELL LOCATION

07-TW01 TEMPORARY MONITORING WELL LOCATION

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

FIGURE 2-3
MONITORING WELL SAMPLING LOCATIONS
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701V02Z

274069RI

APPROXIMATE SITE BOUNDARY

ROAD LEADING FROM TARAWA TERRACE HOUSING COMPLEX TO WASTEWATER TREATMENT PLANT

TARAWA BLVD.

ONE STORY BRICK BUILDING BLDG # TT44

SIDEWALK

CONC WALK

ASPHALT DRIVE

ASPHALT PARKING

GRASS

ASPHALT PARKING

PLAYGROUND

30" RCP HEADWALL

INV OUT=9.54

TOP =15.53

24" RCP

INV OUT=10.98

INV OUT=6.52

7-WT-SW01
7-WT-SD01
7-WT-BN01

7-ET-SW01
7-ET-SD01

AREA 1
07-WM-SB01

INV OUT=2.88

36" RCP

INV OUT=2.9

CONC SPILLWAY

DITCH

CREEK

EASTERN TRIBUTARY

WOODS

POWER LINE R/W

AREA 2
07 WM SB02

AREA 3
(BACKGROUND)
07-WM-SB01
(50' DIRECTLY WEST)

SWAMP

7-DD-SW01
7-DD-SD01

WESTERN TRIBUTARY

DRAINAGE DITCH

APPROXIMATE LIMITS OF MARSH/SWAMP AREA

APPROXIMATE LIMITS OF MARSH/SWAMP AREA

LOCATED 20' UPSTREAM OF CONFLUENCE WITH NORTHEAST CREEK
7-ET-SW02
7-ET-SD02

7-MA-SD02

7-DD-SW02
7-DD-SD02

7-WT-SW02
7-WT-SD02
7-WT-BN02

7-MA-SD03

7-MA-SD04
LOCATED 100' EAST OF EAST TRIBUTARY

7-WT-SW03
7-WT-SD03
7-WT-BN03

LOCATED 1000' UPSTREAM OF EAST TRIBUTARY
7-NC-SW01
7-NC-SD01
7-NC-BN01

LOCATED 300' UPSTREAM OF EAST TRIBUTARY

7-NC-SW04
7-NC-SD04
7-NC-BN03

NORTHEAST CREEK

7-NC-SW03
7-NC-SD03
7-NC-BN02

LOCATED AT MOUTH OF EAST TRIBUTARY

7-NC-SW02
7-NC-SD02

7-MA-SD01

7-NC-SW05
7-NC-SD05

LOCATED 30' UPSTREAM OF TREATMENT PLANT OUTFALL

7-NC-SW06
7-NC-SD06
7-NC-BN04

TARAWA TERRACE WASTEWATER TREATMENT PLANT

125 0 62.5 125
1 inch = 125 ft.

Baker
Baker Environmental, Inc.

LEGEND

- 07-WM-SB01 — EARTH WORM SOIL BORING LOCATION
- 7-NC-SW05 / 7-NC-SD05 — SURFACE WATER/SEDIMENT SAMPLING STATION
- 7-NC-SW06 / 7-NC-SD06 / 7-NC-BN04 — SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLING STATION
- 7-MA-SD01 — SEDIMENT SAMPLING STATION
- EARTHWORM BIOACCUMULATION STATION

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

FIGURE 2-4
APPROXIMATE SURFACE WATER, SEDIMENT, BENTHIC MACROINVERTEBRATE AND EARTHWORM BIOACCUMULATION LOCATIONS
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701V03Z

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. 11 (Site 7). 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 7, Tarawa Terrace Dump, topography is variable with elevations ranging from 20 feet msl to the north to 5 feet msl to the south. The slope of the site is to the south in the direction of Northeast Creek. Several surface water bodies (i.e., eastern tributary and western tributary) and drainage areas (i.e., drainage ditch flowing into the western tributary) within the vicinity of the Tarawa Terrace Dump site are considered significant. Surface waters and runoff from the site flow in a southerly direction into Northeast Creek. Northeast Creek flows in a southwesterly direction along the southern edge of the site and into the New River, approximately 3 miles downstream. Northeast Creek and the surface water bodies are influenced by the tides. During high tides, much of the southern portion of the site is covered with ponded water. Figure 3-1 presents the surface features identified at Site 7.

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. It 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 course, 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 shellfishing) and SA (estuarine waters suited for commercial shellfishing). 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, which drain through 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 7 feet above msl in the upper reaches of the New River.

3.2.2 Site-Specific

There are three surface water bodies identified within the site. These have been named the "eastern tributary", the "western tributary", and a "drainage ditch" which flows into the western tributary. There is also a minor drainage ditch on the eastern side of the site, which only appears to have water flowing in it during heavy rains and/or high water table. Approximately one-half of the site, the southern portion, is classified as a swamp. Northeast Creek is located at the southern edge of the site. Surface drainage is towards the south/southeast. The surface water bodies and the surface water runoff flows towards the south/southeast into Northeast Creek. The water table at Site 7 is near the surface at approximately 3 to 4 feet bgs during low tide. Fluctuations in the water table are approximately 1 to 2 feet with tidal advances, rising to near or at ground surface (within the swamp area) during high tide. Groundwater flow direction across the site ranges from the south to southeast, in the direction of Northeast Creek.

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).

United States Geological Survey (USGS) studies (Harned, et al., 1989 and Cardinell, et al., 1993) conducted at MCB, Camp Lejeune indicates that the base is underlain by seven sand and limestone aquifers separated by confining/semiconfining units of silt and clay. These include the water table (i.e., surficial, water-bearing layer), Castle Hayne, Beaufort, Peedee, Black Creek, and the upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1500 feet. Less permeable clay and silt beds function as confining units or semiconfining units which separate the aquifers and impede the flow of groundwater between aquifers. A generalized hydrogeologic cross-section illustrating the relationship between the aquifers in this area is presented on Figures 3-2 and 3-3.

3.3.2 Site-Specific

The RI was limited to investigating the shallow groundwater zone; therefore, site-specific geology describes the site to depth of approximately 35 feet bgs. The site is primarily underlain by sands and silty sands. These sands are generally overlain by thin layers of silt and silty clay. Occasional

lenses and/or discontinuous layers of sand and clay, and clay are present at depth. 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) indicates the relative density of the soils range from loose/soft to very dense/very stiff. 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 (sandy clay and clay). Fill material was identified at some borehole locations (primarily in the southwest area of the site), ranging in thickness from one to six feet. Most notably, this fill material contained roofing shingles. Only shallow groundwater monitoring wells were installed during the RI, therefore, no specific information on the depth of the surficial soils or the lithology of the underlying soils is available.

Geologic cross-sections were developed for the surficial soils based on samples collected during the RI. As shown on Figure 3-4, two cross-sections were developed using the groundwater monitoring boreholes. Cross-section A-A' (Figure 3-5) depicts the surficial lithology from northwest to southeast and cross-section B-B' (Figure 3-6) depicts the lithology from southwest to northeast of the surficial soils.

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).

The surficial water table aquifer consists of a series of sediments, primarily sand and clay, which commonly extend to depths of 75 feet. This unit is not used as a water supply on the base.

The principal water supply for the base is found in the series of sand and limestone beds that occur between 50 and 300 feet below ground surface (bgs). This series of sediments generally is known as the Castle Hayne Formation, associated with the Castle Hayne Aquifer. This aquifer is about 150 to 450 feet thick in the area and is the most productive aquifer in North Carolina.

Clay layers occur in both of the aquifers. However, the layers are thin and discontinuous in most of the area, and no continuous clay layer separates the surficial aquifer from the Castle Hayne Aquifer. The clay layers range from 10 to 15 feet thick and comprise between 15 and 24 percent of the combined thickness of the two aquifers. The clay layers appear to be thicker and more continuous in the northwest part of the base, particularly in the area of the MCAS. It is inferred from their generally thin and discontinuous nature that considerable leakage of groundwater occurs across and around the clay layers, particularly in the upper portion of the Castle Hayne Aquifer.

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. Overpumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer contains water having less than 250 milligrams per liter (mg/L) chloride (State criteria for saltwater classification) throughout the area of the base.

The aquifers below the Castle Hayne Aquifer lie in a thick sequence of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the MCB, Camp Lejeune area and are not used.

Rainfall in the MCB, Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the water table, which is the top of the saturated zone. In the saturated zone, groundwater flows in the direction of lower hydraulic head, moving through the system to discharge areas such as the New River and its tributaries, or the ocean.

The water table varies seasonally. The water table receives more recharge in the winter and summer than in the fall and spring when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter/summer months and lowest in spring/fall.

In confined aquifers, water is under excess hydraulic (i.e., head) pressure and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in a confined or semiconfined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than in an unconfined aquifer. Some seasonal variation also is common in the water levels of the Castle Hayne Aquifer, but the changes tend to be slower and over a smaller range than for water table wells.

According to the North Carolina Administrative Code, Title 15A, Subchapter 2L, "Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina", the surficial water table aquifer and the Castle Hayne Aquifer are classified as GA - for existing or potential sources of drinking water supplies for humans with a chloride concentration equal to or less than 250 mg/L. This groundwater classification is for waters which are considered suitable for drinking in their natural state.

3.4.2 Site-Specific

Groundwater was encountered during the RI at elevations ranging from 2.25 to 6.09 feet above msl. Measured shallow groundwater levels for Site 7 are presented on Table 3-2. Groundwater elevation contour maps for the shallow aquifer on December 11, 1994 and March 27, 1995 are presented on Figures 3-7 and 3-8, respectively. The contour maps indicate a linear flow towards the south/southeast, in the direction of Northeast Creek. Recharge for this area is from the north/northwest. The shallow groundwater gradient measured from well 7-MW04 to well 7-MW03 to the southeast for December 11, 1994 was 0.007 ft/ft and for March 27, 1995 was 0.01 ft/ft. Shallow groundwater discharges to Northeast Creek.

The shallow aquifer was characterized by performing in situ rising and falling head slug tests in the two newly installed monitoring wells. The tests were performed on December 7 and 8, 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 was 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 computer program for performing quantitative groundwater assessments. Only the data from the rising head tests were analyzed as the water levels in the wells were below the top of the sand pack, thus 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 3-3 lists the K values obtained from the data analysis, the average hydraulic gradient from the two groundwater elevation contour maps, the assumed effective porosity, and the calculated value for groundwater velocity. The average estimated K value from the two wells was 14.91 feet/day (5.26×10^{-3} cm/sec), which is within the typical range for silty sands (Freeze/Cherry, 1979). The average hydraulic gradient from groundwater measurements between wells 7-MW04 and 7-MW03 on December 11, 1994 and March 27, 1995 was 0.009 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 sands, a value of 35 percent was used for effective porosity. The estimated average linear groundwater velocity was calculated by using the following formula:

$$V=Ki/n_e$$

Where: V = groundwater velocity
K = hydraulic conductivity
i = hydraulic gradient
n_e = effective porosity

Using these variables, the groundwater velocity (V) in a northwest to southeast direction is estimated to be 0.38 feet/day (138.7 feet/year). This is a conservative 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 (K) by the saturated thickness (b) of the aquifer. Using a saturated thickness of 31.5 feet, which corresponds to the maximum depth of the shallow wells installed at Site 7, an approximate T value for the shallow aquifer in this direction is 469.67 $feet^2$/day (3.51×10^3 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 94.92 ft^2/day (7.1×10^2 gallons/day/ft) and 6.3 feet/day (2.2×10^{-3} 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 (5.61×10^2 gallons/day/ft). The average transmissivity value from these two pump tests is 85 $feet^2$/day (6.36×10^2 gallons/day/ft). The calculated transmissivity value of 469.67 $feet^2$/day from the slug tests is one order of magnitude higher than the average pump test value.

3.4.3 Tidal Study

A tidal study was conducted at Site 7 to determine the influence of tidal effects on the shallow groundwater within the site boundaries. A staff gauge was installed in Northeast Creek near the confluence of the western tributary, approximately 50 feet from shore. A pressure transducer was attached to the staff gauge, positioned approximately 1 foot off the creek bottom. Monitoring well 7-MW05 also had a pressure transducer installed in it during the study. Well 7-MW05 is located in the southwestern area of the site, at the northern boundary of the swamp, approximately 125 feet from Northeast Creek. Measurements were recorded with a In-Situ Hermit Model 2000 data logger over a period of three days (December 5-8, 1994). Figure 3-9 presents a graph of the readings from the staff gauge and monitoring well 7-MW05. The "0" mark on the Y-axis is referenced to the level of the creek and the groundwater level in well 7-MW05 at the start of the study.

The staff gauge in Northeast Creek indicated fluctuations in the water surface from 0.2 to 0.3 feet. Well 7-MW05 exhibited groundwater level changes of less than 1 foot. Figure 3-9 illustrates that the cyclic nature of the fluctuations of the creek and groundwater are "offset". A rise in the level of the creek coincides with a decrease in the groundwater level. The data indicates that there is a tidal effect on the shallow groundwater at Site 7, but there is a delay between the highest elevations of groundwater and the creek. The tidal influence from Northeast Creek reaches inland, but at a distance probably less than 200 feet.

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, redbreast sunfish, bluegill, chain pickerel, yellow perch, 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 bottomlands 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

Most of the area in the vicinity of Site 7 is forested and includes a deciduous forest and a wooded wetland or swamp. The deciduous forest is diverse, with deciduous trees mixed with occasional pines. Transition areas are present along the edges of the forest where open areas have been cleared as right-of-ways or along edges of the residential areas. The wetland is classified as a palustrine, forested, broad-leaved deciduous/needle-leaved evergreen, seasonally flooded wetland. A scrub shrub wetland is also present east of the site along Northeast Creek. Numerous bird and mammal species were identified in the area. No protected species were observed at Site 7. Site 7 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.

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 largest amount of family housing, roughly 428 acres, exists at Tarawa Terrace. Land use arrangements are logical and compatible. The duplex houses are arranged around a central area of community uses and the residences are buffered from North Carolina (NC) Route 24 by open recreational and natural wooded areas. All 70 one-bedroom housing units are located at Tarawa Terrace.

The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-4. In addition, the number of acres comprising each land use category has been estimated and provided on the table. Site 7 (Tarawa Terrace Dump) is located south/southwest of the family housing areas at Tarawa Terrace.

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 33 to 53 degrees Fahrenheit (°F) in the winter (i.e., January) and 71 to 88 °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 3-5 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 7 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 six base supply wells within a one-mile radius of Site 7: TT-23, TT-31, TT-52, TT-53, TT-54, and TT-67 (Harnad, et al., 1989). These base supply wells are currently not in operation and have been scheduled for demolition. Table 3-6 presents a summary of the water supply wells within a one-mile radius of Site 7. The location of these base water supply wells are shown on Figure 3-10.

3.9 References

ASTM. 1984. American Society of Testing and Materials. Penetration Test and Split Barrel Sampling of Soils. Annual Book of Standards, V.4.08, Philadelphia.

Baker. 1994. Baker Environmental, Inc. Evaluation of Metals in Groundwater for MCB Camp Lejeune, North Carolina. Draft. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Baker. 1994. Baker Environmental, Inc. Site Assessment Report, Additional Assessment Activities at the Campbell Street Fuel Farm and UST System AS-143, MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. April 29, 1994.

Cardinell, A.P., Berg, S.A., and Llyod O.B., Jr. 1993. Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina. USGS. Water-Resources Investigations Report 93-4049.

DoN. 1988. Master Plan, Camp Lejeune Complex, North Carolina. COMNAVFACENGCOM, April 8, 1988.

ESE. 1990. Environmental Science and Engineering, Inc. Site Summary Report. Final. Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. ESE Project No. 49-02036.

Freeze, R. Allan and John A. Cheery. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Harned, D.A., Llyod, O.B., Jr., and Treece, M.W., Jr. 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina. USGS. Water-Resources Investigations Report 89-4096.

North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2B. North Carolina Department of Environment, Health, and Natural Resources. Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina.

North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L. North Carolina Department of Environment, Health, and Natural Resources. Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina.

Water and Air Research. 1983. Water and Air Research, Inc. Initial Assessment Study of Marine Corps Base, Camp Lejeune, North Carolina. Prepared for Naval Energy and Environmental Support Activity.

SECTION 3.0 TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA OPERABLE UNIT NO. 11 (SITE 7) 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 WATER LEVEL MEASUREMENTS FROM MONITORING WELLS ON DECEMBER 11, 1994, AND MARCH 27, 1995
OPERABLE UNIT NO. 11 (SITE 7)
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)
7-MW01	6.25	3.88	2.37	3.83	2.42
7-MW02	9.75	7.09	2.66	6.83	2.92
7-MW03	6.14	3.63	2.51	3.51	2.63
7-MW04	25.90	19.81	6.09	17.5	8.4
7-MW05	6.29	3.95	2.25	3.72	2.57

Notes:

(1) Mean Sea Level (msl)

TABLE 3-3

AQUIFER CHARACTERISTICS - MONITORING WELLS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity (K) (feet/day)	Hydraulic Gradient (i) (feet/feet)	Effective Porosity (n)	Groundwater Velocity (V) (feet/day)
7-MW04	13.75	0.009	0.35	0.35
7-MW05	16.06	0.009	0.35	0.41

TABLE 3-4

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
OPERABLE UNIT NO. 11 (SITE 7)
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 3-5

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
OPERABLE UNIT NO. 11 (SITE 7)
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 3-6

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS OF SITE 7[1]
OPERABLE UNIT NO. 11 (SITE 7)
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 7: TT-23	3444220772148	263	--	Out	NA	2380/north
TT-31	3444020772210	94		Out	NA	1980/northwest
TT-52	3444030772220	98	50-70 125-145	Out	NA	1850/northwest
TT-53	3444140772212	90	45-49 50-54 55-59 60-65 71-73	Out	NA	2570/northwest
TT-54	3444020772204	104	--	Out	NA	1190/northwest
TT-67	3444090772207	98	--	Out	NA	1980/northwest

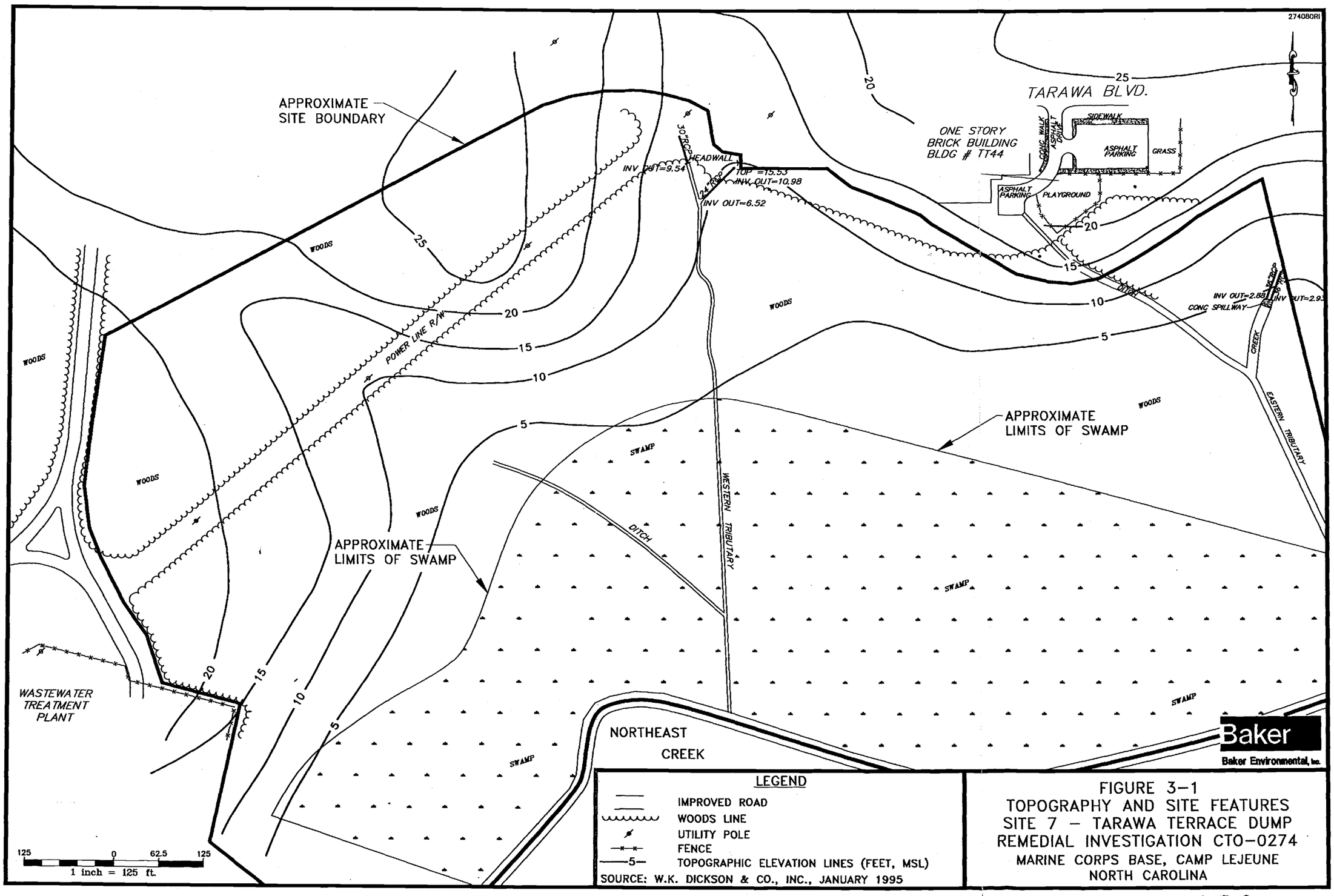
Notes: (1) Information obtained from "Assessment of Hydrogeologic and Hydraulic Data at Camp Lejeune Marine Corps Base, North Carolina," 1989.

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

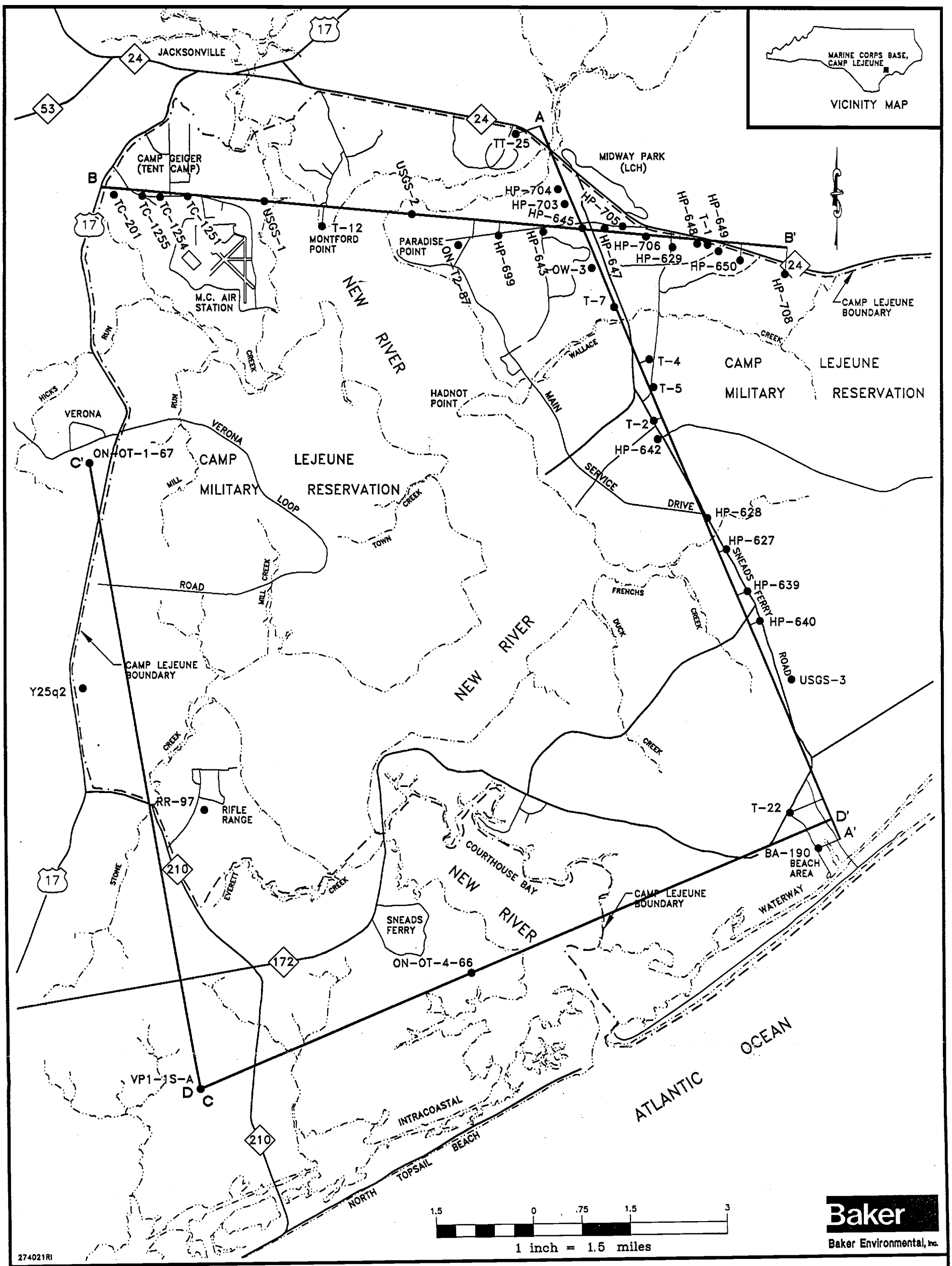
(3) Distance measured from site location mark on Figure 3-10.

NA= Not Applicable

SECTION 3.0 FIGURES


274080RI
APPROXIMATE SITE BOUNDARY
TARAWA BLVD.
ONE STORY BRICK BUILDING BLDG # TT44
SIDEWALK
CONC WALK
ASPHALT DRIVE
ASPHALT PARKING
GRASS
ASPHALT PARKING
PLAYGROUND
30" RCP
HEADWALL
TOP =15.53
INV OUT=10.98
INV OUT=9.54
24" RCP
INV OUT=6.52
INV OUT=2.85
INV OUT=2.93
CONC SPILLWAY
CREEK
EASTERN TRIBUTARY
WOODS
POWER LINE R/W
APPROXIMATE LIMITS OF SWAMP
SWAMP
WESTERN TRIBUTARY
DITCH
WASTEWATER TREATMENT PLANT
NORTHEAST CREEK
25
20
15
10
5
125 0 62.5 125
1 inch = 125 ft.
Baker
Baker Environmental, Inc.
LEGEND
IMPROVED ROAD
WOODS LINE
UTILITY POLE
FENCE
5 TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995
FIGURE 3-1
TOPOGRAPHY AND SITE FEATURES
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701VB2Z



SOURCE: DEPT. OF INTERIOR, WATER-RESOURCES INVESTIGATIONS REPORT, 89-4096, PLATE 4

FIGURE 3-2
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

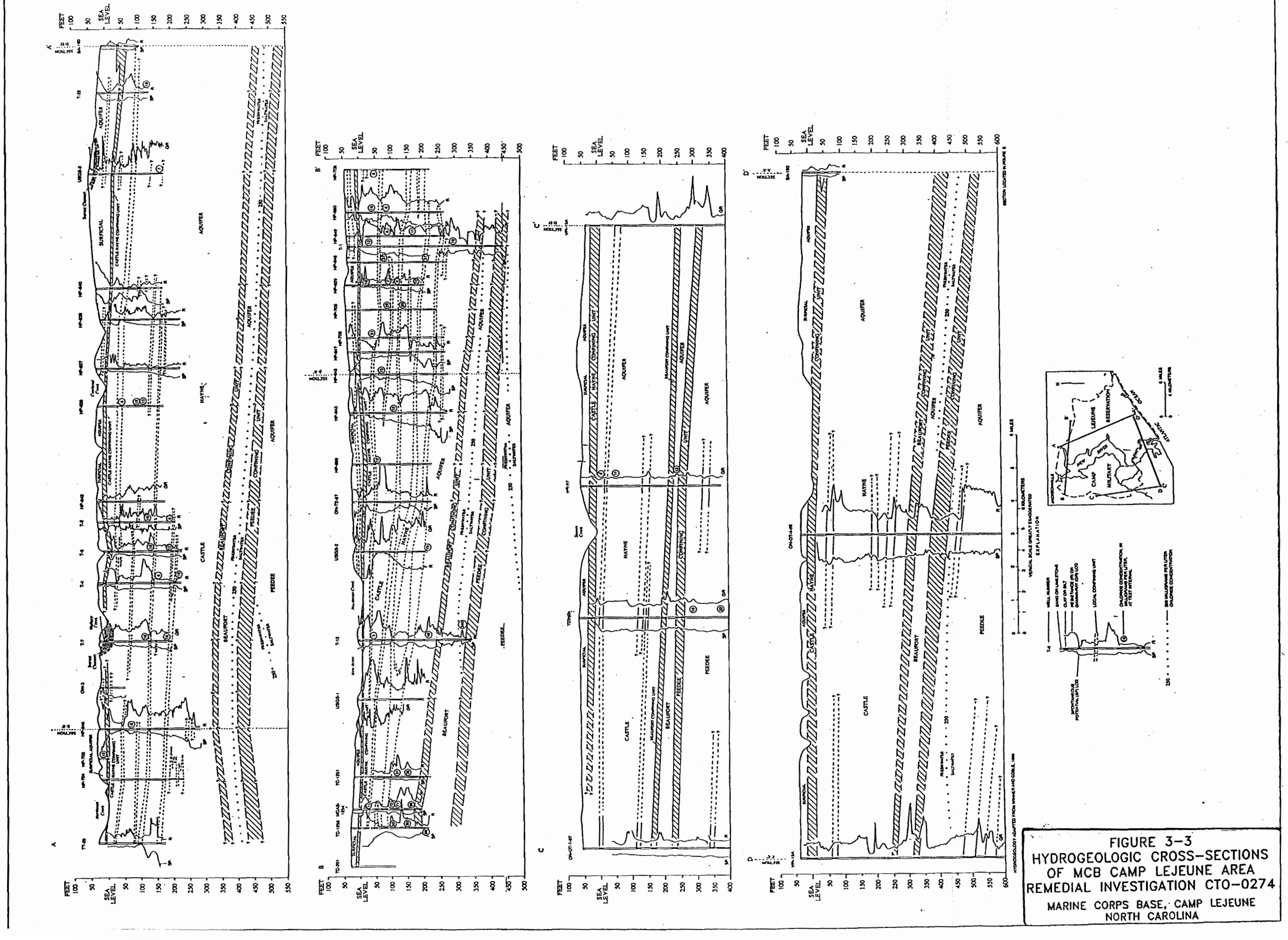
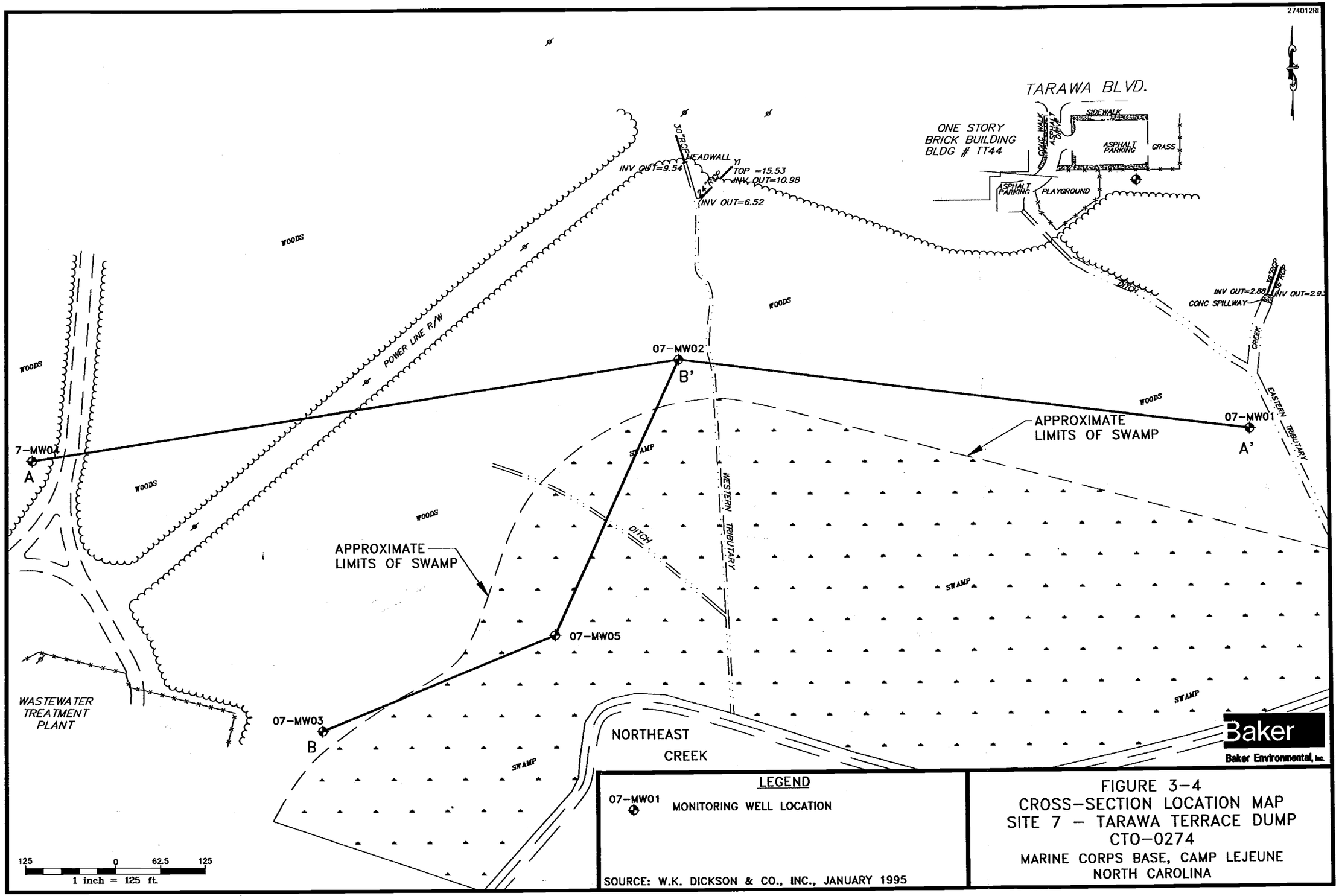


FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJEUNE AREA
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274012RI



Baker
Baker Environmental, Inc.

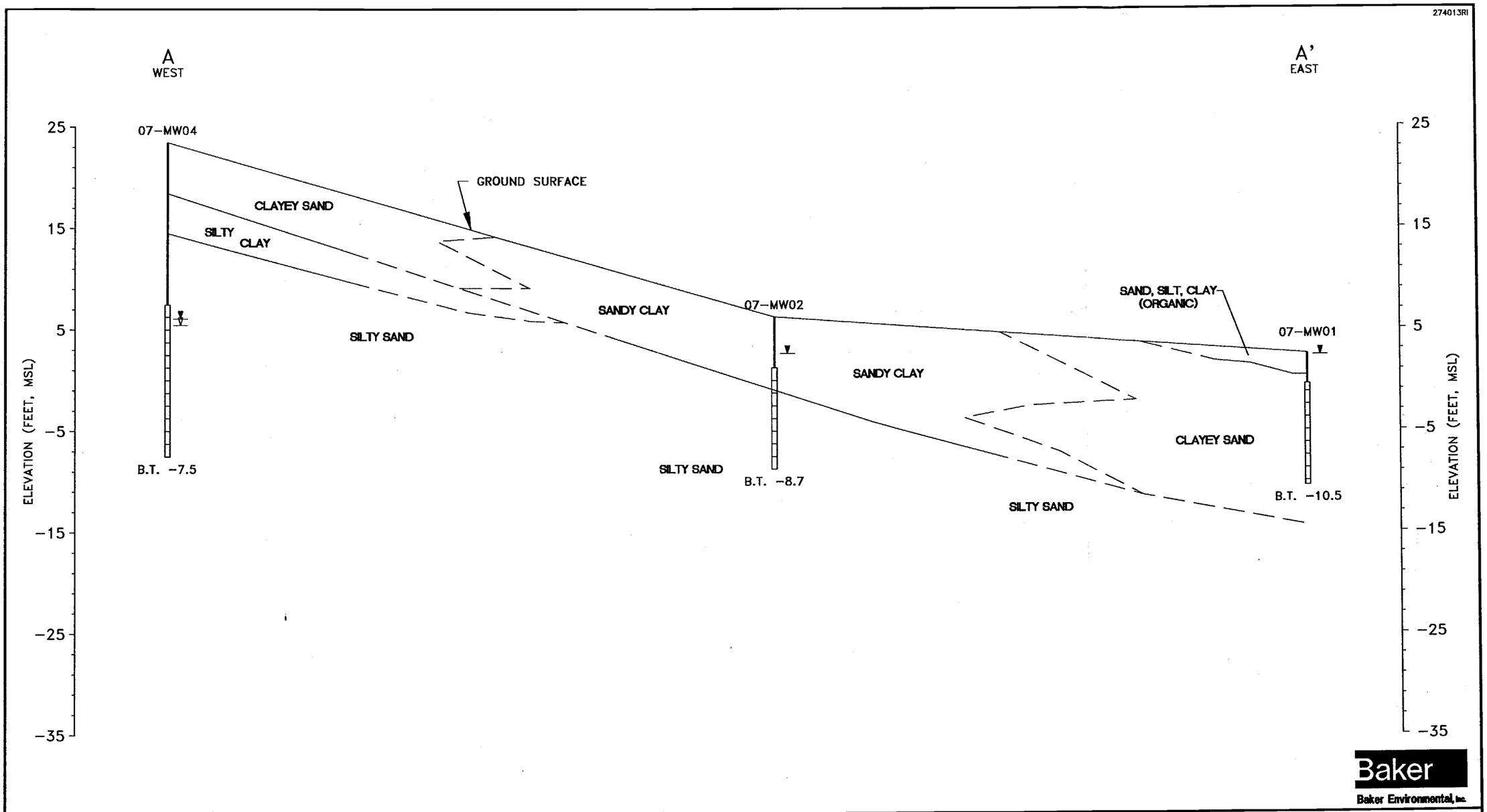
LEGEND

07-MW01 MONITORING WELL LOCATION

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

FIGURE 3-4
CROSS-SECTION LOCATION MAP
SITE 7 - TARAWA TERRACE DUMP
CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274013RI



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (12/11/94)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. X' — BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

150 0 75 150 300
Horizontal Scale: 1 inch = 150 ft.

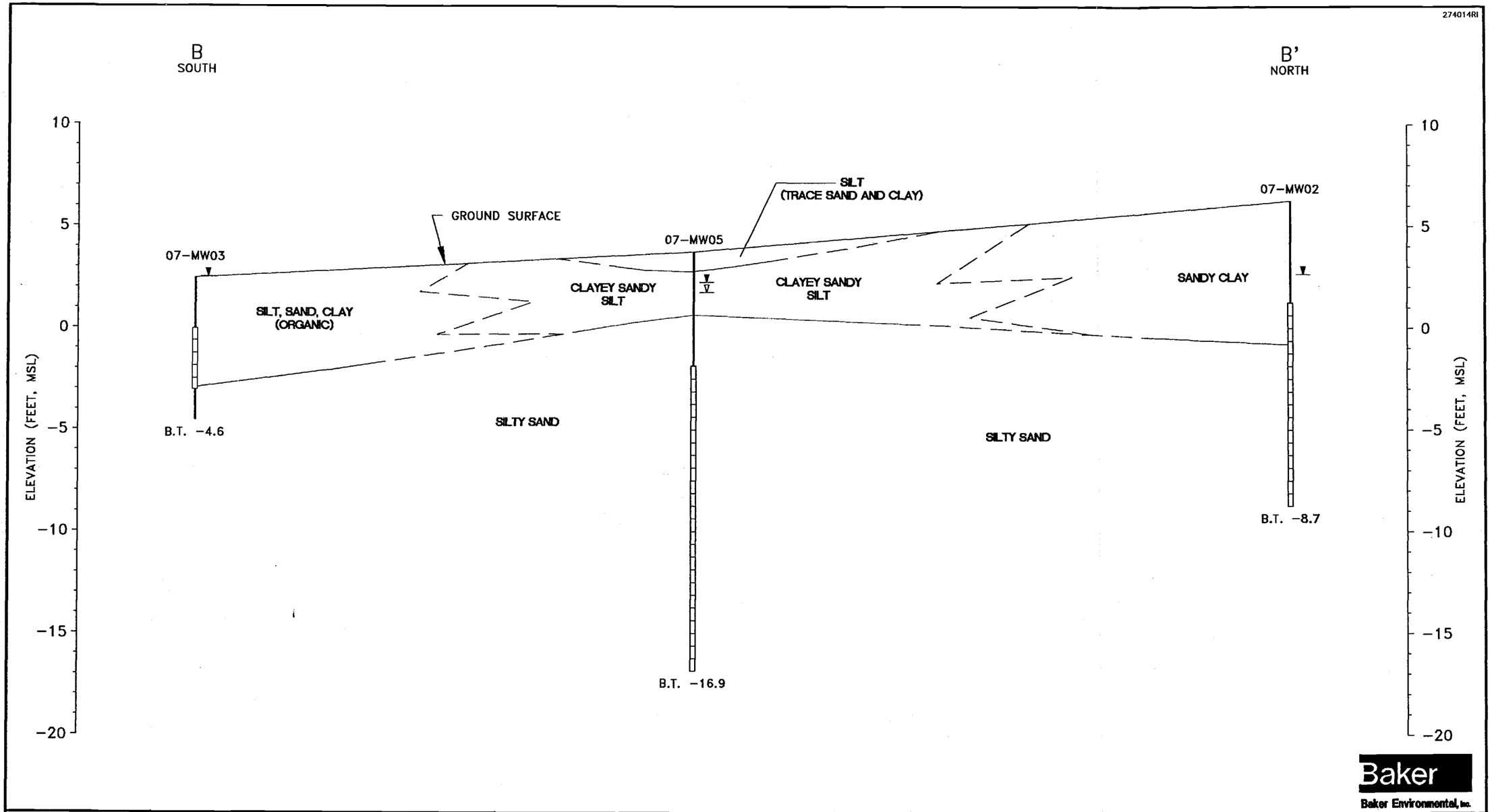
10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

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.

FIGURE 3–5
HYDROGEOLOGIC CROSS–SECTION A–A'
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO–0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274014RI



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (12/11/94)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. −4.5 BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

70 0 35 70 140
Horizontal Scale: 1 inch = 70 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

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.

FIGURE 3−6
HYDROGEOLOGIC CROSS−SECTION B−B'
SITE 7 − TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO−0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROL;INA

274002RI

TARAWA BLVD.

ONE STORY BRICK BUILDING BLDG # TT44

SIDEWALK

CONC WALK

ASPHALT DRIVE

ASPHALT PARKING

GRASS

ASPHALT PARKING

PLAYGROUND

30"RCP

HEADWALL Y1

INV OUT=9.54

12"RCP

TOP =15.53

INV OUT=10.98

INV OUT=6.52

INV OUT=2.88

CONC SPILLWAY

INV OUT=2.9

GREEN

EASTERN TRIBUTARY

WOODS

POWER LINE R/W

07-MW02 (2.66)

07-MW01 (2.37)

7-MW04 (6.09)

APPROXIMATE LIMITS OF SWAMP

SWAMP

WESTERN TRIBUTARY

DITCH

07-MW05 (2.25)

07-MW03 (2.51)

WASTEWATER TREATMENT PLANT

NORTHEAST CREEK

4.5

5

5.5

6

4

3.5

3

2.5

125 0 62.5 125

1 inch = 125 ft.

Baker

Baker Environmental, Inc.

LEGEND

07-MW01 EXISTING SHALLOW MONITORING WELL

(2.37) 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 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274006RI

TARAWA BLVD.

ONE STORY
BRICK BUILDING
BLDG # TT44

CONC WALK
ASPHALT DRIVE
SIDEWALK
ASPHALT PARKING
GRASS
ASPHALT PARKING
PLAYGROUND

30" RCP
HEADWALL
INV OUT=9.54
Y1
TOP =15.53
INV OUT=10.98
24" RCP
INV OUT=6.52

DITCH
INV OUT=2.88
18" RCP
CONC SPILLWAY
INV OUT=2.9
CREEK
EASTERN TRIBUTARY

WOODS
POWER LINE R/W

6.5
6
5.5
5
4.5
4
3.5
3
8
7.5
7
6.5
6
5.5
5

07-MW02
(2.92)

7-MW04
(8.40)

APPROXIMATE
LIMITS OF SWAMP

APPROXIMATE
LIMITS OF SWAMP

07-MW01
(2.42)

SWAMP
WESTERN TRIBUTARY
DITCH

07-MW05
(2.57)

07-MW03
(2.63)

WASTEWATER
TREATMENT
PLANT

NORTHEAST
CREEK

125 0 62.5 125
1 inch = 125 ft.

Baker
Baker Environmental, Inc.

LEGEND

07-MW01 EXISTING SHALLOW MONITORING WELL

(2.427) GROUNDWATER ELEVATION

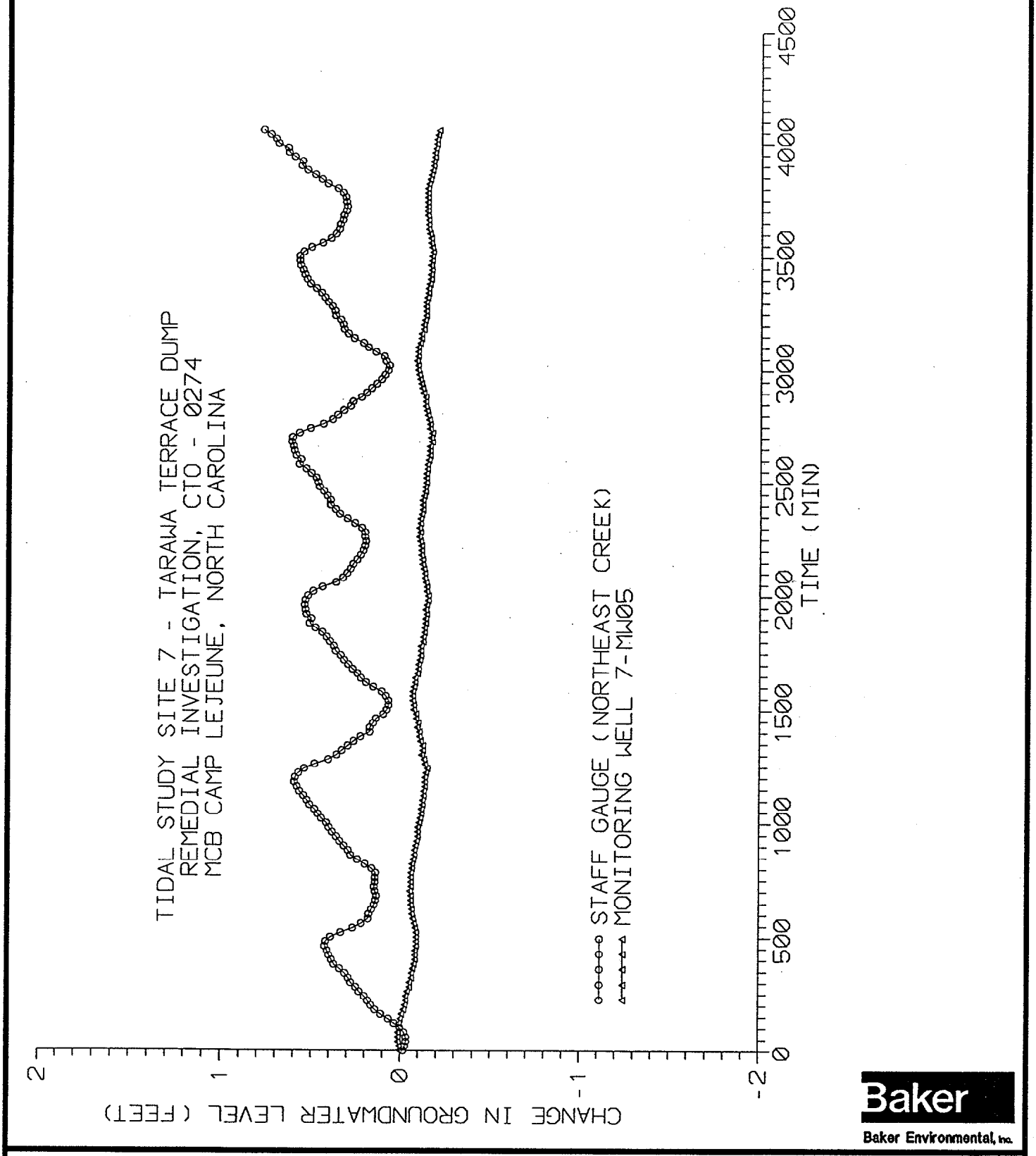
GROUNDWATER ELEVATION CONTOUR

GROUNDWATER ELEVATION CONTOUR – INFERRED

GROUNDWATER FLOW DIRECTION

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

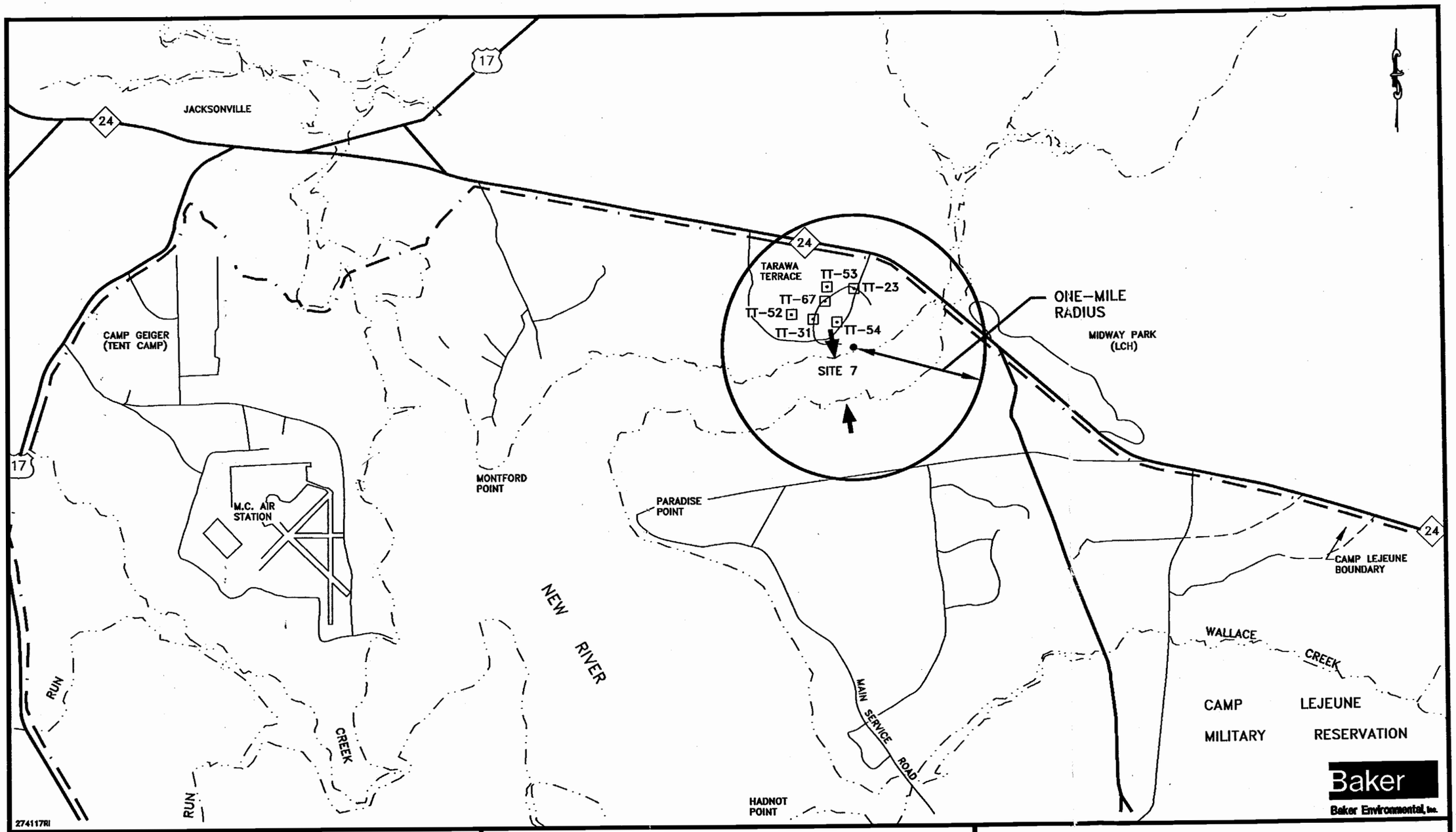
FIGURE 3-8
SHALLOW GROUNDWATER ELEVATION
CONTOUR MAP – MARCH 27, 1995
SITE 7 – TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

FIGURE 3-9
GRAPH OF TIDAL STUDY READINGS
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

TT-31 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 7
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701V042

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 11, Site 7. The objectives of the section are to characterize the nature and extent of contamination at Site 7. This characterization was accomplished through environmental sample collection and laboratory analysis of soil, groundwater, surface water and sediments. The positive detection summary tables and detection 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 was 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 3,500 separate contaminants were included in the Site 7 RI. No data was 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 "B" qualifier identifies a compound that was detected in the method blank associated with the sample.

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-Site Related Analytical Results

Many of the organic and inorganic constituents detected in soil, groundwater, surface water and sediments at Site 7 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 7 is provided in the following subsections.

4.2.1 Laboratory Contaminants

Blank samples (i.e., rinsate, field, 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 140 µg/L
- methylene chloride 27J µg/L
- chloroform 6J µg/L
- 2-butanone 15 µg/L
- 2-hexanone 4J µg/L
- toluene 1J µg/L
- bis(2-ethylhexyl)phthalate 2J 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 13J µg/L
- 1,2-dichloroethane 5J µg/L
- 1,1,2-trichloroethane 1J µg/L
- xylenes (total) 2J µg/L
- pentachlorophenol 1J 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 guidelines were used for each media:

Soil:	MCB, Camp Lejeune Background Soil Samples
Groundwater:	MCB, Camp Lejeune Background Groundwater Samples
Surface Water:	MCB, Camp Lejeune Base Upgradient Levels
Sediment:	MCB, Camp Lejeune Base Upgradient Levels

The following subsections address the various comparison criteria used to evaluate the analytical results from soil, groundwater, surface water and sediment samples collected at Site 7.

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. Therefore, it is probable that all organic contaminants detected in the surface and subsurface soil are attributable to activities which have or are currently taking place within or surrounding the study area.

Site background and base 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. Appendix F contains the summary of the base soil background database for inorganics.

4.2.2.2 Groundwater

A monitoring well (7-MW04) was installed in an upgradient direction of Site 7 to provide groundwater data to assess background groundwater conditions. 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 other base-related activities have altered the natural state of groundwater. In the latter case, the well samples would be classified as "control"

samples. Control samples are samples which may not represent background conditions, but represent the current state of groundwater quality upgradient of the site. During the last 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 provide control samples. 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.

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 Federal MCLs and NCWQS of 300 and 50 µg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCL 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 and manganese concentrations in several monitoring wells at Site 7 exceeded the MCL and NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. In light of this, it is assumed that iron and manganese are naturally-occurring inorganic elements in groundwater, and their presence is not attributable to site operations.

4.2.2.3 Surface Water and Sediment

Upgradient freshwater surface water and sediment samples have been collected at four sites at MCB Camp Lejeune and the results summarized for metals. Samples were collected from the following areas:

Site 2 - Overs Creek

Site 6 - Bearhead Creek
Wallace Creek

Site 41 - unnamed tributary
Tank Creek
northeast tributary to unnamed tributary

Site 69 - unnamed tributary

Metal concentrations in surface water at the base vary widely. A total of 22 samples had been analyzed for metals with aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium detected in at least 75 percent of the upgradient samples. These metals exhibited the highest detected concentrations within the surface water metal concentrations. Table 4-3 contains a summary of the frequency of detection with the calculated average concentrations for each metal.

The most detected metals in sediments include aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc. These metals were detected in approximately 70 percent of the upgradient samples. Table 4-4 contains a summary of the frequency of detection with the calculated average concentrations for each metal.

In the summer of 1994, Baker collected surface water, sediment, fish, and benthic macroinvertebrate samples from the three creeks in the White Oak River basin (Holland Mill Creek, Hadnot Creek, and Webb Creek). The samples collected are used as off-site reference stations to determine the regional levels of contaminants in the surface water and sediment, and regional population of fish and benthic macroinvertebrate species.

Baker collected three samples from Holland Mill Creek. One sample was at an upstream freshwater station, one sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Holland Mill Creek. Baker collected four samples from Hadnot Creek. Two samples were at an upstream freshwater station, one sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Hadnot Creek. Of the two upstream samples in Hadnot Creek, one was collected in a relatively small creek, while the other was collected in a large ponded area. Finally, Baker collected two samples from Webb Creek. One

sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Webb Creek. Appendix H presents the results of the White Oak River Basin study.

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 and surface water. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary. Relevant regulatory guidelines include Federal Ambient Water Quality Criteria (AWQC) and Health Advisories.

In general, chemical-specific criteria and standards are not available for soil. Therefore, 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 OU No. 11, 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.

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.

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair waters for any designated use.

Ambient Water Quality Criteria - AWQCs are non-enforceable Federal regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms

(6.5 grams/day), or from ingestion of water alone (2 liters/day). The AWQCs for the protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e., the 10E-7 to 10E-5 range).

Region IV Sediment Screening Values - Federal sediment quality criteria for the protection of aquatic life are being developed. In the interim, the USEPA Region IV Waste Management Division recommends the use of sediment values compiled by the National Oceanic and Atmospheric Administration (NOAA) as screening values for evaluating the potential for chemical constituents in sediments to cause adverse biological effects. NOAA developed this screening method through evaluation of biological effects data for aquatic (marine and freshwater) organisms, obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed, and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called Effects Range-Median, or ER-M) were determined.

If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-L and the ER-M, adverse effects are considered possible, and USEPA recommends conducting sediment toxicity tests as a follow-up. If contaminant concentrations are below the ER-L, adverse effects are considered unlikely.

4.4 Analytical Results

The analytical results of the soil, groundwater, surface water and sediment sampling performed at Site 7 are presented in the following sections. A summary of site contamination, by media, is provided in Table 4-5. The Data Frequency Summaries for all media at Site 7 are presented in Appendix I.

All samples submitted for analysis were analyzed for full TCL organics, including volatiles, semivolatiles and pesticides/PCBs, and TAL inorganics, using CLP protocols and Level III data quality.

4.4.1 Soil Investigation

Surface soil positive detection summaries for organics and inorganics are presented in Tables 4-6 and 4-7, respectively. Positive detection summary tables for organics and inorganics in subsurface soils are presented in Tables 4-8 and 4-9, respectively.

4.4.1.1 Surface Soil

A total of 50 surface soil samples were collected and submitted from the community center, east area, north area, southwest area and monitoring well locations. Acetone was detected at concentrations of 150 µg/kg (location 7-EA-SB07) and 170 µg/kg (location 7-EA-SB09). These concentrations are less than 10 times the maximum concentration detected in QA/QC blanks. 2-Butanone was detected at a concentration of 52 µg/kg at location 7-EA-SB09, less than 10 times the maximum QA/QC blank concentration. The aforementioned detected compounds are considered to be laboratory contaminants due to the fact that they were detected at concentrations less than 10 times the maximum concentration detected in QA/QC blanks. Toluene was detected in three

samples at concentrations ranging from 9J µg/kg (location 7-NA-SB10) to 46J µg/kg (location 7-EA-SB09). The concentration detected at location 7-NA-SB10 (9J µg/kg) was less than 10 times the maximum concentration detected in the QA/QC blanks and is considered to be a laboratory contaminant. Location 7-EA-SB06 exhibited a trichloroethene concentration of 1J µg/kg.

Of the semivolatile organics, PAHs were the most prevalent. Location 7-NA-SB04 exhibited a total PAH concentration of 4,415 µg/kg. PAH constituents were detected at low levels at isolated locations. Phenol was detected at location 7-EA-SB10 at a concentration of 170NJ µg/kg. Bis(2-ethylhexyl)phthalate was detected in 8 samples at concentrations ranging from 38J µg/kg (7-SWA-SB02) to 600 µg/kg (7-MW04). All bis(2-ethylhexyl)phthalate concentrations exceeded 10 times the maximum QA/QC blank concentration. Location 7-SWA-SB02 exhibited a di-n-butylphthalate concentration of 170J µg/kg.

Pesticides dieldrin and 4,4'-DDE were detected most frequently (7 out of 30 samples) with the maximum concentrations being 57 µg/kg (location 7-NA-SB04) and 65J µg/kg (location 7-MW05), respectively. 4,4'-DDT exhibited the highest pesticide concentration of 280J µg/kg at location 7-MW05. PCBs were detected in the surface soil at Site 7. Aroclor 1254 was detected at location 7-SWA-SB04 (43J µg/kg) and Aroclor 1260 was detected at location 7-NA-SB04 (80NJ µg/kg). Eighteen confirmatory surface soil samples for PCBs were collected from the areas around 7-SB02 and 7-MW02. Sample 7-EPCB-SB09 exhibited the only detected confirmatory concentration of PCBs, Aroclor 1260 (320 µg/kg).

Maximum concentrations of inorganics were within one order of magnitude or less of maximum base background levels. Of the detected inorganics, copper, manganese and silver were not detected above Base background levels. Antimony, cadmium and thallium were not detected.

4.4.1.2 Subsurface Soil

Methylene chloride and acetone were the only volatile organics detected. Methylene chloride was detected in only one sample (7-SWA-SB04, 1 to 3 feet) at a concentration of 12J µg/kg, which is less than 10 times the maximum QA/QC blank concentration. Acetone was detected in 11 of 30 samples at concentrations ranging from 13 µg/kg (7-NA-SB06, 13 to 15 feet) to 2,300 µg/kg. The highest acetone concentration was exhibited in sample 7-EA-SB05 from 13 to 15 feet. Only the concentrations detected in samples 7-NA-SB03 (3 to 5 feet) (2,000 µg/kg) and 7-EA-SB05 (13 to 15 feet) (2,300 µg/kg) were greater than 10 times the maximum concentration detected in a QA/QC blank. Acetone was detected at the three background boring locations at depths of 9 to 11 feet and 17 to 19 feet, with concentrations ranging from 110 µg/kg (7-BB-SB03) to 430 µg/kg (7-BB-SB01).

Sample 7-NA-SB07 (3 to 5 feet) exhibited all detected concentrations of PAH constituents. The total PAH concentration for this sample was 10,418 µg/kg. Dibenzofuran was also detected in sample 7-NA-SB07 (3 to 5 feet) at a concentration of 190J µg/kg. Bis(2-ethylhexyl)phthalate was detected in 5 of 30 samples with concentrations ranging from 39J µg/kg (7-SWA-SB02, 7 to 9 feet) to 80J µg/kg (7-NA-SB04, 3 to 5 feet). The detected concentrations of bis(2-ethylhexyl)phthalate exceeded 10 times the maximum QA/QC blank concentration. Di-n-butylphthalate was detected in 3 samples with concentrations ranging from 42J (7-SWA-SB04, 1 to 3 feet) to 220J µg/kg (7-SWA-SB02, 7 to 9 feet).

Pesticides and PCBs were also detected. Sample 7-SWA-SB04 (1 to 3 feet) exhibited the maximum concentrations for 9 of the 11 detected pesticides. Delta-BHC and eldrin aldehyde were only

detected in sample 7-EA-SB06 (1 to 3 feet) at concentrations of 3J µg/kg and 8.1J µg/kg, respectively. Aldrin was detected in the composite sample from test pit 7-SWA-TP02 at a concentration of 6.3 µg/kg. PCBs were detected in subsurface soil at Site 7. Aroclor 1260 was detected in sample 7-SWA-SB04 (1 to 3 feet) at a concentration of 91J µg/kg. No PCBs were detected in the sixteen confirmatory subsurface soil samples collected in the areas around 7-SB02 and 7-MW02.

Eighteen of 23 inorganics were detected in the subsurface soil at Site 7. Antimony, cadmium, cobalt, silver and thallium were not detected in subsurface soil. Inorganic concentrations were within one order of magnitude or less of the base background concentrations. Aluminum, barium, beryllium, calcium, copper, manganese, nickel and zinc were detected above base background levels.

4.4.2 Groundwater Investigation

One round of groundwater samples was collected from the three existing shallow monitoring wells, and the two newly installed shallow monitoring wells and three temporary wells installed during the RI. The temporary wells were sampled on November 7, 1994, and the permanent wells were sampled on December 1 and 2, 1994. Positive detection summaries for organics and metals (total and dissolved) are presented in Tables 4-10, 4-11 and 4-12, respectively.

The volatile organics detected were chloroform, 2-hexanone and toluene. Chloroform was detected at concentrations of 4J µg/L (7-MW05) and 7J µg/L (7-MW02). Both concentrations of chloroform were above the NCWQS. Monitoring well 7-MW05 exhibited the only detection of 2-hexanone (1J µg/L). Temporary well 7-TW01 exhibited a toluene concentration of 4J µg/L. The concentrations of these three contaminants were less than 10 times their maximum concentrations detected in QA/QC blanks and are considered to be laboratory contaminants.

Phenol and 4-methylphenol were the only semivolatile organics detected. They were detected in well 7-MW01 at concentrations of 4J µg/L and 10 µg/L, respectively. These concentrations were not above State and/or Federal standards.

The only pesticide detected was dieldrin at a concentration of 0.41 µg/L in well 7-MW02. NCWQS or Federal MCL criteria are not established for dieldrin.

Total metals were detected in groundwater. Metal concentrations at Site 7 were generally one to two orders of magnitude less than base background levels. Aluminum, chromium, iron, lead and manganese were detected above State and/or Federal standards. Antimony, arsenic, cadmium, cobalt, nickel, silver and thallium were not detected.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-13. 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 4.46 to 6.10 s.u., specific conductance values ranged from 55 to 299 micromhos/cm, and temperature values ranged from 15.5 to 18.5° C. Turbidity values were all recorded as less than 5 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.). Field parameter values for pH and specific conductance are comparable to values obtained at other sites at MCB Camp Lejeune.

4.4.3 Surface Water Investigation

A total of 13 surface water samples were collected from Northeast Creek (6 samples), eastern tributary (2 samples), western tributary (3 samples), and drainage ditch (2 samples) (which flows into the western tributary). Positive organic and inorganic detection summaries are presented in Tables 4-14 and 4-15, respectively.

Chloroform was detected in three samples at concentrations ranging from 1J µg/L (7-ET-SW02) to 3J µg/L (7-WT-SW01). 2-Butanone and 2-hexanone were detected in sample 7-NC-SW03 at concentrations of 2J µg/L and 1J µg/L, respectively. Chloroform, 2-butanone and 2-hexanone concentrations were less than 10 times the maximum concentrations detected in QA/QC blanks during the surface water and sediment investigation, making them potential laboratory contaminants. Xylene (total) was detected in sample 7-EC-SW02 at a concentration of 1J µg/L. These volatile organics were not detected above applicable NCWQS and/or Federal AWQC standards.

Bis(2-ethylhexyl)phthalate was the only semivolatile organic detected. Sample 7-ET-SW02 exhibited a concentration of 77B µg/L, which is above the Federal AWQC. The "B" qualifier indicates that this contaminant was detected in the method blank associated with the sample. Bis(2-ethylhexyl)phthalate was detected in QA/QC blanks during the surface water and sediment investigations at a maximum concentration of 1J µg/L. Since the detected sample concentration for this phthalate exceeded 10 times the maximum concentration detected in QA/QC blanks, it is considered a positive result.

Dieldrin was detected at concentrations of 0.4 µg/L (7-WT-SW02) and 0.5 µg/L (7-WT-SW01), both above NCWQS and AWQC standards. Endrin ketone was detected in two surface water samples at concentrations of 0.12 µg/L (7-WT-SW01) and 0.13 µg/L (7-WT-SW02). No Federal NCWQS or AWQC standards have been established for endrin ketone.

Thirteen of 23 inorganics were detected in surface water samples. Arsenic, iron and manganese were detected above applicable Federal AWQC criteria. Since iron and manganese are naturally occurring inorganics in groundwater, it is likely that their detection in the surface water is due to groundwater being the source for surface water. Metal concentrations were within one order of magnitude of base upgradient background levels, except for calcium (one order of magnitude higher), and magnesium, potassium and sodium (two orders of magnitude higher). Antimony, beryllium, cadmium, chromium, cobalt, mercury, nickel, selenium, thallium and vanadium were not detected in surface water.

4.4.4 Sediment Investigation

Twenty-seven sediment samples were collected from Northeast Creek (12 samples), eastern tributary (2 samples), western tributary (3 samples), drainage ditch (2 samples), and the swamp area (8 samples) (originally identified as a marsh) in the southern portion of the site. Positive detection summaries for organics and inorganics are presented in Tables 4-16 and 4-17, respectively.

The volatile organics detected were 2-butanone, toluene and styrene. 2-Butanone was detected in 14 samples at concentrations ranging from 1J µg/kg (7-NC-SD02, 0 to 6 inches) to 250J µg/kg (7-ET-SD01, 0 to 6 inches). Toluene was detected in 9 samples at concentrations ranging from 10J µg/kg (7-MA-SD01, 0 to 6 inches) to 39J µg/kg (7-MA-SD04, 6 to 12 inches). Styrene was only detected in sample 7-MA-SD02 (0 to 6 inches) at a concentration of 28J µg/kg. NOAA criteria are not established for these three volatile organics. None of the three compounds were detected in QA/QC blanks during the surface water and sediment investigations.

PAH constituents were the most frequently detected semivolatile organics. Sample 7-MA-SD04 (0 to 6 inches) exhibited the greatest number and maximum concentrations of PAH constituents. Anthracene and pyrene were detected above applicable NOAA Lower Effects Range (ER-L) Criteria. Di-n-butylphthalate was detected in 9 samples at concentrations ranging from 76J µg/kg to 1,300 µg/kg (7-MA-SD04, 0 to 6 inches). Butyl benzyl phthalate, bis(2-ethylhexyl)phthalate and di-n-octylphthalate were also detected, but at isolated locations and lower concentrations. These phthalate esters do not have established NOAA Effects Criteria. No semivolatiles detected in sediment samples were detected in QA/QC blanks.

The pesticide 4,4'-DDE was detected the most frequently and at the maximum concentration. All concentrations of 4,4'-DDE were above the NOAA Lower Effects Range (ER-L) Criteria and 9 of the 13 detected concentrations were above the NOAA Median Effects Range (ER-M) Criteria. Dieldrin, 4,4'-DDD and 4,4'-DDT also exhibited concentrations above applicable NOAA Effects Range Criteria. Other detected pesticides included aldrin, endrin ketone, alpha chlordane and gamma chlordane. These pesticides were detected at low concentrations. Aroclor 1260 was detected in one sample, collected from the swamp area, at a concentration of 450 µg/kg. NOAA criteria is not established for this PCB.

Inorganics were detected in sediment samples. Concentrations of copper, lead, mercury and zinc were above applicable NOAA Effects Range Criteria. Metal concentrations were within one order of magnitude of base upgradient background levels, except for aluminum, barium and mercury (one order of magnitude higher). Antimony, cadmium, cobalt, nickel and silver were not detected.

4.4.5 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 include acetone, methylene chloride, chloroform, 2-butanone, 2-hexanone, toluene, bis(2-ethylhexyl)phthalate, chloromethane, 1,2-dichloroethane, 1,1,2-trichloroethane, xylenes and pentachlorophenol. Acetone was detected in 6 of 13 samples at concentrations ranging from 7J µg/L to 140 µg/L. Methylene chloride was detected in 9 of 13 samples at concentrations ranging from 2J µg/L to 27 µg/L. Eleven of 23 TAL metals were detected, some were quantified with J qualifiers.

A field blank (7-FB01) collected from the potable water source (fire hydrant at the wastewater treatment plant) used for decontamination of heavy equipment exhibited levels of chloroform,

pentachlorophenol and bis(2-ethylhexyl)phthalate. This field blank also contained levels of inorganics.

4.5 Extent of Contamination

4.5.1 Soils

4.5.1.1 Surface Soil

Figure 4-1 presents the positive detections of volatiles, semivolatiles, pesticides and PCBs in surface soil at Site 7.

Acetone, toluene, trichloroethene and 2-butanone were the only volatiles detected. Acetone, 2-butanone, and one toluene concentration were detected at levels less than 10 times the maximum concentration of these compounds in QA/QC blanks, designating them as probable laboratory contaminants. The toluene concentrations at locations 7-NA-SB12 (12J µg/kg) and 7-EA-SB09 (46J µg/kg) were detected at levels greater than 10 times the QA/QC levels, indicating positive results. Trichloroethene was detected at a low level at location 7-EA-SB06. Trichloroethene was not detected in QA/QC blanks. The source of the trichloroethene and toluene is unknown, but may be related to past site activities. Visual inspection of the site indicated discarded oil containers which could be the source of the toluene. The distribution and concentrations of the volatile organic contaminants detected at the site appear to indicate localized source(s).

PAH constituents were the most widely detected semivolatiles. No PAHs were detected in the QA/QC samples. The highest PAH concentrations were exhibited at two locations along the right-of-way. Lower levels of PAHs were detected along the northern border of the site behind the Community Center. The PAH contamination may be related to the reported disposal of construction materials at the site. A specific source for the PAH contamination is not known; however, asphalt roofing shingles were detected in other areas of the site. Bis(2-ethylhexyl)phthalate was also detected in scattered areas of the site. None of the bis(2-ethylhexyl)phthalate concentrations were less than 10 times the maximum QA/QC concentration. Di-n-butylphthalate was detected at one location (7-SWA-SB02, 170J µg/kg), and was not detected in any QA/QC blanks. No specific source can be identified for the phthalate esters.

Pesticides were detected in all areas of the site. The southwest area exhibited the highest concentrations of pesticides; however, pesticide levels are similar to base-wide concentrations from the historical use of pesticides at Camp Lejeune (Water and Air Research, 1983).

Aroclor 1254 was detected in one location in the southwest area (7-SWA-SB04) of the site. Location 7-NA-SB04 exhibited the only detected concentration of Aroclor 1260. Historical records do not indicate the disposal of PCBs. Elevated levels of PCBs were detected during the Site Investigation (SI) conducted in 1991. These concentrations were exhibited in the north area and south of the community center.

Inorganics were detected in all areas of the site. Figure 4-2 presents the positive detections of inorganics above base background levels. The distribution and levels of inorganic contamination across the site does not correlate with a potential source area or an area of concern.

4.5.1.2 Subsurface Soil

Figure 4-3 presents the positive detections of volatiles, semivolatiles, pesticides and PCBs in the subsurface soil at Site 7.

Acetone and methylene chloride were the only volatiles detected. Two concentrations of acetone [2,300 µg/kg, 7-EA-SB05 (13 to 15 feet) and 2,000 µg/kg, 7-NA-SB03 (3 to 5 feet)] exceeded 10 times the maximum concentration in QA/QC blanks. Both of these locations are in the northern portion of the site near Tarawa Boulevard. A specific source cannot be identified for the acetone.

Semivolatiles were only detected in the northern and southwestern areas of the site. PAHs exhibited the highest concentrations and were confined to location 7-NA-SB07 (3 to 5 feet). The reported disposal of construction debris (i.e., asphalt roofing shingles) is the likely source of the PAH contaminants. PAH contamination observed in the subsurface soil was higher than concentrations in the surface soil at location 7-NA-SB04. Location 7-NA-SB04, which exhibited the highest concentrations of PAHs in the surface soil, exhibited no PAHs in subsurface soil. Phthalates were the only other detected semivolatiles, predominantly in the southwest area. All bis(2-ethylhexyl)phthalate concentrations were greater than 10 times the QA/QC blanks. Di-n-butylphthalate was detected at concentrations greater than bis(2-ethylhexyl)phthalate, still within the southwest area of the site. A large quantity of surface debris was observed in the southwest area, and this may be the source of the phthalates.

Pesticides were detected mainly in the southwest area. Location 7-EA-SB06 (1 to 3 feet) southeast of the Community Center also exhibited pesticides, at similar concentrations to the southwest area. The occurrence of pesticides may be attributed to the documented historical usage of pesticides at Camp Lejeune (Water and Air Research, 1983). Aroclor 1260 was only detected at location 7-SWA-SB04 (1 to 3 feet). Aroclor 1254 was detected at this location in the surface soil. Historical records to not indicate disposal of PCBs at Site 7, but disposal of lubricants and oils (as evidenced from the discarded containers), which may have contained PCBs, is a possible source for the isolated detections of these contaminants.

Inorganics were detected in the subsurface soil. Figure 4-4 presents the inorganics detected above base background levels. These inorganics are clustered in the southwest area, with concentrations of barium exhibited in the northern area of the site.

4.5.2 Groundwater

Chloroform was the only organic detected above State and/or Federal standards. Figure 4-5 presents the locations of the detected chloroform concentrations. Chloroform was detected in QA/QC blanks at a maximum concentration of 6J µg/L. The detections of chloroform were less than 10 times the maximum concentrations in QA/QC blanks, making them attributable to laboratory contamination.

Aluminum, chromium, iron, lead and manganese were detected above State and/or Federal standards. Figure 4-6 presents the distribution of these contaminants at Site 7. Aluminum was detected in the upgradient well (7-MW04) above the Federal MCL. Metal concentrations were below base background levels, indicating no significant, if any, effect from past activities at the site. Total metal concentrations were of the same order of magnitude as dissolved metal concentrations. Iron and manganese were detected one order of magnitude higher in total metal as compared to dissolved metal concentrations. This correlates with the evaluation of metals in groundwater (Baker,

1994), which indicates that both of these metals are naturally occurring in shallow groundwater at the base at elevated concentrations.

4.5.3 Surface Water

Figure 4-7 presents the organics detected above NCWQS and/or AWQC standards in the surface water. No volatiles were detected above standards. Bis(2-ethylhexyl)phthalate was the only semivolatile detected above the Federal AWQC. This chemical was only detected in one sample (7-ET-SW02) in the eastern tributary along the eastern boundary of the site.

Dieldrin was the only pesticide detected above NCWQS and AWQC values. It was detected in two samples collected from the western tributary. Pesticides detected in the surface water at the site are likely attributable to the historical usage of pesticides at Camp Lejeune (Water and Air Research, 1983).

Arsenic was detected at two sampling locations in Northeast Creek above the Federal AWQC value (refer to Figure 4-8). These locations (7-NC-SW02 and 7-NC-SW03) are at the mouth of the eastern tributary and approximately 300 feet upstream. The apparent source for this contaminant would not appear to be from on-site, since the metal was detected upstream from the eastern boundary of the site. Iron was detected in surface water samples across the site. The occurrence of iron is natural and would be associated with shallow groundwater discharge being the source. Iron concentrations detected in Northeast Creek upstream of the eastern site boundary was the highest concentration reported in a surface water sample at Site 7. This would support the conclusion that metal concentrations in surface water are not site-related.

4.5.4 Sediments

Figure 4-9 presents the detected organics above National Oceanic and Atmospheric Administrations (NOAA) Effects Range Criteria. No volatile organics were detected above NOAA Effects Range Criteria. Anthracene and pyrene (PAH constituents) were detected in one swamp sediment sample in the eastern portion of the site above NOAA Lower Effects Range (ER-L) Criteria. The source of the PAH contaminants in the sediments is not known. PAHs were not detected in the surface and subsurface soils in the areas of the tributaries and drainage ditch.

Pesticides were detected at all but three sediment sampling locations above both NOAA ER-L and ER-M criteria. The predominant pesticides detected were 4,4'-DDE, 4,4'-DDD and 4,4'-DDT. These detected pesticides are likely associated with the historical usage of pesticides at Camp Lejeune (Water and Air Research, 1983).

Lead was detected within the swamp, drainage ditch and Northeast Creek above NOAA Effects Range Criteria. Copper, mercury and zinc were also detected above NOAA ER-L and ER-M criteria at location 7-MA-SD01 from 0 to 6 inches and 6 to 12 inches. Figure 4-10 presents the positive detections above NOAA criteria in sediment samples. Lead was not detected at elevated levels in the surface soil, subsurface soil or surface water. The shallow groundwater did exhibit lead concentrations above State and/or Federal standards. The lead concentrations detected in the sediment may be associated with past site activities, disposal of construction material and municipal wastes. Upgradient from the site is a former service station, which has been investigated under the UST program. This may also be a source of the lead contamination observed in the western tributary

sediments. The isolated detection of copper, mercury and zinc may be due to an isolated or localized source in the southwest area of the site, but no specific source for these metals has been identified.

4.6 Summary

PAH constituents were detected at elevated levels in both surface and subsurface soil. These contaminants are likely attributable to past activities at the site, due to their distribution and concentrations. Low levels of toluene and trichloroethene were also detected in the surface soil; these chemicals may be attributable to past activities at the site. Pesticides were detected at low levels in surface and subsurface soils over most of the site. These concentrations are most likely due to the historical usage of pesticides at the base. PCBs were exhibited in isolated samples in the soils. While no specific records indicate the disposal of PCBs at Site 7, there are indications of the disposal of oils and lubricants, which may have contained PCBs. No organics were detected in the shallow groundwater which can be attributed as site related due to past activities at the site. Organics in the surface water and sediment were generally limited to pesticides, which are most likely related to the historical usage of pesticides at the base. The soil unit in the areas of wells 7-MW02 and 7-MW04 is Marvyn. This soil is a loamy fine sand which is strongly acidic (4.5 - 6.0 s.u.) throughout its profile. This strongly acidic soil may be contributing to low pH values measured during groundwater purging prior to sampling.

Inorganics were detected in all media at Site 7. Metal concentrations were greater in site surface soil than in base background surface soil. No specific source has been identified for the elevated metal concentrations in the surface soil; however, it may be the result of the variety of construction debris reportedly disposed of at the site. Iron was detected in shallow groundwater above State and/or Federal standards. Iron has been shown to be a naturally occurring metal in shallow groundwater at MCB, Camp Lejeune. Concentrations of iron in shallow groundwater at Site 7 were one to two orders of magnitude less than at other sites at MCB, Camp Lejeune (refer to appendix G).

4.7 References

Baker. 1994. Baker Environmental, Inc. Remedial Investigation/Feasibility Study Project Plans, Operable Unit No. 8 (Site 16), Operable Unit No. 11 (Sites 7 and 80), and Operable Unit No. 12 (Site 3), MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. September 1994.

Greenhorne & O'Mara, Inc. 1992. Preliminary Draft Report Wellhead Monitoring Study Engineering Study 92-34. Prepared for the Department of the Navy Civil Branch. December 1992.

Pagenkopt, Gordon K. 1978. Introduction to Natural Water Chemistry. Marcel Dekker, Inc.

USEPA. 1988. United States Environmental Protection Agency. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-89/004.

USEPA. 1989(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-002. December 1989.

USEPA. 1989(b). United States Environmental Protection Agency. Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-89-043. May 1989.

USEPA. 1991. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

Water and Air Research. 1983. Water and Air Research, Inc. Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for Naval Energy and Environmental Support Activity.

SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF SITE BACKGROUND AND BASE
BACKGROUND INORGANIC LEVELS IN SURFACE SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO - 0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	3,770 - 7,180	17.7 - 9,570
Antimony	ND	0.33 - 8
Arsenic	ND - 3.9	0.065 - 3.9
Barium	9.7 - 12	0.65 - 20.8
Beryllium	ND - 0.26	0.02 - 0.26
Cadmium	ND	0.04 - 0.6
Calcium	ND	4.25 - 10,700
Chromium	3.8 - 10.6	0.33 - 12.5
Cobalt	ND	0.185 - 2.355
Copper	ND - 2.3	0.5 - 87.2
Iron	2,170 - 7,510	69.7 - 9,640
Lead	6.4 - 8.7	0.47 - 142
Magnesium	ND	2.55 - 610
Manganese	ND	0.87 - 66
Mercury	ND	0.01 - 0.08
Nickel	ND	0.6 - 3.55
Potassium	ND	1 - 416
Selenium	ND - 1.3	0.075 - 1.3
Silver	ND	0.0435 - 4.3
Sodium	ND	4.7 - 126
Vanadium	5.4 - 18.2	0.305 - 18.2
Zinc	ND	0.3 - 28.3

ND = Not Detected

TABLE 4-2

SUMMARY OF SITE BACKGROUND AND BASE BACKGROUND INORGANIC LEVELS IN SUBSURFACE SOIL OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	581 - 1,700	16.9 - 11,000
Antimony	ND	0.355 - 6.9
Arsenic	ND	0.033 - 15.4
Barium	10.8 - 22.6	0.65 - 22.6
Beryllium	ND	0.01 - 0.31
Cadmium	ND	0.155 - 1.2
Calcium	ND	4.75 - 4,410
Chromium	3.4 - 6.2	0.65 - 66.4
Cobalt	ND	0.175 - 7
Copper	ND	0.47 - 9.5
Iron	571 - 1,620	63.3 - 90,500
Lead	1.1 - 3	0.465 - 21.4
Magnesium	ND	2.85 - 852
Manganese	ND	0.395 - 19.9
Mercury	ND	0.01 - 0.68
Nickel	ND	0.45 - 4.7
Potassium	ND	1.05 - 1,250
Selenium	ND	0.085 - 2.4
Silver	ND	0.175 - 1
Sodium	ND	5.4 - 141
Vanadium	2.3 - 3.1	0.34 - 69.4
Zinc	ND	0.32 - 26.6

ND = Not Detected

TABLE 4-3

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SURFACE WATER OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Total Metals	Average (µg/L)	Minimum Positive Detect (µg/L)	Maximum Positive Detect (µg/L)
Aluminum	803.4	178	1350
Antimony	NA	ND	ND
Arsenic	NA	ND	ND
Barium	17.9	13.4	27.2
Beryllium	NA	ND	ND
Cadmium	1.5	3	3
Calcium	13,383.7	600	41,600
Chromium	NA	ND	ND
Cobalt	3.7	8	8
Copper	12.7	4	129
Cyanide	NA	ND	ND
Iron	900.6	413	1,460
Lead	2.6	1.17	10.4
Magnesium	1,138	588	2,410
Manganese	13.4	6.2	40
Mercury	0.1	0.52	0.52
Nickel	105.1	1,380	1,380
Potassium	776.8	341	2,210
Selenium	NA	ND	ND
Silver	NA	ND	ND
Sodium	7,835.7	3,930	22,100
Thallium	NA	ND	ND
Vanadium	4.4	1.9	10
Zinc	18	18	111

NA - Not Applicable
ND - Not Detected

TABLE 4-4

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SEDIMENT OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION, CTO-0274 *MCB CAMP LEJEUNE, NORTH CAROLINA*

Total Metals	Average (mg/kg)	Minimum Positive Detect (mg/kg)	Maximum Positive Detect (mg/kg)
Aluminum	4,800.8	351	9,090
Antimony	NA	ND	ND
Arsenic	0.6	0.702	1.6
Barium	15.5	5.2	37.1
Beryllium	0.2	0.13	0.86
Cadmium	0.4	0.54	1.3
Calcium	2,626.4	216	22,200
Chromium	4.7	2.42	10
Cobalt	1	0.6	1.3
Copper	2,424.1	0.43	53,200
Iron	2,268.6	262	6,940
Lead	22.5	1	314
Magnesium	200.5	21.5	852
Manganese	6.4	1.96	23
Mercury	NA	ND	ND
Nickel	2.4	2.8	5.97
Potassium	157.2	81.1	457
Selenium	0.9	0.862	2.9
Silver	0.7	7.3	7.3
Sodium	130.6	73.6	491
Thallium	0.4	0.29	0.31
Vanadium	6.3	3.3	15.7
Zinc	49.2	12	926

NA - Not Applicable
ND - Not Detected

TABLE 4-5

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Surface Soils	Volatile Organic Compounds				(µg/kg)	(µg/kg)					
		Acetone	NE	NE	150	170	7-EA-SB09-00	2/31	NA	NA	East Area
		2-Butanone	NE	NE	52	52	7-EA-SB09-00	1/31	NA	NA	East Area
		Trichloroethene	NE	NE	1J	1J	7-EA-SB06-00	1/30	NA	NA	East Area
		Toluene	NE	NE	9J	46J	7-EA-SB09-00	3/30	NA	NA	East Area, North Area
	Semivolatile Organic Compounds	Phenol	NE	NE	170NJ	170NJ	7-EA-SB10-00	1/32	NA	NA	East Area
		Acenaphthene	NE	NE	37J	37J	7-NA-SB04-00	1/32	NA	NA	North Area
		Fluorene	NE	NE	38J	38J	7-NA-SB04-00	1/32	NA	NA	North Area
		Phenanthrene	NE	NE	63J	400	7-NA-SB04-00	3/32	NA	NA	North Area, East Area
		Anthracene	NE	NE	100J	100J	7-NA-SB04-00	1/32	NA	NA	North Area
		Carbazole	NE	NE	110J	110J	7-NA-SB04-00	1/32	NA	NA	North Area
		di-n-Butyl-phthalate	NE	NE	170J	170J	7-SW-SB02-00	1/32	NA	NA	Southwest Area
		Fluoranthene	NE	NE	110J	750	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		Pyrene	NE	NE	85J	580	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		Benzo(a)anthracene	NE	NE	50J	420	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		Chrysene	NE	NE	55J	420	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		bis(2-Ethylhexyl)phthalate	NE	NE	38J	600	7-MW04-00	8/32	NA	NA	North Area, East Area
		Benzo(b)fluoranthene	NE	NE	45J	380	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		Benzo(k)fluoranthene	NE	NE	60J	370	7-NA-SB04-00	4/32	NA	NA	North Area, East Area
		Benzo(a)pyrene	NE	NE	55J	340J	7-NA-SB04-00	3/32	NA	NA	North Area, East Area
		Indeno(1,2,3-cd)pyrene	NE	NE	41J	250J	7-NA-SB04-00	3/32	NA	NA	North Area, East Area
		Benzo(g,h,i)perylene	NE	NE	44J	220J	7-NA-SB04-00	2/32	NA	NA	North Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Surface Soils (Cont.)	Pesticides/ PCBs				(µg/kg)	(µg/kg)					
		delta-BHC	NE	NE	3.3NJ	3.3NJ	7-SWA-SB03-00	1/30	NA	NA	Southwest Area
		Aldrin	NE	NE	3	3	7-NA-SB04-00	1/30	NA	NA	North Area
		Dieldrin	NE	NE	4.7J	57	7-NA-SB04-00	7/30	NA	NA	North Area, East Area, Community Center
		4,4'-DDE	NE	NE	3.8	65J	7-MW05-00	7/30	NA	NA	Southwest Area, North Area, East Area
		Endosulfan II	NE	NE	7.9J	37NJ	7-SWA-SB03-00	3/30	NA	NA	Southwest Area, North Area
		4,4'-DDD	NE	NE	4.3J	94J	7-MW05-00	3/31	NA	NA	Southwest Area, North Area
		4,4'-DDT	NE	NE	14J	280J	7-MW05-00	4/30	NA	NA	Southwest Area, North Area, East Area
		Endrin aldehyde	NE	NE	39NJ	39NJ	7-SWA-SB03-00	1/30	NA	NA	Southwest Area
		alpha-Chlordane	NE	NE	11J	26J	7-NA-SB04-00	3/30	NA	NA	North Area, Southwest Area
		gamma-Chlordane	NE	NE	6.9J	22J	7-NA-SB04-00	3/30	NA	NA	North Area, Southwest Area
		Aroclor 1254	NE	NE	43J	320	7-EPCB-SB09-00	1/48	NA	NA	Southwest Area
		Aroclor 1260	NE	NE	80NJ	80NJ	7-NA-SB04-00	1/48	NA	NA	North Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Surface Soils (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	17.7 - 9,570	690J	12,900J	7-CC-SB02-00	32/32	NA	4[a]	Community Center, East Area, Southwest Area
		Arsenic	NE	0.065 - 3.9	1.1	5.1J	7-CC-SB02-00	6/32	NA	1	Community Center
		Barium	NE	0.65 - 20.8	5.2	172	7-EA-SB07-00	29/32	NA	6	East Area, North Area, Southwest Area
		Beryllium	NE	0.02 - 0.26	0.15	1.9	7-EA-SB10-00	10/32	NA	7	East Area, North Area, Southwest Area
		Calcium	NE	4.25 - 10,700	72.7	206,000J	7-SWA-SB05-00	19/32	NA	3	Southwest Area, North Area
		Chromium	NE	0.33 - 12.5	2.5	23.1J	7-CC-SB02-00	23/32	NA	4	Community Center, East Area, Southwest Area
		Cobalt	NE	0.185 - 2.355	1.6	4.4	7-EA-SB10-00	2/32	NA	1	East Area
		Copper	NE	0.5 - 87.2	2.6	7.6	7-MW05-00	7/32	NA	0	--
		Iron	NE	69.7 - 9,640	14.4	17,600J	7-CC-SB02-00	32/32	NA	1	Community Area
		Lead	NE	0.47 - 142	4.2	2,620	7-NA-SB03-00	29/32	NA	1	North Area
		Magnesium	NE	2.55 - 610	36.1	1,110	7-MW05-00	15/32	NA	2	Southwest Area, North Area
		Manganese	NE	0.87 - 66	1.7J	42.9	7-MW05-00	18/32	NA	0	--
		Mercury	NE	0.01 - 0.08	0.23	0.23	7-SWA-SB04-00	2/32	NA	2	Southwest Area, East Area
		Nickel	NE	0.6 - 3.55	6.3	13.8	7-EA-SB10-00	2/32	NA	2	East Area, Southwest Area
		Potassium	NE	1 - 416	246J	776J	7-CC-SB02-00	5/32	NA	1	Community Center
		Selenium	NE	0.075 - 1.3	1.1	2.1	7-EA-SB10-00	7/32	NA	3	East Area, Community Center, North Area
		Silver	NE	0.0435 - 4.3	1.2	1.2	7-NA-SB07-00	1/32	NA	0	--
		Sodium	NE	4.7 - 126	24.8	153	7-MW05-00	15/32	NA	1	Southwest Area
		Vanadium	NE	0.305 - 18.2	2.5	41J	7-CC-SB02-00	28/32	NA	5	Community Center, East Area, Southwest Area
		Zinc	NE	0.3 - 28.3	7.8	58.9J	7-MW05-00	15/32	NA	3	Southwest Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Sub-surface Soils					(µg/kg)	(µg/kg)					
	Volatile Organic Compounds	Methylene Chloride	NE	NE	12J	12J	7-SWA-SB04-01	1/30	NA	NA	Southwest Area
		Acetone	NE	NE	13	2,300	7-EA-SB05-07	11/30	NA	NA	Scattered
	Semivolatile Organic Compounds	Naphthalene	NE	NE	120J	120J	7-NA-SB07-02	1/29	NA	NA	North Area
		2-Methyl-naphthalene	NE	NE	48J	48J	7-NA-SB07-02	1/29	NA	NA	North Area
		Acenaphthene	NE	NE	190J	190J	7-NA-SB07-02	1/29	NA	NA	North Area
		Dibenzofuran	NE	NE	120J	120J	7-NA-SB07-02	1/29	NA	NA	North Area
		Fluorene	NE	NE	260J	260J	7-NA-SB07-02	1/29	NA	NA	North Area
		Phenanthrene	NE	NE	1,700	1,700	7-NA-SB07-02	1/29	NA	NA	North Area
		Anthracene	NE	NE	350J	350J	7-NA-SB07-02	1/29	NA	NA	North Area
		Carbazole	NE	NE	450	450	7-NA-SB07-02	1/29	NA	NA	North Area
		di-n-Butyl-phthalate	NE	NE	42J	220J	7-SWA-SB02-04	3/29	NA	NA	Southwest Area
		Fluoranthene	NE	NE	1,800	1,800	7-NA-SB07-02	1/29	NA	NA	North Area
		Pyrene	NE	NE	1,300	1,300	7-NA-SB07-02	1/29	NA	NA	North Area
		Benzo(a)anthracene	NE	NE	740	740	7-NA-SB07-02	1/29	NA	NA	North Area
		Chrysene	NE	NE	770	770	7-NA-SB07-02	1/29	NA	NA	North Area
		bis(2-Ethylhexyl)phthalate	NE	NE	39J	80J	7-NA-SB04-02	5/29	NA	NA	North Area, Southwest Area
		Benzo(b)fluoranthene	NE	NE	690	690	7-NA-SB07-02	1/29	NA	NA	North Area
		Benzo(k)fluoranthene	NE	NE	610	610	7-NA-SB07-02	1/29	NA	NA	North Area
		Benzo(a)pyrene	NE	NE	460	460	7-NA-SB07-02	1/29	NA	NA	North Area
		Indeno(1,2,3-cd)pyrene	NE	NE	390	390	7-NA-SB07-02	1/29	NA	NA	North Area
		Dibenzo(a,h)anthracene	NE	NE	210J	210J	7-NA-SB07-02	1/29	NA	NA	North Area
		Benzo(g,h,i)perylene)	NE	NE	330J	330J	7-NA-SB07-02	1/29	NA	NA	North Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Sub-surface Soils (Cont.)					(µg/kg)	(µg/kg)					
	Pesticides/ PCBs	delta-BHC	NE	NE	3J	3J	7-EA-SB06-01	1/28	NA	NA	East Area
		Aldrin	NE	NE	6.3	6.3	7-SWA-TP02	1/28	NA	NA	Southwest Area
		Dieldrin	NE	NE	17	98J	7-SWA-SB04-01	3/28	NA	NA	Southwest Area
		4,4'-DDE	NE	NE	0.82J	38	7-SWA-SB04-01	4/28	NA	NA	Southwest Area
		Endrin	NE	NE	4.8J	4.8J	7-SWA-SB04-01	1/28	NA	NA	Southwest Area
		Endosulfan II	NE	NE	17J	19J	7-SWA-SB04-01	2/28	NA	NA	Southwest Area, East Area
		4,4-'DDD	NE	NE	1.9J	15J	7-SWA-SB04-01	4/28	NA	NA	Southwest Area
		4,4'-DDT	NE	NE	1.7J	19J	7-SWA-SB04-01	2/28	NA	NA	Southwest Area
		Endrin Aldehyde	NE	NE	8.1J	8.1J	7-EA-SB06-01	1/28	NA	NA	East Area
		alpha-chlordane	NE	NE	120J	120J	7-SWA-SB04-01	1/28	NA	NA	Southwest Area
		gamma-chlordane	NE	NE	2.9	110J	7-SWA-SB04-01	2/28	NA	NA	Southwest Area
		Aroclor 1260	NE	NE	91J	91J	7-SWA-SB04-01	1/44	NA	NA	Southwest Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Sub-surface Soils (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NA	16.9 - 11,000	607	11,600	7-SWA-TP02	29/29	NA	1[2]	Southwest Area
		Arsenic	NA	0.033 - 15.4	2.4J	2.6	7-NA-SB09-02	2/29	NA	0	--
		Barium	NA	0.65 - 22.6	5.7	147	7-SWA-SB01-04	28/29	NA	11	Scattered
		Beryllium	NA	0.01 - 0.31	0.08	0.74	7-SWA-SB01-04	7/29	NA	2	Southwest Area, North Area
		Calcium	NA	4.75 - 4,410	45.5	93,300	7-SWA-TP05	16/29	NA	4	Southwest Area, North Area
		Chromium	NA	0.65 - 66.4	2.1	15.2	7-SWA-TP02	26/29	NA	0	--
		Copper	NA	0.47 - 9.5	0.43J	74.7	7-NA-SB04-02	6/29	NA	2	North Area, Southwest Area
		Iron	NA	63.3 - 90,500	163	8,000	7-NA-SB09-02	26/29	NA	0	--
		Lead	NA	0.465 - 21.4	1	18.3	7-SWA-SB04-01	24/29	NA	0	--
		Magnesium	NA	2.85 - 852	24.3	662	7-NA-SB04-02	17/29	NA	0	--
		Manganese	NA	0.395 - 19.9	1.7	47.6	7-NA-SB04-02	18/29	NA	1	North Area
		Mercury	NA	0.01 - 0.68	0.56	0.56	7-SWA-SB04-01	1/29	NA	0	--
		Nickel	NA	0.45-4.7	6.8	6.8	7-NA-SB04-02	1/29	NA	1	North Area
		Potassium	NA	1.05 - 1,250	369	462J	7-NA-SB04-02	2/29	NA	0	--
		Selenium	NA	0.085 - 2.4	1.2	1.2	7-NA-SB09-02	1/29	NA	0	--
		Sodium	NA	5.4 - 141	22.7	81.2	7-NA-SB04-02	9/29	NA	0	--
		Vanadium	NA	0.34 - 69.4	1.5	18.2	7-NA-SB09-02	22/29	NA	0	--
		Zinc	NA	0.32 - 26.6	4.5	135	7-SWA-SB04-01	11/29	NA	2	Southwest Area, North Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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	
Ground-water	Volatile Organic Compounds	Chloroform	80[2]	0.19	4J	7J	7-MW02-01	2/8	0	2	North Area, Southwest Area
		2-Hexanone	NE	NE	1J	1J	7-MW05-01	1/8	NA	NA	Southwest Area
		Toluene	1,000	1,000	4J	4J	7-TW01-01	1/8	NA	0	--
	Semivolatile Organic Compounds	Phenol	NE	300	4J	4J	7-TW01-01	1/8	0	0	--
		4-Methylphenol	NE	NE	10	10	7-TW01-01	1/8	NA	NA	--
	Pesticides/ PCBs	Dieldrin	NE	NE	0.41	0.41	7-MW02-01	1/8	NA	NA	--
	Inorganics	Aluminum	50-200[3]	NE	1,660	88,800	7-MW03-01	5/8	5	NA	Scattered
		Barium	2,000	2,000	3.2J	370	7-MW03-01	8/8	0	0	--
		Beryllium	4.0	NE	1.2	3	7-MW03-01	3/8	0	NA	--
		Calcium	NE	NE	590	174,000	7-TW02-01	8/8	NA	NA	--
		Chromium	100	50	11.7	104	7-MW03-01	4/8	1	1	Southwest Area
		Copper	1,300[4]	1,000	10.6	20.8	7-MW03-01	2/8	0	0	--
		Iron	300[3]	300	969	25,400	7-MW-3-01	5/8	5	5	Scattered
		Lead	15[4]	15	27.1J	67.5J	7-MW03-01	3/8	3	3	Scattered
		Magnesium	NE	NE	1,860	13,000	7-TW02-01	8/8	NA	NA	--
		Manganese	50[3]	50	5J	445	7-TW02-01	8/8	2	2	North Area, Southwest Area
		Mercury	2.0	1.1	0.32	0.4	7-MW03-01	2/8	0	0	--
		Potassium	NE	NE	1,020	6,430	7-TW02-01	8/8	NA	NA	--
		Selenium	50	50	9.4	9.4	7-MW03-01	1/8	0	0	--
		Sodium	NE	NE	4,420	39,800	7-MW01-01	8/8	NA	NA	--
		Vanadium	NE	NE	24.1	167	7-MW03-01	3/8	NA	NA	--
		Zinc	5,000[2]	2,100	167	180	7-TW02-01	2/8	0	0	--

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
			AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
Surface Water	Volatile Organic Compounds	Chloroform	5.7	NE	1J	3J	7-WT-SW01	3/13	0	NA	Western Tributary
		2-Butanone	NE	NE	2J	2J	7-NC-SW03	1/13	NA	NA	Northeast Creek
		2-Hexanone	NE	NE	1J	1J	7-NC-SW03	1/13	NA	NA	Northeast Creek
		Xylene (total)	2	NE	1J	1J	7-ET-SW02	1/13	0	NA	Eastern Tributary
	Semivolatile Organic Compounds	bis(2-Ethylhexyl)phthalate	1.8	NE	77B	77B	7-ET-SW02	1/13	1	NA	Eastern Tributary
	Pesticides/ PCBs	Dieldrin	0.00014	0.000144	0.4	0.5	7-WT-SW01	2/13	2	2	Western Tributary
		Endrin Ketone	NE	NE	0.12	0.13	7-WT-SW02	2/13	NA	NA	Western Tributary
	Inorganics	Aluminum	NE	NE	77.1	2,200J	7-NC-SW03	13/13	0	NA	Widespread
		Arsenic	0.018	NE	2.1J	2.4J	7-NC-SW02	2/13	2	NA	Northeast Creek
		Barium	2,000	NE	16.4	37.2	7-NC-SW03	13/13	0	NA	Widespread
		Calcium	NE	NE	5.940	171,000J	7-NC-SW03	13/13	NA	NA	Widespread
		Copper	NE	NE	12.3	12.3	7-ET-SW01	1/13	NA	NA	Eastern Tributary
		Iron	300	NE	175J	2,160J	7-NC-SW03	13/13	9	NA	Widespread
		Lead	NE	NE	2.5J	27.1	7-NC-SW03	10/13	NA	NA	Widespread
		Magnesium	4	NE	1,680	573,000	7-NC-SW03	13/13	NA	NA	Widespread
		Manganese	50	NE	10.1	68.9	7-NC-SW03	13/13	1	NA	Widespread
		Potassium	NE	NE	39,600	179,000	7-NC-SW03	9/13	NA	NA	Scattered
		Silver	NE	NE	5.1J	9.6	7-NC-SW03	6/13	NA	NA	Scattered
		Sodium	NE	NE	7,100	4,650,000	7-NC-SW01	13/13	NA	NA	Widespread
		Zinc	NE	NE	6.4	168J	7-WT-SW01	9/13	NA	NA	Scattered

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
			NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
Sediments	Volatile Organic Compounds	2-Butanone	NE	NE	1J	250J	7-ET-SD01-06	14/27	NA	NA	Scattered
		Toluene	NE	NE	10J	39J	7-MA-SD04-612	9/27	NA	NA	Scattered
		Styrene	NE	NE	28J	28J	7-MA-SD02-06	1/27	NA	NA	Swamp Area
	Semivolatile Organic Compounds	Acenaphthylene	NE	NE	250J	250J	7-MA-SD04-06	1/27	NA	NA	Swamp Area
		Dibenzofuran	NE	NE	130J	130J	7-DD-SD02-06	1/27	NA	NA	Drainage Ditch
		Phenanthrene	225	1,380	91J	210J	7-MA-SD04-06	3/27	0	0	--
		Anthracene	85	960	350J	350J	7-MA-SD04-06	1/27	1	0	--
		Di-n-Butyl-phthalate	NE	NE	76J	1,300J	7-MA-SD04-06	9/27	NA	NA	Scattered
		Fluoranthene	600	3,600	42J	450J	7-MA-SD04-06	5/27	0	0	--
		Pyrene	350	2,200	43J	430J	7-MA-SD04-06	6/27	1	0	Swamp Area
		Butyl benzyl phthalate	NE	NE	47J	47J	7-NC-SD04-612 & 7-WT-SD03-06	2/27	NA	NA	Northeast Creek, Western Tributary
		3,3'-Dichlorobenzidine	NE	NE	110J	110J	7-DD-SD02-06	1/27	NA	NA	Drainage Ditch
		Benzo(a)anthracene	230	1,600	74J	74J	7NC-SD04-612	1/27	0	0	--
		Chrysene	400	2,800	70J	320J	7-MA-SD04-06	3/27	0	0	--
		bis(2-Ethylhexyl)phthalate	NE	NE	510	810	7-WT-SD03-06	2/27	NA	NA	Western Tributary
		di-n-Octylphthalate	NE	NE	500J	500J	7-NC-SD05-06	1/27	NA	NA	Northeast Creek
		Benzo(b)fluoranthene	NE	NE	46J	270NJ	7-MA-SD04-06	3/27	NA	NA	Swamp Area
		Benzo(k)fluoranthene	NE	NE	57J	230NJ	7-MA-SD04-06	3/27	NA	NA	Swamp Area
		Benzo(a)pyrene	400	2,500	110J	11J	7-DD-SD02-06	1/27	0	0	--
		Indeno(1,2,3-cd)pyrene	NE	NE	53J	53J	7-NC-SD04-612	1/27	NA	NA	Northeast Creek
		Benzo(g,h,i)perylene	NE	NE	65J	65J	7-DD-SD02-06	1/27	NA	NA	Drainage Ditch

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Sediments (Cont.)			NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
	Pesticides/ PCBs	Aldrin	NE	NE	3.1J	3.1J	7-DD-SD02-06	1/26	NA	NA	Drainage Ditch
		Dieldrin	0.02	8	5.4	71	7-WT-SD01-06	8/26	8	5	Scattered
		4,4'-DDE	2	15	4.5	180J	7-MA-SD04-06	13/26	13	9	Scattered
		4,4'-DDD	2	20	4.3	120J	7-DD-SD02-06	11/26	11	8	Scattered
		4,4'-DDT	1	7	2.3J	110J	7-DD-SD02-06	7/26	7	6	Scattered
		Endrin Ketone	NE	NE	6.5J	6.5J	7-DD-SD02-06	1/26	NA	NA	Drainage Ditch
		alpha-Chlordane	NE	NE	2.7	42J	7-MA-SD01-06	11/26	NA	NA	Scattered
		gamma-Chlordane	NE	NE	4.7J	29J	7-MA-SD01-06	5/26	NA	NA	Scattered
		Aroclor 1260	NE	NE	450J	450J	7-MA-SD01-06	1/26	NA	NA	Swamp Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
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
Sediments (Cont.)			NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	320J	10,500	7-MA-SD01-06	27/27	NA	NA	Widespread
		Arsenic	8.2	70	0.8	3	7-ET-SD02-06	3/27	0	0	--
		Barium	NE	NE	1.4	270	7-ET-SD01-06	27/27	NA	NA	Widespread
		Beryllium	NE	NE	0.28	8	7-ET-SD01-06	4/27	NA	NA	--
		Calcium	NE	NE	299	39,500	7-NC-SD06-06	27/27	NA	NA	Widespread
		Chromium	81	370	2.9	19.4	7-MA-SD01-06	11/27	0	0	--
		Copper	70	390	3.2	95.8	7-MA-SD01-06	7/27	1	0	Swamp Area
		Iron	NE	NE	197	6,060	7-MA-SD01-06	27/27	NA	NA	Widespread
		Lead	46.7	218	3.9J	90.8	7-MA-SD03-06	27/27	6	0	Scattered
		Magnesium	NE	NE	138	13,900	7-NC-SD01-06	25/27	NA	NA	Widespread
		Manganese	NE	NE	1.9	30.6	7-MA-SD01-06	27/27	NA	NA	Widespread
		Mercury	0.15	0.71	1.6	2.6	7-MA-SD01-06	2/27	2	2	Swamp Area
		Potassium	NE	NE	1,540	1,780	7-MA-SD01-06	3/27	NA	NA	Swamp Area
		Selenium	NE	NE	23.4	23.4	7-ET-SD01-06	1/27	NA	NA	Eastern Tributary
		Sodium	NE	NE	29.2	48,700	7-NC-SD01-06	27/27	NA	NA	Widespread
		Thallium	NE	NE	0.61J	4.9J	7-NC-SD05-612	6/27	NA	NA	Scattered
		Vanadium	NE	NE	2.9	37.5	7-ET-SD01-06	14/27	NA	NA	Scattered
		Zinc	150	410	2.9	536	7-MA-SD01-06	26/27	2	2	Swamp Area

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

(1) Detections compared to maximum base background concentrations.
(2) 1994 Proposed rule for Disinfectants and Disinfectant By-Products: Total for all Trihalomethanes cannot exceed the 80 ppb level.
(3) SCML = Secondary Maximum Contaminant Level.
(4) Action Level.
(5) Shaded boxes indicate detections above comparison criteria

NE = No Criteria Established
NA = Not Applicable
NJ = Estimated/tentative value
J = Estimated value
ARAR - Applicable Relevant Appropriate Requirement
MCL - Maximum Contaminant Level
MCWQS - North Carolina Water Quality Standard
AWQC - Ambient Water Quality Standard
µg/L - microgram per liter (ppb)
µg/kg - microgram per kilogram (ppb)
mg/kg - milligram per kilogram (ppm)
NOAA ER-L - National Oceanic Atmospheric Administration Effective Range - Low
NOAA ER-M - National Oceanic Atmospheric Administration Effective Range -Median
"--" - Undefined

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-CC-SB02-00	7-EA-SB01-00	7-EA-SB02-00	7-EA-SB03-00	7-EA-SB04-00	7-EA-SB06-00	7-EA-SB07-00	7-EA-SB09-00
Laboratory Sample ID:		AC5468	AC5347	AC5472	AC5337	AC5488	AC5484	AC5311	AC5325
Date Sampled:		10/24/94	10/23/94	10/25/94	10/23/94	10/25/94	10/25/94	10/22/94	10/22/94
	UNITS								
VOLATILES									
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	150	170
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND	52
Trichloroethene	UG/KG	ND	ND	ND	ND	ND	1 J	ND	ND
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND	46 J
SEMIVOLATILES									
Phenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	63 J	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	200 J	ND	110 J	ND	ND	ND	ND
Pyrene	UG/KG	ND	140 J	ND	85 J	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	86 J	ND	50 J	ND	ND	ND	ND
Chrysene	UG/KG	ND	96 J	ND	55 J	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	73 J	58 J	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	91 J	ND	45 J	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	77 J	ND	60 J	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	61 J	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	47 J	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-CC-SB02-00	7-EA-SB01-00	7-EA-SB02-00	7-EA-SB03-00	7-EA-SB04-00	7-EA-SB06-00	7-EA-SB07-00	7-EA-SB09-00
Laboratory Sample ID:		AC5468	AC5347	AC5472	AC5337	AC5488	AC5484	AC5311	AC5325
Date Sampled:		10/24/94	10/23/94	10/25/94	10/23/94	10/25/94	10/25/94	10/22/94	10/22/94
	UNITS								
PESTICIDES/PCBs									
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	16 J	4.7 J	ND	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	11	ND	12	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-EPCB-SB09-00	7-EA-SB10-00	7-MW04-00	7-MW05-00	7-NA-SB03-00	7-NA-SB04-00	7-NA-SB07-00	7-NA-SB09-00
Laboratory Sample ID:		AH0968	AC5327	AC5450	Q41118003	AC5287	AC5454	AC5315	AC5462
Date Sampled:		10/06/95	10/22/94	10/24/94	11/03/94	10/23/94	10/24/94	10/22/94	10/24/94
	UNITS								
VOLATILES									
Acetone	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
2-Butanone	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
Phenol	UG/KG	NA	170 NJ	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	NA	ND	ND	ND	ND	37 J	ND	ND
Fluorene	UG/KG	NA	ND	ND	ND	ND	38 J	ND	ND
Phenanthrene	UG/KG	NA	ND	ND	ND	ND	400	87 J	ND
Anthracene	UG/KG	NA	ND	ND	ND	ND	100 J	ND	ND
Carbazole	UG/KG	NA	ND	ND	ND	ND	110 J	ND	ND
di-n-Butylphthalate	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	NA	ND	ND	ND	ND	750	130 J	ND
Pyrene	UG/KG	NA	ND	ND	ND	ND	580	110 J	ND
Benzo[a]anthracene	UG/KG	NA	ND	ND	ND	ND	420	60 J	ND
Chrysene	UG/KG	NA	ND	ND	ND	ND	420	75 J	ND
bis(2-Ethylhexyl)phthalate	UG/KG	NA	ND	600	560 J	ND	44 J	ND	ND
Benzo[b]fluoranthene	UG/KG	NA	ND	ND	ND	ND	380	66 J	ND
Benzo[k]fluoranthene	UG/KG	NA	ND	ND	ND	ND	370	64 J	ND
Benzo[a]pyrene	UG/KG	NA	ND	ND	ND	ND	340 J	55 J	ND
Indeno[1,2,3-cd]pyrene	UG/KG	NA	ND	ND	ND	ND	250 J	41 J	ND
Benzo[g,h,i]perylene	UG/KG	NA	ND	ND	ND	ND	220 J	44 J	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-EPCB-SB09-00	7-EA-SB10-00	7-MW04-00	7-MW05-00	7-NA-SB03-00	7-NA-SB04-00	7-NA-SB07-00	7-NA-SB09-00
Laboratory Sample ID:		AH0968	AC5327	AC5450	Q41118003	AC5287	AC5454	AC5315	AC5462
Date Sampled:		10/06/95	10/22/94	10/24/94	11/03/94	10/23/94	10/24/94	10/22/94	10/24/94
	UNITS								
PESTICIDES/PCBs									
delta-BHC	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	NA	ND	ND	ND	ND	3	ND	ND
Dieldrin	UG/KG	NA	9.6 J	ND	14 J	8.5 J	57	ND	ND
4,4'-DDE	UG/KG	NA	17 J	ND	65 J	50 J	ND	ND	ND
Endosulfan II	UG/KG	NA	ND	ND	ND	ND	ND	ND	9.3 J
4,4'-DDD	UG/KG	NA	ND	ND	94 J	9.8 J	ND	ND	ND
4,4'-DDT	UG/KG	NA	14 J	ND	280 J	28 J	ND	ND	ND
Endrin aldehyde	UG/KG	NA	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	NA	ND	ND	ND	12 J	26 J	ND	ND
gamma-Chlordane	UG/KG	NA	ND	ND	ND	6.9 J	22 J	ND	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	320	ND	ND	ND	ND	80 NJ	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NA-SB10-00	7-NA-SB12-00	7-SWA-SB01-00	7-SWA-SB02-00	7-SWA-SB03-00	7-SWA-SB04-00	7-SWA-SB05-00
Laboratory Sample ID:		AC5319	AC5321	AC4834	AC4928	AC4828	AC4935	AC4830
Date Sampled:		10/22/94	10/22/94	10/21/94	10/22/94	10/21/94	10/22/94	10/21/94
	UNITS							
VOLATILES								
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	9 J	12 J	ND	ND	ND	ND	ND
SEMIVOLATILES								
Phenol	UG/KG	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	170 J	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	38 J	ND	61 J	170 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NA-SB10-00	7-NA-SB12-00	7-SWA-SB01-00	7-SWA-SB02-00	7-SWA-SB03-00	7-SWA-SB04-00	7-SWA-SB05-00
Laboratory Sample ID:		AC5319	AC5321	AC4834	AC4928	AC4828	AC4935	AC4830
Date Sampled:		10/22/94	10/22/94	10/21/94	10/22/94	10/21/94	10/22/94	10/21/94
	UNITS							
PESTICIDES/PCBs								
delta-BHC	UG/KG	ND	ND	ND	ND	3.3 NJ	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	ND	ND	6.3 J	ND
4,4'-DDE	UG/KG	ND	ND	4.9	ND	ND	3.8	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	37 NJ	7.9 J	ND
4,4'-DDD	UG/KG	4.3 J	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	42 NJ	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	39 NJ	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	11 J	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	8.1 J	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	43 J	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected
NA - not analyzed
NJ - estimated/tentative identification

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-CC-SB01-00	7-CC-SB02-00	7-EA-SB01-00	7-EA-SB02-00	7-EA-SB03-00	7-EA-SB04-00	7-EA-SB05-00	7-EA-SB06-00
Laboratory Sample ID:		AC5466	AC5468	AC5347	AC5472	AC5337	AC5488	AC5303	AC5484
Date Sampled:		10/24/94	10/24/94	10/23/94	10/25/94	10/23/94	10/25/94	10/24/94	10/25/94
	UNITS								
Aluminum	MG/KG	7040	12900 J	7670	3740	6990	2740	11200	7470
Arsenic	MG/KG	2.3	5.1 J	ND	ND	ND	ND	3.8	3.2
Barium	MG/KG	13.4	18.8	18.1	12.1	16.5	19.2	13.3	12.7
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	0.28	ND
Calcium	MG/KG	1290	3200 J	ND	329	ND	777	ND	1420
Chromium	MG/KG	9.3	23.1 J	9.1	3.7	9.5	3.6 J	17.2	11.1
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	ND	ND	ND	ND	ND	3	ND
Iron	MG/KG	7560	17600 J	5870	2810	5040	2650	8980	8500
Lead	MG/KG	9.9	10.2	13.5	14.9	8.5	9.2	11.5	7.6
Magnesium	MG/KG	223	521 J	ND	126	ND	131	ND	244
Manganese	MG/KG	8.4	9.2	17.4	7.1	ND	4.7	ND	8.9
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	776 J	ND	ND	ND	ND	ND	303 J
Selenium	MG/KG	1.3	ND	ND	1.1	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	28.9	57.2	ND	24.8 J	ND	39.8	ND	41.2
Vanadium	MG/KG	13.9	41 J	15.3	6.6	13	6.8	22.2	17.8
Zinc	MG/KG	11.4	22.4 J	ND	13.4	ND	10.2	ND	10.3

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-EA-SB07-00	7-EA-SB08-00	7-EA-SB09-00	7-EA-SB10-00	7-EA-SB11-00	7-MW04-00	7-MW05-00	7-NA-SB01-00	7-NA-SB02-00
Laboratory Sample ID:		AC5311	AC5313	AC5325	AC5327	AC5329	AC5450	Q41118003A	AC5458	AC5339
Date Sampled:		10/22/94	10/22/94	10/22/94	10/22/94	10/22/94	10/24/94	11/02/94	10/24/94	10/23/94
	UNITS									
Aluminum	MG/KG	6510	1530	8770	3900	10300	3650	9960 J	6710	2360
Arsenic	MG/KG	ND	ND	ND	ND	2.6	ND	1.1	ND	ND
Barium	MG/KG	172	97.8	171	ND	ND	8.5	23.7	9.7	6.6
Beryllium	MG/KG	1.6	ND	1.1	1.9	ND	ND	0.15	ND	ND
Calcium	MG/KG	ND	ND	ND	2920	512	72.7	4410	171	ND
Chromium	MG/KG	ND	ND	10.3	6.4	13.2	ND	13.4 J	9.5	ND
Cobalt	MG/KG	ND	ND	ND	4.4	ND	ND	1.6	ND	ND
Copper	MG/KG	ND	ND	ND	5.5	3	ND	7.6	ND	ND
Iron	MG/KG	3110	1430	6500	3510	5860	1330	4850 J	3550	1670
Lead	MG/KG	34	50.6	38.5	44.3	10.8	5.4	17.2 J	11.8	17.3
Magnesium	MG/KG	ND	ND	ND	ND	ND	82	1110	170	ND
Manganese	MG/KG	ND	ND	ND	ND	13.9	7.1	42.9	3.6	ND
Mercury	MG/KG	ND	ND	ND	0.23	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	13.8	ND	ND	6.3	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND	409 J	302 J	ND
Selenium	MG/KG	ND	ND	ND	2.1	ND	ND	ND	1.4	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	32.4	153	50.9	ND
Vanadium	MG/KG	12.2	ND	18.3	10.3	19	2.5	23.8	15.1	3.3
Zinc	MG/KG	ND	ND	ND	ND	ND	8.3	58.9 J	15.2	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NA-SB03-00	7-NA-SB04-00	7-NA-SB05-00	7-NA-SB06-00	7-NA-SB07-00	7-NA-SB08-00	7-NA-SB09-00	7-NA-SB10-00
Laboratory Sample ID:		AC5287	AC5454	AC5343	AC5361	AC5315	AC5353	AC5462	AC5319
Date Sampled:		10/23/94	10/24/94	10/23/94	10/23/94	10/22/94	10/23/94	10/24/94	10/22/94
	UNITS								
Aluminum	MG/KG	3670	2280	2250	3660	6480	5370	5960	1430
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	16.6	11.5	5.2	10.2	28.4	ND	16	24.1
Beryllium	MG/KG	0.27	ND	ND	ND	0.27	ND	ND	ND
Calcium	MG/KG	2180	16500	ND	ND	2470	ND	458	ND
Chromium	MG/KG	6.1	8.4	ND	2.8	8.7	3.9	7.3	ND
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	2.6	ND	ND	ND	4.1	ND	ND	ND
Iron	MG/KG	14.4	2740	1870	1720	4170	1890	4530	850
Lead	MG/KG	2620	ND	4.2	8.2	29.9	4.2	8.9	8.6
Magnesium	MG/KG	ND	906	ND	ND	ND	ND	157	ND
Manganese	MG/KG	ND	24.6	ND	ND	32.9	ND	7.5	ND
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	1.2	ND	1.3	ND	1.9	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	1.2	ND	ND	ND
Sodium	MG/KG	ND	71	ND	ND	ND	ND	31.1	ND
Vanadium	MG/KG	8.5	5.3	4.4	4.7	14	5.6	11.2	ND
Zinc	MG/KG	ND	24.3	ND	ND	ND	ND	12.5	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NA-SB11-00	7-NA-SB12-00	7-SWA-SB01-00	7-SWA-SB02-00	7-SWA-SB03-00	7-SWA-SB04-00	7-SWA-SB05-00
Laboratory Sample ID:		AC5299	AC5321	AC4834	AC4928	AC4828	AC4935	AC4830
Date Sampled:		10/24/94	10/22/94	10/21/94	10/22/94	10/21/94	10/22/94	10/21/94
	UNITS							
Aluminum	MG/KG	1250	1940	4320 J	1680	690 J	6400	2840 J
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	6.5	7.4	11.9	8.7	12.8	19	11.6
Beryllium	MG/KG	0.24	0.29	ND	ND	ND	0.26 J	ND
Calcium	MG/KG	ND	ND	219 J	168	364 J	137000	206000 J
Chromium	MG/KG	2.5	ND	2.6 J	ND	ND	12.4	8.2 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	ND	ND	ND	ND	3.9	ND
Iron	MG/KG	905	2210	1540 J	917	361 J	3500	2050 J
Lead	MG/KG	7.5	5.9	5.8 J	6.5	6.4 J	ND	ND
Magnesium	MG/KG	ND	ND	109	36.1	147	519	594
Manganese	MG/KG	ND	ND	15.6 J	16.5	1.7 J	23.4	25.2 J
Mercury	MG/KG	ND	ND	ND	ND	ND	0.23	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	246 J	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	26.1	26.3	97.6	71.9	84.4
Vanadium	MG/KG	3.5	3.3	4.6	ND	ND	10.4	4
Zinc	MG/KG	ND	ND	8.9 J	7.8	12.4 J	41.5	11.7 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-EA-SB01-07	7-EA-SB03-08	7-EA-SB05-07	7-EA-SB06-01	7-MW04-08	7-MW05-06	7-NA-SB02-08	7-NA-SB03-02
Laboratory Sample ID:		AC5351	AC5349	AC5305	AC5486	AC5452	Q41118004	AC5341	AC5294
Date Sampled:		10/23/94	10/23/94	10/24/94	10/25/94	10/24/94	11/03/94	10/23/94	10/23/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	110	86	2300	ND	ND	ND	63	2000 J
SEMIVOLATILES									
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	100 J	ND	NA
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	47 J	ND	ND	NA
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-EA-SB01-07	7-EA-SB03-08	7-EA-SB05-07	7-EA-SB06-01	7-MW04-08	7-MW05-06	7-NA-SB02-08	7-NA-SB03-02
Laboratory Sample ID:		AC5351	AC5349	AC5305	AC5486	AC5452	Q41118004	AC5341	AC5294
Date Sampled:		10/23/94	10/23/94	10/24/94	10/25/94	10/24/94	11/03/94	10/23/94	10/23/94
	UNITS								
PESTICIDES/PCBs									
delta-BHC	UG/KG	ND	ND	ND	3 J	ND	ND	ND	NA
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Dieldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND	0.82 J	ND	NA
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Endosulfan II	UG/KG	ND	ND	ND	17 J	ND	ND	ND	NA
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	1.9 J	ND	NA
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	1.7 J	ND	NA
Endrin aldehyde	UG/KG	ND	ND	ND	8.1 J	ND	ND	ND	NA
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	NA

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NA-SB03-04	7-NA-SB04-02	7-NA-SB05-08	7-NA-SB06-07	7-NA-SB07-02	7-NA-SB08-09	7-NA-SB12-02	7-SWA-SB02-04
Laboratory Sample ID:		AC5289	AC5456	AC5345	AC5297	AC5317	AC5355	AC5323	AC4932
Date Sampled:		10/23/94	10/24/94	10/23/94	10/23/94	10/22/94	10/23/94	10/22/94	10/22/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	230	ND	13	1100	880	26	130	ND
SEMIVOLATILES									
Naphthalene	UG/KG	ND	ND	ND	ND	120 J	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	48 J	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	190 J	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	120 J	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	260 J	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	1700	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	350 J	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	450	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	220 J
Fluoranthene	UG/KG	ND	ND	ND	ND	1800	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	1300	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	740	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	770	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	80 J	ND	ND	ND	ND	ND	39 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	690	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	610	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	460	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	390	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	210 J	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	330 J	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NA-SB03-04	7-NA-SB04-02	7-NA-SB05-08	7-NA-SB06-07	7-NA-SB07-02	7-NA-SB08-09	7-NA-SB12-02	7-SWA-SB02-04
Laboratory Sample ID:		AC5289	AC5456	AC5345	AC5297	AC5317	AC5355	AC5323	AC4932
Date Sampled:		10/23/94	10/24/94	10/23/94	10/23/94	10/22/94	10/23/94	10/22/94	10/22/94
	UNITS								
PESTICIDES/PCBs									
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-SWA-SB04-01	7-SWA-SB05-02	7-SWA-TP02
Laboratory Sample ID:		AC4937	AC4832	AD2093
Date Sampled:		10/22/94	10/21/94	12/02/94
	UNITS			
VOLATILES				
Methylene chloride	UG/KG	12 J	ND	ND
Acetone	UG/KG	ND	ND	ND
SEMIVOLATILES				
Naphthalene	UG/KG	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND
di-n-Butylphthalate	UG/KG	42 J	ND	ND
Fluoranthene	UG/KG	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	72 J	60 J	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-SWA-SB04-01	7-SWA-SB05-02	7-SWA-TP02
Laboratory Sample ID:		AC4937	AC4832	AD2093
Date Sampled:		10/22/94	10/21/94	12/02/94
	UNITS			
PESTICIDES/PCBs				
delta-BHC	UG/KG	ND	ND	ND
Aldrin	UG/KG	ND	ND	6.3
Dieldrin	UG/KG	98 J	17	61
4,4'-DDE	UG/KG	38	4.9	19
Endrin	UG/KG	4.8 J	ND	ND
Endosulfan II	UG/KG	19 J	ND	ND
4,4'-DDD	UG/KG	15 J	10	10
4,4'-DDT	UG/KG	19 J	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND
alpha-Chlordane	UG/KG	120 J	ND	ND
gamma-Chlordane	UG/KG	110 J	2.9	ND
Aroclor 1260	UG/KG	91 J	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-EA-SB01-07	7-EA-SB02-02	7-EA-SB03-08	7-EA-SB04-01	7-EA-SB05-07	7-EA-SB06-01	7-EA-SB11-02	7-MW04-08
Laboratory Sample ID:		AC5351	AC5478	AC5349	AC5490	AC5305	AC5486	AC5331	AC5452
Date Sampled:		10/23/94	10/25/94	10/23/94	10/25/94	10/24/94	10/25/94	10/22/94	10/24/94
	UNITS								
Aluminum	MG/KG	1060	2740	1560	2350	2430	2470	1420	1190
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	16.5	8.5	78.5	5.7	6.7	8.4	ND	22.2
Beryllium	MG/KG	ND	ND	0.31	ND	ND	ND	ND	ND
Calcium	MG/KG	ND	93.4	ND	45.5	ND	883	ND	83.2
Chromium	MG/KG	3.4	3.2	7.1	4.3	4.2	ND	ND	2.8 J
Copper	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Iron	MG/KG	ND	1690	534	2490	1720	698	1800	163
Lead	MG/KG	1.9	4.9	1.6	5.1	3	4.2	2.4	1.3
Magnesium	MG/KG	ND	61.9	ND	54.7	ND	54.4	ND	24.3
Manganese	MG/KG	ND	2.7	ND	1.7	ND	1.7	ND	3.1
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	28.5	ND	53.1	ND	32.1
Vanadium	MG/KG	ND	4.6	2.4	6.4	3.6	2.8	3.2	ND
Zinc	MG/KG	ND	8.7	ND	7	ND	6.2	ND	15.8

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-MW05-06	7-NA-SB01-05	7-NA-SB02-08	7-NA-SB03-04	7-NA-SB04-02	7-NA-SB05-08	7-NA-SB06-07	7-NA-SB07-02
Laboratory Sample ID:		Q41118004A	AC5460	AC5341	AC5289	AC5456	AC5345	AC5297	AC5317
Date Sampled:		11/03/94	10/24/94	10/23/94	10/23/94	10/24/94	10/23/94	10/23/94	10/22/94
	UNITS								
Aluminum	MG/KG	887 J	1050	828	2560	3700	607	1840	8010
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	6.4	12.9	6.7	23	56.8	10.6	46.3	21.7
Beryllium	MG/KG	0.08	ND	ND	ND	ND	ND	0.34	ND
Calcium	MG/KG	262	74.2	ND	ND	6810	ND	ND	ND
Chromium	MG/KG	2.9 J	2.5 J	2.1	7.1	6.8	ND	6.8	11.2
Copper	MG/KG	0.43 J	ND	ND	ND	74.7	ND	ND	2.7
Iron	MG/KG	398 J	196	325	2080	3270	ND	732	5310
Lead	MG/KG	1.8 J	1.7	1.9	3	14.6	1	2	8
Magnesium	MG/KG	41.8	33	ND	ND	662	ND	ND	ND
Manganese	MG/KG	4.1	2	ND	ND	47.6	ND	ND	13.6
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	6.8	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	462 J	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	81.2	ND	ND	ND
Vanadium	MG/KG	1.5	ND	3.7	5.2	6.8	ND	3.3	14.7
Zinc	MG/KG	ND	6.6	ND	ND	123	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NA-SB08-09	7-NA-SB09-02	7-NA-SB11-03	7-NA-SB12-02	7-SWA-SB01-04	7-SWA-SB02-04	7-SWA-SB04-01	7-SWA-SB05-02
Laboratory Sample ID:		AC5355	AC5464	AC5301	AC5323	AC4836	AC4932	AC4937	AC4832
Date Sampled:		10/23/94	10/24/94	10/24/94	10/22/94	10/21/94	10/22/94	10/22/94	10/21/94
	UNITS								
Aluminum	MG/KG	1270	7240	1280	3490	2550 J	940	6430	5510 J
Arsenic	MG/KG	ND	2.6	ND	ND	ND	ND	ND	ND
Barium	MG/KG	39.2	15.2	6.9	7.1	147	26.9 J	57	11.1
Beryllium	MG/KG	0.24	ND	ND	ND	0.74	0.23	ND	0.21
Calcium	MG/KG	ND	480	ND	ND	776 J	174	9390	1210 J
Chromium	MG/KG	4	9.9	4.7	7	4.7 J	4.2	10	5.7 J
Copper	MG/KG	ND	ND	ND	ND	ND	ND	23.1	ND
Iron	MG/KG	ND	8000	691	1070	569 J	354	3340	2400 J
Lead	MG/KG	1.4	6.5	2.2	4.3	1.6 J	1.2	18.3	6.9 J
Magnesium	MG/KG	ND	208	ND	ND	51.8 J	50.5	410	167
Manganese	MG/KG	ND	2.1	ND	ND	4.6 J	7.6	12.8	6.8 J
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	0.56	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	1.2	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	28.5	ND	ND	23.8	22.7	34.5	32.2
Vanadium	MG/KG	2.2	18.2	3	8.7	ND	ND	12.8	9.2
Zinc	MG/KG	ND	9.9	ND	ND	9.1 J	4.5	135	11 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-SWA-TP01	7-SWA-TP02	7-SWA-TP03	7-SWA-TP04	7-SWA-TP05
Laboratory Sample ID:		AD2095	AD2093	AD2099	AD2101	AD2097
Date Sampled:		12/02/94	12/02/94	12/02/94	12/02/94	12/02/94
	UNITS					
Aluminum	MG/KG	3330	11600	3470	4450	2490
Arsenic	MG/KG	ND	2.4 J	ND	ND	ND
Barium	MG/KG	16.5	22.7	58.5	17.9	70.8
Beryllium	MG/KG	ND	ND	ND	ND	ND
Calcium	MG/KG	ND	66300	332	254	93300
Chromium	MG/KG	5.1	15.2	5.1	5.8	6.5
Copper	MG/KG	ND	ND	2.7	3.2	ND
Iron	MG/KG	2030	6940	1660	2730	1540
Lead	MG/KG	ND	ND	ND	ND	ND
Magnesium	MG/KG	115	562	135	158	294
Manganese	MG/KG	5.6 J	18	10.4 J	5.4 J	17.4
Mercury	MG/KG	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	369	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND
Vanadium	MG/KG	5.5	15.9	4.1	ND	2.5
Zinc	MG/KG	ND	ND	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-MW02-01	7-MW05-01	7-TW01-01
Laboratory Sample ID:		AD1983	AD1620	AC7823
Date Sampled:		12/02/94	12/01/94	11/07/94
	UNITS			
VOLATILES				
Chloroform	UG/L	7 J	4 J	ND
2-Hexanone	UG/L	ND	1 J	ND
Toluene	UG/L	ND	ND	4 J
SEMIVOLATILES				
Phenol	UG/L	ND	ND	4 J
4-Methylphenol	UG/L	ND	ND	10
PESTICIDES/PCBs				
Dieldrin	UG/L	0.41	ND	ND

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

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL TOTAL METALS

Client Sample ID:		7-MW01-01	7-MW02-01	7-MW03-01	7-MW04-01	7-MW05-01	7-TW01-01	7-TW02-01	7-TW03-01
Laboratory Sample ID:		AD1987	AD1984	AD1975	AD1978	AD1621	AC7824	AC7827	AC7830
Date Sampled:		12/02/94	12/02/94	12/01/94	12/01/94	12/01/94	11/07/94	11/07/94	11/07/94
	UNITS								
Aluminum	UG/L	ND	ND	88800	1660	ND	15600	4550	17800
Barium	UG/L	3.2 J	25.3 J	370	44.6	10.5 J	225	245	142
Beryllium	UG/L	ND	ND	3	ND	ND	1.2	ND	1.6
Calcium	UG/L	5720	590	4450	13900	6990	5540	174000	12400
Chromium	UG/L	ND	ND	104	ND	ND	17.1	17.8	11.7
Copper	UG/L	ND	ND	20.8	ND	ND	10.6	ND	ND
Iron	UG/L	969	ND	25400	ND	ND	8330	6850	6200
Lead	UG/L	ND	ND	67.5 J	ND	ND	41.6 J	ND	27.1 J
Magnesium	UG/L	2080	1860	4670	2500	2040	2590	13000	1980
Manganese	UG/L	18.1 J	5 J	45.4	36.6 J	56.9	42.4	445	18.4
Mercury	UG/L	ND	ND	0.4	ND	ND	0.32	ND	ND
Potassium	UG/L	2080	1330	3690	1510	1020	1750	6430	1260
Selenium	UG/L	ND	ND	9.4	ND	ND	ND	ND	ND
Sodium	UG/L	39800	6750	4420	5460	7530	20700	8190	8310
Vanadium	UG/L	ND	ND	167	ND	ND	24.1	ND	28.4
Zinc	UG/L	ND	ND	ND	ND	ND	ND	180	167

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

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL DISSOLVED METALS

Client Sample ID:		7-MW01D-01	7-MW02D-01	7-MW03D-01	7-MW04D-01	7-MW05D-01	7-TW01D-01	7-TW02D-01	7-TW03D-01
Laboratory Sample ID:		AD2000	AD1999	AD1996	AD1997	AD1652	AC7832	AC7833	AC7834
Date Sampled:		12/02/94	12/02/94	12/01/94	12/01/94	12/01/94	11/07/94	11/07/94	11/07/94
	UNITS								
Aluminum	UG/L	ND	ND	ND	1400	ND	889	ND	ND
Barium	UG/L	ND	21.5 J	3.6 J	43 J	11.6 J	7.1 J	212	28.2 J
Calcium	UG/L	6710	826	710	14300	8330	1030	201000	8440
Chromium	UG/L	ND	ND	ND	ND	ND	ND	11.7	ND
Copper	UG/L	ND	ND	ND	ND	ND	ND	16.2	ND
Iron	UG/L	1040	ND	1590	ND	ND	1010	1390	2250
Lead	UG/L	ND	ND	ND	ND	ND	5.2 J	ND	ND
Magnesium	UG/L	2340	1840	377	2460	2400	556	14800	1320
Manganese	UG/L	21.4 J	6.7 J	2.6 J	35.3 J	66.4	7.3 J	497	9.1 J
Potassium	UG/L	2070	1020	ND	1120	1150	1040	7010	ND
Sodium	UG/L	45300	6710	4500	5230	9140	18300	8930	8480

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

TABLE 4-13

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 11 (SITE 7)
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)
7-MW01	17.45	2.2	2	323	18	6.15	15.8	42
12/2/94			3	283	19.3	6.09	17.2	9.4
			4	290	19.5	6.08	18.3	7
			6	292	19.3	6.06	17.5	4
			7	292	19.3	6.08	18.2	4.2
			8	299	19.5	6.10	17.8	3.3
7-MW02	17.75	1.75	2.3	93	15	4.77	14.3	>100
12/2/94			3.4	89	17	4.79	16.2	12
			4.6	90	18	4.89	17.1	5.2
			5.7	88	18.7	4.93	16.4	3
			6.9	87	19.4	4.97	16.6	3.1
			8	87	19.5	5.03	17	1.4
7-MW03	8.31	0.5	2	59	17	5.09	16.2	-
12/1/94			4	58	17	5.16	15.8	-
			6	55	17	5.03	15.5	-
7-MW04	19.85	2.25	0.8	191	19	4.46	18.1	9
12/1/94			2.2	186	20	4.47	19.1	16
			6.3	192	19	4.42	18.2	3
			4.5	190	19	4.46	18.5	1.5
			5.5	192	18.5	4.46	18.5	1.2
7-MW05	23.15	3	1.3	138	15	5.31	15.3	2.3
12/1/94			2.3	132	17	5.22	16.5	1.6
			3.3	132	17	5.13	16.7	1.0

[1] Measurements taken from top of PVC Casing.

TABLE 4-14
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE WATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-ET-SW02	7-NC-SW03	7-WT-SW01	7-WT-SW02
Laboratory Sample ID:		AB1652	AB1979	AB1618	AB1655
Date Sampled:		6/24/94	6/26/94	6/24/94	6/23/94
	UNITS				
VOLATILES					
Chloroform	UG/L	ND	1 J	3 J	2 J
2-Butanone	UG/L	ND	2 J	ND	ND
2-Hexanone	UG/L	ND	1 J	ND	ND
Xylene (total)	UG/L	1 J	ND	ND	ND
SEMIVOLATILES					
bis(2-Ethylhexyl)phthalate	UG/L	77 B	ND	ND	ND
PESTICIDE/PCBs					
Dieldrin	UG/L	ND	ND	0.5	0.4
Endrin ketone	UG/L	ND	ND	0.12	0.13

UG/L - microgram per liter
B - analyte detected in associated blank(s)
J - value is estimated
ND - not detected

TABLE 4-15
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE WATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-DD-SW01	7-DD-SW02	7-ET-SW01	7-ET-SW02	7-NC-SW01	7-NC-SW02	7-NC-SW03	7-NC-SW04	7-NC-SW05
Laboratory Sample ID:		B1370	B1373	AB1386	AB1654	AB1629	AB1984	AB1981	AB1996	AB1638
Date Sampled:		6/22/94	6/22/94	6/23/94	6/24/94	6/24/94	6/26/94	6/26/94	6/26/94	6/24/94
	UNITS									
Aluminum	UG/L	137	1860	243	123	453	1910 J	2200 J	290 J	839
Arsenic	UG/L	ND	ND	ND	ND	ND	2.4 J	2.1 J	ND	ND
Barium	UG/L	28.9	27.8	26.1	19.5	19.6	27.5	37.2	19	19
Calcium	UG/L	12800	5940	62900	149000	152000	167000 J	171000 J	147000	160000
Copper	UG/L	ND	ND	12.3	ND	ND	ND	ND	ND	ND
Iron	UG/L	727	1630	750	175 J	298 J	1570 J	2160 J	208 J	530 J
Lead	UG/L	ND	15.9	ND	7.1 J	4.2 J	23.6	27.1	ND	5.4 J
Magnesium	UG/L	1960	2870	125000	468000	482000	548000	573000	476000	547000
Manganese	UG/L	11.2	11.8	21.3	15.4	10.1	22.5	68.9	13.4	14
Potassium	UG/L	ND	ND	39600	144000	149000	175000	179000	157000	159000
Silver	UG/L	ND	ND	ND	6.6 J	ND	6.6	9.6	6.8	6.5 J
Sodium	UG/L	12100	14000	1090000	3730000	4650000	4230000 J	4410000 J	3800000	4110000
Zinc	UG/L	6.4	28.5	15.4	ND	27.6 J	ND	ND	ND	32.9 J

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

TABLE 4-15 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SURFACE WATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NC-SW06	7-WT-SW01	7-WT-SW02	7-WT-SW03
Laboratory Sample ID:		AB1635	AB1620	AB1657	AB1623
Date Sampled:		6/24/94	6/23/94	6/23/94	6/24/94
	UNITS				
Aluminum	UG/L	380	155	77.1	274
Arsenic	UG/L	ND	ND	ND	ND
Barium	UG/L	18.9	20.8	16.4	18.5
Calcium	UG/L	160000	10400	9100	131000
Copper	UG/L	ND	ND	ND	ND
Iron	UG/L	313 J	655 J	410 J	213 J
Lead	UG/L	13.2 J	2.5 J	7.8 J	4.3 J
Magnesium	UG/L	531000	1680	2480	410000
Manganese	UG/L	12.6	14.4	11.2	12.8
Potassium	UG/L	158000	ND	ND	126000
Silver	UG/L	5.1 J	ND	ND	ND
Sodium	UG/L	4050000	7100	14500	3260000
Zinc	UG/L	22.5 J	168 J	40 J	8.1 J

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

TABLE 4-16
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-DD-SD01-06	7-DD-SD02-06	7-ET-SD01-06	7-ET-SD02-06	7-MA-SD01-06	7-MA-SD01-612	7-MA-SD02-06
Laboratory Sample ID:		AB1377	AB1374	AB1396	AB1687	AB1399	AB1403	AB1409
Date Sampled:		6/22/94	6/22/94	6/23/94	6/24/94	6/23/94	6/23/94	6/23/94
	UNITS							
VOLATILES								
2-Butanone	UG/KG	ND	7 J	250 J	ND	91	180 J	ND
Toluene	UG/KG	ND	ND	36 J	ND	10 J	20 J	21 J
Styrene	UG/KG	ND	ND	ND	ND	ND	ND	28 J
SEMIVOLATILES								
Acenaphthylene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	130 J	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	100 J	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	76 J	210 J	ND	ND	310 J	ND	880 J
Fluoranthene	UG/KG	ND	170 J	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	130 J	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	110 J	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	110 J	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	510	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	85 J	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	UG/KG	ND	110 J	ND	ND	ND	ND	ND
Benzo(a)pyrene	UG/KG	ND	110 J	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	65 J	ND	ND	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-DD-SD01-06	7-DD-SD02-06	7-ET-SD01-06	7-ET-SD02-06	7-MA-SD01-06	7-MA-SD01-612	7-MA-SD02-06
Laboratory Sample ID:		AB1377	AB1374	AB1396	AB1687	AB1399	AB1403	AB1409
Date Sampled:		6/22/94	6/22/94	6/23/94	6/24/94	6/23/94	6/23/94	6/23/94
PESTICIDE/PCBs	UNITS							
Aldrin	UG/KG	ND	3.1 J	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	17 J	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	14 J	28 J	ND	ND	67 J	39 J	130
4,4'-DDD	UG/KG	23 J	120 J	ND	ND	39 J	33 J	39 J
4,4'-DDT	UG/KG	110 J	110 J	ND	ND	16 J	2.3 J	36 J
Endrin ketone	UG/KG	ND	6.5 J	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	9.2 J	ND	13 J	42 J	30 J	38 J
gamma-Chlordane	UG/KG	ND	4.7 J	ND	ND	29 J	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	450 J	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-MA-SD02-612	7-MA-SD03-06	7-MA-SD03-612	7-MA-SD04-06	7-MA-SD04-612	7-NC-SD01-06	7-NC-SD02-06
Laboratory Sample ID:		AB1413	AB1390	AB1393	AB1405	AB1407	AB1671	AB2051
Date Sampled:		6/23/94	6/23/94	6/23/94	6/23/94	6/23/94	6/24/94	6/26/94
	UNITS							
VOLATILES								
2-Butanone	UG/KG	110 J	47 J	160 J	140 J	190 J	53 J	1 J
Toluene	UG/KG	30 J	17 J	16 J	37 J	39 J	ND	ND
Styrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
Acenaphthylene	UG/KG	ND	ND	ND	250 J	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	210 J	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	350 J	ND	ND	ND
Di-n-butylphthalate	UG/KG	480 J	740 J	390 J	1300 J	560 J	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	450 J	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	430 J	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	320 J	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	ND	ND	270 NJ	ND	ND	ND
Benzo(k)fluoranthene	UG/KG	ND	ND	ND	230 NJ	ND	ND	ND
Benzo(a)pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-MA-SD02-612	7-MA-SD03-06	7-MA-SD03-612	7-MA-SD04-06	7-MA-SD04-612	7-NC-SD01-06	7-NC-SD02-06
Laboratory Sample ID:		AB1413	AB1390	AB1393	AB1405	AB1407	AB1671	AB2051
Date Sampled:		6/23/94	6/23/94	6/23/94	6/23/94	6/23/94	6/24/94	6/26/94
PESTICIDE/PCBs	UNITS							
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	39	41	ND	ND	ND	5.7
4,4'-DDE	UG/KG	ND	89	47	180 J	27	ND	ND
4,4'-DDD	UG/KG	ND	21	ND	65 J	ND	ND	5.3 J
4,4'-DDT	UG/KG	ND	ND	ND	27 J	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	13	ND	ND	ND	ND	5.4
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	5.2
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NC-SD02-612	7-NC-SD04-06	7-NC-SD04-612	7-NC-SD05-06	7-NC-SD06-06	7-NC-SD06-612	7-WT-SD01-06
Laboratory Sample ID:		AB2028	AB2039	AB2022	AB1682	AB1668	AB1658	AB1676
Date Sampled:		6/26/94	6/26/94	6/26/94	6/24/94	6/24/94	6/24/94	6/23/94
	UNITS							
VOLATILES								
2-Butanone	UG/KG	7 J	ND	ND	ND	ND	4 J	ND
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Styrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
Acenaphthylene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	91 J	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	120 J	ND	42 J	ND	ND
Pyrene	UG/KG	ND	ND	170 J	ND	49 J	43 J	ND
Butyl benzyl phthalate	UG/KG	ND	ND	47 J	ND	ND	ND	ND
Benzo(a)anthracene	UG/KG	ND	ND	74 J	ND	ND	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	70 J	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	500 J	ND	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	ND	46 J	ND	ND	ND	ND
Benzo(k)fluoranthene	UG/KG	ND	ND	57 J	ND	ND	ND	ND
Benzo(a)pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND	53 J	ND	ND	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-NC-SD02-612	7-NC-SD04-06	7-NC-SD04-612	7-NC-SD05-06	7-NC-SD06-06	7-NC-SD06-612	7-WT-SD01-06
Laboratory Sample ID:		AB2028	AB2039	AB2022	AB1682	AB1668	AB1658	AB1676
Date Sampled:		6/26/94	6/26/94	6/26/94	6/24/94	6/24/94	6/24/94	6/23/94
PESTICIDE/PCBs	UNITS							
Aldrin	UG/KG	ND	ND	ND	NA	ND	ND	ND
Dieldrin	UG/KG	ND	ND	7.9 J	NA	ND	ND	71
4,4'-DDE	UG/KG	ND	ND	20 J	NA	4.5	5.1	ND
4,4'-DDD	UG/KG	ND	4.3	44 J	NA	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	8.8	NA	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	NA	ND	ND	ND
alpha-Chlordane	UG/KG	4.9 J	ND	14	NA	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	11	NA	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	NA	ND	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		7-WT-SD02-06	7-WT-SD03-06
Laboratory Sample ID:		AB1692	AB1679
Date Sampled:		6/23/94	6/24/94
	UNITS		
VOLATILES			
2-Butanone	UG/KG	9 J	ND
Toluene	UG/KG	ND	ND
Styrene	UG/KG	ND	ND
SEMIVOLATILES			
Acenaphthylene	UG/KG	ND	ND
Dibenzofuran	UG/KG	ND	ND
Phenanthrene	UG/KG	ND	ND
Anthracene	UG/KG	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND
Fluoranthene	UG/KG	ND	72 J
Pyrene	UG/KG	ND	87 J
Butyl benzyl phthalate	UG/KG	ND	47 J
Benzo(a)anthracene	UG/KG	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	ND
Chrysene	UG/KG	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	810
Di-n-butylphthalate	UG/KG	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	ND
Benzo(k)fluoranthene	UG/KG	ND	ND
Benzo(a)pyrene	UG/KG	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-16 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

		Client Sample ID:	7-WT-SD02-06	7-WT-SD03-06
		Laboratory Sample ID:	AB1692	AB1679
		Date Sampled:	6/23/94	6/24/94
		UNITS		
PESTICIDE/PCBs				
Aldrin		UG/KG	ND	ND
Dieldrin		UG/KG	22	5.4
4,4'-DDE		UG/KG	ND	11
4,4'-DDD		UG/KG	ND	8.4
4,4'-DDT		UG/KG	ND	ND
Endrin ketone		UG/KG	ND	ND
alpha-Chlordane		UG/KG	2.7	8.2
gamma-Chlordane		UG/KG	ND	7.5
Aroclor 1260		UG/KG	ND	ND

MG/KG - milligram per kilogram
J - value is estimated
NA - not analyzed
ND - not detected
NJ - estimated/tentative identification

TABLE 4-17
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

	Client Sample ID:	7-DD-SD01-06	7-DD-SD02-06	7-ET-SD01-06	7-ET-SD02-06	7-MA-SD01-06	7-MA-SD01-612	7-MA-SD02-06
	Laboratory Sample ID:	B1378	B1375	AB1397	AB1688	AB1400	AB1404	AB1410
	Date Sampled:	6/22/94	6/22/94	6/23/94	6/24/94	6/23/94	6/23/94	6/23/94
	UNITS							
Aluminum	MG/KG	5720 J	1470	5930	2060 J	10500	4540	1170
Arsenic	MG/KG	ND	ND	ND	3	ND	ND	ND
Barium	MG/KG	18 J	10.4	279	7	206	160	31.7
Beryllium	MG/KG	0.44	ND	8	ND	ND	ND	ND
Calcium	MG/KG	522 J	593	3910	5400	13400	10300	2990
Chromium	MG/KG	7.5 J	ND	ND	ND	19.4	ND	ND
Copper	MG/KG	ND	5.5	ND	ND	95.8	47.6	ND
Iron	MG/KG	757	728	883	1120 J	6060	2990	570
Lead	MG/KG	4.8 J	40.7	9.3	17.3 J	72.2	46.8	46.9
Magnesium	MG/KG	190	153	2920	5390	2730	1930	2420
Manganese	MG/KG	5.1 J	3.4	16.4	5.5	30.6	18.8	4.7
Mercury	MG/KG	ND	ND	ND	ND	2.6	1.6	ND
Potassium	MG/KG	ND	ND	ND	ND	1780	ND	ND
Selenium	MG/KG	ND	ND	23.4	ND	ND	ND	ND
Sodium	MG/KG	40.9	46.8	1190	20700	951	761	3810
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	5.5 J	2.9	37.5	ND	21.5	ND	ND
Zinc	MG/KG	4.7	19.8	45.9	38.1	536	344	10.7 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-17 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-MA-SD02-612	7-MA-SD03-06	7-MA-SD03-612	7-MA-SD04-06	7-MA-SD04-612	7-NC-SD01-06	7-NC-SD01-612
Laboratory Sample ID:		AB1414	AB1391	AB1394	AB1406	AB1408	AB1672	AB1661
Date Sampled:		6/23/94	6/23/94	6/23/94	6/23/94	6/23/94	6/24/94	6/24/94
	UNITS							
Aluminum	MG/KG	1460	9200	7950	3630	1880	1170	727
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	97.9	146	195	86.6	250	6.8	4.6
Beryllium	MG/KG	ND	ND	1.6	ND	ND	ND	ND
Calcium	MG/KG	4750	6550	7780	6280	5800	10900	10400
Chromium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	ND	ND	ND	ND	ND	ND
Iron	MG/KG	627	4690	4180	2900	1060	771	197
Lead	MG/KG	28.4	90.8	34.2	33.1	18.8	14.7 J	8.4 J
Magnesium	MG/KG	3190	2990	3110	6180	5910	13900	12700
Manganese	MG/KG	5.4	18.9	20.7	7.6	5.4	15.2	8.2
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	1610	1540	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	3450	2300	2050	6910	5860	48700	42300
Thallium	MG/KG	ND	ND	ND	ND	ND	4.6 J	4.9 J
Vanadium	MG/KG	ND	14.2	15.8	ND	ND	ND	ND
Zinc	MG/KG	33.8	38.2	42.1	50.8	18.2	11.1	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-17 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NC-SD02-06	7-NC-SD02-612	7-NC-SD03-06	7-NC-SD03-612	7-NC-SD04-06	7-NC-SD04-612	7-NC-SD05-06
Laboratory Sample ID:		AB2052	AB2029	AB2034	AB2017	AB2040	AB2023	AB1683
Date Sampled:		6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/24/94
	UNITS							
Aluminum	MG/KG	855 J	3130 J	320 J	2530 J	820 J	5480 J	2440
Arsenic	MG/KG	ND	1.3 J	ND	ND	ND	ND	ND
Barium	MG/KG	14.8	9.9	1.4	13.9	4.6	9.6	8.4
Beryllium	MG/KG	ND	ND	ND	ND	ND	0.28	ND
Calcium	MG/KG	1420	2830	1300	10000	347	1170	10200
Chromium	MG/KG	3.4	6.2	ND	ND	3.6	10	ND
Copper	MG/KG	ND	ND	ND	ND	9.3 J	3.7 J	ND
Iron	MG/KG	983 J	1670 J	203 J	1160 J	397 J	2370 J	1970
Lead	MG/KG	11.9 J	13.2 J	3.9 J	6.2 J	4.3 J	86 J	28.2 J
Magnesium	MG/KG	ND	1600	1440	9590	ND	963	11200
Manganese	MG/KG	5	5.7	2.2	7.7	1.9	7.6	11.7
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	1400	4750	4740	25600	1590	1730	33600
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	3.2	8.1	ND	ND	ND	10.1	ND
Zinc	MG/KG	20.6 J	15.3 J	2.9 J	20.3 J	5.9 J	74.5 J	15.9

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-17 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (SITE 7)
SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		7-NC-SD05-612	7-NC-SD06-06	7-NC-SD06-612	7-WT-SD01-06	7-WT-SD02-06	7-WT-SD03-06
Laboratory Sample ID:		AB1663	AB1669	AB1659	AB1677	AB1693	AB1680
Date Sampled:		6/24/94	6/24/94	6/24/94	6/23/94	6/23/94	6/24/94
	UNITS						
Aluminum	MG/KG	940	1250	696	4060	1690 J	3130
Arsenic	MG/KG	ND	ND	0.8	ND	ND	ND
Barium	MG/KG	6.8	3.1	2.3	11.3	9	7.1
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	10500	39500	15500	299	877	379
Chromium	MG/KG	ND	4.4	2.9	6.3	4.2	5.7
Copper	MG/KG	ND	ND	6.9	ND	3.2	ND
Iron	MG/KG	322	990	1030	1280	975	1430
Lead	MG/KG	12.3 J	5.4 J	4.7 J	7 J	16.7 J	14.6 J
Magnesium	MG/KG	11300	869	540	210	138	358
Manganese	MG/KG	5.4	10.1	7.2	4.1	3.8	9.5
Mercury	MG/KG	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	23400	1910	1290	29.2	206	426
Thallium	MG/KG	4.9 J	0.61 J	0.7 J	ND	ND	0.66 J
Vanadium	MG/KG	ND	3.1	3	5.7	4.1	5.5
Zinc	MG/KG	16.2	9.6	6.9	4.1	15.2	20.4

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

SECTION 4.0 FIGURES

274027RI

SAMPLE: 7-NA-SB04-00
SEMIVOLATILES
Acenaphthene 37 J
Fluorene 38 J
Phenanthrene 400
Anthracene 100 J
Carbazole 110 J
Fluoranthene 750
Pyrene 580
Benzo[a]anthracene 420
Chrysene 420
bis(2-Ethylhexyl)phthalate 44 J
Benzo[b]fluoranthene 380
Benzo[k]fluoranthene 370
Benzo[a]pyrene 340 J
Indeno[1,2,3-cd]pyrene 250 J
Benzo[g,h,i]perylene 220 J
PESTICIDES/PCBs
Aldrin 3
Dieldrin 57
alpha-Chlordane 26 J
gamma-Chlordane 22 J
Aroclor 1260 80 NJ

SAMPLE: 7-BB-SB02-00
PESTICIDES/PCBs
Dieldrin 14 J
4,4'-DDE 32 J
4,4'-DDT 7.3 J

SAMPLE: 7-NA-SB03-00
PESTICIDES/PCBs
Dieldrin 8.5 J
4,4'-DDE 50 J
4,4'-DDD 9.8 J
4,4'-DDT 28 J
alpha-Chlordane 12 J
gamma-Chlordane 6.9 J

SAMPLE: 7-EA-SB01-00
SEMIVOLATILES
Fluoranthene 200 J
Pyrene 140 J
Benzo[a]anthracene 86 J
Chrysene 96 J
Benzo[b]fluoranthene 91 J
Benzo[k]fluoranthene 77 J
Benzo[a]pyrene 61 J
Indeno[1,2,3-cd]pyrene 47 J
PESTICIDES/PCBs
Dieldrin 4.7 J

SAMPLE: 7-EA-SB04-00
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 73 J
PESTICIDES/PCBs
4,4'-DDE 12

SAMPLE: 7-EA-SB06-00
VOLATILES
Trichloroethene 1 J
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 58 J

TARAWA BLVD.
SIDEWALK
CONC WALK
ASPHALT SHOULDER
ASPHALT PARKING
GRASS
ONE STORY BRICK BUILDING BLDG # TT41
ASPHALT PARKING
PLAYGROUND
07-BB-SB03
07-CC-SB01
07-CC-SB02
07-EA-SB05
07-EA-SB06
07-EA-SB04
07-EA-SB03
07-EA-SB02
07-EA-SB01
07-NA-SB03
07-BB-SB02
07-NA-SB02
07-NA-SB06
07-NA-SB09
30"RCP
HEADWALL
INV OUT=9.54
24" RCP
TOP =15.53
INV OUT=10.98
INV OUT=6.52
WOODS
7-BB-SB01
POWER LINE R/W
07-NA-SB01
07-NA-SB05
07-NA-SB08
07-NA-SB11
07-EPCB-SB09
07-SB01
07-TW03
DITCH
INV OUT=2.88
CONC SPILLWAY
07-EA-SB
07-SB02
07-MW02
07-NA-SB10
07-NA-SB07
07-NA-SB12
07-EA-SB09
07-EA-SB10
07-EA-SB08
07-EA-SB07
APPROXIMATE LIMITS
EASTERN TRIBUTARY
07-MW01
7-MW04
07-NA-SB04
SWAMP
WESTERN TRIBUTARY
DITCH
TEST PIT 5
TEST PIT 4
TEST PIT 3
TEST PIT 2
TEST PIT 1
07-SWA-SB01
07-SWA-SB05
07-TW02
07-SWA-SB04
07-SWA-SB02
07-MW03
07-SWA-SB03
07-TW01
07-MW05
WASTEWATER TREATMENT PLANT
NORTHEAST CREEK

SAMPLE: 7-NA-SB12-00
VOLATILES
Toluene 12 J

SAMPLE: 7-EA-SB03-00
SEMIVOLATILES
Phenanthrene 63 J
Fluoranthene 110 J
Pyrene 85 J
Benzo[a]anthracene 50 J
Chrysene 55 J
Benzo[b]fluoranthene 45 J
Benzo[k]fluoranthene 60 J

SAMPLE: 7-EPCB-SB09-00
PESTICIDES/PCBs
Aroclor 1260 320

SAMPLE: 7-CC-SB02-00
PESTICIDES/PCBs
Dieldrin 16 J

SAMPLE: 7-MW04-00
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 600

SAMPLE: 7-NA-SB07-00
SEMIVOLATILES
Phenanthrene 87 J
Fluoranthene 130 J
Pyrene 110 J
Benzo[a]anthracene 60 J
Chrysene 75 J
Benzo[b]fluoranthene 66 J
Benzo[k]fluoranthene 64 J
Benzo[a]pyrene 55 J
Indeno[1,2,3-cd]pyrene 41 J
Benzo[g,h,i]perylene 44 J

SAMPLE: 7-NA-SB10-00
VOLATILES
Toluene 9 J
PESTICIDES/PCBs
4,4'-DDD 4.3 J

SAMPLE: 7-EA-SB07-00
VOLATILES
Acetone 150

SAMPLE: 7-EA-SB09-00
VOLATILES
Acetone 170
2-Butanone 52
Toluene 46 J

SAMPLE: 7-EA-SB10-00
SEMIVOLATILES
Phenol 170 NJ
PESTICIDES/PCBs
Dieldrin 9.6 J
4,4'-DDE 17 J
4,4'-DDT 14 J

SAMPLE: 7-SWA-SB01-00
PESTICIDES/PCBs
4,4'-DDE 4.9

SAMPLE: 7-SWA-SB05-00
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 170 J

SAMPLE: 7-SWA-SB02-00
SEMIVOLATILES
di-n-Butylphthalate 170 J
bis(2-Ethylhexyl)phthalate 38 J

SAMPLE: 7-SWA-SB04-00
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 61 J
PESTICIDES/PCBs
Dieldrin 6.3 J
4,4'-DDE 7.9 J
Endosulfan II 11 J
alpha-Chlordane 8.1 J
gamma-Chlordane 43 J
Aroclor 1254

SAMPLE: 7-MW05-00
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 560 J
PESTICIDES/PCBs
Dieldrin 14 J
4,4'-DDE 65
4,4'-DDD 94
4,4'-DDT 280

SAMPLE: 7-SWA-SB03-00
PESTICIDES/PCBs
delta-BHC 3.3 NJ
Endosulfan II 37 NJ
4,4'-DDT 42 NJ
Endrin aldehyde 39 NJ

SAMPLE: 7-NA-SB09-00
PESTICIDES/PCBs
Endosulfan II 9.3 J

SAMPLE: 7-NA-SB11-00
PESTICIDES/PCBs
4,4'-DDE 11

125 0 62.5 125
1 inch = 125 ft.

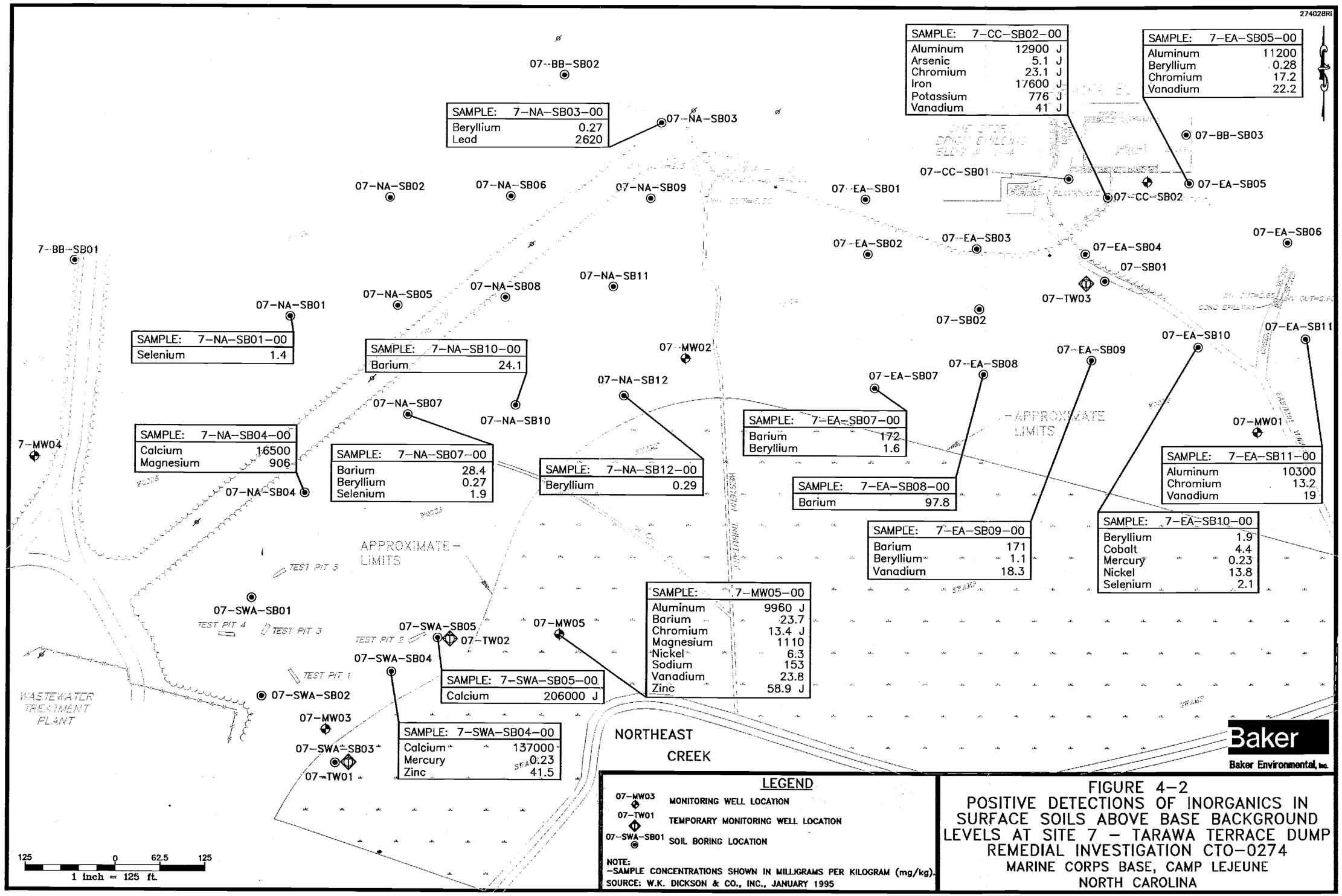
LEGEND
07-MW03 MONITORING WELL LOCATION
07-TW01 TEMPORARY MONITORING WELL LOCATION
07-SWA-SB01 SOIL BORING LOCATION

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

Baker
Baker Environmental, Inc.

FIGURE 4-1
POSITIVE DETECTIONS OF ORGANICS IN SURFACE SOILS
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701VB32


274028RI
SAMPLE: 7-CC-SB02-00
Aluminum 12900 J
Arsenic 5.1 J
Chromium 23.1 J
Iron 17600 J
Potassium 776 J
Vanadium 41 J
SAMPLE: 7-EA-SB05-00
Aluminum 11200
Beryllium 0.28
Chromium 17.2
Vanadium 22.2
07-BB-SB02
SAMPLE: 7-NA-SB03-00
Beryllium 0.27
Lead 2620
07-NA-SB03
07-BB-SB03
07-CC-SB01
07-CC-SB02
07-EA-SB05
07-NA-SB02
07-NA-SB06
07-NA-SB09
07-EA-SB01
7-BB-SB01
07-EA-SB02
07-EA-SB03
07-EA-SB04
07-EA-SB06
07-NA-SB11
07-NA-SB05
07-NA-SB08
07-SB01
07-TW03
07-NA-SB01
07-SB02
SAMPLE: 7-NA-SB01-00
Selenium 1.4
SAMPLE: 7-NA-SB10-00
Barium 24.1
07-MW02
07-EA-SB10
07-EA-SB11
07-EA-SB09
07-EA-SB08
07-NA-SB12
07-EA-SB07
07-NA-SB07
07-NA-SB10
SAMPLE: 7-EA-SB07-00
Barium 172
Beryllium 1.6
APPROXIMATE LIMITS
07-MW01
7-MW04
SAMPLE: 7-NA-SB04-00
Calcium 16500
Magnesium 906
SAMPLE: 7-NA-SB07-00
Barium 28.4
Beryllium 0.27
Selenium 1.9
SAMPLE: 7-NA-SB12-00
Beryllium 0.29
SAMPLE: 7-EA-SB11-00
Aluminum 10300
Chromium 13.2
Vanadium 19
SAMPLE: 7-EA-SB08-00
Barium 97.8
SAMPLE: 7-EA-SB09-00
Barium 171
Beryllium 1.1
Vanadium 18.3
SAMPLE: 7-EA-SB10-00
Beryllium 1.9
Cobalt 4.4
Mercury 0.23
Nickel 13.8
Selenium 2.1
07-NA-SB04
APPROXIMATE LIMITS
TEST PIT 5
07-SWA-SB01
TEST PIT 4
TEST PIT 3
TEST PIT 2
07-SWA-SB05
07-TW02
07-MW05
SAMPLE: 7-MW05-00
Aluminum 9960 J
Barium 23.7
Chromium 13.4 J
Magnesium 1110
Nickel 6.3
Sodium 153
Vanadium 23.8
Zinc 58.9 J
07-SWA-SB04
TEST PIT 1
SAMPLE: 7-SWA-SB05-00
Calcium 206000 J
07-SWA-SB02
WASTEWATER TREATMENT PLANT
07-MW03
07-SWA-SB03
07-TW01
SAMPLE: 7-SWA-SB04-00
Calcium 137000
Mercury 0.23
Zinc 41.5
NORTHEAST CREEK
125 0 62.5 125
1 inch = 125 ft.
LEGEND
07-MW03 MONITORING WELL LOCATION
07-TW01 TEMPORARY MONITORING WELL LOCATION
07-SWA-SB01 SOIL BORING LOCATION
NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MILLIGRAMS PER KILOGRAM (mg/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995
Baker
Baker Environmental, Inc.
FIGURE 4-2
POSITIVE DETECTIONS OF INORGANICS IN SURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274029RI

07-BB-SB02

SAMPLE: 7-BB-SB02-05
VOLATILES
Acetone 320

SAMPLE: 7-NA-SB03-02
VOLATILES
Acetone 2000 J

SAMPLE: 7-NA-SB03-04
VOLATILES
Acetone 230

07-NA-SB03

SAMPLE: 7-BB-SB03-09
VOLATILES
Acetone 110

07-BB-SB03

SAMPLE: 7-BB-SB01-05
VOLATILES
Acetone 430

7-BB-SB01

SAMPLE: 7-NA-SB07-02
VOLATILES
Acetone 880
SEMIVOLATILES
Naphthalene 120 J
2-Methylnaphthalene 48 J
Acenaphthene 190 J
Dibenzofuran 120 J
Fluorene 260 J
Phenanthrene 1700
Anthracene 350 J
Carbazole 450
Fluoranthene 1800
Pyrene 1300
Benzo[a]anthracene 740
Chrysene 770
Benzo[b]fluoranthene 690
Benzo[k]fluoranthene 610
Benzo[a]pyrene 460
Indeno[1,2,3-cd]pyrene 390
Dibenzo[a,h]anthracene 210 J
Benzo[g,h,i]perylene 330 J

07-NA-SB02

SAMPLE: 7-NA-SB02-08
VOLATILES
Acetone 63

07-NA-SB06

07-NA-SB09

SAMPLE: 7-NA-SB06-07
VOLATILES
Acetone 1100

07-NA-SB11

07-NA-SB08

07-NA-SB05

07-NA-SB01

SAMPLE: 7-NA-SB05-08
VOLATILES
Acetone 13

SAMPLE: 7-NA-SB08-09
VOLATILES
Acetone 26

07-NA-SB07

07-NA-SB10

07-MW02

SAMPLE: 7-NA-SB12-02
VOLATILES
Acetone 130

07-NA-SB12

07-CC-SB01

07-CC-SB02

07-EA-SB05

SAMPLE: 7-EA-SB05-07
VOLATILES
Acetone 2300

07-EA-SB01

SAMPLE: 7-EA-SB01-07
VOLATILES
Acetone 110

07-EA-SB06

07-EA-SB02

07-EA-SB03

07-EA-SB04

07-SB01

SAMPLE: 7-EA-SB06-01
PESTICIDES/PCBs
delta-BHC 3 J
Endosulfan II 17 J
Endrin aldehyde 8.1 J

07-TW03

SAMPLE: 7-EA-SB03-08
VOLATILES
Acetone 86

07-SB02

07-EA-SB11

07-EA-SB09

07-EA-SB10

07-EA-SB08

07-EA-SB07

APPROXIMATE LIMITS

07-MW01

7-MW04

SAMPLE: 7-MW04-08
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 47 J

07-NA-SB04

SAMPLE: 7-NA-SB04-02
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 80 J

SAMPLE: 7-SWA-SB05-02
SEMIVOLATILES
bis(2-Ethylhexyl)phthalate 60 J
PESTICIDES/PCBs
Dieldrin 17
4,4'-DDE 4.9
4,4'-DDD 10
gamma-Chlordane 2.9

APPROXIMATE LIMITS

TEST PIT 5

07-SWA-SB01

TEST PIT 4

TEST PIT 3

TEST PIT 2

07-SWA-SB05

07-TW02

07-MW05

SAMPLE: 7-MW05-06
SEMIVOLATILES
di-n-Butylphthalate 100 J
PESTICIDES/PCBs
4,4'-DDE 0.82 J
4,4'-DDD 1.9 J
4,4'-DDT 1.7 J

SAMPLE: 7-SWA-SB02-04
SEMIVOLATILES
di-n-Butylphthalate 220 J
bis(2-Ethylhexyl)phthalate 39 J

07-SWA-SB02

07-SWA-SB04

TEST PIT 1

SAMPLE: 7-SWA-TP02
PESTICIDES/PCBs
Aldrin 6.3
Dieldrin 61
4,4'-DDE 19
4,4'-DDD 10

WASTEWATER TREATMENT PLANT

07-MW03

07-SWA-SB03

07-TW01

SAMPLE: 7-SWA-SB04-01
VOLATILES
Methylene chloride 12 J
SEMIVOLATILES
di-n-Butylphthalate 42 J
bis(2-Ethylhexyl)phthalate 72 J
PESTICIDES/PCBs
Dieldrin 98 J
4,4'-DDE 38
Endrin 4.8 J
Endosulfan II 19 J
4,4'-DDD 15 J
4,4'-DDT 19 J
alpha-Chlordane 120 J
gamma-Chlordane 110 J
Aroclor 1260 91 J

NORTHEAST CREEK

WESTERN TRIBUTARY

EASTERN TRIBUTARY

SWAMP

125 0 62.5 125
1 inch = 125 ft.

Baker
Baker Environmental, Inc.

LEGEND

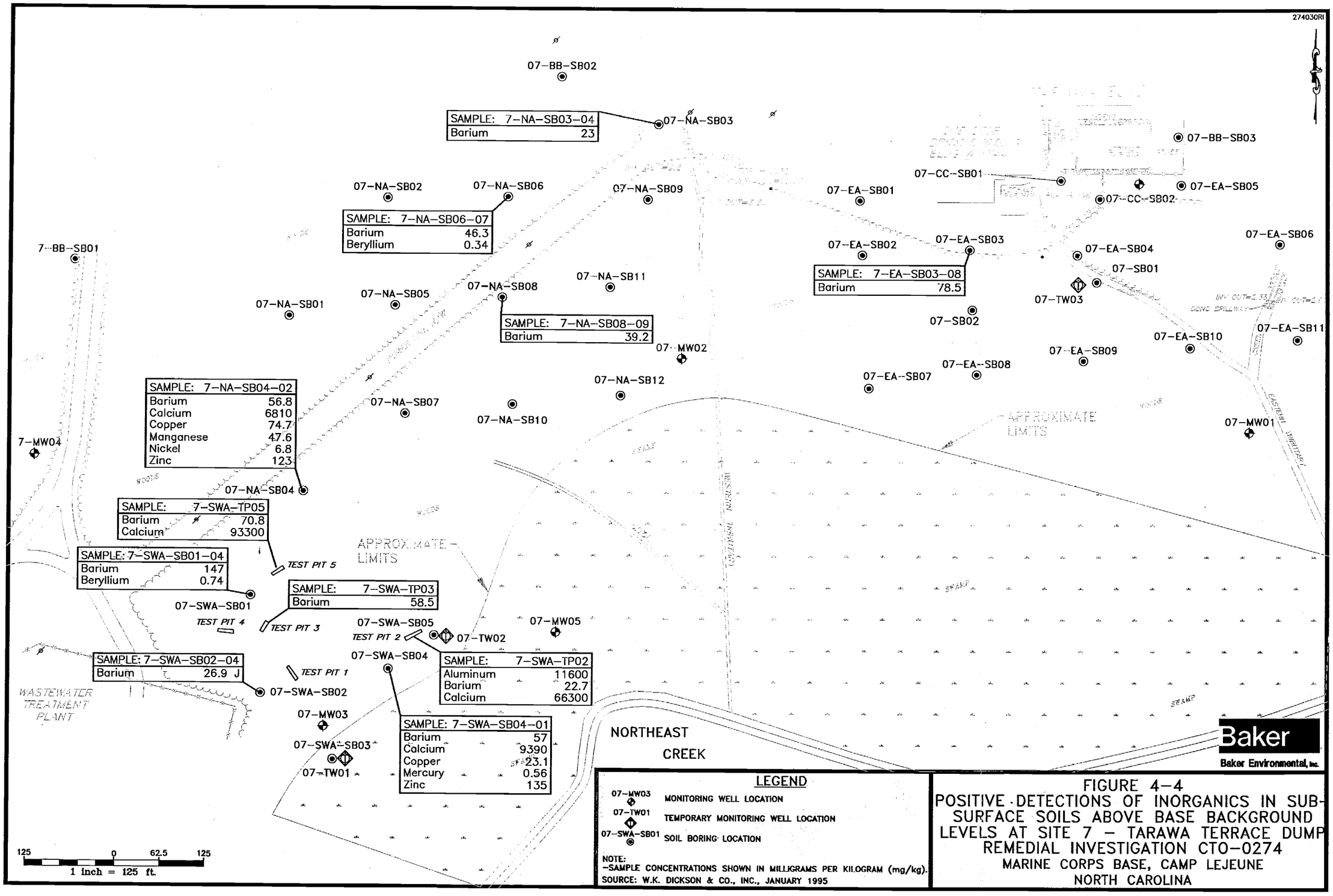
07-MW03 MONITORING WELL LOCATION

07-TW01 TEMPORARY MONITORING WELL LOCATION

07-SWA-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 ORGANICS IN SUBSURFACE SOILS
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA


274030RI
07-BB-SB02
SAMPLE: 7-NA-SB03-04
Barium 23
07-NA-SB03
07-BB-SB03
07-CC-SB01
07-EA-SB05
07-CC-SB02
07-NA-SB02
07-NA-SB06
07-NA-SB09
07-EA-SB01
SAMPLE: 7-NA-SB06-07
Barium 46.3
Beryllium 0.34
7-BB-SB01
07-EA-SB02
07-EA-SB03
07-EA-SB04
07-EA-SB06
SAMPLE: 7-EA-SB03-08
Barium 78.5
07-NA-SB11
07-NA-SB05
07-NA-SB08
07-SB01
07-TW03
07-NA-SB01
SAMPLE: 7-NA-SB08-09
Barium 39.2
07-SB02
07-EA-SB10
07-EA-SB11
07-MW02
07-EA-SB09
07-EA-SB08
07-NA-SB12
07-EA-SB07
SAMPLE: 7-NA-SB04-02
Barium 56.8
Calcium 6810
Copper 74.7
Manganese 47.6
Nickel 6.8
Zinc 123
07-NA-SB07
07-NA-SB10
APPROXIMATE LIMITS
07-MW01
7-MW04
07-NA-SB04
SAMPLE: 7-SWA-TP05
Barium 70.8
Calcium 93300
APPROXIMATE LIMITS
SAMPLE: 7-SWA-SB01-04
Barium 147
Beryllium 0.74
TEST PIT 5
SAMPLE: 7-SWA-TP03
Barium 58.5
07-SWA-SB01
TEST PIT 4
TEST PIT 3
07-SWA-SB05
07-MW05
TEST PIT 2
07-TW02
SAMPLE: 7-SWA-TP02
Aluminum 11600
Barium 22.7
Calcium 66300
07-SWA-SB04
SAMPLE: 7-SWA-SB02-04
Barium 26.9 J
TEST PIT 1
07-SWA-SB02
WASTEWATER TREATMENT PLANT
07-MW03
SAMPLE: 7-SWA-SB04-01
Barium 57
Calcium 9390
Copper 23.1
Mercury 0.56
Zinc 135
07-SWA-SB03
07-TW01
SWAMP
SWAMP
NORTHEAST CREEK
125 0 62.5 125
1 inch = 125 ft.
LEGEND
07-MW03 MONITORING WELL LOCATION
07-TW01 TEMPORARY MONITORING WELL LOCATION
07-SWA-SB01 SOIL BORING LOCATION
NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MILLIGRAMS PER KILOGRAM (mg/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995
Baker
Baker Environmental, Inc.
FIGURE 4-4
POSITIVE DETECTIONS OF INORGANICS IN SUB-SURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274031RI

07-TW03

07-MW02

SAMPLE: 7-MW02-01

VOLATILES

Chloroform 7 J

07-MW01

7-MW04

APPROXIMATE LIMITS

APPROXIMATE LIMITS

TEST PIT 5

TEST PIT 4

TEST PIT 3

TEST PIT 2

TEST PIT 1

07-TW02

07-MW05

SAMPLE: 7-MW05-01

VOLATILES

Chloroform 4 J

WASTEWATER TREATMENT PLANT

07-MW03

07-TW01

NORTHEAST CREEK

SWAMP

ROADS

125 0 62.5 125

1 inch = 125 ft.

Baker

Baker Environmental, Inc.

LEGEND

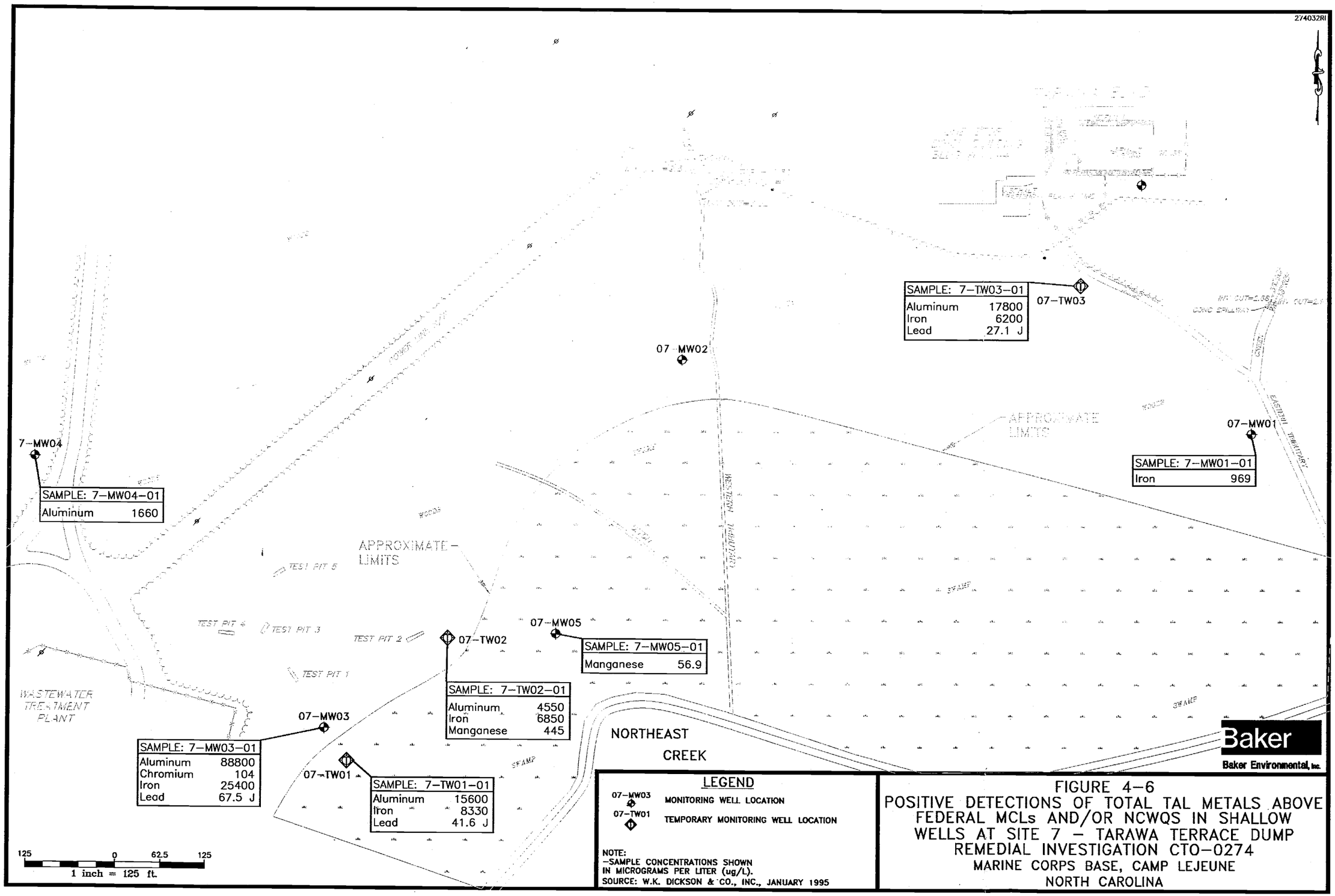
07-MW03 MONITORING WELL LOCATION

07-TW01 TEMPORARY MONITORING WELL LOCATION

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

FIGURE 4-5
POSITIVE DETECTIONS OF ORGANICS ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 7 - TARAWA TERRACE DUMP REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274032RI



Baker
Baker Environmental, Inc.

LEGEND

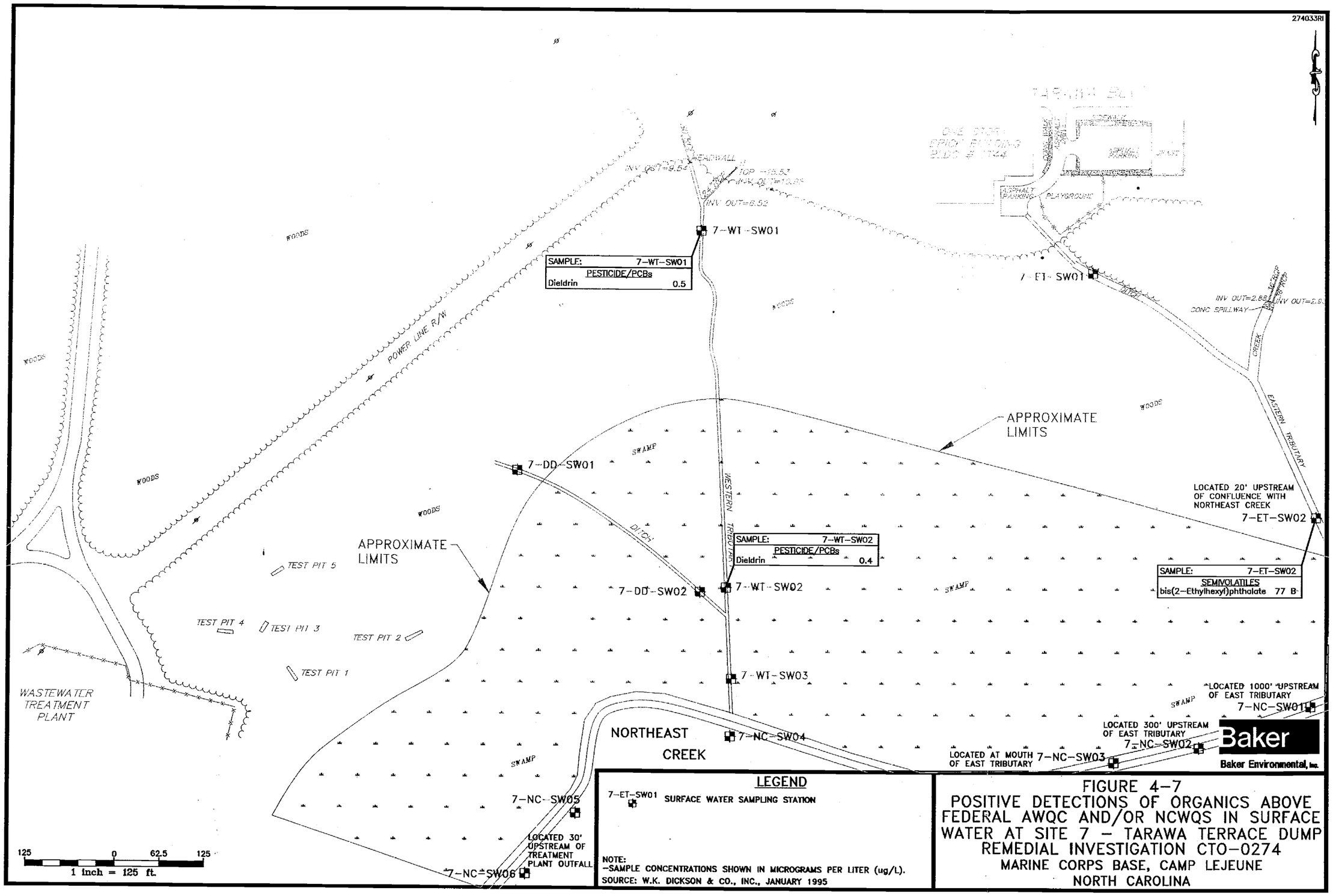
07-MW03 MONITORING WELL LOCATION

07-TW01 TEMPORARY 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 TOTAL TAL METALS ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274033RI



LEGEND

7-ET-SW01 SURFACE WATER SAMPLING STATION

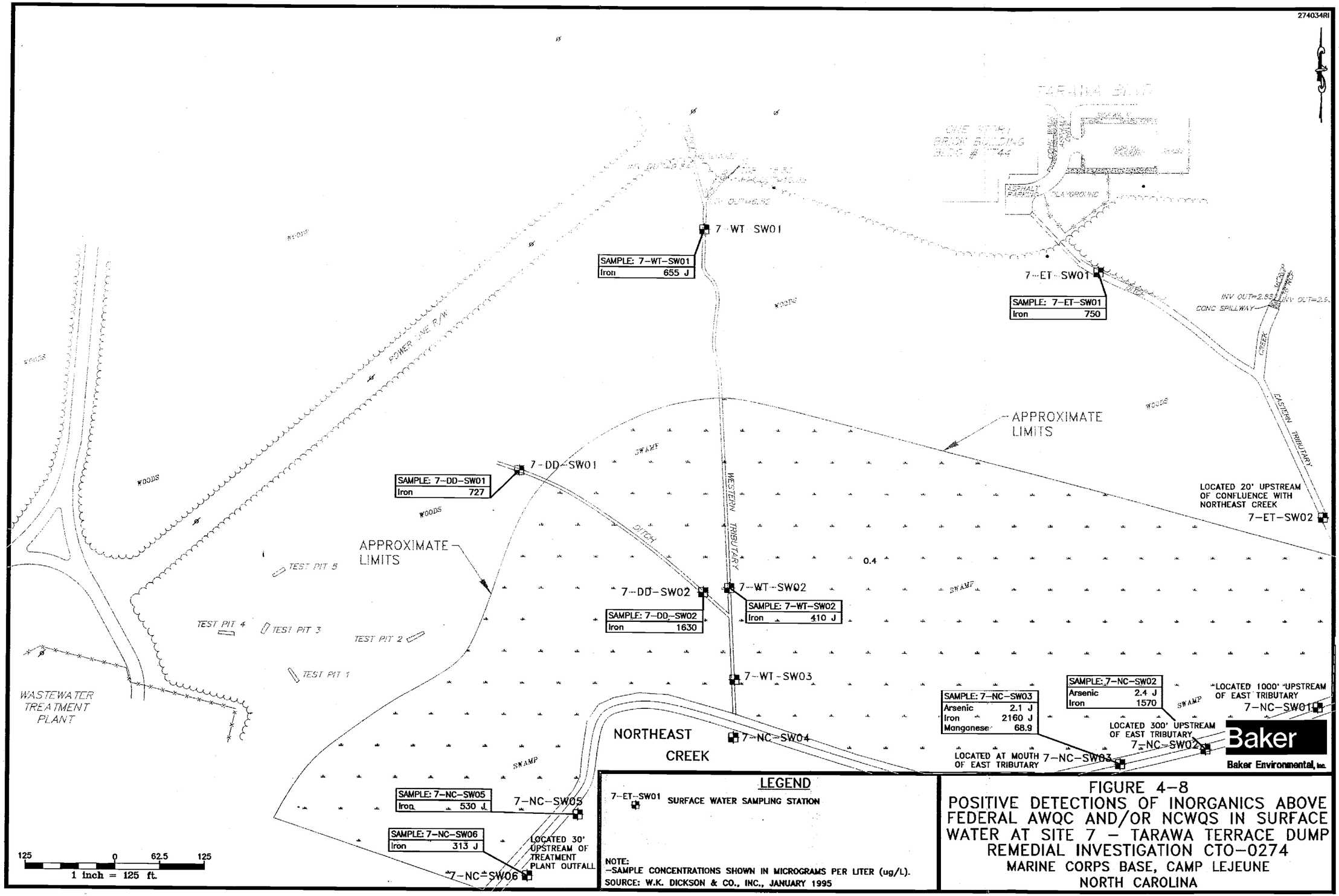
NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER LITER (ug/L).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

Baker

Baker Environmental, Inc.

FIGURE 4-7
POSITIVE DETECTIONS OF ORGANICS ABOVE FEDERAL AWQC AND/OR NCWQS IN SURFACE WATER AT SITE 7 – TARAWA TERRACE DUMP REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274034RI



LEGEND

7-ET-SW01 SURFACE WATER SAMPLING STATION

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

Baker

Baker Environmental, Inc.

FIGURE 4-8
POSITIVE DETECTIONS OF INORGANICS ABOVE FEDERAL AWQC AND/OR NCWQS IN SURFACE WATER AT SITE 7 - TARAWA TERRACE DUMP REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274035RI

7-WT-SD01
7-WT-BN01

SAMPLE: 7-WT-SD01-06
PESTICIDE/PCBs
Dieldrin 71

7-ET-SD01

APPROXIMATE LIMITS

SAMPLE: 7-DD-SD02-06
PESTICIDE/PCBs
Dieldrin 17 J
4,4'-DDE 28 J
4,4'-DDD 120 J
4,4'-DDT 110 J

SAMPLE: 7-WT-SD02-06
PESTICIDE/PCBs
Dieldrin 22

SAMPLE: 7-DD-SD01-06
PESTICIDE/PCBs
4,4'-DDE 14 J
4,4'-DDD 23 J
4,4'-DDT 110 J

7-DD-SD01

SAMPLE: 7-MA-SD02-06
PESTICIDE/PCBs
4,4'-DDE 130
4,4'-DDD 39 J
4,4'-DDT 36 J

7-MA-SD02

7-DD-SD02

7-WT-SD02

SAMPLE: 7-MA-SD03-06
PESTICIDE/PCBs
Dieldrin 39
4,4'-DDE 89
4,4'-DDD 21

SAMPLE: 7-MA-SD03-612
PESTICIDE/PCBs
Dieldrin 41
4,4'-DDE 47

7-MA-SD03

SAMPLE: 7-MA-SD04-06
SEMIVOLATILES
Anthracene 350 J
Pyrene 430 J
PESTICIDE/PCBs
4,4'-DDE 180 J
4,4'-DDD 65 J
4,4'-DDT 27 J

SAMPLE: 7-MA-SD04-612
PESTICIDE/PCBs
4,4'-DDE 27

LOCATED 20' UPSTREAM OF CONFLUENCE WITH NORTHEAST CREEK
7-ET-SD02

7-MA-SD04
LOCATED 100' EAST OF EAST TRIBUTARY

TEST PIT 5
TEST PIT 4
TEST PIT 2
TEST PIT 1

SAMPLE: 7-MA-SD01-06
PESTICIDE/PCBs
4,4'-DDE 67 J
4,4'-DDD 39 J
4,4'-DDT 16 J
Aroclor 450 J

SAMPLE: 7-MA-SD01-612
PESTICIDE/PCBs
4,4'-DDE 39 J
4,4'-DDD 33 J
4,4'-DDT 2.3 J

WASTEWATER TREATMENT PLANT

7-MA-SD01

SAMPLE: 7-WT-SD03-06
PESTICIDE/PCBs
Dieldrin 5.4
4,4'-DDE 11
4,4'-DDD 8.4

7-WT-SD03

SAMPLE: 7-NC-SD04-06
PESTICIDES/PCBs
4,4'-DDD 4.3

SAMPLE: 7-NC-SD04-612
PESTICIDES/PCBs
Dieldrin 7.9 J
4,4'-DDE 20 J
4,4'-DDD 44 J
4,4'-DDT 8.8

7-NC-SD04

NORTHEAST CREEK

SAMPLE: 7-NC-SD02-06
PESTICIDES/PCBs
Dieldrin 5.7
4,4'-DDD 5.3 J

LOCATED 1000' UPSTREAM OF EAST TRIBUTARY
7-NC-SD01

LOCATED 300' UPSTREAM OF EAST TRIBUTARY
7-NC-SD02

LOCATED AT MOUTH OF EAST TRIBUTARY
7-NC-SD03

SAMPLE: 7-NC-SD06-06
PESTICIDES/PCBs
4,4'-DDE 4.5

SAMPLE: 7-NC-SD06-612
PESTICIDES/PCBs
4,4'-DDE 5.1

7-NC-SD05

7-NC-SD06

LOCATED 30' UPSTREAM OF TREATMENT PLANT OUTFALL

SWAMP

125 0 62.5 125
1 inch = 125 ft.

LEGEND

7-ET-SD01 SURFACE WATER/SEDIMENT SAMPLING STATION

7-MA-SD01 SEDIMENT SAMPLING STATION

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

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

Baker
Baker Environmental, Inc.

FIGURE 4-9
POSITIVE DETECTIONS OF ORGANICS ABOVE NOAA CRITERIA IN SEDIMENT AT SITE 7 - TARAWA TERRACE DUMP REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274036RI

7-WT-SD01

7-ET-SD01

APPROXIMATE LIMITS

7-DD-SD01

SAMPLE: 7-MA-SD02-06
Lead 46.9

7-MA-SD02

7-DD-SD02

7-WT-SD02

SAMPLE: 7-MA-SD03-06
Lead 90.8

7-MA-SD03

LOCATED 20' UPSTREAM OF CONFLUENCE WITH NORTHEAST CREEK
7-ET-SD02

7-MA-SD04
LOCATED 100' EAST OF EAST TRIBUTARY

SAMPLE: 7-DD-SD02-06
Lead 40.7

TEST PIT 5
TEST PIT 4
TEST PIT 3
TEST PIT 2

SAMPLE: 7-MA-SD01-06
Copper 95.8
Lead 72.2
Mercury 2.6
Zinc 536

SAMPLE: 7-MA-SD01-612
Lead 46.8
Mercury 1.6
Zinc 344

7-MA-SD01

SAMPLE: 7-NC-SD04-612
Lead 86

7-WT-SD03

LOCATED 1000' UPSTREAM OF EAST TRIBUTARY
7-NC-SD01

7-NC-SD04

LOCATED 300' UPSTREAM OF EAST TRIBUTARY
7-NC-SD02

LOCATED AT MOUTH OF EAST TRIBUTARY
7-NC-SD03

NORTHEAST CREEK

WASTEWATER TREATMENT PLANT

7-NC-SD05

LOCATED 30' UPSTREAM OF TREATMENT PLANT OUTFALL

7-NC-SD06

WOODS
SWAMP
WESTERN TRIBUTARY
EASTERN TRIBUTARY

125 0 62.5 125
1 inch = 125 ft.

LEGEND

7-ET-SD01 SURFACE WATER/SEDIMENT SAMPLING STATION

7-MA-SD01 SEDIMENT SAMPLING STATION

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

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

Baker
Baker Environmental, Inc.

FIGURE 4-10
POSITIVE DETECTIONS OF INORGANICS ABOVE NOAA CRITERIA IN SEDIMENT AT SITE 7 - TARAWA TERRACE DUMP REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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 (OU) No. 11, Site 7, 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 7, the following potential contaminant transport pathways have been identified.

- On-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Migration of contaminants in surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants off site.
- Surface soil run-off from Site 7
- Groundwater discharge to surface water body

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 entire study area at Site 7 is dense with wooded areas and ground cover. This vegetation reduces the likelihood of fugitive dust generation. Consequently, this transport pathway is not significant at the site.

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}).

Several surface water bodies and drainage areas within the vicinity of the Tarawa Terrace Dump site are considered significant. A marsh area is encountered in the southern portion of the study area in the vicinity of Northeast Creek. Northeast Creek flows to the west in the direction of the New River. Two unnamed surface water bodies, within the site boundaries, flow southerly in the direction of Northeast Creek. Northeast Creek and the surface water bodies are influenced by tides. During high tide much of the marsh area is covered with ponded water. Surface water samples were collected in Northeast Creek and the west and east tributaries and drainage ditch at Site 7. PAH's and pesticides were detected in the sediments in these areas but were not detected in the associated surface waters. Inorganics and a few VOCs were detected in both the sediments and surface water.

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 and deep monitoring wells at Site 7. 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 results were discussed in detail in Section 4.0, Nature and Extent of Contamination.

A few VOCs were detected in the groundwater at Site 7, which differed from those detected in the surface soil. This may be due to a number of reasons including:

- VOCs in soil may have degraded, decomposed, or volatilized out of the soil column over time.
- The VOC contamination in groundwater may be from an off-site source.
- The source of VOC contamination may have been removed.

Contaminants detected in Site 7 soil samples, such as PAHs, some pesticides, and polychlorinated biphenyls (PCBs) were not detected in groundwater samples, suggesting that these compounds have not leached to the groundwater. Considering the physical and chemical properties of PAHs and their "moderately immobile" nature (Table 5-1), this is expected.

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. This site is very close to Northeast Creek, and two unnamed surface water bodies, within the site boundaries, also flow in the direction of Northeast Creek. The groundwater may discharge to any of these surface water bodies.

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 may interact with the aquifer solids encountered along the flow path through adsorption, partitioning, ion exchange, and other processes. The interactions result in the contaminant distribution between 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 aquifer solids (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 groundwaters 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).

The slope of the site is to the south toward Northeast Creek. Several surface water bodies and drainage areas within the vicinity of the Tarawa Terrace Dump site are considered significant. Surface waters and runoff from the site flow in a southerly direction into Northeast Creek. Northeast Creek flows in a southwesterly direction along the southern edge of the site and flows into the New River approximately 3 miles downstream. Northeast Creek and the surface water bodies are influenced by the tides.

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at Site 7.

5.2.5 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 site topography is variable with elevations ranging from 20 feet msl to the north to 5 feet msl to the south. The slope of the site is to the south toward Northeast Creek. Several surface water bodies are also within the site boundaries. Northeast Creek and the surface water bodies are influenced by the tides. During high tides much of the southern portion of the site is covered with ponded water. Surface soil and sediment analytical results indicate that surface soil runoff may be an active pathway for the transport of contaminants off-site. PAHs and several pesticides were detected in both the surface soils and the sediments.

The following paragraphs summarize the site-specific fate and transport data for some contaminants of potential concern at Site 7.

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at Site 7.

5.3.1 Volatile Organic Compounds

VOCs (i.e., chloroform, 2-butanone, 2-hexanone, xylenes, toluene, and styrene) 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 Polynuclear Aromatic Hydrocarbons (PAHs)

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, fluoranthene, 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. Benzo(g,h,i)perylene is usually the most abundant compound in soils with low PAH values but becomes less important with increasing total PAH values. Other PAH are anthracene, acenaphthylene, benzo(a)anthracene, chrysene, fluorene, pyrene, dibenz(a,h)anthracene, benzo(g,h,i,)perylene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, naphthalene, 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. The presence of PAHs in the soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

5.3.3 Pesticides/Polychlorinated Biphenyls

Pesticides/PCBs are persistent and immobile contaminants in environmental media. Pesticides travel at varying rates through soil, mainly due to their affinity for soil surfaces. The soil sorption coefficient (K_d) is the distribution of a pesticide between soil and water. In general, the K_d values are higher for high organic carbon soil than for low organic carbon soils. Therefore, soils with high K_d values will retain pesticides (i.e., 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD). As evidenced by the ubiquitous nature of 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD, volatilization is an important transport process from soils and waters.

PCBs have low vapor pressures, low water solubilities, and high K_{oc} and K_{ow} values. Adsorption of these contaminants to soil and sediment is the major fate of these contaminants in the environment.

5.3.4 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. pH values in the soils at Site 7 range from relatively neutral to slightly acidic, therefore, some of the inorganics detected in the subsurface soil may be relatively mobile and migrate towards the groundwater.

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

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Alpha-, Beta-, Gamma-, and Delta- Hexachlorocyclohexane. U.S. Environmental Protection Agency. December 1988.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for p,p'-DDT, p,p'-DDE and p,p'-DDD. April 1989.

Agency of Toxic Substances and Disease Registry. U.S. Public Health Service. Toxicological Profile for Selected PCBs (Aroclor -1260, -1254, -1248, -1242, -1232, -1221 and -1016). U.S. Environmental Protection Agency, Atlanta, Georgia. June 1989.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Naphthalene and 2-Methylnaphthalene. February 1990.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Aldrin/Dieldrin (Draft for Public Comment). U.S. Department of Human and Health Services. Atlanta, Georgia. February 1992.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Endosulfan. April 1993.

Chiou, C.T., L.J. Peters, and V.H. Freed, 1979. "A Physical Concept of Soil-Water Equilibra for Non-Ionic Organic Compounds." Science. Vol. 206, pp. 831-832.

Clement Associates Inc. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, Final Report. September 1985.

Evans, 1989.

Ford and Gurba. 1984. Methods of Determining Relative Contaminant Mobilities and Migration Pathways Using Physical-Chemical Data.

Howard, Philip H. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Lewis Publishers. Chelsea, Michigan. 1991.

Jones, et al., 1989.

Laskowski, 1983.

Lyman, W.J., W.F. Rechl, and D.H. Rosenblatt. 1982. Handbook of Chemical Property Estimation Methods. McGraw-Hill, Inc., New York.

Mackay, P.M., P.V. Roberts, and J.A. Cherry. 1985. "Transport of Organic Contaminants in Groundwater." Environmental Science and Technology. Vol. 19, No. 5, pp. 384-392.

Montgomery, J.H., and L.M. Welkon. Groundwater Chemicals Desk Reference. Lewis Publishers. Chelsea, Michigan. 1980.

SCDM, 1992. Superfund Chemical Data Matrix. Office of Solid Waste and Emergency Response. January 1992.

SPHEM, 1986 U.S. Environmental Protection Agency, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, D.C. October 1986. EPA 540/1-86-060.

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

U.S. Environmental Protection Agency, 1985. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Office of Solid Waste and Remedial Response. Washington, D.C. September 1985.

U.S. Environmental Protection Agency, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Part I. Environmental Research Laboratory. Athens, Georgia. September 1985. EPA/600/6-85/002a.

U.S. Environmental Protection Agency, 1986. Health and Environmental Effects Profile for Carbazole. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development. Cincinnati, OH. April 1986. EPA/600/X-86/334.

Verscheuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Company, New York, 1983.

Versar

SECTION 5.0 TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
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 ($atm\text{-}m^3/mole$)	Mobility Index
Volatiles:							
Methylene Chloride	$4.4 \times 10^{+02(1)}$	$1.3 \times 10^{+04(1)}$	1.54[2]	1.3[1]	1.327[14]	$2.2 \times 10^{-03(1)}$	5.2
Acetone	$2.3 \times 10^{+02(1)}$	$1.0 \times 10^{+06(1)}$	0.34[2]	-0.24[2]	0.791[14]	$3.9 \times 10^{-05(1)}$	8.0
2-Butanone	$9.5 \times 10^{+01(1)}$	$2.2 \times 10^{+05(1)}$	0.65[2]	0.29[1]	0.805[14]	$5.6 \times 10^{-05(1)}$	6.7
Trichloroethene	$6.9 \times 10^{+01(1)}$	$1.1 \times 10^{+03(1)}$	2.1[2]	2.4[1]	1.46[14]	$1.0 \times 10^{-02(2)}$	2.8
Toluene	$2.8 \times 10^{+01(1)}$	$5.3 \times 10^{+02(1)}$	2.48[2]	2.7[1]	0.867[14]	$6.6 \times 10^{-03(1)}$	1.7
Chloroform	$2.0 \times 10^{+02(1)}$	$8.0 \times 10^{+03(1)}$	1.49[2]	2.0[1]	1.489[14]	$3.7 \times 10^{-03(1)}$	4.7
2-Hexanone	2[14]	$3.5 \times 10^{+04(14)}$	1.17-2.13[14]	1.38[14]	0.83[14]	$7.51 \times 10^{-08(15)}$	3.7-2.7
Styrene	6.4[1]	$3.1 \times 10^{+02(1)}$	2.87[14]	3.0[1]	0.9045[14]	$2.8 \times 10^{-03(1)}$	0.42
Xylenes, total	$1.0 \times 10^{+01(2)}$	$1.98 \times 10^{+02(2)}$	2.38[2]	3.26[2]	0.87[14]	$7.04 \times 10^{-03(2)}$	0.92
Semivolatiles:							
Phenol	$3.5 \times 10^{-01(1)}$	$8.3 \times 10^{+04(1)}$	1.15[2]	1.5[1]	1.07[14]	$3.3 \times 10^{-07(1)}$	3.3
4-Methylphenol	$1 \times 10^{+02(14)}$	$4.4 \times 10^{+03(14)}$	2.17[14]	2.56[14]	1.035[14]	--	3.5
Naphthalene	$8.5 \times 10^{-02(1)}$	$3.1 \times 10^{+01(1)}$	2.97[10]	3.6[1]	1.152[14]	$4.8 \times 10^{-04(1)}$	-2.5
2-Methylnaphthalene	--	insoluble	3.03	3.6	1.0058[14]	--	--
Acenaphthene	$1.5 \times 10^{-03(3)}$	3.47[3]	1.25[3]	3.97[3]	0.994[14]	$1.5 \times 10^{-04(3)}$	2.5
Acenaphthylene	$9.1 \times 10^{-04(1)}$	$1.6 \times 10^{+01(1)}$	3.4[2]	4.1[1]	--	$1.1 \times 10^{-05(1)}$	-5.2
Dibenzofuran	--	10[6]	3.9-4.1[6]	4.12-4.31[6]	1.0886[6]	--	--
Fluorene	$1 \times 10^{-02(3)}$	1.69[3]	3.65[3]	4.18[3]	--	$1.29 \times 10^{-03(3)}$	-5.4
Phenanthrene	$9.6 \times 10^{-04(3)}$	1.0[3]	4.2[3]	4.46[3]	1.025[14]	$2.25 \times 10^{-04(3)}$	-7.2
Fluoranthene	$5.0 \times 10^{-06(3)}$	0.26[3]	4.64[3]	5.33[3]	--	$5.12 \times 10^{-06(3)}$	-10.5
Anthracene	$9.6 \times 10^{-04(3)}$	1.0[3]	4.2[3]	4.46[3]	1.25[14]	$2.25 \times 10^{-04(3)}$	-7.2
Carbazole	$7.0 \times 10^{-04(4)}$	1.2[4]	--	3.72[4]	1.1[4]	--	--
Di-n-butylphthalate	$7.3 \times 10^{-05(1)}$	11[1]	5.23[2]	5.2[1]	1.0465[14]	--	-8.3
Pyrene	$2.5 \times 10^{-06(3)}$	0.14[3]	4.64[3]	5.32[3]	1.271[14]	$4.75 \times 10^{-06(3)}$	-11.1

TABLE 5-1 (Continued)

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF POTENTIAL CONCERN
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
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 ($atm\text{-}m^3/mole$)	Mobility Index
Butyl benzyl phthalate	$8.3 \times 10^{-06(1)}$	$2.7^{(1)}$	$4.78^{(14)}$	$4.9^{(3)}$	$1.1^{(14)}$	$1.3 \times 10^{-06(3)}$	-9.4
3,3'-Dichlorobenzidine	$3.7 \times 10^{-08(1)}$	$3.1^{(1)}$	$3.19^{(2)}$	$3.5^{(1)}$	--	$4.0 \times 10^{-09(1)}$	-10.1
Benzo(a)anthracene	$2.2 \times 10^{-08(3)}$	$5.7 \times 10^{-03(3)}$	$5.34^{(3)}$	$5.61^{(3)}$	--	$7.34 \times 10^{-07(3)}$	-15.2
Chrysene	$6.3 \times 10^{-09(3)}$	$1.8 \times 10^{-03(3)}$	$5.34^{(3)}$	$5.61^{(3)}$	$1.274^{(14)}$	$1.05 \times 10^{-06(3)}$	-16.3
Bis(2-ethylhexyl)phthalate	$9.8 \times 10^{-06(1)}$	$0.34^{(1)}$	$8.73^{(2)}$	$5.1^{(1)}$	$0.99^{(4)}$	$1.5 \times 10^{-05(1)}$	-14.2
Di-n-octylphthalate	$2.6 \times 10^{-06(1)}$	$3^{(1)}$	$9.2^{(2)}$	$9.2^{(1)}$	0.99(14)	--	-14.3
Benzo(b)fluoranthene	$5 \times 10^{-07(3)}$	$1 \times 10^{-03(3)}$	--	$6.08^{(3)}$	--	$1.66 \times 10^{-04(3)}$	--
Benzo(k)fluoranthene	$5 \times 10^{-07(3)}$	$5.5 \times 10^{-04(3)}$	--	$6.08^{(3)}$	--	$3.02 \times 10^{-04(3)}$	--
Benzo(a)pyrene	$5.6 \times 10^{-09(3)}$	$3.8 \times 10^{-03(3)}$	--	$6.08^{(3)}$	$1.274^{(14)}$	$4.89 \times 10^{-07(3)}$	--
Indeno(1,2,3-cd)pyrene	$1 \times 10^{-10(3)}$	$5 \times 10^{-04(3)}$	--	$6.51^{(3)}$	--	$6.0 \times 10^{-10(3)}$	--
Dibenz(a,h)anthracene	$1 \times 10^{-10(1)}$	$2.5 \times 10^{-06(1)}$	$6.52^{(2)}$	$6.5^{(1)}$	--	$1.2 \times 10^{-04(1)}$	-22.1
Benzo(g,h,i)perylene	$1 \times 10^{-10(3)}$	$3 \times 10^{-04(3)}$	--	$6.51^{(3)}$	--	$1.21 \times 10^{-07(3)}$	--
Pesticides/PCBs: delta-BHC	$3.5 \times 10^{-05(1)}$	$3.1^{(1)}$	$3.5^{(5)}$	$2.5\text{-}4.14^{(6)}$	$1.87^{(14)}$	$4.3 \times 10^{-07(1)}$	-7.5
Aldrin	$1.4 \times 10^{-04(7)}$	$0.2^{(7)}$	$4.69^{(7)}$	$3.01^{(7)}$	--	$3.2 \times 10^{-04(7)}$	-9.2
Dieldrin	$7.8 \times 10^{-07(7)}$	$0.18^{(7)}$	$3.87^{(7)}$	$4.55^{(7)}$	$1.75^{(14)}$	$1.51 \times 10^{-05(7)}$	-10.7
4,4'-DDE	$6.5 \times 10^{-06(9)}$	$0.12^{(8)}$	$6.6^{(8)}$	$7^{(8)}$	--	$2.1 \times 10^{-05(1)}$	-12.7
Endrin	$3 \times 10^{-06(11)}$	$2.5 \times 10^{-04(11)}$	$3.92^{(6)}$	$4.56^{(11)}$	--	$7.5 \times 10^{-06(11)}$	-13
Endosulfan II**	$1 \times 10^{-05(11)}$	$0.51^{(11)}$	$3.31^{(6)}$	$3.83^{(11)}$	--	$1.1 \times 10^{-05(11)}$	-8.6
4,4'-DDD	$1 \times 10^{-06(9)}$	$0.16^{(8)}$	$5.9^{(8)}$	$6.2^{(8)}$	--	$4 \times 10^{-06(1)}$	-12.7
4,4'-DDT	$1.9 \times 10^{-07(9)}$	$0.0034^{(8)}$	$5.4^{(8)}$	$6.19^{(8)}$	--	$8.3 \times 10^{-06(1)}$	-14.6
Endrin Aldehyde***	$3 \times 10^{-06(11)}$	$2.5 \times 10^{-04(11)}$	$3.92^{(6)}$	$4.56^{(11)}$	--	$7.52 \times 10^{-06(11)}$	-13
Endrin Ketone***	$3 \times 10^{-06(11)}$	$2.5 \times 10^{-04(11)}$	$3.92^{(6)}$	$4.56^{(11)}$	--	$7.52 \times 10^{-06(11)}$	-13
alpha-Chlordane*	$9.8 \times 10^{-06(1)}$	$5.6 \times 10^{-02(1)}$	$5.15^{(2)}$	$5.5^{(1)}$	--	$4.9 \times 10^{-05(1)}$	-11.4
gamma-Chlordane*	$9.8 \times 10^{-06(1)}$	$5.6 \times 10^{-02(1)}$	$5.15^{(2)}$	$5.5^{(1)}$	--	$4.9 \times 10^{-05(1)}$	-11.4

TABLE 5-1 (Continued)

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF POTENTIAL CONCERN
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
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 ($atm\text{-}m^3/mole$)	Mobility Index
Aroclor-1254	7.7×10^{-05}[13]	0.012[13]	5.72[2]	6.5[13]	1.50[16]	2×10^{-03}[13]	-11.7
Aroclor-1260	4.1×10^{-05}[13]	2.7×10^{-03}[13]	5.72[2]	6.8[13]	1.58[16]	4.6×10^{-03}[13]	-12.7

Notes: -- = Value not available.
* - Values are for Total Chlordane
** - Values are for Endosulfan
*** - Values are for Endrin

(1) SCDM, 1992.
(2) SPHEM, 1986.
(3) USEPA, 1985.
(4) USEPA, 1986.
(5) ATSDR, 1988.
(6) Montgomery, 1980.
(7) ATSDR, 1992.
(8) ATSDR, 1989.
(9) Clement, 1985.
(10) ATSDR, 1990.
(11) Howard, 1991.
(12) ATSDR, 1993.
(13) ATSDR, 1989.
(14) Verscheuren, 1983.
(15) Lyman, 1982.
(16) Versar

TABLE 5-2

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Volatiles: Methylene Chloride	--	+	?	--	--	--
Acetone	NA	NA	NA	NA	NA	NA
2-Butanone	NA	NA	NA	NA	NA	NA
Trichloroethene	--	+	?	--	--	--
Toluene	+	+	?	--	--	--
Chloroform	--	+	?	--	--	--
2-Hexanone	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA
Xylenes, total	NA	NA	NA	NA	NA	NA
Semivolatiles: Phenol	--	+	+	--	--	--
4-Methylphenol	NA	NA	NA	NA	NA	NA
Naphthalene	+	--	+	+	--	--
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
Acenaphthene(b)	+	--	+	+	--	--
Acenaphthylene(b)	+	--	+	+	--	--
Dibenzofuran	NA	NA	NA	NA	NA	NA
Fluorene(b)	+	--	+	+	--	--
Phenanthrene(b)	+	+	+	+	--	--
Fluoranthene(b)	+	+	+	+	--	--
Anthracene	+	+	+	+	--	--
Carbazole	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	+	--	+	--	--	+
Pyrene(b)	+	--	+	+	--	--
Butyl benzyl phthalate	+	--	+	--	--	+

TABLE 5-2 (Continued)

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
3,3'-Dichlorobenzidine	++	--	--	+	--	--
Benzo(a)anthracene	+	+	+	+	--	--
Chrysene(b)	+	--	+	+	--	--
Bis(2-ethylhexyl)phthalate	+	--	+	--	--	+
Di-n-octylphthalate	+	--	+	--	--	+
Benzo(b)fluoranthene(b)	+	--	+	+	--	--
Benzo(k)fluoranthene(b)	+	--	+	+	--	--
Benzo(a)pyrene	+	+	+	+	--	--
Indeno(1,2,3-cd)pyrene(b)	+	--	+	+	--	--
Dibenz(a,h)anthracene(b)	+	--	+	+	--	--
Benzo(g,h,i)perylene(b)	+	--	+	+	--	--
Pesticides/PCBs: delta-BHC	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA
Dieldrin	+	+	--	+	--	+
4,4'-DDE	+	+	--	+	--	+
Endrin	?	?	?	+	--	+
Endosulfan II	+	+	+	?	+	--
4,4'-DDD	+	+	--	--	--	+
4,4'-DDT	+	+	--	--	+	+
Endrin Aldehyde	?	?	?	+	--	+
Endrin Ketone	?	?	?	+	--	+
alpha-Chlordane	+	+	?	--	--	+
gamma-Chlordane	+	+	?	--	--	+
Aroclor-1254	+	+	+(a)	?	--	+

TABLE 5-2 (Continued)

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Aroclor-1260	+	+	+(a)	?	--	+

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.

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)
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-274
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. 11, Site 7 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. Five environmental media were investigated during this RI: surface soil, subsurface soil, groundwater, surface water and sediment. 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, whith 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 Feasiblity 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. The 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, 1995).

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 the 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 41 sample locations. The mean for subsurface soil inorganics is estimated using results from 35 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 detection limits. The CRQL for semivolatiles (SVOCs) and pesticide/PCBs in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess SVOC and pesticide/PCB contaminant levels in soil using aqueous blanks, blank concentrations must be multiplied by 33 or 66 to account for variance from 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 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 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.

6.2.1.5 Prevalence

A contaminant's prevalence is determined by the frequency at which it is detected in a given sample set, and by the level at which it is detected. Contaminants are considered infrequently detected if they are present in less than 5 percent of samples, when at least 20 samples are available from any given medium. Infrequently detected contaminants may be eliminated as COPCs, because they may not be considered attributed to site-related contamination. However, if these contaminants are detected at levels exceeding other selection criteria, or if they are detected in other media, they may be considered site-related and subsequently retained as COPCs.

Contaminants detected at frequencies greater than 5 percent are considered in COPC selection. However, if these contaminants are absent from or detected at low concentrations in other media, they may not be retained as COPCs, despite the frequency of detection.

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 7. 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, iron). 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. Relevant regulatory guidelines include Ambient Water Quality Criteria (AWQC) and Health Advisories (HA).

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 6-10 present data compared to applicable standards and criteria.

A brief explanation of the criteria and standards used for qualitative evaluation of COPCs 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.

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations that, either alone or in conjunction with other wastes in surface waters, will neither render waters injurious to aquatic life, wildlife, or public health, nor impair the waters for any designated use.

Ambient Water Quality Criteria - AWQCs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The human health AWQCs for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e. the 10E-7 to 10E-5 range).

Region IV Sediment Screening Values - Currently, federal sediment quality criteria for the protection of aquatic life are being developed. In the interim, the USEPA Region IV Waste Management Division recommends using sediment values, compiled by the National Oceanic and Atmospheric Administration (NOAA), as screening values for evaluating the potential for chemical constituents in sediments to cause adverse biological effects. NOAA developed this screening method through evaluating biological effects data for marine and freshwater organisms obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed, and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called an Effects Range-Median, or ER-M) were determined.

If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-L and the ER-M, adverse effects are considered possible, and the USEPA recommends conducting sediment toxicity tests as a follow-up. If contaminant concentrations are below the ER-L, adverse effects are considered unlikely.

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

Thirty-two surface soil samples were analyzed for VOCs. Acetone, 2-butanone, trichloroethene and toluene were detected at low frequencies. In addition, these VOCs were detected at maximum concentrations below respective residential soil RBCs. For these reasons, acetone, 2-butanone, trichloroethene and toluene are not retained as COPCs.

No VOCs are retained as surface soil COPCs.

Thirty-two surface soil samples were analyzed for SVOCs. The following contaminants were detected in surface soil samples, but are not retained as COPCs because maximum sample concentrations are less than respective residential soil RBC values: phenol, acenaphthene, fluorene, phenanthrene, anthracene, carbazole, di-n-butylphthalate, fluoranthene, pyrene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene.

Benzo(a)pyrene was detected in three surface soil samples at a maximum concentration exceeding the residential soil RBC value. For this reason, it is retained as a COPC.

Thirty-two surface soil samples were analyzed for pesticide/PCBs. Delta-BHC is not retained as a COPC because its frequency of detection is less than 5 percent. The following pesticide/PCBs were detected in surface soil samples, but are not retained as COPCs because maximum concentrations are less than respective residential soil RBC values: aldrin, 4,4'-DDE, endosulfan II, 4,4'-DDD, 4,4'-DDT, endrin aldehyde, alpha-chlordane, gamma-chlordane, Aroclor-1254 and Aroclor-1260.

Dieldrin was detected at a maximum concentration exceeding the residential soil RBC value. For this reason, Dieldrin is retained as a surface soil COPC.

Thirty-two surface soil samples were analyzed for inorganic contaminants. The following inorganics were detected in surface soil samples, but are not retained as COPCs because maximum concentrations are less than respective residential soil RBC values: barium, chromium, cobalt, manganese, mercury, nickel, silver and vanadium. Copper was detected in surface soil samples; however, it is not retained as a COPC because the maximum concentration is below the background level. The following contaminants were detected in surface soil samples, but are not retained as COPCs because maximum concentrations are less than concentrations detected in blanks: magnesium, potassium, selenium, sodium and zinc.

Aluminum, arsenic, beryllium and lead were detected at maximum concentrations exceeding respective background levels and residential soil RBCs. These contaminants are retained as surface soil COPCs.

6.2.2.2 Subsurface Soil

Thirty subsurface soil samples were analyzed for VOCs. Methylene chloride and acetone were detected at maximum concentrations below respective residential soil RBCs. These contaminants are not retained as COPCs.

No VOCs are retained as subsurface soil COPCs.

Thirty subsurface soil samples were analyzed for SVOCs. The following contaminants were detected in samples, but are not retained as COPCs because maximum sample concentrations are less than respective residential soil RBC values: naphthalene, acenaphthene, dibenzofuran, fluorene, anthracene, carbazole, di-n-butylphthalate, fluoranthene, pyrene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene and ideno(1,2,3-cd)pyrene. The following contaminants detected in subsurface soil are not retained as COPCs, because frequencies of detection are less than 5 percent: 2-methylnaphthalene, phenanthrene, benzo(a)pyrene, dibenz(a,h)anthracene and benzo(g,h,i)perylene.

No SVOCs are retained as subsurface soil COPCs.

Thirty subsurface soil samples were analyzed for pesticide/PCBs. The following contaminants are not retained as COPCs because maximum sample concentrations are less than respective residential soil RBCs: aldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, 4,4'-DDT, endrin aldehyde, alpha-chlordane and gamma-chlordane. Delta-BHC and Aroclor-1260 are not retained as COPCs because frequencies of detection are less than 5 percent.

Dieldrin was not detected in background samples or blanks. It was detected at a maximum concentration exceeding the residential soil RBC. For this reason, dieldrin is retained as a subsurface soil COPC.

Thirty subsurface soil samples were analyzed for inorganic contaminants. The following contaminants were detected in samples, but are not retained as COPCs because maximum sample concentrations are less than respective RBCs: barium, chromium, copper, lead, manganese, mercury, nickel, vanadium and zinc. Magnesium, potassium, selenium and sodium were detected at maximum concentrations that are less than respective concentrations in blanks. For this reason, these contaminants are not retained as COPCs. Calcium and iron are not retained as COPCs because they are considered essential nutrients.

Aluminum, arsenic and beryllium were detected at maximum concentrations exceeding both background levels and residential soil RBCs. Consequently, these contaminants are retained as subsurface soil COPCs.

6.2.2.3 Groundwater

Eight groundwater samples were analyzed for VOCs. Chloroform and 2-hexanone were detected in groundwater samples at maximum concentrations less than concentrations detected in blanks. For this reason, these contaminants are not retained as COPCs. Toluene was detected in one groundwater sample; however, it is not retained as a COPC because the maximum concentration is less than the tap water RBC.

No VOCs are retained as groundwater COPCs.

Eight groundwater samples were analyzed for SVOCs. Phenol and 4-methylphenol were detected in groundwater samples; however, these SVOCs are not retained as COPCs because maximum concentrations are less than respective tap water RBCs.

No SVOCs are retained as groundwater COPCs.

Eight groundwater samples were analyzed for pesticides/PCBs. Dieldrin was detected in one sample, at a concentration exceeding the tap water RBC. For this reason, it is retained as a COPC.

Eight groundwater samples were analyzed for inorganic contaminants. The following contaminants were detected in groundwater samples, but are not retained as COPCs because maximum sample concentrations are less than respective tap water RBCs: copper, mercury, selenium and zinc. Calcium, iron, magnesium, potassium and sodium were detected in groundwater samples; however, these contaminants are not retained as COPCs because they are considered essential nutrients.

Aluminum, barium, beryllium, chromium, lead, manganese and vanadium were detected at maximum concentrations exceeding respective tap water RBCs. These contaminants are retained as COPCs.

6.2.2.4 Northeast Creek Surface Water

Six Northeast Creek surface water samples were analyzed for VOCs. Chloroform was detected in one sample, at 1 µg/L. The background level, however, exceeds the maximum concentration detected in surface water. For this reason, chloroform is not retained as a COPC.

2-Butanone and 2-hexanone were detected in one of six samples. These contaminants were not detected in background samples or blanks. For this reason, they are retained as surface water COPCs.

No SVOCs were detected in surface water samples.

No pesticides/PCBs were detected in surface water samples.

Six Northeast Creek surface water samples were analyzed for inorganic contaminants. Arsenic was detected in two samples, silver was detected in five samples and potassium was detected in six samples. For each of these contaminants, however, respective background levels exceed maximum concentrations in surface water samples. For this reason, arsenic, silver and potassium are not retained as COPCs. Aluminum, calcium, iron, magnesium and sodium were detected frequently; however, these inorganics are not retained as COPCs because they are considered essential nutrients.

Barium, lead, manganese and zinc were detected frequently. These contaminants were not detected in blanks, and in each case, maximum concentrations exceed respective background levels. For this reason, barium, lead, manganese and zinc are retained as surface water COPCs.

6.2.2.5 Northeast Creek Sediment

Twelve Northeast Creek sediment samples were analyzed for VOCs. 2-Butanone was detected in four sediment samples. It was not detected in background samples or blanks. For this reason, 2-butanone is retained as a sediment COPC.

Twelve Northeast Creek sediment samples were analyzed for SVOCs. The following SVOCs were detected in at least one sediment sample: phenanthrene, fluorene, pyrene, butyl benzyl phthalate, benzo(a)anthracene, chrysene, di-n-octylphtalate, benzo(b)fluoranthene, benzo(k)fluoranthene and ideno(1,2,3-cd)pyrene. These contaminants, however, were not detected in background samples or blanks. For this reason, these SVOCs are retained as sediment COPCs.

Eleven Northeast Creek sediment samples were analyzed for pesticide/PCBs. 4,4'-DDD and 4,4'-DDT were detected at concentrations exceeding respective background levels. For this reason, these pesticides are retained as COPCs. Dieldrin, 4,4'-DDE, alpha-chlordane and gamma-chlordane were also detected in sediment samples. These contaminants, however, were not detected in background samples or blanks. For this reason, they are retained as sediment COPCs.

Twelve Northeast Creek sediment samples were analyzed for inorganic contaminants. Aluminum, chromium, iron, manganese and vanadium were detected at maximum concentrations below respective background levels. For this reason, these inorganic contaminants are not retained as COPCs. Calcium, magnesium and sodium were detected at high frequencies; however, these inorganics are not retained as COPCs because they are considered essential nutrients.

Barium, lead, thallium and zinc were detected at maximum concentrations exceeding respective background levels. For this reason, these inorganic contaminants are retained as COPCs. Arsenic, beryllium and copper were detected in 2, 1, and 3 out of 12 samples, respectively. These contaminants, however, were not detected in background samples or blanks. For this reason, they are retained as sediment COPCs.

6.2.2.6 Tributary Surface Water

Seven tributary surface water samples were analyzed for VOCs. Chloroform was detected in two samples, at a maximum concentration less than the concentration detected in blanks. For this reason, chloroform is not retained as a COPC.

Total xylenes were detected in one sample; however, they were not detected in background samples or blanks. For this reason, total xylenes are retained as a tributary surface water COPC.

Seven tributary surface water samples were analyzed for SVOCs. Bis(2-ethylhexyl)phthalate was detected in one sample; however, the concentration was B-qualified by the validator. This indicates that it is likely that the presence of bis(2-ethylhexyl)phthalate is associated with laboratory or sampling induced contamination. For this reason, bis(2-ethylhexyl)phthalate is not retained as a COPC.

No SVOCs are retained as COPCs in tributary surface water.

Seven tributary surface water samples were analyzed for pesticide/PCBs. Dieldrin and endrin ketone were detected in two samples; however, these contaminants were not detected in background

samples or blanks. For this reason, dieldrin and endrin ketone are retained as tributary surface water COPCs.

Seven tributary surface water samples were analyzed for inorganic contaminants. Aluminum, calcium, iron, magnesium, potassium and sodium were detected frequently; however, these inorganics are not retained as COPCs because they are considered essential nutrients.

Barium was detected in seven samples, at a maximum concentration exceeding its background level. It is retained as a COPC. Copper, lead, manganese, silver and zinc were detected in surface water samples, but were not detected in background samples or blanks. These inorganic contaminants are also retained as tributary surface water COPCs.

6.2.2.7 Tributary Sediment

Fifteen tributary sediment samples were analyzed for VOCs. 2-Butanone, toluene and styrene were detected in sediment samples, but were not detected in background samples or blanks. These contaminants are retained as tributary sediment COPCs.

Fifteen tributary sediment samples were analyzed for SVOCs. The following contaminants were detected in sediment samples, but were not detected in background samples or blanks: acenaphthylene, dibenzofuran, phenanthrene, anthracene, di-n-butylphthalate, fluoranthene, pyrene, butyl benzyl phthalate, 3,3'-dichlorobenzidine, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene and benzo(g,h,i)perylene. For this reason, these SVOCs are retained as COPCs. Bis(2-ethytlhexyl)phthalate was detected in two samples and in blanks; however, the maximum concentration in samples exceeds the concentration in blanks. For this reason, bis(2-ethylhexyl)phthalate is retained as a tributary sediment COPC.

Fifteen tributary sediment samples were analyzed for pesticide/PCBs. Aldrin, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane and gamma-chlordane were detected in sediment samples at maximum concentrations that exceed respective background levels. For this reason, these contaminants are retained as COPCs. Endrin ketone and Aroclor-1260 were detected in sediment samples, but were not detected in background samples or blanks. For this reason, these contaminants are retained as tributary sediment COPCs.

Fifteen tributary sediment samples were analyzed for inorganic contaminants. Aluminum, calcium, iron, magnesium, potassium and sodium were detected frequently; however, these inorganics are not retained as COPCs because they are considered essential nutrients.

The following inorganics were not detected in blanks, but were detected in sediment samples at maximum concentrations that exceed respective background levels: arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, selenium, thallium, vanadium and zinc. These inorganics are retained as tributary sediment COPCs.

6.2.2.8 Summary of COPCs

Table 6-11 presents a detailed summary of COPCs identified in each environmental medium sampled at Site 7. Worksheets used for COPC selection are presented in Appendix L.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Site 7 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 Conceptual Site Model of Potential Exposure

A conceptual site model of potential sources, migration pathways and human receptors is developed to encompass all current and future routes for potential exposure at Site 7. Figure 6-1 presents the Site 7 conceptual model. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of Site 7. 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 residents (child and adult)
- Future construction worker

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.
- Groundwater discharge into local streams.
- 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 6-12 presents the matrix of human exposure at Site 7.

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 current military residents and for future residential children and adults.

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 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 7 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. In this scenario, potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering (when applicable). There are no volatile COPCs in Site 7 groundwater, so the inhalation valid is not applicable. Groundwater exposure is evaluated for future residential children and adults.

6.3.2.4 Surface Water/Sediment

Access to Northeast Creek surface water and sediment at Site 7 is limited. Wading is most likely the means of exposure to surface water and sediment in the tributaries, and also on the banks of Northeast Creek. However, it is possible that surface water recreational facilities may be expanded in the future. Surface water and sediment exposure pathways include ingestion and dermal contact. Exposure is evaluated for current military residents and for future residential children and adults.

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, surface water and sediment 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 7. Consequently, the most complete groundwater, surface water and sediment contaminant concentrations, from an exposure standpoint, are representative exposure concentrations.

Soils are less transitory than the aforementioned media, 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 7, a CDI must be computed for each COPC, in each relevant exposure pathway.

Appendix N contains CDI equations for specific exposure scenarios (USEPA, 1989a).

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 6-13 through 6-22.

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).

Current Military Residents

Current military residents may be exposed to COPCs in surface soils 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.

The ED for current military residents at Tarawa Terrace is four years. This value represents the average length of time enlisted Marines and their families live at any individual military base. This ED applies to both child and adult military residents. AT values of 25,550 days and 1,460 days (4 years x 365 days/year) are assigned to potentially carcinogenic and noncarcinogenic constituents, respectively. The noncarcinogenic AT applies to both child and adult military residents, as ED (four years) is the same for both children and adults.

The IR, CF, Fi, EF and BW values are the same as those used for children and adults in the future on-site residential exposure scenario.

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, 1991a). 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 6-13.

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:

$$CDI = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

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, 1992b).

Current Military Residents

Current military residents may be exposed to COPCs through dermal contact with surface soil during outdoor activities near their homes.

The ED and EF values for dermal contact with soil are the same as those used for current military residents in the incidental ingestion of soil scenario.

The SA and BW values for current child and adult military residents are the same as those used for future on-site residents.

AT values for military residents are the same as those used in the incidental ingestion of soil scenario.

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 6-14.

6.3.4.3 Inhalation of Fugitive Particulates

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 1989b). Particulate emissions at contaminated sites occur vis-a-vis wind erosion, and thereby vary according to irritability of the surface material. PEF is 6.79E08m^3/kg 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.

The adult IR for residential exposure scenarios is 20 m^3/day, and 12 m^3/day is used for children (USEPA 1989a; USEPA, 1995).

ED, EF, BW and AT values are the same as those used the incidental soil ingestion scenario.

Current Military Residents

Current military residents may be exposed to COPCs in surface soil through inhalation of fugitive particulates during outdoor activities near their homes.

The ED and EF values for particulate inhalation are the same as those used for current military residents in the incidental ingestion of soil scenario.

The IR and BW values for current child and adult military residents are the same as those used for future on-site residents.

AT values for military residents are the same as those used in the incidental ingestion of soil scenario.

A summary of inhalation of fugitive particle exposure assessment input parameters is presented on Table 6-15.

6.3.4.4 Ingestion of Groundwater

Currently at Site 7, 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. Currently, there are five supply wells within a one-half mile radius of this site. These supply wells utilize the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water supplies.

The equation for CDI, calculated for all human receptors potentially ingesting groundwater, is as follows:

$$CDI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

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

Exposure to COPCs by groundwater ingestion is a possible future exposure pathway for children and adults.

A 6-year-old child weighing 15kg has an IR of 1.0 L/day. 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.

IR for adults is 2 L/day (USEPA 1989a). ED is 30 years, the national upper-bound (90th percentile) time spent at one residence (USEPA 1989b). 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.

A summary of groundwater ingestion exposure assessment input parameters is presented in Table 6-16.

6.3.4.5 Dermal Contact with Groundwater

As stated previously, deep groundwater currently provides the potable water supply at Site 7. 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. Currently, there are five supply wells within a one-half mile radius of this site. These supply wells tap the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water 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). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992c).

PC indicates 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. The permeability constant for water (1.55E-03 cm/hr) is used as a default value for those compounds without established PC values (USEPA 1992a). This value may, in fact, be a reasonable estimate of chemical absorption rates when COPC concentrations are in the part-per-billion range.

ET for bathing or showering is 0.25 hours/day, a conservative estimate.

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 6-17.

6.3.4.7 Incidental Ingestion of Surface Water

The equation for surface water ingestion is as follows:

$$CDI = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT \times DY}$$

Where:	C	=	Contaminant concentration in surface water (mg/L)
	IR	=	Ingestion rate (L/hr)
	ET	=	Exposure time (hrs/event)
	EF	=	Exposure frequency (events/year)
	ED	=	Exposure duration (years)
	BW	=	Body weight (kg)
	AT	=	Averaging time (years)
	DY	=	Days per year (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in surface water ingestion.

Future On-Site Residents

The IR, ET and EF values used for future residents apply to both children and adults. IR is 0.05 L/hr (USEPA, 1989a). ET is 2.6 hr/day (USEPA, 1992a). EF is 48 events/yr. This value represents a site-specific professional judgement, according to which exposure to surface water is estimated at 8 days/month, for 6 months/year.

ED values represent lifetime residential exposure durations. They are the same as those used for future children and adult residents in the groundwater exposure scenarios.

BW and AT values are also the same as those used in groundwater exposure scenarios.

Current Military Residents

Current military residents are exposed to surface water during recreational activities in the East and West Tributaries and Northeast Creek, located adjacent to the Tarawa Terrace community.

IR and ET values for current child and adult military residents are the same as those used for future on-site residents.

For both children and adult military residents, EF is estimated at 48 events/year. This value represents a conservative professional judgement; it is assumed that residents experience recreational exposure to surface water eight days/month for six months/year.

BW values for current child and adult military residents are the same as those used for future on-site residents.

The ED for current military residents at Tarawa Terrace is four years. This value represents the average length of time enlisted Marines and their families live at any individual military base. This ED applies to both child and adult military residents. AT values of 25,550 days and 1,460 days (4 years x 365 days/year) are assigned to potentially carcinogenic and noncarcinogenic constituents, respectively. The noncarcinogenic AT applies to both child and adult military residents, as ED (four years) is the same for both children and adults.

A summary of surface water ingestion exposure assessment input parameters is presented in Table 6-18.

6.3.4.8 Dermal Contact with Surface Water

The equation for dermal contact with surface water 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 in surface water (mg/L)
	SA	=	Surface available for contact (cm^2)
	PC	=	Permeability constant (cm/hr)
	ET	=	Exposure Time (hrs/day)
	EF	=	Exposure frequency (days/year)
	ED	=	Exposure duration (years)
	CF	=	Conversion factor ($1L/1000cm^3$)
	BW	=	Body weight (kg)
	AT_c	=	Averaging time carcinogen (days)
	AT_{nc}	=	Averaging time noncarcinogen (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with surface water.

Future On-Site Residents

SA values represent dermal surface area of hands, forearms and lower extremities exposed for contact with surface water. SA is 2100 cm^3 for children and 8300 cm^3 for adults (USEPA, 1992a).

ET, EF, ED, BW and AT values are the same as those used for future children and adult residents in the groundwater ingestion exposure scenario.

PC values are chemical-specific (USEPA, 1992a). They are provided on the CDI spreadsheets in Appendix N.

Current Military Residents

SA is calculated by adding representative values for hands, forearms and lower extremities for children and adults (USEPA, January 1992a). SA for current child residents is 2,100 cm^2, and SA for current adult residents is 8,300 cm^2.

ET, EF, ED, BW and AT values for current child and adult residents are the same as those used in the groundwater ingestion scenario.

A summary of surface water dermal contact exposure assessment input parameters is presented in Table 6-19.

6.3.4.9 Incidental Ingestion of Sediment

The equation for incidental ingestion of sediment is as follows:

$$CDI = \frac{C \times IR \times CF \times EF \times ED}{BW \times AT}$$

Where:	C	=	Contaminant concentration in sediment (mg/kg)
	IR	=	Ingestion rate (mg/day)
	CF	=	Conversion factor for kg to mg (mg/day)
	EF	=	Exposure frequency (days/year)
	ED	=	Exposure duration (years)
	BW	=	Body weight (kg)
	AT	=	Averaging time (years)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in sediment ingestion.

Future On-Site Residents

IR is 200 mg/day for both children and adults (USEPA, 1989a).

EF, ED, BW and AT values are the same as those used for future children and adult residents in the groundwater exposure scenarios.

CF is 1E-06 kg/mg (USEPA, 1989a). It is applied to sediment exposure analyses for both children and adults.

A summary of sediment ingestion exposure assessment input parameters is presented in Table 6-20.

Current Military Residents

IR represents the amount of sediment potentially ingested by current military residents, per exposure event. It is estimated at 200 mg/day for children and 100 mg/day for adults (USEPA, 1989a).

EF, ED, BW and AT values for incidental ingestion of sediment are the same as those used for current child and adult residents in the groundwater ingestion scenario.

Dermal Contact with Sediment

The equation for dermal contact with sediment is as follows:

$$CDI = \frac{C \times CF \times SA \times AF \times Abs \times EF \times ED}{BW \times AT \times DY}$$

Where:	C	=	Concentration of contaminant in sediment (mg/kg)
	CF	=	Conversion factor for kg to mg
	SA	=	Exposed skin surface area (cm^2)
	AF	=	Sediment to skin adherence factor ($mg/cm^{2)}$
	Abs	=	Fraction absorbed (unitless)
	EF	=	Exposure frequency (events/year)
	ED	=	Exposure duration (years)
	BW	=	Body weight (kg)
	AT	=	Averaging time (years)
	DY	=	Days per year (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with sediment.

Future On-Site Residents

SA values are the same as those used for future residential children and adults in the dermal contact with surface water exposure scenario.

AF is 1.0 mg/cm^2. It is used to evaluate dermal contact with sediment for both children and adults. ABS is 1.0 percent for organics and 0.1 percent for inorganics (USEPA, 1991b).

EF, ED, BW, AT and CF values are the same as those used in the sediment ingestion exposure scenario.

Current Military Residents

The SA values used for dermal contact with sediment are the same as those used for current child and adult residents in the dermal contact with surface water scenario.

EF, ED, BW and AT values for current child and adult residents are the same as those used in the sediment ingestion scenario.

A summary of sediment dermal contact exposure assessment input parameters is presented in Table 6-21.

Appendix N contains CDI calculation spreadsheets for specific exposure scenarios (USEPA 1989a).

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 $(mg/kg/day)^{-1}$ 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 6-22. 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:

$$ICR = \sum_{i=1}^{n} CDI_i \times CSF_i$$

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 7 (soil, groundwater and surface water/sediment) are presented in Tables 6-23 through 6-28, 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 7, presented in Tables 6-23 through 6-28.

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 Soil

ICR values calculated for future residential children and adults, current military residential children and adults, and future construction workers fall within or below the USEPA's acceptable risk range. Carcinogens in Site 7 soil do not generate risks beyond the acceptable range. The HI values calculated for these receptors are less than 1.0, below the acceptable risk level. Adverse systemic health effects beyond the acceptable level are not likely to be caused by noncarcinogens in Site 7 soil.

6.5.1.2 Groundwater

The ICR value calculated for future residential children falls within the USEPA's acceptable risk range. However, the ICR for future residential adults exceeds this range (ICR = 1.6E-04). Groundwater ingestion drives the groundwater risk, with beryllium contributing 76 percent to the groundwater ingestion ICR.

The HI values calculated for future residential children (8.84) and for future residential adults (3.8) exceed 1.0, the acceptable risk level. These HI values indicate that adverse systemic health effects are likely to be caused by noncarcinogens in Site 7 groundwater. Groundwater ingestion drives the total groundwater hazard indices for children and adults. Aluminum (64 percent), chromium

(15 percent), manganese (14 percent), and vanadium (17 percent) drive the groundwater ingestion hazard indices for children and adults.

6.5.1.3 Northeast Creek Surface Water/Sediment

ICR values calculated for current and future residential children and adults fall below the USEPA's acceptable risk range. These receptors are then not at risk from carcinogens in northeast creek surface water/sediment at Site 7. The HI values calculated for these receptors are less than 1.0, below the acceptable risk level. Adverse systemic health effects are then not likely to be caused by noncarcinogens in northeast creek surface water/sediment at Site 7.

6.5.1.4 Tributary Surface Water/Sediment

ICR values calculated for current and future residential children and adults fall within or below the USEPA's acceptable risk range. These receptors are then not at risk from carcinogens in tributary surface water/sediment at Site 7. The HI values calculated for these receptors are less than 1.0, below the acceptable risk level. Adverse systemic health effects are then not likely to be caused by noncarcinogens in tributary surface water/sediment.

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 Quantitatively Evaluated

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 7 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 7 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 in environmental media at Site 7 were not quantitatively evaluated in the BRA, as there is no applicable toxicity information promulgated by the USEPA:

2-hexanone
lead
phenanthrene
endrin ketone
benzo(g,h,i)perylene

6.7 BRA Conclusions

The BRA evaluates environmental media at Site 7, in terms of human health risk. Potential receptors at the site include future residential children and adults, current military residential children and adults, 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. Incidental ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater

   c. Incidental ingestion of COPCs in Northeast Creek surface water + incidental ingestion of COPCs in Northeast Creek sediment + dermal contact with COPCs in Northeast Creek surface water + dermal contact with COPCs in Northeast Creek sediment

   d. Incidental ingestion of COPCs in tributary surface water + incidental ingestion of COPCs in tributary sediment + dermal contact with COPCs in tributary surface water + dermal contact with COPCs in tributary sediment

2. Current Military Residents (Children and Adults)

   a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of COPCs in surface soil particulates

   b. Incidental ingestion of COPCs in Northeast Creek surface water incidental ingestion of COPCs in Northeast Creek sediment + dermal contact with COPCs in Northeast Creek surface water + dermal contact with COPCs in Northeast Creek sediment

   c. Incidental ingestion of COPCs in tributary surface water + incidental ingestion of COPCs in tributary sediment + dermal contact with COPCs in tributary surface water + dermal contact with COPCs in tributary sediment

3. Future Construction Worker

   a. Incidental ingestion of COPCs in 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

Total ICR for future residential children, 8.6E-05, is within the USEPA's acceptable cancer risk range. Total HI, 9.16, is greater than 1.0. This value indicates that adverse systemic health effects are likely. Groundwater exposure, groundwater ingestion in particular, drives the total

noncarcinogenic risk for future residential children (97 percent contribution to risk). Aluminum drives the risk associated with groundwater ingestion (64 percent contribution to risk).

6.7.1.2 Future Residential Adults

Total ICR for future residential adult, 1.7E-04, exceeds the USEPA's acceptable cancer risk range. Total HI, 2.74, is greater than 1.0. These values indicate that adverse systemic health effects are likely. Groundwater exposure, groundwater ingestion in particular, drives the total carcinogenic and noncarcinogenic risks for future residential adults (94 percent contribution to both total ICR and total HI). Beryllium drives the carcinogenic risk associated with groundwater ingestion (76 percent contribution), and aluminum drives the noncarcinogenic risk (64 percent contribution).

6.7.1.3 Current Residential Children

Total ICR for current military residential children, 9.3E-06, is within the USEPA's acceptable cancer risk range. Total HI, 0.32, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 7 generate no health risks in excess of acceptable levels.

6.7.1.4 Current Residential Adults

Total ICR for current military residential adults, 1.6E-06, is within the USEPA's acceptable cancer risk range. Total HI, 0.05, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 7 generate no health risks in excess of acceptable levels.

6.7.1.5 Future Construction Workers

Total ICR for future construction workers, 7.19E-09, is below the USEPA's acceptable cancer risk range. Total HI, 0.02, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 7 generate no health risks in excess of acceptable levels.

Total site ICR and HI values are presented in Table 6-29.

6.8 References

Cowherd, C., et al. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared for EPA Office of Health and Environmental Assessment. EPA/600/8-85/002.

Foster, S.A. and P.C. Chrostowski. 1986. Inhalation Exposures to Volatile Organic Contaminants in the Shower. ICF-Clement Associates, Inc. Washington, D.C. 1986.

HEAST, Health Effects Assessment Summary Tables. 1995. Office of Research and Development. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency.

IRIS, Integrated Risk Information System. 1995. Accessed through Chemical Information Systems, Inc., Baltimore, MD.

USEPA. 1989(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-002. December 1989.

USEPA. 1989(b). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume II. Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. May 1989.

USEPA. 1991. United States Environmental Protection Agency. National Functional Guidelines for Organic Data Review. Draft. USEPA Hazardous Site Evaluation Division. June, 1991.

USEPA. 1991(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

USEPA. 1991(b). United States Environmental Protection Agency. Supplemental Region IV Risk Assessment Guidance. Health Assessment Office. March 20, 1991.

USEPA. 1992(a). United States Environmental Protection Agency. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-91/011B. January, 1992.

USEPA. 1992(b). United States Environmental Protection Agency. New Interim Region IV Guidance for Toxicity Equivalency Factor (TEF) Methodology. Region IV Water Management Division. February 11, 1992.

USEPA. 1992(c). United States Environmental Protection Agency. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. Washington, D.C., Publication 9285.7-081. May, 1992.

USEPA. 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening, Philadelphia, PA. January, 1993.

USEPA. 1994. United States Environmental Protection Agency. Drinking Water Regulations and Health Advisories. Office of Water. Washington, D.C. November, 1994.

USEPA. 1995. United States Environmental Protection Agency. Region III Risk-Based Concentration Table. Philadelphia, PA. October 4, 1995.

SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Medium Associated with Maximum Concentration Detected in Blank	Concentration for Comparison[1] (Aqueous - µg/L)	Concentration for Comparison[2] (Solid - µg/L)
Volatiles				
Acetone	140	Soil	1,400	1,400
2-Butanone	15	Soil	150	150
Toluene	1J	Soil	10	10
Methylene Chloride	4J	Soil	40	40
Semivolatiles				
bis(2-Ethylhexyl)phthalate	2J	Soil	20	660[3]
Inorganics				
Aluminum	1,130	Soil	5,650	5,650
Barium	23.5	Soil	117.5	117.5
Calcium	17,000	Soil	85,000	85,000
Iron	392	Soil	1,960	1,960
Magnesium	2,380	Soil	11,900	11,900
Manganese	11.1	Soil	55.5	55.5
Potassium	2,070	Soil	10,350	10,350
Selenium	5.9	Soil	29.5	29.5
Sodium	19,300	Soil	96,500	96,500
Zinc	61.1J	Soil	305.5	305.5
Volatiles				
2-Hexanone	5	Groundwater	25	NA
Toluene	10J	Groundwater	100	NA
Inorganics				
Aluminum	57.8	Groundwater	289	NA
Calcium	89.3	Groundwater	446.5	NA
Iron	97.8	Groundwater	489	NA
Lead	4.1	Groundwater	20.5	NA
Sodium	130	Groundwater	650	NA
Zinc	43J	Groundwater	215	NA

TABLE 6-1 (Continued)

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
TARAWA TERRACE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Medium Associated with Maximum Concentration Detected in Blank	Concentration for Comparison[1] (Aqueous - µg/L)	Concentration for Comparison[2] (Solid - µg/L)
Volatiles				
Chloroform	28	Surface Water/ Sediment	140	140
Semivolatiles				
bis(2-Ethylhexyl)phthalate	330	Surface Water/ Sediment	3,300	108,900[3]
Inorganics				
Calcium	101	Surface Water/ Sediment	505	505
Sodium	179	Surface Water/ Sediment	895	895

(1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum detected concentration in a blank.

(2) Concentration is five or ten times the maximum detected concentration in a blank; converted to µg/kg.

(3) Semivolatile blank concentrations are multiplied by 33 or 66 to account for matrix difference.

NA = Not applicable

TABLE 6-2

ORGANIC DATA SUMMARY
TARAWA TERRACE DUMP SURFACE SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Acetone	150 - 170	2/31
2-Butanone	52	1/31
Trichloroethene	1J	1/30
Toluene	9J - 46J	3/30
Semivolatiles		
Phenol	170J	1/32
Anthracene	100J	1/32
Carbazole	110J	1/32
Di-n-butylphthalate	170J	1/32
Fluoranthene	110 - 750	4/32
Pyrene	85J - 580	4/32
Benzo(a)anthracene	50J - 420	4/32
Chrysene	55J - 420	4/32
bis(2-Ethylhexyl)phthalate	38J - 600	8/32
Benzo(b)fluoranthene	45J - 380	4/32
Benzo(k)fluoranthene	60J - 370	4/32
Benzo(a)pyrene	55J - 340J	3/32
Indeno(1,2,3-cd)pyrene	41J - 250J	3/32
Benzo(g,h,i)perylene	44J - 220J	2/32
Pesticide/PCBs		
Delta-BHC	3.3J	1/30
Aldrin	3	1/30
Dieldrin	4.7J - 57	7/30
4,4'-DDE	3.8 - 65J	7/30
Endosulfan II	7.9J - 37J	3/30
4,4'-DDD	4.3J - 94J	3/31
4,4'-DDT	14J - 280J	4/30
Endrin Aldehyde	39J	1/30
alpha-Chlordane	11J - 26J	3/30
gamma-Chlordane	6.9J - 22J	3/30
Aroclor-1254	43J	1/30
Aroclor-1260	80J	1/30

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-3

INORGANIC DATA SUMMARY
TARAWA TERRACE DUMP SURFACE SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil				
	Average Base-Specific Background[1] Concentration Range	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	2,576	5,152	690J - 12,900J	32/32	15
Antimony	3	6	ND	0/32	NA
Arsenic	1	1	1.1 - 5.1J	6/32	5
Barium	8	15	5.2 - 172	29/32	13
Beryllium	0	0	0.15 - 1.9	10/32	9
Cadmium	0	1	ND	0/32	NA
Calcium	4,79	958	72.7 - 2,069,000J	19/32	10
Chromium	3	6	2.5 - 23.1J	23/32	17
Cobalt	1	2	1.6 - 4.4	2/32	1
Copper	4	7	2.6 - 7.6	7/32	1
Iron	1,630	3,260	14.4 - 17,600J	32/32	14
Lead	11	22	4.2 - 2,620	29/32	6
Magnesium	89	177	36.1 - 1,110	15/32	7
Manganese	9	18	1.7J - 42.9	18/32	5
Mercury	0	0	0.23 - 0.23	2/32	2
Nickel	2	3	6.3 - 13.8	2/32	2
Potassium	93	187	246J - 776J	5/32	5
Selenium	0	1	1.1 - 2.1	7/32	7
Silver	0	1	1.2	1/32	1
Sodium	34	68	24.8J - 153	15/32	5
Thallium	1	1	ND	0/32	NA
Vanadium	4	8	2.5 - 41J	28/32	16
Zinc	6	12	7.8 - 58.9J	15/32	8

Notes: Concentrations are expressed in milligram per kilogram (mg/kg).
Average and Twice Average Base-Specific Background Concentrations are rounded to the nearest whole number.
[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 6-4

ORGANIC DATA SUMMARY
TARAWA TERRACE DUMP SUBSURFACE SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Methylene Chloride	12J	1/30
Acetone	13 - 2300	11/30
Semivolatiles		
Naphthalene	120J	1/29
2-Methylnaphthalene	48J	1/29
Acenaphthene	190J	1/29
Dibenzofuran	120J	1/29
Fluorene	260J	1/29
Phenanthrene	1700	1/29
Anthracene	350J	1/29
Carbazole	450	1/29
Di-n-Butylphthalate	42J - 220J	3/29
Fluoranthene	1800	1/29
Pyrene	1300	1/29
Benzo(a)anthrancene	740	1/29
Chrysene	770	1/29
bis(2-Ethylhexyl)phthalate	39J - 80J	5/29
Benzo(b)fluoranthene	690	1/29
Benzo(k)fluoranthene	610	1/29
Benzo(a)pyrene	460	1/29
Indeno(1,2,3-cd)pyrene	390	1/29
Dibenz(a,h)anthrancene	210J	1/29
Benzo(g,h,i)perylene	330J	1/29
Pesticide/PCBs		
delta-BHC	3J	1/28
Aldrin	6.3	1/28
Dieldrin	17 - 98J	3/28
4,4'-DDE	0.82J - 38	4/28
Endrin	4.8J	1/28
Endosulfan II	17J - 19J	2/28
4,4'-DDD	1.9J - 15J	4/28
4,4'-DDT	1.7J - 19J	2/28
Endrin Aldehyde	8.1J	1/28
alpha-Chlordane	120J	1/28
gamma-Chlordane	2.9 - 110J	2/28
Aroclor-1260	91J	1/28

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-5

INORGANIC DATA SUMMARY
TARAWA TERRACE DUMP SUBSURFACE SOIL
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil				
	Average Base-Specific Background[1] Concentration Range	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	3,615	7,229	607 - 11,600	29/29	3
Antimony	4	7	ND	0/29	NA
Arsenic	1	2	2.4J - 2.6	2/29	2
Barium	7	14	5.7 - 147	28/29	17
Beryllium	0	0	0.08 - 0.34	7/29	6
Cadmium	0	1	ND	0/29	NA
Calcium	225	449	45.5 - 93,300	16/29	8
Chromium	7	14	2.1 - 15.2	26/29	1
Cobalt	1	2	ND	0/29	NA
Copper	1	3	0.43J - 74.7	6/29	3
Iron	4,101	8,202	163 - 8,000	26/29	0
Lead	4	9	1 - 18.3	24/29	2
Magnesium	137	274	24.3 - 662	17/29	4
Manganese	4	9	1.7 - 47.6	18/29	6
Mercury	0	0	1	1/29	1
Nickel	1	3	7	1/29	1
Potassium	197	395	369 - 462J	2/29	1
Selenium	0	1	1	1/29	1
Silver	0	1	ND	0/29	NA
Sodium	28	57	22.7 - 81.2	9/29	1
Thallium	1	1	ND	0/29	NA
Vanadium	7	14	1.5 - 18.2	22/29	3
Zinc	4	8	4.5 - 135	1/29	7

Notes: Concentrations are expressed in milligram per kilogram (mg/kg).
Average and Twice Average Base-Specific Background Concentrations are rounded to the nearest whole number.
[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
TARAWA TERRACE DUMP OPERABLE UNIT NO. 11 (SITE 7)
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
Volatiles										
Chloroform	0.19	80[4]	100	400	2/8	4J - 8J	2	0	0	0
2-Hexanone	NE	NE	NE	NE	1/8	1J	NA	NA	NA	NA
Toluene	1,000	1,000	2,000	7000	1/8	4J	0	0	0	0
Semivolatiles										
Phenol	300	NE	6,000	20,000	1/8	4J	0	NA	0	0
4-Methylphenol	NE	NE	NE	NE	1/8	10	NA	NA	NA	NA
Pesticide/PCBs										
Dieldrin	NE	NE	NE	NE	1/8	0.41	NA	NA	NA	NA
Inorganics										
Aluminum	NE	50 - 200[5]	NE	NE	5/8	1,660 - 888,000	NA	5	NA	NA
Barium	2,000	2,000	NE	NE	8/8	3.2J - 370	0	0	NA	NA
Beryllium	NE	4	4,000	20,000	3/8	1.2 - 3.0	NA	0	0	0
Calcium	NE	NE	NE	NE	8/8	590 - 174,000	NA	NA	NA	NA
Chromium	50	100	200	800	4/8	11.7 - 104	1	1	0	0
Copper	1,000	1,300[6]	NE	NE	2/8	10.6 - 20.8	0	0	NA	NA
Iron	300	300[5]	NE	NE	5/8	969 - 25,400	5	5	NA	NA
Lead	15	15[6]	NE	NE	3/8	27.1J - 67.5J	3	3	NA	NA
Magnesium	NE	NE	NE	NE	8/8	860 - 13,000	NA	NA	NA	NA
Manganese	50	50[5]	NE	NE	8/8	5J - 44.5	0	0	NA	NA
Mercury	1.1	2	NE	2	2/8	0.32 - 0.4	0	0	NA	0
Potassium	NE	NE	NE	NE	8/8	.020 - 6430	NA	NA	NA	NA
Selenium	50	50	NE	NE	1/8	9.4	0	0	NA	NA
Sodium	NE	NE	NE	NE	8/8	4,420 - 39,800	NA	NA	NA	NA
Vanadium	NE	NE	NE	NE	3/8	24.1 - 167	NA	NA	NA	NA
Zinc	2,100	5,000[5]	3,000	10,000	2/8	167 - 180	0	0	0	0

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
TARAWA TERRACE DUMP OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

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
(4) 1994 Proposed rule for Disinfectants and Disinfectant By-products: Total for all Trihalomethanes cannot exceed the 80 level.
(5) SMCL = Secondary Maximum Contaminant Level
(6) Action level.

NE - No Criteria Established
NA - Not Applicable
J - Estimated value

TABLE 6-7

SURFACE WATER DATA SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
		Federal Health AWQCs[2]				Positive Detects Above NCWQS	Positive Detects Above AWQC	
	NCWQS[1]	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Volatiles								
Chloroform	NE	5.7	470	1/6	1J	NA	0	0
2-Butanone	NE	NE	NE	1/6	2J	NA	NA	NA
2-Hexanone	NE	NE	NE	1/6	1J	NA	NA	NA
Inorganics								
Aluminum	NE	NE	NE	6/6	290 - 2,200	NA	NA	NA
Arsenic	NE	0.018	0.14	2/6	2.1 - 2.4J	NA	2	2
Barium	NE	NE	NE	6/6	18.9 - 37.2	NA	NA	NA
Calcium	NE	NE	NE	6/6	147,000 - 171,000J	NA	NA	NA
Iron	NE	NE	NE	6/6	208 - 2,160	NA	NA	NA
Lead	NE	NE	NE	5/6	4.2J - 27.1	NA	NA	NA
Magnesium	NE	NE	NE	6/6	476,000 - 573,000	NA	NA	NA
Manganese	NE	NE	NE	6/6	10.1 - 68.9	NA	NA	NA
Potassium	NE	NE	NE	6/6	149,000 - 179,000	NA	NA	NA
Silver	NE	NE	NE	5/6	5.1 - 9.6	NA	NA	NA
Sodium	NE	NE	NE	6/6	3,800,000 - 4,650,000	NA	NA	NA
Zinc	NE	NE	NE	3/6	22.5J - 32.9	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (μg/L).
[1] NCWQS = North Carolina Water Quality Standards for Surface Water
[2] AWQC = Ambient Water Quality Standard
[3] Insufficient data to develop criteria. Value presented is Lowest Observed Effect Level (LOEL).
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-8

SEDIMENT DATA SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria	
					Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Volatiles						
2-Butanone	NE	NE	1J - 53J	4/12	NA	NA
Semivolatiles						
Phenanthrene	225	1,380	91J	1/12	0	0
Fluoranthene	600	3,600	42J - 120J	2/12	0	0
Pyrene	350	2,200	43J - 170J	3/12	0	0
Butylbenzylphthalate	NE	NE	47J	1/12	NA	NA
Benzo(a)anthracene	230	1600	74J	1/12	0	0
Chrysene	400	2,800	70J	1/12	0	0
Di-n-octylphthalate	NE	NE	500J	1/12	NA	NA
Benzo(b)fluoranthene	NE	NE	46J	1/12	NA	NA
Benzo(k)fluoranthene	NE	NE	57J	1/12	NA	NA
Indeno(1,2,3-cd)pyrene	NE	NE	53J	1/12	NA	NA
Pesticide/PCBs						
Dieldrin	0.02	8	5.7 - 7.95	2/11	2	0
4,4'-DDE	2	15	4.5 - 20J	3/11	3	1
4,4'-DDD	2	20	4.3 - 44J	3/11	3	1
4,4'-DDT	1	7	8.8	1/11	1	1
alpha-Chlordane	NE	NE	4.9J - 14	3/11	NA	NA
gamma-Chlordane	NE	NE	5.2 - 11	2/11	NA	NA
Inorganics						
Aluminum	NE	NE	320J - 5,480J	2/12	NA	NA
Arsenic	33	85	0.8 - 1.3J	12/12	0	0
Barium	NE	NE	1.4 - 14.8	1/12	NA	NA

TABLE 6-8 (Continued)

SEDIMENT DATA SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Beryllium	NE	NE	0.28	12/12	NA	NA
Calcium	NE	NE	347 - 39,500	6/12	NA	NA
Chromium	80	145	2.9 - 10	3/12	0	0
Copper	70	390	3.7J - 9.3J	12/12	0	0
Iron	NE	NE	197 - 2,370J	12/12	NA	NA
Lead	35	110	3.9J - 86J	10/12	1	0
Magnesium	NE	NE	540 - 13,900	12/12	NA	NA
Manganese	NE	NE	1.9 - 15.2	12/12	NA	NA
Sodium	NE	NE	1,290 - 48,700	5/12	NA	NA
Thallium	NE	NE	0.61J - 4.9J	5/12	NA	NA
Vanadium	NE	NE	3 - 10.1	5/12	NA	NA
Zinc	120	270	2.9J - 74.5J	11/12	NA	NA

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
[1] ER-L - Effective Range-Low
[2] ER-M - Effective Range-Medium
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-9

SURFACE WATER DATA SUMMARY
TRIBUTARIES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
		Federal Health AWQCs[2]				Positive Detects Above NCWQS	Positive Detects Above AWQC	
	NCWQS[1]	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Volatiles								
Chloroform	NE	5.7	470	2/7	2J - 3J	NA	0	0
Xylenes	NE	NE	NE	1/7	1J	NA	NA	NA
Semivolatiles								
bis(2-Ethylhexyl)phthalate	NE	1.8	5.9	1/7	77B	NA	1	1
Pesticide/PCBs								
Dieldrin	0.000144	0.00014	0.00014	2/7	0.4 - 0.5	2	2	2
Endrin Ketone	NE	NE	NE	2/7	0.12 - 0.13	NA	NA	NA
Inorganics								
Aluminum	NE	NE	NE	7/7	77.1 - 1,860	NA	NA	NA
Barium	NE	NE	NE	7/7	16.4 - 28.9	NA	NA	NA
Calcium	NE	NE	NE	7/7	5,940 - 149,000	NA	NA	NA
Copper	NE	NE	NE	1/7	12.3	NA	NA	NA
Iron	NE	NE	NE	7/7	175J - 1,630	NA	NA	NA
Lead	NE	NE	NE	5/7	2.5J - 15.9	NA	NA	NA
Magnesium	NE	NE	NE	7/7	1,680 - 468,000	NA	NA	NA
Manganese	NE	NE	NE	7/7	11.2 - 21.3	NA	NA	NA
Potassium	NE	NE	NE	3/7	39,600 - 144,000	NA	NA	NA
Silver	NE	NE	NE	1/7	6.6J	NA	NA	NA
Sodium	NE	NE	NE	7/7	7,100 - 3,730,000	NA	NA	NA
Zinc	NE	NE	NE	6/7	6.4 - 168J	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (µg/L).
[1] NCWQS = North Carolina Water Quality Standards for Surface Water
[2] AWQC = Ambient Water Quality Standard
[3] Insufficient data to develop criteria. Value presented is Lowest Observed Effect Level (LOEL).
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-10

SEDIMENT DATA SUMMARY
TRIBUTARIES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Volatiles						
2-Butanone	NE	NE	7J - 250J	10/15	NA	NA
Toluene	NE	NE	10J - 39J	9/15	NA	NA
Styrene	NE	NE	28J	1/15	NA	NA
Semivolatiles						
Acenaphthylene	ND	ND	250J	1/15	NA	NA
Dibenzofuran	NE	NE	130J	1/15	NA	NA
Phenanthrene	225	1,380	100 - 210J	2/15	0	0
Anthracene	85	960	350J	1/15	1	0
Di-n-butylphthalate	NE	NE	76J - 1,300J	9/15	NA	NA
Fluoranthene	600	3,600	72J - 450J	3/15	0	0
Pyrene	350	2,200	87J - 430J	3/15	1	0
Butyl benzyl phthalate	NE	NE	47J	1/15	NA	NA
3,3'-dichlorobenzidine	NE	NE	110J	1/15	NA	NA
Chrysene	400	2,800	110J - 320J	2/15	0	0
bis(2-Ethylhexyl)phthalate	NE	NE	510 - 810	2/15	NA	NA
Benzo(b)fluoranthene	NE	NE	85J - 270J	2/15	NA	NA
Benzo(k)fluoranthene	NE	NE	110J - 230J	2/15	NA	NA
Benzo(a)pyrene	400	2,500	110J	1/15	0	0
Benzo(g,h,i)perylene	NE	NE	65J	1/15	NA	NA
Pesticide/PCBs						
Aldrin	NE	NE	3.1J	1/15	NA	NA
Dieldrin	0.02	8	5.4 - 71	6/15	6	5
4,4'-DDE	2	15	11 - 180J	10/15	10	8
4,4'-DDD	2	20	8.4 - 120J	8/15	8	7
4,4'-DDT	1	7	2.3J - 110J	6/15	6	5
Endrin Ketone	NE	NE	6.5J	1/15	NA	NA
alpha-Chlordane	NE	NE	2.7 - 42J	8/15	NA	NA

TABLE 6-10 (Continued)

SEDIMENT DATA SUMMARY
TRIBUTARIES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
gamma-Chlordane	NE	NE	4.7J - 29J	3/15	NA	NA
Arclor-1260	NE	NE	450J	1/15	NA	NA
Inorganics						
Aluminum	NE	NE	1,170 - 10,500	15/15	NA	NA
Arsenic	33	85	3	1/15	0	0
Barium	NE	NE	7 - 279	15/15	NA	NA
Beryllium	NE	NE	0.44 - 8	3/15	NA	NA
Calcium	NE	NE	299 - 13,400	15/15	NA	NA
Chromium	80	145	4.2 - 19.4	5/15	0	0
Copper	70	390	3.2 - 95.8	4/15	1	0
Iron	NE	NE	570 - 6,060	15/15	NA	NA
Lead	35	110	4.8J - 90.8	15/15	5	0
Magnesium	NE	NE	138 - 6,180	15/15	NA	NA
Manganese	NE	NE	3.4 - 30.6	15/15	NA	NA
Mercury	0.15	1.3	1.6 - 2.6	2/15	2	2
Potassium	NE	NE	1,540 - 1,780	3/15	NA	NA
Selenium	NE	NE	23.4	1/15	NA	NA
Sodium	NE	NE	29.2 - 20,700	15/15	NA	NA
Thallium	NE	NE	0.66J	1/15	NA	NA
Vanadium	NE	NE	2.9 - 37.5	9/15	NA	NA
Zinc	120	270	4.1 - 536	15/15	2	2

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
[1] ER-L - Effective Range-Low
[2] ER-M - Effective Range-Medium
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-11

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	Subsurface Soil	Groundwater		Surface Water		Sediment	
Volatiles								
Chloroform				●		●		
2-Butanone					X	●	X	●
2-Hexanone				●	X	●		
Toluene				●			X	●
Styrene							X	●
Xylenes (Total)					X	●		
Semivolatiles								
Phenol				●				
4-Methylphenol				●				
Acenaphthylene							X	●
Dibenzofuran							X	●
Phenanthrene							X	●
Anthracene							X	●
Di-n-butylphthalate							X	●
Fluoranthene							X	●
Pyrene							X	●
Butylbenzylphthalate							X	●
3,3-Dichlorobenzidine							X	●
Benzo(a)anthracene							X	●
Chrysene							X	●
bis(2-Ethylhexyl)phthalate					X	●	X	●
Di-n-octylphthalate							X	●
Benzo(b)fluoranthene							X	●
Benzo(k)fluoranthene							X	●
Benzo(a)pyrene	X						X	●
Indeno(1,2,3-cd)pyrene							X	●
Benzo(g,h,i)perylene							X	●
Pesticide/PCBs								
delta-BHC								
Aldrin							X	●
Dieldrin	X	X	X	●	X	●	X	●
4,4'-DDE							X	●
4,4'-DDD							X	●
4,4'-DDT							X	●
Endrin ketone					X	●	X	●

TABLE 6-11 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	Subsurface Soil	Groundwater		Surface Water		Sediment	
alpha-Chlordane							X	●
gamma-Chlordane							X	●
Aroclor-1260							X	●
Inorganics								
Aluminun	X	X	X	●		●		●
Arsenic	X	X				●	X	●
Barium			X	●	X	●	X	●
Beryllium	X	X	X	●			X	●
Calcium				●		●		●
Chromium			X	●			X	●
Copper				●	X	●	X	●
Iron				●		●		●
Lead	X		X	●	X	●	X	●
Magnesium				●		●		●
Manganese			X	●	X	●	X	●
Mercury				●			X	●
Potassium				●		●		●
Selenium				●			X	●
Silver					X	●		
Sodium				●		●		●
Thallium							X	●
Vanadium			X	●			X	●
Zinc				●	X	●	X	●

● = Detected in media; compared to relevant criteria and standards.
X = Selected as a COPC for human health risk assessment.

TABLE 6-12

MATRIX OF POTENTIAL HUMAN EXPOSURE
OU NO. 11 (SITE 7) TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Current Military Residents	Future Residential Population
Surface Soil				
Incidental Ingestion	NE	NE	A,C	A,C
Dermal Contact	NE	NE	A,C	A,C
Subsurface Soil				
Incidental Ingestion	NE	W	NE	NE
Dermal Contact	NE	W	NE	NE
Groundwater				
Ingestion	NE	NE	NE	A,C
Dermal Contact	NE	NE	NE	A,C
Surface Water				
Ingestion	NE	NE	A,C	A,C
Dermal Contact	NE	NE	A,C	A,C
Sediment				
Incidental Ingestion	NE	NE	A,C	A,C
Dermal Contact	NE	NE	A,C	A,C
Air				
Inhalation of Vapor Phase Chemicals Indoor	NE	NE	NE	A,C
Inhalation of Particulates Outdoor	NE	W	A,C	A,C

L = Lifetime exposure
C = Exposure in children may be significantly greater than in adults
M = Military lifetime exposure
W = Construction duration exposure
NE = Not Exposed

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residental Child and Adult, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
IR	Ingestion Rate	Child Adult Construction Worker	200 mg/day 100 mg/day 480 mg/day	USEPA, 1989a USEPA, 1991a
CF	Conversion Factor	1E-6 kg/mg		USEPA, 1989a
Fi	Fraction Ingested from Contaminated Source	100%		Conservative Professional Judgement
EF	Exposure Frequency	Future Residents Current Military Residents Construction Worker	350 days/yr 350 days/yr 90 days/yr	USEPA, 1989a USEPA, 1991a
ED	Exposure Duration	Future Child Resident Future Adult Resident Current Military Residents Construction Worker	6 years 24 years 4 years 1 year	USEPA, 1989a Conservative Professional Judgement USEPA, 1991a
BW	Body Weight	Child Adult Construction Worker	15 kg 70 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Resident Future Adult Resident Current Military Residents Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, 1989a

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
CF	Conversion Factor	1E-6 kg/mg		USEPA, 1989a
SA	Exposed Surface Area of Skin Available for Contact	Child Adult Construction Worker	2,300 cm^2 5,800 cm^2 4,300 cm^2	USEPA, 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2		USEPA, 1991b
ABS	Fraction Absorped (unitless)	Organics Inorganics	1.0% 0.1%	USEPA, 1991b
EF	Exposure Frequency	Future Residents Current Military Residents Construction Worker	350 days/yr 350 days/yr 90 days/yr	USEPA, 1989a USEPA, 1991a
ED	Exposure Duration	Future Child Resident Future Adult Resident Current Military Residents Construction Worker	6 years 24 years 4 years 1 year	USEPA, 1989a Conservative Professional Judgement USEPA, 1991a
BW	Body Weight	Child Adult Construction Worker	15 kg 70 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult Military Residents Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, 1989a

TABLE 6-15

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
EF	Exposure Frequency	Child Adult Construction worker	350 days/yr 350 days/yr 90 days/yr	USEPA, 1989a
ED	Exposure Duration	Future Child Resident Future Adult Resident Current Military Residents Future Construction Worker	6 years 24 years 4 years 1 year	USEPA, 1991a Conservative Professional Judgement USEPA, 1991a
IR	Inhalation Rate	Child Adult	12 m^3 20 m^3	USEPA, 1991a USEPA, 1989b
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult Military Residents	2,190 days 8,760 days 1,460 days	USEPA, 1989a
PEF	Site-Specific Particulate Emission Factor	All	6.79E08m^3/kg	USEPA, 1995

TABLE 6-16

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 11 (SITE 7)
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, 1992b
IR	Ingestion Rate	Child Adult	1 L/day 2 L/day	USEPA, 1991a USEPA, 1989a
EF	Exposure Frequency	Child Adult	350 days/yr 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1991a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, 1989a

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 11 (SITE 7)
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, 1992a
SA	Exposed Surface Area of Skin Available for Contact	Child 10,000 cm^2 Adult 23,000 cm^2	USEPA, 1992a
PC	Permeability Constant	Chemical Specific	USEPA, 1992a
ET	Exposure Time	All 0.25 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, 1991a
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, 1989a
CF	Conversion Factor	1 L/1000 cm^3	USEPA, 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, 1989a

TABLE 6-18

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SURFACE WATER
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, 1992b
IR	Ingestion Rate	Child Adult	0.05 L/hr 0.05 L/hr	USEPA, 1989a
ET	Exposure Time	Child Adult	2.6 hr/day 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	48 events/yr 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Residents Future Adult Residents Current Military Residents	6 years 30 years 4 years	USEPA, 1989a Duration of Residence at Base
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Future Child Residents Future Adult Residents Current Military Residents	2,190 days 10,950 days 1,460 days	USEPA, 1989a

TABLE 6-19

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SURFACE WATER
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, 1992b
SA	Exposed Surface Area of Skin Available for Contact	Child Adult	2,100 cm^2 8,300 cm^2	(hands, forearms, lower extremities) (USEPA, 1992a
ET	Exposure Time	Child Adult	2.6 hr/day 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	48 days/yr 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Residents Future Adult Residents Current Military Residents	6 years 30 years 4 years	USEPA, 1989a Duration of Residence at Base
CF	Volumetric Conversion Factor for Water	1 L/1000 cm^3		USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Residents Future Adult Residents Current Military Residents	2,190 days 10,950 days 1,466 days	USEPA, 1989a
PC	Permeability Constant	Chemical-Specific		USEPA, 1992a

TABLE 6-20

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
IR	Soil Ingestion Rate	Child Adult	200 mg/day 100 mg/day	USEPA, 1989a
EF	Exposure Frequency	Child Adult	48 days/yr 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Residents Future Adult Residents Current Military Resident	6 years 30 years 4 years	USEPA, 1989a Duration of Residence at Base
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Residents Future Adult Residents Current Military Residents	2,190 days 10,950 days 1,460 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg		USEPA, 1989a

TABLE 6-21

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
SA	Surface Area of Skin Available for Contact	Child Adult	2,100 cm^2 8,300 cm^2	(head, arms, hands, forearms, lower extremities) USEPA, 1992a
AF	Sediment Adherence Factor	1.0 mg/cm^2		USEPA, 1991b
ABS	Absorption Factor (dimensionless)	Organics Inorganics	1.0% 0.1%	USEPA, 1991b
EF	Exposure Frequency	Child Adult	48 events/yr 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Residents Future Adult Residents Current Military Residents	6 years 30 years 4 years	USEPA, 1989a Duration of Residence at Base
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Residents Future Adult Residents Current Military Residents	2,190 days 10,950 days 1,460 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg		USEPA, 1989a

TABLE 6-22

TOXICITY FACTORS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

COPC	RfD	RfC	CSF	CSFI	WOE	Reference
Volatiles						
2-Butanone	6.00E-01	2.86E-01	ND	ND	ND	IRIS
Toluene	2.00E-01	1.14E-01	ND	ND	D	IRIS
Styrene	2.00E-01	2.86E-01	ND	ND	C	IRIS
Xylenes (total)	2.00E+00	ND	ND	ND	D	IRIS
Semivolatiles						
Acenaphthylene	6.00E-02[1]	ND	ND	ND	ND	IRIS
Dibenzofuran	4.00E-03	ND	ND	ND	ND	EPA-ECAO
Anthracene	3.00E-01	ND	ND	ND	D	IRIS
Chrysene	ND	ND	7.30E-03	6.10E-03	B2	EPA-ECAO
Fluoranthene	4.00E-02	ND	ND	ND	D	IRIS
Benzo(a)anthracene	ND	ND	7.30E-01	6.10E-01	B2	EPA-ECAO
Benzo(b)fluoranthene	ND	ND	7.30E-01	6.10E-01	B2	EPA-ECAO
Benzo(k)fluoranthene	ND	ND	7.30E-02	6.10E-02	B2	EPA-ECAO
Benzo(a)pyrene	ND	ND	7.30E+00	6.10E+00	B2	IRIS
Indeno(1,2,3-cd)pyrene	ND	ND	7.30E-01	6.10E-01	B	EPA-ECAO
Pyrene	3.00E-02	ND	ND	ND	D	IRIS
Di-n-butylphthalate	1.00E-01	ND	ND	ND	D	IRIS
Butylbenzylphthalate	2.00E-01	ND	ND	ND	C	IRIS
bis(2-Ethylhexyl)phthalate	2.00E-02	ND	1.40E-02	ND	ND	IRIS
Di-n-octylphthalate	2.00E-02	ND	ND	ND	ND	HEAST
3,3'-Dichlorobenzidine	ND	ND	4.50E-01	ND	ND	IRIS
Pesticide/PCBs						
4,4'-DDD	ND	ND	2.40E-01	ND	B2	IRIS
4,4'-DDE	ND	ND	3.40E-01	ND	B2	IRIS
4,4'-DDT	5.00E-04	ND	3.40E-01	3.40E-01	B2	IRIS
Dieldrin	5.00E-05	ND	1.60E+01	1.61E+01	B2	IRIS
Total Chlordane	6.00E-05	ND	1.30E+00	1.29E+00	B2	IRIS
Aldrin	3.00E-05	ND	1.70E+01	1.71E+01	B2	IRIS
Aroclor-1260	ND	ND	7.70E+00[3]	ND	B2	IRIS

TABLE 6-22 (Continued)

TOXICITY FACTORS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

COPC	RfD	RfC	CSF	CSFI	WOE	Reference
Inroganics						
Aluminum	1.00E+00	ND	ND	ND	ND	EPA-NCEA
Arsenic	3.00E-04	ND	1.50E+00	1.51E+01	A	IRIS
Barium	7.00E-02	1.43E-04	ND	ND	D	IRIS; HEAST
Beryllium	5.00E-03	ND	4.30E+00	8.40E+00	B2	IRIS
Chromium[4]	5.00E-03	ND	ND	4.20E+01	D	IRIS
Copper	4.00E-02	ND	ND	ND	D	HEAST
Manganese	2.40E-02[2]	1.43E-05	ND	ND	D	IRIS
Mercury	3.00E-04	8.57E-05	-ND	ND	D	HEAST
Selenium	5.00E-03	ND	ND	ND	D	IRIS
Silver	5.00E-03	ND	ND	ND	D	IRIS
Thallium	8.00E-05	ND	ND	ND	D	IRIS
Vanadium	7.00E-03	ND	ND	ND	D	HEAST
Zinc	3.00E-01	ND	ND	ND	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
EPA-NCEA	Superfund Health Risk Technical Support Center
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
I	Ingestion

(1) Acenaphthene is used as a surrogate
(2) RfD for evaluation in soil and water
(3) CSF for polychlorinated biphenyls
(4) RfD and CSFI for chromium VI

TABLE 6-23

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL
OPERABLE UNIT NO. 11 (SITE 7)
TARAWA TERRACE
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult		Current Residential Child		Current Residential Adult		Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Soil	8.36E-06	0.2	3.58E-06	0.02	5.97E-06	0.2	5.97E-07	0.02	7.10E-08	0.02
Dermal Contact with Soil	3.92E-07	<0.01	8.47E-07	<0.01	2.61E-07	<0.01	1.41E-07	<0.01	8.88E-10	<0.01
Inhalation of Soil Particulates	3.76E-09	NE	5.36E-09	NE	2.50E-09	NE	8.94E-10	NE	NA	NA
Total	8.76E-06	0.2	4.43E-06	0.02	6.2E-06	0.2	7.39E-07	0.02	7.19E-08	0.02

NE = Not Evaluated (no inhalation RfDs are available for noncarcinogenic COPCs).
NA = Not Applicable (the Cowherd Model for particulate inhalation is not applicable to subsurface soil).

TABLE 6-24

**TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH GROUNDWATER
OPERABLE UNIT NO. 11 (SITE 7)
TARAWA TERRACE
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Groundwater	7.2E-05	8.81	1.5E-04	3.78
Dermal Contact with Groundwater	8.4E-07	0.03	2.1E-06	0.02
Inhalation - Shower	NA	NA	NA	NA
Total	7.3E-05	8.84	1.6E-04	3.8

NA - Not Applicable (no volatile organics selected as COPCs)

TABLE 6-25

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
NORTHEAST CREEK (FUTURE RESIDENTS)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Exposed Population			
	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	NA	0.02	NA	<0.01
Dermal Contact with Surface Water	NA	<0.01	NA	<0.01
Incidental Ingestion of Sediment	5.7E-07	0.01	3.1E-07	0.01
Dermal Contact with Sediment	1.0E-08	<0.01	4.4E-08	<0.01
Total	5.8E-07	0.03	3.5E-07	0.01

NA = Not Applicable (no carcinogenic COPCs)

TABLE 6-26

**TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
NORTHEAST CREEK (CURRENT RESIDENTS)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

	Exposed Population			
	Current Residential Child		Current Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	NA	0.02	NA	<0.01
Dermal Contact with Surface Water	NA	<0.01	NA	<0.01
Incidental Ingestion of Sediment	3.8E-07	0.01	4.1E-08	0.01
Dermal Contact with Sediment	6.9E-09	<0.01	5.6E-09	<0.01
Total	3.9E-07	0.03	4.7E-08	0.01

NA = Not Applicable (no carcinogenic COPCs)

TABLE 6-27

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
TRIBUTARY (FUTURE RESIDENTS)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Exposed Population			
	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	7.8E-07	0.02	8.4E-07	<0.01
Dermal Contact with Surface Water	5.3E-07	0.01	2.2E-06	0.01
Incidental Ingestion of Sediment	2.6E-06	0.06	1.4E-06	0.01
Dermal Contact with Sediment	2.1E-07	<0.01	8.8E-07	<0.01
Total	4.1E-06	0.09	5.3E-06	0.02

TABLE 6-28

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
TRIBUTARY (CURRENT RESIDENTS)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Exposed Population			
	Current Residential Child		Current Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	5.2E-07	0.02	1.1E-07	<0.01
Dermal Contact with Surface Water	3.5E-07	0.01	3.0E-07	0.01
Incidental Ingestion of Sediment	1.7E-06	0.06	1.9E-07	0.01
Dermal Contact with Sediment	1.4E-07	<0.01	1.8E-07	<0.01
Total	2.7E-06	0.09	7.8E-07	0.02

TABLE 6-29

TOTAL SITE RISK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

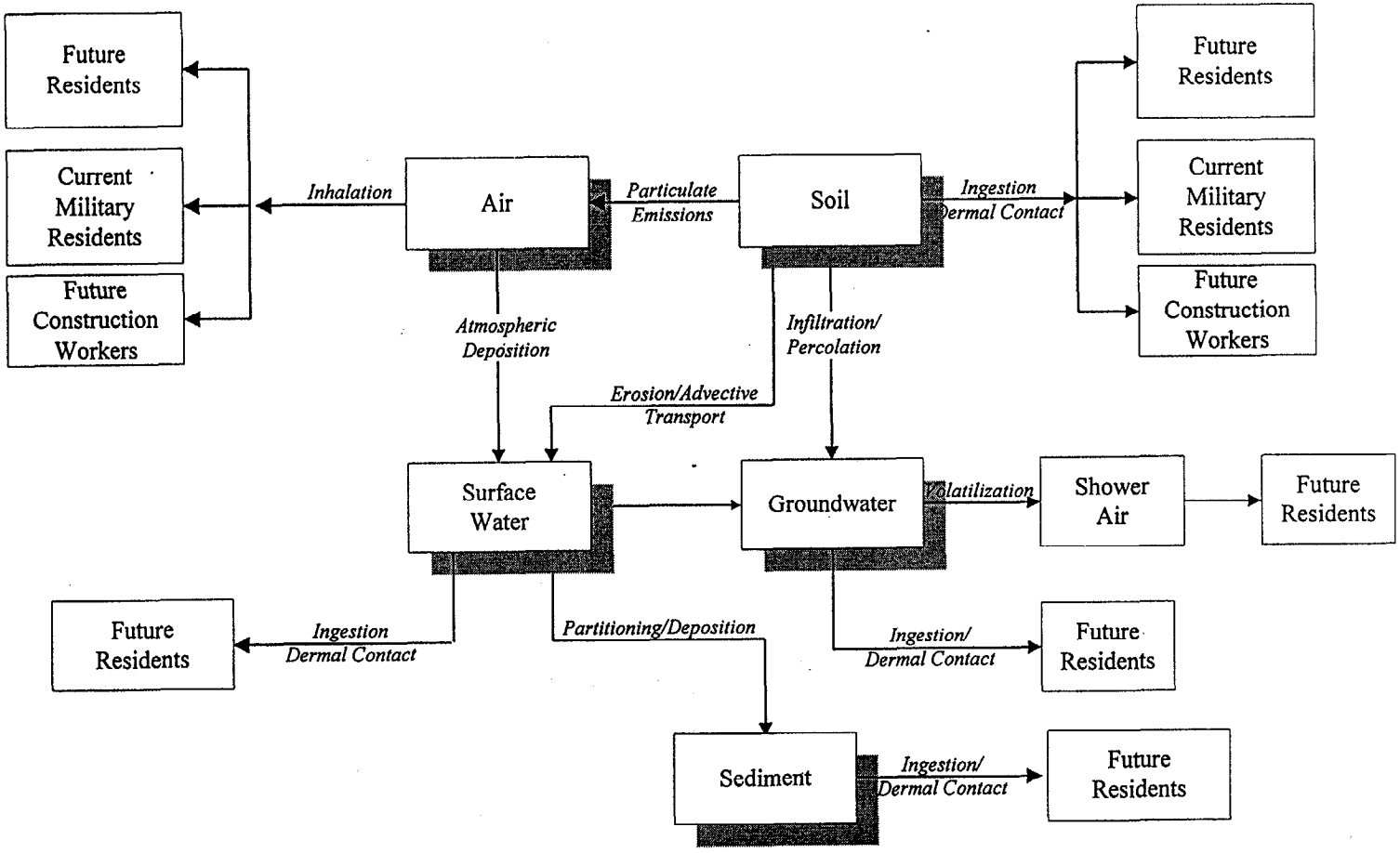
Receptors	Soil		Groundwater		Surface Water/Sediment Tributary		Surface Water/Sediment Northeast Creek		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Residential Child	6.2E-06 (67)	0.2 (63)	NA	NA	2.7E-06 (29)	0.09 (28)	3.9E-07 (4)	0.03 (9)	9.3E-06	0.32
Current Residential Adult	7.39E-07 (47)	0.02 (40)	NA	NA	7.8E-07 (50)	0.02 (40)	4.7E-08 (3)	0.01 (20)	1.6E-06	0.05
Future Residential Child	8.76E-06 (10)	0.2 (2)	7.3E-05 (85)	8.84 (97)	4.1E-06 (5)	0.09 (1)	5.8E-07 (<1)	0.03 (<1)	8.6E-05	9.16
Future Residential Adult	4.43E-06 (3)	0.02 (5)	1.6E-04 (94)	3.8 (94)	5.3E-06 (3)	0.02 (<1)	3.5E-07 (<1)	0.01 (<1)	1.7E-04	2.74
Future Construction Worker	7.19E-08 (100)	0.02 (100)	NA	NA	NA	NA	NA	NA	7.19E-09	0.02

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Approximate percent contribution to the total ICR or HI values
Total = Soil + Groundwater + Surface Water/Sediment
NA = Not Applicable

SECTION 6.0 FIGURES

FIGURE 6-1

CONCEPTUAL SITE MODEL
OPERABLE UNIT NO. 11 (SITE 7)
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. 11 (Site 7) that assesses the potential impacts to ecological receptors from contaminants detected at these 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 7 are potentially adversely impacting the ecological integrity of the terrestrial and aquatic communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants at Site 7 on sensitive environments including wetlands, protected species, and fish nursery areas. 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.

This ERA evaluates and analyzes the results from the Remedial Investigation (RI) including chemical analysis of the surface water, sediment, soil, and groundwater. Benthic Macroinvertebrate samples were collected and identified, and an in-situ earthworm bioaccumulation study was conducted.

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.

The media of concern for this ERA are the surface water, sediment and surface soil. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found 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)
- Macroinvertebrate Field and Laboratory methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990)

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 are evaluated. This section also evaluates the potential impact on the ecological integrity 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 samples collected from the surface water, sediment, soil, and groundwater to evaluate the presence, concentrations, and variabilities of the contaminants. Ecological surveys and a habitat characterization also were conducted as part of the field activities. Based on these observations, potential ecological receptors were 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 ecological effects to the ecological receptors.

The components of the problem formulation include identifying the stressors and their potential ecological effects, identification of ecosystems potentially at risk, defining ecological endpoints and presenting a conceptual model. The following sections discuss 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 water, sediment, and 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 contaminants detected in the environmental media at Site 7 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 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 was 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 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

Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps 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 were then have been 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 were not retained a 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 of the contaminants detected in the media at Site 7 are prevalent, however, their inherent toxicity to aquatic and terrestrial receptors is low (e.g., calcium, magnesium, potassium, and sodium). Therefore, they were not retained as COPCs. In addition, several the contaminants have not been adequately studied to develop published toxicity values, or even accepted toxicological data with which to assess the contaminants. Contaminants that fall into this category are retained as COPCs (if they were 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

Water Quality Standards (WQS) for surface water have been developed for North Carolina (NC DEHNR, 1994). These are the only enforceable surface water standards. In addition to the WQS, Water Quality Screening Values (WQSVs) have been developed by USEPA Region IV (USEPA, 1995a), USEPA Region III (USEPA, 1995b), and Oak Ridge National Laboratory (ORNL) (Suter and Mabrey, 1994). The WQS and WQSVs will be herein referred to as Surface Water Screening Values (SWSVs).

Sediment quality standards have not been developed for North Carolina. However, Sediment Screening Values (SSVs) are available for many contaminants. These SSVs include: SSVs (Long et.al. 1995; Long and Morgan, 1991; and, USEPA, 1995b), calculated sediment quality criteria (SQC) (USEPA, 1993a), Apparent Effect Threshold values (AET) (Tetra-Tech, Inc., 1986), and Wisconsin Department of Natural Resources interim guidance criteria for in-water disposal of dredged sediments (Sullivan, et.al., 1985).

The SWSVs and SSVs are used for comparative purposes to infer potential ecological risks. Contaminants that are detected at concentrations less than these screening values are not retained

as COPCs for aquatic receptors since contaminants detected at concentrations less than these values are not expected to pose a significant risk to the aquatic receptor population. However, these contaminants may be retained as COPCs for the terrestrial receptors.

There are no state or federal soil reference values that can be used to evaluate potential ecological risks to terrestrial receptors (other than plants or invertebrates). Therefore, toxicity of contaminants in the surface soil to terrestrial receptors is not used as a criteria for retaining COPCs except for calcium, magnesium, potassium, and sodium, which are not retained as COPCs in any of the media.

A brief explanation of the standards, criteria, and screening values used for the evaluation of the COPCs is presented below.

North Carolina Water Quality Standards (Surface Water) - WQS are the concentrations of toxic substances that will not result in chronic toxicity to aquatic life (NCDEHNR, 1994). WQS are provided for both freshwater and saltwater aquatic systems.

USEPA Water Quality Screening Values - WQSVs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. WQSVs are provided for both freshwater and aquatic systems, and are reported as acute and/or chronic values (USEPA, 1995a,b). Most of the WQSVs are the same as the USEPA Ambient Water Quality Criteria (AWQC), however, some of the WQSVs are based on more current information.

Oak Ridge National Laboratory Aquatic Benchmarks - ORNL Aquatic Benchmarks were developed for many contaminants in, including those that do not have WQS of WQSVs (Suter and Mabrey, 1994). The ORNL aquatic benchmarks include secondary acute values and secondary chronic values that were calculated using the Tier II method described in the EPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993b). Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA AWQC. The benchmarks are limited to contaminants in freshwater.

Sediment Screening Values - Sediment Screening Values (SSV) have been compiled to evaluate the potential for contaminants in sediments to cause adverse biological effects (Long, et.al, 1995; Long and Morgan 1991; and, USEPA, 1995). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probable occur).

Sediment Quality Criteria - Currently, promulgated sediment quality criteria (SQC) only exist for a few contaminants. However, SQC for nonionic organic compounds can be calculated using the procedures in the Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning (USEPA, 1993) as follows:

$$SQC = (Foc)(Koc)(FCV)/1{,}000{,}000$$

Where:

SQC = sediment quality criteria (ug/kg)
Foc = sediment organic carbon content (mg/kg)
Koc = chemical organic carbon partition coefficient (mL/g)
FCV = final chronic water quality value (μg/L)

Other Sediment Screening Values - In addition to the SSVs, Apparent Effects Threshold (AET) Sediment Quality Values have been developed by Tetra Tech Inc., (1986) for the Puget Sound. AETs are the concentrations of contaminants above which statistically significant biological effects would always be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediments (Sullivan, et.al., 1985). However, these criteria were established using background data and were not based on aquatic toxicity.

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 TCL compounds) are regarded as positive results only when observed concentrations exceed 5 times the maximum concentration detected in any blank (USEPA, 1989d). 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. As is presented in Section 4.0, off-site surface water and sediment samples were collected from several waterbodies in the White Oak River water basin. The off-site samples are used for comparison to the site stations to determine if contaminants are below naturally occurring regional levels. The three off-site upstream (freshwater) samples (HM01, HC01 and HC04) were compared to the two samples collected in the drainage ditch and the two upstream stations collected in the West Tributary. The three off-site downstream (saltwater) samples (HM01, HC03, and WC03) were compared to the six stations in the Northeast Creek, the two stations in the East Tributary, and the downstream station collected in the West Tributary. Contaminants that are detected in the surface water or sediment at concentrations less than the average 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 7. Once this task has been completed, a final list of media-specific COPCs will be 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 each medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria. Calcium, magnesium, potassium, and sodium were not retained as COPCs in any of the media 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 aquatic or terrestrial life.

Tables 7-1 through 7-2 present the comparison of the surface water contaminant concentrations to the SWSVs and background concentrations. Tables 7-3 through 7-4 present the comparison of the sediment contaminant concentrations to applicable SSVs and background concentrations. A comparison of the surface soil contaminant concentrations to Base background concentrations is presented in Section 6.0, Table 6-3. A summary of the COPCs in each media are presented in Table 7-5. All the samples were analyzed for Target Compound List (TCL) organics including, volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), TCL pesticides/PCBs, and Target Analyte List (TAL) inorganics.

7.3.2.1 Surface Water

Thirteen surface water samples were collected at Site 7. Four of these samples were collected in freshwater locations (7-WT-SW01, 7-WT-SW02, 7-DD-SW01, 7-DD-SW02) and nine were collected at saltwater locations (7-WT-SW03, 7-ET-SW01, 7-ET-SW02, 7-NC-SW01, 7-NC-SW02, 7-NC-SW03, 7-NC-SW04, 7-NC-SW05, 7-NC-SW06).

West Tributary and Drainage Ditch (Freshwater)

Chloroform was the only VOC detected in the freshwater surface water samples. It is not retained as a COPC because it was detected at a concentration less than ten times the concentration in the blank sample. Two pesticides (dieldrin and endrin ketone) were detected in the freshwater surface water samples. Both pesticides are retained a COPCs. No SVOCs were detected in the freshwater surface water.

Nine inorganics were detected in the freshwater surface water samples. A hardness of 27 mg/l $CaCO_3$ is used to calculate the SWSVs for metals that have hardness dependent criteria because this is the lowest hardness value for all the surface water samples. Manganese is not retained as a COPC for the aquatic receptors because it was detected at a concentration below the SWSV, however it is retained as a COPC for the terrestrial receptors. As presented above, calcium, magnesium, and sodium are not retained as COPCs. The remaining five inorganics (aluminum, barium, iron, lead, and zinc) are retained as COPC for both the aquatic and terrestrial receptors.

East and West Tributaries and Northeast Creek (Saltwater)

Four VOCs were detected in the saltwater surface water samples. Chloroform is not retained as a COPC because it was detected at a concentration less than ten times the concentration in the blank sample. Xylenes are not retained as COPCs for the aquatic receptors because they were detected at a concentration below the SWSV, however they are retained as COPCs for the terrestrial receptors. The other two VOCs (2-butanone and 2-hexanone) are retained as COPCs for both the aquatic and terrestrial receptors. One SVOC (bis(2-ethylhexyl)phthalate) was detected and retained as a COPC in the saltwater surface water samples.

Thirteen inorganics were detected in the saltwater surface water samples. Arsenic and silver are not retained as COPCs because they were detected at concentrations less than the background concentrations. Zinc is not retained as a COPC for the aquatic receptors because it was detected at a concentration below the SWSV, however it was retained as a COPC for the terrestrial receptors. As presented above, calcium, magnesium, potassium and sodium are not retained as COPCs. The remaining six inorganics (aluminum, barium, copper, iron, lead, and manganese) are retained as COPC for both the aquatic and terrestrial receptors.

7.3.2.2 Sediment

Twenty-seven sediment samples were collected at Site 7. Twelve of these samples were collected in freshwater locations (7-WT-SD01, 7-WT-SD02, 7-DD-SD01, 7-DD-SD02, 7-MA-SD01, 7-MA-SD02, 7-MA-SD03, 7-MA-SD04) and fifteen were collected at saltwater locations (7-WT-SD03, 7-ET-SD01, 7-ET-SD02, 7-NC-SD01, 7-NC-SD02, 7-NC-SD03, 7-NC-SD04, 7-NC-SD05, 7-NC-SD06). The samples collected in the Marsh Area (MA) and in Northeast Creek (NC) consisted of two sampling depths (0-6 inches and 6-12 inches). The samples collected in the West Tributary

(WT), East Tributary (ET), and Drainage Ditch (DD) consisted of one sampling depth (0-6 inches).

None of the contaminants in the sediments are retained as COPCs for the terrestrial receptors because current guidance does not exist to evaluate this pathway. This will be presented in more detail in the uncertainty analysis section of this report.

West Tributary and Drainage Ditch (Freshwater)

Three VOCs were detected in the freshwater sediment samples. 2-Butanone is not retained as a COPC because it was detected at a concentration below the SWSV. The other two VOCs (styrene and toluene) are retained as COPCs.

Fourteen SVOCs were detected in the freshwater sediment samples. Benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene benzo(a)pyrene, chrysene, dibenzofuran, fluoranthene, and pyrene are not retained as COPCs because they do not exceed their respective SSVs. The remaining six SVOCs (acenaphthylene, anthracene, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, 3,3'-dichlorobenzidine, and phenanthrene) are retained as COPCs. Nine pesticides/PCBs were detected in the freshwater sediment samples and all are retained as COPCs. These pesticides/PCBs include: aldrin, alpha-chlordane, gamma-chlordane, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, dieldrin, endrin ketone, and Aroclor-1260.

Fifteen inorganics were detected in the freshwater sediment samples. Barium, chromium, iron, and manganese are not retained as COPCs because they were detected at concentrations below the SWSVs. As presented above, calcium, magnesium, potassium and sodium are not retained as COPCs. The remaining seven inorganics (aluminum, beryllium, copper, lead, mercury, vanadium, and zinc) are retained as COPCs.

East and West Tributaries and Northeast Creek (Saltwater)

Two VOCs were detected in the freshwater sediment samples. Toluene is not retained as a COPC because it was detected at a concentration below the SWSV. 2-Butanone is retained as a COPC.

Eleven SVOCs were detected in the freshwater sediment samples. Benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, chrysene, di-n-octylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene and pyrene are not retained as COPCs because they did not exceed the SSVs. Therefore, no SVOCs are retained as COPCs.

Six pesticides were detected in the freshwater sediment samples (alpha-chlordane, gamma-chlordane, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT and dieldrin). All these pesticides are retained as COPCs.

Sixteen inorganics were detected in the saltwater sediment samples. Aluminum, chromium, iron, and manganese are not retained as COPCs because they were detected at concentrations less than the background concentrations. Arsenic, barium, copper, and zinc are not retained as COPCs because they were detected at concentrations below their respective SWSVs. As presented above, calcium, magnesium, and sodium are not retained as COPCs. The remaining five inorganics (beryllium, lead, selenium, thallium, and vanadium) are retained as COPCs.

7.3.2.3 Surface Soil

Thirty-two surface soil samples were collected at Site 7. Four VOCs were detected in the surface soil samples. 2-Butanone, and trichloroethene are not retained as COPCs because they were detected infrequently (1/31, 1/30, respectively). In addition, acetone is not retained as a COPC because it was detected at a concentration less than ten times the concentration in the blank sample. Toluene is the only VOC that is retained as a COPC.

Seventeen SVOCs were detected in the surface soil samples. The following contaminants are not retained as COPCs because they were detected infrequently (1/32): acenaphthene, anthracene, carbazole, fluorene, and phenol. The remaining twelve SVOCs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h.i)perylene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) are retained as COPCs.

Twelve pesticides/PCBs were detected in the sediment samples. Aldrin, delta-BHC, and endrin aldehyde are not retained as COPCs because they were detected infrequently (1/30). Aroclor-1254 and Aroclor-1260 are retained as COPCs even though they were detected infrequently (1/30) since they may be related to past site activities. The remaining seven pesticides (alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin and endosulfan II) are retained as COPCs.

Twenty inorganics were detected in the surface soil samples. Copper is not retained as a COPC because it was detected at a concentration of less than two times the background concentration. Selenium is not retained as a COPC because it was detected at a concentration less than the blank samples. Silver is not retained as a COPC because it was detected infrequently (1/32). As presented above, calcium, magnesium, potassium, and sodium were not retained as COPCs. The remaining thirteen inorganics (aluminum, arsenic, barium, beryllium, chromium, cobalt, iron, lead, magnesium, mercury, nickel, vanadium, and zinc) are retained as COPCs.

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 7-6 summarizes these values for the COPCs detected in the sediment, surface water, and surface soil samples. Information from these tables is used in the terrestrial intake models and the risk characterization to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs discuss 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 aquatic organisms. Bioconcentration factors are important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCF is unitless. The bioconcentration factor is used in the terrestrial intake model to estimate the COPC concentration in fish that would potentially be ingested by the raccoon.

The organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between soil or sediment 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 organics in the sediments. The Koc is used to calculate sediment quality criteria.

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 in aquatic organisms and with adsorption to soil or sediment. The Kow is used to calculate the plant biotransfer factor 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) measures the potential for a chemical to accumulate in a plant. These factors were 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 were obtained from Baes et.al., 1984, while the factors for organics were 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 factors (Bb) measures the potential for a chemical to accumulate in an animal. This factors 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 were obtained from Baes et.al., 1984, while the factors for organics were 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 7 were identified during the field investigations and the habitat evaluation. Potential receptors of contaminants in surface water and sediment include fish: benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soil include: deer, rabbits, foxes, raccoons, birds and other terrestrial flora and fauna.

7.4.1 Regional Ecology

Camp Lejeune covers approximately 108,800 acres, 84 percent of which is forested (USMC, 1987). Approximately 45.1 percent of this is pine forest, 22 percent is mixed pine/hardwood forest, and 16.8 percent is hardwood forest. Nine percent of the base, a total of 3,587 acres, is wetland and includes pure pond pine stands, mixed pond pine/hardwood stands, marshes, pocosins, and wooded swamps. The base also contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds.

The base drains primarily to the New River or its tributaries. These tributaries include Northeast Creek, Southwest Creek, Wallace Creek, Frenchs Creek, Bear Head Creek, and Duck Creek.

Because of the natural resources on the base, forested areas 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.

MCB Camp Lejeune is located in the Coastal Plain. The ecology of the region is influenced by climate, which is characterized by hot, humid summers and cool winters. Some subfreezing cold spells occur during the winters, and there are occasional accumulations of snow that rarely persist. The average precipitation is 55.96 inches and the mean temperature is 60.9°F. The area exhibits a long growing season, typically more than 230 days. Soils in the region range from very poorly drained muck to well-drained sandy loam.

A number of natural communities are present in the Coastal Plain. Subcommunities and variations of these major community types are also present and alterations of natural communities have occurred in response to disturbance and intervention (i.e., forest cleared to become pasture). The natural communities found in the area are summarized as follows:

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech is an indicator species with white oak, tulip, sweetgum, and holly.

- 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 -- 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 present.

- Maritime Forest - Develops on the lee side of stable sand dunes protected from the ocean. Live oak is an indicator species with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.

- Pocosins - Lowland forest community that develop on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and acidic soils low in nutrients. Pond pine is dominant tree with dense layer 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. On the coast of North Carolina swamps are more common than marshes.

- 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 managed in these ponds include redear, bluegill, largemouth bass, and channel catfish (USMC, 1987).

- Open Water - Marine and estuarine waters as well as all underlying bottoms below the intertidal zone.

7.4.2 Water Body Description

Northeast Creek is designated by the NC DEHNR as SC NSW (NC DEHNR, 1993). The SC classifies the water body as a tidal saltwater, which allows for aquatic life propagation and survival, fishing, wildlife, and secondary recreation (NC DEHNR, 1993). The NSW indicates that the water body is a Nutrient Sensitive Water that requires limitations on nutrient inputs (NC DEHNR, 1993). The West Tributary, East Tributary, and Drainage Ditch also are classified as SC NSW since they are tributaries to Northeast Creek, and they are not specifically named in the schedule of stream classifications.

7.4.3 Site-Specific Ecology

During December 1994, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 7. Appendix O includes data sheets that provide more detailed information.

Site 7

Most of the area in the vicinity of Site 7 is forested and includes a deciduous forest and a wooded wetland or swamp. Ecotones or transition areas are present along the edges of the forest where open areas have been cleared as rights-of-way or along the edges of the residential areas. A scrub shrub wetland is also present east of the site along Northeast Creek.

The deciduous forest at Site 7 is diverse; deciduous trees are mixed with occasional pines. Oaks as a genus are dominant, although no single species of oak is dominant. Species of oaks present included water oak (Quercus nigra), live oak (Q. virginiana), white oak (Q. alba), and southern red oak (Q. falcata). Species mixed among the oaks include the following:

- Sweetgum- Liquidambar styraciflua
- Loblolly Pine- Pinus taeda
- Sourwood- Oxydendrum arboreum
- Red Maple- Acer rubrum
- Black Cherry- Prunus serotina
- Hickory- Carya sp.
- Magnolia- Magnolia grandifolia
- Sweetbay- Magnolia virginiana
- Holly- Ilex opaca

Shrubs and vines are present in the understory of the forest. Three species, firethorn (Cotoneaster pyracantha), privit (Ligustrum vulgare), and red cedar (Juniperus virginiana) were dominant in disturbed areas and in portions of the ecotone where they are found with grasses and sapling loblolly pine. Additional species identified in the understory include the following:

- Huckleberry- Gaylussacia sp.
- Blueberry- Vaccinum sp.
- Redbay- Persea borbonia
- Sweet Myrtle- Myrica cerifera
- Dogwood- Cornus florida
- Beautyberry- Callicarpa americana
- Silverberry- Elaeagnus pungens

Two species of vines were identified at Site 7: greenbriar (Smilax rotundifolia) and bullbriar (Smilax bona-nox). These vines are more common in disturbed areas of the site.

Little vegetation is present on the floor of the deciduous forest. Partridgeberry (Mitchella repens), ebony spleenwort (Asplenium platyneuron), and switch cane (Arundinaria tecta) were all identified at Site 7 during the habitat evaluation.

The deciduous forest grades to a palustrine wetland along Northeast Creek. This wetland is classified as a palustrine, forested, broad-leaved deciduous/needle-leaved evergreen, seasonally flooded wetland. Trees growing in this area exhibited buttressed trunks and surficial roots. Sweetbay (Magnolia virginiana) was dominant in some areas of this wetland. Additional tree species present include

- Tulip Poplar - Liriodendron tulipifera
- Red Maple- Acer rubrum
- Sweetgum- Liquidambar styraciflua
- Redbay- Persea borbonia
- Loblolly- Pinus taeda
- Blackgum- Nyssa sylvatica

Blueberry (Vaccinum sp.), poison ivy (Rhus radicans), and wild grape (Vitis sp.) are all present in the understory. Vegetation of the floor of this wooded wetland is very sparse and is limited to clumps of cinnamon fern (Osmunda cinnamomea).

The wooded wetland at Site 7 becomes a scrub shrub wetland to the east of the site. No trees are present in this wetland, which is dominated by evergreen shrubs and saltmarsh cordgrass (Spartina alterniflora). These shrubs include sweet myrtle (Myrica cerafera), groundseltree (Baccharis halimifolia), live oak (Quercus virginiana), and red cedar (Juniperus virginiana).

In addition to the saltmarsh cordgrass, big cordgrass (Spartina cynosuroides), narrow-leaved cattail (Typha augustifolia), and grasses are growing among the shrubs.

Because of the diverse habitat present at Site 7 a variety of birds was identified in the area. During the habitat evaluation the following birds were observed:

- Catbird- Dumetella carolinensis

- Pileated Woodpecker- Dryocopus pileatus
- Yellow-bellied Sapsucker- Sphyrapicus varius
- Wood Thrush- Hylocichla mustelina
- Carolina Wren- Thryrothorus ludovicianus
- Phoebe- Sayornis phoebe
- Common Crow- Corvus brachyrhynchos
- Myrtle Warbler- Dendroica coronata
- Mockingbird- Mimus polyglottas
- Blue Jay- Cyanocitta cristata
- Carolina Chickadee- Parus carolinensis
- Red-bellied Woodpecker- Melanerpes carolinus
- Flicker- Colaptes auratus
- Swamp Sparrow- Melospiza georgiana
- Mourning Dove- Zenaida macroura
- Robin- Turdus migratorius
- Osprey- Pandion haliaetus
- Pied-bill Grebe- Podilymbus podiceps
- Brown Pelican- Pelecanus occidentalis
- Herring Gull- Larus argentatus
- Laughing Gull- Larus atricilla
- Great Blue Heron- Ardea herodias
- Kingfisher- Megaceryle alcyon
- Cedar Waxwing- Bombycilla cedrorum
- Red-tailed Hawk- Buteo jamaicensis
- Buteo hawk- Buteo sp.

Four mammal species were identified at Site 7 based upon field signs. These included gray squirrel (Sciurus carolinensis), raccoon (Procyon lotor), opossum (Didelphis marsupialis), and whitetail deer (Odocoileus virginianus). A box turtle shell (Terrepene carolina) was also observed, as were several anoles (Anole carolinensis). A small snake was also noted during the habitat evaluation, but could not be identified because only the end of the tail was seen.

Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 7. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992a). In addition, certain activities affecting wetlands also are 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 Camp Lejeune, North Carolina, area by stereoscopic analysis of high altitude aerial photographs (USDI, 1982). Site 7 is included on these maps. The wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et. al., 1979).

NWI maps are intended for an initial identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and/or local regulatory agencies. Information from the wetlands maps was transferred to the site-specific biohabitat maps (Figures 7-1).

Site-specific wetland delineations were not conducted at Site 7, although potential wetland areas were noted during the habitat evaluation. These wetlands are illustrated on the biohabitat maps.

At Site 7 a palustrine (forested) wetland is present along Northeast Creek. This wetland is classified as a broad-leaved, deciduous/needle-leaved evergreen, seasonally-flooded wetland. East of the site this forested wetland becomes a palustrine, scrub shrub, broad-leaved/needle-leaved evergreen, seasonally-flooded wetland.

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/or 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 have the potential for protection in the future.

Surveys have been conducted to identify threatened and endangered species at Camp Lejeune and several programs are underway to manage and protect them. Table 7-7 lists protected species present at the base and their protected classification. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are covered by specific protection programs.

The red-cockaded woodpecker requires a specific habitat in mature, living longleaf or loblolly pine trees. The birds live in family groups and young are raised cooperatively. At Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at 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 endangered in the northern-most part of its range, which includes North Carolina. It is found in freshwater, estuarine, and saltwater wetlands in Camp Lejeune and base wetlands are maintained and protected to protect alligators. Signs have been erected 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 Camp Lejeune. The green turtle was found nesting in 1980; the sighting was the first time the species was 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.

Four bird species, black skimmer, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at Camp Lejeune. The black skimmer and piping plover are sea and

shore birds, respectively. Skimmers nest on low sandy islands and sand bars along the coast and piping plovers prefer beaches with broad open sandy flats above the high tide line. Skimmers feed above open water and piping plovers feed along the edge of incoming waves. Like the black skimmer and piping plover, Bachmans sparrows are very specific in their habitat requirements. They live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern Camp Lejeune.

In addition to the protected species that breed or forage at 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.

No protected species were observed at Site 7 during the habitat evaluation nor would they be expected to occur. Protected species at Camp Lejeune require specific habitats that do not correspond to the habitats identified at the sites. Previous survey results and maps of locations were protected species have been identified were consulted to produce biohabitat maps. No protected species have been identified within half-mile radius of Site 7.

A natural heritage resources was conducted at Camp Lejeune (LeBlond, 1991) to identify threatened or endangered plants and areas of significant natural interest. From this list, the Rough-leaf loosestrife was the only Federally threatened or endangered plant species found on the Marine Corps Base. In addition, several State endangered or threatened and Federal and State candidate species were found on the MCB. The results of this survey are included in Appendix P.

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 7 are discussed below.

- Marine Sanctuary - Site 7 is not located within a Marine Sanctuary (NCMFC, 1994).

- National Park - Site 7 is not located within a National Park (NPS, 1993a).

- Designated Federal Wilderness Area - Site 7 is not located within a Designated Federal Wilderness Area (WS, 1989, 1993).

- 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 7 is not located within a Sensitive Area identified under the NEP or NCWP (NCMFC, 1994).

- Critical Areas Identified under the Clean Lakes Program - Site 7 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1993).

- National Monument - Site 7 is not located near a National Monument (NPS, 1993).

- National Seashore Recreational Area - Sites 7 is not located within a National Seashore Recreational Area (NPS, 1993a).

- National Lakeshore Recreational Area - Site 7 is not located within a National Lakeshore Recreational Area (NPS, 1993a).

- National Preserve - Site 7 is not located within a National Preserve (NPS, 1993).

- National or State Wildlife Refuge - Site 7 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 7 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 7 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 critical spawning areas have been identified within Northeast Creek (USMC, 1997). However, this portion of Northeast Creek is designated as a primary nursery area (NCMFL, 1994).

- 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 - Northeast Creek adjacent to Site 7 is not a migratory pathway or feeding area critical for the maintenance of an anadromous fish species (USMC, 1993).

- National river reach designated as Recreational - Northeast Creek is not designated as a National Recreational River (NPS, 1990, 1993b).

- Federal designated Scenic or Wild River - Northeast Creek is not a Federally designated Scenic or Wild River (NPS, 1990, 1993b).

- State land designated for wildlife or game management - Site 7 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - Northeast Creek is not a State designated Scenic or Wild River (NCMFC, 1992).

- State designated Natural Area - Site 7 not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of Site 7 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 7 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 7 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

7.5 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics and ecosystems potentially at risk) was 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 were 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, measurement endpoints 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 among 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.

7.5.1 Aquatic Endpoints

The assessment endpoints for the aquatic portion of this ERA are changes in the structure of benthic macroinvertebrate communities attributable to site-related contaminants and the potential reduction of an aquatic receptor population or subpopulation that is attributable to site-related contaminants. Measurement endpoints for the first aquatic assessment endpoint include lower species diversity and richness when compared to an ecologically similar background location and the dominance of contaminant-tolerant species (opportunistic) over contaminant sensitive species (equilibrium). The

measurement endpoints for the second aquatic assessment endpoint include exceedances of contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs).

Diversity, richness, and change in species dominance are evaluated by comparing the type of species, the species diversity, and community similarity of the benthic macroinvertebrates collected at Site 7 to the appropriate off-site background stations. Pollution tolerance indices were not used to evaluate the benthic community because tolerance values were not available for most of the species collected at Site 7.

The following paragraphs discuss how the species diversity, and community similarity are calculated and how they are interpreted.

7.5.1.1 Species Diversity

The benthic macroinvertebrate community was examined using a mathematical expression of community structure called a diversity index. Diversity data are useful because they condense a substantial amount of data into a single value. The Shannon-Wiener diversity index and Brillouin diversity index both were calculated for the benthic macroinvertebrate species.

The Shannon-Wiener (H^1) function is one of the more commonly used formulas for calculating species diversity. Species diversity was calculated in logarithmic base 10 using the following equation (Brower and Zar, 1977):

$$H^1 = \sum (p_i * \log(p_i)).$$

H^1 = mean species diversity
p_i = proportion of the total number of individuals occurring in species i.

Brillouin's diversity (H) is used if a data set is not considered to be a random sample. This situation arises when data comprising an entire population are available or for data that are from a sample obtained non-randomly from a population. Brillouin's diversity is calculated using the following equation (Brower and Zar, 1977):

$$H = \frac{(\log n! - \sum (\log(f_i!))}{n}.$$

H = species diversity
n = the sample size
f = the number of observations in category i

The operative assumption in the interpretation of diversity values is that relatively undisturbed environments tend to support communities that consist of a large number of species with no single species present in overwhelming abundance. Many forms of stress tend to reduce diversity by producing an environment that is less desirable for some taxa and, therefore, giving a competitive advantage to other taxa. However, unsuitable habitat in some tidally influenced streams, due to natural salinity fluctuations, will cause the diversity of the benthic macroinvertebrate population to be less than one (Tenore, 1972).

7.5.1.2 Community Similarity

Community similarity between benthic macroinvertebrate stations was measured using two qualitative indices of community similarity, the Jaccard coefficient (S_j) and the SΦrenson index (S_S). The indices use two possible attributes of the ecosystem, that is whether a species was or was not present in the collected sample. Because these coefficients are based on the number of species collected and not the number of individuals, a few organisms from several taxa could significantly change the similarity value, whereas there may not be an overall significant difference between the communities.

The S_j is better than the S_S at discriminating between highly similar collections and has been used widely in stream pollution investigations. The S_j ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower and Zar, 1977):

$$S_j = \frac{a}{a + b + c}$$

a = number of species common to both collections
b = number of species in the first collection but not the second
c = number of species in the second collection but not in the first

The S_S places more emphasis on common attributes, and is better than the S_j at discriminating between highly dissimilar collections. The S_S ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower and Zar, 1977):

$$S_s = \frac{2a}{2a + b + c}$$

Where a, b, and c are as described above.

These indices were used to detect changes in the community structure. Stressed communities presumably will have different species than relatively non-stressed communities, given that all other factors are equal. Several factors determine the type of benthic population that will inhabit an area including salinity fluctuations, sediment type, size of water body, and time of collection. Although the community similarity indices will give some indication as to the similarities of the communities, more weight will be placed on the types of species that were collected, the relative densities, and the species diversities of the site stations as compared to the reference stations.

7.5.2 Terrestrial Endpoints

The assessment endpoint for the terrestrial portion of this ERA is the potential reduction of a receptor population or subpopulation that is attributable to contaminants from the site. The measurement endpoints for the terrestrial ecological RA include exceedances of contaminant-specific soil effect concentrations and contaminant-specific effect doses.

7.6 Conceptional Model

This section of the ERA presents each potential exposure pathway via air, soil, and groundwater, and the likelihood that an exposure will occur through these pathways. Figure 7-2 presents the flowchart of potential exposure pathways and 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 was present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

The following sections discuss the potential exposure scenarios at Site 7 including surface water, sediments, soil, groundwater and air.

7.6.1 Surface Water and Sediment Exposure Pathway

Potential release sources to be considered in evaluating the surface water and sediment pathways are contaminated surface soil and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface water/sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water/sediment on-site or downgradient of the site.

COPCs were detected in the surface water and sediment demonstrating a release from a source to the surface water or sediment transport medium. Potential receptors that may be exposed to contaminants in surface water and sediment include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic receptors are exposed to contaminants in the surface water and sediment by ingesting water while feeding and by direct contact while feeding or swimming. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioaccumulated chemicals from the surface water and sediment. This exposure pathway is likely to occur at Site 7 and is retained for further analysis.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water and sediment through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, small mammals, invertebrates, and plants) that have bioconcentrated contaminates from the surface water and sediment. These exposure pathways are likely to occur at Site 7. However, only the surface water pathway will be retained for further analysis, since current guidance does not exist to evaluate the sediment pathway for terrestrial receptors.

7.6.2 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 including: deer, fox, raccoon, 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 contaminates from the soil. This exposure pathway is likely to occur at Site 7 and will be retained for further analysis.

7.6.3 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.

Sub-surface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. Potential impacts to these biota are not assessed in this ERA because current guidance does not provide sufficient information to evaluate risk. In addition, since the receptors of concern are not directly exposed to groundwater at Site 7, the groundwater to surface water exposure is accounted for in the surface water section of the ERA.

7.6.4 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, groundwater and surface water. The potential exposure points for receptors are areas on or adjacent to the site. The air exposure pathway is not evaluated in this ERA because 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 (COPCs) to the ecological receptors.

The RI included collecting samples for analytical analysis from four media; surface water, sediment, soil, and groundwater. As presented earlier in the ERA, contaminants in the subsurface soil and groundwater are not evaluated. The analytical results for the data used in ERA were presented in Section 4.0 of this report.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 7 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 water and sediment to aquatic receptors were assumed to be equal to the contaminant concentration in the surface water and sediment. Exposure of contaminants in the surface soil to terrestrial flora and fauna (invertebrates and microorganisms) were assumed to be equal to the contaminant concentration in the surface soil. It is noted in the uncertainty section of this ERA that all the contaminants in the surface water may not be bioavailable to the terrestrial flora or fauna. Exposure of contaminants in the surface water and surface soil to other terrestrial fauna (mammals, birds) were estimated using the chronic daily intake models presented in the next section of this ERA.

The following sections presents the results of the ecosystem characterization including the biological sampling, abiotic habitat, and biotic habitat.

7.7.1 Surface Water, Sediment, and Biological Sampling

Biological samples collected at Site 7 included the collection of benthic macroinvertebrates to obtain population statistics. An attempt was made to collect fish at Site 7, however, no fish were collected.

Water quality measurements were collected during the sampling event prior to the surface water and sediment sample collection. These measurements consisted of temperature, ph, specific conductance, salinity, and dissolved oxygen. Site specific descriptions and recording of field measurements can be found recorded on field data sheets in Appendix O. The station locations and sampling procedures for collecting each of the environmental media are discussed in Section 2.0 of this report.

7.7.1.1 Abiotic Habitat

The abiotic habitat consists of the description of the stations with regard to size of the creek, depth of the water, substrate type, water chemistry and other such non-biological descriptors. The following sections present the abiotic habitat for the sampling stations at Site 7.

Table 7-8 presents the sampling station characterization summary which includes the stream width and depth, canopy cover, sediment type, and sediment odor. The stream widths and depths ranged from 1-2 feet and 0.1 feet, respectively, in the drainage ditch, and 20 feet and three feet, respectively, in the East Tributary. The width and depth of Northeast Creek was not determined due to its large size (greater than 0.5 mile). However, all the samples were collected within five feet from the bank and the water depth at these stations was less than one foot. The canopy cover ranged from shaded to open. Finally, the sediment was primarily fine sand or silt, with odors ranging from normal to anaerobic and septic.

Table 7-9 presents the results of the field chemistry including the temperature, pH, dissolved oxygen concentration, conductivity, and salinity. At the freshwater stations, the temperature ranged from 20.6 to 24.2 °C, the pH ranged from 5.49 to 5.83 S.U., the dissolved oxygen ranged from 0.7 to 9.1 mg/L, the conductivity ranged from 34.6 to 161 umhos/cm, and the salinity was 0 ppt. At the saltwater stations, the temperature ranged from 26.4 to 30.3 °C, the pH ranged from 6.95 to 8.45 S.U., the dissolved oxygen ranged from 0.1 to 6.9 mg/L, the conductivity ranged from 12,500 to

32,300 umhos/cm, and the salinity ranged from 10 to 29.5 ppt. The field chemistry at these stations appear to be typical of surface waters at MCB Camp Lejeune.

7.7.1.2 Biotic Habitat

The biotic habitat consists of the description of the stations with regard to the biological community. The following sections present the results of the benthic macroinvertebrate community for the sampling stations at Site 7.

Benthic Macroinvertebrate Community

Tables 7-10 and 7-11 presents the benthic macroinvertebrates collected from the freshwater and saltwater sampling stations at Site 7, respectively. Only one species was collected at each of the freshwater stations, consisting of one individual at the upstream station (7-WT-BN01) and 218 individuals at the mid-stream station (7-WT-BN02). The species collected at 7-WT-BN01 was Chironumus decorus gr., while Limnodrilus hoffmeisteri was the species collected at 7-WT-BN02.

The number of species ranged from 8 to 15 in the saltwater stations, with the number of individuals ranging from 262 to 637. Neries succinea was the most dominant species at all the stations, followed by Capitella capitata.

7.7.2 Earthworm Bioaccumulation Study

7.7.2.1 Study Procedures

The earthworm bioaccumulation study was conducted at Site 7 to determine if earthworms were bioaccumulating PCBs, pesticides, and/or metals from the surface soil.

Canadian nightcrawlers were purchased from a local bait dealership three days prior to deployment. They were held in a refrigerator at less than 22°C during the three day period. On the morning of deployment, sets of ten adult, fully clitellated earthworms were weighed to the nearest tenth of a gram. Lethargic or damaged earthworms were not used.

Test chambers were used to house the earthworms for the duration of the project. The test chambers were constructed from 8-inch sections of 4-inch diameter white polyvinyl chloride (PVC) pipe. The ends of the pipe were covered with a 30 mesh (600 micron openings) polyester monofilament screen of 0.76 mm thickness. The screens were fastened to the pipe with 2-inch sections of 4.5-inch diameter white PVC pipe. The outside walls of the 8-inch PVC pipe was sanded down to allow the 2-inch sections to slip over them.

The stations were set up the day prior to deployment of the worms. Surface debris, such as sticks, twigs, leaves, were removed at each station. Holes, approximately seven inches in depth, were dug with a clean shovel. The soil was placed into the test chambers with the same vertical distribution as it occurred in the ground. Any extra soil was used to fill in the hole surrounding the pipe. There was evidence of animals disturbing the chambers prior to introduction of the worms. Therefore, a wood frame covered with plastic-coated one-inch mesh size chicken wire was placed on top of the chambers to prevent wildlife from disturbing the test chambers.

Each site station consisted of three replicate samples, one control sample, and two instrument samples (one for the replicates and one for the controls). Each of the three replicate samples and the control sample consisted of two chambers containing ten worms. One off-site reference station also was used in this study. This station consisted of two replicate samples and one instrument sample. A control sample was not conducted at this station since it was a background station.

A minimum of 60 grams of worm tissue was needed by the laboratory for chemical analysis. It was recommended by USEPA that no more then ten worms should be placed in each container (Callahan, 1994). Therefore, two chambers were required for each sample since ten worms only weighed 30 to 40 grams. Three sets of worms were sent to the analytical laboratory prior to initiation of the study to determine the baseline concentration of COPCs in the worms.

The artificial soil used for the control stations consisted of 10% Canadian sphagnum peat moss, 20% kaolin clay, 70% silica sand, and calcium carbonate at the rate of about 0.4% of the weight of the combined peat moss, clay, and sand. The artificial soil was obtained from Takene Ecological Services, Inc., in Corvallis, Oregon, and has been used in similar studies (Wilborn et.al., Unpublished).

The soil moisture was measured using a Model "P" irrometer from the Irrometer Company. The irrometer works on the principal of soil suction which is measured in centibars. The correlation between centibars and percent moisture depends on the soil type. Therefore the site soil and control soil was used to "calibrate" the irrometer by adding varying amount of water to soil samples, measuring them with the irrometer, and then sending them to a laboratory for percent moisture analysis. Table 7-12 shows this comparison.

The irrometer reading (in centibars) in the site soil dropped to zero when the percent moisture was approximately 31 percent, and was approximately 29 percent at an irrometer reading of 4. Water was added when the irrometer reading was above ten in either the site or control soil, to keep the soil moisture at around 30 percent or higher. The soil moisture was checked every day using the irrometer, unless it was raining, at which point the soil would be saturated.

At the end of the 28 days, the chambers were removed from the soil and brought back to the site trailer. The chambers were opened one at a time, and the worms were removed, observed for mobility, tumors, and other malformations. The worms from each chamber were then washed in distilled water and weighed. The worms from each of the two chambers for each replicate were combined, wrapped in aluminum foil, and frozen. The samples were sent to the laboratory on dry ice.

7.7.2.2 Study Results

Table 7-13 presents the mortality results of the earthworm bioaccumulation study. The table presents the beginning number of worms and their weight, and the number of worms recovered after the study and their weight. The baseline worms were analyzed to determine the beginning contaminant concentration in the worms. The site worms were exposed to the site soil, while the control worms were exposed to the artificial soil.

Many of the site and control worms in Area 1 were not recovered. Since no holes were observed in the test chambers, the worms must have died and decomposed. Most of the worms that were alive at this station had swollen segments, and did not appear very healthy. Most of the site and control

worms in Area 2 were recovered. Many of these worms had swollen segments and some weight loss was recorded. Finally, most of the background worms in Area 3 were not recovered.

Table 7-14 presents the contaminant concentrations in the worm tissue samples, and the soil samples associated with the worm stations. Appendix Q contains the analytical data. The shaded boxes in the soil concentration columns are samples that exceeded twice the average basewide background concentration. The shaded boxes in the worm concentration columns are samples that exceeded the baseline worm concentrations. Two inorganics (cobalt and lead) in the Area 1 site worms had concentrations that exceeded the concentrations in the baseline worms and control worms. These contaminants only slightly exceeded the baseline worm concentrations. Selenium was the only contaminant in Area 1 that exceeded the basewide background data, however, the worms concentrations were within the range of the baseline worms. 4,4'-DDT was the only pesticide detected in the Area 1 soil samples, however, it was not detected in the worm samples. Finally, Aroclor 1254 was detected in the Area 1 control worms, however it was not detected in the site worms or the soil samples. The source of the PCB is unknown. However, the laboratory report indicated that the sample exhibited an alteration of the standard Aroclor pattern.

Four inorganics (aluminum, barium, iron, and lead) in the Area 2 site worms had concentrations that exceeded the concentrations in the baseline worms and control worms. Some of these contaminants exceeded the baseline worm concentrations by several orders of magnitude. Eight contaminants (aluminum, barium, beryllium, chromium, lead, manganese, vanadium, and zinc) detected in the Area 2 soil exceeded the basewide background data. Beryllium, chromium, and vanadium were not detected in the Area 2 worm samples. Nine pesticides were detected in the Area 2 soil, however only 4,4'-DDE and dieldrin were detected in the worm samples.

None of the contaminants in the Area 3 background soil sample exceeded the basewide background concentrations. No worms from Area 3 were chemically analyzed because most of them were dead and/or decomposed.

7.8 Ecological Effects Characterization

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic and terrestrial screening values as presented in Section 7.3.4.1 to aid in the selection of the COPCs. The following sections present a summary of the ecological effects comparison.

7.8.1 Surface Water

Contaminant concentrations detected in the surface water at Site 7 were compared to the freshwater or saltwater SWSVs to determine if there were any exceedances of the published values (see Tables 7-1 and 7-2).

7.8.1.1 Freshwater Stations

In summary, aluminum, barium, iron, lead, zinc and dieldrin were the only COPCs that exceeded their respective freshwater water SWSVs. No freshwater SWSVs or other toxicological data were available for endrin ketone.

7.8.1.2 Saltwater Stations

In summary, copper, lead, manganese, and bis(2-ethylhexyl)phthalate) are the only COPCs that exceeded their respective saltwater SWSVs. No saltwater SWSVs are available for aluminum, barium, iron, 2-butanone, chloroform, or 2-hexanone.

It was reported that soluble barium concentrations in marine waters generally would have to exceed 50,000 µg/L before toxicity to aquatic life would be expected (USEPA, 1987). The maximum barium concentration was 37.2 µg/L which is well below the reported toxicity level.

The concentrations of total iron (123-2,200 µg/L) in the surface water are above the concentrations that caused adverse impacts to aquatic life of some of the studies obtained from the Aquatic Information Retrieval Database (AQUIRE) (100 to 330,000 µg/L). However, the majority of the effect concentrations from the studies on AQUIRE are several orders of magnitude above the maximum iron concentration detected in the surface water. Most of the studies on iron in AQUIRE were conducted with various marine phytoplankton cultures.

7.8.2 Sediment

Contaminant concentrations detected in the sediments at Site 7 were compared to SSVs to determine if there were any exceedances of the published values (see Tables 7-3 and 7-4). The samples were separated into freshwater and saltwater samples since the SWSVs are used in the SQC calculation.

7.8.2.1 Freshwater Sediments

In summary, beryllium, copper, lead, mercury, and zinc are the only inorganic COPCs that exceed the SSVs. Aldrin, alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, and Aroclor-1260 are the only pesticide/PCB COPCs that exceed the SSVs. Acenaphthylene, anthracene, bis(2-ethylhexyl-phthalate), di-n-butylphthalate, and phenanthrene are the only SVOC COPCs that exceed the SSVs. Finally, toluene is the only VOC COPC that exceeds any of the SSVs

No SSVs or other toxicological data are available for aluminum, vanadium, endrin ketone, 3,3'-dichlorobenzidine, or styrene.

The Marsh Area samples do not appear to be true sediments since they have standing water only during certain high flow events. Therefore, these samples also were compared to SSSVs to evaluate potential impacts to terrestrial receptors (see Table 7-15). Aluminum, copper, iron, mercury, vanadium, zinc, 4,4'-DDE and 4,4'-DDT exceed the SSSVs in several samples. Chromium, Aroclor-1260, and most of the SVOCs exceed the SSSVs in one sample.

7.8.2.1 Saltwater Sediments

In summary, beryllium, lead, selenium, and thallium are the only inorganic COPCs that exceed the SSVs. Alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin, are the only pesticide COPCs that exceed the SSVs. No SVOCs or VOCs exceed any of the SSVs. No SSVs or other toxicological data are available for aluminum, vanadium or 2-butanone.

7.8.3 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 (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. Contaminant concentrations detected in the surface soil at Site 7 were compared to SSSVs to determine if there were any exceedances of the published values (see Table 7-16). Lead, selenium, and zinc exceed the SSSVs in one, two, and one sample, respectively. Whereas aluminum, chromium, iron, mercury, and vanadium exceed the SSSVs in all or most samples they were detected.

4,4'-DDT is the only pesticide that exceeds the SSSVs. Most of the SVOCs exceed the SSSVs in one sample. However, fluoranthene exceeds it's SSSV in four samples, and pyrene exceeds it's SSSV in three samples.

Table 7-17 presents the contaminant concentrations associated with the worm stations compared to the earthworm SSSV. Chromium is the only inorganic detected in these surface soil that exceeds an earthworm SSSV. The chromium SSSV is exceeded in all three worm study areas. 4,4'-DDE, 4,4'-DDT, and dieldrin are the only pesticides that exceed the earthworm SSSV in these soils. 4,4'-DDT exceeds the SSSV in all three worm study areas, while 4,4'-DDE and dieldrin only exceed the SSSV in Area 2.

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 describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 7 by both direct and indirect exposure to COPCs via surface water, soil, and foodchain transfer.

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, raccoon, bobwhite quail, and the short-tailed shrew. The exposure points for these receptors are the surface soil, surface water, and biota. The routes for terrestrial exposure to the COPCs in the soil and water are incidental soil ingestion, drinking water, vegetation (leafy plants, seeds and berries) ingestion, fish ingestion, and ingestion of small mammals or worms.

7.8.4.1 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters is determined by estimating the CDI dose and comparing this dose to Terrestrial Reference Values (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 (SMTA, 1992) or other toxicological data in the literature. Appendix S presents the methodology used in deriving the TRVs and the animals that were used to derive each TRV.

7.8.4.2 Calculation of Chronic Daily Intake

Potential impacts of the terrestrial receptors to the COPCs in the soil and surface water 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 soil, surface water, and vegetation was determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)][H]}{BW} \quad (5)$$

Where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Contaminant concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/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 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 raccoon is determined using the following equation.

$$CDI = \frac{(Cw)(Iw)+(Cf)(If)+[(Cs)(Br)(Iv)+(Cs)(Is)][H]}{BW}$$

where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Contaminant concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/d
Cf	=	Contaminant concentration in the fish, mg/kg
If	=	Rate of fish ingestion, kg/d
Cs	=	Contaminant concentration in soil, mg/kg
Br	=	Soil to plant transfer coefficient (fruit, seeds, tubers, 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

The contaminant concentration in the fish is calculated by multiplying the contaminant concentration in the surface water by the bioconcentration factor (BCF).

The estimated CDI dose of the red fox is determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)+(Cm)(Im)][H]}{BW}$$

where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Contaminant concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/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

The estimated CDI dose of the short-tailed shrew is determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)+(Cwo)(Iwo)][H]}{BW}$$

where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Contaminant concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/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
Cwo	=	Contaminant concentrations in worms, mg/kg
Iwo	=	Rate of worm 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 or Br) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984). The concentrations of the COPCs used in the models were the lower of 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 7-18.

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 are evaluated. This section evaluates the potential decrease in aquatic and terrestrial populations at Site 7 from contaminants identified at the site.

A Quotient Index (QI) approach is used to characterize the risk to aquatic receptors from exposure to surface water and sediments and terrestrial receptors from exposure to surface soil, surface water, and biota. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to the aquatic reference values presented in Section 7.8, Ecological Effects Chacterization. The QI is calculated as follows:

$$QI = \frac{(EC, CDI)}{(SWSV, SSV, TRV}$$

Where: Quotient Index
EC = Exposure Concentration, µg/L, ug/kg or mg/kg
CDI = Chronic Daily Intake, mg/kg/day
SWSV = Surface Water Screening Value, µg/L
SSV = Sediment Screening Value, ug/kg or mg/kg
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. 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.

7.9.1 Surface Water

7.9.1.1 Freshwater Stations

Table 7-19 presents the surface water QI for the freshwater stations. Figure 7-3 graphically displays the QIs that exceed "1". A hardness of 27 mg/L $CaCO_3$ was used to calculate the hardness-dependent SWSVs (lead and zinc) in Section 7.3.2, since this was the lowest hardness detected at any of the stations. The hardness at the stations ranged from 27 to 40 mg/L $CaCO_3$. The SWSVs were recalculated to take into account the station-specific hardness values when calculating the QIs. Aluminum, barium, iron, lead, zinc and dieldrin were the only freshwater surface water COPCs that had QIs greater than "1". Most of the QIs are less than "10" with the exception of one aluminum, two lead samples, and two dieldrin samples.

7.9.1.2 Saltwater Stations

Table 7-20 presents the surface water QI for the saltwater stations. Figure 7-3 graphically displays the QIs that exceed "1". Copper, lead, manganese, silver, and bis(2-ethylhexyl)phthalate are the only

saltwater surface water COPCs that have QIs greater than "1". The QIs of all the copper, lead, and manganese samples are less than "10".

It should be noted that neither silver or bis(2-ethylhexyl)phthalate were detected in the groundwater at Site 7, or the sediment samples adjacent to the surface water samples where they were detected. Also, silver was only detected in one out of 32 samples, and bis(2-ethylhexyl)phthalate was not detected adjacent to the surface water station in which it was detected. Therefore, there does not appear to be a source for these contaminants at Site 7. The bis(2-ethylhexyl)phthalate may be related to laboratory contamination and the silver may be related to natural conditions.

The source for the SWSV for manganese of 10 µg/L is not known. However, AQUIRE reports that 10 µg/L caused decreased growth in the pacific oyster (Crassostrea gigas). This study, which did not meet the criteria for reliability, may be the data source for the Region III value. Other toxicity values for manganese from AQUIRE listed adverse effects at 20,000 µg/L which is higher than any of the samples collected at Site 7. These studies also were conducted with mollusk species.

7.9.2 Sediment

7.9.2.1 Freshwater Stations

Beryllium, copper, lead, mercury, and zinc are the only inorganics detected in the sediment samples had QIs that exceed "1" (see Table 7-21). Figure 7-3 graphically displays the QIs that exceed "1". All these samples that had QIs greater than "1" are located in the Marsh Area. Mercury is the only inorganic with a ER-L QI greater than "10", while mercury and lead are the only inorganics with an ER-M QI greater than "1".

The following pesticides detected in the freshwater sediment samples had QI greater than "1": aldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, and dieldrin. Alpha-chlordane and dieldrin are the only pesticides detected in the freshwater West Tributary samples that had QIs greater than "1". Overall, the concentration of pesticides is relatively similar between the Marsh Area samples. Several of the QIs are greater than "100".

Aroclor-1260 is the only PCB detected in the freshwater sediment samples with a QI greater than "1". It was detected in one Marsh Area sample.

Acenaphthylene, anthracene, di-n-butylphthalate, and phenanthrene are the only SVOCs detected in the Marsh Area freshwater sediment samples that have QIs greater than "1". Bis(2-ethylhexyl)phthalate is the only SVOC detected in the drainage ditch samples that has a QI that exceed "1". No SVOCs detected in the West Tributary sediment samples have QIs greater than "1". Finally, toluene is the only VOC detected in the sediment samples that has a QI greater than "1". It is only detected in the Marsh Area samples.

7.9.2.2 Saltwater Stations

Beryllium, lead, selenium, and thallium are the only inorganics detected in the sediment samples have QIs that exceed "1" (see Table 7-22). Figure 7-3 graphically displays the QIs that exceed "1". The ER-L QI for lead was 1.8. The other QIs ranged from 2.5 to 23.4. No inorganics have ER-M QIs greater than "1". The following pesticides detected in the saltwater sediment samples have QIs

greater than "1": 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, and dieldrin.

7.9.3 Terrestrial Chronic Daily Intake Model

Table 7-23 presents the QI for the terrestrial CDI model. Appendix S contains the CDI spreadsheets. The cottontail rabbit, raccoon, and short-tailed shrew were the only species with QIs that exceeded "1". The QI for the rabbit was 5.13, the QI for the raccoon was 70.4, and the QI for the shrew was 311. Aluminum was the COPC that contributed most of the risk to the three species, with dieldrin adding a significant portion of the risk to the raccoon.

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 7 from the COPCs detected in the media, and determines which COPCs are impacting the site to the greatest degree, and what contaminants are site-related "significant". This information, to be used in conjunction with the human health risk assessment, supports the selection of remedial action(s) for Site 7 that are protective of public health and the environment.

7.10.1 Aquatic Endpoints

7.10.1.1 Freshwater Stations

Several COPCs in the freshwater surface water and sediment samples exceed their applicable SWSVs or SSVs. All the inorganics, SVOCs (with the exception of (bis(2-ethylhexyl)phthalate), and VOCs that exceed SSVs are located in the Marsh Area, and the majority of the pesticides that exceed SSVs are located in the Drainage Ditch or the Marsh Area.

As presented in the Section 7.8, Ecological Effects Characterization, of this report, the Marsh Area sediments do not appear to be true sediments because they are only covered with water during high flow events. In fact, there were puddles of water at some of the stations, and standing water was absent at other stations during the sampling event. Therefore, contaminant exceedences of SSVs in the Marsh Area probably is not ecologically significant for aquatic receptors since aquatic receptors most likely do not exist in the Marsh Area. The ecological significance of the Marsh Area samples for terrestrial receptors is presented below in Section 7.10.2.

Aluminum, barium, iron, and lead were the only COPCs in the Drainage Ditch surface water samples that exceed SWSVs, while several pesticides and bis(2-ethylhexyl)phthalate in the Drainage Ditch sediment samples exceed the SSVs. When the SQC for bis(2-ethylhexyl)phthalate was calculated for the screening values, the lowest organic carbon concentration of all the sediment samples was used in the equation to be conservative. The sample-specific Foc is used to calculate the SQC for bis(2-ethylhexyl)phthalate. The recalculated SQC of 1,035 ug/kg is greater that the concentration of bis(2-ethylhexyl)phthalate (510 ug/kg) in the Drainage Ditch sample. Therefore, bis(2-ethylhexyl)phthalate does not exceed the recalculated SQC. This ditch is very shallow, thereby limiting the aquatic life to relatively small invertebrates and fish.

Aluminum, barium, lead, zinc, and dieldrin were the only COPCs in the West Tributary freshwater surface water samples that exceed SWSVs, while, alpha-chlordane and dieldrin are the only COPCs detected in the West Tributary freshwater sediment stations that exceed SSVs. This creek is very

shallow, thereby limiting the aquatic life to relatively small invertebrates and fish. Some small minnows were observed in this creek.

Table 7-24 presents the freshwater benthic macroinvertebrate summary statistics and their comparison to reference stations. Table 7-25 presents the results of the community similarities between the Site 7 stations and the reference stations. The benthic macroinvertebrate communities at the Site 7 stations are not similar to the benthic macroinvertebrate community at the reference stations. The number of species, species density, and species diversity is lower in the Site 7 samples. Since some contaminants in the West Tributary surface water and sediment samples exceed SWSV and SSVs, the lower summary statistics in the Site 7 stations may be caused by site-related COPCs. However, as is presented below in Section 7.10.1.2, the benthic macroinvertebrate community at the downstream (saltwater) West Tributary station does not appear to be impacted by site-related contaminants.

In summary, the potential risk to aquatic life in both the Drainage Ditch and the West Tributary is from inorganics and dieldrin in the surface water and pesticides in the sediment. Some impacts to the benthic macroinvertebrate population were observed from the field investigations. These impacts may be caused by the contaminants detected in the surface water and sediments. As presented in Section 4.0 of this report, the pesticides in the surface water and sediment are most likely associated with the widespread historical use of these pesticides at MCB Camp Lejeune, and therefore, not related specifically to the site. The source of the metals detected in the surface water may be related to the construction materials and containers that have been observed in the southwest area of the site. It also should be noted that the headwaters of the West Tributary consist of a stormwater pipe leading from a parking area. Runoff from this parking area also may contribute inorganics to the West Tributary. Finally, the impacts in the benthic macroinvertebrate population may be due to natural conditions. The tributary periodically may become tidally influenced which may severely stress the benthic macroinvertebrate population. Also, during high rain events, flow in the tributary is very high and may "wash out" the resident benthic macroinvertebrate population.

7.10.1.2 Saltwater Stations

Table 7-26 presents the benthic macroinvertebrate summary statistics and their comparison to reference stations. Table 7-27 presents the results of the community similarities between the Site 7 stations and the reference stations. The benthic macroinvertebrate communities at the Site 7 stations are not similar to the benthic macroinvertebrate community at the reference stations. The number of species and species density is higher in the Site 7 samples while the diversity indices are similar compared to the benthic macroinvertebrate at the off-site reference stations. Based on these results, the benthic macroinvertebrate population in the downstream West Tributary stations and the Northeast Creek stations adjacent to Site 7 do not appear to be adversely impacted, although there is the potential for a reduction based on the surface water and sediment data.

Manganese was the only COPC in the West Tributary saltwater surface water sample that excees a SWSV, while thallium, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, gamma-chlordane, and dieldrin are the only COPCs detected in the West Tributary saltwater sediment station that exceeded SSVs. Manganese in the surface water and thallium in the sediment were detected in several of the Northeast Creek stations at similar or higher concentrations than those detected in the West Tributary. Therefore, these contaminants do not appear to be site-related. In addition, as presented in the risk characterization section of this report, the reliability of the SWSV for manganese is low, and other data indicate that the concentrations of manganese detected in the surface water may not

cause adverse impacts to aquatic receptors. The pesticides in the surface water and sediment at Site 7 are most likely associated with the widespread historical use of these pesticides at MCB Camp Lejeune, and therefore, not related specifically to the site. The West Tributary at this station was considerably larger than the tributary at the upstream stations. Although no fish were collected during the sampling activities, it is likely that some large fish enter this tributary for protection and cover. In summary, although the potential impacts to these aquatic species may occur from contaminants in the surface water and sediment in the saltwater West Tributary station, these potential impacts are not attributable to site activities.

Lead, manganese, and silver are the only COPCs in the Northeast Creek surface water samples that exceed their SWSVs, while lead, thallium, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, and dieldrin are the only COPCs detected in the Northeast Creek sediment samples that exceed their SSVs. However, lead, manganese, and silver in the surface water and thallium in the sediment were detected at similar concentrations in most of the Northeast Creek samples. Therefore, these contaminants do not appear to be site related. In addition, the reliability of the SWSV for manganese is low, and other data indicate that the concentrations of manganese detected in the surface water may not cause adverse impacts to aquatic receptors. The pesticides in the Northeast Creek sediment are not related specifically to the site. Finally, lead was only detected in the sediment at 7-NC-SD04 which was collected at the mouth of the West Tributary so it may be site-related. However, its QI only slightly exceeds the ER-L (1.8), and it was detected in the 6-12" portion of the sediments which is below the depth where the majority of benthic macroinvertebrates live. In summary, although the potential reduction of aquatic species may occur from contaminants in the surface water and sediment in Northeast Creek, this potential reduction is either very slight (lead in the sediments) or not attributable to site activities. In addition, as presented in the above paragraph, the benthic macroinvertebrate community in the Northeast Creek stations does not appear to be adversely impacted.

Copper, manganese, silver, and bis(2-ethylhexyl)phthalate are the only COPCs in the East Tributary surface water samples that exceed SWSVs, while, beryllium, selenium, and alpha-chlordane are the only COPCs detected in the East Tributary sediment stations that exceed SSVs. The upstream portion of this tributary is very shallow, thereby limiting the aquatic life to relatively small invertebrates and fish, while the downstream portion of the creek is deeper and wider and most likely inhabited by larger fish. Some small minnows were observed in this creek. As presented above and in Section 7.9.1.2, the manganese, silver, and bis (2-ethylhexyl)phthalate in the surface water do not appear to be site-related. However, the copper in the surface water, and beryllium and selenium in the sediment were only detected in the East Tributary samples and may be site related. The alpha-chlordane detected in the sediment is most likely associated with the widespread historical use of these pesticides at MCB Camp Lejeune, and not related specifically to the site. Therefore, slight potential impacts to aquatic receptors in the East Tributary from site-related contaminants in the surface water and sediment are expected.

7.10.2 Terrestrial Endpoints

Several of the COPCs in the surface soils exceed the SSSVs. For the worm stations, Area 2 had the highest concentration of most of the COPCs; however, this area also had the greatest survival of worms. Therefore, the reason for the poor survival rate of the worms in Area 1 and Area 3 probably was due to other factors such as a lack of water. In an effort to keep the soils from becoming anaerobic because of too much water, the soil may have not been watered enough. In addition, during the field investigations the worms were not watered during the four days off between

sampling events which also may have contributed to the lack of water. Since many of the soil concentrations in Area 2 are above the earthworm SSSVs, and the worms in this area appear to be the most healthy, the SSSVs may overestimate the risk to some soil flora. In addition, no stressed or dead vegetation were observed during the field investigations, and some small earthworms (approximately 1 to 2 inches) were observed in the soils when digging holes for some of the test chambers. Therefore, although potential impacts to soil flora and fauna are possible based on the exceedences of SSSVs, the risks to soil flora and fauna are not expected to be high based on the actual field data.

As presented earlier in this ERA, the Marsh Area appear to be more closely related to surface soil than sediments. Therefore, the contaminants detected in samples were evaluated as both sediments and surface soil. Several inorganics, pesticides, SVOCs and one VOC were detected in the Marsh Area samples at concentrations greater than the SSSVs. Chromium, copper, lead, mercury, and Aroclor-1260 only exceed the SSSVs at 7-MA-SD01 which was located in the middle of the site. In addition, the two zinc samples with the highest concentration are located at this station. Therefore, these contaminants appear to be site-related. The pesticides were detected at all four marsh samples including the one east of the East Tributary (considered off-site) and they do not appear site-related. All the SVOCs that exceed the SSSVs were detected at the off-site marsh sample and do not appear site-related. Finally, toluene was detected in all the Marsh Area samples with the highest concentrations in the off-site marsh samples and does not appear to be site-related. In summary, several of the inorganics have the potential for adversely impacting the terrestrial floral and faunal population.

The QI for the cottontail rabbit barely exceeded one (1.82). Due to the conservative nature of these models, this slight exceedence is not expected to cause a significant decrease in the rabbit population.

The QI for the raccoon is 70.4. Most of the risk to the raccoon is caused by aluminum (38.8) and dieldrin (28.7) in the surface water, since the surface water concentration was used to calculate the fish concentration. This value also is overestimated for several reasons. Since the water bodies were divided into freshwater and saltwater stations, a RME over all the stations was not calculated. Therefore, the maximum water concentration (which would be higher than the RME) was used in the model. In addition, only a few small (less than one inch) fish were observed in the West Tributary where the dieldrin detected. Raccoons would need to ingest fish from other sources, or other types of food, in order to survive. Finally, dieldrin in the surface water is not expected to be site-related. Therefore, the actual risk to the raccoon from site-related COPC is expected to be low.

The QI for the short-tailed shrew is 311. The majority of the QI is from aluminum (296), with barium (5.1) and iron (5.2), contributing most of the remaining risk. The aluminum concentration in the surface soil at the worm station used for the model is 1.5 times greater than twice the average basewide background concentration. Therefore, although it exceeds the background concentrations, it most likely is still due to natural variations and, therefore, probably not site-related. In addition, since an RME was not calculated, the maximum worm concentration was used in the model which overestimates the risk since the shrew will not be ingesting all their worms from the same location. In summary, the risk to the short-tailed shrew from site-related COPCs is expected to be low.

7.10.3 Threatened and Endangered Species

No threatened or endangered species are known to occur at Site 7, therefore no adverse impacts to these species from contaminants at Site 7 are expected.

7.10.4 Wetlands

Some wetlands have been identified at Site 7. The samples collected in the Marsh Area were in these wetland areas. Since some of the COPCs in these samples exceed applicable screening values, there is the potential for adverse impacts to wetlands. However, no areas of stressed or dead vegetation were observed during the field investigations.

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 discusses some of the uncertainty in this ERA.

The chemical sampling program at Site 7 consisted of four freshwater and nine saltwater surface water samples, and twelve freshwater and fourteen saltwater sediment samples. Because there were less than twenty samples, contaminants could not be eliminated because of infrequency. Therefore, contaminants not related to the site may have been retained as COPCs and thus carried through the ERA.

There is uncertainty in the ecological endpoint comparison. The SWSVs (WQS and AWQC) are established to be protective of a majority of the potential receptors. However, there will be some species will not be protected by the values because of their increased sensitivity to the chemicals. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, hardness, total organic carbon) that may influence toxicity are most likely at different concentrations in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediments were evaluated by comparing the COPC concentration in the sediments to SSVs. These SSVs have more uncertainty associated with them than do the SWSLs, since the procedures for developing them are not as established as those used in developing SWSLs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) also has a significant impact on the bioavailability and toxicity of contaminants.

Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. Most of these studies 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. In addition, 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 bioconcentration and biotransfer factors. Bioconcentration and biotransfer factors can vary widely from species to species. The species used in the calculation of the bioconcentration and biotransfer factors 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. Finally, terrestrial receptors also may be exposed to contaminants in the sediments. However, currently, there is no guidance in the literature that can be used to evaluate this potential exposure pathway.

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 aquatic receptors from these contaminants

7.12 Conclusions

7.12.1 Aquatic Ecosystem

Based on the results of the surface water, sediment, and benthic macroinvertebrate sampling at the West Tributary freshwater stations, it appears that there is a reduction of the benthic macroinvertebrate population. However, it is not known if this reduction is from site-related inorganics in the surface water, or from non site-related pesticides in the sediment. Other possible sources for the low and poorly diversified benthic macroinvertebrate population is washout of the tributary that occurs as a result of high rainfall events, or periodic high tidal events that would stress the resident benthic population with high saline water. The benthic macroinvertebrate population appears to recover by the downstream saltwater station. The benthic macroinvertebrate population is consistent with the population at the off-site reference stations with respect to species density and diversity. In addition, there are no site-related contaminants at this station that exceed either the SWSVs of the SSVs at this station.

Based on the results of the surface water, sediment, and benthic macroinvertebrate sampling at the Northeast Creek stations, there does not appear to be a significant reduction, or potential reduction of the benthic macroinvertebrate population from site-related contaminants. Lead was the only site-related contaminant that slightly exceeded a screening value. In addition, the benthic macroinvertebrate population is consistent with the population at the off-site reference stations with respect to species density and diversity.

The benthic community in either the Drainage Ditch or the East Tributary were not determined, however, based on the exceedences of the SWSVs and SSVs, potential impacts are expected. Some of the inorganics in the surface water are considered site-related, the pesticides in the sediment are not considered site-related.

Although there are some potential impacts to the aquatic receptor population, remedial actions are not warranted for several reasons. Potential impacts (i.e., SWSV and SSV exceedences, low benthic macroinvertebrate population) appear to be limited to the upstream portion of the West Tributary. Remediation of this area may cause impacts further downstream in non-impacted areas. In addition, the observed potential impacts may be caused by non site-related activities (i.e., parking lot runoff, widespread pesticide use at MCB Camp Lejeune). Finally, most of the screening value exceedences occurred in the Drainage Ditch samples. This ditch is very small with little potential for an ecologically significant aquatic population since it is subject to natural stresses (i.e., low dissolved oxygen, periodic drying). Therefore, remediation of this area would not significantly enhance the aquatic receptor population.

7.12.2 Terrestrial Ecosystem

Based on the comparisons of contaminants in the surface soils to SSSVs, there is a potential for the reduction of the terrestrial floral and faunal population. However, the earthworm bioaccumulation study indicated that the SSSVs appear to overestimate potential risk to earthworms. In addition, this was further reinforced by the observations of worms in soils containing contaminant levels greater that the SSSVs, and no visible signs of stressed or dead vegetation were observed. It should be noted that 7-MA-SD01 had the highest concentration of several inorganics, and the only detection of PCBs, indicating that this area may be a hot spot.

The results of the CDI model indicate that the cottontail rabbit, raccoon, and short-tailed shrew may be potentially at risk from contaminants in the surface water and surface soil. The risk to the rabbit does not appear to be significant because the QI barely exceeded "1". Aluminum causes the majority of the risk in the raccoon and the shrew. However, based on the conservative nature of the models, and the assumption that aluminum is most likely not site related, the potential for a decrease in the raccoon and shrew population from site-related COPCs is expected to be low.

Overall, the potential impacts to the terrestrial population at Site 7 are not significant enough to warrant remedial actions. Although some contaminants in the soil exceed SSSVs, these values are not standards or criteria. Further, as presented earlier in this ERA, these SSSVs appear to be overly conservative based on the results of the earthworm study. Finally, there is a low potential for a decrease in the population of the modeled terrestrial receptors from site-related contaminants.

7.13 References

Arthur and Alldredge. 1979. Public Health Evaluation and Ecological Assessment. Martin Marrietta Astronautics Group, Waterton Facility, Vol. II of III, Appendix A and B. Cited in Scarano, 1993.

Agency for Toxic Substances and Disease Registry (ASTDR). 1993. Toxicological Profile for Endosulfan. Prepared by Clement Associates for the US Department of Health and Human Services.

Baes, C.F., Sharp, A.L., and R.W. Shor. September 1984. "Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture." Oak Ridge National Laboratory.

Baker 1994. Baker Environmental Inc, 1994. Remedial Investigation, Feasibility Study Project Plans For Operable Units No. 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, VA.

Beyer, N., E. Connor, and S. Gerould. 1993. "Estimates of Soil Ingestion by Wildlife". Patuxent Wildlife Research Center, Laurel, MD.

Brower, James E, and Jerrold H. Zar. 1977. Field and Laboratory Methods for General Ecology. Wm. C. Brown Company Publishers.

Callahan, Clarance A. 1994. Personal Communication. USEPA, Environmental Research Laboratory, 200 S.W. 35th Street, Corvallis, OR, 97333.

CAMA, North Carolina Coastal Management Act of 1974. (1973, c.1284, s; 1975, c.452, s.: c. 932, s. 2.1.). 1974.

Collins, Henry Hill, Jr. 1959. Complete Field Guide to American Wildlife. Harper and Row. New York, New York.

Conant, Roger. 1975. A Field Guide to Reptiles and Amphibians. Houghton Mifflin Company. Boston, Massachusetts.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. December 1979. Classification of Wetlands and Deepwater Habitats of the United States. Performed for U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services - FWS/OBS-79/31.

Dee, J.C. November, 1991. "Methodology For Assessing Potential Risks To Deer Populations: A Case Study at a Superfund Site". Paper presented at the 1991 Annual Meeting of the Society of Environmental Toxicology and Chemistry. Abstract No. 426.

Fitchko, J. 1989. Criteria for Contaminated Soil/Sediment Cleanup. Pudvan Publishing Company, Northbrook, Illinois.

Francis, Mary Evans. 1912. The Book of Grasses. Doubleday, Page and Company. Garden City, New York.

Fussell, John. 1991. Progress Reports for Bachmans Sparrow Survey. Mailed to Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

Hulzebos, E.M., Adema, D.M.M., Dirven-van Breemen, E.M., Henzen, L., Van Dis, W.A., Herbold, H.A., Hoekstra, J.A., Baerselman, R., and Van Gestel, C.A.M. 1993. "Phytotoxicity Studies with *Lactuca sativa* in Soil and Nutrient Solution". Environmental Toxicology and Chemistry. Vol. 12, No. 6:1079-1094.

LeBlond, Richard. 1991. Critical Species List - Camp Lejeune Endangered Species and Special-Interest Communities Survey. Principal Investigator.

Long, E.W., D.D. Macdonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management Vol. 19, No.1, pp. 81-97.

Long, E.R and Morgan, L.G. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration Technical Memorandum NOS OMA 52.

Menzie, C.A., Cura J. and J. Freshman. January 1993. Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England. Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Water Environmental Federation.

Montgomery, J.H. and L.M. Welkon. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc. Chelsea, Michigan.

Nagy, Kennith. 1987. "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. Ecological Monographs." 57(2). pp. 111-128.

NAS. 1992. Subcommittee on Mineral Toxicity in Animals. Mineral Tolerance of Domestic Animals. National Academy of Sciences. Washington, D.C. pp 5-7.

NC DEHNR. 1994. 15A NCAC 2b.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina. State of North Carolina Department of Health and Natural Resources. June 1, 1994.

NC DEHNR. 1993. Classifications and Water Quality Standards Assigned to the Waters of the White Oak River Basin. State of North Carolina Department of Health and Natural Resources. February 1, 1993.

NC DEHNR, North Carolina Department of Environment, Health, and Natural Resources. May, 1992. Interim Guidance for Wetlands Protection. Division of Environment, Water Quality Section.

NC MFC. 1994. North Carolina Fisheries Rules for Coastal Waters, 1994-1995. North Carolina marine Fisheries Commission, Division of Marine Fisheries.

NCWRC, North Carolina Wildlife Resources Commission. June, 1992. 1992-1993 Hunting and Fishing Maps for North Carolina Game Lands.

NPS, National Park Service. 1993a. National Park System Map and Guide. U.S. Department of the Interior, National Park Service, Washington D.C.

NPS, Telephone conservation with the National Park Service. 1993b. The Wild and Scenic Rivers Division. U.S. Department of the Interior, National Park Service, Park Planning and Protection Division, Washington D.C.

NPS, National Park Service. 1990. The Wild and Scenic Rivers Act. U.S. Department of the Interior, National Park Service, Park Planning and Protection Division, Washington D.C.

Opresko, D.M., B.E. Sample, and G.W. Suter II. 1994. Toxicological Benchmarks for Wildlife, 1994 Revisions. Prepared for the US Department of Energy, Office of Environmental Restoration and Waste Management. September, 1994. ES/ER/TM-86/R1.

Peterson, Roger Tory. 1980. A Field Guide to the Birds of Eastern and Central North America. Houghton Mifflin Company. Boston, Massachusetts.

Peterson, Roger Tory and Margaret McKenny. 1968. A Field Guide to Wildflowers. Houghton Mifflin Company. Boston, Massachusetts.

Petrides, George A. 1986. A Field Guide to Trees and Shrubs. Houghton Mifflin Company. Boston, Massachusetts.

Scarano, Louis, J. Ph.D. and Daniel M. Woltering, Ph.D. January 1993. "Terrestrial and Aquatic Eco-Assessment for A RCRA Hazardous Waste Site". Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Cited in WEF, 1993.

SCDM. 1991. Superfund Chemical Data Matrix. United States Environmental Protection Agency Hazardous Site Evaluation Division. December 1991.

Sullivan, J., J. Ball, E. Brick, S. Hausmann, G., G. Pilarski, and D. Sopcich. 1985 Report of the Technical Subcommittee on Determination of Dredge Material Suitability for In-Water Disposal. Wisconsin Department of Natural Resources, Madison, WI. November, 1985.

Suter, Glenn W. II. 1993 Ecological Risk Assessment. Lewis Publishers. Chelsea, Michigan.

Suter, G.W. II. and J.B. Mabrey. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota:1994 Revision. Environmental Sciences Division, Oak Ridge National Laboratory.

Tetra Tech, Inc. 1986. Development of Sediment Quality Values for Puget Sound, Volume I. Puget Sound Dredged Disposal Analysis Report. Cited in Fitchko, 1989.

Travis, Curtis C. and Angela Arms. 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science Technology. Vol. 22, No. 3.

USDI, U.S. Department of the Interior. 1993. Correspondence and Maps showing units within the Coastal Barriers Resource System. Fish and Wildlife Service.

USDI, U.S. Department of the Interior. March 1982. National Wetland Inventory Map, Jacksonville South, N.C. Fish and Wildlife Service.

USEPA, 1995a. "Toxic Substance Spreadsheet". US Environmental Protection Agency, Region IV, Atlanta, Georgia. January 26, 1995

USEPA, 1995b. "Region III BTAG Screening Levels". US Environmental Protection Agency, Region III, Philadelphia, PA. January 19, 1995

USEPA, 1993a. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning. United States Environmental Protection Agency, Office of Water. September 1993. EPA-822-R-93-011.

USEPA, 1993b. "Water Quality Guidance for the Great lakes System and Correction: Proposed Rules". Federal Register. 58(72) 20802-21047. Cited in Suter and Mabrey, 1994.

USEPA, 1993c. Wildlife Exposure Factors Handbook. United States Environmental Protection Agency. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December 1993.

USEPA, 1993d. Sediment Quality Criteria for the Protection of Benthic Organisms- Fluoranthene. United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-012. September, 1993.

USEPA, 1993e. Sediment Quality Criteria for the Protection of Benthic Organisms- Phenanthrene. United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-014. September, 1993.

USEPA, 1993F. Sediment Quality Criteria for the Protection of Benthic Organisms- Dieldrin. United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-015. September, 1993.

USEPA. 1992a. Framework for Ecological Risk Assessment. United States Environmental Protection Agency. Risk Assessment Forum. EPA/630/R-92/001. February 1992.

USEPA, 1991a. 1991. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program. June 1991.

USEPA, 1991b. "Water Quality Criteria Summary" (Wall Chart). United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. May 1, 1991.

USEPA. 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final EPA/540/1-89/002. December, 1989.

USEPA. 1989b. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume II, Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. March 1989.

USEPA. 1989c. United States Environmental Protection Agency. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. Environmental Research Laboratory, Corvallis, OR. EPA/600/3-89/013. March 1989.

USEPA. 1987. Quality Criteria for Water-1986. U.S. Environmental Protection Agency, Office of Water Regulations, May 1987.

USEPA. 1986. United States Environmental Protection Agency. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Office of Solid Waste and Remedial Response. Washington D.C. EPA/540/1-86/060. October 1986.

USMC, MCB Camp Lejeune. October, 1993. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base Camp Lejeune, North Carolina. Personal Communication with Charles Peterson.

USMC, MCB Camp Lejeune. 1991. Sea Turtle Inventory for Summer and Fall 1991. Assistant Chief of Staff, Environmental Management Department, Fish and Wildlife Division, Marine Corps Base, Camp Lejeune, North Carolina.

USMC, MCB Camp Lejeune. 1987. Multiple-Use Natural Resources Management Plan. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

Walters, J.R. and J.M. Goodson. 1991. Status of the Red-Cockaded Woodpecker at Camp Lejeune, 1991. North Carolina State University. Submitted to the Department of Defense, USMC, Camp Lejeune, Environmental Management Department.

Water Environment Federation (WEF). 1989. Application of Ecological Risk Assessment to Hazardous Waste Site Remediation. Based on a January 10, 1993 Workshop., 601 Wythe Street, Alexandria, VA 22314-1994.

Wilborn, D.C., Bollman, M.A., Linder, G.L., Callahan, C.A., DalSoglio, J.A., Gillett, C.S., Nwosu, J.U., and S.L. Ott. "A Field Biological Assessment Method Using the Earthworm *Eisenia foetida andrei*: A Case Study at the Milltown Reservoir Superfund Site". Unpublished.

Will, M.E. and Suter, G.W. II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Environmental Sciences Division, Oak Ridge National Laboratory.

Will, M.E. and Suter, G.W. II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants. Environmental Sciences Division, Oak Ridge National Laboratory.

WS, Telephone conservation with the Wilderness Society, Washington D.C. 1993.

WS, The Wilderness Society. 1989 . The National Wilderness Preservation System, 1964-1989. The Wilderness Society, Washington D.C.

SECTION 7.0 TABLES

TABLE 7-1

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO FRESHWATER SURFACE WATER SCREENING VALUES
WEST TRIBUTARY AND DRAINAGE DITCH
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV Water Quality Screening Values (WQSV)[2]			No. of Positive Detects/ No. of Samples *	Range of Positive Detections		
		Acute	Chronic					
Inorganics (µg/L)								
Aluminum	NE	750	87	333	4/4	77.1-1,860	3	1
Barium	NE	69.1[3]	3.8[3]	25.67	4/4	16.4-28.9	4	2
Calcium	NE	NE	NE	17,567	4/4	5,940-12,800	NA	0
Iron	1,000	NE	1,000	576	4/4	410J-1,630	1	3
Lead	25	15.17[3]	0.59[3]	ND	3/4	2.5J-15.9	3	3
Magnesium	NE	NE	NE	1,745	4/4	1,680-2,870	NA	3
Manganese	NE	1,470[3]	80.3[3]	ND	4/4	11.2-14.4	0	4
Sodium	NE	NE	NE	9,830	4/4	7,100-14,500	NA	3
Zinc	50	38[3]	35[3]	ND	4/4	6.4-168J	2	4
Volatiles (µg/L)								
Chloroform	NE	NE	1,240[4]	ND	2/4	2J-3J	0	2

TABLE 7-1 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO FRESHWATER SURFACE WATER SCREENING VALUES
WEST TRIBUTARY AND DRAINAGE DITCH
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV Water Quality Screening Values (WQSV)[2]			No. of Positive Detects/ No. of Samples *	Range of Positive Detections		
		Acute	Chronic					
Pesticides (µg/L) Dieldrin	0.002	2.5	0.0019	ND	2/4	0.4-0.5	2	2
Endrin Ketone	NE	NE	NE	ND	2/4	0.12-0.13	NA	2

* Only the two upstream stations in the West Tributary were included in this evaluation along with the Drainage Ditch samples
NE = Not Established
NA = Not Applicable
[1] NCDEHNR, 1994 (Water Quality Standards)
[2] USEPA, 1995a (Region IV Toxic Substance Spreadsheet)
[3] Criteria are hardness dependent; values are based on a hardness of 27 mg/L as $CaCO_3$
[4] USEPA, 1995b (Region III BTAG Screening Levels)
[5] Suter and Mabrey, 1994 (Toxicological Benchmarks for Screening Potential COCs for Effects on Aquatic Biota)

TABLE 7-2

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SURFACE WATER SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV Water Quality Screening Values (WQSV)[2]			No. of Positive Detects/ No. of Samples*	Range of Positive Detection		
		Acute	Chronic					
Inorganics (µg/L)								
Aluminum	NE	NE	NE	ND	9/9	123-2,200J	NA	9
Arsenic	50	69	36	8.13	2/9	2.1J-2.4J	0	0
Barium	NE	NE	NE	24.25	9/9	18.5-37.2	NA	3
Calcium	NE	NE	NE	134,025	9/9	62,900-171,000J	NA	7
Copper	3	2.9	2.9	ND	1/9	12.3	1	1
Iron	NE	NE	NE	318	9/9	175J-2,160J	NA	4
Lead	25	220	8.5	16.41	7/9	4.2J-27.1	3	2
Magnesium	NE	NE	NE	511,200	9/9	125,000-573,000	NA	4
Manganese	NE	NE	10[3]	ND	9/9	10.1-68.9	9	9
Potassium	NE	NE	NE	207,250	9/9	39,600-179,000	NA	0
Silver	0.1	2.3	NE	19.13	6/9	5.1J-9.6	6	0
Sodium	NE	NE	NE	3,073,750	9/9	1,090,000-4,650,000	NA	8
Zinc	86	95	86	ND	5/9	8.1J-32.9J	0	5

TABLE 7-2 (Continued)

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SURFACE WATER SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV Water Quality Screening Values (WQSV)[2]			No. of Positive Detects/ No. of Samples*	Range of Positive Detection		
		Acute	Chronic					
Volatiles (µg/L) 2-Butanone	NE	NE	NE	ND	1/9	2J	NA	1
Chloroform	NE	NE	NE	ND	1/9	1J	NA	1
2-Hexanone	NE	NE	NE	ND	1/9	1J	NA	1
Xylene (total)	NE	13,500[5]	6,000[5]	ND	1/9	1J	0	1
Semivolatiles (µg/L) Bis(2-ethylhexyl)phthalate	NE	2,944[4]	3.4[4]	ND	1/9	77B	1	1

* Includes Downstream West Tributary Station
NE = Not Established
NA = Not Applicable
[1] NCDEHNR, 1994 (Water Quality Standards)
[2] USEPA, 1995a (Region IV Toxic Substance Spreadsheet)
[3] USEPA, 1995b (Region III BTAG Screening Levels)
[4] USEPA, 1991b (AWQC Wall Chart-Lowest Observed Effects Level) (bis(2-ethylhexyl)phthalate is based on phthalate esters)
[5] Based on the marketability of fish

TABLE 7-3

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO FRESHWATER SEDIMENT SCREENING VALUES WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detects Above the Average Reference Concentration
	ER-L	ER-M	SQC[4]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Inorganics (mg/kg)								
Aluminum	NE	NE	NE	1,166	12/12	1,170-10,500	NA	12
Barium	500[7]	NE	NE	6.46	12/12	9-250	0	12
Beryllium	0.36[6]	NE	NE	0.09	2/12	0.44-1.6	1	2
Calcium	NE	NE	NE	1,967	12/12	299-13,400	NA	8
Chromium	81[1]	370[1]	NE	1.86	4/12	4.2-19.4	0	4
Copper	34[1]	270[1]	NE	0.75	4/12	3.2-95.8	2	4
Iron	27,000[6]	NE	NE	434	12/12	570-6,060	0	12
Lead	46.7[1]	218[1]	NE	0.79	12/12	4.8J-90.8	4	12
Magnesium	NE	NE	NE	45.25	12/12	138-6,180	NA	12
Manganese	230[6]	NE	NE	3.63	12/12	3.4-30.6	0	11
Mercury	0.15[1]	0.71[1]	NE	0.14	2/12	1.6-2.6	2	2

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT
DETECTIONS COMPARED TO FRESHWATER SEDIMENT SCREENING VALUES
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detects Above the Average Reference Concentration
	ER-L	ER-M	SQC[4]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Potassium	NE	NE	NE	ND	3/12	1,540-1,780	NA	3
Sodium	NE	NE	NE	ND	12/12	29.2-6,910	NA	12
Vanadium	NE	NE	NE	1.52	7/12	2.9-21.5	NA	7
Zinc	150[1]	410[1]	NE	5.11	12/12	4.1-536	2	10
Pesticides/PCBs (µg/kg)								
Aldrin	0.1[7]	NE	0.16	1.05	1/12	3.1J	1	1
4,4'-DDD	2[2]	20[2]	0.64	1.57	7/12	21-120J	7	7
4,4'-DDE	2.2[1]	27[1]	3.63	2.42	9/12	14J-180J	9	9
4,4'-DDT	1[2]	7[2]	0.2	2.2	6/12	2.3J-110J	6	6
Alpha-chlordane	0.5[2]	6[2]	0.46	1.2	6/12	2.7-42J	6	6
Gamma-chlordane	0.5[2]	6[2]	0.46	1.44	2/12	4.7J-29J	2	2
Dieldrin	0.02[2]	8[2]	0.29	1.96	5/12	17J-71	5	5
Endrin ketone	NE	NE	NE	ND	1/12	6.5J	NA	1
Aroclor-1260	22.7[1][3]	180[1][3]	0.44	ND	1/12	450J	1	1

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT
DETECTIONS COMPARED TO FRESHWATER SEDIMENT SCREENING VALUES
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detects Above the Average Reference Concentration
	ER-L	ER-M	SQC[4]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Semivolatiles (µg/kg)								
Acenaphthylene	44[1]	640[1]	NE	ND	1/12	250J	1	1
Anthracene	85.3[1]	1,100[1]	1.16	ND	1/12	350J	1	1
Benzo(b)fluoranthene	3,200[6]	NE	NE	ND	2/12	85J-270NJ	0	2
Benzo(k)fluoranthene	3,700[6]	NE	NE	ND	2/12	110J-230NJ	0	2
Benzo(g,h,i)perylene	670[5]	NE	NE	ND	1/12	65J	0	1
Benzo(a)pyrene	430[1]	1,600[1]	13,567	ND	1/12	110J	0	1
Bis(2-ethylhexyl)phthalate	1,900[6]	NE	248	ND	1/12	510	1	1
Chrysene	384[1]	2,800[1]	NE	ND	2/12	110J-320J	0	2
Dibenzofuran	540[5]	NE	NE	ND	1/12	130J	0	1
Di-n-butylphthalate	5,300[5]	NE	421	ND	9/12	76J-1,300J	5	9
3,3'-Dichlorobenzidine	NE	NE	NE	ND	1/12	110J	NA	1
Fluoranthene	600[1]	5,100[1]	508	ND	2/12	170J-450J	0	2
Phenanthrene	240[1]	1,500[1]	150	ND	2/12	100J-210J	1	2

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT
DETECTIONS COMPARED TO FRESHWATER SEDIMENT SCREENING VALUES
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detects Above the Average Reference Concentration
	ER-L	ER-M	SQC[4]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Pyrene	665[1]	2,600[1]	NE	ND	2/12	130J-430J	0	2
Volatiles (µg/kg)								
2-Butanone	NE	NE	11,954	ND	9/12	7J-190J	0	9
Styrene	NE	NE	NE	ND	1/12	28J	NA	1
Toluene	NE	NE	3	ND	8/12	10J-39J	8	8

* The two upstream West Tributary samples, the Drainage Ditch, and the Marsh Area samples were included in this evaluation
NE = Not Established
NA = Not Applicable
ER-L - Effects Range Low
ER-M - Effects Range Median
SQC = Sediment Quality Criteria

[1] Long et.al, 1995
[2] Long and Morgan, 1991
[3] Value for total PCBs
[4] Values were calculated using the following equation: SQC = Foc*Koc*FCV/1000000
Where:
Foc = Fraction of organic carbon in the sediments (used 825 mg/kg)
Koc = Organic carbon partition coefficient (chemical specific)
FCV = Final water chronic value (chemical specific)
[5] USEPA, 1995b (Region III BTAG Screening Levels)
[6] Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values)
[7] Sulliven, et.al., 1985

TABLE 7-4

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SEDIMENT SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC[3]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Inorganics (mg/kg)								
Aluminum	NE	NE	NE	9,864	15/15	320J-5,930J	NA	0
Arsenic	8.2[1]	70[1]	NE	ND	3/15	0.8-3	0	3
Barium	500[6]	NE	NE	12.44	15/15	1.4-279	0	3
Beryllium	0.5[5]	NE	NE	ND	2/15	0.28-8	1	2
Calcium	NE	NE	NE	2,933	15/15	347-39,500	NA	9
Chromium	81[1]	370[1]	NE	30.87	7/15	2.9-10	0	0
Copper	34[1]	270[1]	NE	ND	3/1 5	3.7J-9.3J	0	3
Iron	27,000[5]	NE	NE	12,869	15/15	197-2,370J	0	0
Lead	46.7[1]	218[1]	NE	5.75	15/15	3.9J-86J	1	10
Magnesium	NE	NE	NE	5,081	13/15	358-13,900	NA	6
Manganese	230[5]	NE	NE	45.66	15/15	1.9-16.4	0	0
Selenium	1.0[5]	NE	NE	ND	1/15	23.4	1	1
Sodium	NE	NE	NE	ND	15/15	426-48,700	NA	15
Thallium	0.24[5]	NE	NE	0.25	6/15	0.61J-4.9J	6	6

TABLE 7-4 (Continued)

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SEDIMENT SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC[3]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Vanadium	NE	NE	NE	26.59	7/15	3-37.5	NA	1
Zinc	150[1]	410[1]	NE	30.66	14/15	2.9J-74.5J	0	3
Pesticides (µg/kg) 4,4'-DDD	2[2]	20[2]	1.37	3.38	4/14	4.3-44J	4	4
4,4'-DDE	2.2[1]	27[1]	7.83	ND	4/1 4	4.5-20J	4	4
4,4'-DDT	1[2]	7[2]	0.43	4.12	1/14	8.8	1	1
Alpha-chlordane	0.5[2]	6[2]	1.0	ND	5/14	4.9J-14	5	5
Gamma-chlordane	0.5[2]	6[2]	1.0	ND	3/14	5.2-11	3	3
Dieldrin	0.02[2]	8[2]	0.63	ND	3/14	5.4-7.9J	3	3
Semivolatiles (µg/kg) Benzo(a)anthracene	261[1]	1,600[1]	19,971	ND	1/15	74J	0	1
Benzo(b)fluoranthene	3,200[4]	NE	293,700	ND	1/15	46J	0	1
Benzo(k)fluoranthene	3,700[5]	NE	293,700	ND	1/15	57J	0	1
Bis(2-ethylhexyl)phthalate	1,900[5]	NE	64,080	ND	1/15	810	0	1
Butylbenzyphthalate	5,300[4]	NE	NE	ND	2/15	47J	0	2

TABLE 7-4 (Continued)

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SEDIMENT SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC[3]		No. of Positive Detects/ No. of Samples*	Range of Positive Detections		
Chrysene	384[1]	2,800[1]	106,800	ND	1/15	70J	0	1
Di-n-octylphthalate	5,300[4]	NE	6,790	ND	1/15	500J	0	1
Fluoranthene	600[1]	5,100[1]	527	ND	3/15	42J-120J	0	3
Indeno(1,2,3-cd)pyrene	600[4]	NE	854,400	ND	1/15	53J	0	1
Phenanthrene	240[1]	1,500[1]	424	ND	1/15	91J	0	1
Pyrene	665[1]	2,600[1]	20,292	ND	4/15	43J-170J	0	4
Volatiles (µg/kg) 2-Butanone	NE	NE	NE	ND	5/15	1J-250J	NE	5
Toluene	NE	NE	2,670	ND	1/15	36J	0	1

* Includes downstream West Tributary stations
NE = Not Established
NA = Not Applicable
ER-L - Effects Range Low
ER-M - Effects Range Median
SQC = Sediment Quality Criteria
[1] Long et.al., 1995
[2] Long and Morgan, 1991

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SEDIMENT SCREENING VALUES
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

[3] Values were calculated using the following equation: SQC = Foc*Koc*FCV/1000000

Where:

Foc = Fraction of organic carbon in the sediments (used 1,780 mg/kg)
Koc = Organic carbon partition coefficient (chemical specific)
FCV = Final water chronic value (chemical specific)

[4] USEPA, 1995b (Region III BTAG Screening Levels)

[5] Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values)

[6] Sulliven et.al., 1985

TABLE 7-5

CONTAMINANTS OF POTENTIAL CONCERN IN EACH MEDIA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Freshwater Stations			Saltwater Stations			
	Surface Water			Surface Water			
	Aquatic Receptors	Terrestrial Receptors	Sediment	Aquatic Receptors	Terrestrial Receptor	Sediment	Surface Soil
Inorganics							
Aluminum	X	X	X	X	X		X
Arsenic							X
Barium	X	X		X	X		X
Beryllium			X			X	X
Chromium							X
Cobalt							X
Copper			X	X	X		
Iron	X	X		X	X		X
Lead	X	X	X	X	X	X	X
Manganese		X		X	X		X
Mercury			X				X
Nickel							X
Selenium						X	
Silver							
Thallium						X	
Vanadium			X			X	X
Zinc	X	X	X		X		X
Volatiles							
2-Butanone				X	X	X	
2-Hexanone				X	X		
Styrene			X				
Toluene			X				X
Xylenes					X		
Semivolatiles							
Acenaphthylene			X				
Anthracene			X				
Benzo(a)anthracene							X
Benzo(b)fluoranthene							X
Benzo(k)fluoranthene							X

TABLE 7-5 (Continued)

CONTAMINANTS OF CONCERN IN EACH MEDIA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Freshwater Stations			Saltwater Stations			
	Surface Water			Surface Water			
	Aquatic Receptors	Terrestrial Receptors	Sediment	Aquatic Receptors	Terrestrial Receptor	Sediment	Surface Soil
Benzo(g,h,i)perylene							X
Benzo(a)pyrene							X
Bis(2-ethylhexyl)phthalate			X		X		X
Chrysene							X
Di-n-butylphthalate			X				X
3,3'Dichlorobenzidine			X				
Fluoranthene							X
Indeno(1,2,3-cd) pyrene							X
Phenanthrene			X				X
Pyrene							X
Pesticides/PCBs Aldrin			X				
Alpha-chlordane			X			X	X
Gamma-chlordane			X			X	X
4,4'-DDE			X			X	X
4,4'-DDD			X			X	X
4,4'-DDT			X			X	X
Dieldrin	X	X	X			X	X
Endosulfan II							X
Endrin ketone	X	X	X				
Aroclor-1254							X
Aroclor-1260			X				X

X - Indicates contaminant of concern

TABLE 7-6

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 11 (SITE 7)
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						
Aluminum	231[4]	ND	ND	4.00e-03	6.50e-04	1.50e-03
Arsenic	44[3]	ND	ND	4.00e-02	6.00e-03	2.00e-03
Barium	8[4]	ND	ND	1.50e-01	1.50e-02	1.50e-04
Beryllium	19[3]	ND	ND	1.00e-02	1.50e-03	1.00e-03
Chromium	16[3]	ND	ND	7.50e-03	4.50e-03	5.50e-03
Cobalt	40[4]	ND	ND	2.00e-02	7.00e-03	2.00e-02
Copper	36[3]	ND	ND	4.00e-01	2.50e-01	1.00e-02
Iron	ND	ND	ND	4.00e-03	1.00e-03	2.00e-02
Lead	49[3]	ND	ND	4.50e-02	9.00e-03	3.00e-04
Manganese	35[4]	ND	ND	2.50e-01	5.00e-02	4.00e-04
Mercury	5,500[3]	ND	ND	9.00e-01	2.00e-01	2.50e-01
Nickel	47[3]	ND	ND	6.00e-02	6.00e-02	6.00e-03
Selenium	6[3]	ND	ND	2.50e-02	2.50e-02	1.50e-02
Silver	0.5[3]	ND	ND	4.00e-01	1.00e-01	3.00e-03
Thallium	119[3]	ND	ND	4.00e-03	4.00e-04	4.00e-02
Vanadium	ND	ND	ND	5.50e-03	3.00e-03	2.50e-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]	550000	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
Chrysene	30[3]	200,000[5]	5.7[6]	2.00e-02	2.00e-02	1.26e-02
Di-n-butylphthalate	89[3]	170,000[5]	5.2[6]	3.80e-02	3.80e-02	3.98e-03
3,3'-Dichlorobenzidine	312[3]	1,553[5]	3.5[5]	3.67e-01	3.67e-01	7.94e-05

TABLE 7-6 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 11 (SITE 7)
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		
				$Bv^{(1)(2)}$	$Br^{(1)(2)}$	$Bb^{(1)(2)}$
Fluoranthene	1,150[3]	38,000[8]	4.9[5]	5.70e-02	5.70e-02	2.00e-03
Indeno(1,2,3-cd)pyrene	30[3]	1,600,000[5]	6.5[13]	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
Pesticides/PCBs						
Aldrin	4,670[3]	96,000[5]	3[6]	7.14e-01	7.14e-01	2.51e-05
Alpha-chlordane	14,100[3]	140,000[5]	5.5[6]	2.60e-02	2.60e-02	7.94e-03
Gamma-chlordane	14,100[3]	140,000[5]	5.5[6]	2.60e-02	2.60e-02	7.94e-03
4,4'-DDD	53,600[3]	770,000[5]	6[6]	1.32e-02	1.32e-02	2.51e-02
4,4'-DDE	53,600[3]	4,400,000[5]	5.7[6]	2.00e-02	2.00e-02	1.26e-02
4,4'-DDT	53,600[3]	243,000[5]	6.4[6]	8.00e-03	8.00e-03	6.31e-02
Dieldrin	4,670[3]	177,828[10]	4.6[6]	8.50e-02	8.50e-02	1.00e-03
Endosulfan II	270[3]	3,162[11]	3.6[6]	3.22e-01	3.22e-01	1.00e-04
Endrin ketone	3,970[12]	1,698[12]	5.6[12]	2.20e-01	2.20e-01	1.00e-02
PCBs, total	31,200[3]	530,000[5]	5.6[6]	2.20e-02	2.20e-02	1.00e-02
Volatiles						
2-Butanone	ND	4.5[5]	0.29[6]	2.63e+01	2.63e+01	4.90e-08
2-Hexanone	6[4]	ND	ND	ND	ND	ND
Styrene	13.5[4]	7410[7]	30[6]	7.14e-01	7.14e-01	2.51e-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)
Bb = Biotransfer factor for beef

TABLE 7-6 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

(1) Baes, et.al., 1984 for the inorganics
(2) Travis and Arms, 1988 for the organics
(3) USEPA, 1995b (Region IV)
(4) USEPA, 1995a (Region III)
(5) USEPA, 1986.
(6) SCDM, 1991.
(7) Montgomery, 1990.
(8) USEPA, 1993d (Sediment Quality Criteria for Fluoranthene)
(9) USEPA, 1993e (Sediment Quality Criteria for Phenanthrene)
(10) USEPA, 1993c (Sediment Quality Criteria for Dieldrin)
(11) ASTDR, 1993 (Toxicological Profile for Endosulfan)
(12) Used Endrin Value
(13) USEPA, 1985.

TABLE 7-7

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
American alligator (Alligator mississippienis) [2]	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)[1]	SC
Black skimmer (Rhynochops niger)[1]	SC
Green (Atlantic) turtle (Chelonia m. mydas) [2]	T(f), T(s)
Loggerhead turtle (Caretta caretta) [2]	T(f), T(s)
Peregrine falcon (*)[1]	(*)
Piping plover (Charadrius melodus)[1]	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)[3]	E(f), E(s)
Rough-leaf loosestrife (Lysimachia asperulifolia)[4]	E(f), E(s)

Legend: SC= State Special Concern
E(f) = Federal Endangered
E(s) = State Endangered
T(f) = Federal Threatened
T(s) = State Threatened

* The observer did not differentiate between the American eastern peregrine falcon [E(f), E(s)] or the Arctic peregrine falcon [T(f), T(s)].

Source: [1] Fussell, 1991
[2] USMC, 1991
[3] Walters, 1991
[4] LeBlond, 1991

TABLE 7-8

SAMPLING STATION CHARACTERIZATION SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
NORTHEAST CREEK, WEST AND EAST TRIBUTARIES, DRAINAGE DITCH, MARSH AREA
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Media Sampled	Stream Width (ft)	Stream Depth (ft)	Canopy Cover	Sediment Description	Sediment Odor
7-WT-01	SW,SD,BN	5-7	0.5	Partly Shaded	Fine sand, little silt, sandy in lower 2"	Normal
7-WT-02	SW,SD,BN	3-10	0.4	Shaded	Fine sand, little silt, rooted material in lower 3"	Normal/Anaerobic
7-WT-03	SW,SD,BN	10-15	2	Partly Open	Silty sand, fine grained	Anaerobic
7-DD-01	SW,SD	4	1	Shaded	Silty Sand, fine grained, trace medium grained	Anaerobic/Sewage
7-DD-02	SW,SD	1-2	0.1	Shaded	Silty Sand, fine grained, trace medium grained	Anaerobic/Sewage
7-ET-01	SW,SD	10	0.5	Shaded	Rooted material with little to some silty sand, fine grained	Anaerobic
7-ET-02	SW,SD	20	3	Open	Silt in top 1", Rooted material in lower 5"	Anaerobic
7-NC-01	SW,SD,BN	NM	NM	Open	Silt in top 1", Rooted material in lower 5"	Anaerobic
7-NC-02	SW,SD,BN	NM	NM	Open	Silty sand, fine grained, with rooted material	Normal
7-NC-03	SW,SD,BN	NM	NM	Open	Sand, fine grained, with trace silt and rooted material	Anaerobic
7-NC-04	SW,SD,BN	NM	NM	Open	Sand, fine to medium grained with trace silt	Anaerobic
7-NC-05	SW,SD	NM	NM	Open	Silt in top 1", Rooted material in lower 5"	Anaerobic
7-NC-06	SW,SD	NM	NM	Open	Sand, fine to medium grained with trace silt and shells	Normal

TABLE 7-8 (Continued)

SAMPLING STATION CHARACTERIZATION SUMMARY
OPERABLE UNIT NO. 11 (SITE 7)
NORTHEAST CREEK, WEST AND EAST TRIBUTARIES, DRAINAGE DITCH, MARSH AREA
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Media Sampled	Stream Width (ft)	Stream Depth (ft)	Canopy Cover	Sediment Description	Sediment Odor
7-MA-01	SD	NA	NA	Shaded	Silty sand, fine grained, water at 4"	Anaerobic
7-MA-02	SD	NA	NA	Shaded	Silty sand, fine grained, water at 12"	Anaerobic
7-MA-03	SD	NA	NA	Shaded	Silty sand, fine grained, some rooted material water at 6"	Normal
7-MA-04	SD	NA	NA	Shaded	Silty sand, fine grained, water at 12"	Anaerobic

NM - Not measured due to large size of the Northeast Creek
NA - Not applicable since a creek was not sampled
SW - Surface Water Samples
SD - Sediment Samples
BN - Benthic Macroinvertebrate Samples
WT - West Tributary Stations
ET - East Tributary Stations
DD - Drainage Ditch Stations
NC - Northeast Creek Stations
MA - Marsh Area Samples

TABLE 7-9

FIELD CHEMISTRY DATA
OPERABLE UNIT NO. 11 (SITE 7)
NORTHEAST CREEK, WEST AND EAST TRIBUTARIES, DRAINAGE DITCH
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Temperature (deg. C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Salinity (ppt)
7-WT-01	20.6-21.1	5.49-5.56	2.8-3.6	34.6-35.3	0
7-WT-02	20.3-21.4	5.63-5.79	4.0-9.1	150-161	0
7-WT-03	28.6-30.1	7.33-7.8	3.5-5.2	26,900-31,200	23-28.5
7-DD-01	23	5.83	0.7	199	0
7-DD-02	24.2	5.61	5.6	125	0
7-ET-01	26.4	6.95	1.1	12,500	10
7-ET-02	28.2	7.42-7.49	2.5-3.3	29,600-31,000	26-27.8
7-NC-01	29.5-30.1	7.41-7.53	0.8-3.8	31,000-32,100	28.8-29
7-NC-02	27.9-29.1	7.22	0.1-2.8	25,900-31,800	27-28
7-NC-03	28.7-30.1	7.61-7.66	2.9-3.3	30,000-32,300	27-29
7-NC-04	28.6-29	7.95-8.45	5.3-6.9	28,400-32,300	25-28
7-NC-05	30.3	7.89	4.9	31,800	28.5
7-NC-06	30.1	8.15	2.4	31,800	29.5

S.U. - Standard Units
ppt - Parts Per Thousand
WT - West Tributary Samples
ET - East Tributary Samples
DD - Drainage Ditch Samples
NC - Northeast Creek Samples

TABLE 7-10

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED PER FRESHWATER STATION OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Taxon	7-WT-BN01	7-WT-BN02
Annelida		
Oligochaeta		
Tubificida		
Tubificidae		
Limnodrilus hoffmeisteri		218
Arthropoda		
Insecta		
Diptera		
Chironomidae		
Chironomus decorus gr.	1	

TABLE 7-11

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED PER SALTWATER STATION
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Taxon	7-NC-BN01	7-NC-BN02	7-NC-BN03	7-NC-BN04	7-WT-BN03
Annelida					
Hirudinea					
Rhynchobdellida					
Pisicolidae					
Oligochaeta					
Tubificida					
Tubificidae	50	27			1
Polychaeta					
Capitellida					
Capitellidae					
Capitella capitata	84	39	222	261	99
Heteromastus filiformis				1	
Phyllodocida					
Nereidae					
Nereis succinea	326	180	413	338	179
Spionida					
Spionidae					
Polydora sp.	8	2		1	35
Prionopsio sp.					1
Terebellida					
Ampharetidae					
Hypaniola grayi	24				81
Arthropoda					
Crustacea					
Amphipoda					
Corophiidae					

TABLE 7-11 (Continued)

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED PER SALTWATER STATION
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Taxon	7-NC-BN01	7-NC-BN02	7-NC-BN03	7-NC-BN04	7-WT-BN03
Corophium lacustre	3				
Gammaridae					
Gammarus mucronatus	8	3			
Melita nitida					
Haustoriidae					
Parahaustorius longimerus				1	
Decapoda					
Palaemonidae					
Palaemonetes pugio		2			
Panaeidae					
Panaeus sp.				1	
Isopoda					
Anthuridae					
Cyathura polita		1			
Idoteidae					
Edotea triloba	2	3			
Tanaidacea					
Tanaidae					
Leptochellia rapax	4	1			
Insecta					
Diptera					
Chironomidae					
Chironomus decorus gr.	51				14
Tribelos juncundum	1				
Mollusca					
Bivalvia					

TABLE 7-11 (Continued)

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED PER SALTWATER STATION
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Taxon	7-NC-BN01	7-NC-BN02	7-NC-BN03	7-NC-BN04	7-WT-BN03
Veneroida					
Tellinidae					
Macoma tenta	2	4	1	1	2
Gastropoda					
Mesogastropoda					
Naticidae	1				

TABLE 7-12

IRROMETER CALIBRATION
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Number	Irrometer Reading (centibars)	Moisture Content (percent)
Site Soil		
Site 00	30	16.5
Site 01	20	26.6
Site 02	4	29.3
Site 03	0	30.9
Site 04	0	34.3
Artificial Soil		
Bkg 01	40.5	14.9
Bkg 02	8	34.1
Bkg 03	6	38.9
Bkg 04	0	48.8

TABLE 7-13

MORTALITY AND WEIGHT OF EARTHWORMS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Begining Number of Worms	Begining Worm Weight (grams)	Ending Number of Worms [1]	Ending Worm Weight (grams)
Baseline Worms				
7-EWBK-01	16	61.8	NA	NA
7-EWBK-02	16	59.4	NA	NA
7-EWBK-03	18	62.1	NA	NA
Area 1 Site Worms				
7-EW-01A	10	42.7	0	NA[2]
7-EW-01B	10	43.4	4 dead	NA[2]
7-EW-02A	10	37.5	5 dead	17.5[3]
7-EW-02B	10	45.8	5 alive, 4 dead	NA
7-EW-03A	10	41.5	7 alive	18
7-EW-03B	10	41.6	8 alive, 1 dead	24.3
Area 1 Control Worms				
7-EW-04A	10	41.7	5 alive, 5 dead	23.6
7-EW-04B	10	37.5	6 dead	8.7
Area 2 Site Worms				
7-EW-05A	10	40.7	9 alive	31.7
7-EW-05B	10	44.5	10 alive	37.7
7-EW-06A	10	46.4	10 alive	37.6
7-EW-06B	10	40.8	10 alive	35.4
7-EW-07A	10	42.2	10 alive	34.6
7-EW-07B	10	40.4	10 alive	34.5
Area 2 Control Worms				
7-EW-08A	10	43.4	10 alive	24.5
7-EW-08B	10	36.9	7 alive, 2 dead	21.9

TABLE 7-13 (Continued)

MORTALITY AND WEIGHT OF EARTHWORMS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Begining Number of Worms	Begining Worm Weight (grams)	Ending Number of Worms [1]	Ending Worm Weight (grams)
Background Worms 7-EW-09A	10	37	3 dead	NA[2]
7-EW-09B	10	37	1 live, 1 dead	NA[2]
7-EW-10A	10	33.2	2 dead	NA[2]
7-EW-10B	10	42.6	0	NA[2]

NA - Not Applicable
A and B are replicates of the same sample
(1) Worms not accounted for in this column were decomposed and not recovered
(2) Sample was not weighed due to dead and/or decomposed worms
(3) Both Replicates (7-EW-02A and 7-EW-02B)

TABLE 7-14

CONTAMINANT CONCENTRATIONS IN WORM TISSUE AND SOIL SAMPLES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Baseline Worm Range (EW-BK01, EW-BK02, EW-BK03)	Area 1			Area 2			Background Soil Concentration (WM-SB03)
		Soil Concentration (WM-SB01)	Worm Samples (EW02, EW03)	Control Worms (EW04)	Soil Concentration (WM-SB02)	Worm Samples (EW05, EW06,EW07)	Control Worms (EW08)	
Inorganics (mg/kg)								
Aluminum	59.6-87.8	1500	85.9	100	6450	513-761	164	2610
Barium	1.2-1.9	12.1	0.54J-1.2J	1.4J	29.9	2.2J-3.8J	1.5J	6.4
Beryllium	ND	ND	ND	ND	0.31	ND	ND	ND
Cadmium	0.96J-1.8	ND	1.5	ND	ND	ND	1.4	ND
Calcium	1410-2260	214	792-1480	2080	1270	618-1250	1340	226
Chromium	ND	4	ND	ND	8.3	ND	ND	2.3
Cobalt	2.1-3.5J	ND	2.8-3.7	2.2	ND	2.3-3.5	3.9	ND
Copper	2J-2.2J	ND	ND	ND	5.8	1.9	1.9	ND
Iron	158J-203J	767	72.1-132	76.4	2840	253-331	94.2	1160
Lead	0.67-3	9.3	1J-3.5J	0.72J	131	7J-13.7J	1.1J	8.3
Magnesium	131-168	60.8	125-129	139	221	118-151	112	69.4
Manganese	2.5-3.4	1.9	2J-2.3J	3.6J	18.1	2.5J-3.1J	2.5J	8.3

TABLE 7-14 (Continued)

CONTAMINANT CONCENTRATIONS IN WORM TISSUE AND SOIL SAMPLES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Baseline Worm Range (EW-BK01, EW-BK02, EW-BK03)	Area 1			Area 2			Background Soil Concentration (WM-SB03)
		Soil Concentration (WM-SB01)	Worm Samples (EW02, EW03)	Control Worms (EW04)	Soil Concentration (WM-SB02)	Worm Samples (EW05, EW06,EW07)	Control Worms (EW08)	
Mercury	0.11	ND	0.09	ND	ND	ND	ND	ND
Potassium	1080-1640	ND	1280-1420	1170	ND	1130-1620	1130	ND
Selenium	1.4-3.4	1.4	2.3-3.1	0.98	ND	1.3-1.4	2.1	ND
Sodium	669-811	61.2	665-778	685	57.5	799-942	908	28.2
Vanadium	ND	3.5	ND	ND	10.4	ND	ND	3.1
Zinc	50.3J-218J	6.1	34.4-222	48.4	45.7	63.4-77.2	64.4	7
Pesticides/PCBs (µg/kg) Alpha-chlordane	ND	ND	ND	ND	24J	ND	ND	ND
Gamma-chlordane	ND	ND	ND	ND	7.5J	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	160	2.1-9.8	ND	7.3
4,4'-DDD	ND	ND	ND	ND	18	ND	ND	ND
4,4'-DDT	ND	6.4	ND	ND	140	ND	ND	7.2
Dieldrin	ND	ND	ND	ND	280	2.4-20	ND	ND

TABLE 7-14 (Continued)

CONTAMINANT CONCENTRATIONS IN WORM TISSUE AND SOIL SAMPLES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Baseline Worm Range (EW-BK01, EW-BK02, EW-BK03)	Area 1			Area 2			Background Soil Concentration (WM-SB03)
		Soil Concentration (WM-SB01)	Worm Samples (EW02, EW03)	Control Worms (EW04)	Soil Concentration (WM-SB02)	Worm Samples (EW05, EW06,EW07)	Control Worms (EW08)	
Endosulfan II	ND	ND	ND	ND	4.6J	ND	ND	3.9J
Endrin aldehyde	ND	ND	ND	ND	6.7NJ	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	2.5	ND	ND	ND
Aroclor-1254	ND	ND	ND	110	ND	ND	ND	ND

Notes: Shaded boxes in the soil concentration column are samples that exceeded twice the average basewide background concentration
Shaded boxes in the worm concentration column are samples that exceeded the baseline worm concentration

TABLE 7-15

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS IN THE MARSH AREA SAMPLES COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES OPERABLE UNIT NO. 11 (SITE 7) MCB CAMP LEJEUNE, NORTH CAROLINA REMEDIAL INVESTIGATION CTO-0274

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Inorganics (mg/kg)							
Aluminum	50	NE	NE	600	8/8	3,630-10,500	8
Barium	500	440[2]	440[2]	3,000	8/8	31.7-250	0
Beryllium	10	NE	NE	NE	1/8	1.6	0
Chromium	1	0.4	0.0075[2]	10	1/8	19.4	1
Copper	100	50	20	100	2/8	47.6-95.8	2
Iron	100[2]	NE	3,515	200	8/8	570-6,060	8
Lead	50	500	300	900	8/8	18.8-90.8	2
Manganese	500	330[2]	330[2]	100	8/8	4.7-30.6	0
Mercury	0.3	0.1	300	30	2/8	1.6-2.6	2
Vanadium	2	58[2]	58[2]	20	3/8	14.2-21.5	3
Zinc	50	200	500	100	8/8	10.7J-536	3
Pesticides/PCBs (µg/kg)							
4,4'-DDD	NE	100[2]	100[2]	NE	5/8	21-65J	0
4,4'-DDE	NE	100[2]	100[2]	NE	7/8	27-180J	2

TABLE 7-15 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS IN THE MARSH AREA SAMPLES COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES OPERABLE UNIT NO. 11 (SITE 7) MCB CAMP LEJEUNE, NORTH CAROLINA REMEDIAL INVESTIGATION CTO-0274

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
4,4'-DDT	NE	4[2]	4[2]	NE	4/8	2.3J-36J	3
Alpha-chlordane	NE	<100[2]	<100[2]	NE	4/8	13-42J	0
Gamma-chlordane	NE	<100[2]	<100[2]	NE	1/8	29J	0
Dieldrin	NE	<100[2]	<100[2]	NE	2/8	39-41	0
Aroclor-1260	40,000	40[2]	40[2]	NE	1/8	450J	1
Semivolatiles (µg/kg)							
Acenaphthylene	NE	100[2]	100[2]	NE	1/8	250J	1
Anthracene	NE	100[2]	100[2]	NE	1/8	350J	1
Benzo(b)fluoranthene	NE	100[2]	100[2]	NE	1/8	270NJ	1
Benzo(k)fluoranthene	NE	100[2]	100[2]	NE	1/8	230NJ	1
Chrysene	NE	100[2]	100[2]	NE	1/8	370J	1
Di-n-butylphthalate	200,000	NE	NE	NE	7/8	310J-1,300J	0
Fluoranthene	NE	100[2]	100[2]	NE	1/8	450J	1
Phenanthrene	NE	100[2]	100[2]	NE	1/8	210J	1
Pyrene	NE	100[2]	100[2]	NE	1/8	430J	1

TABLE 7-15 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS IN THE MARSH AREA SAMPLES COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES OPERABLE UNIT NO. 11 (SITE 7) MCB CAMP LEJEUNE, NORTH CAROLINA REMEDIAL INVESTIGATION CTO-0274

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Volatiles (µg/kg)							
2-Butanone	NE	NE	NE	NE	7/8	47J-190J	NA
Styrene	NE	NE	NE	NE	1/8	28J	NA
Toluene	200,000	100[2]	100[2]	NE	8/8	10J-39J	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 inpacts 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 Levels)

TABLE 7-16

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 11 (SITE 7)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0274**

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Inorganics (mg/kg)							
Aluminum	50	NE	NE	600	32/32	690J-12,900J	32
Arsenic	10	60	NE	100	6/32	1.1-5.1J	0
Barium	500	440[2]	440[2]	3,000	29/32	5.2-172	0
Beryllium	10	NE	NE	NE	10/32	0.15-1.9	0
Chromium	1	0.4	0.0075[2]	10	23/32	2.5-23.1	23
Cobalt	20	1,500[2]	1,500[2]	1,000	2/32	1.6-4.4	0
Copper	100	50	20	100	7/32	2.6-7.6	0
Iron	100[2]	NE	3,515	200	32/32	14.4-17,600J	31
Lead	50	500	300	900	29/32	4.2-2,620	1
Manganese	500	330[2]	330[2]	100	18/32	1.7J-42.9	0
Mercury	0.3	0.1	300	30	2/32	0.23	2

TABLE 7-16 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 11 (SITE 7)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0274

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Nickel	30	200	NE	90	2/32	6.3-13.8	0
Selenium	1	70	0.26[2]	100	7/32	1.1-2.1	2
Vanadium	2	58[2]	58[2]	20	28/32	2.5-41J	28
Zinc	50	200	500	100	15/32	7.8-58.9	1
Pesticides (µg/kg) 4,4'-DDD	NE	100[2]	100[2]	NE	3/31	4.3J-94J	0
4,4'-DDE	NE	100[2]	100[2]	NE	7/30	3.8-65J	0
4,4'-DDT	NE	4[2]	4[2]	NE	4/30	14J-280J	4
Alpha-chlordane	NE	<100[2]	<100[2]	NE	3/30	11J-26J	0
Gamma-chlordane	NE	<100[2]	<100[2]	NE	3/30	6.9-22J	0
Dieldrin	NE	<100[2]	<100[2]	NE	7/30	4.7J-57	0
Endosulfan	1,000[3]	NE	NE	NE	3/30	7.9J-37NJ	0
Semivolatiles (µg/kg) Benzo(a)anthracene	NE	100[2]	100[2]	NE	4/32	50J-420	1
Benzo(b)fluoranthene	NE	100[2]	100[2]	NE	4/32	45J-380	1
Benzo(k)fluoranthene	NE	100[2]	100[2]	NE	4/32	66J-370	1
Benzo(g,h,i)perylene	NE	100[2]	100[2]	NE	2/32	44J-220J	1

TABLE 7-16 (Continued)

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 11 (SITE 7)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0274**

Contaminant	Surface Soil Flora and Fauna Screening Values (SSSVs)[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Benzo(a)pyrene	NE	20,000[2]	25,000	NE	3/32	55J-340J	0
Bis(2-ethylhexyl)phthalate	NE	NE	NE	NE	8/32	38J-600	NA
Chrysene	NE	100[2]	100[2]	NE	4/32	55J-420	1
Fluoranthene	NE	100[2]	100[2]	NE	4/32	110-750	4
Indeno(1,2,3-cd)pyrene	NE	100[2]	100[2]	NE	3/32	41J-250J	1
Phenanthrene	NE	100[2]	100[2]	NE	3/32	63J-400	1
Pyrene	NE	100[2]	100[2]	NE	4/32	85J-580	3
Volatiles (µg/kg) Toluene	200,000	100[2]	100[2]	NE	3/30	9J-46J	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 inpacts 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, 1995 (Region III BTAG Soil Screening Levels)

(3) Hulzebos et.al., 1993 (EC50)

TABLE 7-17

CONTAMINANT DETECTIONS IN SOIL ASSOCIATED WITH WORM STATIONS
COMPARED TO EARTHWORM SURFACE SOIL SCREENING VALUES
OPERABLE UNIT NO. 11 (SITE 7)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO0-0274

Contaminant	Earthworm SSSV	Area 1 Soil	Area 2 Soil	Area 3 Soil
Inorganics (mg/kg)				
Aluminum	NE	1,500	6,450	2,610
Barium	440[2]	12.1	29.9	6.4
Beryllium	NE	ND	0.31	ND
Cadmium	20	ND	ND	ND
Chromium	0.4	4	8.3	2.3
Cobalt	1,500[2]	ND	ND	ND
Copper	50	ND	5.8	ND
Iron	NE	767	2,840	1,160
Lead	500	9.3	131	8.3
Manganese	330[2]	1.9	18.1	8.3
Selenium	70	1.4	ND	ND
Vanadium	58[2]	3.5	10.4	3.1
Zinc	200	6.1	45.7	7
Pesticides/PCBs (µg/kg)				
4,4'-DDD	100[2]	ND	18	ND
4,4'-DDE	100[2]	ND	160	7.3
4,4'-DDT	4[2]	6.4	140	7.2
Alpha-chlordane	<100[2]	ND	24J	ND
Gamma-chlordane	<100[2]	ND	7.5J	ND
Dieldrin	<100[2]	ND	280	ND
Endosulfan II	NE	ND	4.6J	ND
Endrin aldehyde	NE	ND	6.7NJ	ND
Heptachlor epoxide	<100[2]	ND	2.5	ND
Arochlor 1254	NE	6.4	ND	ND

Note: Shaded boxes are samples that exceed surface soil screening values

(1) Will and Suter, 1994a unless indicated otherwise (Values presented for earthworms are benchmarks below which adverse inpacts to these species are not expected.

(2) USEPA, 1995b (Region III BTAG Soil Screening Values for Soil Fauna)

TABLE 7-18

EXPOSURE FACTORS FOR TERRESTRIAL CHRONIC DAILY INTAKE MODEL
OPERABLE UNIT NO. 11 (SITE 7)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0274

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Short-Tailed Shrew	Raccoon	Small Mammal
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 10% Worms 90%	Vegetation 40% Fish 60%	Vegetation 100%
Feeding Rate	kg/day	1.6[2]	0.237[4]	0.0135[3]	0.601[3]	0.00877[3]	0.214[6]	0.112[3]
Incident Soil Ingestion	kg/day	0.0185[1]	0.0057[5]	0.0011[5]	0.0168[5]	0.000824[5]	0.0201[5]	0.00269[5]
Rate of Drinking Water Ingestion	L/day	1.1[2]	0.119[3]	0.0191[3]	0.385[3]	0.00385[3]	0.422[3]	0.0652[3]
Rate of Vegetation Ingestion	kg/day	1.6	0.237	0.0135	0.12	0.000877	0.086	0.112
Body Weight	kg	45.4[2]	1.229[3]	0.174[3]	4.54[3]	0.96[3]	5.12[3]	0.3725[3]
Rate of Small Mammal Ingestion	kg/day	NA	NA	NA	0.48	NA	NA	NA
Rate of Fish Ingestion	kg/day	NA	NA	NA	NA	NA	0.128	NA
Rate of Worm Ingestion	kg/day	NA	NA	NA	NA	0.00789	NA	NA
Home Range Size	acres	454[2]	9.30[3]	26.24[3]	1,245[3]	0.96[3]	257[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
[6] Nagy, 1987

TABLE 7-19

FRESHWATER SURFACE WATER QUOTIENT INDEX
WEST TRIBUTARY AND DRAINAGE DITCH
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			North Carolina WQS	USEPA WQSV	
				Acute	Chronic
Inorganics (µg/L)					
Aluminum	7-DD-SW01	137	NE	0.2	1.6
Aluminum	7-DD-SW02	1860	NE	2.5	21.4
Aluminum	7-WT-SW01	155	NE	0.2	1.8
Barium	7-DD-SW01	28.9	NE	0.4	7.6
Barium	7-DD-SW02	27.8	NE	0.4	7.3
Barium	7-WT-SW01	20.8	NE	0.3	5.5
Barium	7-WT-SW02	16.4	NE	0.2	4.3
Iron	7-DD-SW02	1630	1.6	NE	1.6
Lead	7-DD-SW02	15.9	0.6	1.0	26.9
Lead	7-WT-SW01	3J	0.1	0.2	4.2
Lead	7-WT-SW02	8J	0.3	0.5	13.2
Zinc	7-WT-SW01	168J	3.4	4.4	4.8
Zinc	7-WT-SW02	40J	0.8	1.1	1.1
Pesticides (µg/L)					
Dieldrin	7-WT-SW01	0.5	250	0.2	263
Dieldrin	7-WT-SW02	0.4	200	0.2	211

Note: Shaded samples are Quotient Indices that exceed "1"
NE - Not Established
WQS - Water Quality Standard
WQSV - Water Quality Screening Value

TABLE 7-20

SALTWATER SURFACE WATER QUOTIENT INDEX
EAST TRIBUTARY AND NORTHEAST CREEK
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			North Carolina WQS	USEPA WQSV	
				Acute	Chronic
Inorganics (µg/L)					
Copper	7-ET-SW01	12	4.1	4.2	4.2
Lead	7-NC-SW02	23.6	0.9	0.1	2.8
Lead	7-NC-SW03	27.1	1.1	0.1	3.2
Lead	7-NC-SW06	13J	0.5	0.1	1.6
Manganese	7-NC-SW01	10.1	NE	NE	1.0
Manganese	7-NC-SW02	22.5	NE	NE	2.3
Manganese	7-NC-SW03	68.9	NE	NE	6.9
Manganese	7-NC-SW04	13.4	NE	NE	1.3
Manganese	7-NC-SW05	14	NE	NE	1.4
Manganese	7-NC-SW06	12.6	NE	NE	1.3
Manganese	7-ET-SW01	21.3	NE	NE	2.1
Manganese	7-ET-SW02	15.4	NE	NE	1.5
Manganese	7-WT-SW03	12.8	NE	NE	1.3
Silver	7-NC-SW02	6.6	66.0	2.9	NE
Silver	7-NC-SW03	9.6	96.0	4.2	NE
Silver	7-NC-SW04	6.8	68.0	3.0	NE
Silver	7-NC-SW05	7J	65.0	2.8	NE
Silver	7-NC-SW06	5J	51.0	2.2	NE
Silver	7-ET-SW02	7J	66.0	2.9	NE
Semivolatiles (µg/L)					
Bis(2-ethylhexyl)phthalate	7-ET-SW02	77B	NE	0.0	22.6

Note: Shaded Samples are Quotient Indices That Exceed "1"
NE - Not Established
WQS - Water Quality Standard
WQSV - Water Quality Screening Value

TABLE 7-21

FRESHWATER SEDIMENT QUOTIENT INDEX
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
Inorganics (mg/kg)					
Beryllium	7-MA-SD03-612	1.6	3.2	NE	NE
Copper	7-MA-SD01-06	95.8	2.8	0.4	NE
Copper	7-MA-SD01-612	47.6	1.4	0.2	NE
Lead	7-MA-SD01-06	72.2	1.5	0.3	NE
Lead	7-MA-SD01-612	46.8	1.0	0.2	NE
Lead	7-MA-SD02-06	46.9	1.0	0.2	NE
Lead	7-MA-SD03-06	90.8	1.9	0.4	NE
Mercury	7-MA-SD01-06	2.6	17.3	3.7	NE
Mercury	7-MA-SD01-612	1.6	10.7	2.3	NE
Zinc	7-MA-SD01-06	536	3.6	1.3	NE
Zinc	7-MA-SD01-612	344	2.3	0.8	NE
Pesticides/PCBs (ug/kg)					
Aldrin	7-DD-SD02-06	3J	31.0	NE	19.4
4,4'-DDD	7-DD-SD01-06	23J	11.5	1.2	35.9
4,4'-DDD	7-DD-SD02-06	120J	60.0	6.0	188
4,4'-DDD	7-MA-SD01-06	39J	19.5	2.0	60.9
4,4'-DDD	7-MA-SD01-612	33J	16.5	1.7	51.6
4,4'-DDD	7-MA-SD02-06	39J	19.5	2.0	60.9
4,4'-DDD	7-MA-SD03-06	21	10.5	1.1	32.8
4,4'-DDD	7-MA-SD04-06	65J	32.5	3.3	102
4,4'-DDE	7-DD-SD01-06	14J	6.4	0.5	3.9
4,4'-DDE	7-DD-SD02-06	28J	12.7	1.0	7.7
4,4'-DDE	7-MA-SD01-06	67J	30.5	2.5	18.5
4,4'-DDE	7-MA-SD01-612	39J	17.7	1.4	10.7
4,4'-DDE	7-MA-SD02-06	130	59.1	4.8	35.8

TABLE 7-21 (Continued)

FRESHWATER SEDIMENT QUOTIENT INDEX
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
4,4'-DDE	7-MA-SD03-06	89	40.5	3.3	24.5
4,4'-DDE	7-MA-SD03-612	47	21.4	1.7	12.9
4,4'-DDE	7-MA-SD04-06	180J	81.8	6.7	49.6
4,4'-DDE	7-MA-SD04-612	27	12.3	1.0	7.4
4,4'-DDT	7-DD-SD01-06	110J	110	15.7	550
4,4'-DDT	7-DD-SD02-06	110J	110	15.7	550
4,4'-DDT	7-MA-SD01-06	16J	16.0	2.3	80.0
4,4'-DDT	7-MA-SD01-612	2J	2.3	0.3	11.5
4,4'-DDT	7-MA-SD02-06	36J	36.0	5.1	180
4,4'-DDT	7-MA-SD04-06	27J	27.0	3.9	135
Alpha-chlordane	7-DD-SD02-06	9J	18.4	1.5	20.0
Alpha-chlordane	7-MA-SD01-06	42J	84.0	7.0	91.3
Alpha-chlordane	7-MA-SD01-612	30J	60.0	5.0	65.2
Alpha-chlordane	7-MA-SD02-06	38J	76.0	6.3	82.6
Alpha-chlordane	7-MA-SD03-06	13	26.0	2.2	28.3
Alpha-chlordane	7-WT-SD02-06	2.7	5.4	0.5	5.9
Gamma-chlordane	7-DD-SD02-06	5J	9.4	0.8	10.2
Gamma-chlordane	7-MA-SD01-06	29J	58	4.8	63.0
Dieldrin	7-DD-SD02-06	17J	850	2.1	58.6
Dieldrin	7-MA-SD03-06	39	1,950	4.9	134
Dieldrin	7-MA-SD03-612	41	2,050	5.1	141
Dieldrin	7-WT-SD01-06	71	3,550	8.9	245
Dieldrin	7-WT-SD02-06	22	1,100	2.8	75.9
Aroclor-1260	7-MA-SD01-06	450	19.8	2.5	1,023

TABLE 7-21 (Continued)

FRESHWATER SEDIMENT QUOTIENT INDEX
WEST TRIBUTARY; DRAINAGE DITCH; MARSH AREA
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
Semivolatiles (ug/kg)					
Acenaphthylene	7-MA-SD04-06	250J	5.7	0.4	NE
Anthracene	7-MA-SD04-06	350J	4.1	0.3	302
Bis(2-ethylhexyl)phthalate	7-DD-SD02-06	510	0.3	NE	2.1
Di-n-butylphthalate	7-MA-SD02-06	880J	0.2	NE	2.1
Di-n-butylphthalate	7-MA-SD02-612	480J	0.1	NE	1.1
Di-n-butylphthalate	7-MA-SD03-06	740J	0.1	NE	1.8
Di-n-butylphthalate	7-MA-SD04-06	1300J	0.2	NE	3.1
Di-n-butylphthalate	7-MA-SD04-612	560J	0.1	NE	1.3
Phenanthrene	7-MA-SD04-06	210J	0.9	0.1	1.4
Volatiles (ug/kg)					
Toluene	7-MA-SD01-06	10J	NE	NE	3.3
Toluene	7-MA-SD01-612	20J	NE	NE	6.7
Toluene	7-MA-SD02-06	21J	NE	NE	7.0
Toluene	7-MA-SD02-612	30J	NE	NE	10.0
Toluene	7-MA-SD03-06	17J	NE	NE	5.7
Toluene	7-MA-SD03-612	16J	NE	NE	5.3
Toluene	7-MA-SD04-06	37J	NE	NE	12.3
Toluene	7-MA-SD04-612	39J	NE	NE	13.0

Note: Shaded samples are Quotient Indices that exceed "1"
NE - Not Established
ER-L - Effects Range Low
ER-M - Effects Range Median
SQC - Sediment Quality Criteria

TABLE 7-22

SALTWATER SEDIMENT QUOTIENT INDEX
EAST TRIBUTARY AND NORTHEAST CREEK SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
Inorganics (mg/kg)					
Beryllium	7-ET-SD01-06	8	16.0	NE	NE
Lead	7-NC-SD04-612	86J	1.8	0.4	NE
Selenium	7-ET-SD01-06	2	23.4	NE	NE
Thallium	7-NC-SD01-06	5J	19.2	NE	NE
Thallium	7-NC-SD01-612	5J	20.4	NE	NE
Thallium	7-NC-SD05-612	5J	20.4	NE	NE
Thallium	7-NC-SD06-06	1J	2.5	NE	NE
Thallium	7-NC-SD06-612	1J	2.9	NE	NE
Thallium	7-WT-SD03-06	1J	2.8	NE	NE
Pesticides (ug/kg)					
4,4'-DDD	7-NC-SD02-06	5J	2.7	0.3	3.9
4,4'-DDD	7-NC-SD04-06	4.3	2.2	0.2	3.1
4,4'-DDD	7-NC-SD04-612	44J	22.0	2.2	32.1
4,4'-DDD	7-WT-SD03-06	8.4	4.2	0.4	6.1
4,4'-DDE	7-NC-SD04-612	20J	9.1	0.7	2.6
4,4'-DDE	7-NC-SD06-06	4.5	2.0	0.2	0.6
4,4'-DDE	7-NC-SD06-612	5.1	2.3	0.2	0.7
4,4'-DDE	7-WT-SD03-06	11	5.0	0.4	1.4
4,4'-DDT	7-NC-SD04-612	8.8	8.8	1.3	20.5
Alpha-chlordane	7-NC-SD02-06	5.4	10.8	0.9	5.4
Alpha-chlordane	7-NC-SD02-612	5J	9.8	0.8	4.9
Alpha-chlordane	7-NC-SD04-612	14	28.0	2.3	14.0
Alpha-chlordane	7-ET-SD02-06	13J	26.0	2.2	13.0
Alpha-chlordane	7-WT-SD03-06	8.2	16.4	1.4	8.2
Gamma-chlordane	7-NC-SD02-06	5.2	10.4	0.9	5.2

TABLE 7-22 (Continued)

SALTWATER SEDIMENT QUOTIENT INDEX
EAST TRIBUTARY AND NORTHEAST CREEK SEDIMENT
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
Gamma-chlordane	7-NC-SD04-612	11	22.0	1.8	11.0
Gamma-chlordane	7-WT-SD03-06	7.5	15.0	1.3	7.5
Dieldrin	7-NC-SD02-06	5.7	285	0.7	9.0
Dieldrin	7-NC-SD04-612	8J	395	1.0	12.5
Dieldrin	7-WT-SD03-06	5.4	270	0.7	8.6

Note: Shaded samples are Quotient Indices that exceed "1"
NE - Not Established
ER-L - Effects Range Low
ER-M - Effects Range Median
SQC - Sediment Quality Criteria

TABLE 7-23

TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer	Short-tailed Shrew
Aluminum	1.52e-02	3.07e-01	1.82e+00	3.88e+01	1.49e-02	2.96e+02
Pyrene	1.04e-02	2.14e-04	5.12e-03	1.33e-01	3.14e-04	6.93e-01
Toluene	4.03e-02	4.27e-02	5.76e-01	1.32e-01	2.47e-02	5.11e+00
2	2.77e-05	3.71e-04	3.97e-03	1.39e-04	3.14e-05	1.29e-02
2	1.76e-04	9.97e-05	6.48e-04	9.10e-04	1.31e-05	8.32e-02
Xylenes	8.22e-05	1.78e-03	1.42e-02	3.93e-04	3.39e-04	7.36e-01
TOTAL QI	1.54e-04	4.50e-04	1.03e-02	1.68e-03	1.12e-03	2.00e-02
Xylenes	1.79e-02	8.38e-02	9.95e-01	5.19e-02	1.72e-02	5.16e+00
TOTAL QI	1.26e-03	2.57e-02	4.17e-01	1.33e-02	1.47e-02	5.06e-01
Manganese	1.74e-03	2.77e-04	1.95e-02	1.88e-02	2.51e-03	9.05e-02
Mercury	1.03e-04	4.75e-03	7.99e-02	1.08e-04	2.72e-03	5.23e-02
Nickel	2.69e-06	1.88e-04	1.23e-02	1.93e-04	3.50e-04	1.43e-02
Vanadium	9.35e-04	4.94e-04	8.81e-01	4.87e-03	3.40e-04	4.47e-01
Zinc	1.38e-02	3.02e-03	1.04e-01	3.35e-03	4.66e-03	2.33e-01
Alpha-chlordane	7.42e-07	1.98e-06	5.84e-04	1.55e-05	4.55e-08	1.30e-03
Gamma-chlordane	6.34e-07	1.69e-06	4.98e-04	1.32e-05	3.88e-08	1.11e-03
4,4'-DDD	2.75e-07	9.13e-05	4.18e-05	1.41e-06	3.46e-07	1.24e-04
4,4'-DDE	5.26e-07	1.80e-04	9.03e-06	2.66e-06	8.05e-07	2.27e-03
4,4'-DDT	6.71e-07	2.16e-04	8.95e-05	3.46e-06	6.78e-07	3.11e-04
Dieldrin	6.56e-03	6.42e-04	4.15e-02	2.87e+01	1.91e-05	7.02e-01
Endosulfan II	3.91e-07	1.24e-06	5.36e-04	4.36e-06	6.44e-06	1.71e-04
Endrin ketone	3.40e-04	1.24e-05	7.67e-05	1.05e-04	6.38e-05	4.23e-05
Aroclor-1254	9.97e-07	8.29e-05	1.79e-04	5.02e-06	1.75e-05	4.26e-04
Aroclor-1260	3.23e-04	4.51e-03	5.80e-02	1.62e-03	5.29e-04	1.38e-01
Benzo(a)anthracene	3.56e-05	4.92e-04	6.12e-03	1.80e-04	5.45e-05	1.55e-04

TABLE 7-23 (Continued)

TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer	Short-tailed Shrew
Benzo(b)fluoranthene	3.22e-05	4.13e-04	4.07e-03	1.65e-04	2.96e-05	1.50e-04
Benzo(k)fluoranthene	3.21e-05	4.28e-04	4.70e-03	1.65e-04	3.81e-05	1.46e-04
Benzo(g,h,i)perylene	1.87e-05	2.41e-04	2.42e-03	9.61e-05	1.80e-05	8.69e-05
Benzo(a)pyrene	2.97e-05	4.00e-04	4.52e-03	1.52e-04	3.75e-05	1.34e-04
Bis(2-ethylhexyl)phthalate	6.22e-02	3.98e-03	6.17e-02	2.55e+00	3.83e-02	5.12e-02
Chrysene	3.46e-05	4.79e-04	5.95e-03	1.75e-04	5.30e-05	1.51e-04
Di-n-butylphthalate	6.07e-08	1.33e-03	1.33e-05	2.96e-07	1.33e-07	2.37e-05
Fluoranthene	3.48e-06	5.35e-05	9.02e-04	1.64e-05	9.51e-06	1.23e-03
Indeno(1,2,3-cd)pyrene	2.12e-05	2.74e-04	2.74e-03	1.09e-04	2.03e-05	9.87e-05
Phenanthrene	5.47e-07	9.00e-06	1.76e-04	2.44e-06	1.97e-06	1.61e-04
Pyrene	5.01e-06	7.25e-05	1.05e-03	2.47e-05	1.02e-05	2.01e-03
Toluene	1.23e-07	2.55e-06	7.01e-05	4.23e-07	8.63e-07	7.11e-06
2-Hexanone	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND
Xylenes	1.12e-06	2.26e-07	8.24e-07	1.88e-06	6.85e-07	4.55e-07
TOTAL QI	1.72e-01	4.85e-01	**5.13e+00**	**7.04e+01**	1.23e-01	**3.11e+02**

Note: Shaded samples are Quotient Indices that exceed "1"

TABLE 7-24

FRESHWATER BENTHIC MACROINVERTEBRATE SUMMARY STATISTICS AND COMPARISON TO OFF-SITE REFERENCE STATIONS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Organisms	Species Density (#/m^2)	Species Diversity (Shannon-Weiner)	Species Diversity (Brillouin's)
Site 7 Stations 7-WT-BN01	1	1	14	0	0.00
7-WT-BN02	1	218	3,129	0	0.00
Off-Site Reference Stations HM01	13	345	2,199	0.53	0.50
HC04	13	165	1,052	0.81	0.76

WT - West Tributary
HM - Holland Mill Creek
HC - Hadnot Creek

TABLE 7-25

RESULTS OF THE JACCARD COEFFICIENT OF COMMUNITY SIMILARITY (Sj) AND SΦRENSON COEFFICIENT OF COMMUNITY SIMILARITY (SS) BETWEEN THE FRESHWATER BENTHIC MACROINVERTEBRATE STATIONS AND THE OFF-SITE REFERENCE STATIONS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

Ss

Station	7-WT-BN01	7-WT-BN02	HMO1	HC04
7-WT-BN01	NA	0.00	0.08	0.00
7-WT-BN02	0.00	NA	0.08	0.00
HMO1	0.14	0.14	NA	0.18
HC04	0.00	0.00	0.31	NA

TABLE 7-26

SALTWATER BENTHIC MACROINVERTEBRATE SUMMARY STATISTICS AND COMPARISON TO OFF-SITE REFERENCE STATIONS OPERABLE UNIT NO. 11 (SITE 7) REMEDIAL INVESTIGATION CTO-274 MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Organisms	Species Density (#/m^2)	Species Diversity (Shannon-Weiner)	Species Diversity (Brillouin's)
Site 7 Stations					
7-NC-BN01	13	564	8,095	0.61	0.60
7-NC-BN02	15	262	3,760	0.46	0.44
7-NC-BN03	14	637	9,142	0.29	0.29
7-NC-BN04	15	604	8,669	0.32	0.32
7-WT-BN03	8	412	5,913	0.61	0.60
Off-Site Reference Stations					
HM03	7	97	618	0.53	0.50
WC03	7	74	472	0.32	0.28
HC03	8	244	1,555	0.68	0.68

NC - Northeast Creek
WT - West Tributary
HM - Holland Mill Creek
WC - Webb Creek
HC - Hadnot Creek

TABLE 7-27

RESULTS OF THE JACCARD COEFFICIENT OF COMMUNITY SIMILARITY (Sj) AND SΦRENSON COEFFICIENT OF COMMUNITY SIMILARITY (SS) BETWEEN THE SALTWATER BENTHIC MACROINVERTEBRATE STATIONS AND THE OFF-SITE REFERENCE STATIONS
OPERABLE UNIT NO. 11 (SITE 7)
REMEDIAL INVESTIGATION CTO-274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

Ss

Station	7-NC-BN01	7-NC-BN02	7-NC-BN03	7-NC-BN04	7-WT-BN03	HMO3	WC03	HC03
7-NC-BN01	NA	0.40	0.13	0.17	0.50	0.11	0.11	0.24
7-NC-BN02	0.57	NA	0.12	0.15	0.28	0.05	0.05	0.15
7-NC-BN03	0.22	0.21	NA	0.12	0.16	0.05	0.05	0.10
7-NC-BN04	0.29	0.27	0.21	NA	0.21	0.05	0.05	0.15
7-WT-BN03	0.67	0.43	0.27	0.35	NA	0.15	0.15	0.14
HMO3	0.20	0.09	0.10	0.09	0.27	NA	0.27	0.25
WCO3	0.2	0.09	0.10	0.09	0.27	0.43	NA	0.15
HC03	0.38	0.26	0.18	0.26	0.25	0.40	0.27	NA

SECTION 7.0 FIGURES

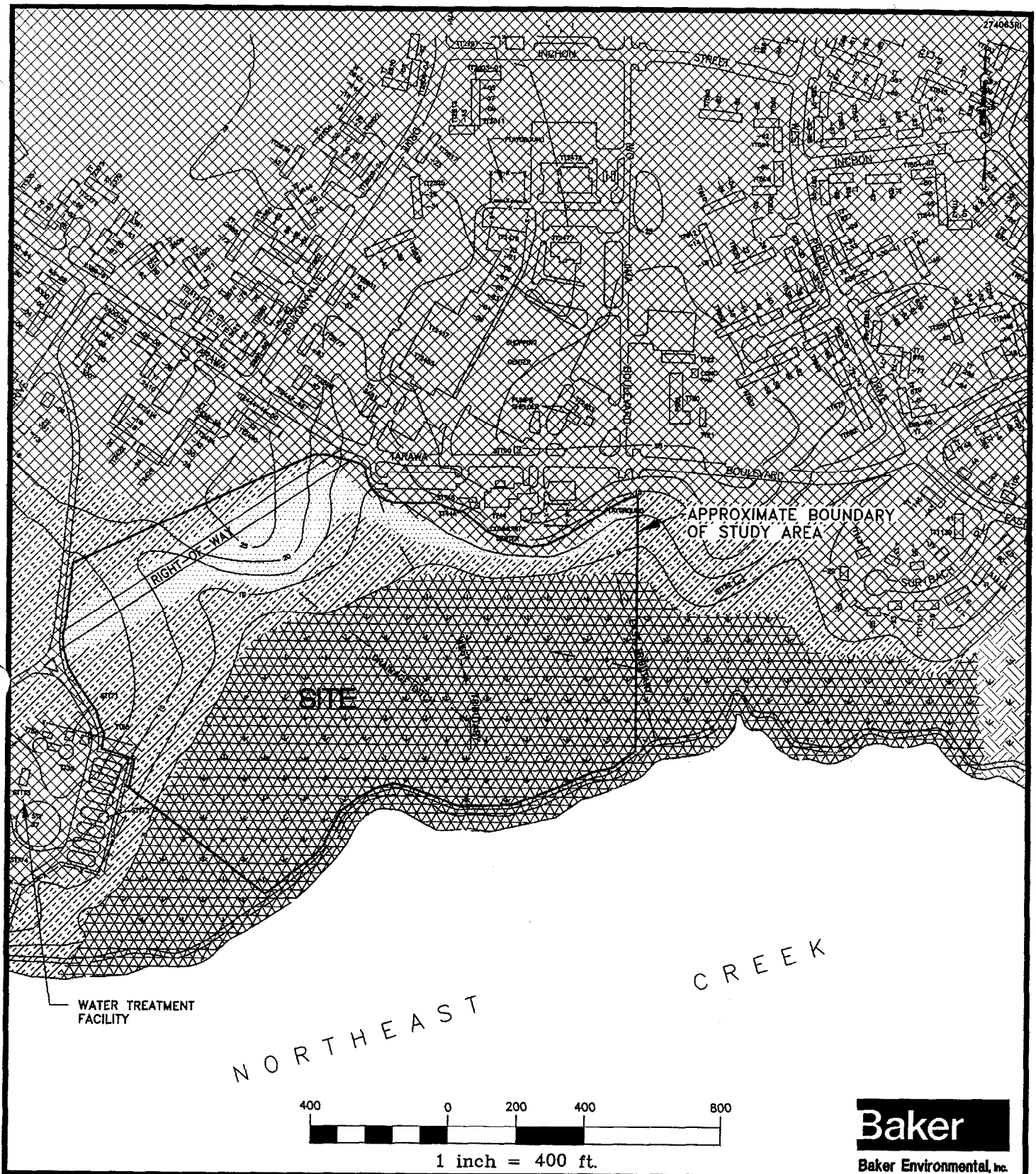
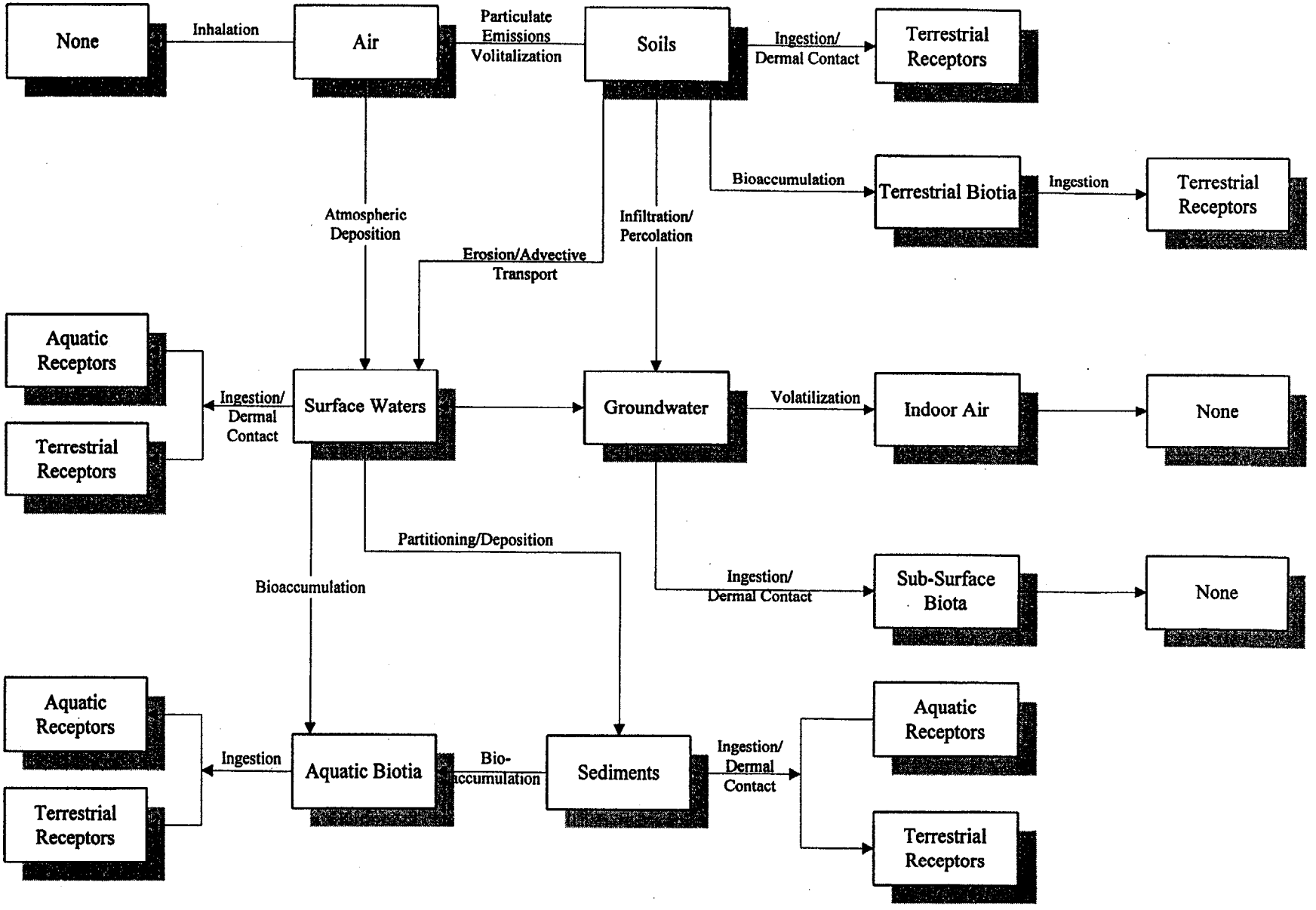


FIGURE 7-1
BIOHABITAT MAP
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0233

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

FIGURE 7-2

CONCEPTIONAL EXPOSURE MODEL FOR ECOLOGICAL RECEPTORS



7-DD-SW02 / 7-DD-SD02 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Aluminum	NA	2.5	21.4
Barium	NA	0.4	7.3
Iron	1.6	NA	1.6
Lead	0.6	1.0	26.9
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
4'4-DDD	60.0	6.0	188
4'4-DDE	12.7	1.0	7.7
4'4-DDT	110	15.7	550
Aldrin	31.0	NE	19.4
Alpha-chlordane	18.4	1.5	20.0
Bis(2-ethylhexyl-phthalate	0.3	NE	2.1
Dieldrin	850	2.1	58.6
Gamma-chlordane	9.4	0.8	10.2

7-DD-SW01 / 7-DD-SD01 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Aluminum	NA	0.2	1.8
Barium	NA	0.4	7.6
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
4'4-DDD	11.5	1.2	35.9
4'4-DDE	6.4	0.5	3.9
4'4-DDT	110	15.7	550

7-MA-SD01 SEDIMENT (0-6")	ERL	ERM	SQC
4'4-DDD	19.5	2.0	60.9
4'4-DDE	30.5	2.5	18.5
4'4-DDT	16.0	2.3	80.0
Alpha-chlordane	84.0	7.0	91.3
Aroclor 1260	19.8	2.5	1,023
Copper	2.8	0.4	NE
Gamma-chlordane	58	4.8	63.0
Lead	1.5	0.3	NE
Mercury	17.3	3.7	NE
Toluene	NE	NE	3.3
Zinc	3.8	1.3	NE
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
4'4-DDD	16.5	1.7	51.6
4'4-DDE	17.7	1.4	10.7
4'4-DDT	2.3	0.3	11.5
Alpha-chlordane	60.0	5.0	65.2
Copper	1.4	0.2	NE
Lead	1.0	0.2	NE
Mercury	10.7	2.3	NE
Toluene	NE	1.8	6.7
Zinc	2.3	0.8	NE

7-MA-SD02 SEDIMENT (0-6")	ERL	ERM	SQC
4'4-DDD	19.5	2.0	60.9
4'4-DDE	59.1	4.8	35.8
4'4-DDT	36.0	5.1	180
Alpha-chlordane	76.0	6.3	82.6
Di-n-butylphthalate	0.2	NE	2.1
Lead	1.0	0.2	NE
Toluene	NE	NE	7.0
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
Di-n-butylphthalate	0.1	NE	1.1
Toluene	NE	NE	10.0

7-NC-SW05 / 7-NC-SD05 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NA	NA	1.4
Silver	65.0	2.8	NA
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
Thallium	20.4	NA	NA

7-NC-SW06 / 7-NC-SD06 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Lead	2.5	0.1	1.6
Manganese	NA	NA	1.3
Silver	51.0	2.2	NA
Manganese	NA	NA	1.3
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
4,4-DDE	2.0	0.2	0.6
Thallium	2.5	NA	NA
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
4,4-DDE	2.3	0.2	0.7
Thallium	2.9	NA	NA

7-WT-SW01 / 7-WT-SD01 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Aluminum	NA	0.2	1.8
Barium	NA	0.3	5.5
Dieldrin	250	0.2	263
Lead	0.1	0.2	4.2
Zinc	3.4	4.4	4.8
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
Dieldrin	3,550	8.9	245

7-WT-SW02 / 7-WT-SD02 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Barium	NA	0.2	4.3
Dieldrin	250	0.2	211
Lead	0.3	0.5	13.2
Zinc	6.3	1.1	1.1
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
Alpha-chlordane	5.4	0.5	5.9
Dieldrin	1,390	2.8	75.9

7-NC-SW04 / 7-NC-SD04 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NA	NA	1.3
Silver	68.0	3.0	NA
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
4,4-DDD	2.2	0.2	3.1
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
4,4-DDD	22.0	2.2	32.1
4,4-DDE	9.1	0.7	2.6
4,4-DDT	8.8	1.3	20.5
Alpha-chlordane	28.0	2.3	14.0
Dieldrin	395	1.0	12.5
Gamma-chlordane	22.0	1.8	11.0
Lead	1.8	0.4	NA

7-MA-SD03 SEDIMENT (0-6")	ERL	ERM	SQC
4'4-DDD	10.5	1.1	32.8
4'4-DDE	40.5	3.3	24.5
Alpha-chlordane	26.0	2.2	26.3
Di-n-butylphthalate	0.1	NE	1.8
Dieldrin	1,950	4.9	134
Lead	1.9	0.4	NE
Toluene	NE	NE	5.7
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
4'4-DDE	21.4	1.7	12.9
Beryllium	3.2	NE	NE
Dieldrin	2,050	5.1	141
Toluene	NE	NE	5.3

7-ET-SW01 / 7-ET-SD01 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Copper	4.1	4.2	4.2
Manganese	NA	NA	2.1
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
Beryllium	16.0	NA	NA
Selenium	23.4	NA	NA
Alpha-chlordane	26.0	2.2	13.0

7-MA-SD04 SEDIMENT (0-6")	ERL	ERM	SQC
4'4-DDD	32.5	3.3	102
4'4-DDE	81.8	6.7	49.6
4'4-DDT	27.0	3.9	135
Acenaphthylene	5.7	0.4	NE
Anthracene	4.1	0.3	302
Di-n-butylphthalate	0.2	NE	3.1
Phenanthrene	0.9	0.1	1.4
Toluene	NE	NE	12.3
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
4'4-DDE	12.3	1.0	7.4
Di-n-butylphthalate	0.1	NE	1.3
Toluene	NE	NE	13.0

7-NC-SW02 / 7-NC-SD02 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Lead	0.9	0.1	2.8
Manganese	NA	NA	2.3
Silver	66.0	4.9	NA
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
4,4-DDD	2.7	0.3	3.9
Alpha-chlordane	10.8	0.9	5.4
Dieldrin	285	0.7	9.0
Gamma-chlordane	10.4	0.9	5.2
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
Alpha-chlordane	9.8	0.8	4.9

7-ET-SW02 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Bis(2-ethylhexyl)phthalate	NA	0.0	22.6
Manganese	NA	NA	1.5
Silver	66.0	2.9	NA

7-NC-SW01 / 7-NC-SD01 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NA	NA	1.0
SEDIMENT (0-6")	**ERL**	**ERM**	**SQC**
Thallium	19.2	NA	NA
SEDIMENT (6-12")	**ERL**	**ERM**	**SQC**
Thallium	20.4	NA	NA

7-WT-SD03 SEDIMENT (0-6")	ERL	ERM	SQC
4,4-DDD	4.2	0.4	6.1
4,4-DDE	5.0	0.4	1.4
Alpha-chlordane	16.4	1.4	8.2
Dieldrin	270	0.7	8.6
Gamma-chlordane	15.0	1.3	7.5
Thallium	2.8	NA	NA

7-NC-SW03 SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Lead	1.1	0.1	3.2
Manganese	NA	NA	6.9
Silver	96.0	4.2	NA

7-WT-SW01
7-WT-SD01
7-WT-BN01

7-ET-SW01
7-ET-SD01

7-DD-SW01
7-DD-SD01

7-MA-SD02

7-DD-SW02
7-DD-SD02

7-WT-SW02
7-WT-SD02
7-WT-BN02

7-MA-SD03

7-WT-SW03
7-WT-SD03
7-WT-BN03

7-MA-SD04
LOCATED 100' EAST OF EAST TRIBUTARY

LOCATED 1080' UPSTREAM OF EAST TRIBUTARY
7-NC-SW01
7-NC-SD01
7-NC-BN01

LOCATED 300' UPSTREAM OF EAST TRIBUTARY

7-NC-SW04
7-NC-SD04
7-NC-BN03

LOCATED AT MOUTH OF EAST TRIBUTARY
7-NC-SW03
7-NC-SD03
7-NC-BN02

7-NC-SW02
7-NC-SD02

LOCATED 20' UPSTREAM OF CONFLUENCE WITH NORTHEAST CREEK
7-ET-SW02
7-ET-SD02

7-MA-SD01

7-NC-SW01
7-NC-SD01

LOCATED 30' UPSTREAM OF TREATMENT PLANT OUTFALL
7-NC-SW06
7-NC-SD06
7-NC-BN04

SWAMP
WOODS
WASTEWATER TREATMENT PLANT
NORTHEAST CREEK
APPROXIMATE

125 0 62.5 125
1 inch = 125 ft.

LEGEND

7-DD-SW01 / 7-DD-SD01 SURFACE WATER/SEDIMENT SAMPLE LOCATION

7-MA-SD01 SEDIMENT SAMPLE LOCATION

7-NC-SW04 / 7-NC-SD04 / 7-NC-BN03 SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLE LOCATION

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

Baker
Baker Environmental, Inc.

FIGURE 7-3
QUOTIENT INDEX RATIOS THAT EXCEEDED "1" IN THE SURFACE WATER AND SEDIMENT
SITE 7 - TARAWA TERRACE DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01701V05Z

8.0 CONCLUSIONS

The following conclusions for Operable Unit (OU) No. 11 (Site 7) are based on the results of the Remedial Investigation, and the human health and ecological risk assessment.

1. The site is primarily underlain by sands and silty sands. These sands are generally overlain by thin layers of silt and silty clay. Occasional lenses and/or discontinuous layers of sand and clay, and clay are present at depth. Fill material (i.e., roofing shingles) was identified in the southwest portion of the study area, ranging in thickness from one to six feet.

2. The hydrogeologic characteristics of the study area were investigated by installing a network of shallow monitoring wells and staff gauges. Groundwater within the surficial aquifer discharges to Northeast Creek. The water table gradient is relatively low (0.009). The groundwater flow velocity in a northwest to southeast direction is estimated to be 0.38 feet/day (138.7 feet/year).

3. Polynuclear aromatic hydrocarbons (PAHs) were the most prevalent semivolatile organic contaminants detected in the soil. The extent of PAH contamination in the surface and subsurface is primarily in the north and eastern portion of the study area. PAHs were not detected in the groundwater.

4. Pesticides were infrequently detected in surface and subsurface soil samples. The pesticides dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, endosulfan II, alpha-chlordane, and gamma chlordane are the most prevalent pesticides in the soil. Pesticide concentrations appear to be consistent or lower than levels detected across the base which are indicative of historical pest control spraying. Dieldrin was the only pesticide detected in one groundwater sample.

5. The occurrence of inorganics is widespread in both the surface and subsurface soil. Inorganics which exceed surface soil and subsurface soil base background concentrations include aluminum, barium, beryllium, calcium, nickel, and zinc. These exceedences do not suggest a gross inorganic contamination problem in either the surface or subsurface soil.

6. Trace levels of (i.e., less than 0.10 ppm) of Aroclors 1254 and 1260 were detected in a limited number of surface and subsurface soil. Aroclor 1254 was not detected in the subsurface soil. The random occurrence of these contaminants may be due to the past disposal of oils. These contaminants were not detected in the groundwater.

7. Levels of arsenic, iron, and manganese in the surface water exceed federal criteria. With the exception of dieldrin no other organic contaminant exceed surface water criteria. No sediment contaminant concentrations exceed NOAA ER-M levels.

8. Under current human health exposure scenarios, there are no adverse carcinogenic or noncarcinogenic risks to human receptors. However, under a future residential scenario a potential noncarcinogenic risk is possible. The potential total noncarcinogenic risk to a future child (6.5) and future adult (2.7) exceed the acceptable noncarcinogenic risk level 1.0. These exceedences are primarily due to the ingestion of manganese in the groundwater.

9. Based on results of the surface water, sediment, and benthic macroinvertebrate sampling at the west tributary freshwater stations, it appears that there is a reduction of the benthic macroinvertebrate population. However, it cannot be determined if this reduction is from inorganics in the surface water, or from pesticides in the sediment. The benthic population is consistent with and respect to density and diversity.

13. The results of the CDI model indicated that the cottontail rabbit, raccoon, and short-tailed shrew may potentially be at risk from contaminants in the surface water and surface soil. The risk to the rabbit does not appear to be significant because the QI barely exceeds 1. Aluminum caused the majority of the risk in the raccoon and shrew.