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FINAL

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT NO. 7
(SITES 1, 28, AND 30)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0231

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	applicable or relevant and appropriate requirements
ARV	Aquatic Reference Value
ATSDR	Agency for Toxic Substances and Disease Registry
ASTM	American Society for Testing Materials
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
bls	below land surface
BOD	biological oxygen demand
BRA	baseline human health risk assessment
Carc.	Carcinogenic Effects
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEJ	Camp Lejeune
CLP	Contract Laboratory Program
COD	chemical oxygen demand
COPC	Contaminant of Potential Concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CSF	Carcinogenic Slope Factor
DOD	Department of the Defense
DoN	Department of the Navy
DQO	Data Quality Objective
EMD	Environmental Management Division (Camp Lejeune)
ERA	Ecological Risk Assessment
ER-L	Effects Range - Low
ESE	Environmental Science and Engineering, Inc.
°F	degrees Fahrenheit
FFA	Federal Facilities Agreement
FMF	Fleet Marine Force
FMFLANT	Fleet Marine Force Atlantic
FFSG	Force Service Support Group
ft	feet
ft/ft	foot per foot
gpm	gallons per minute
GSRA	Greater Sandy Run Area
GW	groundwater well
HA	Health Advisories
HEAST	Health Effects Assessment Summary Tables

HHAG	Human Health Assessment Group
HI	hazard index
HPIA	Hadnot Point Industrial Area
HQ	hazard quotient
IAS	Initial Assessment Study
ICRs	Estimated Incremental Lifetime Cancer Risks
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	lowest-observed-adverse-effect-level
MAGTF	Marine Air Ground Task Force
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
MF	Modifying Factor
mgd	million gallons per day
mg/L	milligram per liter
MILCON	Military Construction
msl	mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCP	National Contingency Plan
NCWQS	North Carolina Water Quality Standard
ND	Nondetect
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic Atmosphere Administration
NOAEL	no-observed-adverse-effect-level
NOEL	no-observed-effect level
Noncarc.	Noncarcinogenic Effects
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NREA	Natural Resources and Environmental Affairs
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PRGs	Preliminary Remediation Goals

QA/QC	quality assurance/quality control
QI	Quotient Index
RBCs	Region II Risk Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RME	Responsible Maximum Exposure
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
Sj	Jaccard Coefficient
SMCL	Secondary Maximum Contaminant Level
SQC	Sediment Quality Criteria
Ss	Sφrenson Index
SSV	Sediment Screening Value
SVOCs	Semivolatile Organic Compounds
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TDS	total dissolved solids
TRV	Terrestrial Reference Value
TSS	total suspended solids
UBK	Uptake/Biokinetic
UCL	Upper Confidence Level
UF	Uncertainty Factor
μg/L	micrograms per liter
μg/kg	micrograms per kilogram
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WAR	Water and Air Research, Inc.
WOE	weight-of-evidence
WQS	Water Quality Standards
WQSV	Water Quality Screening Values

10.0 INTRODUCTION

A detailed introduction is provided in Section 1.0 of Volume I. The Section 1.0 introduction describes the arrangement of OU No. 7 and the background and setting of MCB, Camp Lejeune.

11.0 SITE BACKGROUND AND SETTING

This section provides a description of the physical setting and a detailed history of both operations and previous investigations at Site 28, one of the three sites which comprise OU No. 7.

11.1 Site Description

Site 28, the Hadnot Point Burn Dump, is located along the eastern bank of the New River. The site is within the Hadnot Point development area, approximately one mile south of HPIA on the Mainside portion of MCB, Camp Lejeune (see Figure 1-1). Cogdels Creek flows into the New River at Site 28 and forms a natural divide between the eastern and western portions of the site. A majority of the estimated 23 acres that constitute the site are used for recreation and physical training exercises.

The Hadnot Point development area, which includes Site 28, has evolved over a 40-year period to encompass approximately 1,080 acres of land. Recreational areas are scattered throughout Hadnot Point and comprise nearly 18 percent or 196 acres of the Hadnot Point development area. Administrative buildings are principally situated to the west of Holcomb Boulevard, the main access route to the development area. Troop housing units are located in the western portion of Hadnot Point, toward the New River. Consolidated in the northern portion of Hadnot Point, the industrial area (HPIA), and segregated from administrative buildings and housing units are supply, storage, and maintenance facilities. Administrative and support facilities together account for approximately 29 percent or 310 acres of Hadnot Point land area. Commercial uses, open spaces, and wooded areas constitute the remaining acreage in the Hadnot Point development area (Master Plan, 1988).

The Hadnot Point Sewage Treatment Plant (STP) is located adjacent to Site 28. The facility extends across Cogdels Creek via two 30-inch diameter aqueducts. The STP operates a number of clarifying, settling, and aeration ponds that are located on either side of Cogdels Creek. Both operational areas of the STP are fenced with six-foot chain link. The treated water from the STP discharges into the New River via an outfall pipeline approximately 400 feet from the shoreline. Figure 11-1 depicts the surface features and surrounding conditions at Site 28.

Vehicle access to the site is via Julian C. Smith Boulevard near its intersection with O Street. The site is bordered to the north by the Hadnot Point STP, to the east and south by wooded areas, and to the west by the New River. Site 28 is predominantly comprised of two lawn and recreation areas, known collectively as the Orde Pond Recreation Area, that are separated by Cogdels Creek. The eastern and western portions of the site are served by an improved gravel road. Picnic pavilions, playground equipment, and the stocked fish pond, Orde Pond, located at the site, are regularly used by base personnel and their families. In addition, field exercises and physical training activities frequently take place at the recreation area.

11.2 Site History

Site 28 operated from 1946 to 1971 as a burn area for a variety of solid wastes generated on base. Industrial waste, trash, oil-based paint, and construction debris were reportedly burned and subsequently covered with soil. In 1971 the burn dump ceased operations and the area was graded or seeded with grass. Figure 11-1 depicts the location of the suspected burn dump area. The total volume of fill is estimated to be between 185,000 and 375,000 cubic yards, based upon a surface area of 23 acres and a depth ranging from five to ten feet (Water and Air Research, 1983).

11.3 Previous Investigations

The following sections detail previous investigation activities at OU No.7, Site 28.

11.3.1 Initial Assessment Study

An IAS was conducted at Site 28 by WAR in 1983. The IAS evaluated potential hazards at Site 28 based upon review of historical records and aerial photographs, inspections, and personnel interviews. As a result of this process, the IAS recommended that a confirmation study be performed at Sites 28.

11.3.2 Confirmation Study

A two-part confirmation study was conducted at Site 28 by ESE from 1984 through 1987. The Verification Step was performed in 1984 and the Confirmation Step was performed in 1986 and 1987. The Confirmation Study at Site 28 focused on the presence of potential contaminants in groundwater, surface water, sediment, and fish tissue. Findings from the Confirmation Study are provided below.

11.3.2.1 Groundwater Investigation

A total of four groundwater monitoring wells were installed as part of the Confirmation Study. Three of the wells were installed and sampled in 1984. Wells 28-GW01 and 28-GW02 are located on the downgradient edge of the fill area along the New River, and well 28-GW03 is located downgradient of the eastern portion of the site, east of Cogdels Creek. Well 28-GW04, installed and sampled in 1986 and sampled again in 1987, is located upgradient of the eastern fill area and Orde Pond. Figure 11-2 provides the locations of the four shallow monitoring wells installed between 1984 and 1986. Table 11-1 provides well construction details for the four shallow wells. Groundwater samples collected during the Confirmation Study were analyzed for the following parameters:

- Metals
- Hexavalent chromium
- Organochlorine pesticides (OCP)
- Polychlorinated Biphenyls (PCB)
- Oil and Grease (O&G)
- Volatile Organic Compounds (VOCs)
- Tetrachlorodioxin (TCCD) (1986/1987 only)
- Xylenes (1986/1987 only)
- Methylethyl ketone (MEK) (1986/1987 only)
- Methyl isobutyl ketone (MIBK) (1986/1987 only)

Well 28-GW01 historically has exhibited the highest concentrations of contaminants at Site 28. Table 11-2 provides a summary of groundwater data collected during the Confirmation Study at Site 28. Results of the two sampling events (1984 and 1986) indicated concentrations of VOCs in the sample obtained from well 28-GW01, including 1,2-dichloroethene (38 and 14 μg/L), TCE (15 and 4.9 μg/L), and vinyl chloride (22 and 13 μg/L). The concentrations of these compounds decreased from 1984 to 1986. However, samples retained from well 28-GW01 during the 1984 and

1986 sampling rounds exceeded both the MCL (2 μg/L) and NCWQS (0.015 μg/L) for vinyl chloride. The MCL (5 μg/L) and NCWQS (2.8 μg/L) for TCE were exceeded by the groundwater sample collected from well 28-GW01 in 1984; only the NCWQS was exceeded by the sample from 1986. No volatile organics were detected in any of the other wells during the Confirmation Study.

The pesticide 4,4'-DDD was detected during the 1984 sampling round at concentrations of 0.12, 0.093, and 0.22 μg/L in wells 28-GW01, 28-GW02, and 28-GW03, respectively. Only well 28-GW02 exhibited 4,4'-DDD during the 1986 sampling round, at a concentration of 0.018 μg/L. The pesticide 4,4'-DDE was detected in wells 28-GW01, 28-GW02, and 28-GW03 at concentrations of 0.015, 0.028, and 0.007 μg/L, respectively. Dieldrin was detected at a concentration of 0.003 μg/L during the 1984 sampling event from well 28-GW01 only. Oil and grease were detected at concentrations of less than 10 μg/L in each well sample during Confirmation Study.

During the two rounds of groundwater sampling a number of inorganic contaminants were identified. Among the inorganic contaminants of concern are arsenic (ranging from 9.5 to 21 μg/L), chromium (ranging from 12 to 330 μg/L), lead (ranging from 38 to 336 μg/L), and mercury (ranging from 0.2 to 0.8 μg/L). During the 1984 sampling round, a sample obtained from well 28-GW03 had a lead concentration of 336 μg/L, which surpassed the MCL and NCWQS concentration of 15 μg/L. Samples obtained during 1986 from wells 28-GW01 and 28-GW02 also exceeded water quality standards for lead with concentrations of 140 and 38 μg/L, respectively. The NCWQS for chromium, 50 μg/L, was exceeded during both 1986 (92.6 μg/L) and 1987 (54 μg/L) sampling rounds in samples obtained from well 28-GW04. Well 28-GW03 exhibited a concentration of 330 μg/L of chromium during the 1984 investigation, which exceeded the MCL of 100 μg/L for chromium. Arsenic and mercury were detected in more than one sample during the two sampling rounds, but in both cases did not exceed either MCL or NCWQS criteria.

11.3.2.2 Surface Water and Sediment Investigation

Seven surface water and sediment stations were sampled as part of the Confirmation Study investigation. Figure 11-2 depicts the locations of Confirmation Study surface water and sediment sampling stations on both Cogdels Creek and the New River. Two of the seven sampling locations, 28-SW/SE01 and 28-SW/SE02 located on Cogdels Creek, were sampled in August 1984, August 1986, and December 1986. As part of the December 1986 investigation, five new sampling locations were added; four in the New River and one in Cogdels Creek, placed upstream of the site (28-SW/SE03). The surface water samples were analyzed for the same parameters as the groundwater samples collected during the Confirmation Study.

During the 1984 sampling round, TCE was detected in both of the Cogdels Creek surface water samples 28-SW01 (1.3 μg/L) and 28-SW02 (1.1 μg/L). TCE was not, however, detected in any of the 1986 samples. Pesticides alpha-BHC, beta-BHC, and delta-BHC were detected at concentrations of less than 0.01 μg/L from surface water samples 28-SW01 and 28-SW02 in December 1984. These pesticides were not detected in any of the August 1986 or December 1986 samples, possibly due to an increase of method detection limits from 1984 to 1986.

Mercury was not detected in 1984 samples but was present in 1986 samples from all three locations in Cogdels Creek and at levels greater than the surface water NCWQS of 0.025 μg/L. Mercury was identified in samples collected during the December 1986 sampling round from 28-SW01 (0.8 μg/L), 28-SW02 (0.5 μg/L), and 28-SW03 (0.6 μg/L). The presence of mercury at station 28-SW03 may indicate that a potential source is located upstream of the Hadnot Point Burn Dump.

Cadmium was detected in one of the three samples from Cogdels Creek, 28-SW02, at a concentration of 8.4 μg/L in excess of the surface water NCWQS of 2.0 μg/L.

Seven sediment locations, which correspond to the surface water locations, were sampled as part of the December 1986 investigation. Two stations were sampled as part of the 1984 investigation, and an additional five were added for the 1986 sampling round. The sediment samples were analyzed for the following parameters:

- Metals
- Organochlorine pesticides
- Polychlorinated Biphenyls (PCBs)
- Oil and Grease
- Tetrachlorodioxin (1986 only)
- Hexavalent Chromium

Chlordane was the only parameter detected in the sediment that was not detected in either groundwater or surface water samples. Chlordane was detected during the December 1986 sampling effort in each of the three Cogdels Creek samples; stations 28-SE01, 28-SE02, and 28-SE03 had chlordane concentrations of 0.298, 0.347, and 0.595 mg/kg, respectively. Chlordane concentrations of this range exceed the National Oceanic and Atmospheric Administration's (NOAA) effects range-low (ER-L) sediment screening value for chlordane of 0.0005 mg/kg. The pesticide 4,4'-DDD was detected during the 1984 sampling round at concentrations of 0.084 and 0.0022 mg/kg in samples from stations 28-SE01 and 28-SE02, respectively. The pesticide 4,4'-DDE was detected during both the 1984 and 1986 sampling rounds in samples 28-SE01 and 28-SE02. Samples collected during the 1986 investigation from 28-SE01 and 28-SE02 had 4,4'-DDE concentrations of 0.243 and 0.0619 mg/kg, respectively. NOAA ER-L screening values for 4,4'-DDD (0.001 mg/kg) and 4,4'-DDE (0.002 mg/kg) were exceeded during the Confirmation Study. Table 11-3 presents results of the sediment investigation conducted during the 1984 and 1986 sampling rounds.

Concentrations of O&G within Cogdels Creek samples ranged from 1,520 to 4,630 mg/kg and were, on average, an order of magnitude higher than samples collected from New River, which ranged from not detected to 238 mg/kg. The level of O&G was higher in 1986 than 1984 within sediment samples retained from Cogdels Creek. Detectable levels of arsenic, cadmium, chromium, lead, nickel and zinc were identified in most of the samples in both Cogdels Creek and the New River. Nickel was the only metal of those listed that was not present in all four of the New River samples. Lead was identified in sediment sample 28-SE01 during the 1984 sampling round at 46 mg/kg and in 1986 at 190 mg/kg; both concentrations are in excess of the sediment screening value of 35 mg/kg. Samples that are also in excess of the NOAA screening value for lead are 28-SE02 (42.1 mg/kg) and 28-SE03 (135 mg/kg), from the 1986 sampling round. Zinc from a sample obtained from station 28-SE03 exceeded the NOAA ER-L screening value of 120 mg/kg, with a concentration of 167 mg/kg.

11.3.2.3 Fish Tissue

Two samples of fish tissue were obtained from Orde Pond (Figure 11-1) in 1984 only. The tissue samples were analyzed for orthochlorine pesticides (OCP) and PCBs. Samples 28-TI01 and 28-TI02 had total PCB concentrations of 11 and 10 μg/L, respectively. The pesticide Alpha-BHC was also detected in each of the fish tissue samples at 0.1 μg/L. PCBs were not detected elsewhere during the Confirmation Study investigation at Site 28. PCBs are bioaccumulated in the foodchain and may or may not have originated from the site, depending on the source of the fish in the stocked pond. Available data indicates that Alpha-BHC was present in this area of Site 28 and may be discharging to Cogdels Creek. Levels of PCBs and Alpha-BHC were below acute toxicity levels.

11.3.2.4 Conclusions and Recommendations

The Confirmation Study identified a number of target contaminants in environmental media throughout Site 28. Metals were the most prevalent contaminant group encountered during both rounds of the investigation. Groundwater, surface water, and sediment samples suggested that metal contaminants, with the exception of mercury in surface water, originated from the disposal area of the site. Concentrations of metals in groundwater generally decreased from one sampling round to the next, during 1984 and 1986. Metal concentrations in sediment, however, increased from the first to the second sampling round. Surface water samples obtained from Cogdels Creek identified cadmium and mercury at concentrations that, in certain cases, exceeded state surface water standards. Lead was detected at concentrations exceeding regulatory limits in sediment samples collected from Cogdels Creek and shallow groundwater samples collected during both the 1984 and 1986 investigations. Mercury was detected in surface water and shallow groundwater samples. The distribution of mercury throughout the site suggests that the contaminant is not only present at the site, but may also have migrated from an upstream location.

VOCs were detected in groundwater samples collected from monitoring well 28-GW01 during both rounds of the investigation; the sample exceeded regulatory limits for TCE and vinyl chloride. Volatile contaminants were not detected in groundwater samples from any of the other three wells. Results indicated that O&G were consistent contaminants in groundwater and sediment samples obtained during both rounds of sampling.

The Site Summary Report recommended that further characterization of groundwater and surface water quality be implemented to complete the RI/FS process. Additional surface water and sediment investigations of Cogdels Creek, between Site 28 and HPIA, were suggested to determine possible upstream sources of contamination. In addition to groundwater and surface water, a thorough characterization of unsaturated soils within the identified disposal areas was recommended to fulfil existing data requirements. Following the characterization of potentially impacted environmental media, a risk assessment was also recommended to identify unacceptable risks to human health and the environment.

11.3.3 Additional Investigations

The Confirmation Study at Site 28 focused on the presence of potential contaminants in groundwater, surface water, sediment, and fish tissue. In addition to the two rounds of groundwater data collected during the Confirmation Study, a third round was gathered by Baker in April 1993 to support RI scoping activities. During 1993, a surface water and sediment investigation of Cogdels Creek was conducted as part of RI activities at OU No. 1. Results of the surface water and sediment investigation, and additional groundwater sampling data are presented below.

11.3.3.1 Groundwater Investigation

During April 1993, Baker conducted a groundwater investigation of the shallow aquifer at Site 28. Four existing wells (see Figure 11-2) were sampled for analyses of TCL organics and TAL total metals using CLP protocols and Level IV data quality. Results of this sampling event indicated concentrations of two VOCs in the sample obtained from well 28-GW01; vinyl chloride and 1,2-dichloroethene were detected at concentrations of 6 J and 2 J µg/L, respectively. The positive detection of vinyl chloride (6 J µg/L) exceeded both MCL (2 µg/L) and NCWQS (0.015 µg/L) criteria. Concentrations of these compounds did, however, decrease from those detected during the 1984 and 1986 investigations.

Two polynuclear aromatic hydrocarbons (PAHs) and one phthalate-ester were detected in well 28-GW02. The PAH compounds acenapthene and phenanthrene were detected at estimated concentrations of 2 J and 1 J µg/L, respectively. The phthalate-ester, 2-methylnaphthalene was detected at an estimated concentration of 1 J µg/L. State and federal groundwater evaluation criteria do not exist for these compounds. No other SVOCs were detected in any of the other three shallow monitoring wells.

The pesticide 4,4'-DDD was detected at a concentration of 0.24 µg/L in well 28GW01 during the RI scoping investigation of 1993. Currently, there are no state or federal groundwater quality criteria stipulated for 4,4'-DDD concentrations. No other pesticides or PCBs were detected in any of the three remaining wells.

During the groundwater investigation a number of inorganic contaminants were identified. Among the inorganic contaminants of concern were beryllium, cadmium, chromium, lead, and mercury. Table 11-4 presents inorganic groundwater data collected during the 1993 RI scoping investigation.

Beryllium was detected at an estimated concentration of 9.3 J µg/L from well 28-GW04, which exceeded the MCL of 4 µg/L. Well 28-GW02 exhibited an estimated cadmium concentration of 17.3 J µg/L, which exceeded both MCL and NCWQS criteria of 5 µg/L. Chromium was identified in monitoring wells 28-GW03 and 28-GW04 at concentrations of 140 and 122 µg/L, respectively. These concentrations of chromium represent exceedances of both the NCWQS of 50 µg/L and the MCL of 100 µg/L.

Lead was detected in each of the four groundwater samples retained for analyses from wells at Site 28. In each case, lead concentrations surpassed both the NCWQS and the federal action level of 15 µg/L. The estimated concentrations of lead detected in monitoring wells 28-GW01 and 28-GW02 were 234 J and 197 J µg/L, respectively. Wells 28-GW01 and 28-GW02 are located adjacent to the western disposal area, hydraulically downgradient of the burn dump area (see Figures 11-1 and 11-2). Groundwater samples from wells 28-GW03 and 28-GW04 had estimated lead concentrations of 20.3 J and 22.4 J µg/L, respectively. These two wells are located across Cogdels Creek, hydraulically downgradient of the eastern disposal area. Finally, mercury was detected at an estimated concentration of 1.4 J µg/L in well 28-GW02, which exceeded the NCWQS of 1.1 µg/L.

11.3.3.2 Surface Water and Sediment Investigation

During May of 1993, Baker conducted a surface water and sediment investigation of Cogdels Creek and the New River as part of the RI investigation performed at OU No.1. A total of fifteen surface water and sediment stations were sampled upgradient of Site 28 on Cogdels Creek. An additional three stations were sampled on the New River, adjacent to Site 28. Both surface water and sediment samples were subjected to TCL organic and TAL total metal analyses using CLP protocols and Level IV data quality. Figure 11-3 depicts the locations of these surface water and sediment sampling stations. Results of sediment analyses conducted under the RI investigation of OU No.1 indicate the presence of VOCs, SVOCs, pesticides, and inorganics. The following discussion provides a summary of organic and inorganic contaminants in surface water and sediment samples.

Five of 15 surface water samples retained from Cogdels Creek contained VOCs. TCE was detected in four surface water samples, each located upstream of Site 28, at a maximum concentration of 47 μg/L. Toluene and 1,2-dichlorethene were detected in one surface water sample each at concentrations of 3 J and 6 J μg/L, respectively. None of the detected VOCs exceeded NCWQS standards. The pesticides 4,4'-DDD and 4,4'-DDT were detected in one of the 15 surface water samples collected from Cogdels Creek, both at a concentrations below NCWQS criteria.

Nineteen of 23 TAL inorganics were detected in surface water samples; antimony, cadmium, cobalt, and mercury were not detected. Copper exceeded NCWQS criteria in 16 of the 18 surface water samples and had an estimated maximum concentration of 42 J μg/L. Other inorganic constituents such as chromium, lead, and zinc also exceeded surface water quality standards. Lead exceeded NCWQS criteria in a total of five samples, including one from the New River, at a maximum concentration of 42 μg/L. Zinc was identified at concentrations exceeding the NCWQS in two samples, one from the New River and the other from Cogdels Creek at 125 and 152 J μg/L, respectively. Chromium was detected in sample 78-CC-SW19 (see Figure 11-3) at a concentration of 30 μg/L, which also exceeded the NCWQS criteria.

Sediment sample results from Cogdels Creek and the New River indicated the presence of VOCs, SVOCs, pesticides, and inorganics. No PCBs were detected in sediment samples. Two sediment samples were collected at each of the 18 sampling stations, for a total of 36 samples. VOCs were identified in four of the 36 samples. Ethylbenzene was detected in one sample at 16 J mg/kg and 2-butanone was detected in three samples at a maximum concentration of 60 J mg/kg. No sediment screening values or standards exist for VOCs detected in sediments.

Fifteen of the 36 total sediment samples had positive detections for SVOCs. The most frequently detected SVOCs were polynuclear aromatic hydrocarbons (PAHs). SVOCs such as fluoranthene and pyrene (14 occurrences each), chrysene (13 occurrences), benzo(b)fluoranthene (12 occurrences), benzo(a)pyrene and ideno(1,2,3-cd)pyrene (11 occurrences each), phenanthrene and benzo(a)anthracene (10 occurrences each), and benzo(g,h,i)perylene (eight occurrences) were the only contaminants detected in more than three samples. The majority of SVOC maximum concentrations were found in a sample obtained from the New River, 78-CC-SD18, near Site 28. The SVOCs that exceeded NOAA ER-L screening values and the number of samples with concentrations in excess of those standards are as follows: pyrene (seven samples), phenanthrene (five samples), benzo(a)anthracene (five samples), chrysene (four samples), fluoranthene (three samples), and benzo(a)pyrene (three samples).

Pesticides were detected in 19 of the 36 samples, with 4,4'-DDD detected most frequently. The highest concentrations of pesticides were detected from samples 78-CC-SD19-06 (4,4-DDE-33 μg/Kg), 78-CC-SD18-612 (4,4'-DDD - 350 J μg/Kg and 4,4'-DDT - 150 μg/Kg), 78-CC-SD06-612 (alpha-chlordane 4.7 J μg/Kg), and 78-CC-SD08-612 (gamma-chlordane 6.3 μg/Kg). The frequency of pesticides detected and their range of concentrations are as follows:

- 4,4'-DDE: seven samples (5 - 33 μg/Kg)
- 4,4'-DDD: 17 samples (4.4 - 350 J μg/Kg)
- 4,4'-DDT: nine samples (4.6 - 150 μg/Kg)

- alpha-chlordane: four samples (2.5 J - 4.7 J μg/Kg)
- gamma-chlordane: two samples (3.2 J - 6.3 μg/Kg)

Twenty-two of 23 inorganic constituents (excluding nickel) were detected in Cogdels Creek sediments as part of the OU No. 1 RI investigation. The following metals exceeded the NOAA ER-L screening values for sediments: lead (12 occurrences), zinc (six occurrences), cadmium (three occurrences), copper (two occurrences), and silver (two occurrences). Six metals exhibited maximum concentrations at sample location 78-CC-SD08-06, which lies upstream of Site 28. Sediment samples which exceeded NOAA ER-L metal screening values are as follows:

• 78-CC-SD03-612	lead	48.3 J μg/Kg
• 78-CC-SD04-06	lead	40.4 μg/Kg
• 78-CC-SD06-612	lead	45.7 J μg/Kg
• 78-CC-SD08-06	cadmium	11.9 μg/Kg
	copper	78.3 μg/Kg
	lead	178 μg/Kg
	zinc	301 μg/Kg
• 78-CC-SD08-612	cadmium	10.9 μg/Kg
	lead	296 μg/Kg
	zinc	363 μg/Kg
• 78-CC-SD09-06	cadmium	9.6 μg/Kg
	lead	92.3 μg/Kg
	zinc	254 μg/Kg
• 78-CC-SD18-06	lead	83.6 μg/Kg
• 78-CC-SD18-612	copper	116 μg/Kg
	lead	359 μg/Kg
	zinc	322 μg/Kg
• 78-CC-SD19-06	lead	93.1 μg/Kg
	silver	2.3 μg/Kg
	zinc	162 μg/Kg
• 78-CC-SD19-612	lead	58.5 μg/Kg
• 78-CC-SD20-06	lead	103 μg/Kg
	silver	3.9 μg/Kg
	zinc	140 μg/Kg
• 78-CC-SD20-612	lead	71.6 μg/Kg

The most prevalent contaminants found in Cogdels Creek and New River sediments were PAH compounds, pesticides, and metals. The sample locations that yielded a majority of maximum concentrations were 78-CC-SD08 and 78-CC-SD18. Location 78-CC-SD08 is located upstream of Site 28, to the south and east of HPIA. Location 78-CC-SD18 is located adjacent to Site 28, in the New River.

11.3.3.3 Fish Tissue

An aquatic investigation of Orde Pond was conducted by Baker during October 1993. A total of six fish tissue composite samples were subjected to TCL organic and TAL total inorganic analyses using CLP protocols as part of the investigation; four samples were collected from Orde Pond and two were collected from Hadnot Creek (reference samples). The investigation sought to determine whether contaminants from Site 28 had bioaccumulated in fish found in Orde Pond and to determine if fish were suitable for human consumption, as defined by the U.S. Food and Drug Administration (FDA).

A number of inorganic contaminants were detected in the fish composite samples collected from both Orde Pond and Hadnot Creek. Lead and silver, of those analytes detected, were identified in composite samples from Orde Pond only and not from the reference station in Hadnot Creek. Common laboratory contaminants such as acetone, 2-butanone, methylene chloride, and a number of phthalate esters were identified in samples from both Orde Pond and Hadnot Creek. The frequencies and concentrations of these compounds suggest that they were introduced during laboratory analysis and, therefore, should not be considered relevant to the site. Finally, no PCBs or pesticides were detected in any of the fish samples.

Results of laboratory analysis were compared to federal action levels and contaminant levels in fish collected from the reference station, Hadnot Creek. That comparison was used to determine if a potential health risk existed through consumption of fish from Orde Pond. Contaminant concentrations from Orde Pond and Hadnot Creek were comparable. The similar nature of contaminants suggests that previous disposal practices at Site 28 have adversely impacted fish in Orde Pond.

11.3.3.4 Summary of Additional Investigations

The most prevalent contaminants found in environmental media at Site 28 were PAH compounds, pesticides, and metals. PAH compounds were detected in sediment samples from both Cogdels Creek and the New River. A number of maximum PAH concentrations were detected in a sediment sample from the New River, downstream of Site 28. PAH compounds were also detected upstream of the site, in sediments collected from Cogdels Creek. Three PAH compounds were also identified, at low concentrations, in a groundwater sample collected from well 28-GW02, adjacent to the western disposal area and the mouth of Cogdels Creek.

Pesticides were detected in both surface water and sediments from Cogdels Creek and the New River. The proportional concentrations and widespread occurrence of detected pesticides, particularly in sediments, suggests that their presence may be the result of spraying activities rather than disposal. Positive detections of pesticides in sediments were not exceptionally high or concentrated in any one area. Pesticide concentrations of this magnitude have historically been encountered throughout MCB, Camp Lejeune.

Metals such as cadmium, chromium, and lead were, in general, found throughout the various environmental media at Site 28. Total metals were frequently detected at concentrations in excess of both NCWQS, NOAA, and MCL criteria in surface water, sediment, and groundwater samples.

11.3.4 Aerial Photographic Investigation

Information supplied by USEPA Region IV, as part of the interim report, identified AOCs and verified the occurrence of waste disposal activities at Site 28. Where possible, disposal activities were noted in the EPIC report and annotated on aerial photographs. The analysis of Site 28 was performed by viewing backlit transparencies of aerial photographs through a stereoscope. Stereoscopic viewing of aerial photographs creates a perceived three-dimensional effect which enables the analyst to identify visible characteristics (e.g., color, tone, shadow, texture, size, shape, and pattern). These visible characteristics permit a specific object or condition to be recognized on aerial photographs (EPIC, 1992).

Black-and-white aerial photographs from 1949, 1952, 1956, 1960, and 1964 were used for the analysis of Site 28. Additional photographs from 1938 and 1943 were employed to establish a basis of comparison, prior to development of the Camp Lejeune Military Reservation. Activities noted on aerial photographs from 1984, 1988, and 1990 were briefly summarized as part of the interim report; however, no further disposal operations were observed. Figures 11-4 through 11-8 provide reproductions of the photographs that best illustrate conditions and delineate AOCs within the study areas.

11.3.4.1 Aerial Photograph - October 1949

The STP, located in the northern portion of Site 28, was first noted on an aerial photograph from 1943. Figure 11-4 depicts surface conditions at the time of the photograph, October 1949. Since that time the STP has been expanded and now includes a number of clarifying lagoons and an aeration pond located to the south and southeast of the original facility (see Figure 11-1).

In 1949, a disposal area is evident south of the treatment facility. Smoke, indicative of open burning, is visible along the southern edge of the disposal area. Several vehicles, not annotated, are visible on the eastern end of the disposal area. A drainage analysis also was performed for the 1949 aerial photograph; significant changes are noted in subsequent years of analysis. Cogdels Creek, as annotated on Figure 1-11, flows southwest and enters the New River at Site 28.

11.3.4.2 Aerial Photograph - February 1952

From 1949 to 1952 the disposal area expanded to cover the wetland areas that border Cogdels Creek, as annotated on Figure 11-5. Refuse and debris are scattered along the edge of the disposal area and are in direct contact with surface water. Open burning is evident along the eastern portion of the disposal area where a majority of disposal activity is taking place. Light-toned material is also evident in this portion of the disposal area. Activity, not annotated, on the western portion of the disposal area is probably related to the treatment facility, where an additional clarifier has been constructed.

Across Cogdels Creek from the treatment facility, southeast of the disposal area, access roads lead to a ground-scarred section of Site 28. The visible ground scars are most probably the result of military training exercises. A bulldozer, not annotated, is visible in the ground-scarred area and numerous tracks are evident throughout the surrounding woods.

11.3.4.3 Aerial Photograph - February 1956

The eastern portion of the disposal area expanded during the four years since 1952 and now crosses a section of Cogdels Creek, as annotated on Figure 11-6. According to the EPIC study, it is unclear if the material was deliberately pushed across the creek or if a slope failure occurred, causing material to slump into the creek. A new channel serves to divert water around the filled section of the creek.

Light- and dark-toned material is evident in the eastern portion of the disposal area. In the western portion of the disposal area pools of liquid and possibly the resulting stains are visible in three areas, as annotated. The western most pool of liquid or stain extends to the New River.

The ground-scarred area, first noted on the 1952 aerial photograph, has expanded to the north and west. Two possible trenches and numerous vehicle tracks, not annotated, are visible in this area.

11.3.4.4 Aerial Photograph - November 1960

Additional filling along Cogdels Creek has occurred since 1956. Figure 11-7 depicts surface conditions at the time of the aerial photograph, November 1960. A new drainage channel has diverted the creek farther to the east and south, adjacent to the scarred area noted in 1952 and 1956. Light- and medium-toned material is evident in the southeastern portion of the disposal area. The light-toned area, located in the northeastern portion of the disposal area, may be the result of a liquid discharge that has washed sediment directly into the creek. The western portion of the disposal area has expanded into the New River. Mixed light- and medium-toned material is noted in this area. Probable staining is also evident to the north of the mixed material.

Elsewhere, disturbed ground is apparent to the northwest of the treatment facility, and the scarred area to the southeast of the disposal area has expanded. The two possible trenches noted within the scarred area in 1956 are no longer evident. In addition, a cleared area is now visible to the north of the study area, as annotated.

11.3.4.5 Aerial Photograph - February 1964

During the four years since 1960, the disposal area has expanded further to the east, south, and west. The extent of the active disposal area and future surface features have been annotated, as Figure 11-8 shows. Medium-toned material is visible within the disposal area. Possible leachate, as annotated, is visible along the eastern edge of the disposal area, adjacent to the eastern access road. Probable liquid or stains are visible in the western portion of the disposal area.

The disturbed ground to the north of the treatment plant, as noted on the 1960 aerial photograph, has begun to revegetate. Possible leachate or sediment is visible to the east of this disturbed area, and may have flowed to the east into the drainage. Three new cleared areas are evident to the northeast and southeast of the revegetating disturbed ground.

Disposal activities have extended across Cogdels Creek to the east, via an earthen bridge and culvert. Five pits and dark-toned mounded material are visible in this area. The future locations of Orde Pond and the aeration lagoon have been noted on the annotated aerial photograph.

11.4 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives aimed at characterizing past waste disposal activities at Site 28, 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. As part of the remedial investigation at Site 28, soil, groundwater, surface water, sediment, and aquatic investigations were conducted. The information gathered during these investigations was intended to fill previously existing data gaps and employed to generate human health and ecological risk values. Table 11-5 presents both the RI objectives identified for Site 28 and the criteria necessary to meet those objectives. In addition, the table provides a general description of the study or investigation efforts directed to obtain the required information.

SECTION 11.0 TABLES

TABLE 11-1

SUMMARY OF MONITORING WELL CONSTRUCTION DETAILS
CONFIRMATION STUDY
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Well Depth (feet below ground surface)	Screen Interval Depth (feet below ground surface)	Well Diameter (inches)	Year Installed	Surface Elevation (feet above sea level)
28-GW01	16.5	2.5 - 16.5	2	1984	4.8
28-GW02	21.74	7.74 - 21.74	2	1984	3.8
28-GW03	20.8	6.8 - 20.8	2	1984	3.6
28-GW04	29.02	(1)	2	1986	4.4

Note: (1) Information is not available.
Source: ESE, 1992

TABLE 11-2

DETECTED TARGET CONTAMINANTS IN GROUNDWATER
CONFIRMATION STUDY
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Federal MCLs[1]	North Carolina WQS[2]	Well No./Date							
			28-GW01 7/7/84	28-GW01 12/16/86	28-GW02 7/7/84	28-GW02 12/16/86	28-GW03 7/7/84	28-GW03 12/11/86	28-GW04 12/11/86	28-GW04 3/4/87
Trans-1,2-Dichloroethene	100	70	38	14	ND	ND	ND	ND	ND	ND
Trichloroethene	5	2.8	15	4.9	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2	0.015	22	13	ND	ND	ND	ND	ND	ND
DDD, p-p'	None	None	0.12	ND	0.093	0.018	0.22	ND	ND	ND
DDE, p-p'	None	None	0.015	ND	0.028	ND	0.007	ND	ND	ND
Dieldrin	None	None	0.003	ND	ND	ND	ND	ND	ND	ND
Oil & Grease	None	None	5	8	2	0.4	0.8	ND	ND	9
Arsenic	50	50	18	9.5	ND	ND	21	INTF	INTF	12.1
Chromium (total)	100	50	ND	12	ND	ND	330	15.8	92.6	54
Chromium (+6)	None	None	NA	ND	NA	ND	NA	ND	46.4	ND
Lead	15[3]	15	ND	140	ND	38	336	ND	ND	ND
Mercury	2	1.1	0.3	0.2	ND	0.3	ND	0.8	0.7	0.5
Nickel	100	150	ND	ND	ND	ND	39	ND	43.1	16
Zinc	None	2,100	ND	58	ND	39	143	12.3	142	77

INTF = Interference
NA = Not Analyzed
ND = Not Detected
Values reported are concentrations in micrograms per liter (μg/L); this approximates parts per billion (ppb).
Source: ESE, 1992.

(1) Federal maximum contaminant levels (MCLs) established under the Safe Drinking Water Act of 1986.
(2) NCWQS - North Carolina administrative code, Title 15A, NC DEHNR, Subchapter 2L, Section .0202 - Water Quality Standards (WQS) for groundwater, November 8, 1993. Class GA Standards.
(3) Federal action level established under the Safe Drinking Water Act of 1986.

TABLE 11-3

DETECTED TARGET CONTAMINANTS IN SEDIMENT
CONFIRMATION STUDY
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	NOAA[1] Screening Values	Well No./Date								
		28SE1 08/03/84	28SE1 12/11/86	28SE2 08/03/84	28SE2 12/11/86	28SE3 12/11/86	28SE4 12/15/86	28SE5 12/15/86	28SE6 12/15/86	28SE7 12/15/86
Chlordane	0.0005	ND	0.298	ND	0.347	0.595	ND	ND	ND	ND
DDD, p-p'	0.001	0.084	ND	0.0022	ND	ND	ND	ND	ND	ND
DDE, p-p'	0.002	0.0012	0.243	0.0005	0.0619	ND	ND	ND	ND	ND
Oil & Grease	None	474	1520	1440	2750	4630	238	177	ND	144
Arsenic	33	1.50	6.86	ND	10.3	10.4	ND	ND	1.32	0.645
Cadmium	5	0.100	3.15	ND	ND	4.47	ND	ND	ND	ND
Chromium	80	10	22.5	0.4	18.2	27.4	2.38	3.53	2.69	2.77
Lead	35	46	190	2	42.1	135	ND	ND	4.52	4.75
Nickel	30	2	13.4	0.8	ND	ND	ND	ND	ND	ND
Zinc	120	16	675	1	79.1	167	4.38	3.73	6.06	4.98

ND = Not Detected
Values reported are concentrations in milligrams per kilogram (mg/kg); this approximates parts per million (ppm).
Source: ESE, 1990.
(1) National Oceanic and Atmospheric Administrations (NOAA) Effects Range-Low Sediment Screening Values, Technical Memorandum NOS OMA 52.

TABLE 11-4

INORGANIC CONTAMINANTS IN GROUNDWATER
REMEDIAL INVESTIGATION SCOPING
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Inorganics	Federal MCL(1)	North Carolina WQS(2)	Sample I.D./Date Sampled			
			28-GW01 04/14/93	28-GW02 04/14/93	28-GW03 04/14/93	28-GW04 04/14/93
Aluminum	None	None	16,600	3,280	84,200	43,300
Antimony	6	None	22.0 R	22.0 R	22.0 R	22.0 R
Arsenic	50	50	13.0 J	5.4 J	7.2 J	7.4 J
Barium	2,000	2,000	78.8	556	494	576
Beryllium	4	None	1.2 J	1.0 UJ	1.8 J	9.3 J
Cadmium	5	5	3.0 UJ	17.3 J	3.0 UJ	3.3 J
Calcium	None	None	99,800	53,000	20,200	160,000
Chromium	100	50	39.1 J	9.0 J	140	122
Cobalt	None	None	3.0 U	3.0 U	3.0 U	29.3
Copper	1,300	1,000	19.8	75.4	18.8 J	20.7 J
Iron	None	3,000	15,200	16,000	65,200	35,300
Lead	15(3)	15	234J	197 J	20.3 J	22.4 J
Magnesium	None	None	11,900	26,300	6,020	11,500
Manganese	None	50	138	304	82.2	206
Mercury	2	1.1	0.71 U	1.4 J	0.84 U	0.58 U
Nickel	100	100	17.0 U	17.0 U	17.0 U	59.8
Potassium	None	None	17,800	44,900	5,790	4,810
Selenium	50	50	2.5 UJ	2.4 UJ	2.4 U	10.0 UJ
Silver	None	18	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ
Sodium	None	None	33,600	74,400	9,480.0	37,300
Thallium	2	None	3.0 UJ	3.0 UJ	3.0 UJ	3.0 U
Vanadium	None	None	37.7	6.1	164.0	85.3
Zinc	None	2,100	122 U	423 U	40.2 U	390 U
Cyanide	200	154	10.0 U	10.0 U	10 U	10.0 U

Notes: J - Analyte present. Reported value may not be accurate or precise.
U - Not detected above the level reported in laboratory or field blanks.
UJ - The reported quantitation limits are estimated.
R - Unreliable result. Analyte may or may not be present in the sample.

Values reported are concentrations in micrograms per liter (μg/L); this approximates parts per billion (ppb).

TABLE 11-5

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
REMEDIAL INVESTIGATION, CTO-0231
SITE 28 - HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective		Criteria for Meeting Objective	Proposed Investigation Study
1. Soil	1a.	Assess the extent, if any, of soil contamination at the former burn dump area.	Characterize contaminant levels in surface and subsurface soils at the former burn 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 volatile, semivolatile, metal, and TPH levels in surface and subsurface soils at burn dump area.	Soil 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.	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 the nature and extent of sediment contamination due to burn dump activities.	Characterize contaminant levels in sediment.	Sediment Investigation in Cogdels Creek, Orde Pond, and the New River
	3b.	Assess human health and ecological risks associated with exposure to contaminated sediments in Cogdels Creek, Orde Pond, and the New River.	Characterize the nature and extent of contamination in sediment.	Sediment Investigation in Cogdels Creek, Orde Pond, and the New River
4. Surface Water	4a.	Assess the presence or absence of groundwater contamination in Cogdels Creek, Orde Pond, and the New River.	Determine surface water quality in Cogdels Creek, Orde Pond, and the New River.	Surface Water Investigation
	4b.	Assess human health and ecological risks associated with exposure to contaminated surface water in Cogdels Creek, Orde Pond, and the New River.	Characterize the nature and extent of contamination in surface water.	Surface Water Investigation in Cogdels Creek, Orde Pond, and the New River

SECTION 11.0 FIGURES

LEGEND

	VEGATATION
—x—	FENCE
— —	CREEK/DRAINAGE
↓ ↓	MARSH

SOURCE: LANTDIV, FEBRUARY 1992

DATE	NOVEMBER 1994
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S.O.#	62470-231-0000
CADD#	231104RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

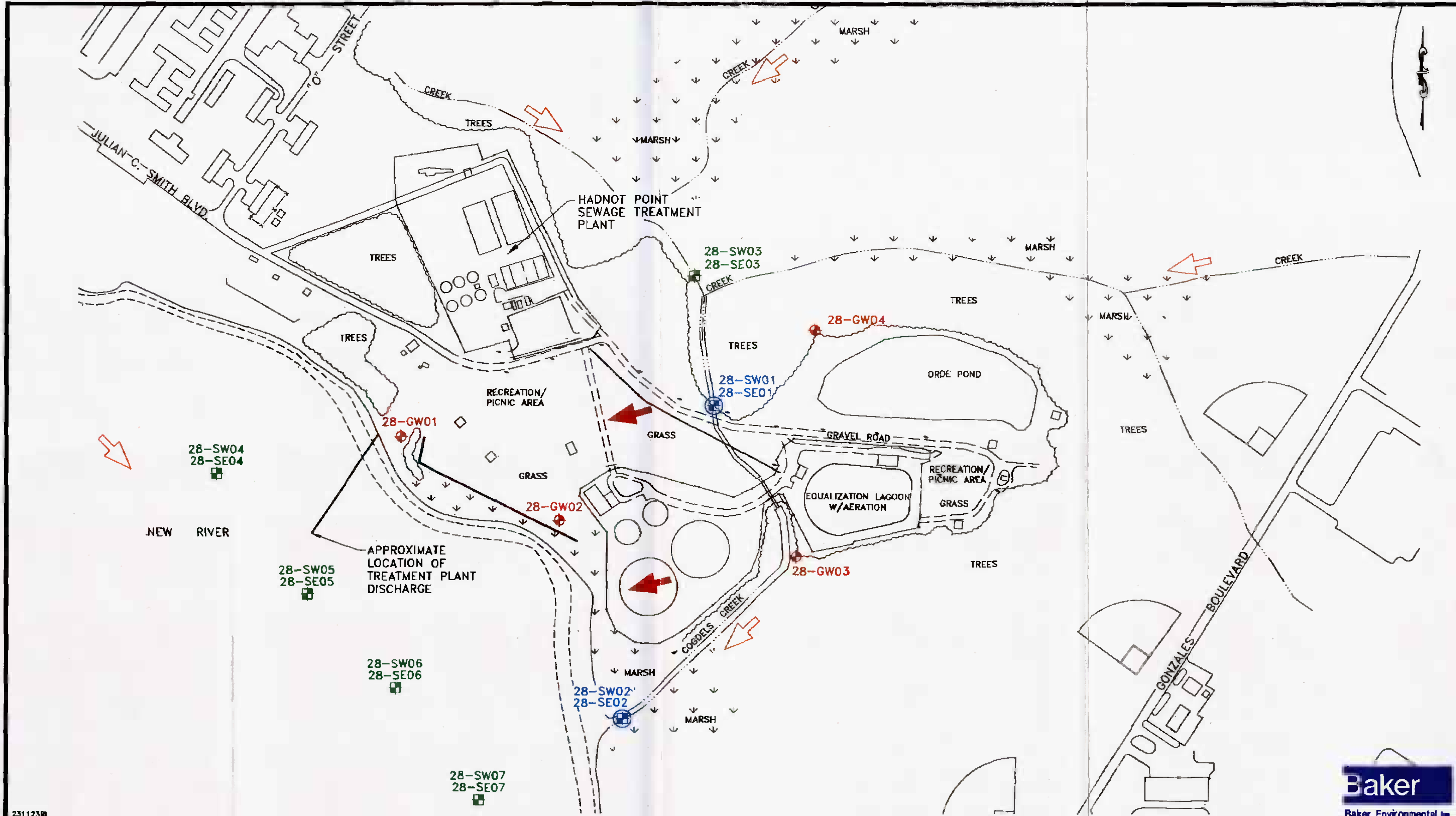
Baker
Baker Environmental, Inc.

SITE MAP
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120'
DATE NOVEMBER 1994

FIGURE No.
11-1

01500Q01X



LEGEND

28-GW01	SHALLOW MONITORING WELL (ESE, 1984)
28-SW03 28-SE03	SURFACE WATER AND SEDIMENT SAMPLING STATION (ESE, 1986)
28-SW01 28-SE01	SURFACE WATER AND SEDIMENT SAMPLING STATION (ESE, 1984)
	APPROXIMATE GROUNDWATER FLOW DIRECTION
	APPROXIMATE SURFACE WATER FLOW DIRECTION

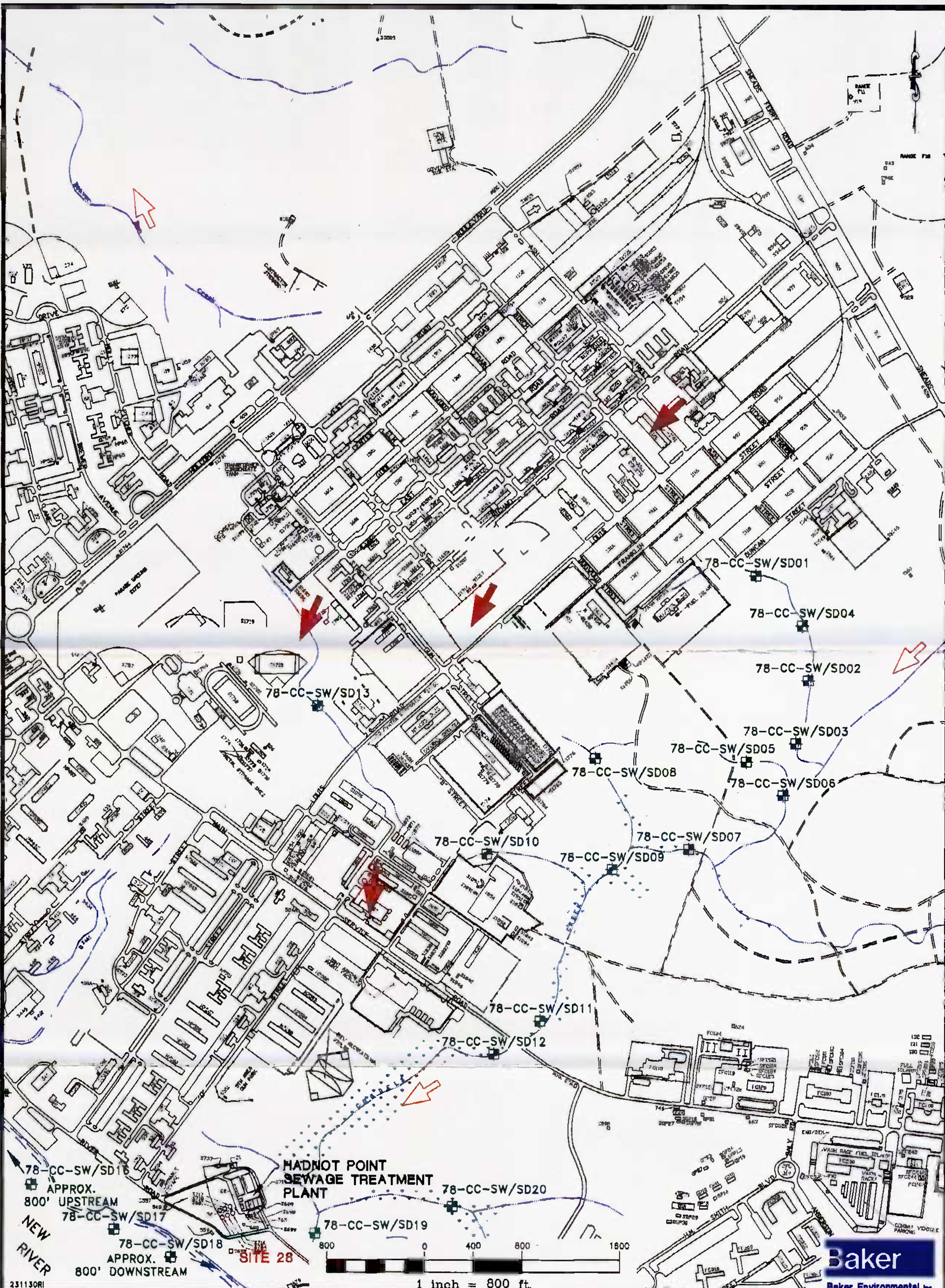
SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 11-2
SAMPLING LOCATIONS
CONFIRMATION STUDY
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CCAMP LEJEUNE
NORTH CAROLINA

01500 Q02 Y



LEGEND

78-CC-SW/SD01 SURFACE WATER(SW) AND SEDIMENT(SD) SAMPLE STATION (BAKER 1993)

APPROXIMATE GROUNDWATER FLOW DIRECTION

APPROXIMATE SURFACE WATER FLOW DIRECTION

NOTES:
- TYPICALLY 2 SEDIMENT SAMPLES (0-6" AND 6"-12") WERE COLLECTED AT EACH STATION.
- SAMPLE STATIONS 16, 17 AND 18 ARE LOCATED WITHIN THE NEW RIVER.

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 11-3
SURFACE WATER AND SEDIMENT STATIONS
HADNOT POINT DEVELOPMENT AREA
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q03X

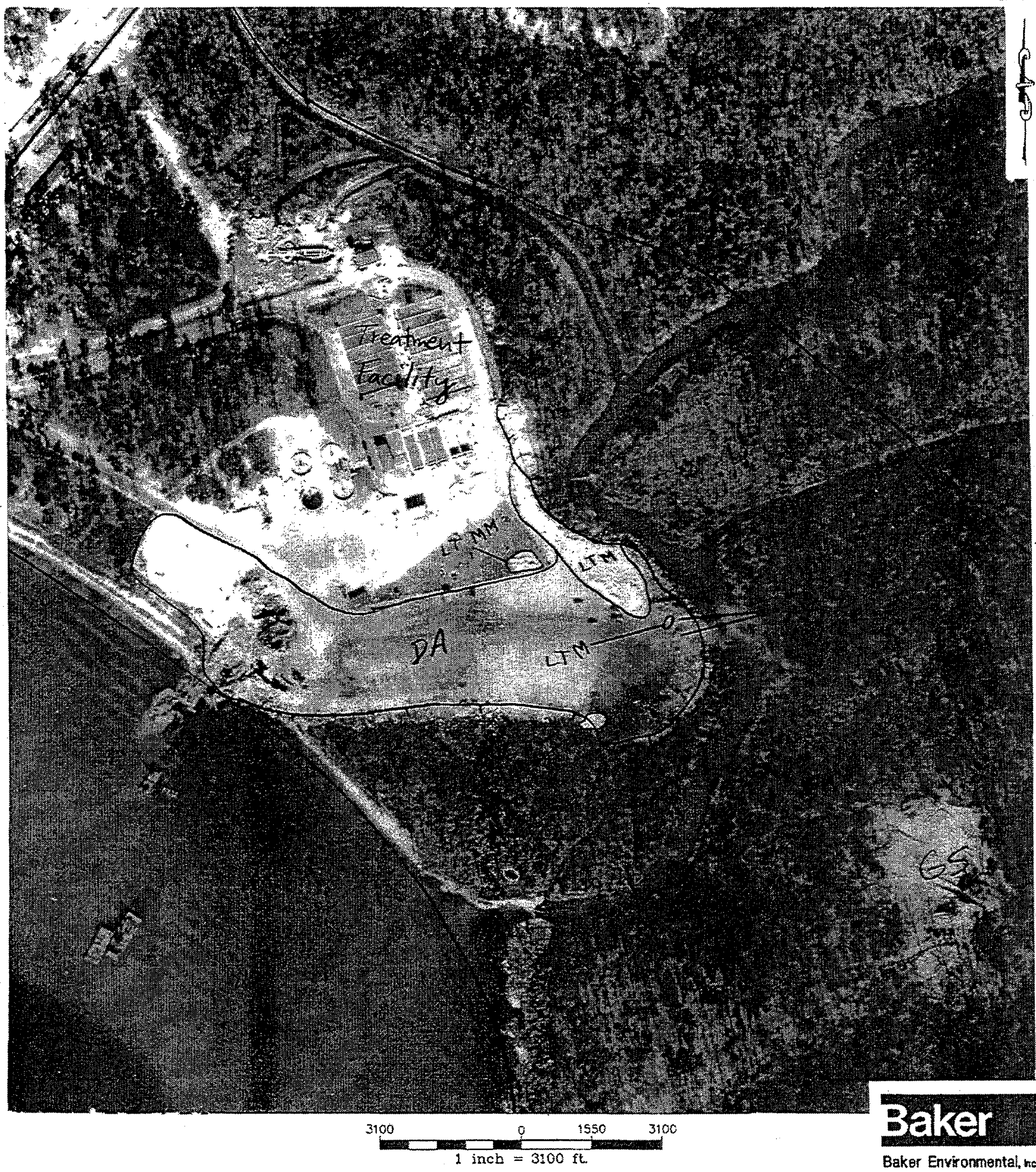
LEGEND

DA —DISTURBED AREA

—SURFACE WATER FLOW DIRECTION

SOURCE: EPIC, 1992

FIGURE 11–4
AERIAL PHOTOGRAPH, OCTOBER 1949
AERIAL PHOTOGRAPHIC INVESTIGATION
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO–0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

DA -DISTURBED AREA
GS -GROUND SCAR
M -MATERIAL
MM -MOUNDED MATERIAL
LT -LIGHT TONED
---- -ACCESS ROAD

SOURCE: EPIC, 1992

FIGURE 11-5
AERIAL PHOTOGRAPH, FEBRUARY 1952
AERIAL PHOTOGRAPHIC INVESTIGATION
SITE 28 - HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3000 0 1500 3000
1 inch = 3000 ft.

Baker
Baker Environmental, Inc.

LEGEND

DA -DISTURBED AREA
DK -DARK TONED
GS -GROUND SCAR
LQ -LIQUID
LT -LIGHT TONED
M -MATERIAL
POSS -POSSIBLE
ST -STAIN
TR -TRENCH

SOURCE: EPIC, 1992

FIGURE 11-6
AERIAL PHOTOGRAPH, FEBRUARY 1956
AERIAL PHOTOGRAPHIC INVESTIGATION
SITE 28 - HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

LEGEND

DA -DISTURBED AREA
DG -DISTURBED GROUND
DK -DARK TONED
GS -GROUND SCAR
LT -LIGHT TONED
M -MATERIAL
MT -MEDIUM TONED
PROB -PROBABLE
ST -STAIN

SOURCE: EPIC, 1992

FIGURE 11-7
AERIAL PHOTOGRAPH, NOVEMBER 1960
AERIAL PHOTOGRAPHIC INVESTIGATION
SITE 28 - HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3100 0 1550 3100
1 inch = 3100 ft.

Baker
Baker Environmental, Inc.

LEGEND

CA	–CLEARED AREA	PROB	–PROBABLE
DA	–DISTURBED AREA	REV	–REVEGATATED
DG	–DISTURBED GROUND		
GS	–GROUND SCAR		
LQ	–LIQUID		
M	–MATERIAL		
MM	–MOUNDED MATERIAL		
MT	–MEDIUM TONED		
POSS	–POSSIBLE		

SOURCE: EPIC, 1992

FIGURE 11–8
AERIAL PHOTOGRAPH, FEBRUARY 1964
AERIAL PHOTOGRAPHIC INVESTIGATION
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO–0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

12.0 STUDY AREA INVESTIGATIONS

The field investigation program at OU No.7, Site 28, was initiated to characterize potential disposal related impacts and threats to human health and the environment resulting from previous operations and disposal activities. This section discusses the site-specific RI field investigation activities that were conducted to fulfill that objective. The initial phase of the RI field investigation commenced on March 14, 1994, and continued through May 12, 1994. A second round of groundwater samples was collected in November of 1994. The RI field program at Site 28 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; and an aquatic and ecological survey. The following sections detail the various investigation activities which were implemented during the RI.

12.1 Site Survey

The site survey task was performed in two phases: Phase I - Initial Survey of Site Features and Proposed Sampling Locations; and Phase II - Post Investigation Survey of Monitoring Wells. W. K. Dickson and Associates was retained to perform both phases of the site survey. Phase I of the survey task was conducted at Site 28 during the week of March 14, 1994. Based upon information supplied in the Final Site Summary Report (ESE, 1990), surface features within and surrounding both the eastern and western suspected disposal areas were surveyed. The proposed soil boring and monitoring well locations, provided in the Final RI/FS Work Plan for OU No.7 (Baker, 1993), were also surveyed and then marked with wooden stakes. Each sample location was assigned a unique identification number that corresponded to the site and sampling media.

Phase II of the site survey task was completed at Site 28 during the week of May 9, 1994. During Phase II, all existing and newly installed monitoring wells were surveyed. Any supplemental or relocated soil borings completed during the investigation were also surveyed. A number of soil borings were relocated (i.e., moved more than ten feet from their proposed location) due to the presence of either underground or overhead utilities. In addition, newly installed staff gauges in Orde Pond and Cogdels Creek were surveyed. For each sampling point, monitoring well, and staff gauge a latitude, longitude, and elevation in feet above mean sea level (msl) were recorded.

12.2 Soil Investigation

The soil investigation performed at Site 28 was intended to assess the nature and extent of contamination that may have resulted from previous disposal practices or site activities. Additionally, the soil investigation was performed to assess the human health, ecological, and environmental risks associated with exposure to surface and subsurface soils. The following subsections describe soil sample collection procedures, locations, and the analytical program for soils at Site 28.

12.2.1 Drilling Procedures

Drilling activities at Site 28 commenced on March 24, 1994, and continued through March 29, 1994. Environmental Monitoring and Testing Corporation was retained to perform the drilling services. Soil borings were advanced by a truck-mounted drill rig using 3-1/4-inch inside diameter (ID), hollow stem augers. Split-spoon samples were collected from inside the augers according to ASTM Method D 1586-84 (ASTM, 1984). All drilling and sampling activities conducted at Site 28 were performed using Level D personnel protection. Soil cuttings obtained during the drilling program were collected, handled, and stored according to the procedures outlined in Section 12.7.

Two types of borings were installed during the soil investigation: exploratory borings (i.e., borings installed for sample collection and lithologic description or lithologic description only) and borings advanced for the purpose of monitoring well installation. Soil sampling intervals for the two types of borings differed only slightly, due to total depth requirements. Selected soil samples from each of the two types of borings were submitted for laboratory analysis (see Section 12.2.4). Soils obtained from exploratory borings were collected from the surface (i.e., ground surface to a depth of twelve inches) and then at continuous two-foot intervals, starting at one foot bgs. Drilling and continuous sample collection continued until the boring was terminated at the approximate depth of the water table, which varied at Site 28 from 3 to 17 feet bgs. An additional split-spoon was driven below the water table to confirm both groundwater depth and the absence of a wetting front (i.e., perched water table). Soils obtained from borings advanced for monitoring well installations were also obtained from the ground surface and at continuous two-foot intervals to the water table. However, once boring continued below the water table, soil samples were collected at five-foot intervals until the pilot boring was terminated. A summary of boring depths and sampling intervals for Site 28 is provided in Tables 12-1 through 12-3.

Each split-spoon soil sample was classified in the field by a geologist. Soils were classified using the Unified 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 site soils are provided on Test Boring Records in Appendix A and on Test Boring and Well Construction Records in Appendix B.

12.2.2 Sampling Locations

Soil samples were collected throughout Site 28, as depicted on Figure 12-1. The sampling distribution was intended to evaluate the vertical and horizontal extent of contamination at the site. The selection of sample locations was based on review of historical aerial photographs, Camp Lejeune historical records, and previous investigation data. Review of historical information indicated that surface activity occurred over several years and within well-defined areas of Site 28. The two suspected disposal areas lie on both the east and west side of Cogdels Creek.

A total of 47 borings were advanced to assess suspected disposal practices at Site 28; seven of those borings were converted to monitoring wells. As indicated on Figure 12-1, 27 of the boring locations were advanced on the western portion of the site, including the monitoring well test borings. A total of 18 soil borings and monitoring well test borings were advanced on the eastern portion of the site. Two additional borings adjacent to the eastern portion of the site, 28-BB-SB37 and 28-BB-SB38, were advanced to assess background contaminant concentrations (refer to Figure 12-1).

Seven exploratory test borings were advanced to further evaluate the nature and extent of fill material and debris within the suspected disposal areas of the site. The locations of these borings (28-W-SB39, 28-E-SB40, 28-W-SB43, 28-W-SB44, 28-W-SB45, 28-W-SB46, and 28-W-SB47) are depicted on Figure 12-1. The borings were advanced to collect soils for identification purposes only (i.e., no samples were submitted for chemical analysis). Exploratory test borings were substituted for test pits during the RI because the site is actively used for recreation.

12.2.3 Sampling Procedures

Surface (i.e., ground surface to 12 inches bgs) and selected subsurface (i.e., greater than one foot bgs) soil samples were retained for laboratory analysis. Both surface and subsurface samples were collected to evaluate the nature and both horizontal and vertical extent of potentially impacted soils. Only the surface soils, however, were employed for human health and ecological risk assessment evaluation. A summary of boring numbers, depths, intervals, and analytical parameters for Site 28 soil samples is provided in Tables 12-1 through 12-3.

Soil samples were obtained via a drill rig (i.e., split-spoon samples) as described in the drilling procedures section. Surface samples were collected by slowly advancing the augers to approximately 12 inches bgs so that the soil cuttings could be retained for the grab sample. When the sampling location was covered with grass or humus material, the first inch of matted roots was removed prior to advancing the augers. Stainless steel sampling spoons were also used to collect grab samples of surface soil, when conditions permitted (i.e., presence of unconsolidated or loose soil material). Deeper subsurface grab samples were collected with a split-spoon sampler in accordance with ASTM Method D 1586-84. The augers, split-spoons samplers, and stainless steel spoons were decontaminated prior to sample collection according to the procedures outlined in Section 12.6.

A minimum of two samples were retained for laboratory analysis from each of the boring locations. In some cases, a third sample from the borehole was also submitted for analysis if indications of contamination (i.e., elevated photoionization detector (PID) readings or visual contamination) were noted or if the encountered groundwater table was greater than ten feet bgs. Soil samples retained for analysis were prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs). Samples collected for volatile organic analysis were extracted with a stainless-steel spoon from different sections of the split-spoon which represented the entire sampling interval. Precautions were taken not to aerate the sample so as to minimize volatilization. Samples retained for other analytical parameters (e.g., semivolatiles, pesticides, PCBs, and metals) were first thoroughly homogenized and then placed in the appropriate laboratory containers.

Following sample collection, each sample retained for laboratory analysis was stored on ice in a cooler. Sample preparation also included documentation of sample number, depth, location, date, time, and analytical parameters in a field logbook. Chain-of-Custody documentation, (provided in Appendix C) which included information such as sample number, date, time of sampling, and sampling personnel, accompanied the samples to the laboratory. Samples were shipped overnight via Federal Express to CEIMIC, Corporation for analysis.

12.2.4 Analytical Program

The analytical program initiated during the soil investigation at Site 28 focused on the suspected contaminants of concern, which were based on previous disposal practices. Soils collected from the former disposal areas were analyzed for the full TCL organics (i.e., TCL volatiles, semivolatiles, pesticides, and PCBs) and TAL inorganics, and in a few cases, for TPH. Soil samples obtained from monitoring well test borings were also analyzed for full TCL organics and TAL inorganics. A summary of test boring numbers, depths, intervals, and analytical parameters for Site 28 is provided in Tables 12-1 through 12-3.

In addition to analyzing for the contaminants of concern, two test borings were advanced and soils were collected for analysis of engineering parameters (i.e., particle size, and Atterberg limits) and Toxicity Characteristic Leaching Procedure (TCLP). Both sample types consisted of composites of individual grab samples collected from the ground surface to the water table. The TCLP samples were employed to characterize the nature of the visually contaminated fill material (i.e., soil comprised primarily of burnt material). Samples were prepared and handled as described in the previous section (i.e., samples were thoroughly homogenized prior to filling the sample jars).

12.2.5 Quality Assurance and Quality Control

Field QA/QC samples were also collected during the soil investigation. These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); (2) evaluate field methodologies (e.g., 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). Four types of field QA/QC samples were collected and analyzed including: duplicate samples, equipment rinsates samples, field blanks, and trip blanks. Section 3.2.5 of Volume I provides a detailed description of the QA/QC Sampling Program.

Table 12-4 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed.

12.2.6 Air Monitoring and Field Screening

Several air monitoring and field screening procedures were implemented during the 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 PID to monitor for airborne contaminants. Moreover, samples (i.e., 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 Well Construction Records which are provided in Appendices A and B. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

12.3 Groundwater Investigation

The groundwater investigations performed at OU No. 7, Site 28, were intended to assess the nature and extent of contamination that may have resulted from previous disposal practices or site activities. Additionally, the groundwater investigations were performed to assess human health and environmental risks associated with exposure to groundwater. The following subsections describe well installation procedures, sample collection procedures, and the analytical program employed during the groundwater investigation at Site 28.

Two rounds of groundwater samples were collected at Site 28. One round, which included sample collection from all existing and newly installed wells, was conducted in April and May of 1994 and was part of the original scope of work. A second round of groundwater sampling was performed in November of 1994 and included the resampling of the round one wells. The second round was conducted to confirm the presence or absence of contaminants detected during round one, specifically metals and pesticides.

12.3.1 Monitoring Well Installation

Six shallow Type II monitoring wells (i.e., wells installed without casing to seal off a confining layer) were installed at Site 28 between April 7, and April 20, 1994. Locations of the newly installed monitoring wells are depicted on Figure 12-2. The six shallow monitoring wells were situated to collect potentially impacted groundwater from the suspected disposal areas, thus characterizing the nature and horizontal extent of contamination, and to evaluate the flow patterns of the surficial aquifer. In addition to the five shallow wells, three deep Type II monitoring wells were installed between April 7, and April 26, 1994, at Site 28, as illustrated on Figure 12-2. The three deep monitoring wells were installed to characterize the nature and vertical extent of contamination and to evaluate the flow pattern of the deeper aquifer (i.e., the Castle Hayne aquifer). Placement of the newly installed monitoring wells was based on review of historical aerial photographs, Camp Lejeune records, and analytical data from previous investigations.

The shallow monitoring wells were installed after the boreholes were advanced. Each borehole was overdrilled with 6-1/4-inch ID hollow stem augers prior to shallow well installation. Shallow well depths ranged from 17 to 30 feet bgs and deep well depths ranged from 126 to 133 feet bgs. In general, the shallow wells were installed approximately 10 feet below the water table encountered during the initial test boring. Shallow monitoring wells were installed at depths and with screen interception intervals sufficient to compensate for seasonal variations in the water table, which is known to fluctuate from 2 to 4 feet. Well construction details are summarized on Table 12-5, and well construction diagrams are shown on the Test Boring and Well Construction Records provided in Appendix B.

The deep monitoring wells were installed upon completion of pilot hole test borings. Pilot hole test borings were advanced using of the mud rotary drilling method. Each borehole was drilled with a 8-3/4-inch OD roller bit prior to well installation. Screened intervals were set in geologic material, from 114 to 126 feet bgs, that best represented the upper portion of the Castle Hayne aquifer. Well construction details are summarized on Table 12-5, and well construction diagrams are depicted on the Test Boring and Well Construction Records provided in Appendix B.

Both the shallow and deep wells were constructed of 2-inch nominal diameter, Schedule 40, flush-joint and threaded PVC casing. Justification for the use of PVC casing is provided in Appendix B of the Field Sampling and Analysis Plan for Operable Unit No.7 (Baker, 1993a). Each well, upon completion, had a 15-foot screened interval comprised of a 10- and five-foot long No. 10 (i.e., 0.01 inch) slotted screen section. A fine-grained sand pack (i.e., No. 1 silica sand), extending approximately 2 feet above the top of the screen, was placed in the annulus between the screen and the borehole wall from inside the augers during shallow well installation. The sandpack was poured manually down the borehole during deep well installation. A 2- to 3-foot sodium bentonite pellet seal was then placed above the sandpack by dropping pellets down the borehole. The bentonite pellets were then hydrated with potable water. The seal was installed to prevent cement or surface run-off from intruding into the sand pack. The remaining annular space was backfilled with a mixture of Portland cement and 5 percent bentonite. A 4-inch protective well casing with cover was then placed over the well and set into the cement. In addition, a protective locking cap was installed at the top of the PVC well. A 5-foot by 5-foot concrete pad was placed around the protective well casing and four protective bollard posts were installed around the corners of the concrete pad. Well tags, which provide construction information, were installed at the top of each well. Typical shallow and deep Type II well construction details are shown on Figures 12-3 and 12-4, respectively.

12.3.2 Monitoring Well Development

Following well construction and curing of the bentonite seal, each newly installed monitoring well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the surrounding formation. The shallow wells were developed by a combination of surging and pumping. The deep wells were development by using a forced air system, with filter and "air lifting" the water out of the well. Typically, 20 to 40 gallons of water were evacuated from the shallow wells, followed by 10 minutes of surging, then continued pumping. Anywhere from 100 to 250 gallons of water, approximately 3 to 5 borehole volumes, were evacuated from the deep wells. Groundwater recovered during well development was temporarily stored in drums, then transferred into an on-site tanker (refer to Section 3.5 for IDW handling). Pumping hoses, constructed of flexible PVC, were used once and discarded to minimize the potential for cross contamination.

Three to five borehole volumes were removed from each well, where conditions permitted, until the groundwater was essentially sediment-free. Measurements of pH, specific conductance, and temperature were recorded at each volume to assist in determining well stabilization. Additionally, periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow water-bearing zone. Well Development Forms that summarize this information are provided in Appendix D.

12.3.3 Water Level Measurements

Static water level measurements were collected after all well development activities had been completed. Measurements were recorded from top-of-casing (TOC) reference points, marked on the PVC casing at each existing and newly-installed well (refer to Section 13). A complete round of the measurements was collected on May 10, 1994. Groundwater measurements were recorded using an electric measuring tape. Measurements were recorded to the nearest 0.01 foot from TOC. Water level data from site monitoring wells and staff gauges were collected within a three-hour period. In addition, water levels within a shallow and deep well cluster were monitored for a 24-hour period using automatic data loggers. The data were employed to evaluate the possible tidal effects of the New River on local groundwater.

12.3.4 Sampling Locations

Round one groundwater samples were collected from four existing shallow wells (28-GW02 through 28-GW04, and 28-GW13), the six newly installed shallow wells (28-GW01, and 28-GW05 through 28-GW09), a temporary well (28-TGWPA), and the three newly installed deep wells (28-GW01DW, 28-GW07DW, and 28-GW09DW) at Site 28. However, a sample was not collected from existing well 28-GW01. As a result of vandalism, existing well 28-GW01 was abandoned according to procedures outlined in Section 12.3.9 and replaced during the groundwater investigation. During round two, groundwater samples were collected from all of the round one wells, with the exception of the temporary wells. The locations of the newly installed, temporary, and existing monitoring wells are depicted on Figure 12-2.

A temporary well (28-7GWPA) was installed near the center of the western disposal area to evaluate the shallow groundwater quality within the burn dump. The very loose nature of the fill material and the presence of buried debris made the installation of a permanent monitoring well at this location impossible.

An existing upgradient well was utilized as a reference sampling station for shallow groundwater. Monitoring well 28-GW13 (see Figure 12-2) was installed as part of a nearby UST investigation and resampled during the RI at Site 28.

A number of monitoring wells were relocated based upon field observations or quick turnaround soil sample analyses. The quick turnaround alanlyses are performed using the same CLP procedures and QA/QC standards as routine samples. Monitoring well 28-GW05 was relocated to the eastern potion of Site 28 in order to evaluate shallow groundwater from the suspected eastern disposal area. A thick lens of clay was encountered at the proposed location of monitoring well 28-GW05 and, as a result, the boring was abandoned in favor of a more suitable well location. A shallow and deep monitoring well cluster, 28-GW07 and 28-GW07DW, was relocated from the eastern to the western portion of the site. The cluster was relocated in order to evaluate groundwater quality, both shallow and deep, downgradient of the former burn dump area. No evidence of burnt material or buried debris was observed during the soil investigation of the eastern portion of the site. An additional shallow and deep well cluster was relocated downgradient of the burn dump area upon quick turn soil analysis, well abandonment activities, previous investigation data, and the unconsolidated nature of the soils on the western portion of the site, The relocated monitoring well cluster, 28-GW01 and 28-GW01DW, was situated to evaluate the shallow and deep aquifer downgradient of the site.

12.3.5 Sampling Procedures

Groundwater samples were collected to confirm the presence of contamination in the shallow and deep aquifers, which may have resulted from previous site disposal practices. At Site 28, the contaminants of concern were volatiles, polynuclear aromatic hydrocarbons (PAHs), pesticides, and PCBs. Information regarding suspected contaminants was based upon previous investigative results and historical records. Accordingly, the sampling program initiated at Site 28 focused on these contaminants.

Prior to groundwater purging, a water level measurement from each well was obtained according to procedures outlined in Section 12.3.3. The total well depth was also recorded from each well to the nearest 0.1 foot using a decontaminated steel tape. Water level and well depth measurements were used to calculate the volume of water in each well and the volume of water necessary to purge the well.

A minimum of three to five well volumes were purged from each well prior to sampling. Measurements of pH, specific conductance, and temperature were taken after each well volume was purged to ensure that the groundwater characteristics had stabilized before sampling. In addition, turbidity was also measured during round two. These measurements were recorded in a field logbook and are provided in Table 12-6. Purge water was contained and handled as described in Section 12.7.

Round one groundwater samples were collected using decontaminated teflon bailers (i.e., bottom loading bailer). A single teflon bailer was employed to both sample and purge groundwater from each of the wells. The samples were introduced directly from the bailer into laboratory-prepared sample containers and stored on ice. Sample bottles for VOC analysis were filled first, followed by SVOCs, pesticides, PCBs, and TAL metals (total and dissolved). Volatile samples were collected by slowly pouring water from the bailer into 40 ml vials to minimize volatilization. Samples analyzed for dissolved metals were filtered in the field and sent in containers with nitric acid

(HNO_3) preservative. The dissolved groundwater samples were filtered through a disposable 0.45 micron membrane using a perstaltic pump.

Analytical results from the first round of sampling exhibited total metal concentrations frequently in excess of state and federal groundwater standards. These elevated metal detections were primarily due to an abundance of total suspended solids, or colloids, in samples collected during the first round. Metals adhere to these colloids, thus yielding artifically high concentrations. The use of a bailer during sample acquisition tends to increase the percentage of colloids. Through agitation, colloids can move from the formation and through the sand pack into the well, and subsequently impact the sample. As a result, data from the first round of sampling reflect the presence of colloids rather than true groundwater conditions. The purpose of the second sampling round was to minimize sample disturbance, thus reducing the occurrance of colloids. The second round of groundwater data more accuaratly depicts actual groundwater conditions at Site 28.

During the round two sampling event, a low flow well purging and sampling technique was employed. The sampling metodology was developed in response to conversations with USEPA Region IV personnel in Athens, Georgia. A submersible pump (Redi-Flow 2), set two to three feet into the static water column, was used to purge each of the wells. While purging groundwater from each of the monitoring wells, a flow rate of less than one gpm was maintained. Samples collected for both organic and metal analyses were obtained directly from the pump discharge. The pump and associated tubing were decontaminated with a Liquinox soap solution and then thoroughly rinsed with deionized water (refer to Section 12.6 for decontamination procedures). Rinsate blanks were collected from the pump to verify that proper decontamination procedures were implemented.

Preparation of groundwater samples incorporated procedures similar to those described for soil samples. Sample information, including well number, sample identification, time and date of sample collection, samplers, analytical parameters, and required laboratory turnaround time, was recorded in a field logbook and on the sample labels. Chain-of-custody documentation (provided in Appendix C) accompanied the samples to the laboratory.

12.3.6 Analytical Program

Round one groundwater samples were analyzed from four existing shallow wells, six newly installed shallow wells, three newly installed deep wells, and one temporary well. During the first groundwater sampling round, representative samples were analyzed for the following: volatiles, semivolatiles, and TAL metals (total and dissolved). During the second sampling round, all groundwater samples were analyzed for TAL metals (total and dissolved), TSS, and TDS; moreover, a limited number of samples were also analyzed for TCL pesticides. Table 12-7 provides a summary of groundwater samples submitted for laboratory analysis. The groundwater samples were analyzed using Contract Laboratory Program (CLP) protocols and Level IV data quality.

In addition to analyzing for the contaminants of concern, one groundwater sample from shallow well 28-GW01 was submitted for analysis of water chemistry parameters. Water chemistry parameters include: total dissolved solids, total suspended solids, fluoride, chloride, total kjeldahl nitrogen, biological oxygen demand, chemical oxygen demand, and alkalinity.

12.3.7 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the groundwater investigation. These samples included trip blanks, equipment rinsates, and duplicates. Equipment rinsates were collected from the sampling bailers and submersible pump prior to usage. Section 12.2.5 provides a summary of QA/QC samples collected during the investigation. Table 12-8 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 28.

12.3.8 Field Screening and Air Monitoring

Several air monitoring and field screening procedures were used during the groundwater sampling activities for health and safety and initial contaminant monitoring. Air monitoring and field screening procedures implemented at Site 28 included the screening of well heads, and the purged groundwater with a PID for volatile organic vapors. Measurements obtained in the field were recorded in a field logbook. Note, prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

12.3.9 Well Abandonment

The objective of well abandonment activities at Site 28 was to remove an existing well, 28-GW01, so that the borehole would not allow contaminants to migrate from the ground surface to the water table or between aquifers. The well was abandoned because a petroleum product, possibly motor oil, had been poured into the protective casing and well stick-up. The well casing, well screen, and filter pack materials were removed and then the borehole was backfilled with mixture of Portland cement and five percent bentonite according to USEPA Region IV procedures. Hollow stem augers were employed to clean the borehole and remove filter pack materials. Backfill material was placed into the borehole from the bottom to the top using the positive displacement method (i.e., tremie method). The concrete pad and protective bollard posts were also removed. Finally, the ground surface was graded and returned to near-original condition.

12.4 Surface Water and Sediment Investigation

An overview of the surface water and sediment investigation conducted at Site 28 is provided in this section. Surface water and sediment samples were collected at Site 28 from March 21, through April 8, 1994. Additionally, prior to collecting the surface water samples, staff gauges (see Figure 12-5) were installed in Orde Pond and Cogdels Creek to monitor surface water levels throughout the field program. The following subsections describe the surface water and sediment sampling locations, sampling procedures, analytical program, and quality assurance and quality control program for Site 28.

12.4.1 Sampling Locations

A total of 14 surface water and 28 sediment samples were collected at Site 28. From each sampling station one surface water and two sediment samples were collected. Two of the sampling stations were located in Orde Pond, seven were located in Cogdels Creek, and five were located in the New River. Figure 12-5 depicts the locations of the 14 surface water and sediment sampling locations. Surface water samples were assigned the designation SW and SD was specified for identification of sediment samples.

12.4.2 Sampling Procedures

At each of the 14 surface water sampling stations, samples were collected by dipping containers directly into the water surface. Samples analyzed for volatiles were obtained first. Additional analytical fractions were collected immediately following the volatile fraction. Care was taken to avoid excessive agitation that could result in loss of VOCs. Water quality readings were taken at each sampling station (i.e., pH, specific conductance, and temperature). The water quality readings compiled during the surface water and sediment investigation are presented in Table 12-9.

Sediment samples were collected below the aqueous layer by driving a sediment corer, equipped with a disposable tube, into the sediments. The sediment was then extruded from the disposable sampling tube and placed into the appropriate sample containers. Sampling containers were provided by the laboratory and certified to be contaminant free. The volatile fraction was collected first, followed by the remaining analytical parameters. Samples to be analyzed for TCL semivolatile, pesticides, PCBs, and TAL metals were thoroughly homogenized before the sample jars were filled. The first six inches of sediment at each station were submitted for analyses separately from sediments collected at the 6- to 12-inch depth. Surface water and sediment samples were collected at downstream sampling locations first, then, at upstream stations. All sample locations were marked by placing a pin flag or wooden stake at the nearest point along the bank.

12.4.3 Analytical Program

The analytical program at Site 28 was intended to accurately assess the nature and extent of contamination in surface waters and sediments that may have resulted from past disposal practices. As a result, the analytical program focused on suspected contaminants of concern and the overall quality of surface water and sediment. Both surface water and sediment samples were analyzed for full TCL organics and TAL inorganics. In addition, surface water samples were analyzed for water hardness. A summary of the surface water and sediment analytical program is provided in Table 12-10.

12.4.4 Quality Assurance and Quality Control

Field QA/QC samples were also collected during the surface water and sediment investigation at Site 28, including duplicate samples, equipment rinsate samples, and trip blanks. Table 12-11 provides a summary of the QA/QC sampling program conducted during the surface water and sediment investigation at Site 28. Section 12.2.5 lists the various QA/QC samples collected during the sampling program at Site 28 and the frequency at which they were obtained.

12.5 Aquatic and Ecological Survey

An aquatic and ecological survey of Site 28 was conducted during the RI field investigations at OU. No. 7, Site 28. The following subsections discuss the type of media sampled, sampling locations, sampling procedures, and the analytical program applied to the survey.

12.5.1 Media Types

Biological samples collected at Site 28 consisted of fish and benthic macroinvertebrates. Crab collection was proposed at Site 28, however, only one was captured during the sampling events and was not sent to the laboratory for tissue analysis. The biological samples were collected to obtain population statistics of fish and benthic macroinvertebrates and to obtain fish tissue samples for chemical analysis.

12.5.2 Sampling Locations

Fish and benthic macroinvertebrates were collected from Orde Pond, from three sampling stations in Cogdels Creek, and from two sampling stations in the New River. Figure 12-6 depicts the locations of the five sampling stations and Orde Pond. Fish and benthic sampling stations were located at or in the immediate vicinity of surface water and sediment stations.

12.5.3 Sampling Procedures

A literature review was conducted to determine the fish species that may potentially be exposed to contaminants. This review included the compilation of information from State and Federal natural resources agencies. In addition, experience with sampling similar areas was employed to form a database of expected species.

Originally, three species of fish were to be sampled for tissue analysis, with each species being a representative of one of three trophic (feeding) groups. These groups included top carnivores (first order predator), forage fish (second order predator), and bottom feeders (third order predator). In addition, flesh from a minimum of ten adult individuals of preferably uniform size per specie, if available, were to be composited and analyzed for whole body burden and fillet burden of chemicals. The same species of fish were to be sampled from each station. A fish species was successfully collected if the above requirements were satisfied. These requirements were identified by the U.S. Fish and Wildlife Service as part of the Work Plan review.

Sampling variability may prevent the same species of fish from being sampled at each station. Two possible scenarios that may contribute to sampling variability are: (1) the preferred species was not captured, or (2) adequate numbers of uniform-size individuals were not captured. If the preferred species was not successfully collected to satisfy the above requirements, an attempt was made to collect a substitute species, exhibiting a similar trophic position in the estuarine ecosystem.

The collected fish species were identified, measured, and counted. The small fish (less than 20 mm) were weighed in groups of 10 or 20 because of their low individual weight; the larger fish were weighed individually. The proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fin damage, and skeletal anomalies was recorded at each station. Fish that exhibited signs of decay prior to sample shipment (i.e., brown gills, bloating) were not retained for tissue analysis, due to potential leaching of contaminants from the organs into the edible portions of the fish.

Prior to initiating the sampling event at each station, the following information describing the site was recorded in the field log book:

- 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

Water quality measurements were collected during the benthic macroinvertebrate sampling and during collection of some of the fish samples. On-site water quality measurements at these stations consisted of temperature, pH, specific conductance, salinity, and dissolved oxygen. Table 12-12 provides a summary of the water quality readings compiled during the aquatic and ecological survey. The following subsections describe specific sampling procedures applied to each of the three estuarine environments:

Orde Pond

Fish were collected in Orde Pond using a boat-mounted Smith-Root, Inc. electrofisher, powered by a 5,000-watt portable generator. A DC current was applied to the water utilizing the boat as the cathode and a hand-held electrode as the anode. The length of shocking time per subsection was recorded as seconds-of-applied-current. Stunned fish were collected with one-inch mesh or smaller dip nets handled by members of the field sampling team.

Cogdels Creek

Fish were collected in Cogdels Creek using gill nets and hoop nets. The gill nets were six feet across by 50 feet long with a mesh size ranging from two to four inches and an approximate twine break strength of 29 pounds. The nets were deployed approximately at the locations shown on Figure 12-6. Weights were attached to the nets to secure them on the bottom of the stream and yellow buoys marked with "Baker Environmental" were attached to the tops of the nets. The nets were deployed in the morning or evening, and they were checked for fish within twelve hours after deployment. Two separate attempts were made to collect fish in Cogdels Creek. However, due to the limited number of fish that were collected during both attempts, fish samples from Cogdels Creek were not submitted for laboratory analysis.

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 in a forty-five 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. Typically, fish survive when captured in these nets.

New River

Fish were collected in the New River over several days using gill nets and haul seine. Crab pots were deployed to collect blue crabs. The gill nets were six feet across by 50 to 100 feet long with a mesh size ranging from two to four inches and an approximate twine break strength of 29 pounds. The nets were deployed at the locations shown on Figure 12-6. Weights were attached to the nets to secure them on the bottom of the stream and yellow buoys marked with "Baker Environmental" were attached to the tops of the nets. The nets were deployed in the morning or evening, and they were checked for fish within twelve hours after deployment.

Crab pots were used to sample for blue crabs at each of the New River stations. The crab pots were baited with dead fish and were deployed with the pot resting on the sediment. The crab pots were checked once or twice daily.

Benthic macroinvertebrates were collected from a boat using a standard ponar grab. The dimensions of the ponar are 23 x 23 cm (9 x 9 in.) for a sampling area of 529 cm^2 or 0.0523 m^2 (81 in^2). The ponar was deployed from a boat, which was positioned in slightly different locations for each replicate to prevent re-sampling the same area. After retrieving the ponar with a sediment sample, it was opened into a clean tub and the sediments were removed with a Teflon spatula. The sediments were transferred to a 0.5 mm sieve that was agitated (by hand) in water to remove the small particles. The remaining contents in the sieve were transferred into 16-ounce plastic sample jars. The jars were filled up to one-half full with sediments, and buffered formalin solution (10 percent by weight) was added to the remainder of the jar to preserve the benthic macroinvertebrates contained in the sediments. A 100 percent cotton paper label, marked in pencil with the sample number, was placed inside the jar. The outside of the jar was labeled with the sample number using a black permanent marker to identify the sample containers.

12.5.4 Analytical Program

The analytical program at Site 28 was intended to accurately represent the nature of contamination in biotic organisms which may have resulted from past disposal practices at Site 28. The analytical program focused on suspected contaminants of concern and specie diversity. Fish tissue samples were analyzed for full TCL organics and TAL inorganics. A taxonomic identification of benthic macroinvertebrates was also performed. The benthic samples were sent to RMC Environmental Services in Spring City, Pennsylvania for identification.

12.6 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 the drill rig, hollow-stem augers, and drill and sampling rods. Routine sample collection equipment included split spoons, stainless steel spoons and bowls, and Teflon bailers.

For heavy equipment, the following procedures were implemented:

- Removal of caked-on soil with 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 twice with isopropol alcohol
- Air dry
- Wrap in aluminum foil, if appropriate

Temporary decontamination pads, constructed of wood and plastic, were constructed 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 12.7.

12.7 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 28 resulted in the generation of various IDW. This IDW included drilling mud, soil cuttings, well development and purge water, and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

1. Collection and containerization of IDW material.
2. Temporary storage of IDW while awaiting confirmatory analytical data.
3. 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.
Both non-contaminated and contaminated wastewater were sent off site to a licensed hazardous waste disposal facility. The IDW soils were returned, based on confirmatory analytical data, to their respective source areas. Appendix F provides information on the management and disposal of the IDW.

SECTION 12.0 TABLES

TABLE 12-1

SOIL SAMPLING SUMMARY
TEST BORINGS
SITE 28, HADNOT POINT BURN DUMP (WEST)
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	Analytical Parameters							
			TCL Organics	TAL Metals	TPH	TCL VOC	TCL SVOC	TCLP	Engineering Parameters(1)	Duplicate Sample
28-W-SB01	19	0-1.0	X	X						
		7-9	X	X						
		15-17	X	X						
28-W-SB02	17	0-1.0	X	X						
		7-9	X	X						
		13-15	X	X						
28-W-SB03	13	0-1.0	X	X						
		5-7	X	X						
		9-11	X	X						
28-W-SB04	15	0-1.0	X	X						X
		5-7	X	X						
		11-13	X	X						
28-W-SB05	9	0-1.0	X	X						
		7-9	X	X						X
28-W-SB06	15	0-1.0	X	X	X					
		11-13	X	X	X					
28-W-SB07	17	0-1.0	X	X						
		1-3	X	X						
		11-13	X	X						
28-W-SB08	11	0-1.0	X	X						
		3-5	X	X						
28-W-SB09	17	0-1.0	X	X						
		13-15	X	X						
28-W-SB10	17	0-1.0	X	X						
		5-7	X	X						
		11-13	X	X						
28-W-SB11	11	0-1.0	X	X						
		5-7	X	X						X
28-W-SB12	15	0-1.0	X	X						X
		9-11	X	X						
28-W-SB13	17	0-1.0	X	X						
		11-13	X	X						
28-W-SB14	9	0-1.0		X	X					
		3-5								
28-W-SB15	15	0-1.0	X	X						
		9-11		X						
28-W-SB16	13	0-1.0	X	X						
		9-11		X						

TABLE 12-1 (Continued)

SOIL SAMPLING SUMMARY
TEST BORINGS
SITE 28, HADNOT POINT BURN DUMP (WEST)
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	Analytical Parameters							
			TCL Organics	TAL Metals	TPH	TCL VOC	TCL SVOC	TCLP	Engineering Parameters[1]	Duplicate Sample
28-W-SB17	13	0-1.0	X	X						
		9-11		X						
28-W-SB18	7	0-1.0	X	X						
		1-3		X						
28-W-SB19	9	0-1.0	X	X						
		5-7		X						
28-W-SB20	5	0-1.0	X	X						
		1-3		X						
28-W-SB39	18	No samples were retained for laboratory analysis								
28-W-SB41	18	0-18/ composite						X	X	
28-W-SB43	24	No samples were retained for laboratory analysis								
28-W-SB44	26	No samples were retained for laboratory analysis								
28-W-SB45	22	No samples were retained for laboratory analysis								
28-S-SB46	26	No samples were retained for laboratory analysis								
28-W-SB47	24	No samples were retained for laboratory analysis								

Notes: (1) Engineering parameters include full TCLP, RCRA hazardous waste characteristics, grain size, and Atterberg limits.

TCL Organics include volatiles, semivolatiles, pesticides, and PCBs.

TABLE 12-2

SOIL SAMPLING SUMMARY
TEST BORINGS
SITE 28, HADNOT POINT BURN DUMP (EAST)
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	Analytical Parameters							
			TCL Organics	TAL Metals	TPH	TCL VOC	TCL SVOC	TCLP	Engineering Parameters(1)	Duplicate Sample
28-E-SB21	7	0-1.0	X	X						
		3-5	X	X						
28-E-SB22	7	0-1.0		X	X					
		3-5		X	X					
28-E-SB23	9	0-1.0	X	X						X
		5-7	X	X						
28-E-SB24	9	1-1.0	X	X						
		5-7		X						
28-E-SB25	11	0-1.0	X	X						
		5-7	X	X						
28-E-SB26	11	0-1.0	X	X						
		5-7		X						
28-E-SB27	11	0-1.0	X	X						
		7-9		X						
28-E-SB28	9	0-1.0	X	X						
		5-7	X	X						
28-E-SB29	7	0-1.0	X	X						X
		5-7		X						
28-E-SB30	13	0-1.0		X	X					
		5-7		X	X					
		9-11		X	X					
28-E-SB31	9	0-1.0	X	X						
		3-5	X	X						
28-E-SB32	15	0-1.0	X	X						
		5-7		X						
		11-13		X						
28-E-SB33	15	0-1.0	X	X						
		5-7		X						
		11-13		X						
28-E-SB34	17	0-1.0	X	X						
		5-7		X						
		11-13		X						
28-E-SB35	13	0-1.0	X	X						
		9-11		X						
28-E-SB36	11	0-1.0	X	X						
		7-9	X	X						

TABLE 12-2 (Continued)

SOIL SAMPLING SUMMARY
TEST BORINGS
SITE 28, HADNOT POINT BURN DUMP (EAST)
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	Analytical Parameters							
			TCL Organics	TAL Metals	TPH	TCL VOC	TCL SVOC	TCLP	Engineering Parameters[1]	Duplicate Sample
28-BB-SB37[2]	9	0-1.0	X	X						
		5-7	X	X						
28-BB-SB38[2]	11	0-1.0	X	X						
		7-9	X	X						
28-E-SB40	16	No samples were retained for laboratory analysis								
28-E-SB42	16	0-16/ composite						X	X	X

Notes: [1] Engineering parameters include full TCLP, RCRA hazardous waste characteristics, grain size, and Atterberg limits.
[2] Background or control sample location.
TCL organics include volatiles, semivolatiles, pesticides, and PCBs.

TABLE 12-3

SOIL SAMPLING SUMMARY
MONITORING WELL TEST BORINGS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	Analytical Parameters							
			TCL Organics	TAL Metals	TPH	TCL VOC	TCL SVOC	TCLP	Engineering Parameters[1]	Duplicate Sample
28-GW05	24	0-1.0	X	X						
		7-9	X	X						
28-GW06	30	0-1.0	X	X						
		7-9	X	X						
28-GW07	18	0-1.0	X	X						
		1-3	X	X						
28-GW08	24	0-1.0	X	X						
		9-11	X	X						
28-GW01DW	134	0-1.0	X	X						
		1-3	X	X						
28-GW07DW	132	0-1.0	X	X						
		1-3	X	X						
28-GW09DW[2]	126	1-3	X	X						

Notes: (1) Engineering parameters include full TCLP, RCRA hazardous waste characteristics, grain size, and Atterberg limits.
(2) Background or control sample location.
TCL organics include volatiles, semivolatiles, pesticides, and PCBs.

TABLE 12-4

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
SOIL INVESTIGATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[(1)]	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks[(2)]	One per cooler	9	TCL Volatiles
Field Blanks[(3)]	One per event	--	--
Equipment Rinsates[(4)]	One per day	6	TCL Organics/TAL Metals
Field Duplicates[(5)]	10% of sample frequency	6	TCL Organics/TAL Metals

Notes:
(1) QA/QC sample types defined in Section 12.2.5 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
(3) Field blank not collected during soil investigation.
(4) Equipment rinsates collected from various sampling equipment (e.g., stainless steel spoons).
(5) Field duplicate samples presented in Appendix F.

TABLE 12-5

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
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)
28-GW01	4/20/94	7.34	4.8	17	17	2.5-16.2	1.5-17	0-1.5
28-GW05	4/7/94	15.47	15.6	24	24	9-23.4	7-24	5-7
28-GW06	4/7/94	19.98	17.2	30	30	15-29.3	10-30	8-10
28-GW07	4/8/94	6.62	3.8	18	18	2.5-17.5	0.5-18	0-0.5
28-GW08	4/9/94	14.16	11.6	24	24	7.9-22.7	6-24	4-6
28-GW01DW	4/21-23/94	7.49	5.5	134	133	117-132	111-134	107-111
28-GW07DW	4/18, 4/20, 4/26/94	6.03	3.6	132	131	114-129	109-132	104-109
28-GW09DW	4/7-12/94	6.91	4.5	126	126	111-126	105-126	96-105

Notes: [1] msl = mean sea level
Horizontal positions are referenced to N.C. State Plane Coordinate System (NAD 27) CF = 0.9999216 from USMC Monument Toney.
Vertical datum NGVD 29.

TABLE 12-6

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (ft.)(1)	Purge Volume (gals.)	Field Parameters				
			Well Volume	Specific Conductance at 25°C (micromhos/cm)	Temperature (°C)	pH(2) (S.U.)	Turbidity(4) (T.U.)
28-GW01 4-25-94	19.48	2.22	3	520	18.5	7.58	NA
			4	550	18.5	7.45	NA
			5	550	18.5	7.31	NA
11-14-94		1.95	2	710	19.5	7.56	25
			3	700	20.1	7.41	8.5
			4	700	19.4	7.63	4.6
28-GW01DW 5-7-94	134.2	22	2.5	4,200	19.5	8.49	NA
			3	4,100	19	8.31	NA
			3.5	4,200	19	8.24	NA
11-14-94		21.4	2.75	4,000	19.4	7.93	30
			3	4,000	19.5	7.94	17.0
			3.5	4,000	19.4	7.94	3.8
28-GW02 4-20-94	21.74	2.75	3	880	20	7.14	NA
			4	910	20	7.24	NA
			5	910	20	7.37	NA
11-15-94		2.9	1	900	21.5	7.38	7.5
			2	910	21.4	7.35	4.1
			3	998	21.5	7.3	2.5
28-GW03 4-21-94	20.80	2.79	3	130	17.5	6.06	NA
			4	120	17.5	5.85	NA
			5	130	18	5.88	NA
11-16-94		2.94	9	100	19.5	5.84	34
			10	100	19.6	5.83	24
			11	100	19.5	5.87	19
28-GW04 4-20-94	29.02	3.75	3	280	20	7.14	NA
			4	450	19	7.12	NA
			5	460	18.5	7.29	NA
11-15-94		3.9	1.5	400	20.3	6.96	5.3
			2	400	20.1	6.91	3.0
			3	400	20.0	6.82	2.3

TABLE 12-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (ft.)[1]	Purge Volume (gals.)	Field Parameters				
			Well Volume	Specific Conductance at 25°C (micromhos/cm)	Temperature (°C)	pH[2] (S.U.)	Turbidity[4] (T.U.)
28-GW05	23.90	1.96	3	300	16.5	5.42	NA
4-23-94			4	290	16.5	5.65	NA
			5	260	16.5	5.28	NA
11-15-94		2.03	9	200	21.2	5.66	36
			10	200	21.2	5.67	34
			11	200	21.1	5.68	34
28-GW06	31.92	2.16	3	130	19.5	4.95	NA
4-21-94			4	120	20	4.97	NA
			5	120	20.5	5.04	NA
11-15-94		1.97	6	90	20.1	4.8	7.7
			7	90	20.1	4.77	16
			8	85	20.1	4.73	10
28-GW07	19.25	2.31	3	2,500	16.5	6.82	NA
4-22-94			4	2,500	17	6.82	NA
			5	2,500	17.5	6.65	NA
11-17-94		2.5	7	1,410	19	6.45	3.0
			8	1,410	19	6.38	5.6
			9	1,400	19.1	6.35	7.5
28-GW07DW	129	90	2	300	20	10.99	NA
5-6-94			3	180	20	10.43	NA
			4	170	19.7	9.95	NA
11-17-94		21.4	2.5	215	19.4	5.05	0.46
			3.0	211	19.8	10.05	0.39
			3.5	217	19.8	9.92	0.32
28-GW08	26.00	2.07	4	2,000	19.5	7.17	NA
4-21-94			5	2,000	19.5	6.74	NA
			6	1,900	20	7.12	NA
11-15-94		1.66	7	1,890	20.6	7.60	18
			8	2,000	20.5	7.59	16
			9	2,000	20.3	7.62	13

TABLE 12-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (ft.)[1]	Purge Volume (gals.)	Field Parameters				
			Well Volume	Specific Conductance at 25°C (micromhos/cm)	Temperature (°C)	pH[2] (S.U.)	Turbidity[4] (T.U.)
28-GW09DW 4-25-94	127.7	20.9	3	290	21	7.83	NA
			4	280	22	7.77	NA
			5	280	22	7.74	NA
11-15-94		20.5	2.5	260	19.9	7.33	12.0
			3.0	253	20.2	7.41	13.0
			3.5	269	20.0	7.26	7.2
28-GW13 4-21-94	14.64	1.5	3	1,400	19.5	6.59	NA
			4	1,400	19.5	6.25	NA
			5	1,400	19.5	6.60	NA
11-15-94		1.44	3	1,300	23.9	6.45	19
			4	1,290	24.4	6.66	26
			5	1,250	24.3	6.53	25
28-TGWPA[3] 4-20-94	22.56	4.5	1	600	20	6.8	NA
			2	570	20	5.8	NA
			3	860	20	6.1	NA

Notes: NA - Not Available
(1) Well depth taken from below ground surface (bgs)
(2) S.U. - Standard Units
(3) Round one samples collected only
(4) T.U. - Turbidity Units

TABLE 12-7

GROUNDWATER SAMPLING SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Analytical Parameters					
	TCL Organics	TCL Pesticides	TAL Metals	Dissolved TAL Metals	Water Chemistry Parameters(1)	Duplicate Sample
28-GW01	X	●	X●	X●	X●	
28-GW01DW	X		X●	X●	●	
28-GW02	X	●	X●	X●	●	
28-GW03	X		X●	X●	●	
28-GW04	X		X●	X●	●	
28-GW05	X		X●	X●	●	
28-GW06	X	●	X●	X●	●	
28-GW07	X	●	X●	X●	●	X
28-GW07DW	X		X●	X●	●	
28-GW08	X	●	X●	X●	●	
28-GW09DW(2)	X		X●	X●	●	
28-GW13(2)	X	●	X●	X●	●	
28-TGWPA(3)	X		X	X		

Notes: (1) Water chemistry parameters include alkalinity, biological oxygen demand, chemical oxygen demand, chloride, fluoride, total dissolved solids (TDS), total suspended solids (TSS), and total Kjeldahl nitrogen. For round two, water chemistry parameters only included TSS and TDS.
(2) Upgradient sample location.
(3) Round two samples were not collected.

X - Indicates round one analyses
● - Indicates round two analyses

TABLE 12-8

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
GROUNDWATER INVESTIGATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks(2)	One per cooler	7	TCL Volatiles
Field Blanks(3)	One per event	1	TCL Organics/TAL Metals
Equipment Rinsates(4)	One per day	3	TCL Organics/TAL Metals
Field Duplicates(5)	10% of sample frequency	3	TCL Organics/TAL Metals

Notes: (1) QA/QC sample types defined in Section 12.2.5 in text. Includesboth round one and two samples.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
(3) Field blank collected was from a water source used for decontamination.
(4) Equipment rinsates collected from various sampling equipment (e.g., bailer and pump).
(5) Field duplicate samples presented in Appendix F.

TABLE 12-9

SUMMARY OF SURFACE WATER FIELD QUALITY PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Location	Salinity (ppt)	Conductivity (micromhos/cm)	DO (mg/L)	pH (S.U.)	Temperature (°C)
28-OP-SW/SD01	Surface	0	70	9.0	6.94	19.4
	Bottom	0	70	9.0	7.03	19.4
28-OP-SW/SD02	Surface	0	72	9.0	6.79	20
	Bottom	0	88	9.0	6.83	19.5
28-CC-SW/SD01	Surface	0.25	600	6.0	8.73	20
28-CC-SW/SD02	Surface	1	1,400	7.74	6.43	22
	Bottom	9	7,500	7.74	6.47	22
28-CC-SW/SD03	Surface	6.82	350	8.3	6.82	17
	Bottom	6.79	9,500	8.3	6.79	16
28-CC-SW/SD04	Surface	6.9	8,800	9.9	7.01	20.2
28-CC-SW/SD05	Surface	0	272	5.6	6.67	17.5
28-CC-SW/SD06	Surface	0.25	500	4.75	6.9	19.5
28-CC-SW/SD07	Surface	0	335	4.4	6.73	17.5
28-NR-SW/SD02	Surface	15.5	18,000	10.5	6.94	22.5
28-NR-SW/SD03	Surface	15	12,000	11.0	7.95	20.0
28-NR-SW/SD04	Surface	0.25	400	7.4	9.23	19.0
28-NR-SW/SD05	Surface	3.5	3,800	10	9.76	19.0

Notes: Sample Location = Water surface or water bottom
DO = Dissolved Oxygen level
ppt = parts per thousand
mg/L = milligrams per liter
S.U. = Standard Units

TABLE 12-10

SURFACE WATER AND SEDIMENT SAMPLING SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Sample Matrix	Sample Depth(1)	Analytical Parameters					
			TCL Organics	TCL VOC	TCL SVOC	TAL Metals	Water Hardness	Duplicate Sample
28-OP-SW/SD01	SW	NA	X			X	X	X
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-OP-SW/SD02	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"		X		X		
28-CC-SW/SD01	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD02	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD03	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD04	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD05	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD06	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-CC-SW/SD07	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-NR-SW/SD01	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-NR-SW/SD02	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		

TABLE 12-10 (Continued)

SURFACE WATER AND SEDIMENT SAMPLING SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Sample Matrix	Sample Depth[1]	Analytical Parameters					
			TCL Organics	TCL VOC	TCL SVOC	TAL Metals	Water Hardness	Duplicate Sample
28-NR-SW/SD03	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-NR-SW/SD04	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		
28-NR-SW/SD05	SW	NA	X			X	X	
	SD	0-6"	X			X		
	SD	6-12"	X			X		

Notes: [1] NA - Not applicable for surface water samples.
SW - Surface Water
SD - Sediment
TCL organics include volatiles, semivolatiles, pesticides, and PCBs.

TABLE 12-11

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
SURFACE WATER AND SEDIMENT INVESTIGATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks(2)	One per cooler	4	TCL Volatiles
Field Blanks(3)	One per event	--	--
Equipment Rinsates(4)	One per day	3	TCL Organics/TAL Metals
Field Duplicates(5)	10% of sample frequency	3	TCL Organics/TAL Metals

Notes:
(1) QA/QC sample types defined in Section 12.2.5 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
(3) Field blank not collected during surface water and sediment investigation.
(4) Equipment rinsates collected from various sampling equipment (e.g., corer).
(5) Field duplicate samples presented in Appendix F.

TABLE 12-12

SUMMARY OF SURFACE WATER QUALITY PARAMETERS - AQUATIC SAMPLING
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Location	Salinity (ppt)	Conductivity (micromhos/cm)	DO (mg/L)	pH (S.U.)	Temperature (°C)
28-FS-BN04	Surface	6.9	8,800	9.9	7.01	20.2
28-FS-BN05	Surface	13.0	14,000	NA	NA	25
	Bottom	10.2	11,800	10.5	7.69	21
28-FS-BN03	Surface	0	1,150	6.8	3.5	22.5
	Bottom	0	1,150	6.8	3.5	22.5
28-FS-BN02	Surface	0	351	6.5	6.8	14.5
	Bottom	1.5	3,100	6.0	6.77	17.5
28-FS-BN01	Surface	NA	440	4.8	6.8	13.3

Notes: Sample Location = Water surface or water bottom
DO = Dissolved Oxygen level
ppt = parts per thousand
mg/L = milligrams per liter
S.U. = Standard Units
NA = Not Applicable

SECTION 12.0 FIGURES

LEGEND	
28GW1	NEWLY INSTALLED SHALLOW MONITORING WELL
28GW01DW	NEWLY INSTALLED DEEP MONITORING WELL
SB6	SOIL BORING
A—A'	GEOLOGIC CROSS-SECTION TRAVERSE

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1"= 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
CADD#	231106RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

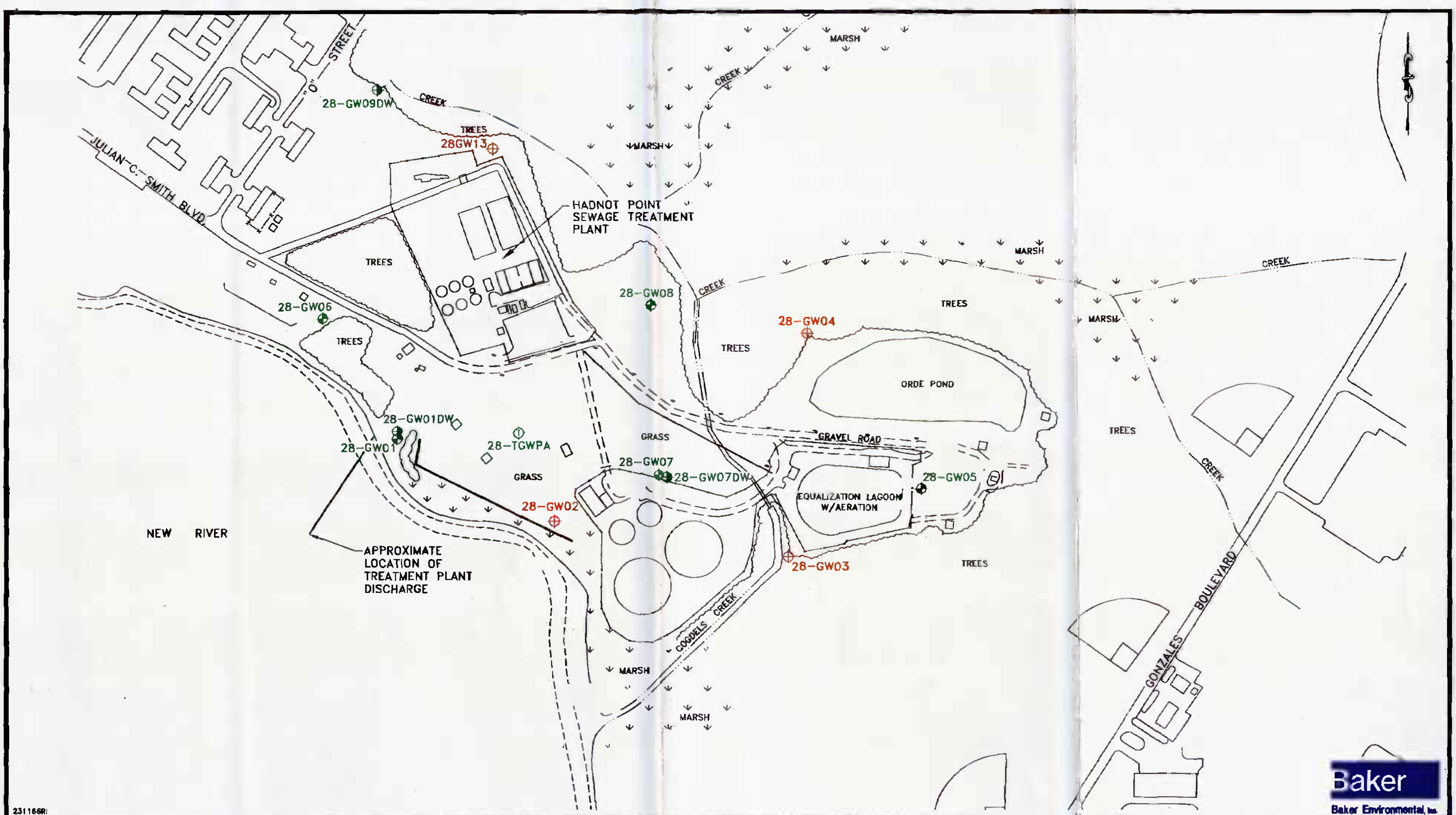
Baker Environmental, Inc

GEOLOGIC CROSS-SECTION LOCATION MAP
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1"= 120' DATE JANUARY 1995

FIGURE No 13-1

01500QC4X



LEGEND

- 28-GW02 — EXISTING SHALLOW MONITORING WELL (ESE, 1984/1986)
- 28-GW01 — NEWLY INSTALLED SHALLOW MONITORING WELL (BAKER, 1994)
- 28-GW01DW — NEWLY INSTALLED DEEP MONITORING WELL (BAKER, 1994)
- 28-TGWPA — TEMPORARY MONITORING WELL (BAKER, 1994)

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

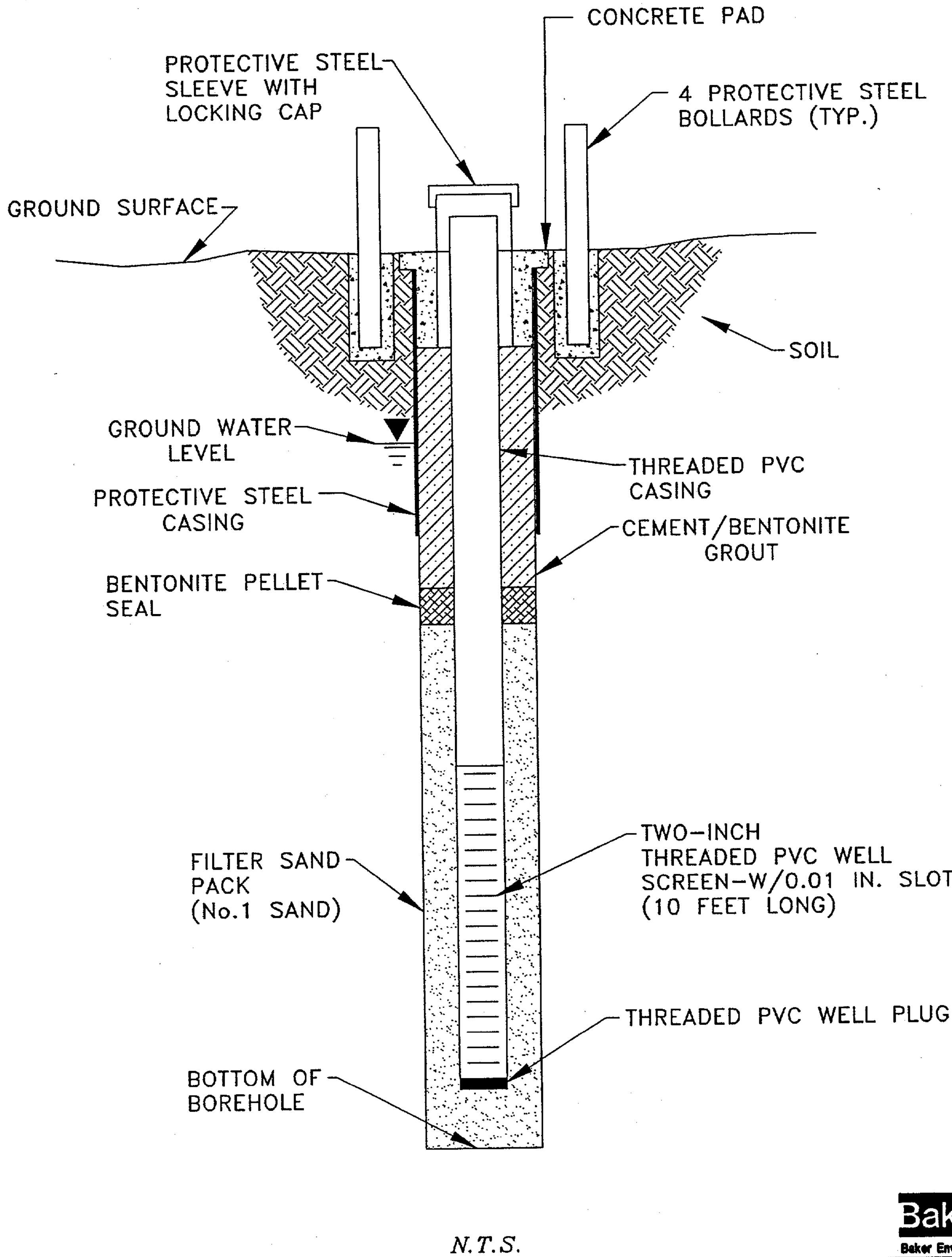
1 inch = 300 ft.

FIGURE 12-2
SHALLOW AND DEEP MONITORING WELL LOCATIONS
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q05Y

231164RI



Baker
Baker Environmental, Inc.

FIGURE 12-3
TYPICAL DEEP GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

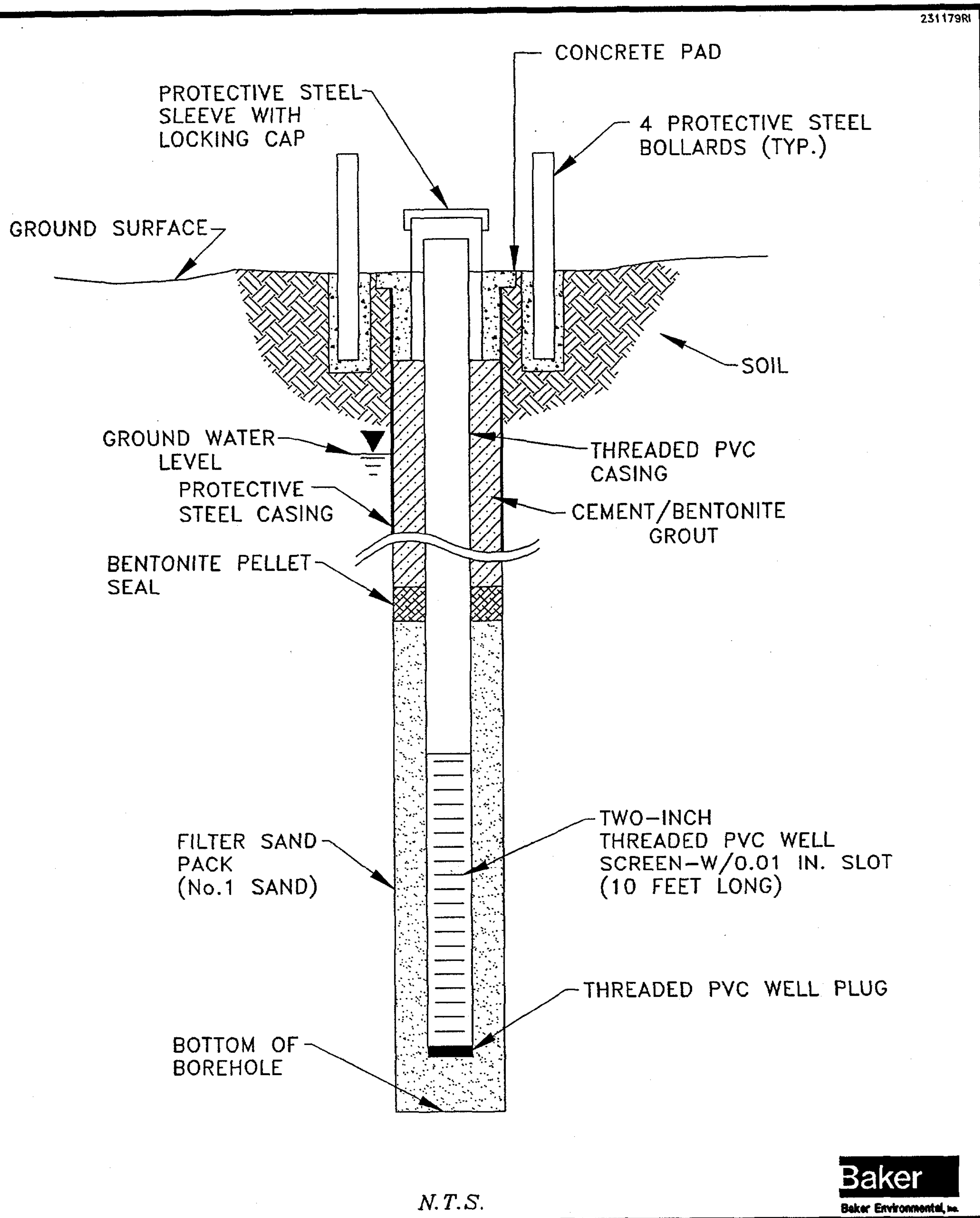
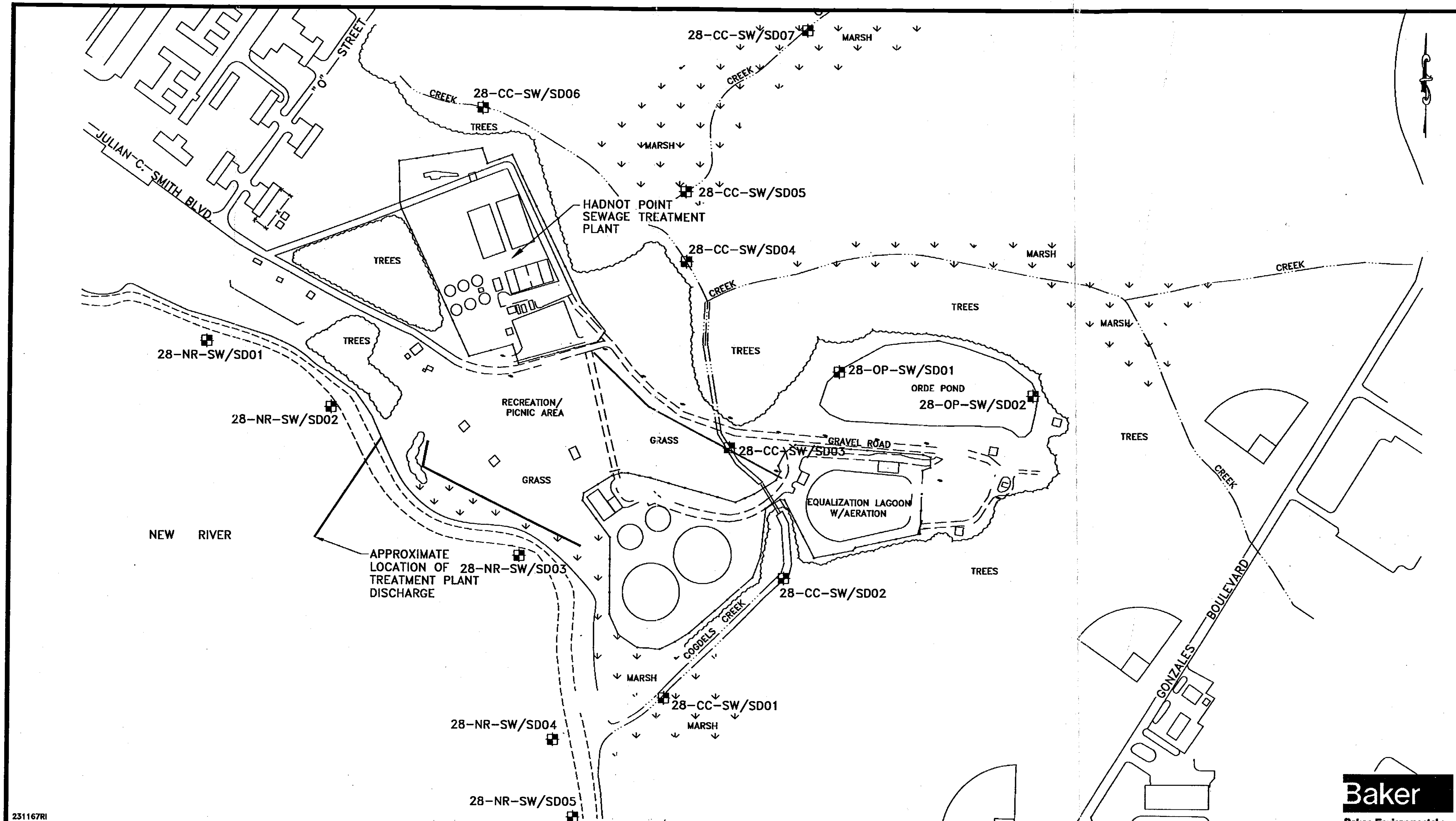


FIGURE 12-4
TYPICAL DEEP TYPE II GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

28-CC-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLING LOCATION

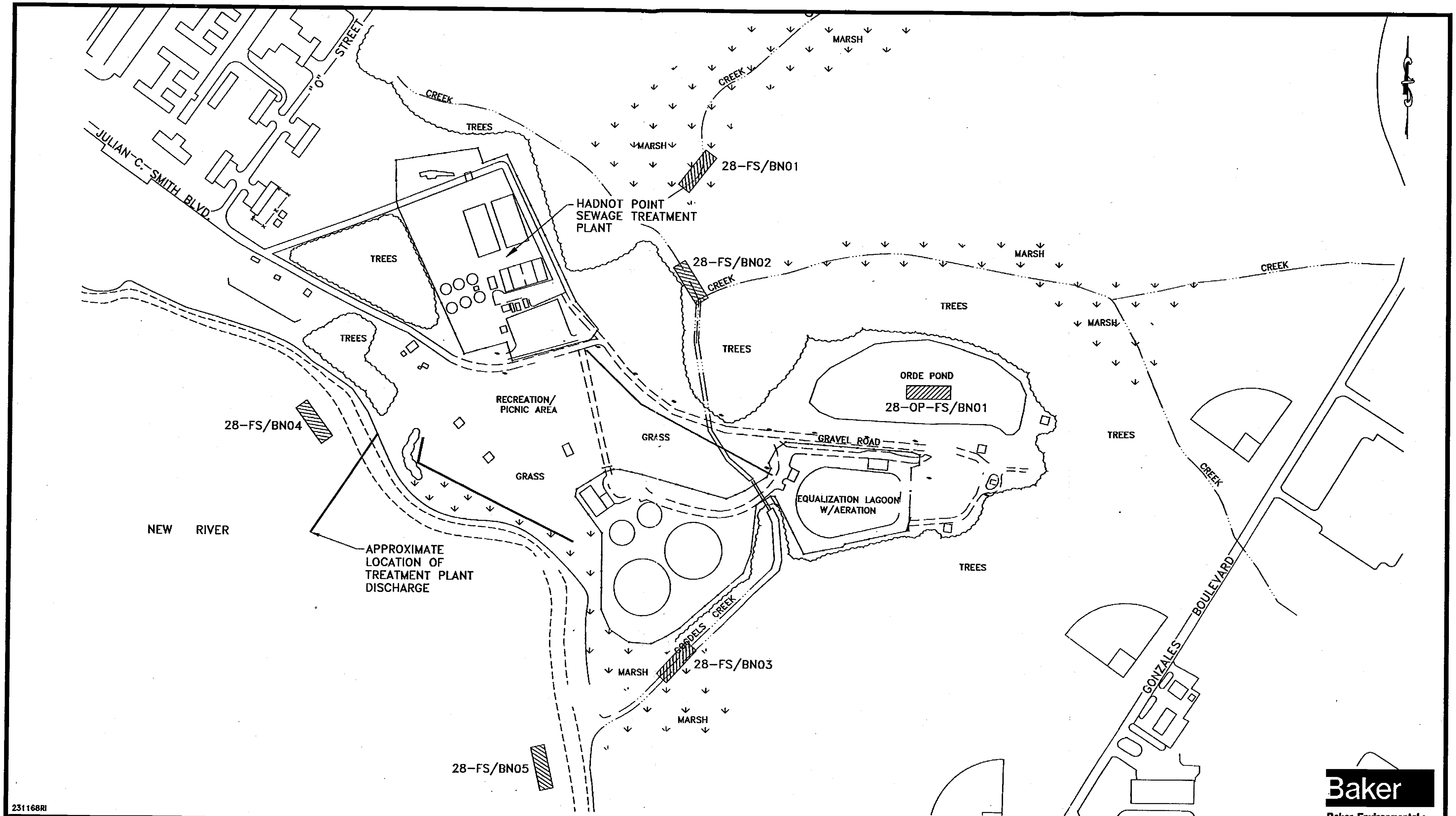
SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 12-5
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q06Z



LEGEND

28-OP-FS/BN01 — FISH AND BENTHIC MACROINVERTEBRATE SAMPLING LOCATION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 12-6
AQUATIC SURVEY SAMPLING LOCATIONS
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q07Z

13.0 SITE PHYSICAL CHARACTERISTICS

Section 13.0 of this report presents information on site-specific physical characteristics. Included in this section is a discussion on the topography, surface water hydrology and drainage features, geology, hydrogeology, ecology, and water supply wells identified near the site.

13.1 <u>Topography</u>

Site 28 is situated between sea level (along the New River) and 25 feet above msl. Note that the original land surface at Site 28 has been altered by the addition of fill material and construction of the sewage treatment plant. Ground surface within the western area slopes from the central portion toward the New River and Cogdels Creek. The topography within the eastern area is generally flat with a slight slope toward Cogdels Creek. Higher land elevations within the eastern area occur near Orde Pond.

13.2 <u>Surface Water Hydrology and Drainage Features</u>

Cogdels Creek, the New River, and Orde Pond serve as the main surface water bodies in the vicinity of Site 28. Of these, the New River and Cogdels Creek have the most influence on surface drainage in the area. Drainage within the central and eastern portions of the site is influenced by Cogdels Creek, and drainage within the western portion of the site is influenced by the New River. Areas along the New River and Cogdels Creek at Site 28 below 10 feet of elevation are within the 100-year flood plain.

Cogdels Creek originates north of Site 28 in the Hadnot Point Industrial Area and flows southward, eventually into the New River, dividing Site 28 into the western and eastern areas. Although Cogdels Creek flows southward, the lower portion of creek receives flow from the New River, creating a salt wedge within the creek. During the RI investigation, the water level in Cogdels Creek was observed to fluctuate several feet, especially after a storm event. Based on surface water elevation data (Table 13-1) from staff gauges and groundwater elevation data from on-site wells, Cogdels Creek appears to receive localized groundwater discharge ("gaining stream") from the Site 28 area.

Orde Pond is located within the eastern area of the site. The pond was constructed during the 1970s and is used for recreational fishing. Based on surface water elevation data (Table 13-1), the pond does not receive groundwater discharge from the Site 28 area. Water within the pond is maintained by supplied water and surface water runoff.

13.3 <u>Subsurface Soil Conditions</u>

13.3.1 Geology

Shallow soils (less than 30 feet) underlying Site 28 consist of predominantly fill material/debris, sand, and silty-sand, with minor amounts of silt (5 to 20 percent) and clay (5 to 10 percent). The appearance of the soils encountered at Site 28 are generally consistent with soils described for Site 1 ("undifferentiated" Formation). Based on the USCS, the shallow soils at Site 28 classify as SM. Results from the standard penetration tests indicated relative densities ranging from very loose to dense.

As mentioned in Section 11.2, a large quantity of fill material was placed over the burn dump after it was no longer needed. Various amounts and types of debris were noted within the fill material. The debris encountered included oxidized metal, glass, bricks, wire, and wood. Most of the debris appeared charred from the burning operations.

Geologic cross-sections depicting the shallow and deep soil lithologies were developed based on information obtained during the test borings. As shown on Figure 13-1, both the eastern and western areas were traversed to provide a cross-sectional view of the lithology. Four shallow traverses (A to A', B to B', C to C', and D to D') and two deep traverses (E to E' and F to F') are presented.

Cross-sections A to A' (west to east) and B to B' (north to south) depict shallow soil conditions across the western area. Fill material and debris, underlain by sand, were encountered in all of the borings as shown on Figures 13-2 and 13-3. The thickness of the fill material and debris varied from approximately 3 to 22 feet. In general the fill and debris horizon is most pronounced within the central portion of the site, with thinning of the horizon toward the New River and Cogdels Creek. The horizontal and vertical extents of the fill material encountered during the drilling program appears to corresponded with existing test boring information and as depicted on the historical aerial photographs.

Cross-sections C to C' (north to south) and D to D' (west to east) depict shallow soil conditions within the eastern area of Site 28. As shown on Figures 13-4 and 13-5, the eastern area is underlain by sand with lenses of clay and silt. Fill material and debris were not encountered within the eastern area, corresponding with historical aerial photographic data. The clay lenses, which are more pronounced toward the eastern portion of the site, vary in thickness from two to five feet and are discontinuous.

Deep soil conditions across Site 28 are depicted on Figures 13-6 (E to E') and 13-7 (F to F'). Sand and sand-shell mixtures are present to a depth of 94 to 112 feet bgs. A layer of sand and marl, marking the top of the River Bend Formation, was also encountered between 40 and 65 feet in well boring 28-GW01DW. A thin layer of sandy-clay was encountered at approximately 92 to 94 feet bgs. As noted for Site 1, the soil appeared visually to have a permeability high enough to permit vertical groundwater movement into the deeper aquifer.

13.3.2 Surface Soils

Information regarding site soil conditions was obtained from the Soil Survey publication prepared by the U.S. Department of Agriculture - SCS for Camp Lejeune, North Carolina (SCS, 1984). As part of the RI, a limited number of soil samples were evaluated for geotechnical properties and classified according to the USCS. The findings of that evaluation, provided in Appendix H, were used to confirm SCS survey results. Due to operational or construction activities at Site 28, however, the soils described in the SCS publication may differ from current site conditions.

According to the SCS Soil Survey, Site 28 is underlain by a number of distinct soil units. The Baymeade (BaB) urban land complex, which underlies the western-most extent of Site 28, is typically found in areas where the original soil has been cut, filled or graded. Soil properties of this unit have been altered through slope modification and smoothing. Due to its rapid infiltration rate and well-drained nature, Baymeade soils tend to be used for parking lots and light duty urban areas. Generally Baymeade soils are moderately to strongly acidic in nature and are classified under the

USCS as SM, SM-SP (i.e., fine sand or loamy fine sand). Table 13-2 provides a summary of soil physical properties found at Site 28.

The Baymeade (BmB) fine sand unit, unlike the Baymeade (BaB) urban land complex, underlies the eastern portion of Site 28. The Baymeade fine sand unit is extensive throughout MCB, Camp Lejeune and occurs in areas with moderately convex slopes of zero to six percent, near major drainageways. Commonly found in wooded areas, the unit exhibits rapid infiltration and slow surface water runoff. Typically, available water capacity is low and the seasonal high water table ranges from four to five feet bgs. The Baymeade unit is well suited for unsurfaced roads and light-duty traffic areas.

The Newhan (NfC) fine sand unit underlies the majority of the western portion of Site 28. The Newhan unit is an excessively drained soil material, typically deposited by dredging operations along the intercoastal waterway. Infiltration is rapid, with low water retention capacity, and surface runoff is slow. The seasonal high water table remains below a depth of six feet. The soil unit is poorly suited for urban development; caving, seepage, and wind erosion are its main limitations.

Cogdels Creek, which bisects the site, is bordered by Muckalee (Mk) loam soils that tend to be poorly drained and found on flood plains. The Muckalee unit is frequently flooded for brief periods and is subject to ponding. Marvyn (MaC) loamy fine sands are found, at Site 28, upland of the Muckalee unit. Marvyn soils are long and narrow, typically on side slopes near large drainages and range from 6 to 15 percent in slope.

13.4 Hydrogeology

The hydrogeologic setting in the vicinity of Site 28 consists of several aquifer systems. For this study, the most upper two aquifer systems were investigated, the surficial and Castle Hayne. The surficial aquifer lies within the "undifferentiated" deposits of sand, silt, and clay. The thickness of the surficial aquifer in the vicinity of Site 28 is approximately 40 feet, based on the occurrence of the sand and marl mixtures which mark the upper portion of the River Bend Formation. The underlying Castle Hayne aquifer consists of sand, silty clay, shell hash, and during the test borings, there does not appear to be a significant hydraulic separation of the aquifers since no distinct groundwater retarding unit was encountered.

The hydrogeologic conditions were evaluated by installing a network of shallow and deep monitoring wells throughout eastern and western areas of Site 28 and installing staff gauges in Cogdels Creek and Orde Pond. Additionally, information on aquifer characteristics for the surficial aquifer was obtained from a pump test conducted by Baker at a UST site located adjacent to the HPIA sewage treatment plant.

Groundwater elevation data for Site 28 are summarized on Table 13-3. Two rounds of groundwater and surface water level measurements were collected. The initial round of measurements (March 19, 1994) were collected prior to the investigation and, therefore, only include the existing wells. Groundwater elevations measured in the shallow wells on May 10, 1994 varied from 1.00 to 3.53 feet above msl. In the existing monitoring wells where two rounds of measurements were collected (March 19 and May 10, 1994), the water levels declined between 0.16 and 0.38 feet. This slight decline in the water table appears to be the result of normal daily and/or seasonal fluctuations. Groundwater elevations measured in the deep wells on May 10, 1994 varied from 1.36 to 2.47 feet above msl. Slightly different groundwater elevations between the surficial and deeper aquifers were measured. The elevation differentials between the surficial and deep aquifers have created a slight vertical gradient which is noteworthy since this may contribute to the vertical migration of contaminants.

An estimate of the horizontal groundwater gradient for the surficial and Castle Hayne aquifers was calculated from the May 10, 1994 elevation data. Based on the May 10, 1994 data, the estimated horizontal gradients for the surficial (toward Cogdels Creek) and deep (toward the New River) aquifers are 0.004 and 0.0013, respectively. Both values indicate a relatively flat water table surface.

Groundwater elevation contour maps were generated for the surficial and Castle Hayne aquifers based on the May 10, 1994 data. Surficial groundwater flow within the site appears to be influenced by Cogdels Creek. As shown on Figure 13-8, groundwater appears to be discharging into the creek. Groundwater flow direction for the Castle Hayne aquifer is to the west-southwest across the site toward the New River, as depicted on Figure 13-9.

Groundwater flow velocity within the surficial aquifer was estimated by employing a variation of Darcy's equation as described in Section 4.4. Based on an average hydraulic conductivity of 3.1 feet/day (Baker, 1992), an average horizontal groundwater gradient of 0.004, and a estimated effective porosity of 0.3 for silty-sands (Fetter, 1980), the estimated groundwater flow velocity is 4.1 x 10^{-2} feet/day (15 feet/year).

13.5 Ecology

At Site 28, an estuarine wetland is present along the banks of the New River, slightly to the south of the wastewater treatment facility. The wetlands along the two tributaries to Cogdels Creek are classified as palustrine forested wetlands, one of which is primarily deciduous while the other is a broad-leaved deciduous, needle-leaved evergreen wetland. Orde Pond is classified as a palustrine open water permanently flooded wetland. These wetlands were investigated during the habitat evaluation. Site-specific habitat types are summarized on Table 13-4, and a biohabitat map for Site 28 is presented as Figure 13-10.

Site 28 is bounded by forests to the east and south, the HPIA to the north, and the New River to the west. The area immediately surrounding Orde Pond and the water treatment plant is described as an open grass area which is utilized for recreation as well as part of the water treatment facility. Dominant vegetation includes cultivated grass as well as sparse plantings of deciduous trees. Songbirds, cottontail rabbit (Sylvilagus floridanus), and the white-tail deer (Odocoileus virginianus) and expected to use this area for feeding.

The area located along the western bank of Cogdels Creek is described as coniferous forest with some inclusions of deciduous trees. There are also several small pockets of emergent wetlands located along the banks of the stream in this area. Dominant vegetation includes loblolly pine (Pinus taeda), red maple (Acer rubrum), sweet gum (Liquidambar styraciflua), and tulip poplar (Liriodendron tulipifera). The scrub/shrub vegetation is dominated by red maple (Acer rubrum), tulip poplar (Liriodendron tulipifera), red cedar (Juniperus virginiana), and southern bayberry (Myrica cerifera). Song birds, white-tail deer (Odocoileus virginianus), cottontail rabbit (Sylvilagus floridanus), raccoon (Procyon lotor) and other small mammals are expected to inhabit this area. This area also may include several varieties of snakes and turtles, as well as other forms of aquatic life.

The area located along the banks of the New River south of the water treatment plant is classified as an estuarine persistent emergent wetland. This area appeared to be periodically flooded during extreme high tides. Dominant vegetation in this area is the common reed (Phragmites australis). Song birds, raccoons (Procyon lotor) and small mammals are expected to inhabit this area. Also, a base Fish and Wildlife Representative indicated that, at times, one of the area alligators (Alligator mississippiensis) has been known to inhabit this area.

The area located along the eastern edge of Cogdels Creek, opposite of the estuarine persistent emergent wetland discussed above, is described as an estuarine forested/scrub shrub wetland. The dominant vegetation includes the red maple (Acer rubrum), baldcypress (Taxodium distichum), sweet gum (Liquidambar styraciflua) and tulip poplar (Liriodendron tulipifera). The scrub/shrub vegetation is dominated by the southern bayberry (Myrica cerifera), red maple (Acer rubrum) and coastal willow (Salix caroliniana). Song birds, osprey (Panadion haliaetus), white-tail deer (Odocoileus virginianus), raccoon (Procyon lotor), gray squirrel (Sciurus carolinensis), and small mammals are expected to inhabit this area.

The area located along the western edge of Cogdels Creek adjacent to the water treatment settling tanks is described as a small pocket of coniferous trees. The vegetation in this area is dominated by loblolly pine (Pinus taeda) with the scrub/shrub vegetation dominated by the red cedar (Juniperus virginiana). Song birds, wild turkey (Meleagris gallopavo), and small mammals may inhabit this area.

The area located to the north and south of Orde Pond, west of Cogdels Creek, and on either side of a tributary to Cogdels Creek is described as mixed forest (deciduous/coniferous) vegetation. Loblolly pine (Pinus taeda) and red cedar (Juniperus virginiana) compose a large portion of the tree population with southern bayberry (Myrica cerifera) dominating the scrub/shrub vegetation. Song birds, wild turkey (Meleagris gallopavo), bobwhite quail (Colinus virginianus), white-tail deer (Odocoileus virginianus), and small mammals are expected to inhabit this area.

The area located along the tributary to Cogdels Creek is described as a forested wetland. The wetland is dominated by trees with some scrub/shrub and emergent vegetation is located throughout the system. The dominant vegetation includes red maple (Acer rubrum), coastal willow (Salix caroliniana), unknown rhododendron (Rhododendron sp.), and alder (Alnus sp.). This area is known as prime American alligator (Alligator mississippienis) habitat. Other possible inhabitants may include small mammals such as the gray squirrel (Sciurus carolinensis) and cottontail rabbit (Sylvilagus floridanus); raccoon (Procyon lotor); white-tail deer (Odocoileus virginianus); and upland birds.

The area located to the south of Firing Range D-30 is described as a coniferous forest. The dominant vegetation includes the loblolly pine (Pinus taeda), red cedar (Juniperus viriniana), and American holly (Ilex opaca). Song birds, white-tail deer (Odocoileus virginianus), and small mammals most likely inhabit this area.

The area found along another tributary to Cogdels Creek is described as scrub/shrub wetland. The dominant vegetation includes scrub/shrub alder (Alnus sp.), coastal willow (Salix caroliniana), southern bayberry (Myrica cerifera), and red maple (Acer rubrum). There is also a large amount of emergent vegetation including soft rush (Juncus effusus), Carex sp., and Sagittaria sp.. This area also is known as prime American alligator (Alligator mississippiensis) habitat. Other possible inhabitants may include small mammals such as the gray squirrel (Sciurus carolinensis) and cottontail rabbit

(Sylvilagus floridanus); raccoon (Procyon lotor); white-tail deer (Odocoileus virginianus); and the wild turkey (Meleagris gallopavo).

According the soil survey performed at MCB, Camp Lejeune, the soils in this area are primarily Marvyn loamy fine sand, Muckalee loam, and Newhan fine sand. The Marvyn sand is found mainly near large drainageways (near Cogdels Creek and the unnamed tributary to Cogdels Creek). Most of the acreage is woodland, but roads for tactical vehicles are often routed through these areas, and they are also used for off-road maneuvers. The major canopy trees found during the survey were the loblolly pine (Pinus taeda), longleaf pine (Pinus palustris), red and white oaks (Quercus falcata and Q. alba), and hickory (Carya sp.). The main understory included American holly (Ilex opaca), flowering dogwood (Cornus florida), persimmon (Diospyros virginiana), blueberry (Vaccinium sp.), black cherry (Prunus serotina), and greenbriar (Smilax rotundifolia). Areas of Marvyn soil are often used as habitat for deer, turkey, squirrel, fox, quail, and other wildlife.

The Muckalee loam is found on the flood plains, the soil is frequently flooded for brief periods and water ponds in low areas on the wider flood plains. Nearly all the acreage is woodland. The dominant native trees are loblolly pine (Pinus taeda) and sweetgum (Liquidambar styraciflua). Other native trees often in this type of soil are the water oak (Quercus nigra), willow oak (Quercus phellos), red maple (Acer rubrum), swamp tupelo (Nyssa sp.), and baldcypruss (Taxodium distichum). Important understory includes redbay (Persea borbonia), sweetbay (Magnolia virginiana), American holly (Ilex opaca), gallberry (Ilex galbra), sweet pepperbush (Clethra alnifolia), switch cane (Arundinaria tecta), wax myrtle (Myrica cerifera), blueberry (Vaccinium spp.), honeysuckle (Lonicera sp.), Virginia chain-fern (Woodwardia virginicia), cinnamon fern (Osmunda cinnamomea), poison-ivy (Rhus radicans), bracken fern (Pteris aquilina), and greenbriar (Smilax rotundifolia). Areas of Muckalee soil are often habitat for deer, raccoon, fox, rabbit, bobcat, opossum, mink, otter, squirrels, birds, and other wildlife.

Newhan sand is soil material deposited by dredging operations along the Intracoastal Waterway. Most of the acreage is sparse in vegetation. A few shrubs, weeds, and grasses grow around the outer edges. Older dredge spoil areas grow eastern red cedar (Juniperus virginiana), live oak (Quercus virginiana), myrtle oak (Quercus myrtifolia), Yaupon holly (Ilex vomitoria), and longleaf pine (Pinus palustris).

13.6 Identification of Water Supply Wells

Potable water supply wells within a one-mile radius of the site were researched by reviewing a USGS publication (Harned, et al., 1989) and conducting interviews with Activity personnel. No supply wells were identified within a one-mile radius of Site 28.

SECTION 13.0 TABLES

TABLE 13-1

SUMMARY OF STAFF GAUGE READINGS
MARCH 19, 1994, AND MAY 10, 1994
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Staff Gauge No.	Top of Staff Gauge Elevation (feet, above msl)(1)	Location	Staff Gauge Reading (feet) March 19, 1994	Staff Gauge Reading (feet) May 10, 1994	Top of Staff Gauge (feet)	Top of Water Elevation (feet, above msl) March 19, 1994	Top of Water Elevation (feet, above msl) May 10, 1994
28-SG01	10.47	Orde Pond	1.52	1.16	3.34	8.65	8.29
28-SG02	1.59	Cogdels Creek	5.98	5.94	6.68	0.89	0.85
28-SG03	1.76	Cogdels Creek	5.38	5.88	6.68	0.46	0.96
28-SG04	1.80	Cogdels Creek	(2)	2.42	3.34	(2)	0.88

Notes: (1) msl = mean sea level
(2) Data not collected.

TABLE 13-2

SUMMARY OF SOIL PHYSICAL PROPERTIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Soil Name	Soil Symbol	USCS Classification	Depth (inches)	Moist Bulk Density (g/cc)	Permeability (cm/s)	Soil Reaction (pH)	Shrink-Swell Potential	Organic Matter (percent)
Baymeade-Urban	BaB	SM, SP-SM	0 - 30	1.60 - 1.75	4.2×10^{-3} - 1.37×10^{-2}	4.5 - 6.5	Low	0.5 - 1.0
Baymeade	BmB	SM, SP-SM	0 - 30	1.60 - 1.75	4.2×10^{-3} - 1.37×10^{-2}	4.5 - 6.5	Low	0.5 - 1.0
Marvyn	MAC	SM	0 - 12	--	1.37×10^{-3} - 4.2×10^{-3}	4.5 - 6.0	Low	<2.0
Muckalee	Mk	ML	0 - 28	--	4.2×10^{-4} - 1.37×10^{-3}	5.1 - 7.3	Low	0.5 - 2.0
Newhan	NfC	SP	0 - 80	--	$>1.37 \times 10^{-2}$	3.6 - 7.8	Low	<2

Source: Soil Survey: Camp Lejeune, North Carolina, U. S. Department of Agriculture - Soil Conservation Service, 1984.

Notes:
- ML - Loam
- SM - Loamy Fine Sand
- SP - Fine Sand
- -- - Not Estimated

TABLE 13-3

SUMMARY OF WATER LEVEL MEASUREMENTS ON MARCH 19, 1994, AND MAY 10, 1994
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) March 19, 1994	Depth to Groundwater (feet, below top of casing) May 10, 1994	Groundwater Elevation (feet, above msl) March 19, 1994	Groundwater Elevation (feet, above msl) May 10, 1994
28-GW01	7.34	(2)	5.71	(2)	1.63
28-GW02	5.96	4.38	4.76	1.58	1.20
28-GW03	5.90	3.35	3.51	2.55	2.39
28-GW04	8.17	5.56	5.85	2.61	2.32
28-GW05	15.47	(2)	11.94	(2)	3.53
28-GW06	19.98	(2)	18.36	(2)	1.62
28-GW07	6.62	(2)	5.15	(2)	1.47
28-GW08	14.16	(2)	13.16	(2)	1.00
28-MW13	7.75	(2)	5.93	(2)	1.82
28-GW01DW(3)	7.49	(2)	6.13	(2)	1.36
28-GW07DW(3)	6.03	(2)	4.01	(2)	2.02
28-GW09DW(3)	6.91	(2)	4.44	(2)	2.47

(1) msl = mean sea level
(2) *Data not collected.*
(3) Deep monitoring well.

TABLE 13-4

SUMMARY OF HABITAT TYPES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Area Designation	Site Description	Dominant Vegetation	Fauna Present
28A	This area is described as an open grass area which is utilized for recreation as well as part of the water treatment facility.	Dominant vegetation includes cultivated grass as well as sparse planting of deciduous trees.	Song birds, rabbit, and white tail deer may use this area for feeding.
28B	This area is located along the western bank of Cogdels Creek. It is described as coniferous forest with some inclusions as deciduous trees. There are several small pockets of emergent wetlands located along the stream.	Dominant vegetation includes loblolly pine, red maple, sweet gum, and yellow poplar. The scrub/shrub vegetation is dominated by red maple, tulip poplar, red cedar, and southern bayberry.	Song birds, white tail deer, rabbit, raccoon, and other small mammals inhabit this area. This area may also include several varieties of snakes and turtles, as well as other forms of aquatic wildlife.
28C	This area is located south of the water treatment facility along the banks of the New River. This area is classified as an estuarine persistent emergent wetland which appears to be periodically flooded during extreme high tides.	Dominant vegetation in this area is common reed, Phragmites australis.	Song birds, raccoons, and small mammals inhabit this area. (Note: A base fish and wildlife representative indicated that at times American alligators have been known to inhabit this area.)
28C.1	This area is located along the eastern edge of Cogdels Creek, opposite of 28C. This area is described as an estuarine forested scrub/shrub wetland.	Dominant vegetation includes red maple, bald cypress, sweet gum, and tulip poplar. The scrub/shrub vegetation is dominated by southern bayberry, red maple, and coastal willow.	Song birds, osprey, white tail deer, raccoon, gray squirrel, and other small mammals inhabit this area.
28D	This area is described as a small pocket of coniferous trees located along the western edge of Cogdels Creek, adjacent to the water treatment settling tanks.	The dominant vegetation is loblolly pine with red cedar dominating the scrub/shrub vegetation.	Song birds, wild turkey, and small mammals may inhabit this area.

TABLE 13-4 (Continued)

SUMMARY OF HABITAT TYPES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Area Designation	Site Description	Dominant Vegetation	Fauna Present
28E	This area is described as a small pocket of coniferous trees located along the western edge of Cogdels Creek, adjacent to the water treatment settling tanks.	The dominant vegetation is loblolly pine with red cedar dominating the scrub/shrub vegetation.	Song birds, wild turkey, and small mammals may inhabit this area.
28F	This area is described as mixed forest. It is located to the south of Orde Pond and west of Cogdels Creek.	Trees are the dominant vegetation with loblolly pine, red maple, and sweet gum constituting the most abundant tree species. The scrub/shrub vegetation is largely composed of southern bayberry.	Song birds, wild turkey, bobwhite, quail, white tail deer, and small mammals may inhabit this area.
28G	This area is described as mixed forest vegetation. This area contains more coniferous trees than 28F.	Loblolly pine and red cedar compose a large portion of the tree population with southern bayberry dominating the scrub/shrub vegetation.	Song birds, wild turkey, bobwhite, quail, white tail deer, and small mammals may inhabit this area.
28H	This area is described as a forested wetland found along a tributary of Cogdels Creek. The wetland is dominated by trees with some scrub/shrub and emergent vegetation located throughout the system.	The dominant vegetation includes red maple, coastal willow, unknown rhododendron, and lader.	This area is known as prime American alligator habitat. Other possible inhabitants may include small mammals such as gray squirrel, rabbit, and raccoon. Other possible inhabitants may include white tail deer and upland birds.
28I	This area is described as a coniferous forest located to the south of the firing range 30D.	The dominant vegetation includes loblolly pine, red cedar, and American holly.	Song birds, small mammals, and white tail deer most likely inhabit this area.

TABLE 13-4 (Continued)

SUMMARY OF HABITAT TYPES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Area Designation	Site Description	Dominant Vegetation	Fauna Present
28J	This area is described as a scrub/shrub wetland found along a tributary of Cogdels Creek.	The dominant vegetation includes scrub/shrub alder, coastal willow, southern bayberry, and red maple. There is also a large amount of emergent vegetation including soft rush, Carex sp., and Sagittaria sp.	This area is known as prime American alligator habitat. Other possible inhabitants may include small mammals such as gray squirrel, rabbit, raccoon, white tail deer, and wild turkey.

Note: Refer to Figure 13-10 for area designation location.

SECTION 13.0 FIGURES

LEGEND

28GW1	EXISTING MONITORING WELL
28SG02	EXISTING STAFF GAUGE
1 63	GROUNDWATER ELEVATION(WELL SPECIFIC), FEET ABOVE MSL
—3 00—	GROUNDWATER ELEVATION CONTOUR LINE FEET ABOVE MSL
→	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
CADD#	231126RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

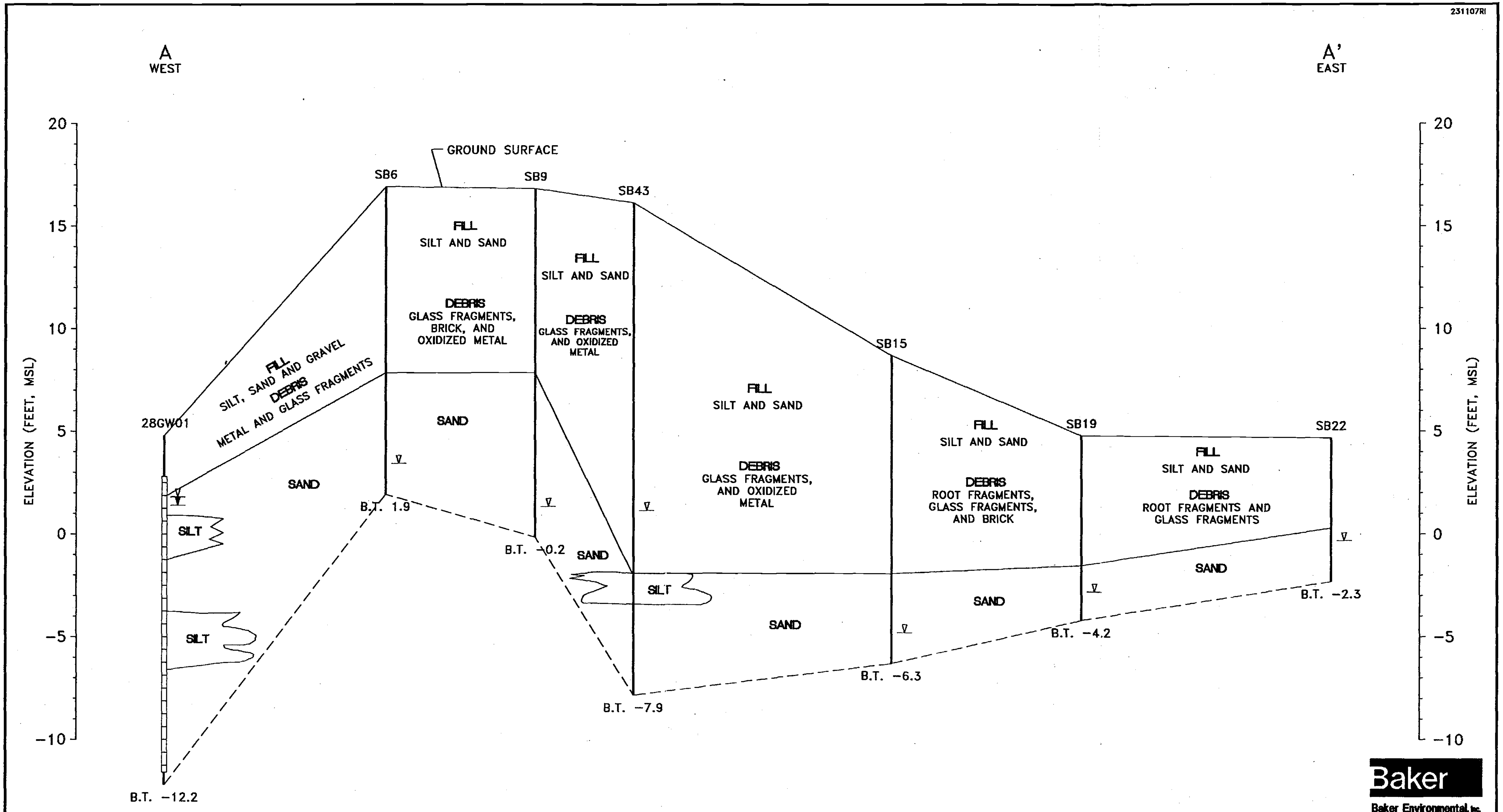
Baker Environmental, Inc

GROUNDWATER CONTOUR MAP FOR THE SURFICIAL AQUIFER – MAY 10, 1994
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1" = 120' DATE JANUARY 1995

FIGURE No 13-8

01500Q08X



LEGEND

▼	GROUNDWATER ELEVATION (5/10/94)
∇	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. -12.2'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

100 0 50 100 200

Horizontal Scale: 1 inch = 100 ft.

5 0 2.5 5 10

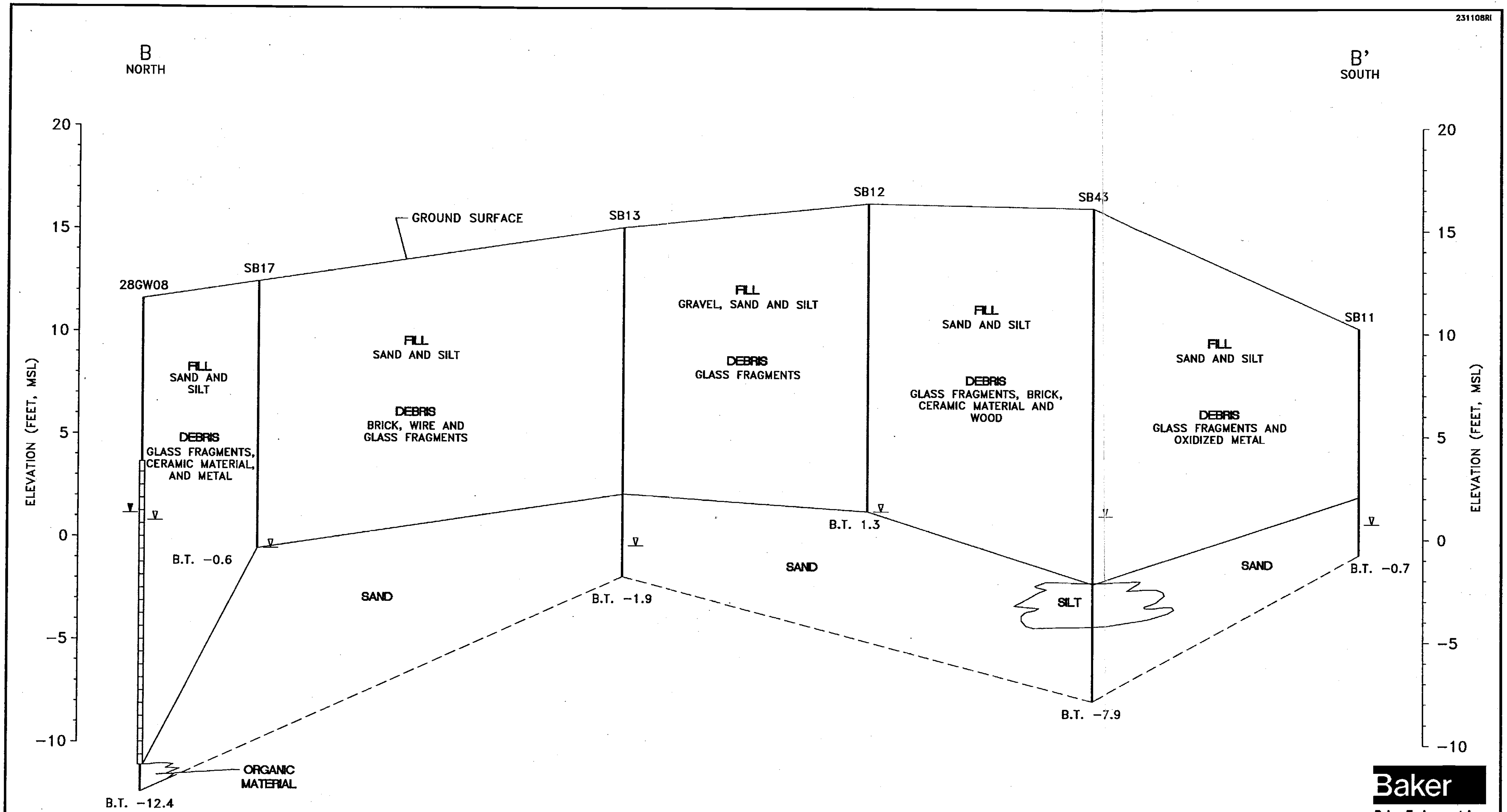
Vertical Scale: 1 inch = 5 ft.

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 13-2
GEOLOGIC CROSS-SECTION A-A'
SHALLOW SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORYTH CAROLINA

01500Q092



Baker
Baker Environmental, Inc.

LEGEND

- ▼ GROUNDWATER ELEVATION (5/10/94)
- ▽ GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. -12.4' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ——— ESTIMATED — — — PROJECTED

60 0 30 60 120
Horizontal Scale: 1 inch = 60 ft.

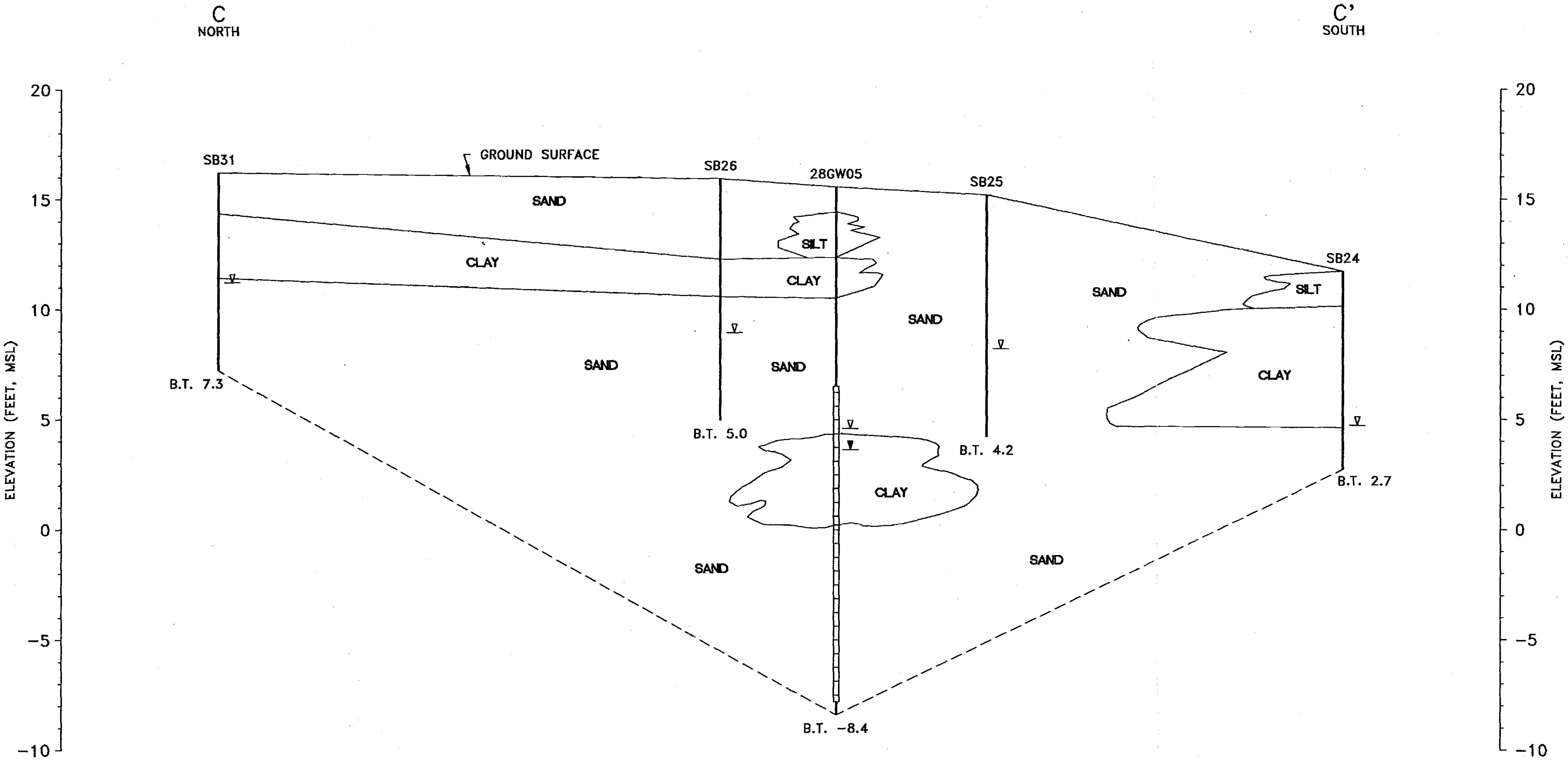
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

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 13-3
GEOLOGIC CROSS-SECTION B-B'
SHALLOW SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q10Z



Baker
Baker Environmental, Inc.

LEGEND

GROUNDWATER ELEVATION (5/10/94)
GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 7.3' BORING TERMINATED, ELEVATION MSL
WELL SCREEN INTERVAL
ESTIMATED — — — PROJECTED

30 0 15 30 60
Horizontal Scale: 1 inch = 30 ft.

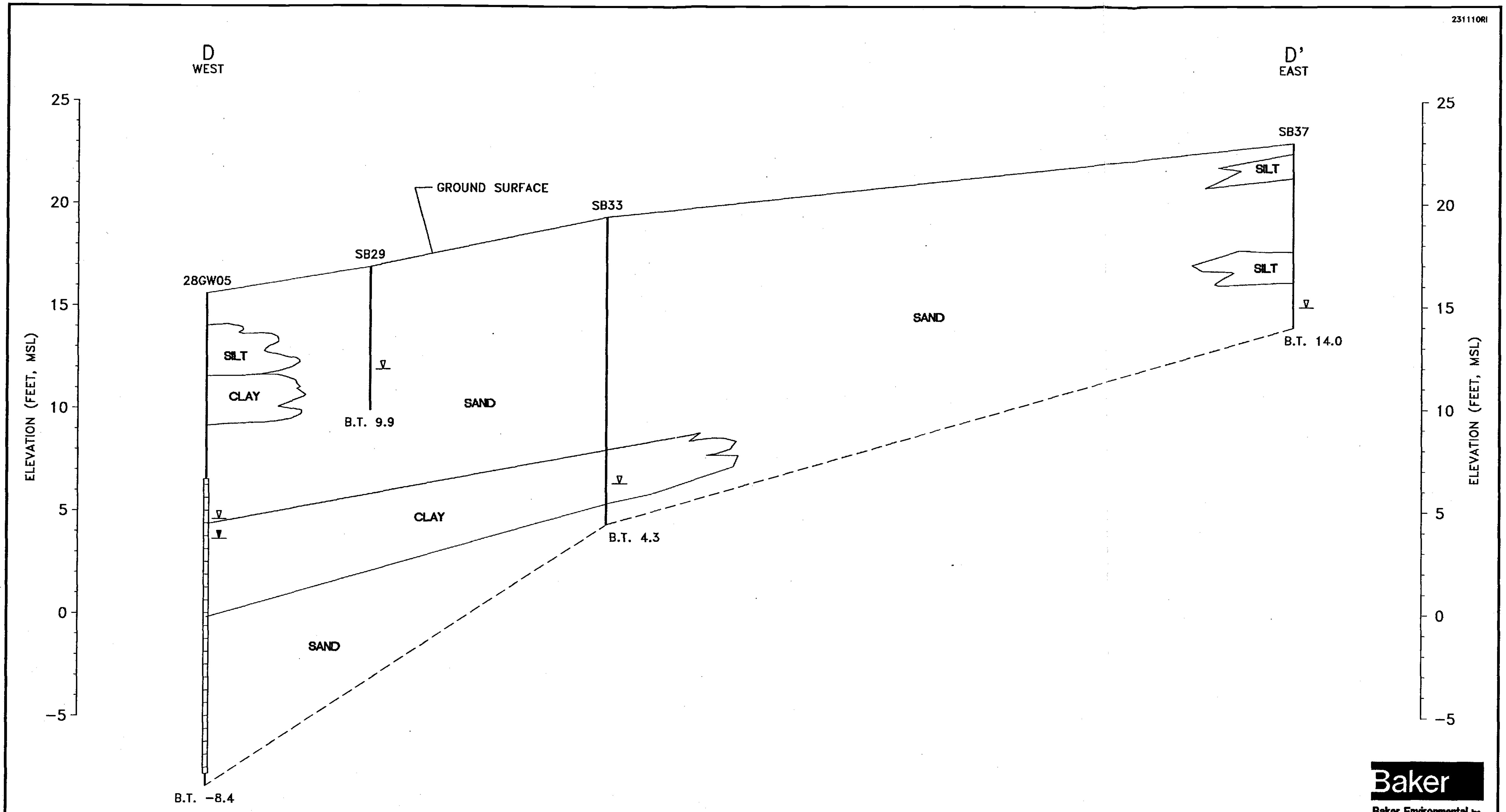
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

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 13-4
GEOLOGIC CROSS-SECTION C-C'
SHALLOW SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q112



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (5/10/94)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. -8.4'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
– – –	PROJECTED

40 0 20 40 80
Horizontal Scale: 1 inch = 40 ft.

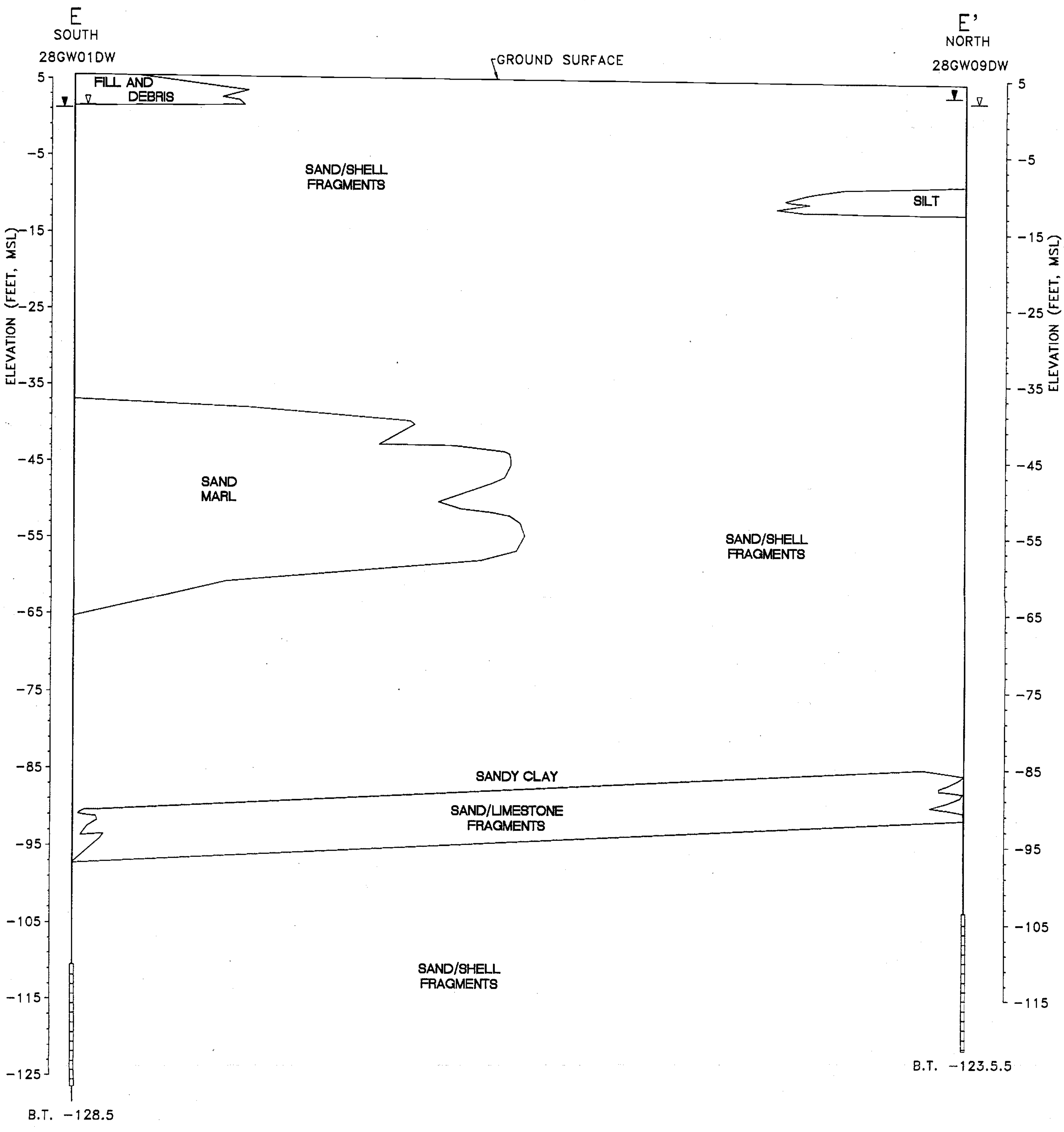
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

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 13-5
GEOLOGIC CROSS-SECTION D-D'
SHALLOW SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q122



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.

231111RI

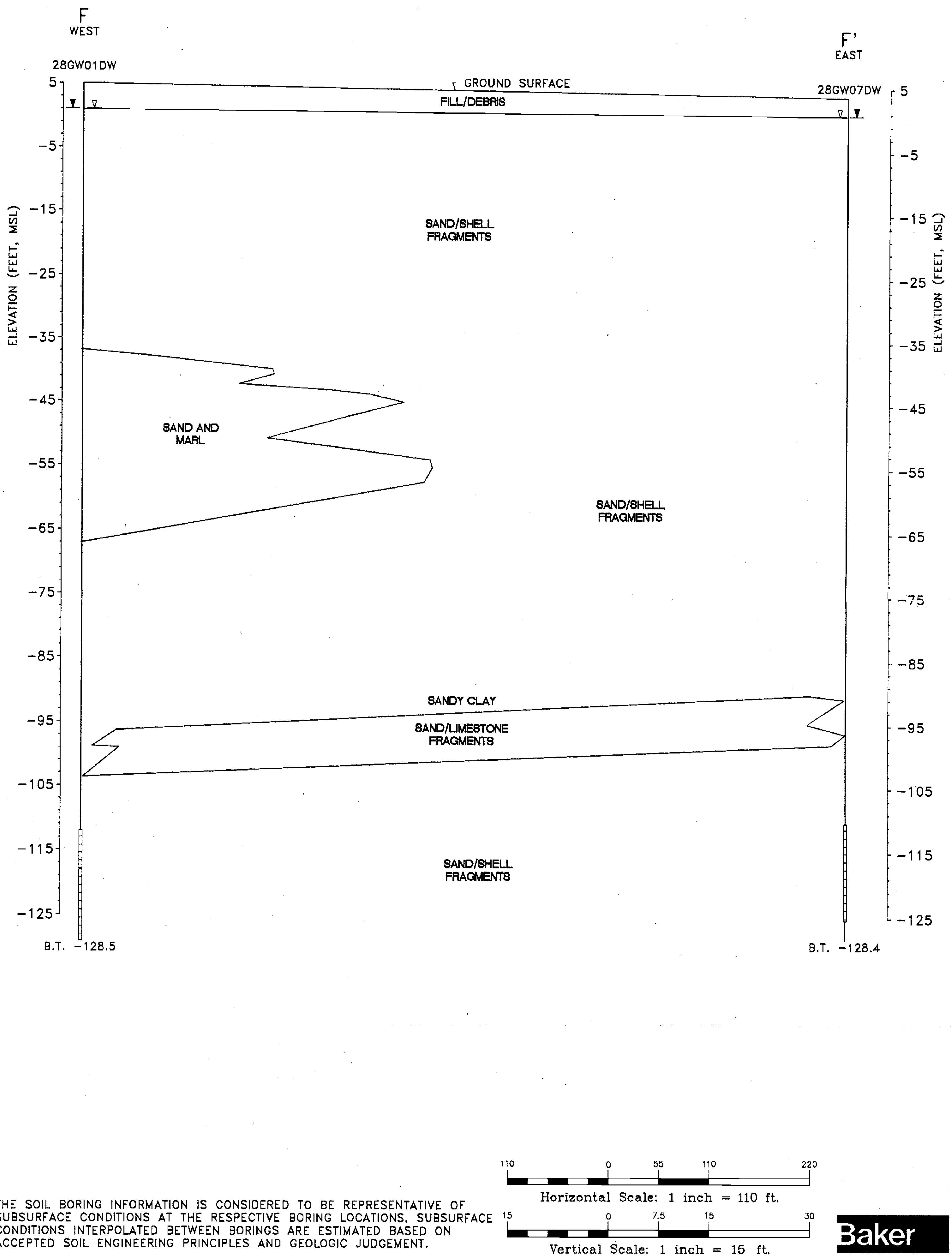
Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (5/10/94)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. -128.5' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED ----- PROJECTED

FIGURE 13-6
GEOLOGIC CROSS-SECTION E-E'
DEEP SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q13Z



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.

231112RI

Baker

Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (5/10/94)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. -128.5'	BORING TERMINATED, ELEVATION MSL
	WELL SCREEN INTERVAL
———	ESTIMATED ------ PROJECTED

FIGURE 13-7
GEOLOGIC CROSS-SECTION F-F'
DEEP SOIL LITHOLOGY
SITE 28
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q142

LEGEND

28GW01DW	EXISTING MONITORING WELL
1 36	GROUNDWATER ELEVATION(WELL SPECIFIC), FEET ABOVE MSL
1 40	GROUNDWATER ELEVATION CONTOUR LINE FEET ABOVE MSL
	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S.O.#	62470-231-0000
CADD#	231127RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

Baker Environmental, Inc

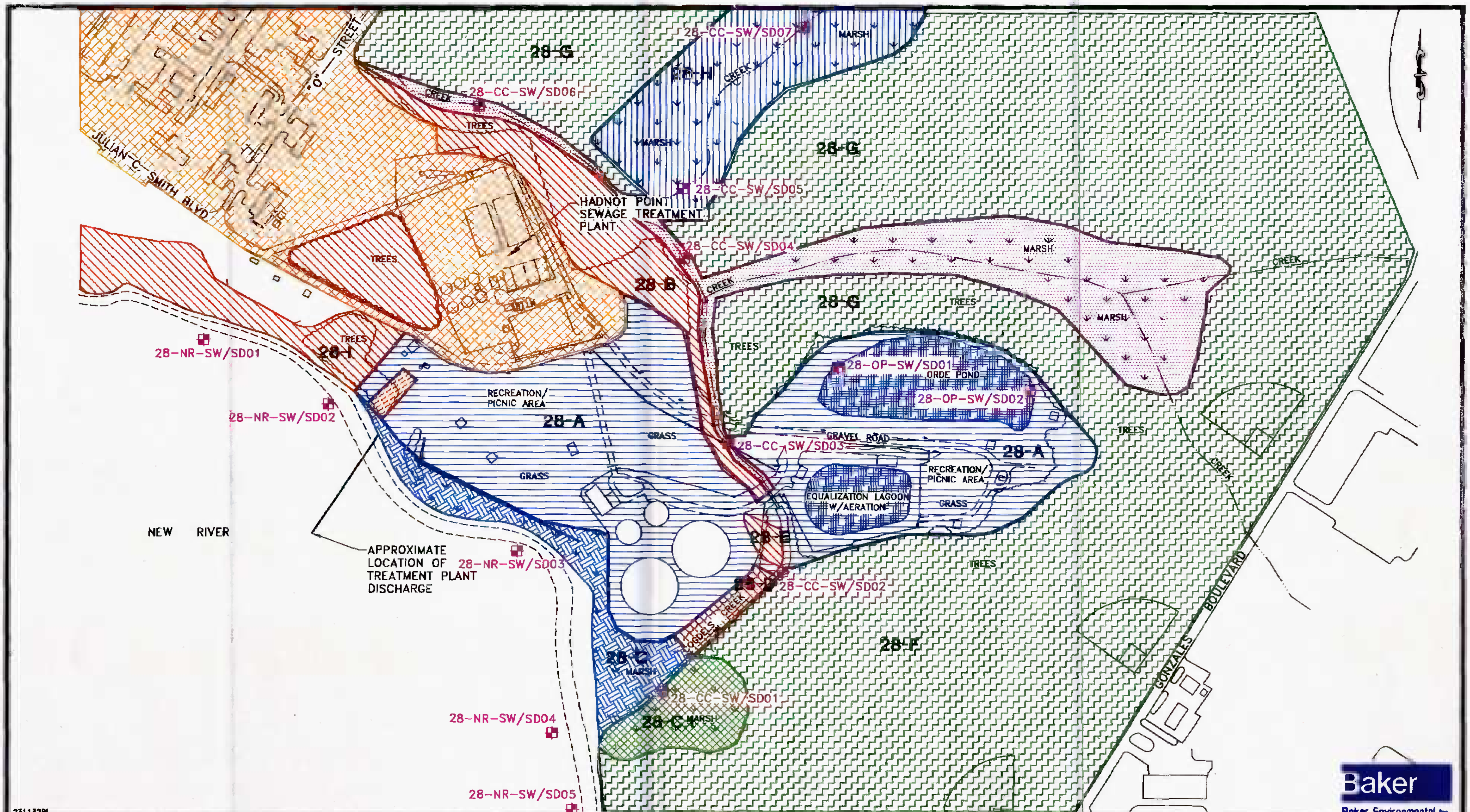
GROUNDWATER CONTOUR MAP FOR THE
DEEP AQUIFER – MAY 10, 1994
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1" = 120'

DATE JANUARY 1995

FIGURE No
13-9

01503Q15X



LEGEND

- INDUSTRIAL AREA
- ESTUARINE FORESTED AND SCRUB SHRUB WETLAND
- ESTUARINE AND PERSISTENT WETLANDS
- OPEN GRASS AREA
- CONIFEROUS FOREST
- EVERGREENS
- MIXED FOREST (DECIDUOUS AND CONIFEROUS)
- OPEN WATER
- SCRUB AND SHRUB WETLAND
- FORESTED WETLANDS
- 28-NR-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLING STATION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 13-10
BIOHABITAT MAP
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q16Y

14.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the analytical findings from the RI performed at OU No. 7, Site 28. The objective of this section is to characterize the nature and extent of contamination at Site 28. The characterization of contaminants at Site 28 was performed through environmental sample collection and laboratory analysis of soil, groundwater, surface water, sediment, and biotic media. Appendices F through L present the Field Duplicate Summaries, TCLP Results, Engineering Parameter Results, Quality Assurance and Quality Control Summaries, Sampling Summaries, Data and Frequency Summaries, and Statistical Summaries, respectively, for the various media at Site 28.

14.1 Data Quality

The entire data set generated during the RI was submitted for third-party data validation to Heartland Environmental Services, Inc. Procedures stipulated by the National Functional Guidelines for Organic (USEPA, 1991a) and Inorganic (USEPA, 1988) Analyses were followed 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 to be 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). Data assigned a rejected "R" qualifier was excluded from the usable data set.

The entire Site 28 data set included analyses for over 20,000 separate contaminants in environmental media. Only 99 of those analyses, less than one percent, were rejected as unusable. Typically, a fraction or specific contaminants within a number of fractions were rejected for reasons such as low surrogate recovery or the presence of compounds in continuing calibrations with differences greater than 90 percent. In the case of the biotic samples, the volatile and semivolatile analyses exceeded the extraction holding time. Under these conditions positive results were designated with "J" (i.e., estimated) qualifiers and all nondetects were assigned the "R" (i.e., rejected) qualifier. Table 14-1 provides a summary of all rejected Site 28 data.

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 that were not detected and had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier.

14.1.1 Data Management and Tracking

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 analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, which have been provided in Appendix C. The chain-of-custody forms were checked against the Field Sampling and Analysis Plan (Baker, 1993) 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 the 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

14.2 Non-Site Related Analytical Results

Many of the organic and inorganic constituents detected in various media at Site 28 are attributable to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally-occurring inorganic contaminants. 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 28 is provided in the following subsections.

14.2.1 Laboratory Contaminants

Blank samples 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, 1989). The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

- Acetone 38 μg/L
- Methylene Chloride 13 μg/L
- bis-(2-Ethylhexyl)phthalate 120 μg/L
- 2-Butanone 7 μg/L
- 2-Hexanone 5 μg/L
- Di-n-octylphthalate 41 μg/L

Blanks containing organic constituents that were not considered common laboratory contaminants (i.e., all other TCL compounds) were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989). All TCL compounds at 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 10 μg/L
- Bromomethane 9 μg/L
- Toluene 2 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.

14.2.2 Naturally-Occurring Inorganic Contaminants

In order to differentiate between inorganic contamination due to site operations and naturally-occurring inorganic contaminants 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 Background Surface Water Samples
Sediment:	MCB, Camp Lejeune Background Sediment Samples

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 28.

14.2.2.1 Soil

In general, chemical-specific ARARs 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 reference levels of inorganic contaminants in the surface and subsurface soil.

Organic contaminants, unlike inorganic contaminants, are not naturally-occurring. Therefore, it is probable that all organic contaminants detected in the surface and subsurface soils are attributable to activities that have or are currently taking place within and surrounding the study area. Typical background concentration values for inorganic contaminants in soils at MCB, Camp Lejeune are presented in Appendix M. These ranges are based on analytical results of background samples collected in areas not known to have been impacted by operations or disposal activities adjacent to Sites 1, 2, 6, 28, 30, 41, 69, 74, and 78 (refer to Figure 1-2 for site locations throughout MCB, Camp Lejeune). In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic contaminants with concentrations exceeding these ranges will be considered.

In general, background soil samples have been collected outside the known boundaries of those sites listed above and in areas with similar soils types. According to the SCS Soil Survey, the greatest portion of MCB, Camp Lejeune is underlain by a number of similar soil units. Soils found on this portion of the coastal plain are moderately to strongly acidic in nature and are classified under the USCS as SM, SM-SP (i.e., fine sand or loamy fine sand) Section 12.2 provides the locations of background soil borings completed at Site 28 during this investigation.

14.2.2.2 Groundwater

Unlike soil, chemical-specific ARARs are available for evaluation of analytical results from groundwater samples. In the subsequent sections which address the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable state or federal 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 contaminants in groundwater at MCB, Camp Lejeune (refer to Appendix M).

Groundwater samples were analyzed for total and dissolved (i.e., "filtered") 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. 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, yielding higher concentrations of inorganic contaminants. The total metal analyses from unfiltered samples thus reflect the concentrations of inorganics in the natural lithology and inorganic contaminants dissolved in the groundwater.

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 M). The difference between the two analytical results (i.e., total 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 state or federal limits) 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 filtered) in groundwater at MCB, Camp Lejeune often exceed the NCWQS of 300 and 50 μg/L, respectively. Elevated levels of iron and manganese, at concentrations above the NCWQS, were reported in samples collected from a number of base potable water supply wells which are installed at depths greater than 162 feet bgs. (Greenhorne and O'Mara, 1992). Iron and manganese concentrations from several wells at Site 28 exceeded the NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. There is no record of any historical use of iron or manganese at Site 28. In light of this, it is assumed that iron and manganese are naturally-occurring inorganic contaminants in groundwater, and their presence is not attributable to site operations.

14.2.2.3 Surface Water

In the subsequent sections, which address the analytical results of samples collected during the surface water investigation, only those inorganic parameters with concentrations exceeding applicable state or federal regulatory limits will be discussed. Base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to supplement the evaluation of detected inorganic contaminants in surface water. Typical inorganic background concentration values for surface waters at MCB, Camp Lejeune are presented in Appendix M. These values are based on analytical results of background samples collected upgradient of areas known or suspected to have been impacted by operations or disposal activities. Inorganic parameters detected below these levels are assumed to be naturally-occurring elements.

14.2.2.4 Sediment

Base-specific inorganic background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to supplement the evaluation of detected inorganic contaminants in sediment. Those inorganic contaminants that exceed applicable state or federal regulatory limits were compared against base-specific background concentrations in subsequent sections. Typical inorganic background concentration values for sediments at MCB, Camp Lejeune are presented in Appendix M. These values are based on analytical results of background samples collected upgradient of areas known or suspected to have been impacted by operations or disposal activities. Inorganic parameters detected below these levels are assumed to be naturally-occurring elements.

14.3 Analytical Results

This section presents the results of the soil, groundwater, surface water, sediment, and aquatic investigations performed at Site 28. A summary of site contamination, by media, is provided in Table 14-2.

14.3.1 Soil Investigation

Unique sample notations were employed to identify soil sampling locations and sample depths at Site 28. Samples designated by "E" were collected from the eastern portion of the site. The "W" designation was assigned to samples obtained from the western portion of the site. Samples designated with the prefix "GW" were collected from monitoring well pilot test borings. The suffix "DW" after the monitoring well number indicates that the sample was obtained from a deep monitoring well test boring. The following suffix designations refer to the depth at which a sample was obtained:

00	-	ground surface to 12 inches bgs
01	-	1 to 3 feet bgs
02	-	3 to 5 feet bgs
03	-	5 to 7 feet bgs
04	-	7 to 9 feet bgs
05	-	9 to 11 feet bgs

Surface soil positive detection summaries for organic and inorganic contaminants are presented in Tables 14-3 and 14-4, respectively. Positive detection summaries of organic contaminants in subsurface soils are presented in Table 14-5; summaries for inorganic contaminants are provided in Table 14-6. The majority of soil samples collected at Site 28 were analyzed for full TCL organics and TAL inorganics using CLP protocols and Level IV data quality. Soil samples obtained from monitoring well test borings were also analyzed for full TCL organics and TAL inorganics. A total of three surface and 19 subsurface soil samples were analyzed for TAL inorganics only. In addition, a limited number of soil samples underwent analyses for total petroleum hydrocarbons (TPH).

14.3.1.1 Surface Soil

A total of 43 surface soil samples were collected at Site 28; 40 of the 43 samples were analyzed for full TCL organics and TAL inorganics. The remaining three samples were analyzed for TAL inorganics only. As indicated on Table 14-2, volatile, semivolatile, pesticide, and PCB organic compounds were detected in surface soils at Site 28. The only volatile compound detected among the 40 surface soils samples was 1,1,1-trichloroethane at an estimated concentration of 2 J µg/Kg from soil boring 28-E-SB27.

Twenty-one semivolatile compounds were detected in 18 of the 40 surface soil samples that were submitted for laboratory analysis. A majority of positive SVOC detections were within soil samples collected from the western portion of the site. Fifteen of the 21 contaminants detected were polynuclear aromatic hydrocarbons (PAHs). Semivolatile concentrations ranged from 41 J µg/Kg of phenanthrene to 2,800 µg/Kg of benzo(b)fluoranthene. As presented in Table 14-2, 12 of the 15 PAH compounds were detected at their respective maximums within a surface soil sample from the pilot test boring 28-GW01. The following PAH compounds were detected with the most frequency, each identified within at least eight of the 40 surface soil samples: phenanthrene, fluoranthene, pyrene, chrysene, and benzo(b)fluoranthene.

Pesticides were detected in 31 of the 40 surface soil samples submitted for analysis from Site 28. Unlike SVOC detections, pesticides were widely scattered at varying concentrations throughout the site. As indicated in Table 14-2, the compounds 4,4'-DDE, 4,4'-DDT, 4,4'-DDD, and alpha-chlordane, in decreasing order of frequency, were the most prevalent among the ten pesticide contaminants detected, each with at least 15 positive detections. Pesticide concentrations ranged from 0.91 NJ µg/Kg of 4,4'-DDD to 1,400 µg/Kg of 4,4'-DDT.

Three separate soil borings, located within each western suspected disposal area, had one positive detection of a PCB organic compound. Aroclor 1254 was detected at concentrations of 47 J and 58 J µg/Kg in samples 28-W-SB06 and 28-W-SB12, respectively. Aroclor 1260 was detected at a concentration of 44 µg/Kg from sample 28-W-SB15.

Twenty-two of 23 TAL inorganics were detected in 43 surface soil samples at Site 28 (beryllium was not detected). Two positive detections of cadmium and one positive detection each of copper, mercury, selenium, and silver were observed at concentrations greater than one order of magnitude above the base-specific (i.e., MCB, Camp Lejeune) background levels for surface soil (refer to Appendix M for base-specific inorganic background concentrations). Zinc was detected within eight surface soil samples at concentrations greater than one order of magnitude above base-specific background levels. Manganese was detected at concentrations of 669 and 39,100 µg/Kg in two surface soil samples obtained from the western portion of Site 28. These two positive detections of manganese exceeded the base-specific background concentration of 16 µg/Kg, by more than one and three orders of magnitude.

Although inorganics were detected in soil samples throughout the site, consistently higher concentrations of metals were identified in samples collected from the western portion of Site 28. Table 14-2 provides a summary of the priority pollutant inorganic contaminants found within soil samples at Site 28. Priority pollutant metals are a subset of TAL metals and include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

14.3.1.2 Subsurface Soil

A total of 51 subsurface (i.e., greater than one-foot bgs) soil samples from Site 28 were submitted for laboratory analysis; 32 of the 51 samples were analyzed for full TCL organics and TAL inorganics. The remaining 19 were analyzed for TAL inorganics only. The results indicate the presence of organic compounds and inorganic contaminants. The VOCs benzene and tetrachloroethene were both detected once, in two separate soil samples from the western portion of the study area (see Table 14-2).

Twenty-three semivolatile compounds were detected in 14 of the 32 subsurface soil samples from Site 28. With the exception of three semivolatile compounds in three separate soil borings, all SVOC detections were within soil samples collected from the western portion of the site. Fifteen of the 21 SVOC contaminants detected were polynuclear aromatic hydrocarbons (PAHs). Semivolatile concentrations ranged from 38 J to 27,000 μg/Kg of phenananthrene in sample 28-W-SB11. As provided in Table 14-2, 12 of the 15 PAH compounds were detected at their respective maximums within a subsurface soil sample from boring 28-W-SB11, located within the western disposal area. The SVOCs phenanthrene, fluoranthene, and bis(2-ethylhexyl)phthalate were detected with the most frequency, each identified within at least nine of the 32 subsurface soil samples.

Five organic pesticide compounds were detected in subsurface soils at Site 28. Positive detections of pesticides were more prevalent in subsurface soils from the western portion of the study area. In general, concentrations of organic pesticides were higher in samples obtained from the suspected western disposal area. As depicted on Table 14-2, pesticide concentrations ranged from 2.7 J μg/Kg of alpha-chlordane to 7,300 μg/Kg of 4,4'-DDT in sample 28-GW01DW.

The organic PCB contaminants aroclor 1242 and aroclor 1260 were detected within two separate subsurface soil samples from Site 28. Aroclor 1242 was detected at an estimated concentration of 140 J μg/Kg in a subsurface sample obtained from pilot test boring 28-GW07. Aroclor 1260 was detected at concentrations of 25 J and 77 μg/Kg in two separate subsurface samples obtained from soil boring 28-W-SB03.

All 23 TAL inorganics were detected in subsurface soils at Site 28. As presented in Table 14-2, arsenic, chromium, copper, lead, and zinc were each detected in at least 40 of the 50 subsurface samples. Arsenic, cadmium, chromium, nickel, and silver were found within samples at concentrations greater than one order of magnitude above the base-specific background levels for subsurface soil (refer to Appendix M for base-specific inorganic background concentrations). Additionally, the inorganic contaminants copper, lead, and zinc were observed at concentrations greater than two orders of magnitude above their respective base-specific background levels. As with surface soils, inorganics were detected in subsurface samples from the western portion of Site 28 at consistently higher concentrations than from the eastern portion.

14.3.1.3 Summary

Semivolatile compounds within soil samples at Site 28 appear to be the most directly linked, among organic compounds, to past disposal practices. Several SVOCs were identified in both surface and subsurface soil samples, primarily from the western disposal area. A majority of SVOCs detected in soil samples were PAH compounds, most probably resulting from combustion of waste material or refuse. As provided in Table 14-2, several of the semivolatile compounds were detected at concentrations greater than 1,000 µg/Kg.

Inorganic contaminants were detected in both surface and subsurface soil samples from the western portion of the study area at concentrations greater than one order of magnitude above of base-specific background levels. In general, elevated metal concentrations were limited to soils obtained from the western portion of the study area. The metals copper, lead, manganese, and zinc were observed at maximum concentrations greater than two orders of magnitude above base-specific background levels. The same three metals had several positive detections in excess of the one order of magnitude level.

The pesticides dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane appear to be the most widely scattered contaminants within soils at Site 28. Each of the five pesticides was detected in at least 15 of the 72 soil samples. The pesticide 4,4'-DDE was the most prevalent, with 44 positive detections ranging from 3.1 J to 1,600 µg/Kg. The highest pesticide concentration was that of 4,4'-DDT at 7,300 µg/Kg. In general, higher concentrations of those pesticides more frequently detected, were limited to the western portion of the study area, and in particular among borings 28-GW01, 28-GW01DW, and 28-W-SB12.

Three organic PCB contaminants, aroclor 1242, 1254, and 1260, were detected in soil samples obtained from borings at Site 28. The maximum PCB concentration was 140 J µg/Kg from the pilot test boring 28-GW07.

Volatile compounds were found in one surface soil sample and two subsurface samples at very low concentrations. The VOCs benzene, tetrachloroethene, and 1,1,1-trichloroethane were each detected once within the 72 soil samples collected at Site 28. Based upon their distribution, infrequent detection, and low concentration, the occurrence of volatile compounds in soils at Site 28 does not appear to be the result of past disposal practices.

14.3.2 Groundwater Investigation

The groundwater investigation at Site 28 entailed the collection of 13 groundwater samples obtained from one temporary shallow, nine shallow, and three deep monitoring wells. Groundwater samples collected at Site 28 were analyzed for full TCL organics and TAL inorganics, both total and dissolved fractions, using CLP protocols and Level IV data quality. (Dissolved or filtered TAL inorganic results are presented in this report for comparative purposes only. These results were not used to evaluate site-related risks or to determine compliance with groundwater standards.)

A second, supplemental, sampling round was performed on each of the 12 permanent monitoring wells at Site 28. The analytical results from both sampling rounds are provided in the following subsections. A positive detection summary of organic compounds from the first sampling round is provided in Table 14-7. No organic compounds were detected in samples acquired during the second sampling round. Total metal results from both the first and second sampling rounds are presented in Tables 14-8 and 14-10, respectively. In addition, Tables 14-9 and 14-11 provide positive detection summaries for dissolved metals in groundwater samples obtained from the two sampling rounds. A comparison of analytical results from both rounds of groundwater samples is provided in Table 14-12.

14.3.2.1 Shallow Groundwater

Round One

A total of 10 shallow groundwater samples from Site 28 were submitted for laboratory analysis. The samples were collected from the uppermost portion of the surficial aquifer (i.e., the water table). As indicated in Table 14-2, volatile detections were limited to a temporary well, 28-TGWPA, located near the center of the western disposal area. Chloroform, ethylbenzene, and xylenes were detected in the temporary well at concentrations of 2, 5, and 19 μg/L, respectively.

A total of 16 semivolatile compounds were detected in five shallow monitoring wells located adjacent to or within the western disposal area. The majority of the SVOCs were detected within the temporary well, 28-TGWPA. The highest positive detection of a semivolatile compound was 99 μg/L of naphthalene from the temporary well. Seven of the 16 maximum SVOC detections were less than 5 μg/L.

The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and gamma-chlordane were detected in groundwater samples obtained from monitoring wells located on the western portion of the study area. The maximum pesticide concentration was 6.6 J μg/L of 4,4'-DDE from temporary well, 28-TGWPA. As Table 14-2 depicts, 4,4'-DDE and 4,4'-DDD were detected the most frequently of pesticide fractions. No organic PCB contaminants were detected in any of the 10 shallow groundwater samples obtained from Site 28.

TAL metals, both total and dissolved fractions, were detected in each of the 10 monitoring wells at Site 28. Complete positive detection summaries for total and dissolved metals are provided on Tables 14-8 and 14-9, respectively. Each of the 23 TAL total metals were detected within at least one groundwater sample at Site 28. Eighteen of 23 TAL dissolved metals were also detected within at least one of the 10 groundwater samples (beryllium, cadmium, mercury, selenium, and thallium were not detected). Lead and manganese were detected within a groundwater sample from 28-GW07 at concentrations greater than one order of magnitude above their respective base-specific background levels (refer to Appendix M). Lead was also detected above ten times the base-specific background level in a sample from the temporary well.

Round Two

During the second sampling round, groundwater samples from each of the nine shallow monitoring wells at Site 28 were submitted for laboratory analysis of total and dissolved metals, TDS, and TSS. Additionally, five of the nine groundwater samples were also submitted for organic pesticide analyses. The additional pesticide analyses were obtained from monitoring wells that exhibited pesticide contamination from the first round. No pesticides were detected in any of the five groundwater samples submitted during the round two sampling event, however.

Total and dissolved TAL metals were detected in each of the nine shallow groundwater samples submitted for analysis from Site 28. Positive detection summaries for round two total and dissolved metal analyses are provided in Tables 14-10 and 14-11, respectively. Fifteen of 23 TAL total metals were detected in at least one shallow groundwater sample from Site 28 (antimony, beryllium, cadmium, chromium, cobalt, selenium, silver, and thallium were not detected). Twelve of 23 TAL dissolved metals were also detected within at least one of the nine groundwater samples (antimony, beryllium, cadmium, chromium, cobalt, mercury, nickel selenium, silver, thallium, and zinc were not detected). Iron, lead, and manganese were detected during the second sampling round at concentrations in excess of either the MCL or NCWQS, based on total metal analyses. Iron exceeded the NCWQS of 300 μg/L in seven of the nine shallow groundwater samples, with a maximum concentration of 40,600 μg/L. Manganese was detected in groundwater samples from each of the nine shallow monitoring wells, with a maximum concentration of 1,450 μg/L. Seven of the nine groundwater samples had positive detections of manganese in excess of the 50 μg/L NCWQS. Lead was detected in only one of the nine groundwater samples in excess of the NCWQS and federal action level of 15 μg/L. Both lead and manganese were detected above the base-specific background levels in only one of the nine shallow groundwater samples, 28-GW08 (see Appendix M for base-specific background inorganic concentrations). Table 14-12 provides a comparison of round one versus round two sampling results.

14.3.2.2 Deep Groundwater

Round One

A total of three groundwater samples were obtained from the deep aquifer (i.e., the Castle Hayne aquifer) at Site 28. Volatile, semivolatile, pesticide, and PCB organic compounds were not detected in any of the three samples obtained from the deep aquifer.

TAL metals, both total and dissolved fractions, were detected in each of the three deep monitoring wells at Site 28. Seventeen of the 23 TAL total metals were detected within at least one of the deep groundwater samples. Twelve of 23 TAL dissolved metals were also detected within at least one of the three deep groundwater samples. The total metals iron, lead, and manganese were detected at concentrations in excess of either the MCL or NCWQS in upgradient well 28-GW09DW. Iron and thallium were detected above federal or state standards in well 28-GW01DW.

Round Two

Groundwater samples from the three deep monitoring wells at Site 28 were submitted for TAL total and dissolved metal, TDS, and TSS analyses as part of the second sampling round. Both total and dissolved TAL metals were detected in each of the three deep groundwater samples. Among the total metal results, manganese was the only potential contaminant identified above MCL or NCWQS levels. The groundwater sample from well 1-GW01DW had a manganese concentration of 66 μg/L, in excess of the 50 μg/L state standards.

14.3.2.3 Summary

Inorganic contaminants were the most prevalent and widely distributed contaminants in groundwater at Site 28 and were found throughout the site. Concentrations of TAL total metals, in samples obtained during both sampling rounds, were generally higher in shallow groundwater samples than in samples collected from the deeper aquifer. Lead was detected, and confirmed by the second sampling round, within only 1 of the 12 shallow and deep groundwater samples at a concentration that exceeded the NCWQS and federal action level from 28-GW08. Lead was also detected during the first sampling round in a sample retained from temporary well 28-TGWPA at a concentration which exceeded the NCWQS and federal action level. Iron and manganese were the most prevalent inorganic contaminants detected during both sampling rounds. Concentrations of iron and manganese were confirmed by the second sampling round to have exceeded either federal or state standards within 7 groundwater samples. Table 14-2 presents a summary of inorganic contaminants in excess of applicable federal or state standards.

Semivolatile compounds were detected in five of ten shallow groundwater samples obtained from the western portion of the study area during the first sampling round. The maximum SVOC concentration, 99 µg/L of naphthalene, was detected within the sample from temporary monitoring well 28-TGWPA, located in the central western portion of the study area. Semivolatile analyses of groundwater samples were not performed as part of the second sampling round.

The organic pesticide compounds 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and gamma-chlordane were each detected at least once within samples obtained from six shallow monitoring wells located on the western portion of Site 28, during the first sampling round. Pesticides 4,4'-DDE and 4,4'-DDD were detected within five and six shallow groundwater samples, respectively. The highest pesticide concentration detected was 9 µg/L, within the sample obtained from monitoring well 28-GW07. A second round of groundwater samples was obtained from those monitoring wells that presented evidence of pesticide contamination during the first sampling round. However, groundwater samples obtained during the second sampling round did not exhibit pesticides.

Positive detections of VOCs in groundwater were limited to the central western portion of the study area. The volatile compounds chloroform, ethylbenzene, and xylene were detected in a single shallow groundwater sample obtained from temporary well 28-TGWPA.

14.3.3 Surface Water Investigation

Environmental samples were collected from Orde Pond, Cogdels Creek, and the New River as part of the surface water investigation at Site 28. A total of 14 surface water samples were collected at Site 28. Two of the 14 samples were retained from Orde Pond, seven from Cogdels Creek, and five from the New River. Each of the 14 surface water samples was analyzed for full TCL organics and TAL inorganics, using CLP protocols and Level IV data quality.

Analytical results from the surface water investigation at Site 28 are provided in the following subsections. Table 14-2 provides a summary of results of surface water contamination. Positive detection summaries of organic compounds found in Orde Pond, Cogdels Creek, and the New River are provided in Tables 14-13, 14-15, and 14-17, respectively. Total metal results of samples retained from each of the three surface water bodies are presented in Tables 14-14, 14-16, and 14-18. Volatile and PCB organic compounds were not detected in any of 14 surface water samples and, therefore, will not be considered further. Semivolatile and pesticide organic compounds were not detected in any of the surface water samples retained from either Orde Pond or Cogdels Creek and, correspondingly, will not be addressed.

14.3.3.1 Orde Pond

Fourteen of 23 TAL total metals were positively identified in the two surface water samples from Orde Pond. As depicted in Table 14-2, thallium was the only metal identified at a concentration in excess of chronic screening values established by the National Oceanic and Atmospheric Administration (NOAA). The thallium concentration in sample 28-OP-SW02, obtained from the eastern end of Orde Pond, exceeded the NOAA chronic screening value of 4.0 µg/L by only 0.7 µg/L. No other total metal concentrations were in excess of chronic screening values.

14.3.3.3 Cogdels Creek

Laboratory analyses of the seven Cogdels Creek surface water samples indicate that 14 of 23 possible total metals were positively detected. As indicated in Table 14-2, lead was the only metal identified at a concentration in excess of the NOAA chronic screening values. Lead was detected within each of the seven surface water samples in excess of the 1.32 µg/L screening value. The maximum concentration of lead, 4.2 µg/L, was observed in a sample collected upstream of the study area. None of the positive lead detections exceeded the maximum base-specific surface water background concentration of 10.4 µg/L (see Appendix M). No other total metal concentrations in the seven surface water samples exceeded chronic screening values.

14.3.3.2 New River

A positive detection of one semivolatile organic compound was observed among the five New River surface water samples. The SVOC phenanthrene was detected at a trace concentration of 1 µg/L in sample 28-NR-SW02, located slightly upstream of the study area. The pesticide organic compounds 4,4'-DDE and 4-4'-DDD were detected in surface water sample 28-NR-SW03, located adjacent to the western disposal area, at estimated concentrations of 0.04 J and 0.05 J µg/L, respectively. Table 14-2 provides a summary of surface water contamination in samples retained from the New River.

Sixteen of 23 TAL total metals were positively identified in the five surface water samples collected from the New River. Copper, lead, thallium, and zinc were each identified at concentrations in excess of NOAA chronic screening values. As depicted in Table 14-2, thallium and zinc were detected in excess of surface water screening values in one sample each. Copper, and lead each exceeded screening values in a total of three surface water samples. The thallium concentration in sample 28-NR-SW04, located at the mouth of Cogdels Creek, exceeded the NOAA chronic screening value of 4.0 µg/L by 1.6 µg/L. Copper and lead were detected, among the five New River surface water samples, at maximum concentrations of 181 and 23.4 µg/L, respectively. Both maximum detections of copper and lead were observed in sample 28-NR-SW01, located approximately 100 yards upstream of the study area. The sample 28-NR-SW03, collected adjacent to the western disposal area, had copper, lead, and zinc concentrations of 6.6, 3.1, and 363 µg/L, respectively. Each of these three detections were in excess of the established chronic surface water screening values for copper, lead, and zinc of 6.5, 1.32, and 58.9 µg/L, respectively. No other total metal concentrations in the seven surface water samples exceeded chronic screening values.

14.3.4 Sediment Investigation

Environmental samples were collected from Orde Pond, Cogdels Creek, and the New River as part of the sediment investigation at Site 28. A total of 28 sediment samples, two from each sampling station, were collected at Site 28. At each sampling station a sample was collected from zero to six inches and also from six to twelve inches. Four of the 28 samples were retained from Orde Pond, 14 from Cogdels Creek, and 10 from the New River. Each of the 28 sediment samples was analyzed for full TCL organics and TAL inorganics, using CLP protocols and Level IV data quality.

Analytical results from the surface water investigation at Site 28 are provided in the following subsections. Table 14-2 provides a summary of results surface water contamination. Positive detection summaries of organic compounds found in Orde Pond, Cogdels Creek, and the New River are provided in Tables 14-19, 14-21, and 14-23, respectively. Total metal results of sediment samples retained from each of the three surface water bodies are presented in Tables 14-20, 14-22, and 14-24. Organic PCB compounds were not detected in any of 28 sediment samples and therefore will not be addressed.

14.3.4.1 Orde Pond

Volatile and semivolatile organic compounds were not detected among the samples retained for analysis from Orde Pond. The pesticide 4,4'-DDD was detected at an estimated concentration of 8.3 J µg/Kg within sample 28-OP-SD01, located near the western bank of Orde Pond. The positive detection of 4,4'-DDD at this location is in excess of the NOAA Effects Range - Low (ER-L) screening criteria of 2 µg/Kg. No total metal concentrations in any of the Orde Pond samples exceeded NOAA screening values.

14.3.4.2 Cogdels Creek

Carbon disulfide was the only volatile organic compound detected among the 14 Cogdels Creek sediment samples. The maximum detection of carbon disulfide, 13 J µg/Kg, was identified within sample 28-CC-SD07, collected upstream of the study area. The other detection of carbon disulfide was from a sample located downstream of the site, near the mouth of Cogdels Creek.

A number of semivolatile organic compounds were identified within Cogdels Creek sediment samples. As provided on Table 14-2, a total of 12 SVOCs were detected in the 14 Cogdels Creek samples. Nine of the 12 detected SVOCs were identified exclusively in samples 28-CC-SD03 and 28-CC-SD02, located adjacent to and downstream of the disposal area. The maximum semivolatile concentration, 1,700 µg/Kg, was that of both BEHP and the PAH benzo(a)pyrene. As indicted in Table 14-2, benzo(a)pyrene was positively detected within nine of the 14 samples submitted for laboratory analysis. Five of those nine positive benzo(a)pyrene detections exceeded the NOAA screening value of 400 µg/Kg, all within samples collected upstream of the study area. The phenanthrene concentration in sample 28-CC-SD03, located adjacent to the study area, exceeded the NOAA screening value of 225 µg/Kg by 35 µg/Kg.

The organic pesticides 4,4'-DDE and 4,4'-DDD were detected within nine and seven of the 14 Cogdels Creek sediment samples, respectively. As indicted on Table 14-2, each of the detections found upstream and downstream of the study area was in excess of NOAA screening values. Both 4,4'-DDE and 4,4'-DDD were detected at their respective maximum concentrations at sample station 28-CC-SD01, located at the mouth of Cogdels Creek. The positive 4,4'-DDE and 4,4'-DDD detections of 200 J and 450 J µg/Kg, respectively, exceeded the NOAA screening value for both pesticide contaminants of 2 µg/Kg. The pesticides 4,4'-DDT, alpha-chlordane, and gamma-chlordane were also detected at concentrations which, in each case, exceeded screening values. The three pesticides were observed in only two samples retained from upstream locations. The estimated maximum concentrations of 4,4'-DDT, alpha-chlordane, and gamma-chlordane were 50 J, 5.9 NJ, and 8.4 J µg/Kg, respectively.

Twenty-two of 23 TAL total metals were positively identified in the 14 sediment samples retained from Cogdels Creek (selenium was not detected). Lead, mercury, silver, and zinc were each identified at concentrations in excess of NOAA ER-L screening values. As provided in Table 14-2, silver and zinc were detected in excess of sediment screening values within one and two Cogdels Creek sediment samples, respectively. Lead and mercury exceeded screening values in seven and four of the 14 Cogdels Creek sediment samples. The silver concentration of 2 mg/Kg in sample 28-CC-SD04, located adjacent to the disposal area, exceeded the NOAA screening value for of 1.0

mg/Kg. Lead and mercury were detected, among the 14 Cogdels Creek sediment samples, at maximum concentrations of 202 and 0.41 mg/Kg, respectively. The maximum detection of lead was observed in sample 28-CC-SD04, located adjacent to the study area. Mercury was observed at a maximum concentration at sample station 28-CC-SD01, located near the mouth of Cogdels Creek. Table 14-2 provides a summary of contamination in sediment samples retained from Cogdels Creek. No other total metal concentrations among the 14 Cogdels Creek sediment samples exceeded screening values.

14.3.4.3 New River

Carbon disulfide was the only volatile organic compound detected among the ten sediment samples collected from the New River. The only detection of carbon disulfide, 2 J µg/Kg, was identified within sample 28-NR-SD02, located slightly upstream of the study area. No other volatile compounds were detected.

A number of semivolatile organic compounds were identified within sediment samples retained from the New River. As provided on Table 14-2, a total of 17 SVOCs, 13 of which were PAHs, were detected in the ten New River sediment samples. Twelve of the 17 positively detected SVOCs were identified at their respective maximum concentrations in sample 28-NR-SD01, located approximately 100 yards upstream of the study area. The maximum PAH concentration, 2,100 µg/Kg, was that of chrysene. As indicted on Table 14-2, chrysene was positively detected within five of the sediment samples submitted for laboratory analysis from the New River. Three of those five positive chrysene detections exceeded the NOAA screening value of 400 µg/Kg. As indicated in Table 14-2, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, and benzo(a)pyrene were also detected within sediment samples in excess of sediment screening values. In general, concentrations of SVOCs in the two samples obtained adjacent to the western disposal area were lower than those detections observed both upstream and downstream of the study area.

The organic pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were each detected in either two or three of the ten New River sediment samples. As indicted on Table 14-2, each of the detections were in excess of NOAA screening values. Both 4,4'-DDE and 4,4'-DDD were detected at their respective maximum concentrations at sample station 28-NR-SD01, located upstream of the study area. The positive 4,4'-DDE and 4,4'-DDD detections of 8.5 and 15 µg/Kg, respectively, exceeded the NOAA screening value for both pesticide contaminants of 2 µg/Kg. The pesticides 4,4'-DDT, alpha-chlordane, and gamma-chlordane were also detected at concentrations which, in each case, exceeded screening values. Alpha- and gamma-chlordane were observed in only two samples retained from the New River, located adjacent to and downstream of the site. The maximum concentrations of 4,4'-DDT, alpha-chlordane, and gamma-chlordane were 300, 6.6 J, and 4.6 J µg/Kg, respectively.

Nineteen of 23 TAL total metals were positively identified in the ten New River sediment samples (beryllium, cadmium, selenium, and thallium were not detected). Antimony, copper, lead, and silver were each identified at concentrations in excess of NOAA ER-L screening values. As provided in Table 14-2, each of the four metal contaminants were detected in excess of sediment screening values within two samples retained from the New River. Antimony, copper, and lead were each detected at their respective maximum concentrations among the ten New River samples at station 28-NR-SD01, located upstream of the study area. The copper concentration of 1,340 mg/Kg in sample 28-NR-SD01 exceeded the NOAA screening value of 70 mg/Kg. Antimony and lead were detected at maximum concentrations of 263 and 38,800 mg/Kg, respectively. The NOAA screening values for antimony and lead are 2 and 35 mg/Kg, respectively. Concentrations of silver in samples 28-NR-SD03, 3.4 J mg/Kg, and 28-NR-SD05, 3.1 J mg/Kg, slightly exceeded the NOAA value of 1 mg/Kg. No other total metal concentrations among the ten New River sediment samples exceeded screening values.

14.3.5 Aquatic Investigation

An aquatic investigation, which consisted of the collection and analysis of various fish species, was conducted at Site 28 within Orde Pond, Cogdels Creek, and the New River. Due to weather conditions, an inadequate number of fish species were collected for laboratory analysis from Cogdels Creek.

Fillet and whole body tissue samples were analyzed for TCL organics and TAL inorganics. Appendix L presents statistical summary results of organic and inorganic analyses performed on biotic samples. Tables presented in Appendix L include the minimum and maximum detected concentrations, the location of the maximum detection, and the frequency of detection. Appendix J contains the complete analytical results. The following subsections provide discussions of analytical results for the New River and Orde Pond biotic samples.

14.3.5.1 Orde Pond

The pesticides 4,4'-DDE and alpha-chlordane were detected among the whole body tissue samples collected in Orde Pond. The maximum pesticide concentration was that of 4,4'-DDE at 38 µg/Kg. Positive detections of VOCs and SVOCs in whole body tissue samples were rejected due to laboratory contamination. Total xylenes were detected in the American eel tissue sample at an estimated concentration of 8 J µg/Kg. The analytical data for these organic constituents are presented in Table 14-25.

Sixteen metals were detected in the whole body tissue samples collected from Orde Pond. The metals antimony, arsenic, chromium, copper, mercury, selenium, and zinc were found in Orde Pond biotic samples at maximum concentrations of 0.17 J, 0.10 J, 10.7 J, 1.2 J, 0.18 J, 0.45 J, and 26.3 J µg/Kg, respectively. Table 14-26 presents the analytical data associated with these whole body tissue samples.

The majority of volatile and semivolatile contaminant analyses from Orde Pond fillet samples were rejected due to laboratory interference. Therefore, the results of those analyses are inconclusive. There were no pesticides or PCBs detected in the fillet tissue samples, however. Organic data from fillet tissue samples are provided in Table 14-27.

Thirteen metals were detected in the fillet tissue samples collected from Orde Pond. The metals arsenic, chromium, copper, mercury, selenium, and zinc were detected in Orde Pond fillet samples at maximum concentrations of 0.1 J, 0.63 J, 0.22 J, 0.23 J, 0.32 J, and 22.9 µg/Kg, respectively. Table 14-28 presents the positive detection summary of Orde Pond fillet samples. The maximum tissue levels of metals in fillet tissue samples were found in the largemouth bass, blue gill, and redear sunfish.

14.3.5.2 New River

The pesticides beta BHC, 4,4'-DDE, 4,4'-DDD, endrin aldehyde, and alpha-chlordane were detected among the whole body stripped mullet, summer flounder, and Atlantic menhaden in New River tissue samples. Positive detections of VOCs and SVOCs were considered common laboratory contaminants. Table 14-29 summarizes the positive detections for the organic analysis for the whole body tissue samples.

Twenty of 23 TAL metals were detected in New River whole body tissue samples that were obtained from stripped mullet, summer flounder, and Atlantic menhaden. The metals antimony, arsenic, beryllium, cadmium, chromium, copper, mercury, selenium, silver, and zinc were detected in New River whole body samples at maximum concentrations of 0.23 J, 1.2 J, 0.007 J, 0.02 J, 5.4 J, 4.6 J, 0.014 J, 0.41 J, 0.10 J, and 1.8 J, μg/Kg respectively. A positive detection summary of the metals is represented in Table 14-30.

The pesticides detected in the fillet tissue samples were identical to the pesticides found in the whole body samples. The VOCs and SVOCs detected in the whole body samples were considered common laboratory contaminants. The organic analytical data for the whole body tissue samples are summarized in Table 14-31.

Fillet tissue samples, as with whole body samples, from the stripped mullet, summer flounder, spotted sea trout, and black drum contained metals. Similar concentrations of metals were found in both fillet and whole body samples. Although metals were detected in all species, not all species contained the same metals. The positive detection summary for the metals is presented in Table 14-32.

14.4 Extent of Contamination

This section addresses the extent of contamination within soil, groundwater, surface water, and sediment at OU No. 7, Site 28.

14.4.1 Extent of Soil Contamination

Positive detections of organic compounds in surface and subsurface soil samples collected at Site 28 are depicted on Figures 14-1 and 14-2, respectively. The following subsections detail the presence of both organic and inorganic contaminants in soil samples from Site 28.

14.4.1.1 Volatiles

Volatile compounds within soils at Site 28 do not appear to be the result of widespread disposal activities. VOCs were positively detected in only three of the 72 soil samples collected throughout Site 28. The positive detections were identified in samples retained from both the eastern and western portions of Site 28. The VOCs benzene, tetrachloroethene, and 1,1,1-trichloroethane were each detected once at very low concentrations (i.e., less than 5 μg/Kg). Given the limited extent and low concentration of volatile compounds at Site 28, their presence is most likely the result of previous burning operations.

14.4.1.2 Semivolatiles

The presence and dispersion of SVOCs in soil, particularly PAH compounds, are also most likely the result of former burning operations at Site 28. Concentrations of PAH compounds in soil samples are consistent with the historical use of the site as a burn dump and indicative of waste or refuse incineration. Semivolatile compounds were identified in both surface and subsurface soil samples throughout the site. However, considerably higher concentrations of SVOCs were limited to the western portion of the study area. As depicted on Figures 14-1 and 14-2, concentrations of SVOCs were typically higher in subsurface samples than in those obtained from the surface. In general, subsurface soil analytical results correspond directly to the visual identification of fill and burn material recorded during the field investigation of the western portion of the study area (see Appendix A for Test Boring Logs).

14.4.1.3 Pesticides

Positive detections of pesticides were observed in both surface and subsurface soil samples throughout Site 28. As Figures 14-1 and 14-2 depict, the detected pesticide levels were generally low and most likely the result of routine pesticide application. A number of the pesticide detections were from subsurface samples (i.e., samples obtained from greater than one foot bgs). Soil samples obtained from the western portion of the study area and at depths of greater than one feet bgs, had a majority of the higher pesticide concentrations. As described in Section 2.2, the western portion of the study area is composed of fill and burn material which may have also included residual concentrations of pesticides. The frequency and overall concentration of pesticides in soil, however, does not suggest pesticide disposal activities.

14.4.1.4 Polychlorinated Biphenyls

Six positive detections of PCBs were observed in samples obtained from five separate soil borings, all located on the western portion of the site. Each of the six positive detections of a PCB organic compounds was observed in conjunction with positive pesticide detections. At one time it was not uncommon to use oil, possibly containing PCBs, as a dust suppressor and to apply pesticides. The occurrence of both pesticides and PCBs within each of the six soil samples suggests that these organic compounds were introduced to the site concurrently. The observed levels of PCB contaminants from soil analyses at Site 28 are not characteristic of PCB disposal activities.

14.4.1.5 Metals

As addressed in Section 14.3.1 and depicted in Table 14-2, a number of the 93 samples submitted for analysis had TAL metal concentrations greater than one order of magnitude above base-specific background levels. Inorganic contaminants were detected in both surface and subsurface soil samples from the western portion of the study area at concentrations greater than one order of magnitude above of base-specific background levels. The metals copper, lead, manganese, and zinc were observed at maximum concentrations greater than two orders of magnitude above base-specific background levels in a limited number of soil samples from the western portion of the study area. Findings from the analytical program are consistent with visual observations of buried metallic objects and fill material recorded during the field investigation (see Appendix A). Concentrations of metals in samples obtained from the western portion of the study area coincide directly with areas of fill and buried material. The buried metal, in the presence of naturally-occurring acidic soils, is most probably the source of metal contamination.

14.4.2 Extent of Groundwater Contamination

Positive detections of organic compounds in shallow and deep groundwater samples collected at Site 28 are depicted on Figure 14-3. Figure 14-4 presents TAL metal sampling results in excess of either Federal MCL or North Carolina WQS levels. As addressed in Section 14.3.2, organic PCB contaminants were not detected in any of the shallow or deep groundwater samples submitted for analysis from Site 28. As a result of those analyses, the extent of PCB contamination in groundwater will not be addressed.

14.4.2.1 Volatiles

Positive detections of volatile compounds were limited to a shallow groundwater sample obtained from a temporary well, 28-TGWPA, located near the center of the western disposal area. The lack of positive VOC detections in samples obtained from surrounding shallow monitoring wells and the deep aquifer suggest that volatile contaminants have not migrated from the western disposal area. The residual levels (i.e., less than 20 µg/L) of chloroform, ethylbenzene, and total xylenes that were observed, most probably are the remains of accelerants once used to ignite waste material.

14.4.2.2 Semivolatiles

Semivolatile organic compounds were detected in four of the nine shallow monitoring wells and the one temporary monitoring well, 28-TGWPA. Each of the monitoring wells with positive SVOC concentrations is located within or adjacent to the western disposal area. No SVOCs were detected in the three samples obtained from the deep aquifer (i.e., the Castle Hayne aquifer), which suggests that contamination has not migrated to depths greater than 100 feet bgs.

A total of six semivolatile compounds were detected in samples obtained from four permanent monitoring wells (see Figure 14-3). Five of the six SVOCs were detected at concentrations of less than 2 µg/L, 4-methylphenol was detected at a concentration of 29 µg/L. Twelve semivolatiles were identified in the groundwater sample from the temporary well. The highest detection of an SVOC from 28-TGWPA was 99 µg/L of naphthalene. In general, subsurface soil analytical results from monitoring well test borings and nearby soil borings correspond to results from the groundwater investigation and the presence of fill and burn material.

14.4.2.3 Pesticides

During the first sampling round, organic pesticide compounds were detected in five of the nine shallow monitoring wells and the one temporary monitoring well. No pesticides were observed in the three groundwater samples collected from the deep aquifer. Each of the six groundwater samples with pesticide detections were obtained from wells located on the western portion of the study area. The five shallow monitoring wells that exhibited concentrations during the first round were resampled for pesticides as part of the second sampling round. The absence of pesticide compounds in those five samples suggests that the reduction of suspended colloids, through use of the low-flow sampling technique, correlated with the lack of positive pesticide detections. Subsurface soil analytical results throughout the western portion of the study area indicated the presence of pesticides. Suspended soil particles, colloids, in groundwater samples collected during the first sampling round are likely to have introduced pesticide contaminants into the sample set; pesticides tend to adhere to soil material. As a result of the confirmatory groundwater sampling results, the extent of groundwater pesticide contamination will not be considered further.

14.4.2.4 Metals

Inorganic contaminants were detected in each of the 13 groundwater samples submitted for analysis from Site 28. Iron, manganese, and lead were the only TAL total metals detected, among samples obtained from the 12 permanent monitoring wells, at levels in excess of either Federal MCL or North Carolina WQS (see Figure 14-4). Positive detections of both iron and manganese were distributed throughout the site, indicative of natural site conditions rather than disposal activities. Lead was detected within one sample at a concentration which exceeded the NCWQS of 15 μg/L. The sample from monitoring well 28-GW08, located within the western disposal area, had a positive lead detection of 126 μg/L. During the installation of well 28-GW08 several buried metallic objects, including steel cable material, were brought to the surface (see Appendix A). Generally, concentrations of TAL metals in shallow groundwater at Site 28 appear to be higher in samples obtained from the western portion of the study area.

The decrease of total metal concentrations between the first and second sampling rounds was the result of modified sample acquisition procedures. Elevated total metal observations have been recorded at other MCB, Camp Lejeune sites and are likely the consequence of loose surficial soils. During the resampling, a low flow purge method was utilized to minimize the presence suspended solids or colloids in samples that are associated with the surficial soils. The resulting data set yielded a more accurate assessment of existing conditions. The DoN is currently evaluating the presence and distribution of total and dissolved metals in groundwater throughout the facility. The draft report entitled "Evaluation of Metals in Groundwater at MCB, Camp Lejeune, North Carolina," (Baker, 1994) addressed the pervasiveness of total metals in groundwater and identified a number of potential causes. Preliminary conclusions of the study support the opinion that total metal concentrations in groundwater are due more to geologic conditions (i.e., naturally occurring concentrations and unconsolidated soils) and sample acquisition methods than to actual metal concentrations in the surficial aquifer.

14.4.3 Extent of Surface Water Contamination

Positive detections of organic compounds in surface water samples collected at Site 28 are depicted on Figure 14-5. Figure 14-6 presents TAL metal sampling results in excess of Federal surface water screening values. A summary of site contamination is presented in Table 14-2. As addressed in Section 14.3.3, volatile organic and PCB contaminants were not detected in any of the 14 surface water samples submitted for analysis from Site 28. As a result of those analyses, the extent of volatile organic and PCB contamination in surface water will not be addressed. Semivolatile organic and pesticide compounds were not detected in any of the surface water samples retained from both Orde Pond and Cogdels Creek. Correspondingly, the extent of semivolatile and pesticide contamination will not be addressed for either surface water body.

14.4.3.1 Semivolatiles

New River

One semivolatile contaminant, phenanthrene, was detected at the trace concentration of 1 μg/L. Sediment results from the same sample location exhibited a positive detection of phenanthrene. As depicted on Figure 14-5, the sampling station is located slightly upstream of the western disposal area, on the New River. The occurrence of one trace positive detection suggests that semivolatile compounds are not migrating from surface and subsurface soils at Site 28 via surface water.

14.4.3.2 Pesticides

New River

The pesticides 4,4'-DDE and 4,4'-DDD were detected in one surface water sample at estimated concentrations of 0.04 J and 0.05 J, respectively. The suspect sample was retained from the New River at a location adjacent to the western disposal area (see Figure 14-5). Pesticides were also identified in a sediment sample retained from the same sampling station. These concentrations are not indicative of disposal operations, rather, are more likely residuals from the base-wide application and use of pesticides.

14.4.3.3 Metals

Orde Pond

As depicted on Figure 14-6, thallium was the only TAL metal identified in two Orde Pond surface water samples at a concentration in excess of chronic screening values. The detected thallium concentration of 4.0 µg/L exceeded the screening value by only 0.7 µg/L.

Cogdels Creek

Lead was the only TAL metal identified in the seven Cogdels Creek surface water samples which exceeded NOAA chronic screening values. As depicted on Figure 14-6, each of the seven Cogdels Creek sampling stations had a positive detection of lead above the 1.32 µg/L screening value. The range of positive lead detections was between 1.9 and 4.2 µg/L. Cogdels Creek serves as the main drainage for much of HPIA and may help to explain the general dispersion of lead in surface water samples. As the most active area of the facility, several maintenance and storage areas are located within HPIA.

New River

Copper, lead, thallium, and zinc were each identified at concentrations in excess of NOAA chronic screening values among the five New River surface water samples. As depicted on Figure 14-6, thallium and zinc were detected in excess of surface water screening values in one sample each. Copper and lead each exceeded screening values in a total of three surface water samples. Both maximum detections of copper and lead were observed at a sample station located approximately 100 yards upstream of the study area. Sediment samples retained from the same upstream location indicate the presence of lead at three orders of magnitude above the lead sediment screening value. As shown on Figure 14-6, a pistol firing range is located directly adjacent to the upstream sampling station. The lead shot used at the firing range may explain both sediment and surface water detections of lead.

14.4.4 Extent of Sediment Contamination

Positive detections of organic compounds in sediment samples collected at Site 28 are depicted on Figure 14-7. Figure 14-8 presents TAL metal sampling results in excess of Federal sediment screening values. A summary of site contamination is presented in Table 14-2. As addressed in Section 14.3.4, PCB contaminants were not detected in any of the 28 sediment samples submitted for analysis from Site 28. As a result of those analyses, the extent of PCB contamination in sediment will not be addressed. Volatile and semivolatile organic compounds also were not detected in either of the four sediment samples collected from Orde Pond. In addition, none of the total metals in Orde Pond sediment samples were detected in excess of screening values.

14.4.4.1 Volatiles

Cogdels Creek

Carbon disulfide was the only VOC detected among the 14 Cogdels Creek sediment samples. As Figure 14-7 depicts, the maximum detection of carbon disulfide, 13 J µg/Kg, was observed in a sample collected upstream of the study area. The only other positive detection was from a sample located downstream of the site. The dispersion and low concentration of carbon disulfide suggests that its presence may be the result of upstream surface runoff.

New River

Only one VOC was detected among the ten New River sediment samples. Carbon disulfide was identified at the trace concentration of 2 J µg/Kg in a sample obtained from slightly upstream of the study area. The low concentration of carbon disulfide suggests that its presence may also be the result of upstream surface runoff.

14.4.4.2 Semivolatiles

Cogdels Creek

A number of semivolatile organic compounds were identified within Cogdels Creek sediment samples. As indicated on Figure 14-7, a total of 12 SVOCs were detected in the 14 Cogdels Creek samples. Nine of the 12 detected SVOCs were identified solely in samples obtained directly adjacent to the site. Benzo(a)pyrene and BEHP were identified in samples retained from upstream locations. The localized dispersion of SVOCs in sediment at Site 28 may indicate that semivolatile contaminants have migrated to the sediments of Cogdels Creek. Soil erosion may provide one possible explanation for the relatively low concentrations of SVOCs in sediments. Between the Orde Pond access road and the eastern extent of the STP, Cogdels Creek is subject to frequent flooding. At this location soil from the western disposal area may have been washed into the creek channel.

New River

A total of 17 semivolatile compounds were detected within the ten sediment samples obtained from the New River. As Figure 14-7 suggests, the highest concentrations of SVOCs were detected in an upstream sediment sample. The maximum PAH concentration was that of chrysene, 2,100 µg/Kg, in a sample obtained downstream of the Cogdels Creek discharge. Concentrations of SVOCs in the two samples located immediately to the west of the disposal area were lower than those detections observed both upstream and downstream of the study area. Discharge from Cogdels Creek and another unnamed drainage to the north of the study area may have contributed to elevated SVOC detections in these two areas.

14.4.4.3 Pesticides

Orde Pond

The pesticide 4,4'-DDD was detected at an estimated concentration of 8.3 J µg/Kg in a sample located near the western bank of Orde Pond, as depicted on Figure 14-7. The positive detection was in excess of the NOAA ER-L screening value of 2 µg/Kg. The concentration of 4,4'-DDD is typical of concentrations observed throughout the base and is indicative of the base-wide application and use of pesticides.

Cogdels Creek

The organic pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected within sediment samples retained for analysis from Cogdels Creek. As depicted on Figure 14-7, the maximum concentrations of 4,4'-DDE and 4,4'-DDD were obtained from a sample located at near the mouth of Cogdels Creek. Higher detections of pesticides at this downstream location may be the result of particles settling out of suspension as they reach this area of lesser hydraulic gradient. In general, pesticides were observed throughout Cogdels Creek at low and varying concentrations.

New River

The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected within four of the New River sediment samples. As depicted on Figure 14-7, the maximum concentrations of 4,4'-DDE and 4,4'-DDD were obtained from a sample located approximately 100 yards upstream of the study area. The maximum pesticide concentration was that of 4,4'-DDT, 300 µg/Kg, in a sample obtained adjacent to the western disposal area. Positive detections of pesticides observed in samples collected during the field investigation are not atypical of concentrations observed in sediments throughout MCB, Camp Lejeune.

14.4.4.4 Metals

Cogdels Creek

Lead concentrations in Cogdels Creek sediment samples, like the surface water samples from Cogdels Creek, exceeded NOAA chronic screening values. At least one of the two sediment samples from each of the seven sampling stations had a concentration of lead that exceeded the lead screening value. Mercury was detected in four of the 14 samples in excess of the 0.15 µg/Kg screening value. The maximum concentrations of lead and mercury detected in sediment samples from Cogdels Creek were 202 and 0.41 µg/Kg, respectively. Silver and zinc were also identified in sediment samples and at concentrations exceeding their respective screening values of 1 and 120 µg/Kg. As Figure 14-8 suggests, there is no distinguishable pattern of dispersal among metal contaminants in sediment samples. As mentioned previously, Cogdels Creek serves as the main drainage for much of HPIA, which may account for the general dispersion of lead and mercury in sediment samples.

New River

Antimony, copper, lead, and silver were each identified at concentrations in excess of NOAA ER-L screening values. As depicted on Figure 14-8, each of the four metal contaminants was detected in excess of sediment screening values within two samples retained from the New River. Silver was detected at two locations adjacent to and downstream of the study area at concentrations which only slightly exceeded the screening value. Antimony, copper, and lead were each detected at their respective maximum concentrations among the ten New River samples at a station located approximately 100 yards upstream of the study area. The concentrations of antimony, copper, and lead at that location were 263 J, 1,340, and 38,800 mg/Kg, respectively. The NOAA ER-L screening values for antimony, copper, and lead are 2, 70, and 35 mg/Kg, respectively. As shown on Figure 14-8, a pistol firing range is located directly adjacent to the upstream sampling station. The lead shot used at the firing range may explain both sediment and surface water detections of lead at this location.

SECTION 14.0 TABLES

TABLE 14-1

SUMMARY OF REJECTED DATA
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample No.	Chemical/Category	Comment
Soils	28-W-SB07-06	Bis(2-ethylhexyl)phthalate	5
	28-E-SB25-03	Bis(2-ethylhexyl)phthalate	5
	28-W-SB08-00	Bis(2-ethylhexyl)phthalate	5
	28-W-SB11-03	Pyrene/fluoranthene	5
	28-W-SB12-00D	Dieldrin/endrin	6
	28-W-SB12-00	Dieldrin/endrin	6
	28-W-SB01-04	Copper	7
	28-W-SB02-04	Copper	7
	28-W-SB02-07	Copper	7
	28-W-SB29-02	Copper	7
	28-W-SB10-03	Antimony	4
	28-W-SB19-03	Antimony	4
	28-W-SB20-01	Antimony	4
	28-E-SB25-03	Antimony	4
	28-E-SB28-04	Antimony	4
	28-W-SB09-00	Antimony	4
	28-W-SB10-00	Antimony	4
	28-W-SB16-00	Antimony	4
	28-E-SB21-00	Antimony	4
	28E-SB31-00	Antimony	4
Groundwater	28-GW01-01	SVOCs Acid Fraction	1
Surface Water	28-NR-SW04D	SVOC Acid Fraction	1
Sediment	28-OP-SD01-06	Endrin	2
	28-OP-SD01-06D	Endrin	2
	28-OP-SD02-612	TCL Pesticide and PCB Fraction	3
	28-CC-SD04-06D	Antimony	4
	28-CC-SD03-612	Antimony	4
	28-CC-SD03-612	Antimony	4
	28-CC-SD04-06	Antimony	4
	28-CC-SD04-612	Antimony	4
	28-OP-SD01-06D	Antimony	4
	28-NR-SD03-06	Antimony	4
	28-NR-SD03-612	Antimony	4
	28-NR-SD04-06	Antimony	4
	28-NR-SD04-612	Antimony	4
	28-NR-SD05-06	Antimony	4
	28-NR-SD05-612	Antimony	4
	28-NR-SD02-612D	Antimony	4

TABLE 14-1 (Continued)

SUMMARY OF REJECTED DATA
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample No.	Chemical/Category	Comment
Biotic	All samples	TCL Volatile Fraction	8
	28-OPFS-AE-WB01R	TCL Volatile Fraction	9
	All samples	TCL Semivolatile Fraction	8
	28-F05-SF-F01	4-Nitrophenol	10
	28-F05-SF-F02	4-Nitrophenol	10
	28-F05-SR-WB01	4-Nitrophenol	10
	28-OPFS-LB-F01	4-Nitrophenol	10
	28-OPFS-LB-WB01	4-Nitrophenol	10
	28-OPFS-AE-WB01	4-Nitrophenol	10
	28-OPFS-RS-WB01	4-Nitrophenol	10
	28-OPFS-WM-F01	4-Nitrophenol	10
	28-FS04-AM-WB01	4-Nitrophenol	10
	28-FS04-AM-WB02	4-Nitrophenol	10
	28-FS04-AM-WB03	4-Nitrophenol	10
	28-FS04-BD-F01	4-Nitrophenol	10
	28-FS04-SS-F01	4-Nitrophenol	10
	28-FS04-SM-F01	gamma-BHC	11
	All samples	Arsenic	12
		Chromium	12
		Copper	12
		Nickel	12
		Selenium	12
		Silver	12
		Zinc	12

Comments:

1. Surrogate recoveries were less than 10 percent. Therefore, for the acid fraction, positive results were designated as estimated (J) and all nondetects were rejected (R).

2. Matrix Spike recoveries were less than 10 percent. Therefore, the results for Endrin were rejected (R).

3. Surrogate recoveries were less than 10 percent. Therefore, positive results were designated as estimated (J) and all nondetects were rejected (R).

4. Matrix Spike Recovery for antimony was below 30 percent. Therefore, positive results were designated as estimated (J) and all nondetects were rejected (R).

5. Sample results initially flagged with an "E" are rejected (R) in favor of the "D" flagged result in the diluted sample.

TABLE 14-1 (Continued)

SUMMARY OF REJECTED DATA
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

6. Matrix Spike/Matrix Spike Duplicate recoveries were less than 10 percent. Therefore, the results for dieldrin and endrin were rejected (R).

7. Matrix Spike recovery for copper was below 30 percent. Therefore, positive results were designated as estimated (J) and all nondetects were rejected (R).

8. For each of these samples, all analytical positive results were identified as estimated (J) and all parameters reported as nondetect were rejected (R). This action was taken because the samples exceeded analytical holding times by more than 30 days.

9. Reject all results in favor of the original sample 28-OPFS-AE-WB01. Results are rejected due to noncompliant internal standards.

10. Continuing calibration contained compounds with RRFs less than 0.05. Therefore, for the listed compounds positive results are estimated (J) and nondetects are rejected (R).

11. The reported nondetect result for this sample is rejected (R) because the spike recovery is less than 10 percent in the associated MS.

12. Matrix spike recoveries for the listed metals were below 30 percent. Therefore, all positive results are noted as estimated (J) and all nondetects are rejected (R).

TABLE 14-2

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Surface Soil	Volatiles	1,1,1-Trichloethane	NA	NA	2 J	2 J	28-E-SB27	1/40	eastern, adjacent Orde Pond
	Semivolatiles	bis(2-Chloroethyl)ether	NA	NA	69 J	69 J	28-E-SB28	1/40	eastern
		Naphthalene (PAH)	NA	NA	69 J	69 J	28-GW01	1/40	western
		Acenaphthene (PAH)	NA	NA	49 J	83 J	28-GW01	2/40	western
		Dibenzofuran	NA	NA	70 J	70 J	28-GW01	1/40	western
		Fluorene (PAH)	NA	NA	56 J	88 J	28-GW01	2/40	western
		Pentachlorophenol	NA	NA	46 J	46 J	28-E-SB26	1/40	eastern
		Phenanthrene (PAH)	NA	NA	41 J	1,100	28-W-SB17	8/40	primarily western
		Anthracene (PAH)	NA	NA	120 J	240 J	28-W-SB17	3/40	western
		Carbazole	NA	NA	69 J	170 J	28-GW01	3/40	western
		di-n-Butylphthalate	NA	NA	58 J	70 J	28-GW01DW	2/40	1 eastern, 1 western
		Fluoranthene (PAH)	NA	NA	43 J	1,800	28-GW01	12/40	primarily western
		Pyrene (PAH)	NA	NA	51 J	2,100	28-GW01	11/40	primarily western
		Butyl benzyl phthalate	NA	NA	88 J	88 J	28-W-SB02	1/40	western
		B(A)anthracene (PAH)	NA	NA	56 J	1,300	28-GW01	7/40	primarily western
		Chrysene (PAH)	NA	NA	43 J	1,200	28-GW01	9/40	primarily western
		B(B)fluoranthene (PAH)	NA	NA	41 J	2,100	28-GW01	10/40	primarily western
		B(K)fluoranthene (PAH)	NA	NA	41 J	740	28-W-SB17	7/40	primarily western
		Benzo(A)pyrene (PAH)	NA	NA	58 J	1,600	28-GW01	8/40	primarily western
		I(1,2,3-cd)pyrene (PAH)	NA	NA	44 J	1,500	28-GW01	6/40	western
		D(a,h)anthracene (PAH)	NA	NA	120 J	120 J	28-GW01	1/40	western
		B(g,h,i)perylene (PAH)	NA	NA	49 J	1,700	28-GW01	6/40	western

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Surface Soil (Continued)	Pesticides	Heptachlor epoxide	NA	NA	8 J	43 J	28-E-SB31	3/40	2 eastern, 1 western
		Dieldrin	NA	NA	7.1 J	7.1 J	28-E-SB28	1/40	eastern
		4-4'-DDE	NA	NA	4.4 NJ	1,300	28-GW01	25/40	scattered
		Endrin	NA	NA	35 J	35 J	28-E-SB28	1/40	western
		4-4'-DDD	NA	NA	0.91 NJ	320 J	28-GW01	17/40	scattered
		Endosulfan Sulfate	NA	NA	41 J	41 J	28-GW01	1/40	western
		4-4'-DDT	NA	NA	2.7 J	1,400	28-E-SB33	20/40	scattered
		Endrin aldehyde	NA	NA	7.1 J	7.1 J	28-E-SB28	1/40	eastern
		alpha-Chlordane	NA	NA	1.9 NJ	160 NJ	28-E-SB31	15/40	scattered
		gamma-Chlordane	NA	NA	1.9 NJ	96 J	28-E-SB34	9/40	primarily eastern
	PCBs	Aroclor 1254	NA	NA	47 J	58 J	28-W-SB12	2/40	western
		Aroclor 1260	NA	NA	44	44	28-W-SB15	1/40	eastern
	Metals (1)	Antimony	NA	0.3 - 8.0	6.4 J	28 J	28-W-SB08	6/43	4 exceed BB, western
		Arsenic	NA	0.2 - 1.8	0.56 J	16	28-W-SB08	25/43	7 exceed BB, primarily western
		Cadmium	NA	0.18 - 0.58	0.66	12.5	28-W-SB08	13/43	13 exceed BB, primarily western
		Chromium	NA	0.3 - 12.5	1.4 J	26	28-W-SB18	42/43	8 exceed BB, primarily western
		Copper	NA	0.5 - 87.2	1.5	4,260 J	28-W-SB11	42/43	7 exceed BB, western
		Lead	NA	0.5 - 142.0	3.9	551	28-W-SB18	43/43	6 exceed BB, western
		Mercury	NA	0.01 - 0.08	0.05	1.1	28-E-SB34	28/43	22 exceed BB, scattered
		Nickel	NA	0.6 - 3.6	1.1 J	36	28-GW01	25/43	11 exceed BB, primarily western
		Selenium	NA	0.27 - 0.94	1.5	10 J	28-W-SB08	2/43	2 exceed BB, eastern & western
		Silver	NA	0.04 - 4.30	1.5 J	6 J	28-E-SB34	7/43	1 exceeds BB, eastern
		Thallium	NA	0.11 - 0.56	0.8	2.5	28-W-SB19	3/43	3 exceed BB, eastern & western
		Zinc	NA	0.3 - 28.3	6.7 J	23,100	28-W-SB08	41/43	24 exceed BB, higher detects west

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Subsurface Soil	Volatiles	Benzene	NA	NA	2 J	2 J	28-GW01DW	1/32	western
		Tetrachlorethene	NA	NA	5 J	5 J	28-W-SB11	1/32	western
	Semivolatiles	1,4-Dichlorobenzene	NA	NA	44 J	140 J	28-W-SB12	2/32	western
		4-Methylphenol	NA	NA	250 J	250 J	28-W-SB10	1/32	western
		Naphthalene (PAH)	NA	NA	39 J	2,600	28-W-SB10	6/32	western
		2-Methylnaphthalene	NA	NA	82 J	89 J	28-W-SB10	2/32	western
		Dimethyl phthalate	NA	NA	79 J	220 J	28-W-SB10	2/32	western
		Acenaphthene (PAH)	NA	NA	510	2,500 J	28-W-SB11	2/32	western
		Dibenzofuran	NA	NA	220 J	1,300 J	28-W-SB11	2/32	western
		Diethylphthalate	NA	NA	100 J	100 J	28-W-SB12	1/32	western
		Fluorene (PAH)	NA	NA	78 J	2,600 J	28-W-SB11	4/32	western
		Phenanthrene (PAH)	NA	NA	38 J	27,000	28-W-SB11	9/32	western
		Anthracene (PAH)	NA	NA	330 J	8,600	28-W-SB11	2/32	western
		Carbazole	NA	NA	94 J	4,700	28-W-SB11	2/32	western
		Fluoranthene (PAH)	NA	NA	40 J	2,700	28-GW01	9/32	primarily western
		Pyrene (PAH)	NA	NA	51 J	2,600	28-GW01	6/32	western
		B(a)anthracene (PAH)	NA	NA	120 J	24,000	28-W-SB11	3/32	western
		Chrysene (PAH)	NA	NA	46 J	22,000	28-W-SB11	5/32	western
		BEHP	NA	NA	62 J	1,300	28-W-SB10	15/32	scattered, western
		B(b)fluoranthene (PAH)	NA	NA	38 J	21,000	28-W-SB11	6/32	western
		B(k)fluoranthene (PAH)	NA	NA	50 J	18,000	28-W-SB11	3/32	western
		Benzo(a)pyrene (PAH)	NA	NA	43 J	21,000	28-W-SB11	4/32	western
		I(1,2,3-cd)pyrene (PAH)	NA	NA	100 J	11,000	28-W-SB11	3/32	western
		D(a,h)anthracene (PAH)	NA	NA	110 J	2,800 J	28-W-SB11	2/32	western
		B(g,h,i)perylene (PAH)	NA	NA	50 J	10,000	28-W-SB11	4/32	western

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Subsurface Soil (Continued)	Pesticides	4,4'-DDE	NA	NA	3.1 J	1,600	28-W-SB07	19/32	scattered
		4,4'-DDD	NA	NA	6.2	880 NJ	28-GW01DW	17/32	scattered
		4,4'-DDT	NA	NA	3 J	7,300	28-GW01DW	13/32	scattered
		alpha-Chlordane	NA	NA	2.7 J	65 J	28-W-SB12	3/32	western
		gamma-Chlordane	NA	NA	2.6 NJ	11 NJ	28-W-SB12	3/32	western
	PCBs	Aroclor 1242	NA	NA	140 J	140 J	28-GW07	1/32	western
		Aroclor 1260	NA	NA	25 J	77	28-W-SB03	2/32	western
	Metals (1)	Antimony	NA	0.4 - 6.9	5.9 J	46.7 J	28-W-SB09	16/51	15 exceed BB, western
		Arsenic	NA	0.03 - 1.50	0.69	25.1	28-W-SB06	41/51	30 exceed BB, scattered
		Beryllium	NA	0.03 - 2.30	0.24	1.1	28-W-SB13	4/51	none exceed BB
		Cadmium	NA	0.17 - 1.20	0.77	15.6	28-W-SB18	22/51	22 exceed BB, scattered
		Chromium	NA	0.7 - 10.5	2 J	128	28-W-SB18	50/51	27 exceed BB, primarily western
		Copper	NA	0.5 - 6.6	1.0 J	3,280	28-W-SB09	43/51	23 exceed BB, western
		Lead	NA	0.5 - 11.5	1.9 J	2,060 J	28-W-SB10	49/51	25 exceed BB, primarily western
		Mercury	NA	0.01 - 0.68	0.05	2.8	28-GW01	15/51	3 exceed BB, western
		Nickel	NA	0.6 - 4.7	1.6	102 J	28-W-SB06	23/51	14 exceed BB, western
		Selenium	NA	0.12 - 0.55	6 J	6 J	28-W-SB13	1/51	1 exceeds BB, western
		Silver	NA	0.18 - 1.00	1.1 J	18.4 J	28-W-SB12	13/51	13 exceed BB, scattered
		Thallium	NA	0.12 - 0.50	1	1	28-W-SB17	1/51	1 exceeds BB, western
		Zinc	NA	0.3 - 11.6	0.95 J	4,330 J	28-W-SB08	43/51	24 exceed BB, primarily western

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Groundwater	Volatiles	Chloroform	MCL - 0.1	NA	2	2	28-TGWPA	1/13	1 exceeds ARAR, central western
		Ethylbenzene	NCWQS -29	NA	5	5	28-TGWPA	1/13	does not exceed ARAR
		Xylenes (total)	NCWQS - 530	NA	19	19	28-TGWPA	1/13	does not exceed ARAR
	Semivolatiles	2-Methylphenol	NA	NA	1.3 J	1.3 J	28-GW07	1/13	western
		4-Methylphenol	NA	NA	29	29	28-GW07	1/13	western
		2,4-Dimethylphenol	NA	NA	2.2 J	4.0 J	28-TGWPA	2/13	central western
		2,4-Dichlorophenol	NA	NA	1.6 J	1.6 J	28-TGWPA	1/13	central western
		Naphthalene	NCWQS - 21	NA	99	99	28-TGWPA	1/13	1 exceeds ARAR, central western
		2-Methylnaphthalene	NA	NA	33	33	28-TGWPA	1/13	central western
		Dimethylphthalate	NA	NA	1 J	1 J	28-GW01	1/3	central western
		Acenapthene (PAH)	NA	NA	1.3 J	31	28-TGWPA	2/13	central western
		Dibenzofuran	NA	NA	12	12	28-TGWPA	1/13	central western
		Fluorene (PAH)	NCWQS - 280	NA	18	18	28-TGWPA	1/13	does not exceed ARAR
		Phenanthrene (PAH)	NCWQS - 210	NA	14	14	28-TGWPA	1/13	does not exceed ARAR
		Anthracene (PAH)	NA	NA	2.6 J	2.6 J	28-TGWPA	1/13	central western
		Carbazole	NA	NA	11	11	28-TGWPA	1/13	central western
		di-n-Butylphthalate	NA	NA	1 J	1 J	28-GW06	1/13	western
		Fluoranthene (PAH)	NA	NA	1.7 J	1.7 J	28-TGWPA	1/13	central western
		Pyrene (PAH)	NA	NA	1 J	1 J	28-TGWPA	1/13	central western
	Pesticides (2)	4,4'-DDE	NA	NA	0.06 J	6.6 J	28-TGWPA	5/13	western
		4,4'-DDD	NA	NA	0.06 J	9	28-GW07	6/13	western
		4,4'-DDT	NA	NA	0.05 J	0.37 J	28-TGWPA	2/13	western
		gamma-Chlordane	NCWQS - 0.027	NA	0.05 J	0.05 J	28-GW08	1/13	does not exceed ARAR, western
	PCBs	ND	NA	NA				0/13	
	Total Metals (3)	Iron	NCWQS - 300	882 -55,300	147 J	40,600	28-GW07	11/12	7 exceed ARAR, none exceed BB
		Lead	NCWQS - 15	3.0 - 78.8	8.2	126	28-GW08	2/12	1 exceeds ARAR and BB
		Manganese	NCWQS - 50	10 - 290	16.9	1,450	28-GW08	11/12	7 exceed ARAR, 1 exceeds BB

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Orde Pond Surface Water	Volatiles	ND	NOAA/NCWQS	NA				0/2	
	Semivolatiles	ND	NOAA/NCWQS	NA				0/2	
	Pesticides	ND	NOAA/NCWQS	NA				0/2	
	PCBs	ND	NOAA	NA				0/2	
	Metals (3)	Thallium	NOAA - 4.0	ND	4.7	4.7	28-OP-SW02	1/2	1 exceeds ARAR and BB
Cogdels Creek Surface Water	Volatiles	ND	NOAA/NCWQS	NA				0/7	
	Semivolatiles	ND	NOAA/NCWQS	NA				0/7	
	Pesticides	ND	NOAA/NCWQS	NA				0/7	
	PCBs	ND	NOAA	NA				0/7	
	Metals (3)	Lead	NOAA - 1.32	1.2 - 10.4	1.9	4.2	28-CC-SW06	7/7	7 exceed ARAR, none exceed BB
New River Surface Water	Volatiles	ND	NOAA/NCWQS	NA				0/5	
	Semivolatiles	Phenanthrene (PAH)	NA	NA	1.4 J	1.4 J	28-NR-SW02	1/5	adjacent to study area
	Pesticides	4,4'-DDE	NOAA - 10.5	NA	0.04 J	0.04 J	28-NR-SW03	1/5	does not exceed ARAR
		4,4'-DDD	NOAA - 0.0064	NA	0.05 J	0.05 J	28-NR-SW03	1/5	1 exceeds ARAR
	PCBs	ND	NOAA	NA				0/5	
	Metals (3)	Copper	NOAA - 6.5	4 - 129	6.6	18.1	28-NR-SW01	3/5	3 exceed ARAR, none exceed BB
		Lead	NOAA - 1.32	1.2 - 10.4	1.7	23.4	28-NR-SW01	3/5	3 exceed ARAR, 1 exceeds BB
		Thallium	NOAA - 4	ND	5.6 J	5.6 J	28-NR-SW04	1/5	1 exceeds ARAR and BB
		Zinc	NOAA - 58.9	18 - 111	10.4	363	28-NR-SW03	3/5	1 exceeds ARAR and BB
Orde Pond Sediment	Volatiles	ND	NA	NA				0/4	
	Semivolatiles	ND	NOAA	NA				0/3	
	Pesticides	4,4'-DDD	NOAA - 2	NA	8.3 J	8.3 J	28-OP-SD01	1/3	1 exceeds ARAR
	PCBs	ND	NOAA	NA				0/3	
	Metals (3)	ND	NOAA	BB				0/3	

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
Cogdels Creek Sediment	Volatiles	Carbon disulfide	NA	NA	9 J	13 J	28-CC-SD07	2/14	maximum upstream of site
	Semivolatiles	Phenanthrene (PAH)	NOAA - 225	NA	260 J	260 J	28-CC-SD03	1/14	1 exceeds ARAR, adjacent to site
		Anthracene (PAH)	NOAA - 85	NA	61 J	61 J	28-CC-SD03	1/14	does not exceed ARAR, adjacent
		Fluoranthene (PAH)	NOAA - 600	NA	77 J	340 J	28-CC-SD03	3/14	none exceed ARAR, adjacent
		Pyrene (PAH)	NOAA - 350	NA	63 J	250 J	28-CC-SD03	5/14	none exceed ARAR, scattered
		Butyl benzyl phthalate	NA	NA	410 J	410 J	28-CC-SD02	1/14	adjacent to site
		3,3'-Dichlorobenzidine	NA	NA	410 J	410 J	28-CC-SD02	1/14	adjacent to site
		B(a)anthracene (PAH)	NOAA - 230	NA	56 J	140 J	28-CC-SD03	2/14	niether exceed ARAR, adjacent
		Chrysene (PAH)	NOAA - 400	NA	58 J	160 J	28-CC-SD03	2/14	niether exceed ARAR, adjacent
		BEHP	NA	NA	100 J	1,700 J	28-CC-SD06	12/14	scattered up and downstream
		B(b)fluoranthene (PAH)	NA	NA	63 J	63 J	28-CC-SD02	1/14	adjacent to site
		B(k)fluoranthene (PAH)	NA	NA	42 J	42 J	28-CC-SD02	1/14	adjacent to site
		Benzo(a)pyrene (PAH)	NOAA - 400	NA	47 J	1,700 J	28-CC-SD05	9/14	5 exceed ARAR, all upstream
	Pesticides	4,4'-DDE	NOAA - 2	NA	6.4 J	200 J	28-CC-SD01	9/14	9 exceed ARAR, scattered
		4,4'-DDD	NOAA - 2	NA	4.3 J	450 J	28-CC-SD01	7/14	7 exceed ARAR, scattered
		4,4'-DDT	NOAA - 1	NA	50 J	50 J	28-CC-SD07	1/14	1 exceeds ARAR, upstream of site
		alpha-Chlordane	NOAA - 0.5	NA	2.6 NJ	5.9 NJ	28-CC-SD06	2/14	2 exceed ARAR, upstream of site
		gamma-Chlordane	NOAA - 0.5	NA	6.1 J	8.4 J	28-CC-SD07	2/14	2 exceed ARAR, upstream of site
	PCBs	ND	NOAA	NA				0/14	
	Metals (3)	Lead	NOAA - 35	1 - 314	6.8	202	28-CC-SD04	14/14	7 exceed ARAR, none exceed BB
		Mercury	NOAA - 0.15	ND	0.12	0.41	28-CC-SD01	6/14	4 exceed ARAR, 6 exceed BB
		Silver	NOAA - 1	7.3	2 J	2 J	28-CC-SD04	1/14	1 exceeds ARAR, downstream
		Zinc	NOAA - 120	12 - 926	9.3 J	303	28-CC-SD04	14/14	2 exceed ARAR, none exceed BB

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
New River Sediment	Volatiles	Carbon disulfide	NA	NA	2 J	2 J	28-NR-SD04	1/10	adjacent to site
	Semivolatiles	Acenaphthene	NOAA - 150	NA	150 J	150 J	28-NR-SD01	1/10	does not exceed ARAR, upstream
		Dibenzofuran	NA	NA	60 J	60 J	28-NR-SD01	1/10	upstream of site
		Fluorene (PAH)	NOAA - 35	NA	120 J	120 J	28-NR-SD01	1/10	exceeds ARAR, upstream of site
		Phenanthrene (PAH)	NOAA - 225	NA	47 J	1,200	28-NR-SD01	4/10	2 exceed ARAR, max. upstream
		Anthracene (PAH)	NOAA - 85	NA	97 J	320 J	28-NR-SD01	4/10	2 exceed ARAR, max. upstream
		Carbazole	NA	NA	57 J	160 J	28-NR-SD01	3/10	maximum upstream of site
		Fluoranthene (PAH)	NOAA - 600	NA	80 J	1,600	28-NR-SD01	6/10	3 exceed ARAR, max. upstream
		Pyrene (PAH)	NOAA - 350	NA	75 J	1,700	28-NR-SD01	6/10	5 exceed ARAR, max. upstream
		B(a)anthracene (PAH)	NOAA - 230	NA	150 J	1,500	28-NR-SD05	5/10	4 exceed ARAR, max. downstream
		Chrysene (PAH)	NOAA - 400	NA	160 J	2,100	28-NR-SD05	5/10	3 exceed ARAR, max. downstream
		BEHP	NA	NA	580	2,400	28-NR-SD04	3/10	scattered up and downstream
		B(b)fluoranthene (PAH)	NA	NA	55 J	1,100	28-NR-SD01	6/10	maximum upstream of site
		B(k)fluoranthene (PAH)	NA	NA	120 J	840	28-NR-SD05	5/10	maximum downstream of site
		Benzo(a)pyrene (PAH)	NOAA - 400	NA	130 J	710	28-NR-SD01	5/10	3 exceed ARAR, max. upstream
		I(1,2,3-cd)pyrene (PAH)	NA	NA	68 J	320 J	28-NR-SD01	6/10	maximum upstream of site
		D(a,h)anthracene (PAH)	NOAA - 60	NA	47 J	47 J	28-NR-SD03	1/10	does not exceed ARAR, adjacent
		B(g,h,i)perylene (PAH)	NA	NA	65 J	320 J	28-NR-SD01	5/10	maximum upstream of site
	Pesticides	4,4'-DDE	NOAA - 2	NA	8.4	8.5	28-NR-SD01	2/10	2 exceed ARAR, max. upstream
		4,4'-DDD	NOAA - 2	NA	8.6	15	28-NR-SD01	3/10	3 exceed ARAR, max. upstream
		4,4'-DDT	NOAA - 1	NA	33	300	28-NR-SD03	3/10	3 exceed ARAR, max. adjacent
		alpha-Chlordane	NOAA - 0.5	NA	4.8	6.6 J	28-NR-SD04	2/10	2 exceed ARAR, max. at Cogdels
		gamma-Chlordane	NOAA - 0.5	NA	3.1 J	4.6 J	28-NR-SD04	2/10	2 exceed ARAR, max. at Cogdels

TABLE 14-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination				
			ARAR	Base Background	Min.	Max.	Max. Location	Detection Frequency	Distribution
New River Sediment (Continued)	PCBs	ND	NOAA	NA				0/10	
	Metals (3)	Antimony	NOAA - 2	ND	8.7 J	263	28-NR-SD01	2/10	2 exceed ARAR, max. upstream
		Copper	NOAA - 70	0.43 - 53,200	1.5	1,340	28-NR-SD01	10/10	2 exceed ARAR, both upstream
		Lead	NOAA - 35	1 - 314	3.5 J	38,800	28-NR-SD01	10/10	2 exceed ARAR, both upstream
		Silver	NOAA - 1	7.3	3.1 J	3.4 J	28-NR-SD03	2/10	2 exceed ARAR, max. adjacent

Notes:
- Concentrations are presented in µg/L for liquid and µg/Kg for solids (ppb), metal concentrations for soils and sediments are presented in mg/Kg (ppm).

(1) Metals in both surface and subsurface soils were compared to the range of base background positive detections for priority pollutant metals only (i.e., antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc).

(2) An additional round of groundwater samples were collected from wells which exhibited concentrations of pesticides during the first round.

(3) Total metals in groundwater, surface water, and sediment were compared to the range of positve detections in upgradient samples at MCB, Camp Lejeune.

ARAR - Applicable or Relevant and Appropriate Requirements
BB - Base background (refer to Appendix M)
BEHP - bis(2-ethylhexyl)phthalate
NA - Not applicable
NCWQS - North Carolina Water Quality Standard
ND - Not detected
NOAA - National Oceanic and Atmospheric Administration
MCL - Federal Maximum Contaminant Level
PAH - Polynuclear aromatic hydrocarbon

TABLE 14-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB01-00	28-W-SB02-00	28-W-SB03-00	28-W-SB04-00	28-W-SB05-00	28-W-SB06-00	28-W-SB07-00	28-W-SB08-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/27/94	3/27/94	3/26/94	3/27/94
	UNITS								
VOLATILES									
Chloromethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
bis(2-Chloroethyl) ether	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	43 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	ND	ND	79 J	50 J	ND	120 J	ND
Pyrene	UG/KG	ND	ND	ND	79 J	ND	ND	89 J	ND
Butyl benzyl phthalate	UG/KG	ND	88 J	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	43 J	ND
bis(2-Ethylhexyl)phthalate	UG/KG	2000	ND	ND	ND	1400	2000	ND	5900 R
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	110 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	41 J	ND	ND	47 J	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 4-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB01-00	28-W-SB02-00	28-W-SB03-00	28-W-SB04-00	28-W-SB05-00	28-W-SB06-00	28-W-SB07-00	28-W-SB08-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/27/94	3/27/94	3/26/94	3/27/94
	UNITS								
PESTICIDES/PCBs									
Heptachlor epoxide	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	950	52	ND	11 J	7.7 J	ND	ND
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	43 NJ	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	770	16	ND	5.8 J	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	1.9 NJ	90 J	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	49 J	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	47 J	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 14-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB09-00	28-W-SB10-00	28-W-SB11-00	28-W-SB12-00	28-W-SB13-00	28-W-SB15-00	28-W-SB16-00	28-W-SB17-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/25/94	3/26/94	3/27/94	3/27/94	3/27/94	3/25/94	3/27/94	3/25/94
	UNITS								
VOLATILES									
Chloromethane	UG/KG	2 J	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
bis(2-Chloroethyl) ether	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	49 J
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	56 J
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	58 J	ND	ND	ND	ND	1100
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	240 J
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	76 J
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	140 J	ND	ND	ND	ND	1700
Pyrene	UG/KG	ND	ND	98 J	ND	ND	ND	ND	1200
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	56 J	ND	ND	ND	ND	990
Chrysene	UG/KG	ND	ND	62 J	ND	ND	ND	ND	1000
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	78 J	120 J	160 J	ND	1600	ND
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	78 J	ND	ND	ND	ND	650
Benzo[k]fluoranthene	UG/KG	ND	ND	41 J	ND	ND	ND	ND	740
Benzo[a]pyrene	UG/KG	ND	ND	69 J	ND	ND	ND	ND	610
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	44 J	ND	ND	ND	ND	270 J
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	54 J	ND	ND	ND	ND	220 J

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABL[illegible]4-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB09-00	28-W-SB10-00	28-W-SB11-00	28-W-SB12-00	28-W-SB13-00	28-W-SB15-00	28-W-SB16-00	28-W-SB17-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/25/94	3/26/94	3/27/94	3/27/94	3/27/94	3/25/94	3/27/94	3/25/94
	UNITS								
PESTICIDES/PCBs									
Heptachlor epoxide	UG/KG	ND	ND	ND	8.0 J	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	3.7 R	ND	ND	ND	ND
4,4'-DDE	UG/KG	26	28	200 J	4.7 J	ND	12	ND	4.4 NJ
Endrin	UG/KG	ND	ND	ND	3.7 R	ND	ND	ND	ND
4,4'-DDD	UG/KG	5.3 J	7.3	130 J	ND	230 J	ND	ND	ND
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	2.7 J	5.4 J	57 J	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	13 J	29 J	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	1.9 NJ	ND	ND	ND	ND
Aroclor 1254	UG/KG	ND	ND	ND	58 J	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	44	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB.. 4-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB18-00	28-W-SB19-00	28-W-SB20-00	28-E-SB21-00	28-E-SB23-00	28-E-SB24-00	28-E-SB25-00	28-E-SB26-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/27/94	3/25/94	3/25/94	3/25/94	3/26/94	3/26/94	3/25/94	3/26/94
	UNITS								
VOLATILES									
Chloromethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	2 J	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
bis(2-Chloroethyl) ether	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	46 J
Phenanthrene	UG/KG	41 J	ND	540	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	120 J	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	ND	69 J	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	79 J	ND	920	ND	ND	ND	ND	ND
Pyrene	UG/KG	59 J	ND	610	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	390 J	ND	ND	ND	ND	ND
Chrysene	UG/KG	56 J	ND	430 J	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	220 J	ND	1300	ND	ND	ND	ND	ND
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	96 J	ND	270 J	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	70 J	ND	320 J	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	61 J	ND	260 J	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	170 J	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	160 J	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB. 4-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB18-00	28-W-SB19-00	28-W-SB20-00	28-E-SB21-00	28-E-SB23-00	28-E-SB24-00	28-E-SB25-00	28-E-SB26-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/27/94	3/25/94	3/25/94	3/25/94	3/26/94	3/26/94	3/25/94	3/26/94
	UNITS								
PESTICIDES/PCBs									
Heptachlor epoxide	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	130	ND	ND	5.1	ND	22 J	19 J	19
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	6.4 J	ND	19	21 NJ	16 J
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	6.3	ND	50	40	7.2 J
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	18 NJ	ND	ND	12 J	ND	15 NJ	62 J	ND
gamma-Chlordane	UG/KG	ND	ND	ND	5.4 J	ND	5.0 NJ	29 J	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 - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABL[illegible]4-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-E-SB27-00	28-E-SB28-00	28-E-SB29-00	28-E-SB31-00	28-E-SB32-00	28-E-SB33-00	28-E-SB34-00	28-E-SB35-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/28/94	3/25/94	3/26/94	3/25/94	3/26/94	3/26/94	3/28/94	3/27/94
	UNITS								
VOLATILES									
Chloromethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	7 J	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	2 J	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
bis(2-Chloroethyl) ether	UG/KG	ND	69 J	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	53 J	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	58 J	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	43 J	ND	ND	ND	ND	ND	120 J	ND
Pyrene	UG/KG	51 J	ND	ND	ND	ND	ND	99 J	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	64 J	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	80 J	ND
bis(2-Ethylhexyl)phthalate	UG/KG	40 J	1000	ND	1100	580	ND	54 J	91 J
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	120 J	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	65 J	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	44 J	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	49 J	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 14-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-E-SB27-00		28-E-SB28-00		28-E-SB29-00		28-E-SB31-00		28-E-SB32-00		28-E-SB33-00		28-E-SB34-00		28-E-SB35-00
Sample Depth:		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'
Date Sampled:		3/28/94		3/25/94		3/26/94		3/25/94		3/26/94		3/26/94		3/28/94		3/27/94
	UNITS															
PESTICIDES/PCBs																
Heptachlor epoxide	UG/KG	ND		ND		ND		43	NJ	ND		ND		30	J	ND
Dieldrin	UG/KG	ND		7.1	J	ND		ND		ND		ND		ND		ND
4,4'-DDE	UG/KG	ND		ND		20	J	ND		9.6	J	1300		340	J	ND
Endrin	UG/KG	ND		35	J	ND		ND		ND		ND		ND		ND
4,4'-DDD	UG/KG	ND		53	NJ	ND		ND		0.91	NJ	120	NJ	48	NJ	ND
Endosulfan sulfate	UG/KG	ND		ND		ND		ND		ND		ND		ND		ND
4,4'-DDT	UG/KG	ND		15	NJ	20	J	ND		ND		1400		37	J	ND
Endrin aldehyde	UG/KG	ND		7.1	J	ND		ND		ND		ND		ND		ND
alpha-Chlordanc	UG/KG	2.3	NJ	16	NJ	ND		160	NJ	ND		36	NJ	130	J	ND
gamma-Chlordane	UG/KG	2.2	J	ND		ND		50	NJ	ND		ND		96	J	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 - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 14-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-E-SB36-00	28-GW01-00	28-GW01DW-00	28-GW05-00	28-GW06-00	28-GW07-00	28-GW07DW-00	28-GW08-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/26/94	4/20/94	4/21/94	4/7/94	4/7/94	4/8/94	4/18/94	4/9/94
	UNITS								
VOLATILES									
Chloromethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	6 J
Acetone	UG/KG	ND	ND	10 J	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
bis(2-Chloroethyl) ether	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	69 J	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	83 J	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	70 J	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	88 J	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	890	170 J	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	170 J	ND	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	170 J	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	70 J	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	98 J	1800	380	ND	ND	ND	ND	ND
Pyrene	UG/KG	83 J	2100	280 J	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	65 J	1300	210 J	ND	ND	ND	ND	ND
Chrysene	UG/KG	69 J	1200	250 J	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	53 J	59 J	ND	82 J	ND	ND	45 J
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	48 J	2800	270 J	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	100 J	700	210 J	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	58 J	1600	200 J	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	1500	150 J	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	120 J	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	1700	160 J	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 14-3
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-E-SB36-00		28-GW01-00		28-GW01DW-00		28-GW05-00		28-GW06-00		28-GW07-00	28-GW07DW-00	28-GW08-00
Sample Depth:		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'	0-1'	0-1'
Date Sampled:		3/26/94		4/20/94		4/21/94		4/7/94		4/7/94		4/8/94	4/18/94	4/9/94
	UNITS													
PESTICIDES/PCBs														
Heptachlor epoxide	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	56		1300	J	530		22	J	28	J	ND	ND	8.5
Endrin	UG/KG	ND		ND		ND		ND		ND		ND	ND	ND
4,4'-DDD	UG/KG	4.4	NJ	320	J	57	J	33	J	ND		ND	ND	ND
Endosulfan sulfate	UG/KG	ND		41	J	ND		ND		ND		ND	ND	ND
4,4'-DDT	UG/KG	14	J	680	J	230		21	J	9.2	J	ND	14	ND
Endrin aldehyde	UG/KG	ND		ND		ND		ND		ND		ND	ND	ND
alpha-Chlordane	UG/KG	2.5	NJ	ND		ND		38	J	ND		ND	ND	ND
gamma-Chlordane	UG/KG	ND		ND		ND		18	J	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 - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		28-W-SB01-00	28-W-SB02-00	28-W-SB03-00	28-W-SB04-00	28-W-SB05-00	28-W-SB06-00	28-W-SB07-00	28-W-SB08-00
Sample ID:		28-W-SB01-00	28-W-SB02-00	28-W-SB03-00	28-W-SB04-00	28-W-SB05-00	28-W-SB06-00	28-W-SB07-00	28-W-SB08-00
Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/27/94	3/27/94	3/26/94	3/27/94
Percent Solids		81.0	86.0	85.0	82	70.0	87.0	84.0	84.0
	UNITS								
Aluminum	MG/KG	821	1240	911	2310	1290 J	1070 J	3260	5290 J
Antimony	MG/KG	ND	6.4 J	ND	ND	ND	ND	ND	27.5 J
Arsenic	MG/KG	ND	1.1	ND	ND	0.63	0.78	ND	15.7
Barium	MG/KG	5.1	13.3	11.3	8.0	7.6	39.5	12.7	94.7
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND	0.73	12.5
Calcium	MG/KG	875	16000 J	29600	2260	951 J	696 J	1600	960 J
Chromium	MG/KG	1.6	5.8	2.5	3.3	2.6 J	1.7 J	5.6	21.9 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	8.0
Copper	MG/KG	1.5	26.4	7.0	9.9	13.5 J	21.8 J	12.2	210 J
Iron	MG/KG	536	2140	800	2820	1800 J	953 J	2370	5920 J
Lead	MG/KG	4.4	46.9 J	16.2	13.9	30.2 J	19.8 J	29.1	514 J
Magnesium	MG/KG	ND	214 J	123	241	84.3 J	51.1 J	132	292 J
Manganese	MG/KG	7.3 J	28.3	20.0 J	20.1 J	43.5 J	43.9 J	42.7 J	39100 J
Mercury	MG/KG	0.08	ND	0.33	ND	ND	0.17	0.08	0.46
Nickel	MG/KG	ND	ND	ND	ND	1.7 J	3.2 J	1.6	16.6 J
Potassium	MG/KG	35.1 J	111 J	61.4 J	429 J	83.9 J	79.7 J	93.6 J	201 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	10.4 J
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	1.1
Vanadium	MG/KG	2.5	4.5	2.5	6.4	3.2	2.5	6.0	14.5
Zinc	MG/KG	ND	50.1	36.2	25.2 J	160 J	89.6 J	88.3 J	23100 J

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TA[illegible]4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-W-SB09-00	28-W-SB10-00	28-W-SB11-00	28-W-SB12-00	28-W-SB13-00	28-W-SB14-00	28-W-SB15-00	28-W-SB16-00
	Sample Depth:	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
	Date Sampled:	3/25/94	3/26/94	3/27/94	3/27/94	3/27/94	3/27/94	3/25/94	3/27/94
Percent Solids		90.0	83.0	85.0	89.0	86.0	84.0	80.0	88.0
	UNITS								
Aluminum	MG/KG	2300	4370	5860 J	7150 J	1190 J	2460 J	5320	3170 J
Antimony	MG/KG	5.8 R	8.2 R	ND	ND	ND	ND	11.4 J	7.2 R
Arsenic	MG/KG	0.77	ND	3.0	1.1	ND	ND	1.5	1.6
Barium	MG/KG	11.5	25.6	40.5	58.1	24.2	5.0	75.2	10.4
Cadmium	MG/KG	ND	1.3	7.5	2.4	ND	ND	4.1	ND
Calcium	MG/KG	667 J	1870 J	11400 J	2030 J	210000 J	361 J	1690 J	1410 J
Chromium	MG/KG	4.8	9.9	21.7 J	11.8 J	2.4 J	2.8 J	17.9	8.6
Cobalt	MG/KG	ND	1.2	1.4	1.1	ND	ND	1.7	ND
Copper	MG/KG	13.2	36.9	4260 J	119 J	7.6 J	3.8 J	104	5.7
Iron	MG/KG	2340	4470	34100 J	5430 J	1660 J	1670 J	21900	3620 J
Lead	MG/KG	44.1 J	112 J	276 J	128 J	9.9 J	13.4 J	281 J	15.1
Magnesium	MG/KG	110 J	152 J	364 J	199 J	523 J	92.3 J	250 J	159
Manganese	MG/KG	22.3 J	153	176 J	94.2 J	36.3 J	11.3 J	222	20.0
Mercury	MG/KG	ND	0.29	0.27	0.21	0.09	ND	0.40	0.07
Nickel	MG/KG	1.6	4.4	17.2 J	4.1 J	1.1 J	1.9 J	8.3	2.2
Potassium	MG/KG	580 J	156 J	304 J	201 J	84.1 J	119 J	223 J	233 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	4.3 J	2.2 J	ND	ND	2.2 J	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	5.8	9.5	14.5	7.9	2.8	3.9	10.5	8.3
Zinc	MG/KG	59.3	289	4140 J	519 J	24.4 J	16.3 J	540	26.2

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TABLE 4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:		28-W-SB17-00	28-W-SB18-00	28-W-SB19-00	28-W-SB20-00	28-E-SB21-00	28-E-SB22-00	28-E-SB23-00	28-E-SB24-00
	Sample Depth:		0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
	Date Sampled:		3/25/94	3/27/94	3/25/94	3/25/94	3/25/94	3/26/94	3/26/94	3/26/94
Percent Solids			77.0	83.0	79.0	74.0	78.0	84.0	80.0	74.0
		UNITS								
Aluminum		MG/KG	1700	8410 J	1730	4070	3240	1830	2100	2480
Antimony		MG/KG	ND	8.3 J	ND	ND	6.3 R	ND	ND	ND
Arsenic		MG/KG	ND	3.5	2.3 J	1.9 J	1.9	1.1	1.3 J	1.2 J
Barium		MG/KG	12.9	92.4	28.4	38.5	13.0	12.5	8.9	12.4
Cadmium		MG/KG	1.1	5.8	2.5	1.9	ND	ND	ND	ND
Calcium		MG/KG	684	3080 J	12600	3500	35600 J	79100	291	58300
Chromium		MG/KG	4.7	25.9	13.4	14.1	6.8	4.2	4.5	4.9
Cobalt		MG/KG	ND	2.4	2.5	ND	ND	ND	ND	ND
Copper		MG/KG	27.2	233	36.1	92.8	10.8	3.0	2.9	3.1
Iron		MG/KG	5030	27300 J	40800	10500	3380	2180	2800	2680
Lead		MG/KG	78.3	551	99.9	157	15.0 J	10.8	5.0	8.2
Magnesium		MG/KG	83.9	444	223	441	489 J	289	76.8	344
Manganese		MG/KG	71.7	669	226	136	31.1	22.9 J	2.4 J	20.1 J
Mercury		MG/KG	0.12	0.75	0.16	0.29	ND	ND	ND	0.12
Nickel		MG/KG	1.7	26.7	8.8	4.2	1.3	ND	ND	1.7
Potassium		MG/KG	71.2 J	274 J	102 J	370 J	188 J	129 J	115 J	362 J
Selenium		MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver		MG/KG	ND	3.0 J	ND	2.9 J	ND	ND	ND	ND
Sodium		MG/KG	ND	130	ND	276	ND	66.6	17.1	ND
Thallium		MG/KG	ND	ND	2.5	ND	ND	ND	ND	ND
Vanadium		MG/KG	4.2	14.9	12.2	10.1	8.4	4.9	6.0	6.1
Zinc		MG/KG	249	1020	157	334	29.3	14.0 J	ND	16.6

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TABLE 4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-E-SB25-00	28-E-SB26-00	28-E-SB27-00	28-E-SB28-00	28-E-SB29-00	28-E-SB30-00	28-E-SB31-00	28-E-SB32-00
	Sample Depth:	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
	Date Sampled:	3/25/94	3/26/94	3/28/94	3/25/94	3/26/94	3/26/94	3/25/94	3/26/94
Percent Solids		81.0	80.0	84.0	68.0	90.0	87.0	74.0	64.0
	UNITS								
Aluminum	MG/KG	3080	3520	1930 J	3350	1200 J	1960 J	2260	2960
Antimony	MG/KG	ND	ND	ND	ND	ND	ND	6.9 R	ND
Arsenic	MG/KG	0.56 J	ND	1.8	ND	ND	ND	0.77	ND
Barium	MG/KG	16.4	23.5	4.9	24.5	10.2	6.8	7.4	19.2
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	68800	94300	2260 J	1650	3920 J	450 J	414 J	2260
Chromium	MG/KG	6.1	5.8	4.8 J	14.6	1.4 J	3.5 J	2.6	2.3
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	6.6	25.1	6.7 J	47.1	4.5 J	4.3 J	1.9	3.7
Iron	MG/KG	2900	2930	2870 J	2530	638 J	1150 J	1140	922
Lead	MG/KG	14.3	30.9	5.5 J	94.3	6.9 J	7.7 J	4.7 J	18.8
Magnesium	MG/KG	363	351	113 J	141	52.2 J	48.2 J	68.1 J	117
Manganese	MG/KG	22.9 J	27.8 J	16.0 J	17.3 J	9.4 J	10.2 J	14.4 J	58.9 J
Mercury	MG/KG	0.12	0.18	ND	0.40	0.25	ND	ND	0.08
Nickel	MG/KG	1.6	3.8	ND	3.3	ND	ND	ND	2.2
Potassium	MG/KG	135 J	99.7 J	115 J	109 J	26.3 J	54.7 J	77.2 J	740 J
Selenium	MG/KG	ND	ND	ND	1.5	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	0.80	ND	ND	ND
Vanadium	MG/KG	6.7	7.1	6.8	9.2	2.0	3.7	4.6	3.9
Zinc	MG/KG	28.2	57.2 J	6.7 J	39.5	9.8 J	8.7 J	8.0	14.6 J

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TA 4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-E-SB33-00		28-E-SB34-00		28-E-SB35-00		28-E-SB36-00		28-GW01-00		28-GW01DW-00		28-GW05-00		28-GW06-00	
	Sample Depth:	0-1'		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'		0-1'	
	Date Sampled:	3/26/94		3/28/94		3/27/94		3/26/94		4/20/94		4/21/94		4/7/94		4/7/94	
Percent Solids		75.0		85.0		86.0		82.0		87.0		94.0		91.0		90.0	
	UNITS																
Aluminum	MG/KG	2270		2540	J	2170	J	3720		5000		3000		3630		2390	
Antimony	MG/KG	ND		ND		ND		ND		16.1	J	7.9	J	ND		6.6	
Arsenic	MG/KG	ND		0.71		0.79		ND		4.9		1.7		1.4		ND	
Barium	MG/KG	21.7		61.7		9.1		9.9		88.5		36.1		14.6		6.1	
Cadmium	MG/KG	ND		0.81		ND		0.66		2.7		ND		ND		ND	
Calcium	MG/KG	8890		35800	J	3350	J	3880		49100	J	75100	J	41900		4190	
Chromium	MG/KG	4.6		9.8	J	4.1	J	8.9		24.3		8.4		6.2		6.9	
Cobalt	MG/KG	ND		ND		ND		ND		2.0		ND		1.2		ND	
Copper	MG/KG	7.1		22.1	J	2.5	J	9.2		154		25.4		5.5		4.5	
Iron	MG/KG	1700		1710	J	1510	J	2360		18900		4970		3960		1280	
Lead	MG/KG	18.5		47.8	J	6.8	J	19.4		512		316		11.4	J	59.4	
Magnesium	MG/KG	178		293	J	109	J	168		1700		654		370		128	
Manganese	MG/KG	62.6		38.4	J	14.8	J	16.0	J	357		95.1		21.1		7.0	
Mercury	MG/KG	0.10		1.1		0.05		0.46		0.09		ND		0.07		ND	
Nickel	MG/KG	ND		ND		ND		1.1		36.3		5.2		ND		ND	
Potassium	MG/KG	127	J	81.7	J	109	J	174	J	411	J	242	J	171		63.7	J
Selenium	MG/KG	ND		ND		ND		ND		ND		ND		ND		ND	
Silver	MG/KG	ND		5.9	J	ND		ND		1.5	J	ND		ND		ND	
Sodium	MG/KG	ND		ND		ND		ND		128		ND		25.4		ND	
Thallium	MG/KG	ND		ND		ND		ND		ND		ND		ND		ND	
Vanadium	MG/KG	6.1		3.5		4.8		6.9		19.0		6.1		7.4		4.1	
Zinc	MG/KG	15.9		101	J	13.5	J	40.5		696		160		19.8		10.4	

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TABLE 4-4
SURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-GW07-00	28-GW07DW-00	28-GW08-00
	Sample Depth:	0-1'	0-1'	0-1'
	Date Sampled:	4/8/94	4/18/94	4/9/94
Percent Solids		76.0	83.0	85.0
	UNITS			
Aluminum	MG/KG	920	846	1530
Antimony	MG/KG	ND	ND	ND
Arsenic	MG/KG	ND	ND	1.2
Barium	MG/KG	1.7	2.6	14.7
Cadmium	MG/KG	ND	ND	ND
Calcium	MG/KG	349	4020 J	644
Chromium	MG/KG	ND	2.0	5.0
Cobalt	MG/KG	ND	ND	ND
Copper	MG/KG	ND	3.1	32.3
Iron	MG/KG	630	775	3430
Lead	MG/KG	3.9	5.1	73.2
Magnesium	MG/KG	41.4	70.3	69.2
Manganese	MG/KG	5.9	7.5	74.2
Mercury	MG/KG	ND	ND	0.22
Nickel	MG/KG	ND	ND	ND
Potassium	MG/KG	ND	ND	63.4 J
Selenium	MG/KG	ND	ND	ND
Silver	MG/KG	ND	ND	ND
Sodium	MG/KG	ND	ND	ND
Thallium	MG/KG	ND	ND	ND
Vanadium	MG/KG	2.0	1.3	3.6
Zinc	MG/KG	6.8	7.2	110

MG/KG - milligrams per kilogram
ND - not detected
J - estimated
R - rejected

TABLE 4-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB01-04	28-W-SB01-08	28-W-SB02-04	28-W-SB02-07	28-W-SB03-03	28-W-SB03-05	28-W-SB04-03	28-W-SB04-06
Sample Depth:		7-9'	15-17'	7-9'	13-15'	5-7'	9-11'	5-7'	11-13'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	16	ND	ND	51	9 J	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	44 J	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dimethyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Diethylphthalate	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	ND	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
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	610	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB_ 4-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB01-04	28-W-SB01-08	28-W-SB02-04	28-W-SB02-07	28-W-SB03-03	28-W-SB03-05	28-W-SB04-03	28-W-SB04-06
Sample Depth:		7-9'	15-17'	7-9'	13-15'	5-7'	9-11'	5-7'	11-13'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94
	UNITS								
PESTICIDES/PCBs									
4,4'-DDE	UG/KG	ND	3.5 J	ND	4.0	20	5.3	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	7.8 NJ	ND	ND	ND
4,4'-DDT	UG/KG	ND	4.2 J	ND	3.0 J	5.4 J	6.8 J	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 1242	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	77	25 J	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TA[illegible]4-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB06-05	28-W-SB07-01	28-W-SB07-06	28-W-SB08-04	28-W-SB09-07	28-W-SB10-03	28-W-SB10-06	28-W-SB11-03
Sample Depth:		9-11'	1-3'	11-13'	7-9'	13-15'	5-7'	11-13'	5-7'
Date Sampled:		3/27/94	3/26/94	3/26/94	3/27/94	3/25/94	3/26/94	3/26/94	3/27/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	28	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND	ND	ND	5 J
SEMIVOLATILES									
1,4-Dichlorobenzene	UG/KG	44 J	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	UG/KG	ND	ND	ND	ND	ND	ND	250 J	ND
Naphthalene	UG/KG	ND	ND	39 J	ND	ND	78 J	2600	730 J
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	89 J	82 J	ND
Dimethyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	220 J	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	2500 J
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	1300 J
Diethylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	87 J	ND	2600 J
Phenanthrene	UG/KG	ND	ND	38 J	ND	ND	150 J	ND	27000
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	8600
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	4700
Fluoranthene	UG/KG	ND	140 J	57 J	ND	ND	ND	ND	53000 R
Pyrene	UG/KG	ND	54 J	62 J	ND	ND	ND	ND	32000 R
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	24000
Chrysene	UG/KG	ND	46 J	49 J	ND	ND	ND	ND	22000
bis(2-Ethylhexyl)phthalate	UG/KG	1100	150 J	7200 R	330 J	ND	ND	1300	960 J
Benzo[b]fluoranthene	UG/KG	ND	38 J	62 J	ND	ND	ND	ND	21000
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	18000
Benzo[a]pyrene	UG/KG	ND	ND	43 J	ND	ND	ND	ND	21000
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	11000
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	2800 J
Benzo[g,h,i]perylene	UG/KG	ND	ND	50 J	ND	ND	ND	ND	10000

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB. [illegible]-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB06-05	28-W-SB07-01	28-W-SB07-06	28-W-SB08-04	28-W-SB09-07	28-W-SB10-03	28-W-SB10-06	28-W-SB11-03
Sample Depth:		9-11'	1-3'	11-13'	7-9'	13-15'	5-7'	11-13'	5-7'
Date Sampled:		3/27/94	3/26/94	3/26/94	3/27/94	3/25/94	3/26/94	3/26/94	3/27/94
	UNITS								
PESTICIDES/PCBs									
4,4'-DDE	UG/KG	500	ND	1600	ND	270	46	41	41 J
4,4'-DDD	UG/KG	130	ND	780	ND	150	130	60 J	60 J
4,4'-DDT	UG/KG	ND	ND	22 NJ	ND	16	17 J	ND	ND
alpha-Chlordane	UG/KG	45 J	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	2.6 NJ	ND	ND	2.7 J
Aroclor 1242	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TA. 4-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB12-05	28-W-SB13-06	28-E-SB21-02	28-E-SB23-03	28-E-SB25-03	28-E-SB28-04	28-E-SB31-02	28-E-SB36-04	28-GW01-01
Sample Depth:		9-11'	11-13'	3-5'	5-7'	5-7'	7-9'	3-5'	7-9'	1-3'
Date Sampled:		3/27/94	3/27/94	3/25/94	3/26/94	3/26/94	3/26/94	3/25/94	3/26/94	4/20/94
	UNITS									
VOLATILES										
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	8 J
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	40 J
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES										
1,4-Dichlorobenzene	UG/KG	140 J	ND	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	47 J	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethyl phthalate	UG/KG	ND	79 J	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diethylphthalate	UG/KG	100 J	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	78 J
Phenanthrene	UG/KG	44 J	ND	ND	44 J	ND	ND	ND	ND	1200
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	330 J
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	94 J
Fluoranthene	UG/KG	ND	ND	40 J	76 J	ND	ND	ND	42 J	2700
Pyrene	UG/KG	ND	ND	ND	56 J	ND	ND	ND	ND	2600
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1900
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1600
bis(2-Ethylhexyl)phthalate	UG/KG	240 J	550	ND	ND	14000 R	ND	ND	1100	110 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1600
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1500
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1600
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1100 J
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	110 J
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	1200 J

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB. [illegible]-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-W-SB12-05	28-W-SB13-06	28-E-SB21-02	28-E-SB23-03	28-E-SB25-03	28-E-SB28-04	28-E-SB31-02	28-E-SB36-04	28-GW01-01
Sample Depth:		9-11'	11-13'	3-5'	5-7'	5-7'	7-9'	3-5'	7-9'	1-3'
Date Sampled:		3/27/94	3/27/94	3/25/94	3/26/94	3/26/94	3/26/94	3/25/94	3/26/94	4/20/94
	UNITS									
PESTICIDES/PCBs										
4,4'-DDE	UG/KG	650 J	410 J	8.4	ND	3.1 J	ND	ND	ND	610 J
4,4'-DDD	UG/KG	260 J	280 J	15	ND	15	ND	ND	6.7	630 J
4,4'-DDT	UG/KG	43 J	ND	7.4	ND	ND	ND	ND	6.1 J	430 J
alpha-Chlordane	UG/KG	65 J	ND	ND	ND	ND	ND	2.7 J	ND	ND
gamma-Chlordane	UG/KG	11 NJ	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE [illegible]-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-GW01DW-01	28-GW05-04	28-GW06-04	28-GW06-08	28-GW07-01	28-GW07DW-01	28-GW08-05
Sample Depth:		1-3'	7-9'	7-9'	15-17'	1-3'	1-3'	9-11'
Date Sampled:		4/20/94	4/7/94	4/7/94	4/7/94	4/8/94	4/18/94	4/9/94
	UNITS							
VOLATILES								
Methylene chloride	UG/KG	4 J	ND	ND	ND	ND	ND	5
Acetone	UG/KG	99	ND	ND	ND	ND	40 J	ND
2-Butanone	UG/KG	21	ND	ND	ND	ND	ND	ND
Benzene	UG/KG	2 J	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	UG/KG	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dimethyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	510	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	220
Diethylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	99 J	ND
Phenanthrene	UG/KG	84 J	ND	ND	ND	44 J	ND	49
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	180 J	ND	ND	ND	81 J	48 J	ND
Pyrene	UG/KG	170 J	ND	ND	ND	51 J	ND	ND
Benzo[a]anthracene	UG/KG	120 J	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	140 J	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	640	66 J	62
Benzo[b]fluoranthene	UG/KG	210 J	ND	ND	ND	49 J	ND	ND
Benzo[k]fluoranthene	UG/KG	50 J	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	110 J	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	100 J	ND	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	120 J	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TABLE 4-5
SUBSURFACE SOILS - POSITIVE DETECTIONS SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-GW01DW-01	28-GW05-04	28-GW06-04	28-GW06-08	28-GW07-01	28-GW07DW-01	28-GW08-05
Sample Depth:		1-3'	7-9'	7-9'	15-17'	1-3'	1-3'	9-11'
Date Sampled:		4/20/94	4/7/94	4/7/94	4/7/94	4/8/94	4/18/94	4/9/94
	UNITS							
PESTICIDES/PCBs								
4,4'-DDE	UG/KG	1400	ND	ND	ND	35	12	56
4,4'-DDD	UG/KG	880 NJ	ND	ND	ND	20 J	15	6.2
4,4'-DDT	UG/KG	7300 D	ND	ND	ND	3.2 J	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	UG/KG	ND	ND	ND	ND	140 J	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
NJ - tentatively identified
R - rejected

TAB. 4-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-W-SB01-04	28-W-SB01-08	28-W-SB02-04	28-W-SB02-07	28-W-SB03-03	28-W-SB03-05	28-W-SB04-03	28-W-SB04-06
	Sample Depth:	7-9'	15-17'	7-9'	13-15'	5-7'	9-11'	5-7'	11-13'
	Date Sampled:	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/26/94
Percent Solids		91.0	85.0	96.0	89.0	85.0	84.0	83.0	85.0
	UNITS								
Aluminum	MG/KG	921 J	1090 J	688 J	832 J	4490 J	2580 J	2410	3090
Antimony	MG/KG	5.9 J	ND	9.0 J	ND	12.5 J	13.8 J	ND	ND
Arsenic	MG/KG	ND	ND	ND	0.86	2.0	16.7	ND	ND
Barium	MG/KG	3.5	4.6	3.9	3.7	41.3	74.2	7.7	9.9
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	ND	1.7	0.77	ND
Calcium	MG/KG	150 J	275 J	51.3 J	170 J	98400 J	71400 J	12000	1010
Chromium	MG/KG	2.0 J	3.3 J	ND	2.1 J	5.7 J	57.9 J	5.7	6.0
Cobalt	MG/KG	ND	ND	ND	ND	ND	5.5	ND	ND
Copper	MG/KG	0.98 R	1.3 J	1.1 R	1.3 R	48.4 J	138 J	2.7	1.7
Iron	MG/KG	779 J	915 J	584 J	765 J	2560 J	78000 J	2310	2460
Lead	MG/KG	ND	2.5 J	ND	2.2 J	18.1 J	414 J	6.5	5.3
Magnesium	MG/KG	31.4 J	50.6 J	44.6 J	48.4 J	1040 J	717 J	227	134
Manganese	MG/KG	4.7 J	9.8 J	4.6 J	5.7 J	29.9 J	238 J	12.7 J	9.9 J
Mercury	MG/KG	ND	ND	ND	ND	0.06	0.05	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	3.3 J	45.9 J	ND	1.6
Potassium	MG/KG	ND	64.1 J	358 J	54.5 J	287 J	195 J	428 J	111 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	4.0 J	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	1.4	1.8	0.98	1.9	6.5	19.6	5.9	6.4
Zinc	MG/KG	0.95 J	2.7 J	1.0 J	1.9 J	28.1 J	359 J	8.6 J	4.1 J

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TAb. 4-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-W-SB06-05	28-W-SB08-04	28-W-SB09-07	28-W-SB10-03	28-W-SB10-06	28-W-SB11-03	28-W-SB12-05	28-W-SB13-06
	Sample Depth:	9-11'	7-9'	13-15'	5-7'	11-13'	5-7'	9-11'	11-13'
	Date Sampled:	3/27/94	3/27/94	3/25/94	3/26/94	3/26/94	3/27/94	3/27/94	3/27/94
Percent Solids		79.0	87.0	83.0	91.0	91.0	85.0	84.0	60.0
	UNITS								
Aluminum	MG/KG	10800 J	9590 J	8270 J	2760	6710	3050 J	10000 J	13800 J
Antimony	MG/KG	20.6 J	ND	46.7 J	7.0 R	43.0 J	9.8 J	44.0 J	ND
Arsenic	MG/KG	25.1	4.7	19.8	ND	2.8 J	3.3	18.7	14.1
Barium	MG/KG	198	105	215	15.9	84.1	40.2	226	200
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	1.1
Cadmium	MG/KG	14.8	4.5	6.3	0.90	2.0	2.3	10.5	1.6
Calcium	MG/KG	17200 J	9910 J	20400 J	59800 J	7660 J	63200 J	16100 J	18900 J
Chromium	MG/KG	98.5 J	20.1 J	82.2 J	10.2	14.5	34.7 J	79.7 J	12.4 J
Cobalt	MG/KG	15.4	3.1	12.2	0.90	ND	2.8	10.0	6.0
Copper	MG/KG	697 J	256 J	3280 J	14.5	919	33.8 J	531 J	47.8 J
Iron	MG/KG	95400 J	9610 J	145000 J	3060	7310	35500 J	154000 J	10000 J
Lead	MG/KG	1700 J	299 J	1670 J	36.4 J	2060 J	146 J	1670 J	25.1 J
Magnesium	MG/KG	1060 J	616 J	1350 J	869 J	632 J	3660 J	1220 J	1040 J
Manganese	MG/KG	1340 J	3340 J	1270 J	43.1	70.5	325 J	2100 J	53.2 J
Mercury	MG/KG	0.60	0.45	0.42	0.08	0.22	ND	1.0	0.27
Nickel	MG/KG	102 J	17.8 J	53.1 J	2.7	2.5	38.5 J	60.3 J	17.2 J
Potassium	MG/KG	583 J	515 J	501 J	271 J	597 J	216 J	450 J	4200 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	6.0 J
Silver	MG/KG	9.6 J	6.0 J	9.5 J	ND	ND	ND	18.4 J	ND
Sodium	MG/KG	267	201	408	100	405	ND	316	1220
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	31.8	15.0	45.3	6.3	11.4	16.7	35.4	90.7
Zinc	MG/KG	1510 J	4330 J	1870	101	1040	343 J	2600 J	39.5 J

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-W-SB14-02	28-W-SB15-05	28-W-SB16-04	28-W-SB17-05	28-W-SB18-01	28-W-SB19-03	28-W-SB20-01	28-E-SB21-02
	Sample Depth:	3-5'	9-11'	7-9'	9-11'	1-3'	5-7'	1-3'	3-5'
	Date Sampled:	3/27/94	3/25/94	3/27/94	3/26/94	3/27/94	3/26/94	3/26/94	3/25/94
Percent Solids		84.0	80.3	83.0	87.2	76.3	81.7	82.9	87.0
	UNITS								
Aluminum	MG/KG	3480 J	9280 J	1720 J	12400	20700 J	2710	12000	6360 J
Antimony	MG/KG	7.9 J	19.1 J	7.6 R	19.7 J	30.2 J	6.4 R	7.8 R	ND
Arsenic	MG/KG	3.2	8.9	0.69	9.9	11.3	1.5	5.4	1.9
Barium	MG/KG	21.5	110	9.6	120	269	23.6	147	11.9
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	1.3	7.9	ND	9.6	15.6	1.8	9.3	ND
Calcium	MG/KG	892 J	55800 J	1560 J	6370 J	17900 J	32000 J	13400 J	1050 J
Chromium	MG/KG	10.8 J	51.9 J	7.8	34.5	128	10.2	38.0	11.8 J
Cobalt	MG/KG	ND	4.1	ND	6.6	7.8	1.2	4.9	ND
Copper	MG/KG	35.1 J	204 J	6.2	464	469	43.5	373	2.3 J
Iron	MG/KG	16100 J	92600 J	2540 J	54500	92300 J	14400	51900	6680 J
Lead	MG/KG	234 J	1300 J	18.9	1150 J	1670	697 J	572 J	6.8 J
Magnesium	MG/KG	151 J	812 J	92.2	828 J	1310	523 J	1440 J	343 J
Manganese	MG/KG	78.8 J	674 J	17.5	356	1720	165	940	5.5 J
Mercury	MG/KG	ND	1.0	ND	ND	1.2	0.15	0.28	ND
Nickel	MG/KG	5.8 J	24.2 J	ND	24.3	39.7	ND	24.9	ND
Potassium	MG/KG	235 J	269 J	169 J	867 J	655 J	189 J	817 J	305 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	2.0 J	5.0 J	ND	5.5 J	15.7 J	1.1 J	6.5 J	ND
Sodium	MG/KG	ND	399	ND	363	425	ND	461	ND
Thallium	MG/KG	ND	ND	ND	1.0	ND	ND	ND	ND
Vanadium	MG/KG	10.7	24.0	5.7	23.0	33.8	8.8	22.1	14.3
Zinc	MG/KG	133 J	1070 J	46.8	737	2420	197	1630	7.4 J

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample ID:		28-E-SB22-02	28-E-SB23-03	28-E-SB24-03	28-E-SB25-03	28-E-SB26-03	28-E-SB27-04	28-E-SB28-04	28-E-SB29-02	28-E-SB30-03
Sample Depth:		3-5'	5-7'	5-7'	5-7'	5-7'	7-9'	7-9'	3-5'	5-7'
Date Sampled:		3/26/94	3/26/94	3/26/94	3/26/94	3/26/94	3/28/94	3/26/94	3/26/94	3/26/94
Percent Solids		86.0	87.0	80.9	86.0	70.4	86.0	72.0	90.0	89.0
	UNITS									
Aluminum	MG/KG	4460	3840 J	12200 J	7080	11800	2510 J	14200	6140 J	1480 J
Antimony	MG/KG	ND	ND	ND	7.1 R	ND	ND	7.6 R	ND	ND
Arsenic	MG/KG	1.9	2.6	6.2	0.69	2.0 J	2.9	5.8	1.5	1.1
Barium	MG/KG	12.7	8.4	19.9	16.7	23.8	7.2	17.5	29.0	3.0
Beryllium	MG/KG	ND	ND	ND	ND	0.28	ND	0.25	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	0.99	ND	ND	ND	ND
Calcium	MG/KG	21100	453 J	515 J	711 J	2570	1110 J	132 J	486 J	86.5 J
Chromium	MG/KG	10.2	9.0 J	30.6 J	8.4	30.4	9.0 J	38.2	6.4 J	4.4 J
Cobalt	MG/KG	ND	1.2	ND	0.98	ND	ND	1.4	ND	ND
Copper	MG/KG	3.5	2.5 J	3.8 J	3.8	4.3	4.9 J	4.7	1.2 R	1.0 J
Iron	MG/KG	5230	5770 J	15500 J	2100	11700	3990 J	18100	3370 J	1540 J
Lead	MG/KG	13.4	6.1 J	7.6 J	10.2 J	10.2	14.3 J	10.9 J	4.8 J	1.9 J
Magnesium	MG/KG	637	152 J	503 J	250 J	1160	287 J	819 J	214 J	53.4 J
Manganese	MG/KG	10.0 J	5.4 J	6.3 J	10.4	11.7 J	6.7 J	5.5 J	6.8 J	1.8 J
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	261 J	228 J	434 J	214 J	1030 J	419 J	750 J	159 J	67.9 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	1.2 J	ND	ND
Sodium	MG/KG	553	ND	ND	ND	ND	202	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	12.2	9.9	36.1	8.3	30.9	9.8	43.6	9.8	6.4
Zinc	MG/KG	6.4 J	5.6 J	5.7 J	9.1	8.3 J	31.8 J	7.3	ND	ND

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TAB. 4-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample ID:		28-E-SB30-05	28-E-SB31-02	28-E-SB32-03	28-E-SB32-06	28-E-SB33-03	28-E-SB33-06	28-E-SB34-03	28-E-SB34-06	28-E-SB35-05
Sample Depth:		9-11'	3-5'	5-7'	11-13'	5-7'	11-13'	5-7'	11-13'	9-11'
Date Sampled:		3/26/94	3/25/94	3/26/94	3/26/94	3/25/94	3/25/94	3/28/94	3/28/94	3/27/94
Percent Solids		87.0	87.0	78.5	74.3	89.6	84.1	90.2	76.1	83.2
	UNITS									
Aluminum	MG/KG	2490 J	7650 J	1950	7950	2220 J	6330 J	3370 J	2830 J	5810 J
Antimony	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	MG/KG	3.0	1.5	ND	ND	ND	2.4	ND	2.4	5.2
Barium	MG/KG	5.5	12.3	5.3	10.3	5.3	9.7	4.2	7.6	12.4
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	ND	ND	ND	1.10	ND	ND	ND	ND	ND
Calcium	MG/KG	103 J	1280 J	ND	ND	199 J	301 J	ND	ND	107 J
Chromium	MG/KG	11.4 J	15.9 J	2.1	13.9	2.7 J	17.0	4.6 J	8.8 J	21.2 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	2.4 J	2.6 J	ND	2.2	1.0 R	1.8 J	1.1 R	1.6 J	1.8 J
Iron	MG/KG	5560 J	8190 J	873	7930	949 J	10900 J	456 J	2290 J	8550 J
Lead	MG/KG	6.3 J	8.8 J	2.6	7.1	2.7 J	5.4 J	2.1 J	4.6 J	5.7 J
Magnesium	MG/KG	182 J	400 J	64.6	414	60.8 J	435 J	96.0 J	234 J	382 J
Manganese	MG/KG	2.0 J	6.6 J	2.7 J	4.3 J	1.5 J	4.0 J	2.1 J	2.2 J	4.4 J
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Nickel	MG/KG	ND	ND	3.1	3.5	ND	ND	ND	ND	ND
Potassium	MG/KG	225 J	309 J	419 J	708 J	95.2 J	431 J	137 J	229 J	327 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	1.8 J	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	10.6	16.6	4.2	18.4	3.2	19.9	4.0	8.4	22.9
Zinc	MG/KG	ND	8.8	1.1 J	3.6 J	1.3 J	3.8 J	ND	ND	ND

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TAB[illegible]-6
SUBSURFACE SOILS - POSITIVE DETECTION SUMMARY
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-E-SB36-04	28-GW01-01	28-GW01DW-01	28-GW05-04	28-GW06-04	28-GW06-08	28-GW07-01	28-GW07DW-01	28-GW08-05
	Sample Depth:	7-9'	1-3'	1-3'	7-9'	7-9'	15-17'	1-3'	1-3'	9-11'
	Date Sampled:	3/26/94	4/20/94	4/21/94	4/7/94	4/7/94	4/7/94	4/8/94	4/18/94	4/9/94
Percent Solids		82.0	86.0	91.0	79.0	74.0	77.0	76.0	82.0	74.0
	UNITS									
Aluminum	MG/KG	2710 J	4610	2720	6900	7660	4330	3510	2320	9830
Antimony	MG/KG	ND	ND	ND	ND	7.8	ND	11.7	ND	17.5
Arsenic	MG/KG	0.91	3.3	2.4	5.8	1.3	1.8	1.8	1.3	3.6
Barium	MG/KG	9.6	60.8	52.4	9.3	8.1	9.4	29.9	13.5	32.1
Beryllium	MG/KG	ND	0.24	ND	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	ND	1.1	1.2	ND	ND	ND	2.0	ND	3.4
Calcium	MG/KG	1490 J	78700 J	155000 J	79.1	396	58.8	8600	1750 J	2360
Chromium	MG/KG	4.9 J	12.0	9.6	19.6	14.3	12.9	35.3	5.8	18.6
Cobalt	MG/KG	ND	1.6	ND	ND	ND	ND	3.2	ND	ND
Copper	MG/KG	7.7 J	40.9	14.3	3.1	ND	1.7	39.6	12.5	31.3
Iron	MG/KG	1750 J	10900	9370	8840	3320	1290	9880	4140	13200
Lead	MG/KG	23.4 J	162	92.1	6.1 J	5.5	9.8	105	27.2	122
Magnesium	MG/KG	99.7 J	1960	1340	403	268	395	8190	107	631
Manganese	MG/KG	10.8 J	188	88.3	4.9	3.0 J	6.0	131	156	69.8
Mercury	MG/KG	ND	2.8	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	1.9 J	10.9	6.4	ND	ND	ND	48.6	ND	14.5 J
Potassium	MG/KG	674 J	492 J	139 J	399	312 J	540 J	159 J	131 J	950 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	146	ND	28.8	ND	ND	ND	ND	175
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	6.1	40.6	4.5	21.7	9.5	18.1	8.8	4.2	20.5
Zinc	MG/KG	55.0 J	233	72.7	3.9	ND	ND	271	75.4	160

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-7
SHALLOW AND DEEP GROUNDWATER - POSITVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-GW01-01	28-GW01DW-01	28-GW02-01	28-GW05-01	28-GW06-01	28-GW07-01	28-GW07DW-01
Date Sampled:		4/25/94	5/7/94	4/20/94	4/23/94	4/21/94	4/21/94	5/8/94
	UNITS							
VOLATILES								
Chloroform	UG/L	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	UG/L	ND	2 R	ND	ND	ND	ND	2 R
Toluene	UG/L	ND	ND	ND	ND	ND	3	ND
Ethylbenzene	UG/L	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	UG/L	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
Phenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
bis(2-Chloroethyl) ether	UG/L	10 R	ND	ND	ND	ND	ND	ND
2-Chlorophenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
2-Methylphenol	UG/L	10 R	ND	ND	ND	ND	1 J	ND
4-Methylphenol	UG/L	10 R	ND	ND	ND	ND	29	ND
N-Nitroso-di-n-propylamine	UG/L	10 R	ND	ND	ND	ND	ND	ND
2-Nitrophenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	UG/L	10 R	ND	ND	ND	ND	2 J	ND
2,4-Dichlorophenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
Naphthalene	UG/L	ND	ND	ND	ND	ND	ND	ND
4-Chloro-3-methylphenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/L	ND	ND	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	UG/L	10 R	ND	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol	UG/L	25 R	ND	ND	ND	ND	ND	ND
Dimethyl phthalate	UG/L	1 J	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/L	ND	ND	1 J	ND	ND	ND	ND
2,4-Dinitrophenol	UG/L	25 R	ND	ND	ND	ND	ND	ND
4-Nitrophenol	UG/L	25 R	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/L	ND	ND	ND	ND	ND	ND	ND
4-Chlorophenyl phenyl ether	UG/L	10 R	ND	ND	ND	ND	ND	ND
Fluorene	UG/L	ND	ND	ND	ND	ND	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected
R - rejected

TAB[illegible]4-7
SHALLOW AND DEEP GROUNDWATER - POSITVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-GW01-01	28-GW01DW-01	28-GW02-01	28-GW05-01	28-GW06-01	28-GW07-01	28-GW07DW-01
Date Sampled:		4/25/94	5/7/94	4/20/94	4/23/94	4/21/94	4/21/94	5/8/94
	UNITS							
SEMIVOLATILES Cont.								
4,6-Dinitro-2-methylphenol	UG/L	25 R	ND	ND	ND	ND	ND	ND
N-nitrosodiphenylamine	UG/L	10 R	ND	ND	ND	ND	ND	ND
4-Bromophenyl-phenylether	UG/L	10 R	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/L	25 R	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/L	ND	ND	ND	ND	ND	ND	ND
Anthracene	UG/L	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/L	ND	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/L	ND	ND	ND	ND	1 J	ND	ND
Fluoranthene	UG/L	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/L	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/L	ND	ND	ND	1 J	ND	17	ND
PESTICIDES/PCBs								
4,4'-DDE	UG/L	0.06 J	ND	0.14 J	ND	ND	0.67 J	ND
4,4'-DDD	UG/L	0.06 J	ND	0.22 J	ND	ND	9.0	ND
4,4'-DDT	UG/L	0.05 J	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/L	ND	ND	ND	ND	ND	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected
R - rejected

TAB.]-7
SHALLOW AND DEEP GROUNDWATER - POSITVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Units	Sample ID: 28-GW08-01 Date Sampled: 4/21/94	28-MW13-01 4/21/94	28-TGWPA01 4/20/94
VOLATILES				
Chloroform	UG/L	ND	ND	2
2-Chloroethylvinylether	UG/L	ND	ND	ND
Toluene	UG/L	ND	ND	2
Ethylbenzene	UG/L	ND	ND	5
Xylene (total)	UG/L	ND	ND	19
SEMIVOLATILES				
Phenol	UG/L	ND	ND	ND
bis(2-Chloroethyl) ether	UG/L	ND	ND	ND
2-Chlorophenol	UG/L	ND	ND	ND
2-Methylphenol	UG/L	ND	ND	ND
4-Methylphenol	UG/L	ND	ND	ND
N-Nitroso-di-n-propylamine	UG/L	ND	ND	ND
2-Nitrophenol	UG/L	ND	ND	ND
2,4-Dimethylphenol	UG/L	ND	ND	4 J
2,4-Dichlorophenol	UG/L	ND	ND	2 J
Naphthalene	UG/L	ND	ND	99
4-Chloro-3-methylphenol	UG/L	ND	ND	ND
2-Methylnaphthalene	UG/L	ND	ND	33
2,4,6-Trichlorophenol	UG/L	ND	ND	ND
2,4,5-Trichlorophenol	UG/L	ND	ND	ND
Dimethyl phthalate	UG/L	ND	ND	ND
Acenaphthene	UG/L	ND	ND	31
2,4-Dinitrophenol	UG/L	ND	ND	ND
4-Nitrophenol	UG/L	ND	ND	ND
Dibenzofuran	UG/L	ND	ND	12
4-Chlorophenyl phenyl ether	UG/L	ND	ND	ND
Fluorene	UG/L	ND	ND	18

UG/L - micrograms per liter
J - estimated
ND - not detected
R - rejected

TAB. 4-7
SHALLOW AND DEEP GROUNDWATER - POSITVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Sample ID:	28-GW08-01	28-MW13-01	28-TGWPA01
	Date Sampled:	4/21/94	4/21/94	4/20/94
	UNITS			
SEMIVOLATILES Cont.				
4,6-Dinitro-2-methylphenol	UG/L	ND	ND	ND
N-nitrosodiphenylamine	UG/L	ND	ND	ND
4-Bromophenyl-phenylether	UG/L	ND	ND	ND
Pentachlorophenol	UG/L	ND	ND	ND
Phenanthrene	UG/L	ND	ND	14
Anthracene	UG/L	ND	ND	3 J
Carbazole	UG/L	ND	ND	11
di-n-Butylphthalate	UG/L	ND	ND	ND
Fluoranthene	UG/L	ND	ND	2 J
Pyrene	UG/L	ND	ND	1 J
bis(2-Ethylhexyl)phthalate	UG/L	ND	1 J	1 J
PESTICIDES/PCBs				
4,4'-DDE	UG/L	0.23 J	ND	6.6 J
4,4'-DDD	UG/L	0.10 J	0.34 J	4.6 J
4,4'-DDT	UG/L	ND	ND	0.37 J
gamma-Chlordane	UG/L	0.049 J	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected
R - rejected

TAB. 4-8
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-GW01-01	28-GW01DW-01	28-GW02-01	28-GW03-01	28-GW04-01	28-GW05-01	28-GW06-01	28-GW07-01
	Date Sampled:	4/25/94	5/7/94	4/20/94	4/21/94	4/20/94	4/23/94	4/21/94	4/21/94
	UNITS								
Aluminum	UG/L	95900 J	253	ND	37100	50800	100000 J	81500	72800
Antimony	UG/L	ND	ND	42.7	ND	ND	ND	74.4	5340
Arsenic	UG/L	15.8	5.2	10.3	15.6	13.9	13.2	34.5	76.7
Barium	UG/L	183	29.1	ND	248	503	220	1270	1980
Beryllium	UG/L	1.9	ND	ND	1.1	9.6	ND	5.6	3.5
Cadmium	UG/L	9.6	ND	5.2	3.5	8.1	7.4	3.3	35.4
Calcium	UG/L	75700	96200	ND	17400	178000	16100	17800	200000
Chromium	UG/L	172 J	ND	ND	90.9 J	196 J	122 J	188 J	308 J
Cobalt	UG/L	8.6	ND	ND	ND	28.4	ND	8.2	30.4
Copper	UG/L	35.4	ND	ND	ND	ND	20.3	12.2	2250
Iron	UG/L	87800	417	ND	35800	37400	91800 J	46400	245000
Lead	UG/L	114	1.5	449	27.7	21.2	95.5 J	70.8	4810
Magnesium	UG/L	22500	13600	ND	3830	8990	7790	9180	52900
Manganese	UG/L	186	29.6	ND	61.5	207	100	397	3330
Mercury	UG/L	0.21	ND	1.7 J	ND	0.17 J	0.37	0.16 J	2.0 J
Nickel	UG/L	ND	10.4	ND	12.9	86.5	15.8	18.0	165
Potassium	UG/L	16100 J	17100	ND	3210	5470	4790 J	6370	63500
Selenium	UG/L	ND	ND	ND	ND	ND	ND	ND	5.6 J
Silver	UG/L	ND	ND	ND	ND	ND	6.4 J	ND	37.9 J
Sodium	UG/L	14000	744000	ND	10100	15000	13200	6770	223000
Thallium	UG/L	ND	6.9 J	ND	ND	ND	ND	ND	ND
Vanadium	UG/L	190 J	ND	ND	83.6	107	105	135	120
Zinc	UG/L	129	ND	ND	34.2	251	72.2	110	9220

UG/L - micrograms per liter
J - estimated
ND - not detected

TA. 14-8
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		28-GW07DW-01	28-GW08-01	28-GW09DW-01	28-MW13-01	28-TGWPA01
Sample ID:		28-GW07DW-01	28-GW08-01	28-GW09DW-01	28-MW13-01	28-TGWPA01
Date Sampled:		5/8/94	4/21/94	4/25/94	4/21/94	4/20/94
	UNITS					
Aluminum	UG/L	225	11600	10600 J	21600	21300
Antimony	UG/L	ND	ND	ND	ND	139
Arsenic	UG/L	ND	8.9	ND	10.5	23.9
Barium	UG/L	13.7	433	75.8	142	335
Beryllium	UG/L	ND	ND	ND	ND	ND
Cadmium	UG/L	ND	4.8	ND	3.2	8.0
Calcium	UG/L	27600	69400	175000	245000	120000
Chromium	UG/L	ND	43.2 J	44.4 J	33.2 J	83.6
Cobalt	UG/L	ND	ND	4.1	ND	11.3
Copper	UG/L	ND	398	95.5	ND	386
Iron	UG/L	ND	29900	9320	44200	56500
Lead	UG/L	ND	704	18.0	15.9	1210
Magnesium	UG/L	498	37400	5380	12900	3020
Manganese	UG/L	ND	1350	116	527	704
Mercury	UG/L	ND	0.41 J	ND	0.18 J	1.5
Nickel	UG/L	ND	45.2	ND	10.5	48.1
Potassium	UG/L	2100	60900	4830 J	6360	43400
Selenium	UG/L	ND	ND	ND	ND	ND
Silver	UG/L	ND	5.4 J	ND	ND	17.4
Sodium	UG/L	11900	183000	27200	22600	144000
Thallium	UG/L	ND	ND	ND	ND	ND
Vanadium	UG/L	ND	13.4	32.3 J	44.3	27.9
Zinc	UG/L	ND	1450	89.5	23.1	2490

UG/L - micrograms per liter
J - estimated
ND - not detected

TAB.. 4-9
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
DISSOLVED METALS

Sample ID:		28-GW01D-01	28-GW01DWD-01	28-GW02D-01	28-GW03D-01	28-GW04D-01	28-GW05D-01	28-GW06D-01	28-GW07D-01
Date Sampled:		4/24/94	5/7/94	4/20/94	4/21/94	4/20/94	4/23/94	4/21/94	4/21/94
	UNITS								
Aluminum	UG/L	33.4 J	ND	ND	ND	ND	ND	112	ND
Antimony	UG/L	ND	ND	ND	ND	ND	34.5 J	ND	ND
Arsenic	UG/L	ND	4.6	3.1	ND	ND	ND	ND	4.0
Barium	UG/L	21.5	23.8	423	ND	24.8	43.0	39.5	412
Calcium	UG/L	67700	90400	48700	8810	73200	12200	6400	105000
Chromium	UG/L	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	UG/L	ND	ND	ND	ND	ND	ND	4.5	ND
Copper	UG/L	ND	ND	ND	ND	ND	ND	ND	ND
Iron	UG/L	5760	ND	ND	2160	ND	30200 J	112	15100
Lead	UG/L	ND	ND	ND	ND	ND	ND	1.8	ND
Magnesium	UG/L	16100	13900	23800	1160	2920	4430	3370	41200
Manganese	UG/L	91.7	31.0	136	20.2	53.2	39.3	115	264
Nickel	UG/L	ND	7.1	9.5	ND	ND	ND	7.1	ND
Potassium	UG/L	12100 J	17300	41700	ND	1070	1730 J	1760	61700
Silver	UG/L	ND	ND	ND	7.8	ND	ND	ND	ND
Sodium	UG/L	14500	778000	71800	8090	12900	16900	7280	233000
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	UG/L	10.3	ND	ND	ND	ND	ND	44.6	ND

UG/L - micrograms per liter
J - estimated
ND - not detected

TAB. 4-9
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 1
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
DISSOLVED METALS

	Sample ID:	28-GW07DWD-01	28-GW08D-01	28-GW09DWD-01	28-MW13D-01	28-TGWPAD01
	Date Sampled:	5/8/94	4/21/94	4/25/94	4/21/94	4/20/94
	UNITS					
Aluminum	UG/L	50.8	49.1	35.2 J	205	706
Antimony	UG/L	ND	ND	ND	ND	70.2
Arsenic	UG/L	ND	ND	ND	4.4	7.8
Barium	UG/L	ND	180	26.5	72.1	50.0
Calcium	UG/L	7620	57300	34100	187000	83200
Chromium	UG/L	ND	ND	ND	7.5 J	ND
Cobalt	UG/L	ND	ND	ND	ND	ND
Copper	UG/L	ND	ND	11.3	ND	ND
Iron	UG/L	ND	57.8	ND	14100	ND
Lead	UG/L	ND	ND	ND	ND	ND
Magnesium	UG/L	455	34100	1240	9690	ND
Manganese	UG/L	7.1	603	1.7 J	385	ND
Nickel	UG/L	ND	ND	ND	ND	ND
Potassium	UG/L	2140	59600	2860 J	4540	42900
Silver	UG/L	ND	ND	ND	ND	ND
Sodium	UG/L	11300	194000	26600	17600	151000
Vanadium	UG/L	4.2	ND	ND	ND	ND
Zinc	UG/L	ND	ND	7.3	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected

TAB. 4-10
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 2
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		Sample ID:	28-GW01-02		28-GW02-02		28-GW03-02		28-GW04-02		28-GW05-02		28-GW06-02		28-GW07-02		28-GW08-02	
		Date Sampled:	11/14/94		11/15/94		11/16/94		11/15/94		11/15/94		11/15/94		11/17/94		11/16/94	
	UNITS																	
Aluminum	UG/L		ND		ND		ND		ND		898		ND		ND		1670	
Arsenic	UG/L		ND		ND		ND		ND		ND		ND		3.7		4	
Barium	UG/L		173		647		6.3		13.6		40.7		62.6		346		759	
Calcium	UG/L		114000		54000		8210		84200		5550		2890		183000		56400	
Copper	UG/L		ND		ND		ND		ND		ND		ND		14.5		44	
Iron	UG/L		1770	J	4020	J	1640	J	147	J	28700	J	186	J	40600		17000	J
Lead	UG/L		ND		ND		ND		ND		ND		ND		8.2		126	
Magnesium	UG/L		15300		26900		1190		2620		3690		3000		25700		35400	
Manganese	UG/L		225		185		17		55.6		27.5		16.9		694		1450	
Mercury	UG/L		0.14	J	ND		0.33	J	0.58	J	0.4	J	ND		0.14		0.45	J
Nickel	UG/L		ND		ND		ND		ND		ND		ND		13.5		ND	
Potassium	UG/L		15600		59300		866		1310		1560		1190		20700		84700	
Sodium	UG/L		20100		88000		7870		13500		12700		5670		76000		284000	
Vanadium	UG/L		ND		ND		ND		ND		ND		ND		ND		ND	
Zinc	UG/L		ND		ND		ND		ND		ND		ND		ND		331	

UG/L - micrograms per liter
J - estimated
ND - not detected

TAB[illegible]-10
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 2
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		Sample ID:	28-MW13-02	28-GW01DW-02	28-GW07DW-02	28-GW09DW-02
		Date Sampled:	11/15/94	11/14/94	11/17/94	11/15/94
	UNITS					
Aluminum	UG/L		420	ND	ND	ND
Arsenic	UG/L		4.7	ND	ND	ND
Barium	UG/L		81.7	17.3	14	17.2
Calcium	UG/L		180000	96200	47000	44600
Copper	UG/L		ND	ND	ND	ND
Iron	UG/L		25400 J	224 J	ND	287 J
Lead	UG/L		ND	ND	ND	ND
Magnesium	UG/L		8760	16100	ND	1680
Manganese	UG/L		347	65.8	ND	23.5
Mercury	UG/L		ND	0.31 J	ND	ND
Nickel	UG/L		ND	ND	ND	ND
Potassium	UG/L		5690	23000	963	963
Sodium	UG/L		19200	803000	10800	10800
Vanadium	UG/L		ND	ND	6.9	ND
Zinc	UG/L		ND	ND	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected

TAB. 4-11
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 2
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
DISSOLVED METALS

Sample ID:		28-GW01D-02	28-GW02D-02	28-GW03D-02	28-GW04D-02	28-GW05D-02	28-GW06D-02	28-GW07D-02
Date Sampled:		11/14/94	11/15/94	11/16/94	11/15/94	11/15/94	11/15/94	11/17/94
	UNITS							
Aluminum	UG/L	ND	41.3	19.6	ND	ND	105	ND
Arsenic	UG/L	ND	2.4	ND	2	2.3	ND	5.6
Barium	UG/L	147	532	6.4	13.1	34.6	70.3	281
Calcium	UG/L	106000	48000	9220	83600	5110	3820	170000
Copper	UG/L	5.5	5.4	6.3	8.7	5.3	10.4	5.8
Iron	UG/L	314	684	1520	95.8	24600	140	32600
Lead	UG/L	ND	ND	ND	ND	ND	ND	ND
Magnesium	UG/L	14200	23800	1360	2620	3300	3810	21900
Manganese	UG/L	215	160	19.7	51.4	25.2	22.4	641
Potassium	UG/L	14000	52700	981	1350	1370	1580	16700
Sodium	UG/L	18500	78500	9110	13300	11400	7180	63900
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	ND

UG/L - micrograms per liter
J - estimated

TABL -11
SHALLOW AND DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ROUND 2
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
DISSOLVED METALS

Sample ID:		28-GW08D-02	28-MW13D-02	28-GW01DWD-02	28-GW07DWD-02	28-GW09DWD-02
Date Sampled:		11/16/94	11/15/94	11/14/94	11/17/94	11/15/94
	UNITS					
Aluminum	UG/L	ND	26.8	ND	ND	ND
Arsenic	UG/L	2.8	4	2.5	2.2	ND
Barium	UG/L	606	70.6	17.2	10.2	17
Calcium	UG/L	52200	195000	93000	36800	41700
Copper	UG/L	17.1	6.4	5.4	13.3	8.8
Iron	UG/L	561	12100	78.8	ND	10
Lead	UG/L	ND	ND	ND	ND	6.9
Magnesium	UG/L	34400	9530	15700	ND	1680
Manganese	UG/L	1160	374	63.3	ND	20.7
Potassium	UG/L	89100	6430	22000	2260	969
Sodium	UG/L	331000	21400	785000	9030	10800
Vanadium	UG/L	ND	ND	ND	6	ND

UG/L - micrograms per liter
J - estimated

TABLE 14-12

COMPARISON OF GROUNDWATER ANALYTICAL RESULTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Detected Contaminants	Round 1 Results				Round 2 Results			
	Min.	Max.	Freq.	Max. Location	Min.	Max.	Freq.	Max. Location
Pesticides								
4,4'-DDE	0.06 J	6.6 J	5/13	28-TGWPA	ND	ND	0/5	NA
4,4'-DDD	0.06 J	9	6/13	28-GW07	ND	ND	0/5	NA
4,4'-DDT	0.05 J	0.37 J	2/13	28-TGWPA	ND	ND	0/5	NA
gamma-Chlordane	0.05 J	0.05 J	1/13	28-GW08	ND	ND	0/5	NA
Total Metals								
Aluminum	225	100,000 J	12/13	28-GW05	420	1,670	3/12	28-GW08
Antimony	42.7	5,340	4/13	28-GW07	ND	ND	0/12	NA
Arsenic	5.2	76.7	11/13	28-GW07	3.7	4.7	3/12	28-MW13
Barium	13.7	1,980	12/13	28-GW07	6.3	759	12/12	28-GW08
Beryllium	1.1	9.6	5/13	28-GW04	ND	ND	0/12	NA
Cadmium	3.2	35.4	10/13	28-GW07	ND	ND	0/12	NA
Calcium	16,100	245,000	12/13	28-MW13	2,890	183,000	12/12	28-GW07
Chromium	33.2 J	308 J	10/13	28-GW07	ND	ND	0/12	NA
Cobalt	4.1	30.4	6/13	28-GW07	ND	ND	0/12	NA
Copper	12.2	2,250	7/13	28-GW07	14.5	44	2/12	28-GW08
Iron	417	245,000	11/13	28-GW07	147 J	40,600	11/12	28-GW07
Lead	1.5	4,810	12/13	28-GW07	8.2	126	2/12	28-GW08
Magnesium	498	52,900	12/13	28-GW07	1,190	35,400	11/12	28-GW08
Manganese	29.6	3,330	11/13	28-GW07	16.9	1,450	11/12	28-GW08
Mercury	0.16 J	2 J	9/13	28-GW07	0.14 J	0.58 J	7/12	28-GW04
Nickel	10.4	165	9/13	28-GW07	13.5	13.5	1/12	28-GW07
Potassium	2,100	63,500	12/13	28-GW07	866	84,700	12/12	28-GW08
Selenium	5.6 J	5.6 J	1/13	28-GW07	ND	ND	0/12	NA
Silver	5.4 J	37.9 J	4/13	28-GW07	ND	ND	0/12	NA
Sodium	6,770	744,000	12/13	28-GW01DW	5,670	803,000	12/12	28-GW01DW
Thallium	6.9 J	6.9 J	1/13	28-GW01DW	ND	ND	0/12	NA
Vanadium	13.4	190 J	10/13	28-GW01	6.9	6.9	1/12	28-GW07DW
Zinc	23.1	9,220	10/13	28-GW07	331	331	1/12	28-GW08

TABLE 14-12 (Continued)

COMPARISON OF GROUNDWATER ANALYTICAL RESULTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Detected Contaminants	Round 1 Results				Round 2 Results			
	Min.	Max.	Freq.	Max. Location	Min.	Max.	Freq.	Max. Location
Dissolved Metals								
Aluminum	33.4 J	706	7/13	28-TGWPA	19.6	105	4/12	28-GW06
Antimony	35.5 J	70.2	2/13	28-TGWPA	ND	ND	0/12	NA
Arsenic	3.1	7.8	5/13	28-TGWPA	2	5.6	8/12	28-GW07
Barium	21.5	423	11/13	28-GW02	6.4	606	12/12	28-GW08
Calcium	6,400	187,000	13/13	28-MW13	3,820	195,000	12/12	28-MW13
Chromium	7.5 J	7.5 J	1/13	28-MW13	ND	ND	0/12	NA
Cobalt	4.5	4.5	1/13	28-GW06	ND	ND	0/12	NA
Copper	11.3	11.3	1/13	28-GW09DW	5.3	17.1	12/12	28-GW08
Iron	57.8	30,200 J	7/13	28-GW05	10	32,600	11/12	28-GW07
Lead	1.8	1.8	1/13	28-GW06	6.9	6.9	1/12	28-GW09DW
Magnesium	455	41,200	12/13	28-GW07	1,360	34,400	11/12	28-GW08
Manganese	1.7 J	603	12/13	28-GW08	20	1,160	11/12	28-GW08
Nickel	7.1	9.5	3/13	28-GW02	ND	ND	0/12	NA
Potassium	1,070	61,700	12/13	28-GW07	969	89,100	12/12	28-GW08
Silver	7.8	7.8	1/13	28-GW03	ND	ND	0/12	NA
Sodium	7,280	778,000	13/13	28-GW01DW	7,180	785,000	12/12	28-GW01DW
Vanadium	4.2	4.2	1/13	28-GW07DW	6.0	6.0	1/12	28-GW07
Zinc	7.3	44.6	3/13	28-GW06	ND	ND	0/12	NA

Notes: Groundwater concentrations are presented in µg/L (ppb)

J - Estimated

NA - Not applicable

ND - Not detected

TAL)4-13
SURFACE WATER - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Sample ID:	28-OP-SW01	28-OP-SW02
	Date Sampled:	3/28/94	3/28/94
	UNITS		
VOLATILES			
Methylene chloride	UG/L	10	7 J

UG/L - micrograms per liter
J - estimated

TABLE 4-14
SURFACE WATER - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-OP-SW01		28-OP-SW02	
	Date Sampled:	3/28/94		3/28/94	
	UNITS				
Aluminum	UG/L	170		97.5	
Calcium	UG/L	7610		8460	
Iron	UG/L	421	J	431	J
Magnesium	UG/L	693		752	
Nickel	UG/L	ND		12.8	
Potassium	UG/L	1100	J	1180	J
Sodium	UG/L	3070	J	3470	J
Thallium	UG/L	ND		4.7	

UG/L - micrograms per liter
J - estimated
ND - not detected

TABL -15
SURFACE WATER - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Sample ID:	28-CC-SW01	28-CC-SW02	28-CC-SW07
	Date Sampled:	3/28/94	3/27/94	3/27/94
	UNITS			
VOLATILES				
Methylene chloride	UG/L	4 J	ND	ND
Acetone	UG/L	ND	ND	12
2-Hexanone	UG/L	ND	16	ND

UG/L - micrograms per liter
J - estimated
ND - not detected

TABL. -16
SURFACE WATER - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		28-CC-SW01	28-CC-SW02	28-CC-SW03	28-CC-SW04	28-CC-SW05	28-CC-SW06	28-CC-SW07
Sample ID:		28-CC-SW01	28-CC-SW02	28-CC-SW03	28-CC-SW04	28-CC-SW05	28-CC-SW06	28-CC-SW07
Date Sampled:		3/28/94	3/27/94	3/27/94	3/27/94	3/27/94	3/27/94	3/27/94
	UNITS							
Aluminum	UG/L	936	672	773	866	767	347	699
Arsenic	UG/L	ND	ND	3.9	ND	ND	ND	ND
Barium	UG/L	21.0	18.4	15.9	17.8	13.2	17.1	12.8
Calcium	UG/L	40400	35400	32900	34900	29500	45900	35200
Copper	UG/L	ND	ND	ND	ND	ND	6.2	ND
Iron	UG/L	1390 J	1090 J	985 J	1140 J	950 J	838 J	948 J
Lead	UG/L	1.9	3.0	3.5	2.9	2.4	4.2	2.7
Magnesium	UG/L	4550	22500	14900	3690	3030	7310	5500
Manganese	UG/L	56.1	45.3	23.8	39.7	24.0	23.6	20.2
Nickel	UG/L	7.2	ND	ND	ND	ND	ND	ND
Potassium	UG/L	2250 J	7720 J	5440 J	1870 J	1660 J	2550 J	1770 J
Sodium	UG/L	26100 J	183000 J	120000 J	20900 J	15200 J	42900 J	29900 J
Vanadium	UG/L	3.6	ND	ND	ND	ND	ND	ND
Zinc	UG/L	ND	13.0	10.9	10.0	10.8	10.0	8.0

UG/L - micrograms per liter
J - estimated
ND - not detected

TABLE 4-17
SURFACE WATER - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-NR-SW02	28-NR-SW03	28-NR-SW04	28-NR-SW05
Date Sampled:		3/28/94	3/28/94	3/29/94	3/29/94
	UNITS				
VOLATILES					
Acetone	UG/L	ND	ND	ND	14 J
SEMIVOLATILES					
Phenanthrene	UG/L	1 J	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/L	2 J	ND	1 J	600
PESTICIDES/PCBs					
4,4'-DDE	UG/L	ND	0.04 J	ND	ND
4,4'-DDD	UG/L	ND	0.05 J	ND	ND

UG/L - micrograms per liter
J - estimated
ND - not detected

TABL. -18
SURFACE WATER - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample ID:		28-NR-SW01		28-NR-SW02		28-NR-SW03		28-NR-SW04		28-NR-SW05	
Date Sampled:		3/28/94		3/28/94		3/28/94		3/29/94		3/29/94	
	UNITS										
Aluminum	UG/L	1660		1660		1090		817		1270	
Arsenic	UG/L	ND		4.3	J	4.3		ND		4.2	
Barium	UG/L	20.5		17.4		16.8		17.3		17.7	
Cadmium	UG/L	ND		4.2		3.8		ND		ND	
Calcium	UG/L	130000		119000		115000		36700		47600	
Copper	UG/L	18.1		7.2		6.6		ND		ND	
Iron	UG/L	2010	J	1530	J	1440	J	1190		1590	
Lead	UG/L	23.4		ND		3.1		ND		1.7	
Magnesium	UG/L	396000		362000		337000		4910	J	55300	J
Manganese	UG/L	24.3	J	20.7	J	29.1		49.8		43.4	
Nickel	UG/L	ND		ND		ND		ND		8.2	
Potassium	UG/L	131000	J	119000	J	109000	J	2310	J	17700	J
Sodium	UG/L	3430000	J	3040000	J	3040000	J	31100	J	443000	J
Thallium	UG/L	ND		ND		ND		5.6	J	ND	
Vanadium	UG/L	4.9		6.1		3.6		ND		ND	
Zinc	UG/L	27.4		10.4		363		ND		ND	

UG/L - micrograms per liter
J - estimated
ND - not detected

TABL_ .4-19
SEDIMENT - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Sample ID:	28-OP-SD01-06	28-OP-SD01-612	28-OP-SD02-06	28-OP-SD02-612
	Sample Depth:	0-6"	6-12"	0-6"	6-12"
	Date Sampled:	3/28/94	3/28/94	3/28/94	3/28/94
VOLATILES	**UNITS**				
Acetone	UG/KG	79 J	46 J	37 J	130 J
2-Butanone	UG/KG	19 J	ND	14 J	35 J
Toluene	UG/KG	ND	ND	2 J	4 J
SEMIVOLATILES					
bis(2-Ethylhexyl)phthalate	UG/KG	120 J	NA	120 J	430
PESTICIDES/PCBs					
alpha-BHC	UG/KG	ND	NA	2.5 R	ND
beta-BHC	UG/KG	ND	NA	2.5 R	ND
delta-BHC	UG/KG	ND	NA	2.5 R	ND
Lindane (gamma-BHC)	UG/KG	ND	NA	2.5 R	ND
Heptachlor	UG/KG	ND	NA	2.5 R	ND
Aldrin	UG/KG	ND	NA	2.5 R	ND
Heptachlor epoxide	UG/KG	ND	NA	2.5 R	ND
Endosulfan I	UG/KG	ND	NA	2.5 R	ND
Dieldrin	UG/KG	ND	NA	4.8 R	ND
4,4'-DDE	UG/KG	ND	NA	4.8 R	ND
Endrin	UG/KG	4.7 R	NA	4.8 R	ND
Endosulfan II	UG/KG	ND	NA	4.8 R	ND
4,4'-DDD	UG/KG	8.3 J	NA	4.8 R	ND
Endosulfan sulfate	UG/KG	ND	NA	4.8 R	ND
4,4'-DDT	UG/KG	ND	NA	4.8 R	ND
Methoxychlor	UG/KG	ND	NA	25 R	ND
Endrin ketone	UG/KG	ND	NA	4.8 R	ND
Endrin aldehyde	UG/KG	ND	NA	4.8 R	ND
alpha-Chlordane	UG/KG	ND	NA	2.5 R	ND
gamma-Chlordane	UG/KG	ND	NA	2.5 R	ND

UG/KG - micrograms per kilogram
J - estimated
NA - not analyzed
ND - not detected
R - rejected

TABL.)-19
SEDIMENT - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

		Sample ID:	28-OP-SD01-06	28-OP-SD01-612	28-OP-SD02-06	28-OP-SD02-612
		Sample Depth:	0-6"	6-12"	0-6"	6-12"
		Date Sampled:	3/28/94	3/28/94	3/28/94	3/28/94
	VOLATILES	**UNITS**				
Toxaphene		UG/KG	ND	NA	250 R	ND
Aroclor 1016		UG/KG	ND	NA	48 R	ND
Aroclor 1221		UG/KG	ND	NA	97 R	ND
Aroclor 1232		UG/KG	ND	NA	48 R	ND
Aroclor 1242		UG/KG	ND	NA	48 R	ND
Aroclor 1248		UG/KG	ND	NA	48 R	ND
Aroclor 1254		UG/KG	ND	NA	48 R	ND
Aroclor 1260		UG/KG	ND	NA	48 R	ND

UG/KG - micrograms per kilogram
J - estimated
NA - not analyzed
ND - not detected
R - rejected

TABL_ _-20
SEDIMENT - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-OP-SD01-06		28-OP-SD01-612		28-OP-SD02-612	
	Sample Depth:	0-6"		6-12"		6-12"	
	Date Sampled:	3/28/94		3/28/94		3/28/94	
Percent Solids		70.0		68.0		81.0	
	UNITS						
Aluminum	MG/KG	4340	J	4880	J	2060	J
Antimony	MG/KG	9.3	R	8.9	R	8.3	R
Arsenic	MG/KG	2.3		6.4		ND	
Barium	MG/KG	13.5		15.8		6.6	
Beryllium	MG/KG	ND		0.32		ND	
Calcium	MG/KG	1540	J	1790	J	271	J
Chromium	MG/KG	10.9		11.8		3.6	
Cobalt	MG/KG	ND		1.7		ND	
Copper	MG/KG	1.7		ND		1.7	
Iron	MG/KG	4050	J	4550	J	1240	J
Lead	MG/KG	8.3		7.9		3.8	
Magnesium	MG/KG	298		412		52.8	
Manganese	MG/KG	6.9		9.8		1.8	J
Nickel	MG/KG	2.1		2.2		ND	
Potassium	MG/KG	253	J	202	J	59.8	J
Vanadium	MG/KG	11.3		11.5		4.0	
Zinc	MG/KG	4.2		4.4		1.3	

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-21
SEDIMENT - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-CC-SD01-06	28-CC-SD01-612	28-CC-SD02-06	28-CC-SD02-612	28-CC-SD03-06	28-CC-SD03-612	28-CC-SD04-06	28-CC-SD04-612
Sample Depth:		0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
Date Sampled:		3/26/94	3/26/94	3/27/94	3/27/94	3/28/94	3/28/94	3/28/94	3/28/94
	UNITS								
VOLATILES									
Acetone	UG/KG	ND	ND	ND	ND	7 J	ND	46 J	58 J
Carbon Disulfide	UG/KG	ND	9 J	ND	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	9 J	ND	ND	16 J	14 J
SEMIVOLATILES									
Phenanthrene	UG/KG	ND	ND	ND	ND	260 J	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	61 J	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	81 J	ND	340 J	77 J	ND	ND
Pyrene	UG/KG	140 J	140 J	73 J	ND	250 J	63 J	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	410 J	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	ND	410 J	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	56 J	ND	140 J	ND	ND	ND
Chrysene	UG/KG	ND	ND	58 J	ND	160 J	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	140 J	250 J	300 J	210 J	110 J	200 J
Benzo[b]fluoranthene	UG/KG	ND	ND	63 J	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	42 J	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	47 J	ND	140 J	ND	440	500
PESTICIDES/PCBs									
4,4'-DDE	UG/KG	160 J	200 J	ND	9.5 J	6.4 J	ND	ND	ND
4,4'-DDD	UG/KG	370	450 J	ND	ND	13 J	4.3 J	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	2.6 J
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected

TABLE 14-21
SEDIMENT - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-CC-SD05-06	28-CC-SD05-612	28-CC-SD06-06	28-CC-SD06-612	28-CC-SD07-06	28-CC-SD07-612
Sample Depth:		0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
Date Sampled:		3/27/94	3/27/94	3/27/94	3/27/94	3/27/94	3/27/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	13 J	ND
2-Butanone	UG/KG	ND	ND	ND	ND	38 J	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	220 J	480 J	100 J	1700 J	740 J	240 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	240 J	1700 J	73 J	510 J	ND	700 J
PESTICIDES/PCBs							
4,4'-DDE	UG/KG	28 J	ND	23 J	20 J	12 J	9 J
4,4'-DDD	UG/KG	ND	ND	ND	38 J	37 J	16 J
4,4'-DDT	UG/KG	ND	ND	ND	ND	50 J	ND
alpha-Chlordane	UG/KG	ND	ND	5.9 NJ	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	6.1 J	ND	8.4 J	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected

TABLE 14-22
SEDIMENT - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-CC-SD01-06	28-CC-SD01-612	28-CC-SD02-06	28-CC-SD02-612	28-CC-SD03-06	28-CC-SD03-612	28-CC-SD04-06
	Sample Depth:	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"
	Date Sampled:	3/26/94	3/26/94	3/27/94	3/27/94	3/28/94	3/28/94	3/28/94
Percent Solids		33.0	28.0	80.0	75.0	78.0	77.0	76.0
	UNITS							
Aluminum	MG/KG	29900	3920	678	2330	4020 J	403 J	864 J
Antimony	MG/KG	ND	ND	ND	ND	8.1 R	8.8 R	9.0 R
Arsenic	MG/KG	11.9	ND	0.67	1.8	1.5	ND	ND
Barium	MG/KG	37.3	12.0	2.7	3.8	8.7	2.1	47.8
Beryllium	MG/KG	0.57	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	2.2	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	4990	8480	9390	173	1980 J	341 J	496 J
Chromium	MG/KG	47.2	ND	2.7	6.0	9.6	2.5	4.0
Cobalt	MG/KG	3.2	ND	ND	ND	ND	ND	ND
Copper	MG/KG	47.2	ND	2.2	2.7	43.7	4.1	5.3
Iron	MG/KG	27100	3700	1480	3100	6220 J	1680 J	1980 J
Lead	MG/KG	130	12.7	7.8	6.8	69.7	30.7	15.3
Magnesium	MG/KG	4560	7480	223	259 J	482	79.6	412
Manganese	MG/KG	91.7	ND	10.9 J	2.4 J	63.0	5.7 J	17.7
Mercury	MG/KG	0.41	ND	ND	ND	0.29	ND	ND
Nickel	MG/KG	8.5	ND	ND	ND	3.1	2.2	ND
Potassium	MG/KG	2650 J	1020 J	70.1 J	199 J	337 J	ND	129 J
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	5530	16800	232	194	529	226	104
Thallium	MG/KG	4.1	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	56.0	8.9	2.9	6.5	8.7	1.9	3.1
Zinc	MG/KG	222	25.0	19.1 J	9.3 J	105	26.6	22.0

MG/KG - milligrams per kilogram
J - estimated
ND - not detected

TABLE 14-22
SEDIMENT - POSITIVE DETECTION SUMMARY
CODGELS CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-CC-SD04-612		28-CC-SD05-06		28-CC-SD05-612		28-CC-SD06-06		28-CC-SD06-612		28-CC-SD07-06		28-CC-SD07-612	
	Sample Depth:	6-12"		0-6"		6-12"		0-6"		6-12"		0-6"		6-12"	
	Date Sampled:	3/28/94		3/27/94		3/27/94		3/27/94		3/27/94		3/27/94		3/27/94	
Percent Solids		77.0		20.0		12.0		57.0		15.0		26.0		14.0	
	UNITS														
Aluminum	MG/KG	3060	J	13700		6360		4320		4760		12700		12000	
Antimony	MG/KG	7.9	R	ND		ND		ND		ND		ND		ND	
Arsenic	MG/KG	2.1		6.4		ND		1.0		1.2		2.8		5.8	
Barium	MG/KG	59.4		29.7		22.6		10.4		11.5		26.9		48.3	
Beryllium	MG/KG	ND		ND		ND		ND		ND		ND		ND	
Cadmium	MG/KG	ND		ND		ND		ND		ND		1.5		ND	
Calcium	MG/KG	5470	J	8420		13000		2650		2050		3830		13700	
Chromium	MG/KG	16.5		17.7		13.3		16.7		20.9		18.4		14.5	
Cobalt	MG/KG	0.93		ND		ND		ND		ND		2.3		ND	
Copper	MG/KG	63.7		20.5		15.2		6.5		6.8		14.5		17.6	
Iron	MG/KG	36000	J	13300		11300		2510		2600		6780		16900	
Lead	MG/KG	202		91.9		30.4		33.4		43.4		80.3		55.4	
Magnesium	MG/KG	1210		3050		4640		717		247		1650		4670	
Manganese	MG/KG	226		50.3	J	31.9	J	9.0	J	3.7	J	16.3	J	31.3	J
Mercury	MG/KG	0.25		0.29		ND		0.12		0.15		ND		ND	
Nickel	MG/KG	6.3		ND		ND		1.9		ND		ND		ND	
Potassium	MG/KG	161	J	685	J	476	J	171	J	167	J	693	J	531	J
Silver	MG/KG	2.0	J	ND		ND		ND		ND		ND		ND	
Sodium	MG/KG	133		2710		4590		359		154		744		2480	
Thallium	MG/KG	ND		ND		ND		ND		ND		ND		ND	
Vanadium	MG/KG	11.3		31.2		13.4		9.8		10.0		28.6		28.5	
Zinc	MG/KG	303		94.7	J	36.6	J	36.1	J	39.0	J	70.2	J	100	J

MG/KG - milligrams per kilogram
J - estimated
ND - not detected

TABL[illegible]-23
SEDIMENT - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28-NR-SD01-06	28NR-SD02-06	28-NR-SD02-612	28NR-SD03-06	28-NR-SD03-612	28NR-SD04-06	28-NR-SD04-612
Sample Depth:		0-6"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
Date Sampled:		3/28/94	3/26/94	3/26/94	3/25/94	3/25/94	3/25/94	3/25/94
	UNITS							
VOLATILES								
Methylene chloride	UG/KG	ND	ND	2 J	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	26 J	11 J	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	ND	ND	2 J
2-Butanone	UG/KG	ND	ND	ND	7 J	ND	ND	ND
SEMIVOLATILES								
Acenaphthene	UG/KG	150 J	ND	ND	ND	ND	ND	ND
Dibenzofuran	UG/KG	60 J	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	120 J	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	1200	47 J	ND	450	150 J	ND	ND
Anthracene	UG/KG	320 J	ND	ND	97 J	ND	ND	120 J
Carbazole	UG/KG	160 J	ND	ND	57 J	ND	ND	ND
Fluoranthene	UG/KG	1600	80 J	ND	910	300 J	ND	510
Pyrene	UG/KG	1700	75 J	ND	670	210 J	ND	420 J
Benzo[a]anthracene	UG/KG	890	ND	ND	440 J	150 J	ND	1100
Chrysene	UG/KG	790	ND	ND	400 J	160 J	ND	1500
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	2400	580
Benzo[b]fluoranthene	UG/KG	1100	55 J	ND	450	150 J	ND	920
Benzo[k]fluoranthene	UG/KG	470	ND	ND	290 J	120 J	ND	300 J
Benzo[a]pyrene	UG/KG	710	ND	ND	400 J	130 J	ND	480 J
Indeno[1,2,3-cd]pyrene	UG/KG	320 J	ND	ND	210 J	68 J	ND	160 J
Dibenz[a,h]anthracene	UG/KG	ND	ND	ND	47 J	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	320 J	ND	ND	220 J	65 J	ND	130 J
PESTICIDES/PCBs								
4,4'-DDE	UG/KG	8.5	ND	ND	8.4	ND	ND	ND
4,4'-DDD	UG/KG	15	ND	ND	14 J	ND	ND	8.6
4,4'-DDT	UG/KG	50	ND	ND	33	300	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	4.8	ND	ND	6.6 J
gamma-Chlordane	UG/KG	ND	ND	ND	3.1 J	ND	ND	4.6 J

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TAB... 4-23
SEDIMENT - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	UNITS		
Sample ID:		28NR-SD05-06	28-NR-SD05-612
Sample Depth:		0-6"	6-12"
Date Sampled:		3/25/94	3/25/94
VOLATILES			
Methylene chloride	UG/KG	ND	ND
Acetone	UG/KG	ND	47 J
Carbon Disulfide	UG/KG	ND	ND
2-Butanone	UG/KG	ND	ND
SEMIVOLATILES			
Acenaphthene	UG/KG	ND	ND
Dibenzofuran	UG/KG	ND	ND
Fluorene	UG/KG	ND	ND
Phenanthrene	UG/KG	ND	ND
Anthracene	UG/KG	170 J	ND
Carbazole	UG/KG	68 J	ND
Fluoranthene	UG/KG	760	ND
Pyrene	UG/KG	620 J	ND
Benzo[a]anthracene	UG/KG	1500	ND
Chrysene	UG/KG	2100	ND
bis(2-Ethylhexyl)phthalate	UG/KG	980	ND
Benzo[b]fluoranthene	UG/KG	1000	ND
Benzo[k]fluoranthene	UG/KG	840	ND
Benzo[a]pyrene	UG/KG	660	ND
Indeno[1,2,3-cd]pyrene	UG/KG	200 J	ND
Dibenz[a,h]anthracene	UG/KG	ND	ND
Benzo[g,h,i]perylene	UG/KG	170 J	ND
PESTICIDES/PCBs			
4,4'-DDE	UG/KG	ND	ND
4,4'-DDD	UG/KG	ND	ND
4,4'-DDT	UG/KG	ND	ND
alpha-Chlordane	UG/KG	ND	ND
gamma-Chlordane	UG/KG	ND	ND

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 14-24
SEDIMENT - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28-NR-SD01-06		28-NR-SD01-612		28-NR-SD02-06		28-NR-SD02-612		28-NR-SD03-06		28-NR-SD03-612		28-NR-SD04-06	
	Sample Depth:	0-6"		6-12"		0-6"		6-12"		0-6"		6-12"		0-6"	
	Date Sampled:	3/28/94		3/28/94		3/26/94		3/26/94		3/25/94		3/25/94		3/25/94	
Percent Solids		80.0		87.0		77.0		73.0		74.0		75.0		73.0	
	UNITS														
Aluminum	MG/KG	919		1100		6890		5420		514		1090		2300	
Antimony	MG/KG	263	J	ND		ND		6.7	R	6.4	R	6.2	R	8.7	J
Arsenic	MG/KG	12.5		ND		0.59	J	1.8		1.6		2.2		5.0	
Barium	MG/KG	2.2		2.5		7.0		8.7		3.4		4.8		4.5	
Calcium	MG/KG	4090		329		967		825	J	11300	J	16700	J	96800	J
Chromium	MG/KG	ND		2.1		8.3		9.8		4.1		6.1		10.0	
Cobalt	MG/KG	ND		ND		ND		ND		ND		ND		0.92	
Copper	MG/KG	1340		78.3		1.7		1.6		7.6		10.1		2.4	
Iron	MG/KG	1620		1660		1560		1900		6110		4420		12200	
Lead	MG/KG	38800		170		7.2		6.0	J	20.6	J	26.6	J	5.8	J
Magnesium	MG/KG	277		252		408		296	J	304	J	406	J	1920	J
Manganese	MG/KG	2.8	J	6.9	J	4.9	J	1.9	J	4.0	J	17.8	J	18.8	J
Mercury	MG/KG	ND		0.05		ND		ND		ND		ND		ND	
Nickel	MG/KG	ND		3.2		ND		1.4		ND		ND		ND	
Potassium	MG/KG	71.0	J	97.2	J	373	J	345	J	75.5	J	126	J	336	J
Silver	MG/KG	ND		ND		ND		ND		3.4	J	ND		ND	
Sodium	MG/KG	820		593		150		ND		461		554		1290	
Vanadium	MG/KG	2.8		3.6		10.2		20.9		5.3		6.0		21.9	
Zinc	MG/KG	117	J	24.1	J	5.3		3.7		23.9		40.5		10.2	

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 14-24
SEDIMENT - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

		Sample ID:	28-NR-SD04-612		28-NR-SD05-06		28-NR-SD05-612	
		Sample Depth:	6-12"		0-6"		6-12"	
		Date Sampled:	3/25/94		3/25/94		3/25/94	
Percent Solids			66.0		53.0		51.0	
	UNITS							
Aluminum	MG/KG		1090		11700		9590	
Antimony	MG/KG		7.5	R	11.0	R	12.0	R
Arsenic	MG/KG		2.8		2.5		1.7	
Barium	MG/KG		3.3		11.9		28.9	
Calcium	MG/KG		42600	J	748	J	941	J
Chromium	MG/KG		4.3		34.1		25.1	
Cobalt	MG/KG		ND		ND		ND	
Copper	MG/KG		1.5		8.8		8.5	
Iron	MG/KG		6370		30600		7730	
Lead	MG/KG		3.5	J	11.1	J	17.3	J
Magnesium	MG/KG		788	J	2390	J	1190	J
Manganese	MG/KG		8.0	J	3.6	J	7.4	J
Mercury	MG/KG		ND		ND		ND	
Nickel	MG/KG		ND		ND		ND	
Potassium	MG/KG		169	J	2210	J	1470	J
Silver	MG/KG		ND		3.1	J	ND	
Sodium	MG/KG		964		3870		3740	
Vanadium	MG/KG		9.7		37.4		22.1	
Zinc	MG/KG		5.4		10.7		8.5	

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-25
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	UNITS	28OPFSLBWB01		28OPFSAEWB01		28OPFSRSWB01	
Sample ID:		28OPFSLBWB01		28OPFSAEWB01		28OPFSRSWB01	
Date Sampled:		4/17/94		4/17/94		4/17/94	
VOLATILES							
Chloromethane	UG/KG	10	R	10	R	10	R
Bromomethane	UG/KG	10	R	10	R	10	R
Vinyl chloride	UG/KG	10	R	10	R	10	R
Chloroethane	UG/KG	10	R	10	R	10	R
Methylene chloride	UG/KG	6	J	4	J	2	J
Acetone	UG/KG	25	J	9	J	37	J
Carbon Disulfide	UG/KG	10	R	10	R	10	R
1,1-Dichloroethene	UG/KG	10	R	10	R	10	R
1,1-Dichloroethane	UG/KG	10	R	10	R	10	R
1,2-Dichloroethene(total)	UG/KG	10	R	10	R	10	R
Chloroform	UG/KG	10	R	10	R	10	R
1,2-Dichloroethane	UG/KG	10	R	10	R	10	R
2-Butanone	UG/KG	10	R	10	R	10	R
1,1,1-Trichloroethane	UG/KG	10	R	10	R	10	R
Carbon tetrachloride	UG/KG	10	R	10	R	10	R
Bromodichloromethane	UG/KG	10	R	10	R	10	R
1,2-Dichloropropane	UG/KG	10	R	10	R	10	R
cis-1,3-Dichloropropene	UG/KG	10	R	10	R	10	R
Trichloroethene	UG/KG	10	R	10	R	10	R
Dibromochloromethane	UG/KG	10	R	10	R	10	R
1,1,2-Trichloroethane	UG/KG	10	R	10	R	10	R
Benzene	UG/KG	10	R	10	R	10	R
trans-1,3-Dichloropropene	UG/KG	10	R	10	R	10	R
Bromoform	UG/KG	10	R	10	R	10	R
4-Methyl-2-pentanone	UG/KG	10	R	10	R	10	R
2-Hexanone	UG/KG	10	R	10	R	10	R

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABL. .-25
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	UNITS	Sample ID: 28OPFSLBWB01, Date Sampled: 4/17/94		Sample ID: 28OPFSAEWB01, Date Sampled: 4/17/94		Sample ID: 28OPFSRSWB01, Date Sampled: 4/17/94	
VOLATILES Cont.							
Tetrachloroethene	UG/KG	10	R	10	R	10	R
1,1,2,2-Tetrachloroethane	UG/KG	10	R	10	R	10	R
Toluene	UG/KG	10	R	7	J	10	R
Chlorobenzene	UG/KG	10	R	10	R	10	R
Ethylbenzene	UG/KG	10	R	10	R	10	R
Styrene	UG/KG	10	R	10	R	10	R
Xylenes (total)	UG/KG	10	R	8	J	10	R
SEMIVOLATILES							
Phenol	UG/KG	490	R	480	R	970	R
bis(2-Chloroethyl) ether	UG/KG	490	R	480	R	970	R
2-Chlorophenol	UG/KG	490	R	480	R	970	R
1,3-Dichlorobenzene	UG/KG	490	R	480	R	970	R
1,4-Dichlorobenzene	UG/KG	490	R	480	R	970	R
1,2-Dichlorobenzene	UG/KG	490	R	480	R	970	R
2-Methylphenol	UG/KG	490	R	480	R	970	R
2,2'-oxybis-(1-chloropropane)	UG/KG	490	R	480	R	970	R
4-Methylphenol	UG/KG	490	R	480	R	970	R
N-Nitroso-di-n-propylamine	UG/KG	490	R	480	R	970	R
Hexachloroethane	UG/KG	490	R	480	R	970	R
Nitrobenzene	UG/KG	490	R	480	R	970	R
Isophorone	UG/KG	490	R	480	R	970	R
2-Nitrophenol	UG/KG	490	R	480	R	970	R
2,4-Dimethylphenol	UG/KG	490	R	480	R	970	R
bis(2-Chloroethoxy) methane	UG/KG	490	R	480	R	970	R
2,4-Dichlorophenol	UG/KG	490	R	480	R	970	R
1,2,4-Trichlorobenzene	UG/KG	490	R	480	R	970	R

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABLE 14-25
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28OPFSLBWB01		28OPFSAEWB01		28OPFSRSWB01	
Date Sampled:		4/17/94		4/17/94		4/17/94	
	UNITS						
SEMIVOLATILES Cont.							
Naphthalene	UG/KG	490	R	480	R	970	R
4-Chloroaniline	UG/KG	490	R	480	R	970	R
Hexachlorobutadiene	UG/KG	490	R	480	R	970	R
4-Chloro-3-methylphenol	UG/KG	490	R	480	R	970	R
2-Methylnaphthalene	UG/KG	490	R	480	R	970	R
Hexachlorocyclopentadiene	UG/KG	490	R	480	R	970	R
2,4,6-Trichlorophenol	UG/KG	490	R	480	R	970	R
2,4,5-Trichlorophenol	UG/KG	1200	R	1200	R	2400	R
2-Chloronaphthalene	UG/KG	490	R	480	R	970	R
2-Nitroaniline	UG/KG	1200	R	1200	R	2400	R
Dimethyl phthalate	UG/KG	490	R	480	R	970	R
Acenaphthylene	UG/KG	490	R	480	R	970	R
2,6-Dinitrotoluene	UG/KG	490	R	480	R	970	R
3-Nitroaniline	UG/KG	1200	R	1200	R	2400	R
Acenaphthene	UG/KG	490	R	480	R	970	R
2,4-Dinitrophenol	UG/KG	1200	R	1200	R	2400	R
4-Nitrophenol	UG/KG	1200	R	1200	R	2400	R
Dibenzofuran	UG/KG	490	R	480	R	970	R
2,4-Dinitrotoluene	UG/KG	490	R	480	R	970	R
Diethylphthalate	UG/KG	490	R	480	R	970	R
4-Chlorophenyl phenyl ether	UG/KG	490	R	480	R	970	R
Fluorene	UG/KG	490	R	480	R	970	R
4-Nitroaniline	UG/KG	1200	R	1200	R	2400	R
4,6-Dinitro-2-methylphenol	UG/KG	1200	R	1200	R	2400	R
N-nitrosodiphenylamine	UG/KG	490	R	480	R	970	R

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABLE 4-25
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	UNITS	Sample ID: 28OPFSLBWB01		28OPFSAEWB01		28OPFSRSWB01	
		Date Sampled: 4/17/94		4/17/94		4/17/94	
SEMIVOLATILES Cont.							
4-Bromophenyl-phenylether	UG/KG	490	R	480	R	970	R
Hexachlorobenzene	UG/KG	490	R	480	R	970	R
Pentachlorophenol	UG/KG	1200	R	1200	R	2400	R
Phenanthrene	UG/KG	490	R	480	R	970	R
Anthracene	UG/KG	490	R	480	R	970	R
Carbazole	UG/KG	490	R	480	R	970	R
di-n-Butylphthalate	UG/KG	490	R	480	R	970	R
Fluoranthene	UG/KG	490	R	480	R	970	R
Pyrene	UG/KG	490	R	480	R	970	R
Butyl benzyl phthalate	UG/KG	490	R	480	R	970	R
3,3'-Dichlorobenzidine	UG/KG	490	R	480	R	970	R
Benzo[a]anthracene	UG/KG	490	R	480	R	970	R
Chrysene	UG/KG	490	R	480	R	970	R
bis(2-Ethylhexyl)phthalate	UG/KG	490	R	2900	J	4000	J
di-n-Octylphthalate	UG/KG	490	R	480	R	970	R
Benzo[b]fluoranthene	UG/KG	490	R	480	R	970	R
Benzo[k]fluoranthene	UG/KG	490	R	480	R	970	R
Benzo[a]pyrene	UG/KG	490	R	480	R	970	R
Indeno[1,2,3-cd]pyrene	UG/KG	490	R	480	R	970	R
Dibenz[a,h]anthracene	UG/KG	490	R	480	R	970	R
Benzo[g,h,i]perylene	UG/KG	490	R	480	R	970	R
PESTICIDES/PCBs							
4,4'-DDE	UG/KG	5.4		38		4.4	J
alpha-Chlordane	UG/KG	ND		13	NJ	ND	

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABLE 14-26
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28OPFSLBWB01	28OPFSAEWB01	28OPFSRSWB01
	Date Sampled:	4/17/94	4/17/94	4/17/94
	UNITS			
Antimony	MG/KG	ND	ND	0.17 J
Arsenic	MG/KG	0.01 R	0.02 R	0.10 J
Barium	MG/KG	0.42 J	0.80 J	1.5 J
Calcium	MG/KG	8410	5600	14000
Chromium	MG/KG	0.58 R	10.7 J	2.3 R
Cobalt	MG/KG	ND	0.09 J	0.04 J
Copper	MG/KG	0.23 J	1.2 J	0.42 J
Iron	MG/KG	ND	63.2	46.6
Magnesium	MG/KG	365	258	389
Manganese	MG/KG	ND	0.83 J	1.4 J
Mercury	MG/KG	0.14 J	0.18 J	ND
Nickel	MG/KG	0.08 R	3.1 R	0.46 R
Potassium	MG/KG	3050	2580	2270
Selenium	MG/KG	0.35 J	0.45 J	0.31 J
Silver	MG/KG	0.02 R	0.03 R	0.02 R
Sodium	MG/KG	707	714	844
Vanadium	MG/KG	ND	ND	0.02 J
Zinc	MG/KG	12.8 J	26.3 J	21.3 J

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-27
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28OPFSLBF01	OP1A-BGA	OP1A-BGB	OP1A-RDA	OP1A-RDB	28OPFSWMF01
Date Sampled:		3/28/94	10/4/93	10/4/93	10/4/93	10/4/93	3/28/94
	UNITS						
VOLATILES							
Chloromethane	UG/KG	10 R	ND	ND	ND	ND	NA
Bromomethane	UG/KG	10 R	ND	ND	ND	ND	NA
Vinyl chloride	UG/KG	10 R	ND	ND	ND	ND	NA
Chloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
Methylene chloride	UG/KG	10 R	ND	ND	ND	ND	NA
Acetone	UG/KG	16 J	55 J	73 J	110 J	82 J	NA
Carbon Disulfide	UG/KG	10 R	ND	ND	ND	ND	NA
1,1-Dichloroethene	UG/KG	10 R	ND	ND	ND	ND	NA
1,1-Dichloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
1,2-Dichloroethene(total)	UG/KG	10 R	ND	ND	ND	ND	NA
Chloroform	UG/KG	10 R	ND	ND	ND	ND	NA
1,2-Dichloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
2-Butanone	UG/KG	10 R	ND	ND	ND	ND	NA
1,1,1-Trichloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
Carbon tetrachloride	UG/KG	10 R	ND	ND	ND	ND	NA
Bromodichloromethane	UG/KG	10 R	ND	ND	ND	ND	NA
1,2-Dichloropropane	UG/KG	10 R	ND	ND	ND	ND	NA
cis-1,3-Dichloropropene	UG/KG	10 R	ND	ND	ND	ND	NA
Trichloroethene	UG/KG	10 R	ND	ND	ND	ND	NA
Dibromochloromethane	UG/KG	10 R	ND	ND	ND	ND	NA
1,1,2-Trichloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
Benzene	UG/KG	10 R	ND	ND	ND	ND	NA
trans-1,3-Dichloropropene	UG/KG	10 R	ND	ND	ND	ND	NA
Bromoform	UG/KG	10 R	ND	ND	ND	ND	NA
4-Methyl-2-pentanone	UG/KG	10 R	ND	ND	ND	ND	NA
2-Hexanone	UG/KG	10 R	ND	ND	ND	ND	NA
Tetrachloroethene	UG/KG	10 R	ND	ND	ND	ND	NA

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TABL[illegible]-27
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28OPFSLBF01	OP1A-BGA	OP1A-BGB	OP1A-RDA	OP1A-RDB	28OPFSWMF01
Date Sampled:		3/28/94	10/4/93	10/4/93	10/4/93	10/4/93	3/28/94
VOLATILES Cont.							
1,1,2,2-Tetrachloroethane	UG/KG	10 R	ND	ND	ND	ND	NA
Toluene	UG/KG	10 R	ND	ND	ND	ND	NA
Chlorobenzene	UG/KG	10 R	ND	ND	ND	ND	NA
Ethylbenzene	UG/KG	10 R	ND	ND	ND	ND	NA
Styrene	UG/KG	10 R	ND	ND	ND	ND	NA
Xylenes (total)	UG/KG	10 R	ND	ND	ND	ND	NA
SEMIVOLATILES							
Phenol	UG/KG	490 R	ND	ND	ND	ND	500 R
bis(2-Chloroethyl) ether	UG/KG	490 R	ND	ND	ND	ND	500 R
2-Chlorophenol	UG/KG	490 R	ND	ND	ND	ND	500 R
1,3-Dichlorobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
1,4-Dichlorobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
1,2-Dichlorobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
2-Methylphenol	UG/KG	490 R	ND	ND	ND	ND	500 R
2,2'-oxybis-(1-chloropropane)	UG/KG	490 R	ND	ND	ND	ND	500 R
4-Methylphenol	UG/KG	490 R	180	ND	ND	ND	500 R
N-Nitroso-di-n-propylamine	UG/KG	490 R	ND	ND	ND	ND	500 R
Hexachloroethane	UG/KG	490 R	ND	ND	ND	ND	500 R
Nitrobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
Isophorone	UG/KG	490 R	ND	ND	ND	ND	500 R
2-Nitrophenol	UG/KG	490 R	ND	ND	ND	ND	500 R
2,4-Dimethylphenol	UG/KG	490 R	ND	ND	ND	ND	500 R
bis(2-Chloroethoxy) methane	UG/KG	490 R	ND	ND	ND	ND	500 R
2,4-Dichlorophenol	UG/KG	490 R	ND	ND	ND	ND	500 R
1,2,4-Trichlorobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
Naphthalene	UG/KG	490 R	ND	ND	ND	ND	500 R

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 14-27
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28OPFSLBF01	OP1A-BGA	OP1A-BGB	OP1A-RDA	OP1A-RDB	28OPFSWMF01
Date Sampled:		3/28/94	10/4/93	10/4/93	10/4/93	10/4/93	3/28/94
SEMIVOLATILES Cont.							
4-Chloroaniline	UG/KG	490 R	ND	ND	ND	ND	500 R
Hexachlorobutadiene	UG/KG	490 R	ND	ND	ND	ND	500 R
4-Chloro-3-methylphenol	UG/KG	490 R	ND	ND	ND	ND	500 R
2-Methylnaphthalene	UG/KG	490 R	ND	ND	ND	ND	500 R
Hexachlorocyclopentadiene	UG/KG	490 R	ND	ND	ND	ND	500 R
2,4,6-Trichlorophenol	UG/KG	490 R	ND	43 J	ND	ND	500 R
2,4,5-Trichlorophenol	UG/KG	1200 R	ND	ND	ND	ND	1200 R
2-Chloronaphthalene	UG/KG	490 R	ND	ND	ND	ND	500 R
2-Nitroaniline	UG/KG	1200 R	ND	ND	ND	ND	1200 R
Dimethyl phthalate	UG/KG	490 R	ND	ND	ND	ND	500 R
Acenaphthylene	UG/KG	490 R	ND	ND	ND	ND	500 R
2,6-Dinitrotoluene	UG/KG	490 R	ND	ND	ND	ND	500 R
3-Nitroaniline	UG/KG	1200 R	110 J	ND	ND	ND	1200 R
Acenaphthene	UG/KG	490 R	ND	ND	ND	ND	500 R
2,4-Dinitrophenol	UG/KG	1200 R	ND	ND	ND	ND	1200 R
4-Nitrophenol	UG/KG	1200 R	ND	ND	ND	ND	1200 R
Dibenzofuran	UG/KG	490 R	ND	ND	ND	ND	500 R
2,4-Dinitrotoluene	UG/KG	490 R	ND	ND	ND	ND	500 R
Diethylphthalate	UG/KG	490 R	ND	ND	ND	ND	500 R
4-Chlorophenyl phenyl ether	UG/KG	490 R	ND	ND	ND	ND	500 R
Fluorene	UG/KG	490 R	ND	ND	ND	ND	500 R
4-Nitroaniline	UG/KG	1200 R	ND	ND	ND	ND	1200 R
4,6-Dinitro-2-methylphenol	UG/KG	1200 R	ND	ND	ND	ND	1200 R
N-nitrosodiphenylamine	UG/KG	490 R	ND	ND	ND	ND	500 R
4-Bromophenyl-phenylether	UG/KG	490 R	ND	ND	ND	ND	500 R
Hexachlorobenzene	UG/KG	490 R	ND	ND	ND	ND	500 R
Pentachlorophenol	UG/KG	1200 R	ND	ND	ND	ND	1200 R

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 4-27
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28OPFSLBF01	OP1A-BGA	OP1A-BGB	OP1A-RDA	OP1A-RDB	28OPFSWMF01
Date Sampled:		3/28/94	10/4/93	10/4/93	10/4/93	10/4/93	3/28/94
SEMIVOLATILES Cont.							
Phenanthrene	UG/KG	490 R	ND	ND	ND	ND	500 R
Anthracene	UG/KG	490 R	ND	ND	ND	ND	500 R
Carbazole	UG/KG	490 R	ND	ND	ND	ND	500 R
di-n-Butylphthalate	UG/KG	490 R	ND	ND	ND	ND	500 R
Fluoranthene	UG/KG	490 R	ND	ND	ND	ND	500 R
Pyrene	UG/KG	490 R	ND	ND	ND	ND	500 R
Butyl benzyl phthalate	UG/KG	490 R	ND	ND	ND	ND	500 R
3,3'-Dichlorobenzidine	UG/KG	490 R	ND	ND	ND	ND	500 R
Benzo[a]anthracene	UG/KG	490 R	ND	ND	ND	ND	500 R
Chrysene	UG/KG	490 R	ND	ND	ND	ND	500 R
bis(2-Ethylhexyl)phthalate	UG/KG	2600 J	12000 J	20000 J	ND	ND	730 R
di-n-Octylphthalate	UG/KG	490 R	210 J	610 J	170 J	72 J	500 R
Benzo[b]fluoranthene	UG/KG	490 R	ND	ND	ND	ND	500 R
Benzo[k]fluoranthene	UG/KG	490 R	ND	ND	ND	ND	500 R
Benzo[a]pyrene	UG/KG	490 R	ND	ND	ND	ND	500 R
Indeno[1,2,3-cd]pyrene	UG/KG	490 R	ND	ND	ND	ND	500 R
Dibenz[a,h]anthracene	UG/KG	490 R	ND	ND	ND	ND	500 R
Benzo[g,h,i]perylene	UG/KG	490 R	ND	ND	ND	ND	500 R

UG/KG - micrograms per kilogram
J - estimated
ND - not detected
R - rejected

TABLE 14-28
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28OPFSLBF01		28OPFSWMF01		OP1A-BGA		OP1A-BGB		OP1A-RDA		OP1A-RDB	
	Date Sampled:	3/28/94		3/28/94		10/4/93		10/4/93		10/4/93		10/4/93	
	UNITS												
Arsenic	MG/KG	0.01	R	0.01	R	0.09	L	0.1	L	ND		0.08	L
Barium	MG/KG	0.36	J	0.60	J	ND		ND		ND		ND	
Calcium	MG/KG	825		1420		13300		7300		10800		17000	
Chromium	MG/KG	0.66	R	0.34	R	0.63	L	0.29	L	0.4	L	0.47	L
Cobalt	MG/KG	0.02	J	ND		ND		ND		ND		ND	
Copper	MG/KG	0.22	J	0.15	J	0.31	J	0.17	J	0.19	J	ND	
Magnesium	MG/KG	287		238		465		364		414		537	
Manganese	MG/KG	ND		ND		2.2		1.3		1.5		1.8	
Mercury	MG/KG	0.23	J	0.16	J	0.1		0.15		0.12		0.12	
Nickel	MG/KG	0.29	R	0.12	R	ND		ND		ND		ND	
Potassium	MG/KG	3450		2720		2940		3100		2870		3070	
Selenium	MG/KG	0.32	J	0.26	J	ND		ND		ND		ND	
Silver	MG/KG	0.02	R	0.02	R	ND		ND		ND		ND	
Sodium	MG/KG	452		560		1000		905		975		1010	
Zinc	MG/KG	5.5	R	6.1	R	19.3		14.7		18.6		22.9	

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected
L - biased low

TABLE 14-29
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMWB01		28FS04SMWB02		28FS04AMWB01		28FS04AMWB02		28FS04AMWB03		28F5SFWB01
Date Sampled:		3/26/94		3/26/94		3/25/94		3/25/94		3/25/94		3/27/94
	UNITS											
VOLATILES												
Chloromethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Bromomethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Vinyl chloride	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Chloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Methylene chloride	UG/KG	10	R	10	R	13	J	2	J	10	R	NA
Acetone	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Carbon Disulfide	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,1-Dichloroethene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,1-Dichloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,2-Dichloroethene(total)	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Chloroform	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,2-Dichloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
2-Butanone	UG/KG	6	J	36	J	10	R	10	R	10	R	NA
1,1,1-Trichloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Carbon tetrachloride	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Bromodichloromethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,2-Dichloropropane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
cis-1,3-Dichloropropene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Trichloroethene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Dibromochloromethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,1,2-Trichloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Benzene	UG/KG	10	R	10	R	10	R	1	J	10	R	NA
trans-1,3-Dichloropropene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
Bromoform	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
4-Methyl-2-pentanone	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
2-Hexanone	UG/KG	10	R	4	J	10	R	10	R	10	R	NA
Tetrachloroethene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA
1,1,2,2-Tetrachloroethane	UG/KG	10	R	10	R	10	R	10	R	10	R	NA

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected
NA - not analyzed

TABLE 14-29
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMWB01		28FS04SMWB02		28FS04AMWB01		28FS04AMWB02		28FS04AMWB03		28F5SFWB01	
Date Sampled:		3/26/94		3/26/94		3/25/94		3/25/94		3/25/94		3/27/94	
	UNITS												
VOLATILES Cont.													
Toluene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA	
Chlorobenzene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA	
Ethylbenzene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA	
Styrene	UG/KG	10	R	10	R	10	R	10	R	10	R	NA	
Xylenes (total)	UG/KG	10	R	10	R	10	R	10	R	10	R	NA	
SEMIVOLATILES													
Phenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
bis(2-Chloroethyl) ether	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2-Chlorophenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
1,3-Dichlorobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
1,4-Dichlorobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
1,2-Dichlorobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2-Methylphenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,2'-oxybis-(1-chloropropane)	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
4-Methylphenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
N-Nitroso-di-n-propylamine	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Hexachloroethane	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Nitrobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Isophorone	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2-Nitrophenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4-Dimethylphenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
bis(2-Chloroethoxy) methane	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4-Dichlorophenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
1,2,4-Trichlorobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Naphthalene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
4-Chloroaniline	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Hexachlorobutadiene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected
NA - not analyzed

TABLE 14-29
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMWB01		28FS04SMWB02		28FS04AMWB01		28FS04AMWB02		28FS04AMWB03		28F5SFWB01	
Date Sampled:		3/26/94		3/26/94		3/25/94		3/25/94		3/25/94		3/27/94	
	UNITS												
SEMIVOLATILES Cont.													
4-Chloro-3-methylphenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2-Methylnaphthalene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Hexachlorocyclopentadiene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4,6-Trichlorophenol	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4,5-Trichlorophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
2-Chloronaphthalene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Dimethyl phthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Acenaphthylene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,6-Dinitrotoluene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
3-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Acenaphthene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4-Dinitrophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
4-Nitrophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Dibenzofuran	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
2,4-Dinitrotoluene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Diethylphthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
4-Chlorophenyl phenyl ether	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Fluorene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
4-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
4,6-Dinitro-2-methylphenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
N-nitrosodiphenylamine	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
4-Bromophenyl-phenylether	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Hexachlorobenzene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Pentachlorophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Phenanthrene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Anthracene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Carbazole	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected
NA - not analyzed

TABLE 14-29
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMWB01		28FS04SMWB02		28FS04AMWB01		28FS04AMWB02		28FS04AMWB03		28F5SFWB01	
Date Sampled:		3/26/94		3/26/94		3/25/94		3/25/94		3/25/94		3/27/94	
	UNITS												
SEMIVOLATILES Cont.													
di-n-Butylphthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Fluoranthene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Pyrene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Butyl benzyl phthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
3,3'-Dichlorobenzidine	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Benzo[a]anthracene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Chrysene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
bis(2-Ethylhexyl)phthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	1600	J
di-n-Octylphthalate	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Benzo[b]fluoranthene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Benzo[k]fluoranthene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Benzo[a]pyrene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Indeno[1,2,3-cd]pyrene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Dibenz[a,h]anthracene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
Benzo[g,h,i]perylene	UG/KG	490	R	490	R	490	R	490	R	490	R	490	R
PESTICIDES/PCBs													
beta-BHC	UG/KG	ND		ND		ND		2.4	NJ	ND		ND	
4,4'-DDE	UG/KG	42		21	J	5.4		7.1		5.2		10	
4,4'-DDD	UG/KG	23	J	12	J	4.7	J	6.1	J	3.9	J	3.1	J
Endrin aldehyde	UG/KG	ND		6.9	NJ	ND		ND		ND		ND	
alpha-Chlordane	UG/KG	4.4	NJ	1.7	NJ	ND		ND		ND		ND	

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected
NA - not analyzed

TABL ‑30
FISH TISSUE (WHOLE BODY) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample ID:		28FS04SMWB01		28FS04SMWB02		28F5SFWB01		28FS04AMWB01		28FS04AMWB02		28FS04AMWB03	
Date Sampled:		3/26/94		3/26/94		3/27/94		3/25/94		3/25/94		3/25/94	
	UNITS												
Aluminum	MG/KG	251		41.3		ND		286		272		462	
Antimony	MG/KG	ND		0.18	J	ND		ND		0.23	J	ND	
Arsenic	MG/KG	0.40	J	0.72	J	0.23	J	0.54	J	0.77	J	1.2	J
Barium	MG/KG	4.0	J	2.4	J	0.45	J	1.3	J	1.4	J	1.8	J
Beryllium	MG/KG	ND		ND		ND		ND		ND		0.0068	J
Cadmium	MG/KG	0.03	J	ND		ND		ND		ND		0.02	J
Calcium	MG/KG	5760		8440		8690		5130		7050		10900	
Chromium	MG/KG	5.4	J	4.4	J	1.3	R	1.7	R	2.3	R	3.2	J
Cobalt	MG/KG	0.09	J	0.07	J	0.02	J	0.06	J	0.10	J	0.10	J
Copper	MG/KG	4.6	J	1.1	J	0.35	J	1.2	J	1.8	J	2.4	J
Iron	MG/KG	162		70.4		ND		157		165		258	
Magnesium	MG/KG	243		310		301		176		242		370	
Manganese	MG/KG	3.6	J	2.0	J	1.2	J	2.4	J	2.9	J	4.7	J
Mercury	MG/KG	0.0024	J	0.014	J	0.0048	J	ND		0.0025		0.011	J
Potassium	MG/KG	1980		2810		2130		884		1340		1960	
Selenium	MG/KG	0.23	J	0.24	J	0.15	J	0.17	J	0.27	J	0.41	J
Silver	MG/KG	0.10	J	0.10	J	0.03	R	0.03	R	0.02	R	0.02	R
Sodium	MG/KG	824		822		842		441		598		983	
Vanadium	MG/KG	0.39	J	0.14	J	ND		0.92	J	1.1	J	1.8	J
Zinc	MG/KG	11.6	J	18.3	J	13.9	J	8.0	R	10.8	J	15.3	J

MG/KG - milligrams per kilogram
J - estimated
R - rejected
ND - not detected

TABL -31
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMF01	28FS04SMF02	28FS05SMF01	28F05SFF01	28F05SFF02	28FS04SSF01
Date Sampled:		3/27/94	3/26/94	3/25/94	3/25/94	3/27/94	3/29/94
	UNITS						
VOLATILES							
Methylene chloride	UG/KG	10 R	10 R	10 R	3 J	4 J	25 R
Acetone	UG/KG	56 J	32 J	10 R	36 J	170 J	230 J
SEMIVOLATILES							
Phenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
bis(2-Chloroethyl) ether	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2-Chlorophenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
1,3-Dichlorobenzene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
1,4-Dichlorobenzene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
1,2-Dichlorobenzene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2-Methylphenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2,2'-oxybis-(1-chloropropane)	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
4-Methylphenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
N-Nitroso-di-n-propylamine	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
Hexachloroethane	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
Nitrobenzene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
Isophorone	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2-Nitrophenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2,4-Dimethylphenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
bis(2-Chloroethoxy) methane	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2,4-Dichlorophenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
1,2,4-Trichlorobenzene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
Naphthalene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
4-Chloroaniline	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
Hexachlorobutadiene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
4-Chloro-3-methylphenol	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R
2-Methylnaphthalene	UG/KG	480 R	490 R	500 R	490 R	490 R	490 R

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABLE 31
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

	Sample ID:	28FS04SMF01		28FS04SMF02		28FS05SMF01		28F05SFF01		28F05SFF02		28FS04SSF01	
	Date Sampled:	3/27/94		3/26/94		3/25/94		3/25/94		3/27/94		3/29/94	
	UNITS												
SEMIVOLATILES cont.													
Hexachlorocyclopentadiene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2,4,6-Trichlorophenol	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2,4,5-Trichlorophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
2-Chloronaphthalene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Dimethyl phthalate	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Acenaphthylene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2,6-Dinitrotoluene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
3-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Acenaphthene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2,4-Dinitrophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
4-Nitrophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Dibenzofuran	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
2,4-Dinitrotoluene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Diethylphthalate	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
4-Chlorophenyl phenyl ether	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Fluorene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
4-Nitroaniline	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
4,6-Dinitro-2-methylphenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
N-nitrosodiphenylamine	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
4-Bromophenyl-phenylether	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Hexachlorobenzene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Pentachlorophenol	UG/KG	1200	R	1200	R	1200	R	1200	R	1200	R	1200	R
Phenanthrene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Anthracene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Carbazole	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
di-n-Butylphthalate	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABL. .4-31
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Sample ID:		28FS04SMF01		28FS04SMF02		28FS05SMF01		28F05SFF01		28F05SFF02		28FS04SSF01	
Date Sampled:		3/27/94		3/26/94		3/25/94		3/25/94		3/27/94		3/29/94	
	UNITS												
SEMIVOLATILES cont.													
Fluoranthene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Pyrene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Butyl benzyl phthalate	UG/KG	51	J	64	J	500	R	490	R	490	R	78	J
3,3'-Dichlorobenzidine	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Benzo[a]anthracene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Chrysene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
bis(2-Ethylhexyl)phthalate	UG/KG	480	R	490	R	500	R	2000	J	630	R	490	R
di-n-Octylphthalate	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Benzo[b]fluoranthene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Benzo[k]fluoranthene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Benzo[a]pyrene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Indeno[1,2,3-cd]pyrene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Dibenz[a,h]anthracene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
Benzo[g,h,i]perylene	UG/KG	480	R	490	R	500	R	490	R	490	R	490	R
PESTICIDES/PCBs													
4,4 - DDE	UG/KG	20		160		9	J	4	J	4.9	J	7.1	
4,4 - DDD	UG/KG	16	J	58	J	7.2	J	ND		ND		ND	
Endrin aldehyde	UG/KG	4.9	J	ND		ND		ND		ND		ND	
alpha - Chlordane	UG/KG	1.5	NJ	3.6	NJ	ND		ND		ND		ND	

UG/KG - micrograms per kilogram
J - estimated
R - rejected
ND - not detected
NJ - tentatively identified

TABL. .-32
FISH TISSUE (FILLETS) - POSITIVE DETECTION SUMMARY
NEW RIVER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO - 0231
MCB, CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample ID:	28FS04SMF01	28FS04SMF02	28FS05SMF01	28F04SFF01	28F05SFF01	28F05SFF02	28FS04SSF01	28FS04BDF01
	Date Sampled:	3/27/94	3/26/94	3/25/94	3/28/94	3/25/94	3/27/94	3/29/94	3/28/94
Percent Solids		23	22	22	20	21	22	22	21
	UNITS								
Antimony	MG/KG	ND	ND	ND	ND	0.19 J	ND	0.24 J	ND
Arsenic	MG/KG	0.30 J	0.38 J	0.58 J	0.64 J	0.77 J	0.83 J	0.17 J	0.95 J
Barium	MG/KG	0.70 J	0.76 J	0.88 J	0.98 J	0.41 J	0.62 J	0.49 J	0.46 J
Calcium	MG/KG	600	732	1280	288	ND	ND	331	812
Chromium	MG/KG	1.4 R	1.1 R	1.2 R	0.56 R	1.5 R	0.84 R	0.29 R	1.2 R
Cobalt	MG/KG	0.03 J	ND	0.03 J	ND	ND	ND	ND	ND
Copper	MG/KG	0.61 J	0.36 J	0.47 J	0.18 J	0.29 J	0.18 J	0.44 J	0.44 J
Magnesium	MG/KG	172	193	271	217	244	246	228	178
Mercury	MG/KG	0.0024 J	0.0037 J	ND	0.011 J	0.009 J	0.019 J	0.061 J	0.024 J
Nickel	MG/KG	0.85 R	0.42 R	0.66 R	0.36 R	0.81 R	0.12 R	0.10 R	0.61 R
Potassium	MG/KG	2570	2760	3810	3010	3780	3680	3180	2210
Selenium	MG/KG	0.10 J	0.15 J	0.13 J	0.16 J	0.24 J	0.25 J	0.27 J	0.39 J
Silver	MG/KG	0.02 R	0.02 R	0.03 R	0.04 R	0.03 R	0.02 R	0.02 R	0.03 R
Sodium	MG/KG	380	402	504	501	420	408	464	529
Vanadium	MG/KG	ND	ND	ND	ND	ND	ND	ND	0.03 J
Zinc	MG/KG	3.4 R	4.3 R	6.5 R	4.4 R	4.1 R	5.4 R	3.2 R	3.9 R

MG/KG - milligrams per kilogram
J - estimated
ND - not detected
R - rejected

SECTION 14.0 FIGURES

NOTES
- ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)
- BORINGS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS
- ENVIRONMENTAL SAMPLES WERE NOT COLLECTED FROM EXPLORATORY TEST BORINGS

LEGEND

28GW01	PILOT TEST BORING FOR SHALLOW MONITORING WELL
28GW01DW	PILOT TEST BORING FOR DEEP MONITORING WELL
SB1	SOIL BORING LOCATION
SB40	EXPLORATORY TEST BORING
	VEGETATION
— — —	CREEK/DRAINAGE
- x -	FENCE
	MARSH

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S.O.#	62470-231-0000
CADD#	231153RI

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

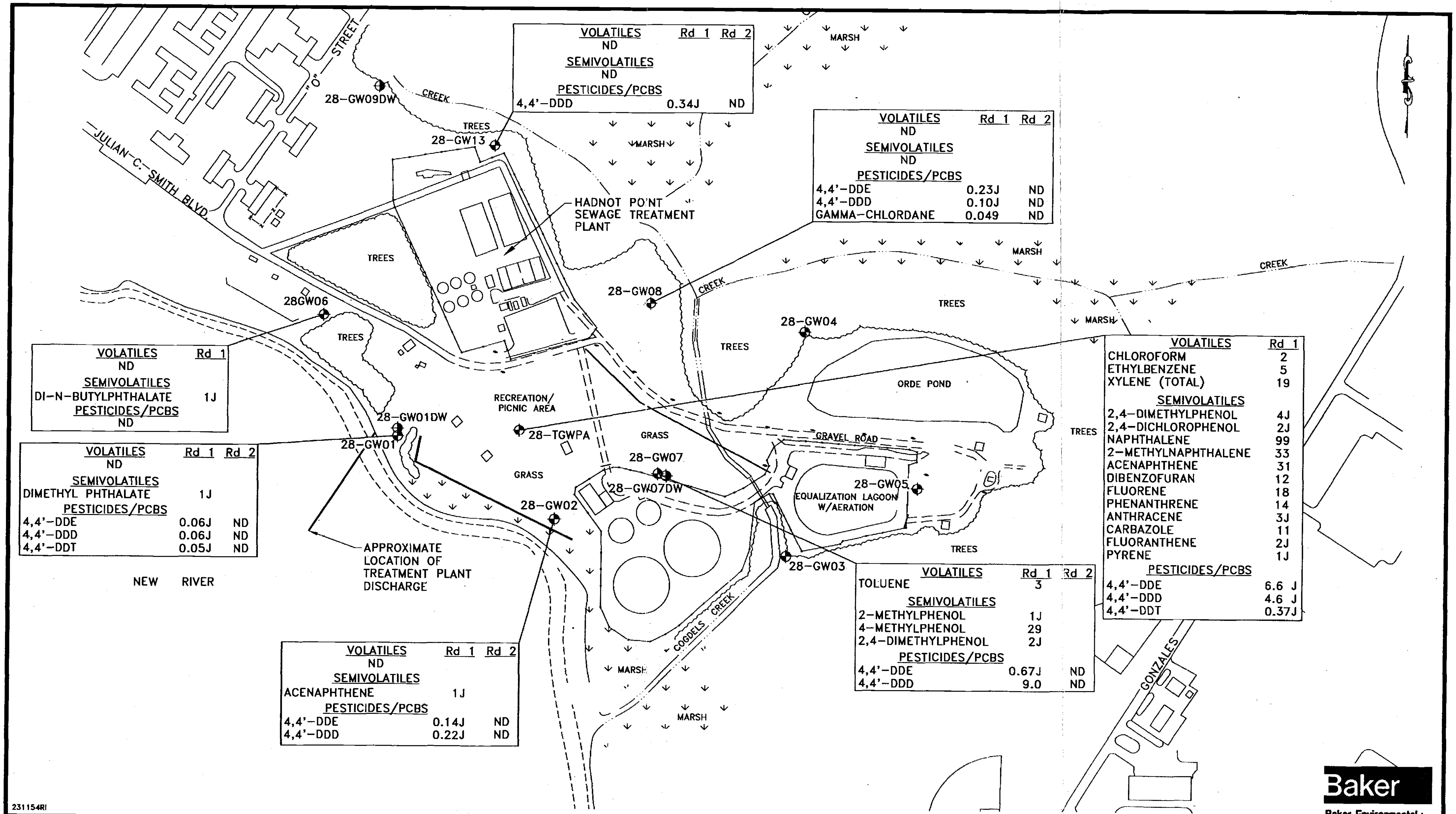
Baker
Baker Environmental, Inc

POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SUBSURFACE SOILS
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120'
DATE JANUARY 1995

FIGURE No
14-2

01500Q17X



LEGEND

28-GW01 SHALLOW MONITORING WELL

28GW01DW DEEP MONITORING WELL

NOTES:
- SHALLOW MONITORING WELL GW01 WAS ABANDONED AND REPLACED DURING THE RI FIELD INVESTIGATION.
- ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
- WELLS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS.

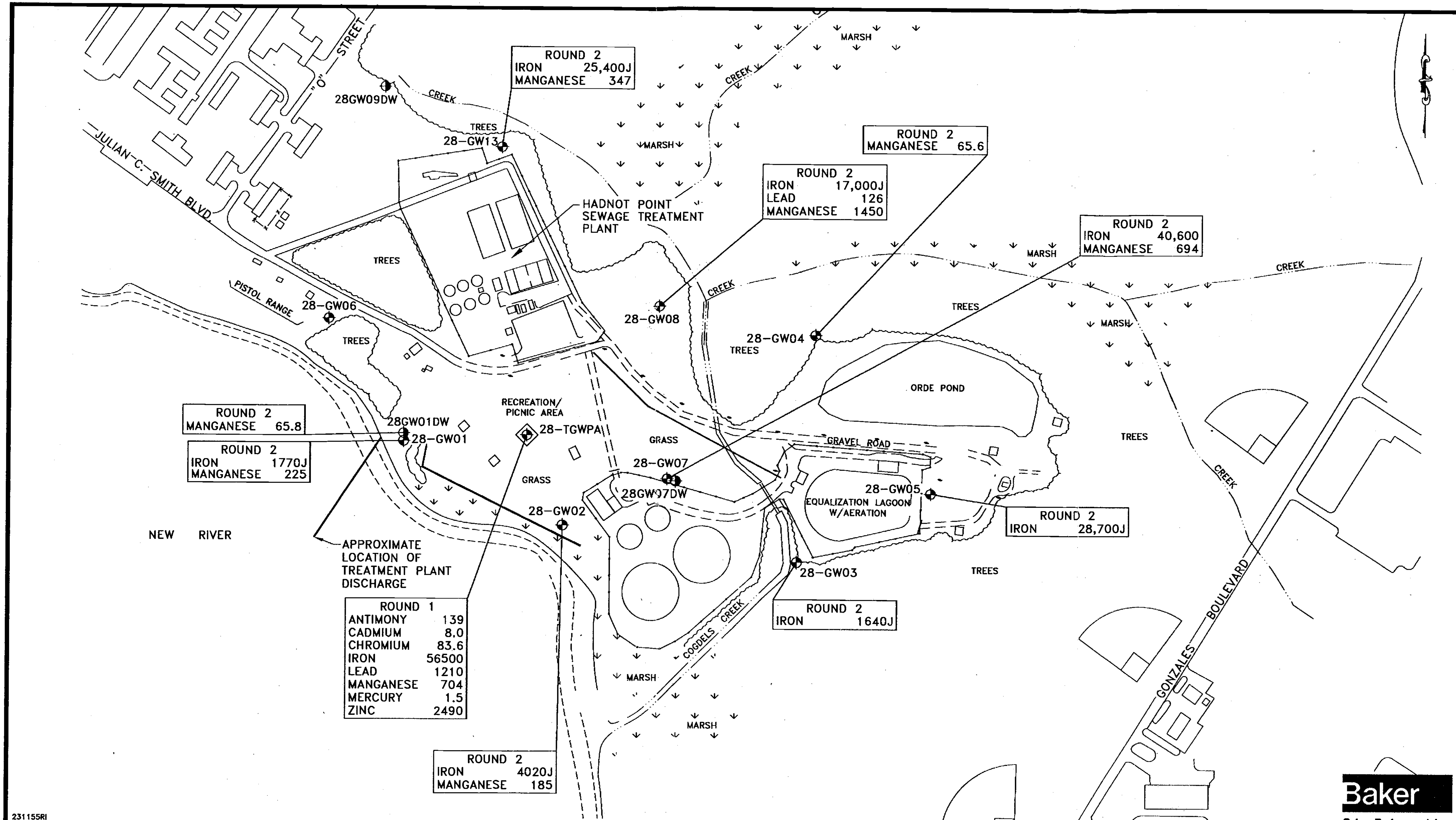
SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 14-3
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN GROUNDWATER
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q182



LEGEND

28-GW01 SHALLOW MONITORING WELL

28-TGWPA TEMPORARY SHALLOW MONITORING WELL

28GW01DW DEEP MONITORING WELL

NOTES:
- ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
- SHALLOW MONITORING WELL GW01 WAS ABANDONED AND REPLACED DURING THE RI FIELD INVESTIGATION.

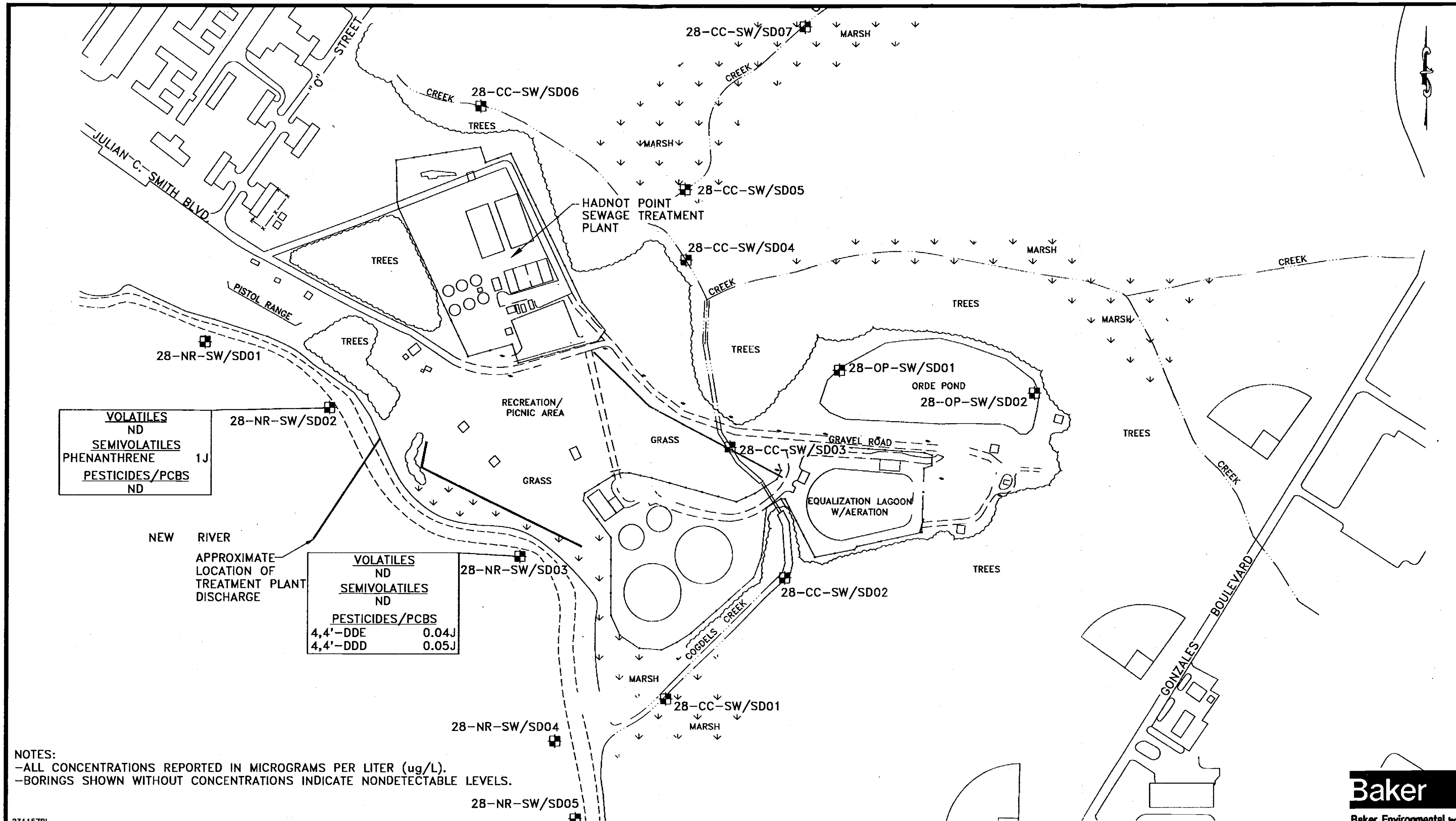
SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 14-4
POSITIVE DETECTIONS OF TAL METALS ABOVE FEDERAL MCL AND/OR NCWQS IN GROUNDWATER
SITE 28 - HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q192



NOTES:
- ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
- BORINGS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS.

Baker

Baker Environmental, Inc.

LEGEND

28-CC-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLING STATION LOCATION

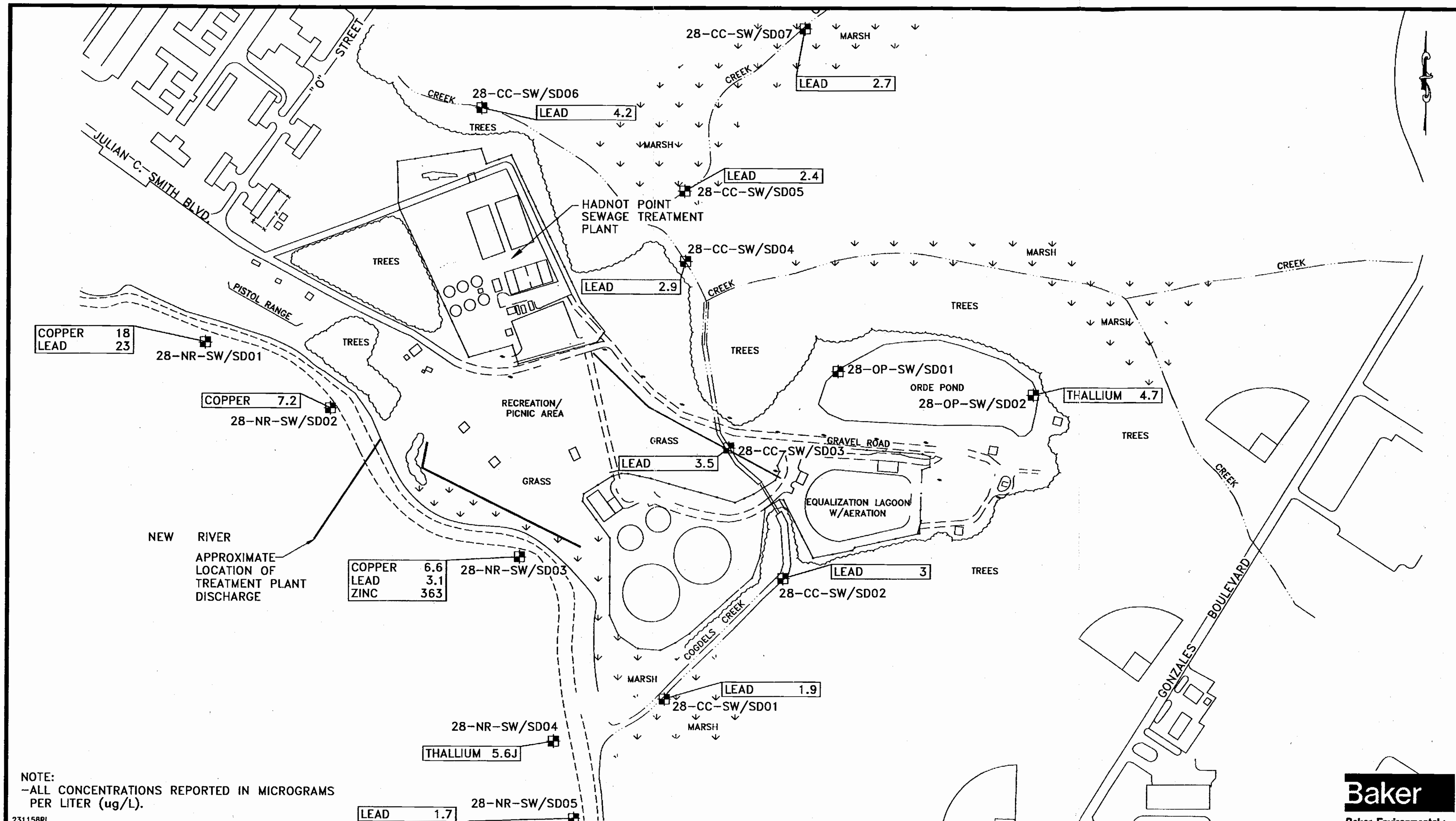
300 0 150 300 600

1 inch = 300 ft.

FIGURE 14-5
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE WATER
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

01500Q202



NOTE:
-ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

231158RI

Baker
Baker Environmental, Inc.

LEGEND

28-CC-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLING STATION LOCATION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 14-6
POSITIVE DETECTIONS OF TAL METALS ABOVE FEDERAL SCREENING VALUES IN SURFACE WATER
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q21Z

NOTES
- ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)
- BORINGS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS
- ENVIRONMENTAL SAMPLES WERE NOT COLLECTED FROM EXPLORATORY TEST BORINGS

LEGEND

28GW01	PILOT TEST BORING FOR SHALLOW MONITORING WELL
28GW01DA	PILOT TEST BORING FOR DEEP MONITORING WELL
SB1	SOIL BORING LOCATION
SB40	EXPLORATORY TEST BORING
	VEGATATION
- x -	FENCE
	CREEK/DRAINAGE
	MARSH

SOURCE: LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S.O.#	62470-231-0000
CADD#	231152RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

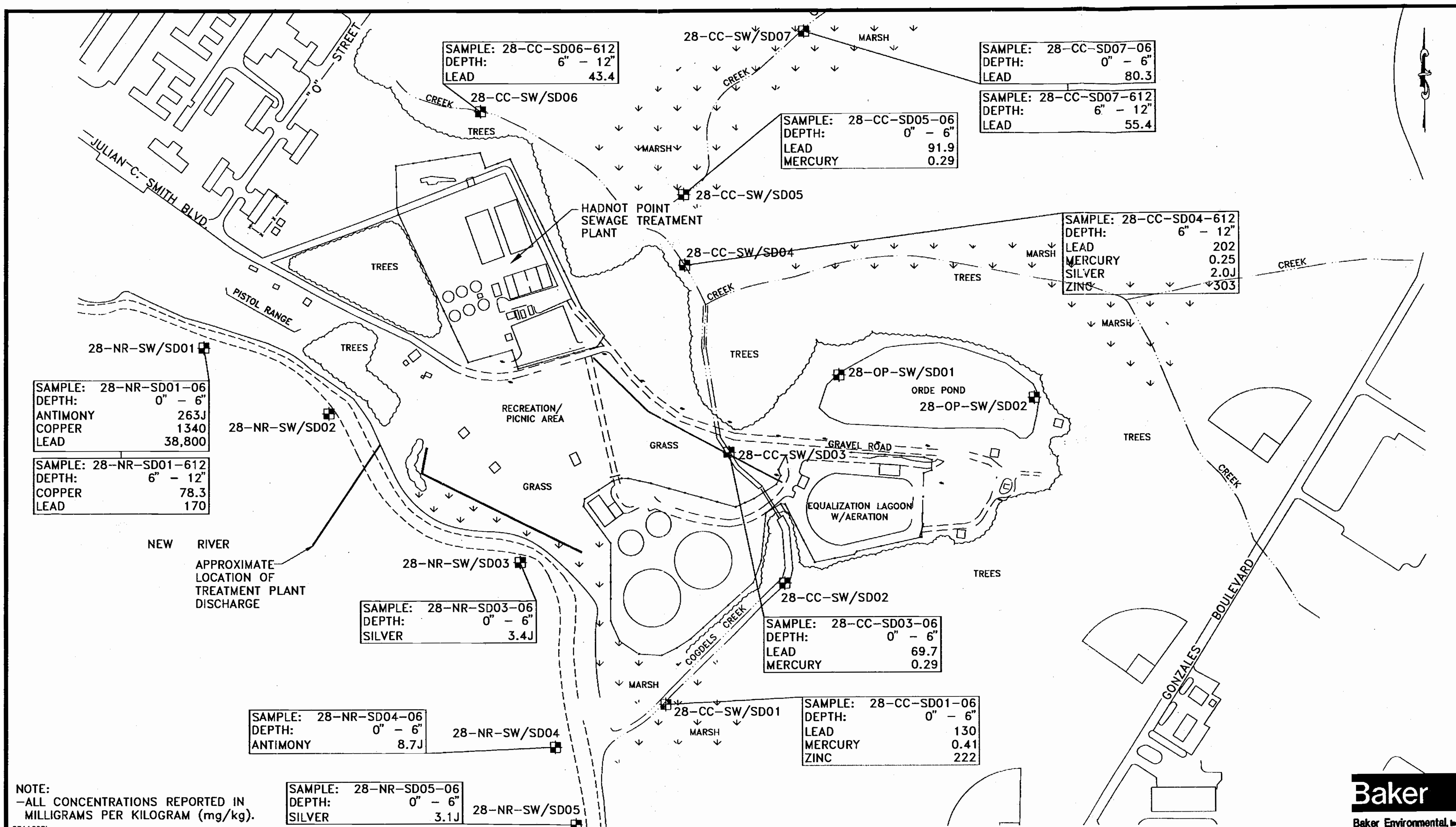
BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc

POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOILS
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120'
DATE JANUARY 1995

FIGURE No.
14-1



LEGEND

28-CC-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLING STATION LOCATION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 14-8
POSITIVE DETECTIONS OF TAL METALS ABOVE FEDERAL SCREENING VALUES IN SEDIMENT
SITE 28 – HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01500Q232

15.0 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 Site 28 of OU No.7 and their fate and transport through the environment.

15.1 Chemical and Physical Properties Impacting Fate and Transport

Table 15-1 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 is generally higher than vapor pressures for 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 coefficients 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 the organic carbon is soil particles. 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 soil 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) as follows:

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

15.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 28, 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.
- Groundwater infiltration from the shallow aquifer to the deep aquifer.

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.

15.2.1 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.

A majority of the surface area of Site 28 is vegetated. This vegetation reduces the likelihood of fugitive dust generation. Consequently, this transport pathway is not significant at the site.

15.2.2 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. 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}).

At Site 28, there were three surface water bodies of concern: the New River, Cogdels Creek, and Orde Pond. Similar constituents were found in the surface water and sediment samples collected from these areas of concern (e.g., primarily metals). In addition, similar metals were also found in the fish tissue samples collected from the New River and Orde Pond.

A considerable fraction of the metals in water, particularly rivers and estuaries, is associated with suspended particles. The extent of this association varies greatly with the metal, the properties of the particles, and the type of water. Metal levels decrease as the distance from a river's mouth increases.

Metals in surface water carried on particles of different types will settle in areas of active sedimentation and will be deposited in the sediments. The metals may be released again through microbial activity and changes in various physical and chemical factors, including pH and redox potential. The mechanisms caused by increasing salinity and microbial activity may account for either (a) salting out of the large molecular weight fraction, e.g., humic acids of fresh water and flocculation of inorganic matter, resulting in increased particle size, will remove absorbed and incorporated metals to the sediment or (b) mobilization from carrier particles by chlorine ions and chelating substances and also by microbial decomposition of suspended organic matter, resulting in increased availability to the biota. Aquatic organisms will concentrate metals from ambient water to levels far exceeding the metal levels in the water, thus, to a large extent, retaining them within the biologically active coastal waters.

However, the fraction of total metal load to which these mechanisms apply is difficult to estimate. It is likely that a large portion is carried over great distances and thus impossible to detect. The size of this fraction would vary for different metals and with the form of emission.

15.2.3 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 28. 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 14.0, Nature and Extent of Contamination.

15.2.4 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 that occur during advection. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants.

Advection is the process that 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 that are commonly found in coastal regions. In general, groundwater flow velocities, in sandy aquifers, under natural gradient conditions are probably between 32.8 feet/year to 328 feet/year (10 meters/year to 100 meters/year) (Lyman, et al., 1982).

The average seepage velocity of groundwater flow at Site 28 for both the shallow and deep water-bearing zones can be estimated by using a variation of Darcy's equation:

$$Vx = (K*i)/Ne$$

where,

Vx = average seepage velocity
K = hydraulic conductivity (cm/sec)
i = hydraulic gradient
Ne = effective porosity

For the shallow lithology at Site 28 of OU No.7, the hydraulic conductivity (K) was estimated at 3.1 ft/day (Baker, 1992). The average calculated groundwater gradient was 0.004. An estimated effective porosity of 0.3 was used for silty-sands (Fetter, 1980). This resulted in an estimated groundwater flow velocity is 0.041 ft/day or 15 ft/yr.

Based on soil lithology information obtained during the test borings and on groundwater elevation data, there are two aquifer systems underlying OU No. 7. The aquifers are separated by a thin semi-confining layer (typically less than three feet) of sandy-clay. Although the semi-confining layer exists, there is vertical groundwater movement between the aquifers. Data obtained from a pump test performed within Hadnot Point (ESE, 1988) indicated a hydraulic conductivity (or leakage characteristic) ranging from 1.4×10^{-3} ft/day (4.9×10^{-7} cm/sec) to 5.1×10^{-2} ft/day (1.8×10^{-5} cm/sec) for semi-confining clayey interval. This range of values suggests that the clayey interval has a high enough permeability to permit vertical movement of groundwater between the aquifers. Accordingly, contaminants introduced in the shallow soils over time could migrate vertically from the surficial to the Castle Hayne aquifer.

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).

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. The sorption of certain halogenated organic solvents 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 average velocity of the groundwater 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 that affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, 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 TCE, TCA, and 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 depend 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 or the metallic cation.

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

Table 15-2 presents the general processes which influence the aquatic fate of contaminants at Site 28.

15.3 Fate and Transport Summary

The following paragraphs summarize the site-specific fate and transport data for contaminants detected in media collected at Site 28.

15.3.1 Volatile Organic Compounds

VOCs (i.e., vinyl chloride, TCE, and PCE) 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.

In surface media, VOCs will readily volatilize into the atmosphere. Because VOCs are highly mobile in soil, they will leach to underlying groundwater, but will not partition significantly from the water column to sediment. In natural water and soil systems, VOCs will be slowly biodegraded. Consequently, in subsurface environments, VOCs will tend to persist. Hydrolysis, oxidation and direct photolysis are not important fate processes for VOCs in water.

At Site 28, VOCs were found primarily in the shallow groundwater. One VOC, carbon disulfide, was found only once in the sediment of Cogdels Creek and the New River. It is expected that the VOCs found in these media will biodegrade slowly over time. Rapid biodegradation VOCs in these media would require appropriate conditions and adaptation.

15.3.2 Polynuclear Aromatic Hydrocarbons

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(ghi)perylene is usually the most abundant compound in soils with low PAH values but becomes less important with increasing total PAH values. Other PAHs are benzo(a)anthracene, chrysene, pyrene, benzo(ghi)perylene, benzo(b)fluoranthene, 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 that result in selective microbial degradation/breakdown.

15.3.3 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.

15.3.4 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 that 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 15-3 presents an assessment of relative environmental mobilities of inorganics as a function of Eh and pH. Soils at MCB Camp Lejeune are relatively neutral; therefore, inorganics in the subsurface soil should be relatively immobile.

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

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

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

SECTION 15.0 TABLES

TABLE 15-1

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log Kow	Log Koc	Specific Gravity (g/cm^3)	Henry's Law Constant ($atm\text{-}m^3/mole$)	Mobility Index	Comments
SEMIVOLATILES								
2,4-Dimethylphenol	0.098	6200	2.30	1.98	NA	6.30E-07	NA	NA
Acenaphthene	<0.02	3.42	4.33	1.25	1.225	1.50E-04	NA	NA
Anthracene	1.95E-04	0.073	4.45	4.20	1.24	1.25E-03	NA	NA
Benzo(a)anthracene	5.0E-09	0.014	5.61	5.34	NA	1.00E-06	-15.50	Very Immobile
Benzo(a)pyrene	5.0E-09	0.0038	6.04	5.72	NA	4.90E-07	-16.40	Very Immobile
Benzo(b)fluoranthene	1E-06 to 1E-07	0.009	6.57	6.26	NA	1.22E-06	-14.00	Very Immobile
Benzo(g,h,i)perylene	0	0	6.51	NA	NA	1.21E-07	NA	NA
Benzo(k)fluoranthene	9.6E-11	0.0016	6.84	6.22	NA	3.87E-05	-19.00	Very Immobile
Bis(2-ethylhexyl)phthalate	6.45E-06	0.3	5.11	4-5	NA	1.1E-05	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	1E-06 to 1E-11	0.006	5.61	5.44	1.274	1.10E-06	-13.70	Very Immobile
Fluoranthene	1E-06 to 1E-04	0.265	5.33	4.84	NA	6.50E-06	-9.40	Immobile
Fluorene	8.4E-03*	1.9	4.2	NA	NA	1E-04	NA	NA
Indeno(1,2,3-cd)pyrene	1.0E-10	5.3E-04	6.51	6.20	1.070	6.95E-08	-19.50	Very Immobile
Naphthalene	0.082	31.7	3.30	2.74-3.53	1.152	4.83E-04	NA	NA
Phenanthrene	6.8E-04	1.29	4.46		1.025	2.25E-04	NA	NA
Pyrene	6.85	0.14	5.32	4.91	NA	5.10E-06	-11.90	Very Immobile

TABLE 15-1 (Continued)

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log Kow	Log Koc	Specific Gravity (g/cm^3)	Henry's Law Constant ($atm\text{-}m^3/mole$)	Mobility Index	Comments
PESTICIDES								
4,4'-DDD	1.0E-06	0.09	5.99	4.47	NA	2.20E-08	-12.00	Very Immobile
4,4'-DDE	0.0000065	0.04	4.28	3.66	NA	6.80E-05	-10.00	Immobile
4,4'-DDT	1.9E-07	0.0034	6.19	4.89	NA	1.58E-05	-14.00	Very Immobile
Heptachlor epoxide	1.95E-05	0.200	5.40	NA	NA	3.20E-05	NA	NA
alpha-Chlordane	4.6E-04	1.0E-01	5.54	NA	NA	4.85E-05	NA	NA
gamma-Chlordane	4.6E-04	1.0E-01	5.54	NA	NA	4.85E-05	NA	NA

NA = Not Available
* = Units in torr

References:

Howard, 1989-1991
Montgomery, 1990
Sax and Lewis, 1987
SCDM, 1991
USEPA, 1986
USEPA, 1986a
Verscheuren, 1983

TABLE 15-2

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Processes					
	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Pesticides/PCBs						
Aldrin	+	+	?	-	-	+
Chlordane	+	+	?	-	-	+
DDD	+	+	-	-	-	+
DDE	+	+	-	+	-	+
DDT	+	+	-	-	+	+
Dieldrin	+	+	-	+	-	+
Endosulfan and Endosulfan Sulfate	+	+	+	?	+	-
Endrin and Endrin Aldehyde	?	?	?	+	-	+
Heptachlor	+	+	-	?	++	+
Heptachlor Epoxide	+	-	?	?	-	+
PCBs	+	+	+(1)	?	-	+
Halogenated Aliphatic Hydrocarbons						
Chloromethane (methyl chloride)	-	+	-	-	-	-
Dichloromethane (methylene chloride)	-	+	?	-	-	-
1,1-Dichloroethane (ethylidene chloride)	-	+	?	-	-	-
1,2-Dichloroethane (ethylene dichloride)	-	+	?	-	-	-
1,1,2-Trichloroethane	?	+	-	-	-	?
Chloroethene (vinyl chloride)	+	-	-	-	-	-
1,1,-Dichloroethene (vinylidene chloride)	?	+	?	-	-	?
Trichloroethene	-	+	?	-	-	-
Tetrachloroethene (perchloroethylene)	-	+	+	-	-	-

TABLE 15-2 (Continued)

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Processes					
	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Bromodichloromethane	?	?	?	?	-	+
Dichlorodifluoromethane	?	+	-	?	-	?
Monocyclic Aromatics						
Benzene	+	+	-	-	-	-
Ethylbenzene	?	+	?	-	-	-
Toluene	+	+	?	-	-	-
Phenol	-	+	+	-	-	-
2,4-Dimethyl phenol (2,4-xylenol)	-	-	?	+	-	-
Phthalate Esters						
Dimethyl phthalate	+	-	+	-	-	+
Diethyl phthalate	+	-	+	-	-	+
Di-n-butyl phthalate	+	-	+	-	-	+
Di-n-octyl phthalate	+	-	+	-	-	+
Bis (2-ethylhexyl) phthalate	+	-	+	-	-	+
Butyl benzyl phthalate	+	-	+	-	-	+
Polycyclic Aromatic Hydrocarbons						
Acenaphthene(3)	+	-	+	+	-	-
Acenaphthylene(3)	+	-	+	+	-	-
Fluorene(3)	+	-	+	+	-	-
Naphthalene	+	-	+	+	-	-
Anthracene	+	+	+	+	-	-
Fluoranthene(3)	+	+	+	+	-	-

TABLE 15-2 (Continued)

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Processes					
	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Phenanthrene[3]	+	+	+	+	-	-
Benzo(a)anthracene	+	+	+	+	-	-
Benzo(b)fluoranthene[3]	+	-	+	+	-	-
Benzo(k)fluoranthene[3]	+	-	+	+	-	-
Chrysene[3]	+	-	+	+	-	-
Pyrene[3]	+	-	+	+	-	-
Benzo(g,h,i)perylene[3]	+	-	+	+	-	-
Benzo(a)pyrene	+	+	+	+	-	-
Dibenzo(a,h)anthracene[3]	+	-	+	+	-	-
Ideno(1,2,3-cd)pyrene[3]	+	-	+	+	-	-

++ Predominate fate determining process
+ Could be an important fate process
- Not Likely to be an important process
? Importance of process uncertain or not known

Notes: (1) 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.
(2) Based on information for 4-nitrophenol.
(3) Based on information for PAHs as a group. Little or no information for these compounds exists.

Source: USEPA. 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater - Part I.

TABLE 15-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
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:

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

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

16.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The following subsections present the baseline human health risk assessment (BRA) conducted for Site 28, Hadnot Point Burn Dump Area. This assessment was performed in accordance with the USEPA document Risk Assessment Guidance for Superfund, Human Health Evaluation Manual: Part A (USEPA, 1989). The purpose of the BRA is to assess whether the contaminants of potential concern (COPCs) at the site pose a current or future risk to human health in the absence of remedial action. COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects. Because the purpose of the risk assessment is to estimate the degree of risk to human health and to be protective of human health, the approach of the USEPA guidance is designed to be conservative. This protectiveness is achieved by the use of assumptions and models that result in upper bound estimates of risk, i.e., the true or actual risk is expected to fall between the estimated value and zero. As a result, the actual site risks are unlikely to exceed the estimated upper bound values and are probably lower. The following paragraphs present a brief overview of the risk assessment process and how the assessment affects further activity at the sites.

For the BRA, both current and future land use exposure scenarios were assumed for the site. The current scenario reflects potential human exposure pathways to the COPCs that presently exist at the site (i.e., exposure pathways currently available). Likewise, the future use scenario represents exposure pathways that are conceivable in the future (e.g., residential development). The future use is typically determined by zoning and the environmental setting of the site. The development of current and future use exposure scenarios is consistent with the methodology for baseline risk assessment, as specified by USEPA.

The National Contingency Plan (NCP) stipulates a range of acceptable cancer risk levels of 1×10^{-4} to 1×10^{-6} for total risk at a hazardous waste site (USEPA, 1990). These cancer risk levels represent the probability of an individual developing cancer over his or her lifetime if exposed to the COPCs at the site. For example, a risk level of 10^{-6} is the probability that one person in 1,000,000 exposed persons will develop cancer in a lifetime. The total noncarcinogenic acceptable risk level is a hazard index of less than or equal to 1.0. This noncancer risk level depicts a level at or below which adverse systemic effects are not expected in the exposed population.

A remedial action is recommended when either the total cancer or noncancer risks are above the criteria established by the NCP. Some form of remedial action also is necessary when either the current or future exposure point concentrations at the site are above the applicable or suitable analogous standards (e.g., maximum contaminant levels [MCLs] for drinking water) for those COPCs for which standards exist. When a remedial action is necessary, applicable or relevant and appropriate requirements (ARARs) and/or risk-based cleanup levels are used in determining acceptable concentrations in the environmental media. No remedial response is required when the cancer and noncancer criteria and the ARARs are not exceeded.

16.1 Introduction

The BRA investigates the potential for COPCs to affect human health and/or the environment, both now and in the future, under a "no further remedial action scenario." The BRA process evaluates the data generated during the sampling and analytical phase of the RI, identifying areas of interest and COPCs with respect to geographical, demographic, and physical and biological characteristics of the study area. These, combined with the current understanding of physical and chemical properties of the site-associated constituents (with respect to environmental fate and transport processes), are then used to estimate the concentrations of contaminants at the end points of logical exposure pathways. Finally, contaminant intakes by hypothetical receptors are determined and combined with the toxicological properties of the contaminants to estimate (inferentially) the potential public health impacts posed by constituents detected at the site.

The BRA for the site was conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989 and USEPA, 1991), and USEPA Region IV Supplemental Risk Guidance (USEPA, 1992d).

The components of the BRA include the following:

- Hazard Identification: determination as to whether a substance has the potential to elicit an adverse effect (toxicity) upon exposure to humans

- Exposure Assessment: identification of the human population(s) likely to be exposed and the development of specific exposure pathways for the population

- Toxicity Assessment: quantification of the relationship between the human exposure and the probability of occurrence (risk) of a toxic response

- Risk Characterization: development of a quantitative estimation of the potential risk from a combination of information collected during the exposure and toxicity assessment

- Uncertainty Analysis: identification and qualitative discussion of any major sources of uncertainty pertaining to the finding of the BRA

- Conclusions: summarization and conclusion of the results of the BRA relating to the total site risk are drawn

Each of these components of the BRA is discussed and addressed for the site. Introductory text is presented first, followed by a site-specific discussion. Referenced tables and figures are presented after the text portion of this section.

16.2 Hazard Identification

Data generated during the remedial investigation and previous studies at the site were used to draw conclusions and to identify data gaps in the BRA. The data were evaluated to assess which data were of sufficient quality to include in the risk assessment. The objective when selecting data to include in the risk assessment was to provide accurate and precise data to characterize contamination and evaluate exposure pathways.

16.2.1 Data Evaluation and Reduction

The initial hazard identification step entailed the validation and evaluation of the site data to determine its usability in the risk assessment. This process resulted in the identification of COPCs for the site. During this validation and evaluation, data that would result in inaccurate conclusions (e.g., data that were rejected or attributed to blank contamination, as qualified by the validator) were reduced within the data set. Data reduction entailed the removal of unreliable data from the original data set based on the guidelines established by USEPA. A summary of the data quality was presented in Section 14.1.

16.2.2 Identify Data Suitable for Use in a Quantitative Risk Assessment

To provide for accurate conclusions to be drawn from sampling results, analytical data were reviewed and evaluated. During this review and evaluation, data that would lead to inaccurate conclusions were reduced within each data set. This section presents the criteria that were used to review, reduce, and summarize the analytical data. These criteria are consistent with USEPA guidance for data reduction.

Six environmental media were investigated at the site during this RI: surface soils, subsurface soils, groundwater, surface water, sediment, and biota (i.e., fish tissue and benthic macroinvertebrates). For Site 28, these media were assessed for potential risk to human receptors. Specifically, surface water, sediment, fish tissue, and macroinvertebrate samples were collected from the three surface water bodies of concern at the site: the New River, Cogdels Creek, and Orde Pond. The macroinvertebrate results are discussed in Section 17 of this volume, Ecological Risk Assessment. In addition, an insufficient amount of fish tissue sample was collected from Cogdels Creek. Consequently, there were no fish tissue results to evaluate from Cogdels Creek.

Information relating to the nature and extent of contamination at the site is provided in detail in Section 14 of this volume of the report. The discussion provided in Section 14 also was utilized in the selection of COPCs at the site. The reduced data sets for all media of concern at the site are provided in Appendices K and L of this report.

16.2.3 Criteria Used in Selection of COPCs

This section presents the selection of COPCs for the evaluation of potential human health risk. As exemplified by the data summary tables in Appendices K and L, the number of constituents positively detected at least once during the field investigation is large. Quantifying risk for all positively identified parameters may distract from the dominant risks presented by the site. Therefore, the data set (resulting data set after applying the criteria listed in the previous section) was reduced to a list of COPCs. As stated previously, COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects.

The selection of the COPCs was based on a combination of detected concentrations; toxicity; frequency of detection; comparison to background values, including site-specific, base-wide and published ranges; and comparison of physiochemical properties, including mobility, persistence, and toxicity. In addition, historical information pertaining to past site activities was considered. USEPA guidance states that a contaminant may not be retained for quantitative evaluation in the BRA if: (1) it is detected infrequently in an environmental medium (e.g., less than 5 percent for at least 20 samples per data set), (2) it is absent or detected at low concentrations in other media, or (3) site history does not provide evidence the contaminant to be present (USEPA, 1989). To qualitatively assess the COPCs, comparisons of results to federal and state criteria and Region III Risk-Based Concentrations (RBCs) (USEPA, 1994) were used. A brief description of the selection criteria used in choosing final COPCs is presented below. A contaminant did not need to meet the criteria of all of these three categories in order to be retained as a COPC.

16.2.3.1 <u>Site History</u>

Reportedly, Site 28 was used for solid waste disposal. This solid waste, which consisted of industrial solid waste, municipal waste, and oil-based paints, was burned and covered with fill. The area is now grass-covered. The site is located adjacent to the Mainside sewage treatment plant, which is enclosed with a six-foot high chain-link fence. Codgels Creek divides the site into east and west areas. The New River borders the site in the southwest. Currently, the site is a recreational/picnic area used by adults and children. An on-site pond, Orde Pond, is stocked with fish and used for recreational fishing. Military personnel conduct physical training, equipment assembly and other related activities at this site.

Field investigations conducted by ESE in 1984 and 1986, and by Baker in 1993 revealed specific contaminants in the groundwater, surface water, sediment and fish tissue. Of the four wells sampled, the monitoring well situated beside the New River had the highest levels of contamination. VOCs, pesticides, and metals were present and included 1,2-dichloroethene, trichloroethene, vinyl chloride, 4,4'-DDD, 4,4'-DDE, dieldrin, arsenic, lead, and mercury. Samples from the other three wells contained SVOCs, pesticides, and chromium. Chromium and zinc were detected at elevated levels in the surface water samples collected from the New River.

During recent field investigations (Baker, 1994), samples of background surface and subsurface soils, site surface and subsurface soils, shallow and deep groundwater, surface water, sediment, fish tissue, and benthic macroinvertebrates were collected from Orde Pond, the New River and Cogdels Creek. A second round of groundwater samples were collected using a different sampling method to reduce turbidity. A discussion of this sampling event is presented in Section 3.0 of this report.

Although media samples were collected from the eastern and western portions of the site and designated accordingly, the results were evaluated as a single data set per medium for the human health risk assessment. Similar historical operations occurred at both the eastern and western portions of the site, and current activities are similar at these two areas. Section 11.0, Site Background and Setting, provides further detailed discussion for the site. In addition, it is important to note that the data from the first round of sample collection was used to assess potential risk, with the exception of the groundwater data. Two different sampling methods were used for each round of groundwater data collection. The first round of groundwater results indicated elevated levels of metals. Therefore, a second round of groundwater data was collected for metals analysis. The second round results overall were less than the round one results. It was determined that the second round metals results were more representative of the site groundwater. Therefore, the second round metals groundwater data were used to assess risk.

16.2.3.2 <u>Frequency of Detection</u>

In general, constituents that were detected infrequently (e.g., equal to or less than 5 percent, when at least 20 samples of a medium are available) may be anomalies due to sampling or analytical errors or may be present simply in the environment due to past or current site activities. It should be noted, however, that detected constituents were individually evaluated prior to exclusion from the BRA. Physiochemical properties (i.e., fate and transport) and toxicological properties for each detected constituent were evaluated (see following sections).

16.2.3.3 Comparison to Background

Sample concentrations were compared to site-specific (i.e., twice the base-wide average concentration) background levels. Background information was available for all media of concern at the site. Groundwater results were compared to results from the upgradient wells for the site. In addition to site background levels, (as presented in a study of base-wide inorganic levels [Baker, 1994]), soil metal concentrations were compared to published background levels, as recommended by USEPA guidance (USEPA, 1989). The soil metal background ranges are typical levels found in the eastern U.S. (USGS, 1984). Soil metal concentrations within the observed range were considered to be naturally-occurring and/or representative of background conditions. The results of this comparison are presented in Tables 16-1 through 16-6.

16.2.3.4 Physiochemical Properties

The physical and chemical properties of a contaminant are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will tend to volatilize into the air from surface soils or surface waters or be transported via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also describe a contaminant's tendency to adsorb onto soil/sediment particles. Environmental mobility can correspond to either an increased or decreased potential to affect human health and/or the environment.

Persistence

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

Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the human health assessment. For example the weight-of-evidence (WOE) classification should be considered in conjunction with concentrations detected at the site. Some effects considered in the selection of COPCs include carcinogenicity, mutagenicity, teratogenicity, systemic effects, and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of the toxic response in an organism and/or subsequent receptors and are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic contaminants are essential nutrients. Essential nutrients need not be considered for further consideration in the quantitative risk assessment if they are present in relatively low concentrations (i.e., below twice the average base-wide background levels or slightly elevated above naturally occurring levels) or if the contaminant is toxic at doses much higher than those which could be assimilated through exposures at the site. Due to the difficulty of determining nutrient levels that were within acceptable dietary levels, only essential nutrients present at low concentrations (i.e., only slightly elevated above background) were eliminated from the BRA. Essential nutrients, however, were included in the ecological risk evaluation.

16.2.3.5 Contaminant Concentrations in Blanks

Sample concentrations were compared quantitatively to investigation-related blank concentrations. Sample concentrations of parameters that are typical laboratory or field contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) that exceeded blank concentrations by a factor of 10 and other parameter concentrations that exceeded blank concentrations by a factor of five were considered to be site related. Parameters not meeting this criteria were considered artifacts from field or laboratory practices and treated as non-detects.

For Site 28, the following organics were found in the blanks: acetone (20 µg/L), methylene chloride (3 µg/L), 2-butanone (5 µg/L), 2-hexanone (5 µg/L), chloromethane (10 µg/L), bromomethane (9 µg/L), toluene (2 µg/L) and BEHP (94 µg/L). Upon application of the 5-10 rule described above, the media sample results were compared to the following levels to determine if the results were related to the blanks: acetone (200 µg/L), methylene chloride (30 µg/L), 2-butanone (50 µg/L), 2-hexanone (50 µg/L), chloromethane (50 µg/L), bromomethane (45 µg/L), toluene (10 µg/L), and BEHP (940 µg/L).

16.2.3.6 Federal and State Criteria and Standards

Contaminants detected at the site were compared to state and federal standards, criteria, and/or To Be Considered levels (TBCs). These comparisons may provide some qualitative information as to the relative potential for health impacts resulting from the site. It should be noted that COPC concentration ranges were directly compared to each standard/criteria/TBC. This comparison did not take into account the additive or synergistic effects of those constituents without standards or criteria. Consequently, conclusions regarding potential risk posed by each site cannot be inferred from this comparison. A brief explanation of the standards/criteria/TBCs used for the evaluation of COPCs is presented in Section 7.0 of Volume I.

As stated previously, COPCs in all media of concern at the site were compared these aforementioned criteria. The results of the standards/criteria/TBC comparison for the site are presented in Tables 16-1 through 16-6. The results are discussed in Section 16.6.

16.2.4 Contaminants of Potential Concern (COPCs)

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

16.2.4.1 Surface Soil

In surface soil, the COPCs were identified as the following: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, silver, thallium, vanadium, zinc, heptachlor epoxide, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, phenanthrene, anthracene, carbazole, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, and B(a)P. In general, these COPCs were detected frequently (greater than 5 percent) and exceeded site background levels.

The following chemicals were detected in the surface soils, but were excluded from the risk evaluation due to low frequency of detection (equal to or less than 5 percent): selenium, dieldrin, endrin, endosulfan sulfate, endrin aldehyde, Aroclor-1254, Aroclor-1260, bis(2-chloroethyl)ether, naphthalene, acenaphthene, dibenzofuran, fluorene, pentachlorophenol, dibenz(a,h)anthracene, chloromethane, methylene chloride, acetone, and 1,1,1-trichloroethane (TCA).

The following SVOCs were found in the surface soils, but were excluded as common laboratory contaminants: di-n-butyl phthalate, butyl benzyl phthalate, di-n-octylphthalate, and BEHP. These COPCs were found infrequently (e.g., 2 out of 40 analyzed for di-n-butyl phthalate), at low levels (e.g., butyl benzyl phthalate at 0.088 mg/kg), and only slightly above blank levels (e.g., BEHP ranged from 40 to 2,000 μg/kg. Seven of the 19 detections were greater than 940 μg/L). Although BEHP was found at levels greater than blank levels and a frequency greater than 5 percent, the maximum concentration found in soil (2 mg/kg) was less than the Region III residential soil RBC (46 mg/kg). Consequently, BEHP was not evaluated as a COPC.

On comparison to Region III residential soil RBCs, the following SVOCs were found at maximum levels were below the RBCs: fluoranthene, pyrene, and benzo(k)fluoranthene. Essential nutrients also were excluded. In surface soil, these chemicals included calcium, iron, magnesium, potassium, and sodium.

16.2.4.2 Subsurface Soil

In subsurface soil, the COPCs were identified as the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, silver, vanadium, zinc, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, naphthalene, fluorene, phenanthrene, chrysene, 2-methylnaphthalene, benzo(a)anthracene, benzo(k)fluoranthene indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, BEHP, and benzo(a)pyrene. These COPCs were found frequently and exceeded site background levels.

The following chemicals were detected in the subsurface soils, but were excluded from the risk evaluation due to low frequency of detection (less than 5 percent): selenium, thallium, and Aroclor-1254. Although Aroclor-1260 was detected in the subsurface soils at a frequency of 6 percent, the maximum concentration (77 μg/kg) was below the Region III residential soil RBC (83 μg/kg). Consequently, it was not included as a COPC.

The maximum concentrations of 1,4-dichlorobenzene, dibenzofuran, anthracene, and carbazole did not exceed Region III residential soil RBCs. Consequently, they were not included as COPCs.

Essential nutrients also were excluded. In subsurface soil, these chemicals included calcium, iron, magnesium, potassium, and sodium. Acetone and methylene chloride were also found in the subsurface soil. However, both chemicals are common lab contaminants, were found infrequently (e.g., methylene chloride found 2 out of 40 times analyzed), and fell below the levels found in the blanks (e.g., acetone at 10 μg/kg versus 200 μg/L). Consequently, both VOCs were not included as COPCs.

16.2.4.3 Shallow and Deep Groundwater

In the shallow and deep groundwater, the COPCs were identified as the following: arsenic, barium, lead, manganese, mercury, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, chloroform, 2-methylnaphthalene, phenanthrene, 2,4-dimethylphenol, 4-methylphenol, and acenaphthene. These COPCs were detected frequently and exceeded federal MCLs and Region III RBCs for tap water.

The following chemicals were detected in the shallow and deep groundwater, but were excluded from the risk evaluation due to low frequency of detection (less than 5 percent): dimethylphthalate and di-n-butylphthalate. Aluminum, copper, nickel, vanadium, and zinc also were found infrequently and at levels below Region III RBCs in tap water and federal MCLs. Consequently, they were not evaluated. Essential nutrients also were excluded. In shallow and deep groundwater, these chemicals included calcium, iron, magnesium, potassium, and sodium.

2-Methylphenol , 4-methylphenol, and 2,4-dichlorophenol were detected in the groundwater at a frequency of 7.7 percent. However, the maximum concentrations of 2-methylphenol and 2,4-dichlorophenol were less than the Region III tap water RBCs (i.e., 2-methylphenol at 1.3 µg/L vs. 180 µg/L and 2,4-dichlorophenol at 1.6 µg/L vs. 11 µg/L. Consequently, they were not included as COPCs. The maximum concentration of 4-methylphenol is greater than the RBC (i.e., 29 µg/L vs. 18 µg/L). Consequently, it was included as a COPC in groundwater.
Similarly, gamma-chlordane, naphthalene, 2-methylnaphthalene, dibenzofuran, fluorene, phenanthrene, anthracene, carbazole, fluoranthene, pyrene, chloroform, ethylbenzene, and xylene were detected at a frequency of 7.7 percent. However, upon comparison of the maximum concentrations of these contaminants to the Region III tap water RBCs, chloroform exceeded the RBC. There are no RBCs available for 2-methylnaphthalene and phenanthrene. Consequently, these three compounds were evaluated as COPCs.

BEHP and toluene were found in the shallow and deep groundwater. Both chemicals are common lab contaminants. Toluene was found at a maximum level of 3 µg/L, which is below the blank level of 10 µg/L. BEHP was detected at a maximum concentration of 17 µg/L, which is below the blank level of 940 µg/L. Consequently, they were not included as COPCs.

16.2.4.4 Surface Water

New River

In the surface water of the New River, the following chemicals were identified as COPCs: aluminum, arsenic, cadmium, copper, lead, manganese, vanadium, zinc, 4,4'-DDD, and 4,4'-DDE. These COPCs were found frequently and exceeded site background levels.

Nickel, thallium and phenanthrene were found at low frequencies of detection. Barium was found at levels within site background (i.e, 20.5 vs. 24.25 µg/L). Calcium, iron, magnesium, potassium and sodium are essential nutrients. BEHP and acetone were detected in the surface water. However, both chemical are common laboratory contaminants. BEHP was found at 600 µg/L, which is below the blank level of 940 µg/L. Acetone was found once out of five times analyzed at a estimated concentration of 14 µg/L, which is below the blank level of 100 µg/L. As a result, these constituents were not included as COPCs.

Cogdels Creek

The COPCs identified in the surface water of Cogdels Creek were the following: aluminum, arsenic, lead, manganese, vanadium, and zinc. These two COPCs were found frequently and exceeded site background levels.

No pesticides, PCBs or SVOCs were detected.

Arsenic, barium, copper, nickel, and vanadium were detected in the surface water of Cogdels Creek at frequencies exceeding 5 percent. On comparison of these levels to site background levels and ambient water quality criteria, barium, copper and nickel did not exceed the criteria. Hence, arsenic and vanadium were included as COPCs. The remaining metals were excluded from evaluation. Methylene chloride, acetone and 2-hexanone were infrequently detected. Calcium, iron, magnesium, potassium ,and sodium are essential nutrients. Consequently, these constituents were not included as COPCs.

Orde Pond

Aluminum, nickel, and thallium were identified as COPCs in the surface water of Orde Pond. These COPCs were found frequently and exceeded site background concentrations.

No pesticides, PCBs or SVOCs were detected.

Methylene chloride is a common laboratory contaminant. It was found at a maximum level of 10 µg/L, which is below the blank level of 30 µg/L. Calcium, iron, magnesium, potassium, and sodium are essential nutrients. Consequently, these constituents were not included as COPCs.

16.2.4.5 Sediment

New River

The following chemicals were selected as COPCs for the sediment of the New River: antimony, arsenic, barium, copper, lead, silver, zinc, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, phenanthrene, anthracene, carbazole, dibenzofuran, fluoranthene, pyrene, BEHP, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, and benzo(ghi)perylene. These COPCs were found frequently and exceeded site background levels.

The following chemicals were found at concentrations within site background levels: aluminum, chromium, manganese, nickel, and vanadium. Calcium, iron, magnesium, potassium, and sodium are essential nutrients. As a result, these metals were not included as COPCs.

The following chemicals were infrequently detected and not identified as COPCs: cobalt, mercury, carbon disulfide, methylene chloride, and methyl ethyl ketone (MEK). Acenaphthene, dibenzofuran, fluorene, and dibenz(a,h)anthracene were detected in the sediment of the New River at frequencies greater than 5 percent. On comparison of these compounds to sediment screening values, all values fell within the screening level ranges, with the exception of dibenzofuran which does not have a screening values available. Consequently, dibenzofuran was included in the evaluation.

Common laboratory contaminants found in the sediment were methylene chloride, acetone and MEK. Methylene chloride was found only once at 2 µg/kg. MEK was found only once at 7 µg/kg. Both levels are within blanks levels. Consequently, these chemicals were not included as COPCs.

Cogdels Creek

The following chemicals were identified as COPCs for the sediment of Cogdels Creek: aluminum, arsenic, barium, chromium, copper, lead, manganese, mercury, thallium, vanadium, zinc, 4,4'-DDD, 4,4'-DDE, alpha-chlordane, gamma-chlordane, carbon disulfide, BEHP, fluoranthene, pyrene, benzo(a)anthracene, phenanthrene, 3,3'-dichlorobenzidine, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and benzo(a)pyrene. These COPCs were detected frequently and exceeded site background levels.

Cobalt and nickel were found at levels within site background concentrations. Calcium, iron, magnesium, potassium and sodium are essential nutrients. As a result, these metals were not included as COPCs. 4,4'-DDT and butylbenzylphthalate were infrequently detected and was not included as a COPC. On comparison to sediment screening levels and site background concentrations, beryllium, cadmium and silver were found at levels within background or screening levels. Consequently, they were not evaluated as COPCs.

Carbon disulfide, phenanthrene, anthracene, 3,3'-dichlorobenzidine, benzo(b)fluoranthene, and benzo(k)fluoranthene were found in Cogdels Creek sediment at a frequency greater than 5 percent. On comparison of these results to sediment screening levels, only anthracene has available levels, which it does not exceed. Consequently, the remaining compounds were included as COPCs in the sediment at Cogdels Creek.

Acetone and MEK are common laboratory contaminants. Acetone and MEK were found at low frequencies of detection and levels, which were below blank levels. Consequently, these chemicals were not identified as COPCs.

Orde Pond

The COPCs identified for the sediment of Orde Pond were the following: aluminum, arsenic, beryllium, chromium, cobalt, copper, lead, manganese, nickel, vanadium, and 4,4'-DDD. These COPCs were found frequently and at levels which exceeded site background concentrations.

Barium and zinc were found at levels within site background. Calcium, iron, magnesium, potassium, and sodium are essential nutrients. As a result, these metals were not included as COPCs.

Acetone, MEK, toluene, and BEHP are common laboratory contaminants. The maximum levels of these COPCs fell below the blank levels (e.g., BEHP was found at a maximum level of 430 µg/kg, which fell below the blank level of 940 µg/L). Consequently, these chemicals were not identified as COPCs.

16.2.4.6 Fish Tissue

New River

The COPCs identified in the fish tissue fillet samples collected from the New River are as follows: antimony, barium, cobalt, copper, selenium, 4,4'-DDD, 4,4'-DDE, and alpha-chlordane. These COPCs were found frequently and exceeded site background levels in fish tissue.

Arsenic, mercury, and BEHP were found at levels within site background concentrations. Calcium, magnesium, and sodium are essential nutrients. Consequently, these chemicals were not included as COPCs.

Vanadium, dieldrin, and endrin aldehyde were infrequently detected. Methylene chloride, acetone, and butylbenzylphthalate are common laboratory contaminants. Methylene chloride and acetone were found at levels which fell below or only slightly above blank concentrations (e.g., acetone at 230 μg/kg versus 200 μg/L in the blank). These chemicals were not identified as COPCs.

Cogdels Creek

A insufficient amount of fish tissue sample was collected for analysis from this surface water body. As a result, potential risk from fish ingestion from this area could not be evaluated. Resampling is not planned for Cogdels Creek for several reasons. At least three attempts were made to sample the creek for fish. High salinity, conductivity and turbidity prevented electrofishing. Netting was also attempted, and negligible quantities of fish were obtained. There is limited access to Cogdels Creek, and fishermen have not been observed at this creek. Consequently, it is unlikely that resampling will occur at the creek.

Orde Pond

Barium, manganese, selenium, and zinc were identified as COPCs for the fish tissue fillet samples collected from Orde Pond. These COPCs were found frequently and at levels that exceeded site background levels.

Arsenic, chromium, copper, and mercury were found at concentrations within site background levels. For example, mercury was found in the fish fillet samples collected from Orde Pond ranging from 0.1 to 0.23 mg/kg. Background values ranged between 0.02 and 0.24 mg/kg. Calcium, magnesium, potassium, and sodium are essential nutrients. Cobalt, 2-methylphenol, 2,4,6-trichlorophenol, and 3-nitroaniline were detected at low frequencies. Acetone, BEHP, and di-n-octyl phthalate are common laboratory contaminants. Acetone was found below the blank levels (110 μg/kg versus 200 μg/L in the blank). As a result, these chemicals were not included as COPCs.

Table 16-7 presents a summary of the COPCs chosen for all media of concern for Site 28. Also included on these tables are the constituents excluded from COPC selection.

16.3 Exposure Assessment

The exposure assessment addresses each potential exposure pathway via soil (surface and subsurface), groundwater, surface water, sediment, biota, and air. To determine if human exposure via these pathways may occur in the absence of remedial action, an analysis including the identification and characterization of exposure pathways was conducted. The following four elements were examined to determine if a complete exposure pathway was present:

1) a source and mechanism of chemical release
2) an environmental transport medium
3) a feasible receptor exposure route
4) a receptor exposure point

The exposure scenarios presented in the following sections are used to estimate individual risks. Unless otherwise noted, all the statistical data associated with the factors used in the dose evaluation equations for assessing exposure were obtained from the Exposure Factors Handbook (USEPA, 1989b) and the accompanying guidance manuals. A reasonable maximum exposure (RME) scenario was utilized in this assessment, which is consistent with USEPA Region IV recommendations regarding human health risk assessment. As a result, the exposure scenarios presented include RME assumptions for the input parameters in the dose evaluation equations. These values are summarized in Table 16-8.

Several mathematical models to estimate exposure concentrations were used. To estimate exposure from the inhalation of volatile contaminants in groundwater while showering, the "Integrated Household Exposure Model for Use of Tap Water Contaminated with Volatile Organic Chemicals," developed by S.A. Foster and P.C. Chrostowski, was applied. To evaluate the health effects of lead, the USEPA lead uptake/biokinetic model was used. The model addresses the lowest age groups because children are exceptionally sensitive to the adverse effects of lead. These models are presented in Appendices O and P.

16.3.1 Potential Human Receptors and Adjacent Populations

The following sections provide a discussion of the potential exposure pathways and receptors at Site 28.

16.3.1.1 Site Conceptual Model for Site 28

A site conceptual model of potential sources, migration pathways and human receptors was developed to encompass all current and future potential routes of exposure at the site. This document is presented in Appendix Q. Figure 16-1 presents the potential exposure pathways and receptors for Site 28. Qualitative descriptions of current and future land use patterns in the vicinity of OU No.7 were provided in the model. All available analytical data and meteorological data were considered in addition to general understanding of the demographics of surrounding communities.

From this information, the following general list of potential receptors was developed for inclusion in the quantitative health risk analysis for Site 28:

- Current military personnel
- Current recreational residents (child and adult)
- Current and future fisherman
- Future on-site residents (child and adult)
- Future construction worker

The following sections present a discussion of the potential exposure pathways and receptors at Site 28.

16.3.1.2 Current and Future Scenarios

At Site 28, on-site military personnel and adults and children engaging in recreation frequent the area. In addition, anglers mainly fish at Orde Pond and the New River. Fishing at Cogdels Creek is less frequent. No swimming has been observed at any of the surface water bodies, although wading is possible. Signs prohibiting swimming are posted at Orde Pond. However, it is important to note that the military personnel conduct training exercises at this site, including training activities in Orde Pond.

In the current exposure scenario, potential receptors includemilitary personnel, adults and children engaged in recreation, and fishermen. Potential exposure pathways include surface soil ingestion, dermal contact , and inhalation for the military personnel and civilians. Adults and children are expected to become exposed to surface water and sediment while playing/wading in the New River and possibly in Cogdels Creek. Fishermen may become exposed to these media while fishing at Orde Pond and the New River, with less frequent exposure at Cogdels Creek. It is assumed that exposure to surface water and sediment at Cogdels Creek and the New River will be minimal for the on-site military personnel during physical training exercises. However, exposure to the surface water and sediment of Orde Pond via incidental ingestion and dermal contact was evaluated for the on-site military personnel. In addition, fish ingestion for the fisherman was evaluated, using fish tissue samples (fillets) collected from the New River and Orde Pond. There were no tissue samples available from Cogdels Creek for analysis.

At present, groundwater is not used for drinking (see following section). As a result, current groundwater exposure was not assessed. Exposure to subsurface soil in the current scenario is unlikely for the receptor population. Consequently, subsurface soil exposure is not considered.

In the future case, it is unlikely that a residential scenario will be implemented at the site. It is assumed that the present activities will continue into the foreseeable future. However, to be conservative, groundwater exposure to both the shallow and deep groundwater for the residential child and adult receptor was assessed. Soil (subsurface soil in the future case), surface water, sediment, and biota exposure, as calculated in the current scenario for the child and adult receptor, was expected to remain the same in the future case.

Like Site 1 (Volume I, Section 7 of this report), groundwater exposure for future on-site military personnel was not be assessed. However, exposure for a construction worker was evaluated in the future case. It is assumed that subsurface soil exposure via incidental ingestion , dermal contact and inhalation may occur as a result of excavation for potential construction activities at the site.

Potable Water Supply

At the site, groundwater exposure is assumed to occur in the future case. At present, potable water for the site is supplied by the base treatment facilities via water supply wells. There are no potable wells located within a mile radius of Site 28. Consequently, the future groundwater exposure scenario is highly unlikely. However, this exposure pathway was evaluated in accordance with USEPA guidance.

In addition, the shallow and deep groundwater at Site 28 were evaluated as a single exposure source. Although shallow groundwater is not used potably at the sites, it has been shown that there is a potential interconnection between the shallow and deep aquifers (see Sections 13.3 and 13.4). Consequently, exposure to both sources of groundwater were evaluated.

16.3.2 Exposure Pathways

In general, the migration of COPCs from site soil sources could potentially occur by the following routes:

- Vertical migration of potential contaminants from surficial soils to subsurface soils.
- Leaching of potential contaminants from subsurface soils to the 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 constituent to migrate spatially and persist in environmental media is important in the estimation of potential exposure. This section describes the potential exposure pathways presented on Figure 16-1 associated with each medium and each potential human receptor group, then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 16-9 presents the potential human exposure scenarios for this site.

16.3.2.1 Surface Soil

The potential release source considered in the soil pathway was the chemical residuals in the surface soils. The release mechanisms considered were volatilization, fugitive dust generation/deposition, leaching, and surface runoff. The transport media were the surface soils and air. The routes for human exposure to the contaminated soils included inhalation, ingestion, and dermal contact. Potential exposure points from the site were areas of human activity on and adjacent to the site.

Soil Ingestion and Dermal Contact

Incidental ingestion and dermal contact with surface soil in the current case are complete exposure pathways at Site 28. These exposure pathways were evaluated for the current military receptor.

Soil Inhalation Via Volatilization

The soil represents a potential source of exposure at the site via volatilization of COPCs. The potentially exposed population includes current military personnel who may inhale contaminated air. However, no VOCs were identified as COPCs in either media at the site. As a result, this pathway is not considered to be significant for the site and was not evaluated for the surface soils.

Soil Inhalation Via Fugitive Dust Generation

The surface soils in the current case and the subsurface soils in the future case represent a potential source of exposure at the site via fugitive dust generation from wind erosion and vehicular traffic on surface soils. Current military personnel may inadvertently inhale the contaminated particulates as dust while engaging in outdoor activities.

16.3.2.2 Subsurface Soil

The potential release source considered in the subsurface soil pathway was the chemical residuals in the contaminated soils. The release mechanism considered was leaching to groundwater. The transport medium was the groundwater infiltrating the subsurface soil. Therefore, exposure to subsurface soils would be indirect (i.e., leaching of contaminants to groundwater). As such, subsurface soil exposure was addressed in the groundwater pathway analysis. Additionally, subsurface soil exposure was mentioned as part of the soil medium. It was assumed that the subsurface soil would be excavated and used as surface grading, landscaping, etc., in the foreseeable future. As a result, exposure to subsurface soil via ingestion and dermal contact was evaluated for the future construction worker and child and adult receptor. The inhalation exposure pathway was also evaluated for the future child and adult receptors. It was assumed that this exposure would result from outdoor activities.

16.3.2.3 Groundwater

The potential release source considered in evaluating the groundwater pathway was contaminated soils. The release mechanism considered was soil leaching. The transport medium was the groundwater. The routes considered for human exposure to the groundwater were direct ingestion of groundwater, dermal contact during showering, and inhalation of volatilized contaminants during showering.

Residences located on-site in the future scenario were considered to be potential exposure points. At present, on-site groundwater is not potable. As a result, groundwater from on-site sources is not significant and was not evaluated for potential risk in the current scenario. In the future scenario, it is conservatively assumed that a potable well will be installed on-site. However, as stated previously, it is not expected that this residential scenario will be implemented in the future at these military sites. As a result, future groundwater risks on-site were assessed conservatively in accordance with guidance.

16.3.2.4 Surface Water

Potential release sources considered in evaluating the surface water pathway were the contaminated soils and groundwater. The release mechanisms considered were surface runoff and groundwater seepage. The transport medium was the surface water. The potential routes considered for human exposure to the contaminated surface water were incidental ingestion, dermal contact, and inhalation. Potential exposure points were areas of human activity on and adjacent to the site.

At Site 28, current military personnel were evaluated for potential exposure to Orde Pond surface water while participating in training exercises. Current and future residential children and adults were evaluated for exposure from the New River and Cogdels Creek while engaging in outdoor recreation. A current and future fisherman receptor was evaluated for surface water exposure from the New River and Orde Pond.

16.3.2.5 Sediment

The chemical residuals in the contaminated soils and groundwater are the potential release sources to be considered in the sediment pathway. The routes for human exposure to the contaminated sediments by the sediment pathway include ingestion and dermal contact. Potential exposure points from the site are areas of human activity adjacent to the site.

The receptors previously described under the Surface Water Pathway were assumed to also come in contact with the underlying sediment while engaging in outdoor activities. Consequently, the receptors identified for the surface water exposure pathway were also evaluated for exposure to sediment in the current and future scenarios.

16.3.2.6 Air

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates (i.e., fugitive dust generation) and volatilization of contaminants from soil and groundwater. The transport mechanism is the air, and the potential exposure points are the areas of human activity on and adjacent to the site.

Fugitive Dust Generation

This air pathway was evaluated as a source of exposure outdoors at the site via fugitive dust generation of contaminants. Air exposure may occur when surface soils become airborne due to wind erosion or vehicular traffic. It is assumed that military personnel, as well as child and adult receptors, may inhale soil particulates while engaging in outdoor activities. This is applicable for both the current and future cases. This exposure pathway is further assessed in Section 16.4.2, Exposure Pathways, under Surface Soil and Subsurface Soil.

Volatilization

The air pathway, specifically, volatilization of contaminants from groundwater, is a source of exposure at Site 28. It is assumed in the future scenario that an adult and child receptor will inhale volatilized contaminants present in groundwater while showering. This pathway is further discussed in Section 16.4.2, Exposure Pathways, under Groundwater. Also, see the section on Surface Soil for a discussion of the volatilization of contaminants from surface soil.

16.3.2.7 Biota

The potential release sources to be considered in evaluating exposure via fish consumption are contaminated surface water and sediments. Fish can uptake contaminants present in these media by bioaccumulation and biomagnification. The exposure route for human receptors is fish ingestion.

At Site 28, only the fisherman was evaluated for potential risk from fish ingestion. The fish tissue samples collected from the New River and Orde Pond were used in this evaluation.

16.3.3 Quantification of Exposure

The concentrations used in the estimation of chronic daily intakes (CDIs) must be representative of the type of exposure being considered. Exposure to groundwater, sediments, and surface waters can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within this site. As a result, the best way to represent groundwater, sediment, and surface water contaminants from an exposure standpoint is to use a representative exposure concentration. Soils are less transitory than the aforementioned media and in most cases, exposure occurs over a wider area (i.e., residential exposure). Therefore, an upper confidence interval was used to represent a soil exposure concentration. Soil data collected from each of these areas was used separately in estimating the potential human health risks under current and future exposure scenarios. The human health assessment for future groundwater use considered groundwater data collected from all of the monitoring wells within a site and estimated risks to individuals per area of concern.

Since all the data sets originate from a skewed underlying distribution and since log-normal distribution best fits the majority of environmental data sets, the lognormal distribution was used to represent all facility media. This ensures conservatism in the estimation of chronic daily intake associated with potential exposures. Ninety-five percent upper confidence levels (95 percent UCL) derived for lognormal data sets produce concentrations in excess of the 95 percent interval derived assuming normality. For the sake of conservatism, the 95 percent UCL for the lognormal distribution was used for each contaminant in a given data set for quantifying potential exposure. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent UCL can be greater than the maximum measured concentration; therefore, in cases where the 95 percent UCL for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure of the 95 percent UCL However, the true mean may still be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

The following criteria were used to calculate media-specific average concentrations for each parameter that was detected at least once:

- For results reported as "non-detect" (e.g., ND, U, etc.), a value of one-half of the sample-specific detection limit was used to calculate the mean. The use of one-half the detection limit commonly is assigned to non-detects when averaging data for risk assessment purposes, since the actual value could be between zero and a value just below the detection limit.

- Reported concentrations that were less than the detection limit were used to calculate the mean. Typically, these values are qualified with a "J" meaning that the value was estimated.

- Reported concentrations qualified with "R" were excluded from the data set. The data flag "R" means that the QA/QC data indicated that analytical results were not usable for quantitative purposes.

The reduced data were summarized by medium and analytical parameter type (i.e., organics and inorganics) for the site. For each parameter detected during the sampling programs, the frequency of detection, maximum concentration, minimum concentration, average (arithmetic mean) concentration, and both the normal and lognormal upper 95 percent level for the arithmetic average were summarized. This information is presented in Appendix L. It should be noted that the number of times analyzed may differ per parameter per media per area of concern. This is primarily due to data rejected due to QA/QC problems and excluded from the data set. Consequently, these data are not reflected in the number of times analyzed. Data and frequency summaries and statistical summaries are presented in Appendices K and L, respectively.

16.3.4 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at Site 28, a CDI must be estimated for each COPC in every retained exposure pathway. Appendix R contains the specific CDI equations for each exposure scenario of interest. These equations were obtained from USEPA guidance (USEPA, 1989).

The following paragraphs present the general equations and input parameters used in the calculation of CDIs for each potential exposure pathway. Input parameters were taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure or from best professional judgment. All exposure assessments incorporate the representative contaminant concentrations in the estimation of intakes. Therefore, only one exposure scenario was developed for each exposure route/receptor combination.

Carcinogenic risks were calculated as an incremental lifetime risk and, therefore, incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years, or 25,550 days).

Noncarcinogenic risks, on the other hand, were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency representing the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic risks for many exposure routes (e.g., soil ingestion) are greater for children than adults because of the differences in body weights, similar exposure frequencies, and higher ingestion rates.

Future residential exposure scenarios consider 1 to 6 year old children weighing 15 kg and adults weighing 70 kg on average. For current military personnel, an exposure duration of 4 years was used to estimate a military residence. A one-year duration was used for future construction worker exposure scenarios.

16.3.4.1 <u>Incidental Ingestion of Soil</u>

The CDI for COPCs detected in soil was estimated for all potential human receptors and was expressed as:

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

Where:

C	=	Contaminant concentration in soil (mg/kg)
IR	=	Ingestion rate (mg/day)
Fi	=	Fraction ingested from source (dimensionless)
CF	=	Conversion factor ($1x10^{-6}$ kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs associated with the potential ingestion of soils.

<u>Military Personnel</u>

During the course of daily activities at Site 28, military personnel could potentially be exposed to COPCs by the incidental ingestion of surface soils. The IR for military personnel exposed to surficial soils was assumed to be 100 mg/day (USEPA, 1989) and 100 percent of the exposure was assumed to be with facility soils containing COPCs. An exposure frequency (EF) of 250 days per year was used in conjunction with an exposure duration of 4 years. An averaging time (AT) of 70 years or 25,550 days was used for exposure to potentially carcinogenic compounds while an averaging time of 1,460 (4 years x 365 days/year) days was used for noncarcinogenic exposures. An adult average body weight (BW) of 70 kg was used (USEPA, 1989).

Future On-Site Residents

Future on-site residents could potentially be exposed to COPCs in the surficial soils during recreational or landscaping activities around their homes. Children and adults could potentially be exposed to COPCs in soils by incidental ingestion via hand to mouth contact. Ingestion rates (IR) for adults and children in this scenario were assumed to be 100 mg/day and 200 mg/day, respectively. EFs for both receptor groups were assumed to be 350 days per year. The residential exposure duration (ED) was divided into two parts. First, a six-year exposure duration was evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day), and second a 30-year exposure was assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) (USEPA, 1991). The BW for a resident child was assumed to be 15 kg, representing younger individuals. The rationale was that the younger child (1 to 6 years), as a resident, will have access to affected on-site soils. The body weight for the future resident adult is assumed to be 70 kg. Averaging times of 25,550 days for potential carcinogens and 10,950 days (30 years x 365 days/year) for noncarcinogenic constituents was used for estimating potential CDIs for adults. An AT of 2,190 days (6 years x 365 days/year) was used to estimate potential CDIs for children potentially exposed to noncarcinogens.

Future Construction Worker

During excavation activities, construction workers may be exposed to COPCs through the incidental ingestion of subsurface soil. The IR for future construction workers exposed to subsurface soils was assumed to be 480 mg/day (USEPA, 1991). An exposure frequency of 90 days per year was used in conjunction with an exposure duration of one year (USEPA, 1991). An adult BW of 70 kg was used.

A summary of the exposure factors used in the estimation of soil CDIs associated with incidental ingestion is presented in Table 16-8.

16.3.4.2 Dermal Contact with Soil

Chronic daily intakes associated with potential dermal contact of soils containing COPCs were expressed using the following equation:

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

Where:

C	=	Contaminant concentration in soil (mg/kg)
CF	=	Conversion factor (kg/mg)
SA	=	Skin surface available for contact (cm^2)
AF	=	Soil to skin adherence factor (1.0 mg/cm^2)

ABS	=	Absorption factor (dimensionless) - 0.01 for organics, 0.001 inorganics (USEPA, Region IV, 1992d)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with soils.

Military Personnel

There is a potential for base personnel to absorb COPCs by dermal contact. The exposed skin surface area (4,300 cm^2) was limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992). Values for exposure duration (ED), exposure frequency (EF), body weight (BW), and averaging time (AT) were the same as those used for the incidental ingestion of soil scenario. The values for AF and ABS were provided above and are in accordance with USEPA and Region IV guidance.

Future On-Site Residents

Future on-site residents could also be potentially exposed to COPCs in on-site soil through dermal contact experienced during activities near their homes. Skin surface areas (SA) used in the on-site resident exposure scenario were developed for a reasonable worse case scenario for an individual wearing a short-sleeved shirt, shorts, and shoes. The exposed skin surface area was limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the total body surface area results in a default of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) was 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, 1992). Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the incidental ingestion scenario presented previously. The values for AF and ABS were provided above and are in accordance with USEPA and Region IV guidance.

Future Construction Worker

Dermal contact with subsurface soil COPCs could potentially occur during excavation activities. Skin surface area (SA) used for the construction worker exposure scenario were developed for an individual wear a short-sleeved shirt, long pants, and boots. The exposed skin surface area (4,300 cm^2) was limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992). The exposure frequency and exposure duration are the same as those discussed for incidental ingestion of subsurface soil. The values for AF and ABS were provided above and are in accordance with USEPA and Region IV guidance.

A summary of the soil exposure assessment input parameters for dermal contact is presented in Table 16-8.

16.3.4.3 Inhalation of Fugitive Particulates

Exposure to fugitive particulates was estimated for future residents and base personnel. These populations may be exposed during daily recreational or work-related activities. The chronic daily intake of contaminants associated with the inhalation of particulates was estimated using the following equation:

$$CDI = \frac{C \ x \ IR \ x \ EF \ x \ ED \ x \ 1/PEF}{BW \ x \ AT}$$

Where:

C	=	Contaminant concentration in soil (mg/kg)
IR	=	Inhalation rate (m^3/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)

The PEF relates the concentration in soil with the concentration of respirable particles in the air from fugitive dust emission. This relationship is derived by Cowherd (1985). The particulate emissions from contaminated sites are caused by wind erosion, and, therefore, depend on erodibility of the surface material. A default PEF obtained from USEPA guidance (USEPA, 1989b) was used in this assessment.

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from the inhalation of particulates.

Military Personnel

During work related activities, military personnel may inhale COPCs emitted as fugitive dust. An inhalation rate 30 m^3/day was used for military personnel (USEPA, 1991). Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the incidental ingestion scenario.

Future On-Site Residents

Future on-site residents may also inhale particulates. Inhalation rates (IR) used in the on-site resident exposure scenario were 20 m^3/day and 10 m^3/day for adults and children, respectively (USEPA, 1989). Exposure frequencies, duration, body weights, and averaging time were the same as those used for the incidental ingestion scenario. Table 16-8 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

Future Construction Worker

Future construction workers could become exposed to subsurface soil particulates during excavation activities. The inhalation rate (IR) used was 20 m^3/day (USEPA, 1989). Exposure frequencies, duration, body weight, and averaging time were the same as those used for the soil incidental ingestion scenario. Table 16-8 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

16.3.4.4 Ingestion of Groundwater

As stated previously, shallow groundwater is not currently being used as a potable supply at Site 28. Development of the shallow aquifer for potable use is unlikely because of its general water quality and poor flow rates. However, residential housing could be constructed in the future and groundwater used for potable purposes.

The CDI of contaminants associated with the future potential consumption of groundwater was estimated using the following general equation:

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

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 discuss the exposure assumptions used in the estimation of exposure to COPCs from the ingestion of groundwater.

Future On-Site Residents

Exposure to COPCs via ingestion of groundwater was retained as a potential future exposure pathway for both children and adults. An IR of 1.0 L/day was used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. This ingestion rate provides a conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who may be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year (which represents the exposure frequency [EF]). An averaging time (AT) of 2,190 days (6 years x 365 days/year) is used for noncarcinogenic compound exposure. The ingestion rate (IR) for adults was 2 liters/day (USEPA, 1989a). The ED used for the estimation of adult CDIs was 30 years (USEPA, 1989), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens was 10,950 days. An averaging time (AT) of 25,550 days (70 years x 365 days/year) was used to evaluate exposure for both children and adults to potential carcinogenic compounds. Table 16-8 presents a summary of the input parameters for the ingestion of groundwater scenarios.

16.3.4.5 Dermal Contact with Groundwater

The CDI associated with the dermal contact with groundwater was estimated using the following general equation:

$$CDI = \frac{C \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

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 discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with groundwater.

Future On-Site Residents

Children and adults could contact COPCs through dermal contact with groundwater while bathing or showering. It was assumed that bathing would take place 350 days/year using site groundwater as the sole source. The whole body skin surface area (SA) available for dermal absorption was estimated to be 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose, yet many compounds do not have literature PC values. For contaminants in which a PC value has not been established, the permeability constant was calculated (see Appendix O) . An exposure time (ET) of 0.25 hour/day was used to conservatively estimate the duration of bathing or showering. The exposure duration, body weight, and averaging time were the same as those used for the ingestion of groundwater scenario. Table 16-8 presents the exposure factors used to estimate CDIs associated with the future dermal contact with COPCs in groundwater.

16.3.4.6 Inhalation of Volatile Organics While Showering

In order to quantitatively assess the inhalation of contaminants volatilized from shower water, the model developed by Foster and Chrostowski (1986) was utilized. Contaminant concentrations in air were modeled by estimating the following: the rate of chemical releases into air (generation rate), the buildup of VOCs in the shower room air while the shower was on, the decay of VOCs in the shower room after the shower was turned off, and the quantity of airborne VOCs inhaled while the shower was both on and off. The contaminant concentrations calculated to be in the air were then used as the concentration term.

The CDIs associated with the inhalation of airborne (vapor phase) VOCs from groundwater while showering were estimated using the following general equation:

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

Where:

C	=	Contaminant concentration in air (mg/m^3)
IR	=	Inhalation rate (m^3/hr)
ET	=	Exposure time (hr/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT_c	=	Averaging time carcinogen (days)
AT_{nc}	=	Averaging time noncarcinogen (days)

Future On-Site Residents

Both children and adults could inhale vaporized volatile organic COPCs during showering. It was assumed that showering would take place 350 days/year, using site groundwater as the sole source, for children weighing 15 kg, and adults weighing 70 kg (USEPA, 1989). An inhalation rate of 0.6 m^3/hr was used for both receptors (USEPA, 1989). An exposure time of 0.25 hrs/day was used for both receptors (USEPA, 1989). The exposure duration and averaging times remained the same as for groundwater ingestion. Table 16-8 presents the exposure factors used to estimate CDIs associated with the inhalation of VOCs from groundwater while showering.

16.3.4.7 Incidental Ingestion of Surface Water

The CDIs for contaminants associated with incidental ingestion of surface water were expressed using the following equation:

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

Where:

C	=	Contaminant concentration in surface water (mg/L)
IR	=	Ingestion rate (L/day)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from the incidental ingestion of surface water.

Current Military Personnel

Current military personnel may incidentally ingest surface water while engaging in training exercises in Orde Pond. They may conservatively ingest surface water at a rate of 0.005 L/hour, (USEPA, 1989). In addition, an exposure frequency (EF) of 45 days/year (9 days/month x 5 months) and an exposure duration (ED) of 4 years (USEPA, 1989) was assumed. An exposure time (ET) of 2.6 hours/day was assumed for all receptors.

Current and Future Children and Adults

Adults and children who may potentially come into contact with the surface water were assumed to conservatively ingest surface water at a rate of 0.005 L/hour (USEPA, 1989). In addition, an exposure frequency (EF) of 45 days/year (9 days/month x 5 months), an ET of 2.6 hours/day and an exposure duration (ED) of 6 years (age 1-6) for a child, and 30 years for an adult were used (USEPA, 1989).

Current and Future Fisherman

A fisherman may potentially come into contact with the surface water was assumed to conservatively ingest surface water at a rate of 0.005 L/hour, (USEPA, 1989). In addition, an exposure frequency (EF) of 48 days/year (USEPA, 1989), an ET of 2.6 hours/day, and an exposure duration (ED) of 30 years were used.

A summary of the surface water exposure factors associated with incidental ingestion of surface water is presented in Table 16-8.

16.3.4.8 Dermal Contact with Surface Water

The CDIs of contaminants associated with dermal contact of surface water were determined using the following general equation:

$$CDI = \frac{C \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

Where:

C	=	Contaminant concentration in surface water (mg/L)
CF	=	Conversion factor (1 L/1000 cm^3)
SA	=	Surface area available for contact (cm^2)
PC	=	Chemical-specific dermal permeability constant (cm/hr)
ET	=	Exposure time (hour/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with surface water.

Current Military Personnel

Current military personnel may contact surface water while engaging in training exercises in Orde Pond. The surface area (SA) for this receptor was assumed to be 4,300 cm^2; which was discussed under the soil exposure scenario. In addition, an exposure frequency (EF) of 45 days/year (9 days/month x 5 months) and an exposure duration (ED) of 4 years (USEPA, 1989) was assumed. The exposure rate used for swimming, 2.6 hours/day, was conservatively used for this receptor. The values for PC were chemical-specific. For COPCs with no PC available, the values were calculated (see Appendix O).

Current and Future Children and Adults

The SA for adults and children who may potentially come into contact with the surface water was assumed to be 5,800 and 2,300 cm^2, respectively, as previously described in the soil exposure scenario. In addition, an exposure frequency (EF) of 45 days/year (9 days/month x 5 months) and an exposure duration (ED) of 6 years (age 1-6) for a child, and 30 years for an adult were used (USEPA, 1989). It was conservatively assumed that 2.6 hours/day would be the exposure time for these receptors. The values for PC were chemical-specific. For COPCs with no PC values available, the values were calculated (see Appendix O).

Current and Future Fisherman

The SA for the fisherman who may potentially come into contact with the surface water was assumed to be 5,800 cm^2.. In addition, an exposure frequency (EF) of 48 days/year and an exposure duration (ED) of 30 years for an adult were used (USEPA, 1989). The ET of 2.6 hours/day was also used for this receptor. Exposure time, frequency, and duration were the same as for the surface water ingestion scenario. The values for PC were chemical-specific. For COPCs with no PC available, the value was calculated (see Appendix O). The exposure factors for this potential exposure pathway are summarized in Table 16-8.

16.3.4.9 Incidental Ingestion of Sediment

The CDI of COPCs associated with the incidental ingestion of sediment was expressed using the following general equation:

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

Where:

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

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from incidental ingestion of sediments.

Current Military Personnel

Incidental ingestion of COPCs in sediments is also possible during activities occurring in the surface water bodies at Site 28, namely Orde Pond. An ingestion rate (IR) of 100 mg/day was used in calculating the chronic daily intake for children and adults. The exposure frequency (EF) of 45 days/year (9 days/month x 5 months) was used as a conservative site-specific assumption. An exposure duration (ED) of 4 years was used in the estimation of potential COPCs for the receptor.

Current and Future Children and Adults

Incidental ingestion of COPCs in sediments is also possible during activities occurring in the surface water bodies at Site 28, specifically the New River and Cogdels Creek. An ingestion rate (IR) of 100 mg/day was used in calculating the chronic daily intake for children and adults. The exposure frequency (EF) of 45 days/year (9 days/month x 5 months) was used as a conservative site-specific assumption. An exposure duration (ED) of 6 years and 30 years was used in the estimation of potential COPCs for a child and adult, respectively.

Current and Future Fisherman

Incidental ingestion of COPCs in sediments is also possible during activities occurring in the surface water bodies at Site 28, particularly the New River and Orde Pond. An ingestion rate (IR) of 100 mg/day was used in calculating the chronic daily intake for children and adults. The exposure frequency (EF) of 48 days/year was used. An exposure duration (ED) of 30 years was used.

A summary of exposure factors for this scenario is presented in Table 16-8.

16.3.4.10 Dermal Contact with Sediment

The CDI of contaminants associated with the dermal contact of affected sediments was expressed using the following general equation:

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

Where:

C	=	Contaminant concentration in sediment (mg/kg)
CF	=	Conversion factor ($1x10^{-6}$ kg/mg)
SA	=	Surface area available for contact (cm^2/day)
AF	=	Adherence factor (1.0 mg/cm^2)
ABS	=	Absorption factor (dimensionless) - 0.01 organics, 0.001 inorganics (USEPA, Region IV, 1992d)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with sediment.

Current Military Personnel

Dermal contact with COPCs in sediments is also possible during activities occurring in the surface water bodies at Site 28, particularly Orde Pond. It was assumed that military personnel have approximately 4,300 cm^2 (USEPA, 1992) of skin surface (SA) available for dermal exposure with COPCs. Values for exposure duration (ED), exposure frequency (EF), body weight (BW), and averaging time (AT) were the same as those used for the incidental ingestion of surface water scenario. The values for AF and ABS were provided with the equation and are in accordance with USEPA and Region IV guidance.

Current and Future Children and Adults

Future on-site residents could also be potentially exposed to COPCs in sediment via dermal contact. Skin surface areas (SA) used in the resident exposure scenario were developed for a reasonable worse case scenario for an individual wearing a short -leeved shirt, shorts, and shoes. The exposed skin surface area was limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the total body surface area results in a default of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) was 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. The child SA was calculated using information presented in USEPA guidance (USEPA, 1992). Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the surface water exposure scenario presented previously. The values for AF and ABS were provided with the equation and are in accordance with USEPA and Region IV guidance.

Current and Future Fisherman

The exposed skin surface area for the fisherman was limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the total body surface area results in a default of 5,800 cm^2 for adults. The exposed skin surface for a fisherman was estimated as 5,800 cm^2. Exposure duration, exposure frequencies, body weight, and averaging times were the same as those discussed for the surface water exposure scenario presented previously. The values for AF and ABS were provided with the equation and are in accordance with USEPA and Region IV guidance. Table 16-8 provides a complete summary of the input parameters used in the estimation of CDIs for this scenario.

16.3.4.11 Biota

The CDI associated with the potential ingestion of biota was expressed using the following equation:

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

Where:

C	=	Contaminant concentration in fish (mg/kg)
IR	=	Ingestion rate (kg/meal)
Fi	=	Fraction ingested from source(dimensionless)
EF	=	Exposure frequency (meals/year)

ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

Current and Future Fisherman

The ingestion rate was 0.284 kg/day which represents the upper 95th percentile consumption rate occurring in conjunction with recreational fishing (USEPA, 1989). The fraction of fish ingested from the source (Fi) for adults was estimated to be 100 percent (1.0) for the 90th percentile consumption rate. The exposure frequency is 48 meals/year. The exposure duration (ED) for adults was set at 30 years, and an averaging time (AT) of 70 years or 25,550 days was used for exposure to carcinogenic compounds. An AT of 10,950 days was used for exposure to noncarcinogenic COPCs (USEPA, 1989).

Table 16-8 presents a summary of the exposure factors used for the ingestion of fish scenario.

16.4 Toxicity Assessment

The purpose of this section is to define the toxicological values used to evaluate the exposure to the COPCs identified in Section 16.2. A toxicological evaluation characterizes the inherent toxicity of a compound. 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.

Human data from occupational exposures are often insufficient for determining quantitative indices of toxicity because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results are extrapolated to humans. There are several stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors and modifying factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate effects at high doses to effects at lower doses. Epidemiological data can be used for inferential purposes to establish the credibility of the experimentally derived indices.

The available toxicological information indicates that many of the COPCs have both potential carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although the COPCs may cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risk to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

An important component of the risk assessment is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) 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.

Standard carcinogenic slope factors (CSFs) and/or reference doses (RfDs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

16.4.1 Carcinogenic Slope Factor

CSFs are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989). This factor is generally reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95th percent confidence limit.

These slope factors are also accompanied by USEPA weight-of-evidence (WOE) classifications, which designate the strength of the evidence that the COPC is a potential human carcinogen.

In assessing the carcinogenic potential of a chemical, the Human Health Assessment Group (HHAG) of USEPA classifies the chemical into one of the following groups, according to the weight of evidence from epidemiologic 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)

16.4.2 Reference Dose

The RfD is developed for chronic and/or subchronic human exposure to chemicals and is based solely on the noncarcinogenic effects of chemical substances. It is defined as an estimate of a daily exposure level for the human population, including sensitive populations, that is not likely to cause 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 an appropriate uncertainty factor (UF). Effect levels are determined from 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, 1989):

- 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:

- A 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 16-10. The hierarchy (USEPA, 1989) for choosing these values was as follows:

- Integrated Risk Information System (IRIS, 1994)
- Health Effects Assessment Summary Table (HEAST, 1994)

The IRIS data base 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 validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they appear in the IRIS data base. Like the CSF Workgroup, the USEPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses has 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 data base.

Toxicity values will be obtained primarily from the Region III Risk-Based Concentration Table, which is based on IRIS, HEAST and provisional and/or recommended USEPA toxicity values, in accordance with Region IV recommendations.

For some chemicals, there are no USEPA-verified toxicity values(i.e., RfDs and CSFs) available for risk quantitation. This is the case for lead. The following section provides a discussion of how lead health effects were quantified for this assessment.

16.4.3 Lead

Lead was identified as a COPC across most media of concern at Site 28. Currently, health-based criteria are not available for evaluating either the noncarcinogenic or carcinogenic effects of lead exposure. The USEPA has not developed health-based criteria because a threshold level for many noncancer health effects has not been identified in infants and younger children (i.e., the most sensitive populations). Consequently, risk from lead exposure was not calculated for the site.

To evaluate lead at waste sites, the USEPA had developed a lead uptake/biokinetic (UBK) model. This model utilizes site-specific exposure parameters to estimate blood lead levels in infants and young children. The USEPA considers remediation necessary if a 5 percent probability or greater exists that the predicted child blood level will exceed 10 µg/dl as a result of contact with lead-containing media at the site.

There are several criteria available for lead level comparisons in the form of standards, criteria and/or TBCs. These standards/criteria/TBCs include federal and state MCLs, AWQC and USGS background levels for metals in urban soils. In addition, there is an Office of Solid Waste and Emergency Response (OSWER) directive for lead in soil. The concentration range was 500 to 1,000 ppm. However, according to the USEPA Region IV office, there is an upcoming addendum which states that the level is now 400 ppm. At Site 28, the maximum concentrations of lead found in the soils and sediment (New River) of Site 28 exceeded this OSWER level. Lead in groundwater at the site exceeded standards/criteria/TBCs. Consequently, the lead UBK model was utilized to evaluate the risk associated with exposure to lead-containing media at Site 28.

16.4.4 Dermal Adjustment of Toxicity Factors

Because there are few toxicity reference values for dermal exposure, oral values are frequently used to assess risk from dermal exposure. Most RfDs and some slope factors are expressed as the amount of substance administered per unit time and unit body weight, while exposure estimates for the dermal route are expressed as absorbed dose. Consequently, it may be necessary to adjust an oral toxicity value from an administered dose to an absorbed dose.

Region IV provides absorption efficiency values for each class of chemicals. They are as follows:

VOCs	=	0.80
SVOCs	=	0.50
Inorganics	=	0.20
Pesticides/PCBs	=	0.50

An adjusted oral RfD is the product of the absorption efficiency and the oral toxicity reference value. The adjusted oral CSF is the ratio of the oral toxicity value and the absorption efficiency. Table 16-11 presents of summary of the dermally-adjusted toxicity values used in this BRA.

16.5 <u>Risk Characterization</u>

This section presents and discusses the estimated incremental lifetime cancer risks (ICRs) and hazard indices (HIs) for identified potential receptor groups which could be exposed to COPCs via the exposure pathways presented in Section 16.3.

These quantitative risk calculations for potentially carcinogenic compounds estimate ICRs levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an ICR of 1×10^{-6} indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

The ICR to individuals was estimated from the following relationship:

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

where CDI_i is the chronic daily intake (mg/kg/day) for compound i and CSF_i is the cancer slope in (mg/kg/day)-1for contaminant i. The CSF is defined in most instances as an upper 95th percentile confidence limit of the probability of a carcinogenic response based on experimental animal data, and the CDI is defined as the 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 was 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.

In contrast to the above approach for potentially carcinogenic effects, quantitative risk calculations for noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects is calculated by comparing CDIs with threshold levels (reference doses).

Noncarcinogenic effects were estimated by calculating the hazard index (HI) which is defined as:

$$HI = HQ_1 + HQ_2 + ...HQ_n \text{ or}$$

$$HI = \sum_{i=1}^{n} HQ_i$$

$$\text{where } HQ_i = CDI_i / RfD_i$$

HQi is the hazard quotient for contaminant i, CDI_i is the chronic daily intake (mg/kg/day) of contaminant i, and RfD_i is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure.

16.5.1 Human Health Risks

The following paragraphs present the quantitative results of the human health evaluation for each medium and area of concern at Site 28.

Estimated ICRs were compared to the target risk range of 1×10^{-4} to 1×10^{-6}. A value of 1.0 was used for examination of the HI. The HI was calculated by comparing estimated CDIs with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggested that noncarcinogenic health effects were possible. If the HI was less than 1.0, then systemic human health effects were considered unlikely. Tables 16-12 through 16-14 present these risk results.

16.5.1.1 Current Military Personnel

The current military receptor was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to the surface soil and surface water and sediment from Orde Pond. The noncarcinogenic (i.e., HI=0.098) and carcinogenic risks (i.e., CR=$1.4x10^{-6}$) from exposure to all media fell below the acceptable risk levels (i.e., HI<1 and $1x10^{-4}$<CR<$1x10^{-6}$). These results are presented in Table 16-14.

16.5.1.2 Current Recreational Child

In the current scenario, a recreational child receptor was evaluated for potential risk from exposure to site surface soils and surface water and sediment from the New River and Cogdels Creek. In the sediment of the New River, there was a potential noncarcinogenic risk from the ingestion route. The noncarcinogenic risk from the ingestion pathway was 1.2. The COPC driving the noncarcinogenic risk was antimony.

The potential noncarcinogenic and carcinogenic risks from exposure to the surface soil (i.e., HI=0.62 and CR=$7.4x10^{-6}$), the surface water of the New River (i.e., HI= 0.013 and CR=$2.8x10^{-7}$) and the surface water and sediment of Cogdels Creek (i.e., HI=0.17 and CR=$3.5x10^{-6}$) were within acceptable risk levels (i.e., HI<1 and $1x10^{-4}$<CR<$1x10^{-6}$). The results are summarized in Table 16-12.

16.5.1.3 Future Residential Child

The child receptor was evaluated for potential risk from exposure to subsurface soil and groundwater in the future scenario. It was assumed that current exposure to the surface water and sediment of the New River and Cogdels Creek also would occur in the future case.

In subsurface soil, the potential noncarcinogenic risk from ingestion was 1.6, which exceeds the acceptable level of one for noncarcinogens. The COPCs contributing to this risk were antimony (HQ=0.38), arsenic (HQ=0.34), copper (HQ=0.31), and zinc (HQ=0.18). It is important to note that the noncarcinogenic risk associated with each metal does not exceed one, but the summation of the risks is greater than one. If these risks are segregated based on target organ effects, the total risk may be an overestimate. Antimony and zinc affect the blood system. Copper effects the gastrointestinal system. Arsenic affects the skin. Based on target organ effect, the total noncarcinogenic risks are segregated and do not exceed one.

In groundwater, there is a potential noncarcinogenic risk from ingestion for the child receptor. The noncarcinogenic risk level was 20 from groundwater ingestion. This value exceeded the acceptable risk level of one for noncarcinogenic risks. Manganese in groundwater contributed to this risk. As stated in the current case, there is a potential noncarcinogenic risk from the sediment ingestion pathway at the New River. Antimony contributes to this risk. The risk results are presented in Table 16-12.

16.5.1.4 Current Recreational Adult

In the current scenario, a recreational adult receptor was evaluated for potential risk from exposure to site surface soils (i.e., HI=0.08 and CR=$6x10^{-6}$) and surface water and sediment from the New River (i.e., HI=0.16 and CR=$4.5x10^{-6}$), and Cogdels Creek (i.e., HI=0.03 and CR=$3x10^{-6}$). For this receptor in the current case, the potential noncarcinogenic and carcinogenic risks from exposure to these media were within acceptable risk levels (i.e., HI<1 and $1x10^{-4}$<CR<$1x10^{-6}$). These results are provided in Table 16-13.

16.5.1.5 Future Residential Adult

The adult receptor was evaluated for potential risk from exposure to subsurface soil and groundwater in the future scenario. Similar to the child receptor, it was assumed that current exposure to the surface water and sediment of the New River and Cogdels Creek also would occur in the future case.

In subsurface soil (i.e., HI=0.22 and CR=$2.1x10^{-5}$), surface water (i.e., New River - HI=$5.7x10^{-3}$ and CR=$2x10^{-6}$; Cogdels Creek - HI=$3.1x10^{-3}$ and CR=$3x10^{-7}$) and sediment (i.e., New River - HI=0.16 and CR=$2.5x10^{-6}$; Cogdels Creek - HI=0.02 and CR=$2.6x10^{6}$), the potential noncarcinogenic and carcinogenic risks from exposure to these media were within acceptable levels (i.e., HI<1 and $1x10^{-4}$<CR<$1x10^{-6}$).

In groundwater, the potential noncarcinogenic and carcinogenic risks from ingestion and dermal contact do not fall within acceptable risk levels. The potential noncarcinogenic risk from groundwater ingestion was 8.6. The total potential carcinogenic risk from groundwater was $1.4x10^{-4}$. These risk values exceeded the acceptable risk levels of one for noncarcinogenic risks and $1x10^{-4}$for carcinogenic risks. Manganese contributed to the risks. Table 16-13 is a summary of these results.

16.5.1.6 Current Fisherman

A fisherman receptor was evaluated for risk from exposure to the surface water (i.e., Orde Pond - HI=0.01; New River - HI=$6.1x10^{-3}$ and CR=$7x10^{-7}$), sediment (i.e., Orde Pond - HI=$6.8x10^{-3}$ and CR=$1.3x10^{-6}$; New River - HI=0.18 and CR=$2.7x10^{-7}$)and fish tissue (i.e., Orde Pond - HI=0.09; New River - HI=0.4 and CR=$5.6x10^{-6}$) of the New River and Orde Pond. The potential noncarcinogenic and carcinogenic risks from exposure to these media were within acceptable risk levels (i.e., HI<1 and $1x10^{-4}$<CR<$1x10^{-6}$). These results are provided in Table 16-14.

16.5.1.7 Future Construction Worker

The construction worker was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to the subsurface soil in the future case. Both noncarcinogenic (i.e., HI=0.2) and carcinogenic risks (i.e., CR=$6x10^{-7}$) from exposure to the subsurface soil for this receptor fell within the acceptable risk levels. Table 16-14 presents these results.

16.6 Standard/Criteria/TBCs Comparison Results

The following subsections provide a brief summary of the COPCs identified in each medium of concern which exceed a standard/criteria/TBC. The results of the comparison of sediment and fish tissue results to standard/criterias/TBCs can be found in Section 17, Ecological Risk Assessment, of this report.

16.6.1 Surface Soil

On comparison of Site 28 background surface soil total metal concentrations to maximum USGS levels, there were no exceedances. On comparison of the total metal levels in the site surface soils to the maximum USGS levels, antimony (3/38), cadmium (10/38), copper (1/43), lead (4/43), manganese (1/43), selenium (1/43), silver (1/43) and zinc (2/43) exceeded the levels at the noted frequencies. All the inorganic COPCs in the site surface soil exceeded twice the average site background level at the noted frequencies: aluminum (7/43), antimony (12/38), arsenic (18/43), barium (20/43), cadmium (13/43), calcium (31/43), chromium (25/43), cobalt (3/43), copper (23/43), iron (22/43), lead (20/43), magnesium (20/43), manganese (35/43), mercury (25/43), nickel (13/43), potassium (17/43), selenium (2/43), silver (7/43), sodium (4/43), thallium (2/43), vanadium (17/43) and zinc (36/43).

16.6.2 Subsurface Soil

On comparison of Site 28 background subsurface soil total metal concentrations to maximum USGS levels, there were no exceedances. On comparison of the total metal levels in the site subsurface soils to the maximum USGS levels, the following metals exceeded at the noted frequencies: antimony (13/45), cadmium (19/51), copper (2/45), iron (2/51), lead (10/51), selenium (1/51), silver (8/51) and zinc (1/51). All the inorganic COPCs in the site subsurface soil exceeded twice the average site background level at the noted frequencies: aluminum (19/51), antimony (18/45), arsenic (38/51), barium (30/51), beryllium (4/51), cadmium (22/51), calcium (41/51), chromium (35/51), cobalt (18/51), copper (33/45), iron (38/51), lead (37/51), magnesium (36/51), manganese (29/51), nickel (10/51), potassium (31/51), selenium (1/51), silver (13/51), sodium (15/51), thallium (1/51), vanadium (30/51) and zinc (36/51).

16.6.3 Groundwater

The VOCs found in the groundwater were compared to federal and state MCLs. Chloroform, toluene, ethylbenzene and xylene did not exceed Federal MCLs. Chloroform did exceed the state MCL at a frequency of 1 out of 13 analyzed. The remaining VOCs did not exceed the state levels.

Of the 17 SVOCs found in the groundwater, only one, BEHP, has Federal and state criteria. BEHP exceeded both levels at a frequency of 1 out of 13 analyzed. Di-n-butylphthalate has a state MCL. It did not exceed this level.

Of the total metals detected in the shallow and deep groundwater at Site 28, the following metals have federal MCLs: arsenic, barium, copper, lead, mercury, and nickel. On comparison of total metals concentrations in the shallow and deep groundwater to federal MCLs, only lead exceeded (1/12). There are currently no federal MCLs available for the following inorganic COPCs: aluminum, calcium, iron, magnesium, manganese, potassium, sodium and zinc.

The following detected metals have state MCLs available for comparison: arsenic, barium, copper, iron, lead, manganese, mercury, nickel and zinc. On comparison of total metals concentrations in the shallow and deep groundwater to the state MCLs, the following metals exceeded the state criteria: iron (7/12); lead (1/12); and manganese (7/12). There are currently no state MCLs available for the following inorganic COPCs found in the groundwater: aluminum, calcium, magnesium, potassium, sodium and vanadium.

16.6.4 Surface Water - New River

Acetone was found in the surface water of the New River. There are no available Federal AWQC or state WQC for comparison.

Phenanthrene and BEHP were detected in the New River surface water. Both SVOCs have Federal and state levels available for comparison. On comparison to the Federal human health AWQC and state WQC, phenanthrene exceeded all criteria (based on the ingestion of water and organisms and organisms only) at a frequency of 1 out of 5 analyzed. BEHP also exceeded the criteria at exceedance frequencies of 1 out of 5 (water and organisms), 1 out of 5 (Federal - organisms only) and 3 out of 5 (state)

4,4'-DDE and 4,4'-DDD were found in the surface water of the New River. Only Federal criteria were available for these pesticides. Both exceeded criteria at a frequency of 1 out of 5 analyzed.

Total metals detected in the surface water of the New River were compared to available Federal AWQC (human health criteria based on the ingestion of water and organisms). Of the 16 metals found, arsenic, barium, cadmium, copper, iron, lead, manganese, nickel and thallium have available Federal levels. Arsenic (3/5) and iron (5/5) exceeded the Federal AWQC. Barium, cadmium, copper, lead, manganese nickel and thallium did not exceed the levels. There were no state WQC criteria available for any of the detected metals.

Total metals detected in the surface water of the New River were compared to available Federal AWQC (human health criteria based on the ingestion of organisms only). Of the 16 metals found, arsenic, manganese, nickel and thallium have available Federal levels. Only arsenic exceeded the Federal AWQC at a frequency of 3 out of 5 analyzed. Manganese, nickel and thallium did not exceed the levels.

16.6.5 Surface Water - Cogdels Creek

Methylene chloride, acetone and 2-hexanone were found in the surface water of Cogdels Creek. Only methylene chloride has Federal AWQC (human health criteria based on ingestion of water and organisms and organisms only), which it did not exceed. There is no state criteria available for any of the detected VOCs.

Total metals detected in the surface water of Cogdels Creek were compared to available Federal AWQC (human health criteria based on the ingestion of water and organisms). Of the 14 metals found, arsenic, barium, copper, iron, lead, manganese and nickel have available Federal levels. Arsenic (1/7), iron (7/7), and manganese (1/7) exceeded the Federal AWQC. Barium, copper, lead and nickel did not exceed the levels. There were no state WQC criteria available for any of the detected metals.

Total metals detected in the surface water of Cogdels Creek were compared to available Federal AWQC (human health criteria based on the ingestion of organisms only). Of the 14 metals found, arsenic, manganese and nickel have available Federal levels. Only arsenic exceeded the Federal AWQC at a frequency of 1 out of 7 analyzed. Manganese and nickel did not exceed the levels.

16.6.6 Surface Water - Orde Pond

Methylene chloride was found in the surface water of Orde Pond. On comparison to Federal AWQC (human health criteria based on the ingestion of water and organisms), methylene chloride exceeded at a frequency of 2 out of 2 analyzed. There was no state WQC available for this VOC.

Total metals detected in the surface water of Orde Pond were compared to available Federal AWQC (human health criteria based on the ingestion of organisms only). Of the 8 metals found, nickel and thallium have available Federal levels. Both metals did not exceed the levels.

16.6.7 Sediment

Discussion of the sediment results on comparison to NOAA criteria is provided in Section 17.0, Ecological Risk Assessment.

16.7 Lead UBK Model Results

The USEPA lead UBK model was used to determine if exposure to site media would result in unacceptable blood lead levels in younger children upon exposure to the soil and groundwater at Site 28. Blood lead levels are considered unacceptable when a greater than 5 percent probability exists that the blood lead levels will exceed 10 µg/dl.

The average concentrations of lead found in the surface soil (current case), subsurface (future case) and groundwater were used in the model. The remaining model parameters used were the default factors supplied in the model. The average concentrations in surface soil, subsurface soil and groundwater resulted in a less than 5 percent probability of the blood lead levels exceeding 10 µg/dl, which is within acceptable levels. Figures 16-2 through 16-5 illustrate these results.

16.8 Sources of Uncertainty

Uncertainties may be encountered throughout the BRA process. This section discusses the sources of uncertainty involved with the following:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Qualitatively Evaluated

In addition, the USEPA stresses the importance of recognizing the unique characteristics and circumstances of each facility and the need to formulate site-specific responses. However, many of the assumptions presented in this document were derived from USEPA guidance, which is designed to provide a conservative approach and cover a broad variety of cases. As such, the generic application of such assumptions to a site in the RME case scenario may work against the objective of formulating a site-specific response to a constituent presence (i.e., it is possible that the site risks may be overestimated).

The following sections provide a discussion of the sources of uncertainty associated with this BRA and the effects on total site risk.

16.8.1 Analytical Data Uncertainty

The development of a BRA depends on the reliability of and uncertainties with 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 the data (mean concentration, standard deviation, and detection frequencies) are subject to the uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with the 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 the estimation of risk. Data qualified as "J" (estimated) were retained for the estimation of risk at OU No.7. Data can be qualified as estimated for many reasons including a slight exceedance of holding times, high or low surrogate recovery, or intra sample variability. Organic data qualified "B" (detected in blank) or "R" (unreliable) were not used in the estimation of risk due to the unusable nature of the data. Due to the comprehensive sampling and analytical program at OU No.7, the loss of some data points qualified "B" or "R" did not significantly increase the uncertainty in the estimation of risk.

16.8.2 Exposure Assessment Uncertainty

In 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 the estimation of contaminant intakes resulting from contact by a receptor with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor could potentially be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a data set. More complex methods of deriving the contaminant concentration are necessary when exposure to COPCs in a given medium occurs subsequent to release from another medium, or when analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate the potential human exposure.

The potential inhalation of fugitive dusts from affected soils was estimated in the BRA using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites (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 estimate of the PEF was derived for Site 28 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential. Modeling results for fugitive dust emission exposure suggested that the potential risk associated with this pathway was not significant.

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, for the sake of conservatism, total organic results were used to estimate the potential intake associated with groundwater use.

Currently, the shallow groundwater is not used as a potable source. Current receptors (military personnel, military dependents, and civilian base personnel) are exposed via ingestion, dermal contact, and inhalation to groundwater drawn from the deep zone. Therefore, assessing current risks to contaminants detected in the shallow aquifer for current receptors is unnecessary and, if estimated, may present an unlikely risk. Therefore, groundwater exposure to current receptors was not estimated for this investigation.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of contaminants by the receptor. Exposure factors, have been generated by the scientific community and have undergone review by the USEPA. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited number of individuals. In all instances, values used in the risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA. Conservative assumptions designed not to underestimate daily intakes were employed throughout the BRA and should error conservatively, thus adequately protecting human health and allowing the establishment of reasonable clean-up goals.

16.8.3 Sampling Strategy Uncertainty

Soil represents a medium of direct contact exposure and often is the main source of contaminants released into other media. The soil sampling depth should be applicable for the exposure pathways and contaminant transport routes of concern and should be chosen purposely within that depth interval. If a depth interval is chosen purposely, a random sample procedure to select a sampling point may be established. The assessment of surface exposure at the site is certain based on collection of samples from the shallowest depth, zero to one foot. Subsurface soil samples are important, however, if soil disturbance is likely or leaching of chemicals to groundwater is of concern.

The surface soil samples at all sites were obtained directly or very near the suspected disposal areas. Therefore, these areas would be considered areas of very high concentration which would have a significant impact on exposures.

Because buried chemical agents may have been present, the subsurface soil investigation did not include extensive sampling. The subsurface soil concentrations used in determining construction workers exposures were derived from subsurface soils which were from around the site or off-site. Consequently, the risk to future construction workers from ingestion, dermal contact, and inhalation with subsurface soils may be biased low. However, given the limited contaminants detected in the surface soil and groundwater, it does not appear as if additional subsurface soil sampling is needed.

16.8.4 Toxicity Assessment Uncertainty

In making quantitative estimates of the toxicity of varying doses of a compound to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are available at all. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used; and, therefore, new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental animals, high doses of a compound are used over a relatively short time period. In this situation, a high dose means that experimental animal exposures are much greater than human environmental exposures. Therefore, when applying the results of the animal experiment to humans, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from animals to humans and 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 where the animal closely mimics human pharmacokinetics

- Studies are preferred where dose intake most closely mimics the intake route and duration for humans

- Studies are preferred which demonstrate the most sensitive response to the compound in question

For compounds believed to cause threshold effects (i.e., noncarcinogens), safety factors are employed in the extrapolation of effects from animals to humans and from high to low doses.

The use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

16.9 Conclusions of the BRA for Site 28

The BRA highlights the media of interest from the human health standpoint at Site 28 by identifying areas with risk values greater than acceptable levels. Current and future potential receptors at the site included current military personnel, current recreational receptors (i.e., children and adults), future residents (i.e., children and adults), a current and future fisherman, and future construction workers. The total risk from each site for the these receptors was estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. Exposure to surface soil, surface water and sediment was assessed for the current receptors. Fish ingestion was only evaluated for the fisherman. Subsurface soil, groundwater, surface water and sediment exposure were evaluated for the future receptors.

In the current case, potential noncarcinogenic and carcinogenic risks to the military personnel, recreational adult, and fisherman were within acceptable risk levels. For the current recreational child receptor , there was a potential noncarcinogenic risk from New River sediment. The noncarcinogenic risk from the ingestion pathway was 1.2, which is slightly greater than the acceptable risk level of one. The COPC driving this noncarcinogenic risk was antimony.

In the future case, the total potential noncarcinogenic risk to the child receptor (i.e., total noncancer risk is 23) exceeds the acceptable risk level of one. This risk is attributed to exposure to groundwater, subsurface soil, and sediment from the New River. For the adult receptor, there were noncarcinogenic and carcinogenic risks from exposure to groundwater. The risks to the construction worker were within acceptable risk levels.

The results indicate that metals in groundwater, subsurface soil and sediment are driving the potential noncarcinogenic and carcinogenic risks at the site. These metals are antimony, arsenic, copper and zinc in subsurface soil; manganese in groundwater, and antimony in the sediment of the New River. It is important to note that upon the segregation of the soil noncarcinogenic risks based on the effects on different target organs, the soil noncarcinogenic risk may be an overestimate.

It also is important to note that the future exposure scenario is based on potential residential development of Site 28. At present, the site is a recreational/picnic area located within training areas on the base. It is highly unlikely that a residence will be implemented on-site in the foreseeable future. Consequently, exposure to subsurface soil and groundwater under a residential scenario is highly conservative and unlikely given the present site conditions. It follows that the potential risks associated with this exposure scenario are conservative and may be overestimated values.

In terms of lead health impacts, use of the lead UBK model indicates that exposure to surface soil, subsurface soil and groundwater at this site generates blood lead levels in children that are within acceptable levels.

SECTION 16.0 TABLES

TABLE 16-1

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS FOR TOTAL METALS IN SURFACE SOIL SITE 28, HADNOT POINT BURN DUMP REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Twice Site Background Average (mg/kg)	No. Times Exceeds	USGS Background (mg/kg)	No. Times Exceeds
Aluminum	821.00	8410.00	2833.67	43	43	100%	4201.05	7/43	100000.0	0/43
Antimony	6.40	27.50	5.04	7	38	18%	4.81	12/38	8.8	3/38
Arsenic	0.56	15.70	1.37	25	43	58%	0.79	18/43	73.0	0/43
Barium	1.70	94.70	24.22	43	43	100%	13.61	20/43	1500.0	0/43
Cadmium	0.66	12.50	1.25	13	43	30%	0.63	13/43	1.0	10/43
Calcium	291.00	210000.00	20390.74	43	43	100%	1064.06	31/43	280000.0	0/43
Chromium	1.40	25.90	7.57	42	43	98%	4.80	25/43	1000.0	0/43
Cobalt	1.10	8.00	0.82	9	43	21%	2.39	3/43	70.0	0/43
Copper	1.50	4260.00	130.87	42	43	98%	9.06	23/43	700.0	1/43
Iron	536.00	40800.00	5662.88	43	43	100%	2515.18	22/43	100000.0	0/43
Lead	3.90	551.00	86.88	43	43	100%	24.70	20/43	300.0	4/43
Magnesium	41.40	1700.00	242.47	42	43	98%	170.30	20/43	50000.0	0/43
Manganese	2.40	39100.00	978.99	43	43	100%	14.19	35/43	7000.0	1/43
Mercury	0.05	1.10	0.18	28	43	65%	0.08	25/43	3.4	0/43
Nickel	1.10	36.30	4.16	25	43	58%	3.11	13/43	700.0	0/43
Potassium	26.30	740.00	173.26	41	43	95%	155.30	17/43	37000.0	0/43
Selenium	1.50	10.40	0.79	2	43	5%	0.76	2/43	3.9	1/43
Silver	1.50	5.90	0.98	7	43	16%	0.98	7/43	5.0	1/43
Sodium	17.10	276.00	33.70	6	43	14%	61.93	4/43	50000.0	0/43
Thallium	0.80	2.50	0.48	3	43	7%	0.83	2/43	23.0	0/43
Vanadium	1.30	19.00	6.53	43	43	100%	6.52	17/43	300.0	0/43
Zinc	6.70	23100.00	752.10	41	43	95%	9.67	36/43	2900.0	2/43

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-2

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SUBSURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Twice Site Background Average (mg/kg)	No. Times Exceeds	USGS Background (mg/kg)	No. Times Exceeds
Aluminum	688.00	20700.00	5855.51	51	51	100%	6439.90	0/51	100000.0	0/51
Antimony	5.90	46.70	9.58	16	45	36%	7.54	0/51	8.8	0/51
Arsenic	0.69	25.10	4.25	41	51	80%	0.89	0/51	73.0	0/51
Barium	3.00	269.00	46.70	51	51	100%	11.06	0/51	1500.0	0/51
Beryllium	0.24	1.10	0.14	4	51	8%	0.21	0/51	7.0	0/51
Cadmium	0.77	15.60	2.16	22	51	43%	0.62	0/51	1.0	0/51
Calcium	51.30	155000.00	15749.80	47	51	92%	118.75	0/51	280000.0	0/51
Chromium	2.00	128.00	21.68	50	51	98%	8.52	0/51	1000.0	0/51
Cobalt	0.90	15.40	2.03	18	51	35%	0.90	0/51	70.0	0/51
Copper	1.00	3280.00	172.48	43	45	96%	2.46	0/51	700.0	0/51
Iron	456.00	154000.00	20685.51	51	51	100%	2373.67	0/51	100000.0	0/51
Lead	1.90	2060.00	282.02	49	51	96%	5.84	0/51	300.0	0/51
Magnesium	31.40	8190.00	744.64	51	51	100%	209.74	0/51	50000.0	0/51
Manganese	1.50	3340.00	266.00	51	51	100%	7.16	0/51	7000.0	0/51
Mercury	0.05	2.80	0.19	15	51	29%	0.19	0/51	3.4	0/51
Nickel	1.60	102.00	11.44	23	51	45%	2.06	0/51	700.0	0/51
Potassium	54.50	4200.00	443.04	50	51	98%	241.18	0/51	37000.0	0/51
Selenium	6.00	6.00	0.62	1	51	2%	0.83	0/51	3.9	0/51
Silver	1.10	18.40	2.11	13	51	25%	1.03	0/51	5.0	0/51
Sodium	28.80	1220.00	127.21	16	51	31%	30.76	0/51	50000.0	0/51
Thallium	1.00	1.00	0.45	1	51	2%	0.83	0/51	23.0	0/51
Vanadium	0.98	90.70	16.64	51	51	100%	9.54	0/51	300.0	0/51
Zinc	0.95	4330.00	381.47	43	51	84%	3.70	0/51	2900.0	0/51

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-3

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SHALLOW AND DEEP GROUNDWATER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (μg/L)	Maximum Value (μg/L)	Arithmetic Average (μg/L)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Federal MCL (μg/L)	No. Times Exceeds	State MCL (μg/L)	No. Times Exceeds	Federal Health Advisories (μg/L)			
											10 kg Child	No. Times Exceeds	70 kg Adult	No. Times Exceeds
Aluminum	420	1,670	306.8	3	12	25%	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	3.7	4.70	1.78	3	12	25%	50	0/12	50	0/12	NA	NA	NA	NA
Barium	6.3	759	181.53	12	12	100%	2000	0/12	2000	0/12	NA	NA	NA	NA
Calcium	2,890	183,000	73,004	12	12	100%	NA	NA	NA	NA	NA	NA	NA	NA
Copper	14.5	44	6.96	2	12	17%	1300	0/12	1000	0/12	NA	NA	NA	NA
Iron	147	40,600	9,999.86	11	12	92%	NA	NA	300	7/12	NA	NA	NA	NA
Lead	8.2	126	11.77	2	12	17%	15	1/12	15	1/12	NA	NA	NA	NA
Magnesium	1,190	35,400	11,701.6	11	12	92%	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	16.90	1,450	258.99	11	12	92%	NA	NA	50	7/12	NA	NA	NA	NA
Mercury	0.14	0.58	0.22	7	12	58%	2	0/12	1.1	0/12	NA	NA	2	0/12
Nickel	13.5	13.5	6.63	1	12	8%	100	0/12	100	0/12	500	0/12	1700	0/12
Potassium	866	84,700	18,124.9	12	12	100%	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	5,760	803,000	112,636	12	12	100%	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	6.9	6.9	1.95	1	12	8%	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	331	331	34.24	1	12	8%	NA	NA	2100	0/12	3000	0/12	12000	0/12

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-4

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR ORGANICS IN SHALLOW AND DEEP GROUNDWATER
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (μg/L)	Maximum Value (μg/L)	Arithmetic Average (μg/L)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Federal MCL (μg/L)	No. Times Exceeds	State MCL (μg/L)	No. Times Exceeds	Federal Health Advisories (μg/L)			
											10 kg Child	No. Times Exceeded	70 kg Adult	No. Times Exceeded
4,4'-DDE	0.06	6.60	0.70	5	13	38%	NA	0/13	NA	0/13	NA	NA	NA	NA
4,4'-DDD	0.06	9.00	1.20	6	13	46%	NA	0/13	NA	0/13	NA	NA	NA	NA
4,4'-DDT	0.05	0.37	0.11	2	13	15%	NA	0/13	NA	0/13	NA	NA	NA	NA
gamma-Chlordane	0.05	0.05	0.05	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
2-Methylphenol	1.30	1.30	4.69	1	12	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
4-Methylphenol	29.00	29.00	7.00	1	12	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
2,4-Dimethylphenol	2.20	4.30	4.71	2	12	17%	NA	0/13	NA	0/13	NA	NA	NA	NA
2,4-Dichlorophenol	1.60	1.60	4.72	1	12	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Naphthalene	99.00	99.00	12.23	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
2-Methylnaphthalene	33.00	33.00	7.15	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Dimethylphthalate	1.40	1.40	4.72	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Acenaphthene	1.30	31.00	6.72	2	13	15%	NA	0/13	NA	0/13	NA	NA	NA	NA
Dibenzofuran	12.00	12.00	5.54	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Fluorene	18.00	18.00	6.00	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Phenanthrene	14.00	14.00	5.69	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Anthracene	2.60	2.60	4.82	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Carbazole	11.00	11.00	5.46	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
di-n-Butylphthalate	1.00	1.00	4.69	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Fluoranthene	1.70	1.70	4.75	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Pyrene	1.00	1.00	4.69	1	13	8%	NA	0/13	NA	0/13	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	1.30	17.00	5.08	4	13	31%	6	1/13	3	1/13	NA	NA	NA	NA
Chloroform	2.00	2.00	1.08	1	13	8%	100	0/13	0.19	1/13	100	0/13	400	0/13
Toluene	2.00	3.00	1.23	2	13	15%	1000	0/13	1000	0/13	2000	0/13	7000	0/13
Ethylbenzene	5.00	5.00	1.31	1	13	8%	700	0/13	29	0/13	1000	0/13	3000	0/13
Xylenes	19.00	19.00	2.38	1	13	8%	10000	0/13	530	0/13	40000	0/13	100000	0/13

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-5

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SURFACE WATER - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (μg/L)	Maximim Value (μg/L)	Arithmetic Average (μg/L)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Federal AWQC (Water & Org.) (μg/L)	No. Times Exceeded	Federal AWQC (Org. Only) (μg/L)	No. Times Exceeded	State WQS (μg/L)	No. Times Exceeded
NEW RIVER												
Aluminum	817	1660	1299.4	5	5	100%	NA	NA	NA	NA	NA	NA
Arsenic	4.2	4.3	3.2	3	5	60%	0.0022	3/5	0.0175	3/5	NA	NA
Barium	16.8	20.5	17.9	5	5	100%	1000	0/5	NA	NA	NA	NA
Cadmium	3.8	4.2	2.5	2	5	40%	10	0/5	NA	NA	NA	NA
Calcium	36700	130000	89660.0	5	5	100%	NA	NA	NA	NA	NA	NA
Copper	6.6	18.1	7.6	3	5	60%	1300	0/5	NA	NA	NA	NA
Iron	1190	2010	1552.0	5	5	100%	300	5/5	NA	NA	NA	NA
Lead	1.7	23.4	5.8	3	5	60%	50	0/5	NA	NA	NA	NA
Magnesium	4910	396000	231042.0	5	5	100%	NA	NA	NA	NA	NA	NA
Manganese	20.7	49.8	33.5	5	5	100%	50	0/5	100	0/5	NA	NA
Nickel	8.2	8.2	4.4	1	5	20%	13.4	0/5	100	0/5	NA	NA
Potassium	2310	131000	75802.0	5	5	100%	NA	NA	NA	NA	NA	NA
Sodium	31100	3430000	1996820.0	5	5	100%	NA	NA	NA	NA	NA	NA
Thallium	5.6	5.6	2.7	1	5	20%	13	0/5	48	0/5	NA	NA
Vanadium	3.6	6.1	3.5	3	5	60%	NA	NA	NA	NA	NA	NA
Zinc	10.4	363	81.8	3	5	60%	NA	NA	NA	NA	NA	NA
Acetone	14	14	6.8	1	5	20%	NA	NA	NA	NA	NA	NA
Phenanthrene	1.4	1.4	4.3	1	5	20%	0.0003	1/5	0.0311	1/5	0.0311	1/5
bis(2-Ethylhexyl) phthalate	1.2	600	122.6	3	5	60%	1.8	1/5	5.9	1/5	0.0311	3/5
4,4'-DDE	0.04	0.04	0.048	1	5	20%	0.0006	1/5	0.00059	1/5	NA	NA
4,4'-DDD	0.05	0.05	0.050	1	5	20%	0.0008	1/5	0.00083	1/5	NA	NA

TABLE 16-5 (Continued)

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SURFACE WATER - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (μg/L)	Maximim Value (μg/L)	Arithmetic Average (μg/L)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Federal AWQC (Water & Org.) (μg/L)	No. Times Exceeded	Federal AWQC (Org. Only) (μg/L)	No. Times Exceeded	State WQS (μg/L)	No. Times Exceeded
COGDELS CREEK												
Aluminum	347	936	722.9	7	7	100%	NA	NA	NA	NA	NA	NA
Arsenic	3.9	3.9	1.8	1	7	14%	0.0175	1/7	0.0022	1/7	NA	NA
Barium	12.8	21	16.6	7	7	100%	1000	0/7	NA	NA	NA	NA
Calcium	29500	45900	36314.3	7	7	100%	NA	NA	NA	NA	NA	NA
Copper	6.2	6.2	3.5	1	7	14%	1300	0/7	NA	NA	NA	NA
Iron	838	1390	1048.7	7	7	100%	300	7/7	NA	NA	NA	NA
Lead	1.9	4.2	2.9	7	7	100%	50	NA	NA	NA	NA	NA
Magnesium	3030	22500	8782.9	7	7	100%	NA	NA	NA	NA	NA	NA
Manganese	20.2	56.1	33.2	7	7	100%	50	1/7	100	0/7	NA	NA
Nickel	7.2	7.2	4.0	1	7	14%	13.4	0/7	100	0/7	NA	NA
Potassium	1660	7720	3322.9	7	7	100%	NA	NA	NA	NA	NA	NA
Sodium	15200	183000	62571.4	7	7	100%	NA	NA	NA	NA	NA	NA
Vanadium	3.6	3.6	1.8	1	7	14%	NA	NA	NA	NA	NA	NA
Zinc	8	13	10.0	6	7	86%	NA	NA	NA	NA	NA	NA
Methylene chloride	4	4	4.9	1	7	14%	4.7	0/7	1600	0/7	NA	NA
Acetone	12	12	7.4	1	7	14%	NA	NA	NA	NA	NA	NA
2-Hexanone	16	16	6.6	1	7	14%	NA	NA	NA	NA	NA	NA

TABLE 16-5 (Continued)

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SURFACE WATER - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (μg/L)	Maximim Value (μg/L)	Arithmetic Average (μg/L)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Federal AWQC (Water & Org.) (μg/L)	No. Times Exceeded	Federal AWQC (Org. Only) (μg/L)	No. Times Exceeded	State WQS (μg/L)	No. Times Exceeded
ORDE POND												
Aluminum	97.5	170	133.8	2	2	100%	NA	NA	NA	NA	NA	NA
Calcium	7610	8460	8035.0	2	2	100%	NA	NA	NA	NA	NA	NA
Iron	421	431	426.0	2	2	100%	NA	NA	NA	NA	NA	NA
Magnesium	693	752	722.5	2	2	100%	NA	NA	NA	NA	NA	NA
Nickel	12.8	12.8	8.2	1	2	50%	75	0/2	100	0/2	NA	NA
Potassium	1100	1180	1140.0	2	2	100%	NA	NA	NA	NA	NA	NA
Sodium	3070	3470	3270.0	2	2	100%	NA	NA	NA	NA	NA	NA
Thallium	4.7	4.7	3.4	1	2	50%	2130	0/2	48	0/2	NA	NA
Methylene chloride	7	10	8.5	2	2	100%	4.7	2/2	1600	0/2	NA	NA

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-6

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SEDIMENT - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Range of Positive Detects Reference Station (mg/kg)	Exceeded Maximum Reference Concentration ? Yes or No
NEW RIVER								
Aluminum	514	11,700	4,061	10	10	100%	3,120-14,600	No
Antimony	8.7	263	69.8	2	4	50%	ND	Yes
Arsenic	0.59	12.5	3.1	9	10	90%	ND	Yes
Barium	2.2	28.9	7.7	10	10	100%	10.2-19.2	Yes
Calcium	329	96,800	17,530	10	10	100%	2,000-3,380	Yes
Chromium	2.1	34.1	10.5	9	10	90%	16.1-42.6	No
Cobalt	0.92	0.92	0.51	1	10	10%	3.9-5	No
Copper	1.5	1,340	146.1	10	10	100%	ND	Yes
Iron	1,560	30,600	7,417	10	10	100%	1,700-20,700	Yes
Lead	3.5	38,800	3,907	10	10	100%	3.7-9.2	Yes
Magnesium	252	2,390	823.1	10	10	100%	4,130-6,540	No
Manganese	1.9	18.8	7.6	10	10	100%	17.1-64.7	No
Mercury	0.05	0.05	0.04	1	10	10%	0.23-0.42	No
Nickel	1.4	3.2	1.1	2	10	20%	5.5-14.2	No
Potassium	71	2,210	527.3	10	10	100%	1,250-1,840	Yes
Silver	3.1	3.4	1.1	2	10	20%	ND	Yes
Sodium	150	3,870	1,248	9	10	90%	ND	Yes

TABLE 16-6 (Continued)

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SEDIMENT - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Range of Positive Detects Reference Station (mg/kg)	Exceeded Maximum Reference Concentration ? Yes or No
NEW RIVER (Continued)								
Vanadium	2.8	37.4	14	10	10	100%	18.4-36.9	Yes
Zinc	3.7	117	24.9	10	10	100%	20.8-40	Yes
COGDELS CREEK								
Aluminum	403	29,900	7,073	14	14	100%	7,820-14,800	Yes
Arsenic	0.67	11.9	2.9	10	14	71%	1.1-1.9	Yes
Barium	2.1	59.4	23.1	14	14	100%	8.7-28.2	Yes
Beryllium	0.57	0.57	0.31	1	14	7%	0.25-0.32	Yes
Cadmium	1.5	2.2	1.2	2	14	14%	0.04-0.26	Yes
Calcium	173	13,700	5,355	14	14	100%	1,610-7,860	Yes
Chromium	2.5	47.2	14	13	14	93%	6-38.4	Yes
Cobalt	0.93	3.2	1.4	3	14	21%	3.5-4.4	No
Copper	2.2	63.7	18.2	13	14	93%	0.81-1.5	Yes
Iron	1,480	36,000	9,618	14	14	100%	3,660-32,400	Yes
Lead	6.8	202	57.8	14	14	100%	6-16.9	Yes
Magnesium	79.6	7,480	2,120	14	14	100%	618-4,940	Yes
Manganese	2.4	226	40	13	14	93%	4.9-67.2	Yes
Mercury	0.12	0.41	0.16	6	14	43%	0.27-0.4	Yes

TABLE 16-6 (Continued)

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SEDIMENT - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Range of Positive Detects Reference Station (mg/kg)	Exceeded Maximum Reference Concentration ? Yes or No
COGDELS CREEK (Continued)								
Nickel	1.9	8.5	3.2	5	14	36%	1.8-11.2	No
Potassium	70.1	2,650	522	13	14	93%	623-1,600	Yes
Silver	2	2	1.6	1	14	7%	ND	Yes
Sodium	104	16,800	2,485	14	14	100%	1,630-2,750	Yes
Thallium	4.1	4.1	1.4	1	14	7%	0.28-0.42	Yes
Vanadium	1.9	56	15.8	14	14	100%	7-30	Yes
Zinc	9.3	303	79.2	14	14	100%	27.8-52	Yes
ORDE POND								
Aluminum	2,060	4,880	3,760	3	3	100%	337-2,940	Yes
Arsenic	2.3	6.4	3.0	2	3	67%	0.26-0.46	Yes
Barium	6.6	15.8	12	3	3	100%	4.1-16.3	No
Beryllium	0.32	0.32	0.2	1	3	33%	0.14	Yes
Calcium	271	1,790	1,200	3	3	100%	282-3,620	No
Chromium	3.6	11.8	8.8	3	3	100%	1.1-3.2	Yes
Cobalt	1.7	1.7	0.9	1	3	33%	ND	Yes
Copper	1.7	1.7	1.4	2	3	67%	0.66-1.1	Yes
Iron	1,240	4,550	3,280	3	3	100%	225-648	Yes

TABLE 16-6 (Continued)

SUMMARY OF STANDARDS/CRITERIA COMPARISON RESULTS
FOR TOTAL METALS IN SEDIMENT - NEW RIVER, COGDELS CREEK AND ORDE POND
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Minimum Value (mg/kg)	Maximum Value (mg/kg)	Arithmetic Average (mg/kg)	No. of Times Detected	No. of Times Analyzed	Frequency of Detection	Range of Positive Detects Reference Station (mg/kg)	Exceeded Maximum Reference Concentration ? Yes or No
ORDE POND (Continued)								
Lead	3.8	8.3	6.7	3	3	100%	0.62-1	Yes
Magnesium	52.8	412	254.3	3	3	100%	26.7-87.7	Yes
Manganese	1.8	9.8	6.2	3	3	100%	1.3-6.9	Yes
Nickel	2.1	2.2	1.7	2	3	67%	ND	Yes
Potassium	59.8	253	171.6	3	3	100%	ND	Yes
Vanadium	4	11.5	8.9	3	3	100%	0.66-2.8	Yes
Zinc	1.3	4.4	3.3	3	3	100%	6.7-9.7	No

Note: The data frequencies do not included rejected data. Consequently, these values may differ slightly from the frequencies presented in Appendix K.

TABLE 16-7

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Soil	Excluded - Low Frequency of Detection	Excluded - Below RBCs	Excluded - Common Laboratory Contaminants	Excluded - Essential Nutrients
aluminum	selenium	fluoranthene	di-n-butylphthalate	calcium
antimony	dieldrin	pyrene	butylbenzylphthalate	iron
arsenic (c-Class A)	endrin	benzo(k)fluoranthene	di-n-octylphthalate	magnesium
barium	endosulfan sulfate	bis(2-ethylhexyl)phthalate	bis(2-ethylhexyl)phthalate	potassium
cadmium	endrin aldehyde			sodium
chromium	Aroclor-1254			
cobalt	Aroclor-1260			
copper	bis(2-chloroethyl)ether			
lead (NA)	naphthalene			
manganese	acenaphthene			
mercury	dibenzofuran			
nickel	fluorene			
silver	pentachlorophenol			
thallium	dibenz(a,h)anthracene			
vanadium	chloromethane			
zinc	methylene chloride			
heptachlor epoxide (c-Class B2)	acetone			
4,4'-DDD (c-Class B2)	1,1,1-trichloroethane			
4,4'-DDE (c-Class B2)				
4,4'-DDT (c-Class B2)				
alpha-chlordane (c-Class B2)				
gamma-chlordane (c-Class B2)				
phenanthrene				
anthracene				
benzo(a)anthracene (c-Class B2)				
benzo(b)fluoranthene (c-Class B2)				
indeno(1,2,3-cd)pyrene (c-Class B2)				
benzo(g,h,i)perylene (D)				
carbazole (c-Class B2)				
chrysene (c-Class B2)				
benzo(a)pyrene (c-Class B2)				

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

**SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA**

COPCs Subsurface Soil	Excluded - Low Frequency of Detection or Below RBCs	Excluded - Common Laboratory Contaminants	Excluded - Essential Nutrients
aluminum antimony arsenic (c-Class A) barium beryllium (c-Class B2) cadmium chromium cobalt copper lead (NA) manganese mercury nickel silver vanadium zinc 4,4'-DDD (c-Class B2) 4,4'-DDE (c-Class B2) 4,4'-DDT (c-Class B2) alpha-chlordane (c-Class B2) gamma-chlordane (c-Class B2) 2-methylnaphthalene naphthalene fluorene phenanthrene chyrsene (c-Class B2) bis(2-ethylhexyl)phthalate benzo(a)pyrene (c-Class B2) benzo(a)anthracene (c-Class B2) benzo(b)fluoranthene (c-Class B2) benzo(k)fluoranthene (c-Class B2) indeno(1,2,3-cd)pyrene (c-Class B2) benzo(g,h,i)perylene (D) dibenz(a,h)anthracene (c-Class B2)	selenium thallium fluoranthene pyrene 1,4-dichlorobenzene dibenzofuran anthracene carbazole Aroclor-1254 Aroclor-1260	acetone methylene chloride	calcium iron magnesium potassium sodium

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Shallow and Deep Groundwater	Excluded - Low Detection of Frequency	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
arsenic (c-Class A) barium lead (NA) manganese mercury 4,4'-DDD (c-Class B2) 4,4'-DDE (c-Class B2) 4,4'-DDT (c-Class B2) 2,4-dimethylphenol 4-methylphenol acenaphthene chloroform 2-methylnaphthalene phenanthrene	aluminum copper nickel vanadium zinc gamma-chlordane 2-methylphenol 2,4-dichlorophenol naphthalene dimethylphthalate dibenzofuran fluorene anthracene carbazole di-n-butylphthalate fluoranthene pyrene ethylbenzene xylene	calcium iron magnesium potassium sodium	bis(2-ethylhexyl)phthalate toluene

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water New River	Excluded - Low Detection of Frequency	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
aluminum arsenic (c-ClassA) cadmium copper lead (NA) manganese vanadium zinc 4,4'-DDD (c-Class B2) 4,4'-DDE (c-Class B2)	nickel thallium phenanthrene	barium	calcium iron magnesium potassium sodium	bis(2-ethylhexyl)phthalate acetone

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water Cogdels Creek	Excluded - Low Detection of Frequency	Excluded - Essential Nutrients
aluminum	barium	calcium
arsenic (c-ClassA)	copper	iron
lead (NA)	nickel	magnesium
manganese	methylene chloride	potassium
vanadium	acetone	sodium
zinc	2-hexanone	

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water Orde Pond	Excluded - Common Laboratory Contaminant	Excluded - Essential Nutrients
aluminum nickel thallium	methylene chloride	calcium iron magnesium potassium sodium

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment New River	Excluded - Low Detection of Frequency or Below Criteria	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
antimony	cobalt	aluminum	calcium	methylene chloride
arsenic (c-ClassA)	mercury	chromium	iron	acetone
barium	acenaphthene	manganese	magnesium	methyl ethyl ketone
copper	fluorene	nickel	potassium	
lead (NA)	dibenz(a,h)anthracene	vanadium	sodium	
silver	methylene chloride			
zinc	carbon disulfide			
4,4'-DDD (c-Class B2)	methyl ethyl ketone			
4,4'-DDE (c-Class B2)				
4,4'-DDT (c-Class B2)				
alpha-chlordane (c-Class B2)				
gamma-chlordane (c-Class B2)				
phenanthrene				
anthracene				
carbazole (c-Class B2)				
dibenzofuran				
fluoranthene				
pyrene				
benzo(a)anthracene (c-Class B2)				
chrysene (c-Class B2)				
benzo(b)fluoranthene (c-Class B2)				
benzo(k)fluoranthene (c-Class B2)				
benzo(a)pyrene (c-Class B2)				
indeno(1,2,3-cd)pyrene (c-Class B2)				
benzo(g,h,i)perylene (D)				
bis(2-ethylhexyl)phthalate				

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment Cogdels Creek	Excluded - Low Detection of Frequency	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
aluminum	beryllium	cobalt	calcium	acetone
arsenic (c-ClassA)	cadmium	nickel	iron	methyl ethyl ketone
barium	silver		magnesium	
chromium	4,4'-DDT		potassium	
copper	anthracene		sodium	
lead (NA)	butylbenzylphthalate			
manganese				
mercury				
thallium				
vanadium				
zinc				
bis(2-ethylhexyl)phthalate				
carbon disulfide				
4,4'-DDD (c-Class B2)				
4,4'-DDE (c-Class B2)				
alpha-chlordane (c-Class B2)				
gamma-chlordane (c-Class B2)				
3,3'-dichlorobenzidine				
benzo(b)fluoranthene (c-Class B2)				
benzo(k)fluoranthene (c-Class B2)				
fluoranthene				
phenanthrene				
pyrene				
benzo(a)anthracene (c-Class B2)				
chrysene				
benzo(a)pyrene (c-Class B2)				

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment Orde Pond	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
aluminum arsenic (c-ClassA) beryllium chromium cobalt copper lead (NA) manganese nickel vanadium 4,4'-DDD (c-Class B2)	barium zinc	calcium iron magnesium potassium sodium	acetone methyl ethyl ketone toluene bis(2-ethylhexyl)phthalate

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Tissue New River	Excluded - Low Frequency of Detection	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
antimony barium cobalt copper selenium 4,4'-DDD (c-Class B2) 4,4'-DDE (c-Class B2) alpha-chlordane (c-Class B2)	vanadium dieldrin endrin aldehyde	arsenic mercury bis(2-ethylhexyl)phthalate	calcium magnesium sodium	acetone methylene chloride butylbenzylphthalate

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-7 (Continued)

SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN (COPCs) SURFACE SOIL, SUBSURFACE SOIL, AND SHALLOW AND DEEP GROUNDWATER, SURFACE WATER, SEDIMENT, AND FISH TISSUE
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Tissue Orde Pond	Excluded - Low Frequency of Detection	Excluded - Within Base-wide Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminant
barium manganese selenium zinc	cobalt 2-methylphenol 2,4,6-trichlorophenol 3-nitroaniline	arsenic chromium copper mercury	calcium magnesium potassium sodium	acetone bis(2-ethylhexyl)phthalate di-n-octylphthalate

Notes: (c) = Carcinogen and Class
(NA) = No USEPA-verified toxicological factors (i.e., RfDs and CSFs) available

TABLE 16-8

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor			
		Child	Adult	Military Personnel	Construction Worker
Soil (mg/kg)					
Ingestion Rate, IR	mg/d	200	100	100	480
Fraction Ingested, FI	unitless	1	1	1	1
Exposure Frequency, EF	d/y	350	350	250	90
Exposure Duration, ED	y	6	30	4	1
Surface Area, SA	cm^2	2300	5800	4,300	4300
Absorption Factor, AF	mg/cm^3	1	1	1	1
Averaging Time, Noncarc., ATnc	d	2190	10,950	1,460	365
Averaging Time, Carc., ATcarc	d	25550	25,550	25,550	25,550
Body Weight, BW	kg	15	70	70	70
Conversion Factor, CF	kg/mg	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$
Absorbance Factor, ABS	unitless	Organics = 0.01; Inorganics = 0.001			
Groundwater (mg/L)					
Ingestion Rate, IR	L/d	1	2	NA	NA
Exposure Frequency, EF	d/y	350	350	NA	NA
Exposure Duration, ED	y	6	30	NA	NA
Exposure Time, ET	h/d	0.25	0.25	NA	NA
Surface Area, SA	cm^2	10000	23000	NA	NA
Averaging Time, Noncarc., ATnc	d	2,190	10,950	NA	NA
Averaging Time, Carc., ATcarc	d	25,550	25,550	NA	NA
Conversion Factor, CF	L/cm^3	0.001	0.001	NA	NA
Body Weight, BW	kg	15	70	NA	NA
Sediment (mg/kg)					
Ingestion Rate, IR	mg/d	200	100	100	NA
Fraction Ingested, FI	unitless	1	1	1	NA
Exposure Frequency, EF	d/y	45	45	45	NA
Exposure Duration, ED	y	6	30	4	NA
Surface Area, SA	cm^2	2300	5800	5800	NA
Absorption Factor, AF	mg/cm^3	1	1	1	NA
Averaging Time, Noncarc., ATnc	d	2,190	10,950	1,460	NA
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550	NA
Body Weight, BW	kg	15	70	70	NA
Conversion Factor, CF	kg/mg	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	NA
Absorbance Factor, ABS	unitless	Organics = 0.01; Inorganics = 0.001			

TABLE 16-8 (Continued)

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 30, SNEADS FERRY ROAD FUEL TANK SLUDGE AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor			
		Child	Adult	Military Personnel	Construction Worker
Surface Water (mg/L)					
Ingestion Rate, IR	L/h	0.005	0.005	0.005	NA
Exposure Time, ET	h/d	2.6	2.6	2.6	NA
Exposure Frequency, EF	d/y	45	45	45	NA
Exposure Duration, ED	y	6	30	4	NA
Surface Area, SA	cm^2	2300	5800	5800	NA
Averaging Time, Noncarc., ATnc	d	2,190	10,950	1,460	NA
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550	NA
Conversion Factor, CF	L/cm^3	0.001	0.001	0.001	NA
Air (mg/m^3)					
Outdoor Air					
Inhalation Rate, IR	m^3/d	10	20	30	20
Exposure Frequency, EF	d/y	350	350	250	90
Exposure Duration, ED	y	6	30	4	1
Averaging Time, Noncarc., ATnc	d	2,190	10,950	1,460	365
Averaging Time, Carc,. ATcarc	d	25,550	25,550	25,550	25,550
Body Weight, BW	kg	15	70	70	70
Shower Air					
Inhalation Rate, IR	m^3/h	0.6	0.6	NA	NA
Exposure Time, ET	h/d	0.25	0.25	NA	NA
Exposure Frequency, EF	d/y	350	350	NA	NA
Exposure Duration, ED	y	6	30	NA	NA
Averaging Time, Noncarc., ATnc	d	2,190	10,950	NA	NA
Averaging Time, Carc., ATcarc	d	25,550	25,550	NA	NA
Body Weight, BW	kg	15	70	NA	NA
Fish (mg/kg)					
Ingestion rate, IR	kg/d	NA	0.284	NA	NA
Fraction Ingested, FI	unitless	NA	1	NA	NA
Exposure Frequency, EF	meals/yr	NA	48	NA	NA
Exposure Duration, ED	y	NA	30	NA	NA
Averaging Time, Noncarc., ATnc	d	NA	10,950	NA	NA
Averaging Time, Carc, ATcarc	d	NA	25,550	NA	NA
Body Weight, BW	kg	NA	70	NA	NA

References:

USEPA Risk Assessment For Superfund Volume I. Human Health Manual (Part A) Interim Final, December, 1989.
USEPA Exposure Factors Handbook, July, 1989.
USEPA Risk Assessment For Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance, "Standard Default Exposure Factors" Interim Final. March 25, 1991.
USEPA Dermal Exposure Assessment: Principles and Applications. Interim Report. January, 1992.
USEPA Region IV Guidance for Soil Absorbance. (USEPA, 1992d)

TABLE 16-9

SUMMARY OF EXPOSURE PATHWAYS
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptor	Exposure Pathway
Current Military Personnel	Surface soil ingestion, dermal contact and inhalation Surface water ingestion and dermal contact (Orde Pond) Sediment ingestion and dermal contact (Orde Pond)
Current Residential Adult and Child	Surface soil ingestion, dermal contact and inhalation Surface water ingestion and dermal contact (New River and Cogdels Creek) Sediment ingestion and dermal contact (New River and Cogdels Creek)
Fisherman	Surface water ingestion and dermal contact (New River and Orde Pond) Sediment ingestion and dermal contact (New River and Orde Pond) Fish ingestion (New River and Orde Pond)
Future Construction Worker	Subsurface soil ingestion, dermal contact, and inhalation
Future Residential Adult and Child	Subsurface soil ingestion, dermal contact and inhalation Groundwater ingestion, dermal contact and inhalation Surface water ingestion and dermal contact (New River and Cogdels Creek) Sediment ingestion and dermal contact (New River and Cogdels Creek)

TABLE 16-10

SUMMARY OF HEALTH-BASED CRITERIA
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	RfD (Oral) (mg/kg/d)	RfC (Inhal.) (mg/kg/d)	CSF (Oral) $(mg/kg/d)^{-1}$	CSF (Inhal.) $(mg/kg/d)^{-1}$	Weight-of-Evidence
SEMIVOLATILES					
2,4-Dimethylphenol	2.0E-02	-	-	-	-
4-Methylphenol	5.0E-03	-	-	-	C
Acenaphthene	6.0E-02	-	-	-	-
Anthracene	3.0E-01	-	-	-	D
Benzo(a)anthracene	-	-	7.3E-01	6.1E-01	B2
Benzo(a)pyrene	-	-	7.3E+00	6.1E+00	B2
Benzo(b)fluoranthene	-	-	7.3E-01	6.1E-01	B2
Benzo(g,h,i)perylene*	3.0E-02	-	-	-	D
Benzo(k)fluoranthene	-	-	7.3E-02	6.1E-02	B2
Bis(2-ethylhexyl)phthalate	2.0E-02	-	1.4E-02	-	B2
Carbazole	-	-	2.0E-02	-	-
Chrysene	-	-	7.3E-03	6.1E-03	B2
Fluoranthene	4.0E-02	-	-	-	D
Fluorene	4.0E-02	-	-	-	D
Indeno(1,2,3-cd)pyrene	-	-	7.3E-01	6.1E-01	B2
2-Methylnaphthalene**	4.0E-02w	-	-	-	D
Naphthalene	4.0E-02w	-	-	-	D
Phenanthrene*	3.0E-02	-	-	-	D
Pyrene	3.0E-02	-	-	-	D
METALS					
Aluminum	1.0	-	-	-	-
Antimony	4.0E-04	-	-	-	-
Arsenic	3.0E-04	-	1.8E+00	1.5E+01	A
Barium	7.0E-02	1.4E-04	-	-	-
Beryllium	5.0E-03	-	4.3E+00	8.4E+00	B2
Cadmium (water) (food/soil)	5.0E-04 1.0E-03	-	-	6.3E+00	B1
Chromium	1.0E+00	-	-	-	-
Cobalt	6.0E-02	-	-	-	-
Copper	3.7E-02	-	-	-	D
Lead	-	-	-	-	B2
Manganese (water) (food/soil)	5.0E-03 1.4E-01	1.4E-05	-	-	D
Mercury	3.0E-04	8.6E-05	-	-	D

TABLE 16-10 (Continued)

SUMMARY OF HEALTH-BASED CRITERIA
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	RfD (Oral) (mg/kg/d)	RfC (Inhal.) (mg/kg/d)	CSF (Oral) $(mg/kg/d)^{-1}$	CSF (Inhal.) $(mg/kg/d)^{-1}$	Weight-of-Evidence
Nickel	2.0E-02	-	-	-	-
Selenium	5.0E-03	-	-	-	D
Silver	5.0E-03	-	-	-	-
METALS (Continued) Thallium carbonate	8.0E-05	-	-	-	-
Vanadium	7.0E-03	-	-	-	-
Zinc	3.0E-01	-	-	-	D
PESTICIDES 4,4'-DDD	-	-	2.4E-01	-	B2
4,4'-DDE	-	-	3.4E-01	-	B2
4,4'-DDT	5.0E-04	-	3.4E-01	3.4E-01	B2
Heptachlor epoxide	1.3E-05	-	9.1E+00	9.1E+00	B2
alpha-Chlordane	6.0E-05	-	1.3E+00	1.3E+00	B2
gamma-Chlordane	6.0E-05	-	1.3E+00	1.3E+00	B2

* = Oral RfD for pyrene was substituted.
** = Oral RfD for naphthalene was substituted.
w= Withdrawn from IRIS, but used in assessment, as recommended by Region IV
References:
IRIS, 1994
HEAST, 1994
Region III RBC Table, November, 1994

TABLE 16-11

SUMMARY OF DERMALLY-ADJUSTED HEALTH-BASED CRITERIA*
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Oral RfD (Dermally-Adjusted) mg/kg/d	Oral CSF (Dermally-Adjusted) $(mg/kg/d)^{-1}$	Weight-of-Evidence
SEMIVOLATILES			
2,4-Dimethylphenol	0.01	-	-
4-Methylphenol	0.0025	-	C
Acenaphthene	0.03	-	-
Anthracene	0.15	-	D
Benzo(a)anthracene	-	1.46	B2
Benzo(a)pyrene	-	14.6	B2
Benzo(b)fluoranthene	-	1.46	B2
Benzo(g,h,i)perylene	0.015	-	D
Benzo(k)fluoranthene	-	0.146	B2
Bis(2-ethylhexyl)phthalate	0.01	0.028	B2
Carbazole	-	0.04	-
Chrysene	-	0.0146	B2
Fluoranthene	0.02	-	D
Fluorene	0.02	-	D
Indeno(1,2,3-cd)pyrene	-	1.46	B2
2-Methylnaphthalene	0.008		
Naphthalene	0.008	-	D
Phenanthrene	0.015	-	D
Pyrene	0.015	-	D
METALS			
Aluminum	-	-	-
Antimony	0.00008	-	-
Arsenic	0.00006	8.75	A
Barium	0.014	-	-
Beryllium	0.001	21.5	B2
Cadmium (water) (food/water)	0.0001 0.0002	-	B1
Chromium	0.2	-	-
Cobalt	0.012	-	-
Copper	0.00742	-	D
Lead	-	-	B2
Manganese (water) (food/water)	0.001 0.028	-	D

TABLE 16-11 (Continued)

SUMMARY OF DERMALLY-ADJUSTED HEALTH-BASED CRITERIA*
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Oral RfD (Dermally-Adjusted) mg/kg/d	Oral CSF (Dermally-Adjusted) $(mg/kg/d)^{-1}$	Weight-of-Evidence
Mercury	0.00006	-	D
Nickel	0.004	-	-
Selenium	0.001	-	D
Silver	0.001	-	-
METALS (Continued) Thallium carbonate	0.000016	-	-
Vanadium	0.0014	-	-
Zinc	0.06	-	D
PESTICIDES 4,4'-DDD	-	0.48	B2
4,4'-DDE	-	0.68	B2
4,4'-DDT	0.00025	0.68	B2
Heptachlor epoxide	0.0000065	18.2	B2
alpha-Chlordane	0.00003	2.6	-
gamma-Chlordane	0.00003	2.6	-

- = Not Applicable
* = Only oral toxicity values were dermally adjusted. Inhalation toxicity values were not adjusted.
References:
IRIS, 1994
HEAST, 1994
Region III RBC Table, November, 1994

TABLE 16-12

SUMMARY OF POTENTIAL RISKS FOR THE CHILD RECEPTOR
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil Ingestion	5.8E-01	6.5E-06
Surface Soil Dermal Contact	3.7E-02	9.2E-07
Surface Soil Inhalation	3.4E-05	3.4E-10
total	6.2E-01	7.4E-06
Subsurface Soil Ingestion	1.6	2.5E-05
Subsurface Soil Dermal Contact	9.1E-02	3.0E-06
Subsurface Soil Inhalation	7.6E-05	1.5E-09
total	1.6	2.8E-05
Groundwater Ingestion	20	4.1E-05
Groundwater Dermal Contact	3.5E-01	2.1E-05
Groundwater Inhalation	NA	8.0E-07
total	20	6.3E-05
NEW RIVER		
Surface Water Ingestion	3.9E-03	6.9E-08
Surface Water Dermal Contact	9.0E-03	2.1E-07
total	1.3E-02	2.8E-07
Sediment Ingestion	1.2	3.1E-06
Sediment Dermal Contact	6.9E-02	2.9E-07
total	1.2	3.4E-06
COGDELS CREEK		
Surface Water Ingestion	2.1E-03	4.1E-08
Surface Water Dermal Contact	4.8E-03	9.5E-08
total	6.9E-03	1.4E-07
Sediment Ingestion	1.6E-01	3.0E-06
Sediment Dermal Contact	9.2E-03	3.8E-07
total	1.7E-01	3.4E-06
Current Risk (New River)	1.9	1.1E-05
Current Risk (Cogdels Creek)	7.9E-01	1.1E-05
Future Risk (New River)	23.2	9.5E-05
Future Risk (Cogdels Creek)	22.1	9.5E-05

Noncarcinogenic Risk (Shaded Areas indicate risk > "1")
Carcinogenic Risk (Shaded Areas indicate risk > "1E-4")
NA = Not Applicable

TABLE 16-13

SUMMARY OF POTENTIAL RISKS FOR THE ADULT RECEPTOR
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil Ingestion	6.2E-02	3.5E-06
Surface Soil Dermal Contact	2.0E-02	2.5E-06
Surface Soil Inhalation	1.5E-05	7.3E-10
total	8.3E-02	6.0E-06
Subsurface Soil Ingestion	1.7E-01	1.3E-05
Subsurface Soil Dermal Contact	4.9E-02	8.1E-06
Subsurface Soil Inhalation	3.3E-05	3.2E-09
total	2.2E-01	2.1E-05
Groundwater Ingestion	8.6	8.8E-05
Groundwater Dermal Contact	1.7E-01	5.2E-05
Groundwater Inhalation	NA	4.4E-07
total	8.7	1.4E-04
NEW RIVER		
Surface Water Ingestion	8.5E-04	7.4E-08
Surface Water Dermal Contact	4.8E-03	1.9E-06
total	5.7E-03	2.0E-06
Sediment Ingestion	1.3E-01	1.7E-06
Sediment Dermal Contact	3.7E-02	8.9E-07
total	1.6E-01	2.5E-06
COGDELS CREEK		
Surface Water Ingestion	4.5E-04	4.4E-08
Surface Water Dermal Contact	2.6E-03	2.6E-07
total	3.1E-03	3.0E-07
Sediment Ingestion	1.7E-02	1.6E-06
Sediment Dermal Contact	5.0E-03	1.0E-06
total	2.2E-02	2.6E-06
Current Risk (New River)	0.25	1.1E-05
Current Risk (Cogdels Creek)	0.11	8.9E-06
Future Risk (New River)	9.1	1.7E-04
Future Risk (Cogdels Creek)	9.0	1.7E-04

Noncarcinogenic Risk (Shaded Areas indicate risk > "1")
Carcinogenic Risk (Shaded Areas indicate risk > "1E-4")
NA = Not Applicable

TABLE 16-14

SUMMARY OF POTENTIAL RISKS FOR THE
MILITARY, FISHERMAN, AND CONSTRUCTION WORKER RECEPTORS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Military		Fisherman		Construction Worker	
	Nc Risk	Carc Risk	NC Risk	Carc Risk	NC Risk	Carc Risk
Surface Soil Ingestion	4.5E-02	3.3E-07	-	-	-	-
Surface Soil Dermal Contact	1.1E-02	1.7E-07	-	-	-	-
Surface Soil Inhalation	1.6E-05	1.0E-10	-	-	-	-
total	5.5E-02	5.1E-07	-	-	-	-
Subsurface Soil Ingestion	-	-	-	-	2.1E-01	5.5E-07
Subsurface Soil Dermal Contact	-	-	-	-	9.3E-03	5.1E-08
Subsurface Soil Inhalation	-	-	-	-	8.4E-06	2.8E-11
total	-	-	-	-	2.1E-01	6.0E-07
Orde Pond						
Surface Water Ingestion	1.4E-03	-	2.0E-03	-	-	-
Surface Water Dermal Contact	7.8E-03	-	8.4E-03	-	-	-
total	9.2E-03	-	1.0E-02	-	-	-
Sediment Ingestion	2.8E-02	9.8E-07	5.3E-03	1.0E-06	-	-
Sediment Dermal Contact	5.9E-03	2.9E-07	1.5E-03	2.9E-07	-	-
total	3.4E-02	1.3E-06	6.8E-03	1.3E-06	-	-
Fish Ingestion	-	-	8.8E-02	-	-	-
New River						
Surface Water Ingestion	-	-	9.0E-04	7.9E-08	-	-
Surface Water Dermal Contact	-	-	5.2E-03	6.2E-07	-	-
total	-	-	6.1E-03	7.0E-07	-	-
Sediment Ingestion	-	-	1.4E-01	1.8E-06	-	-
Sediment Dermal Contact	-	-	4.0E-02	9.4E-07	-	-
total	-	-	1.8E-01	2.7E-06	-	-
Fish Ingestion	-	-	4.1E-01	5.6E-06	-	-
Current Risk (Orde Pond)	**9.8E-02**	**1.4E-06**	**0.1**	**1.3E-06**	-	-
Current Risk (New River)	-	-	**0.6**	**9.0E-06**	-	-
Future Risk (Orde Pond)	-	-	**0.1**	**1.3E-06**	**0.2**	**6.0E-07**
Future Risk (New River)	-	-	**0.6**	**9.0E-06**	**0.2**	**6.0E-07**

NC = Noncarcinogenic Risk (Shaded Areas indicate risk > "1")
Carc = Carcinogenic Risk (Shaded Areas indicate risk > "1E-4")
- = The exposure pathway was not applicable to the receptor. There were no toxicity values available or applicable to calculate risk.

TABLE 16-15

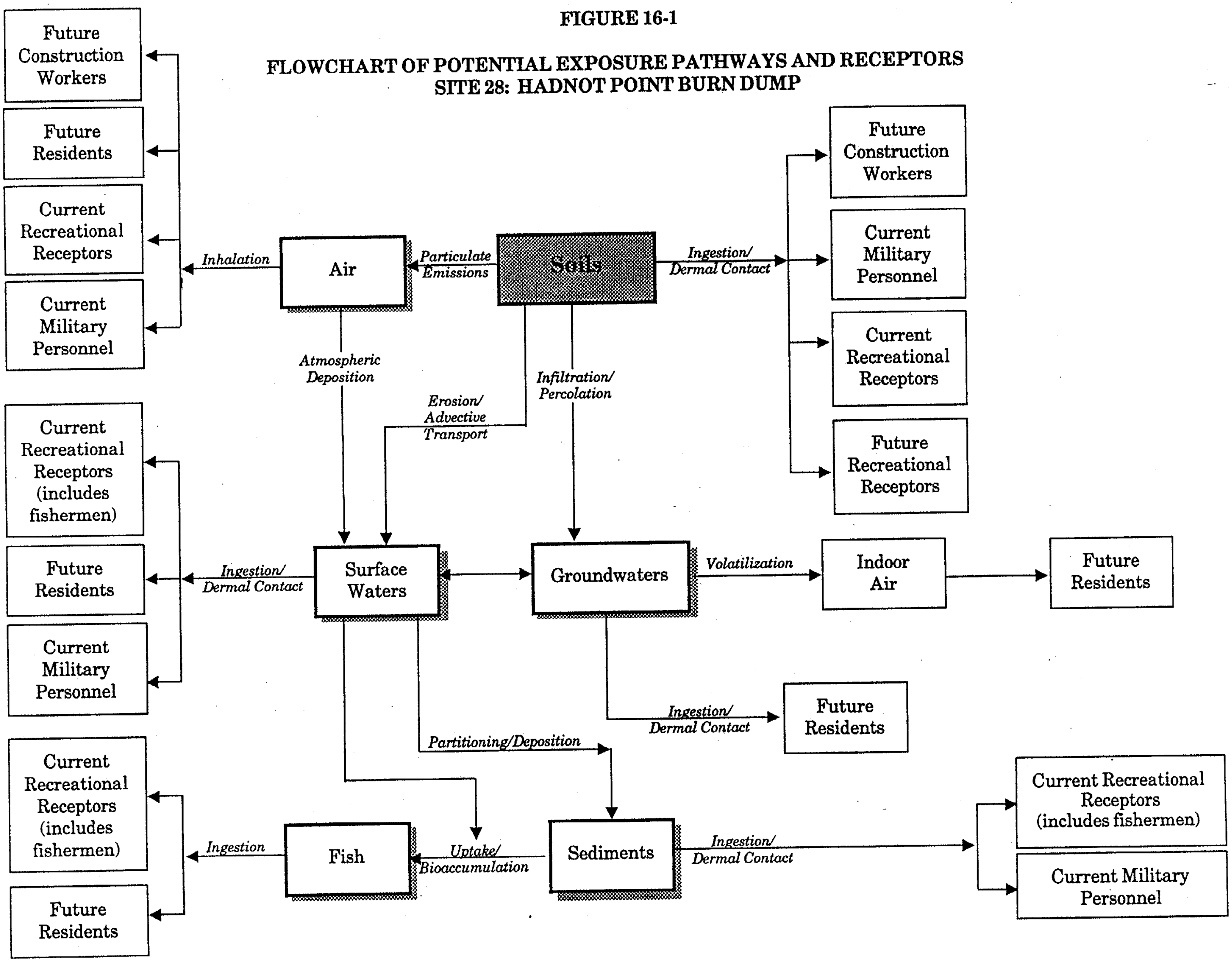
SUMMARY OF COPCs CONTRIBUTING TO RISKS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium of Concern	COPC
Groundwater	Arsenic (0.0027 mg/L) Manganese (1.5 mg/L)
Subsurface Soil	Antimony (11.8 mg/kg) Arsenic (7.9 mg/kg) Copper (886.2 mg/kg) Zinc (4,330 mg/kg)
Sediment - New River	Antimony (263 mg/kg)

SECTION 16.0 FIGURES

FIGURE 16-1

FLOWCHART OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS
SITE 28: HADNOT POINT BURN DUMP



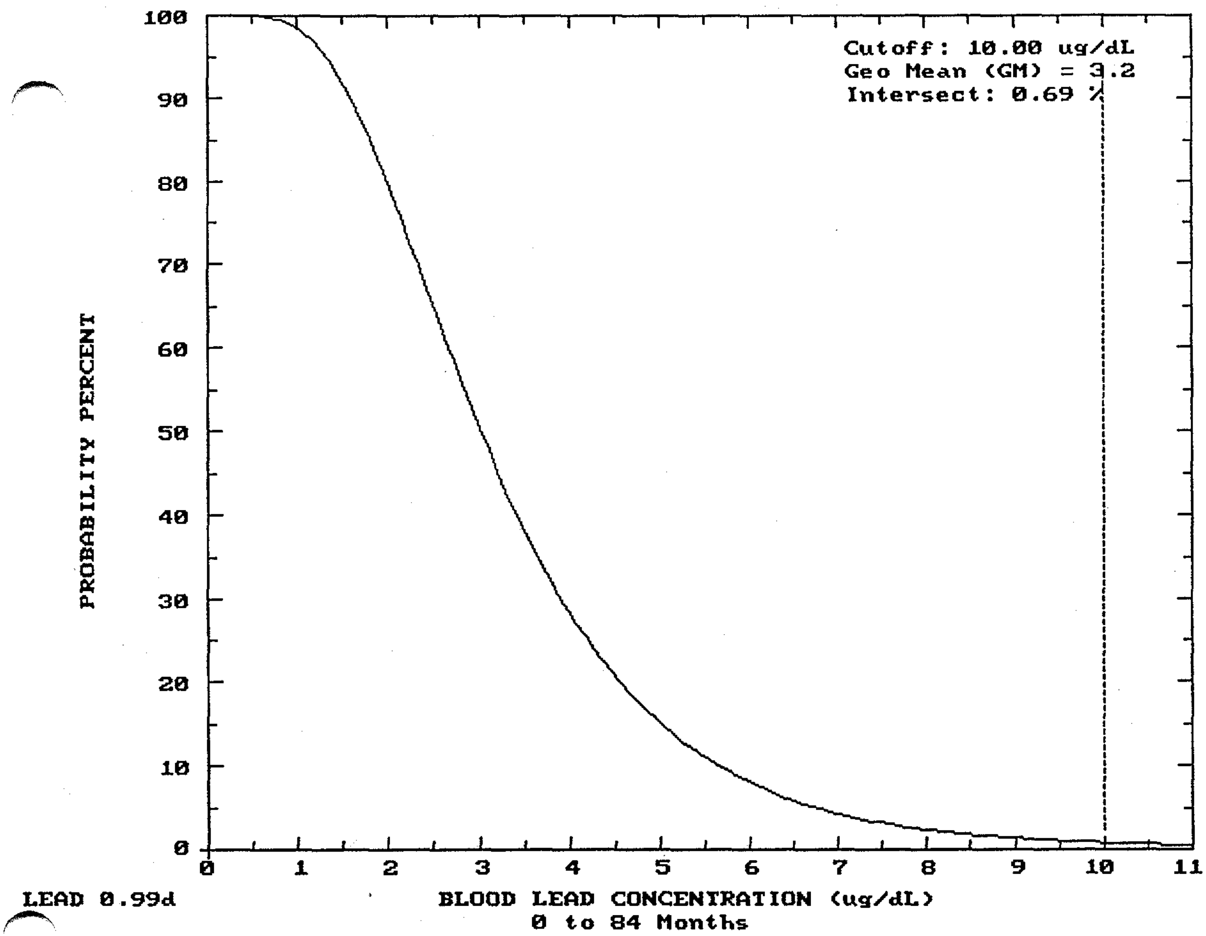


Figure 16-2
The Cumulative Probability Percent of Blood Lead Levels for Site 28, Hadnot Point Burn Dump - Current Scenario

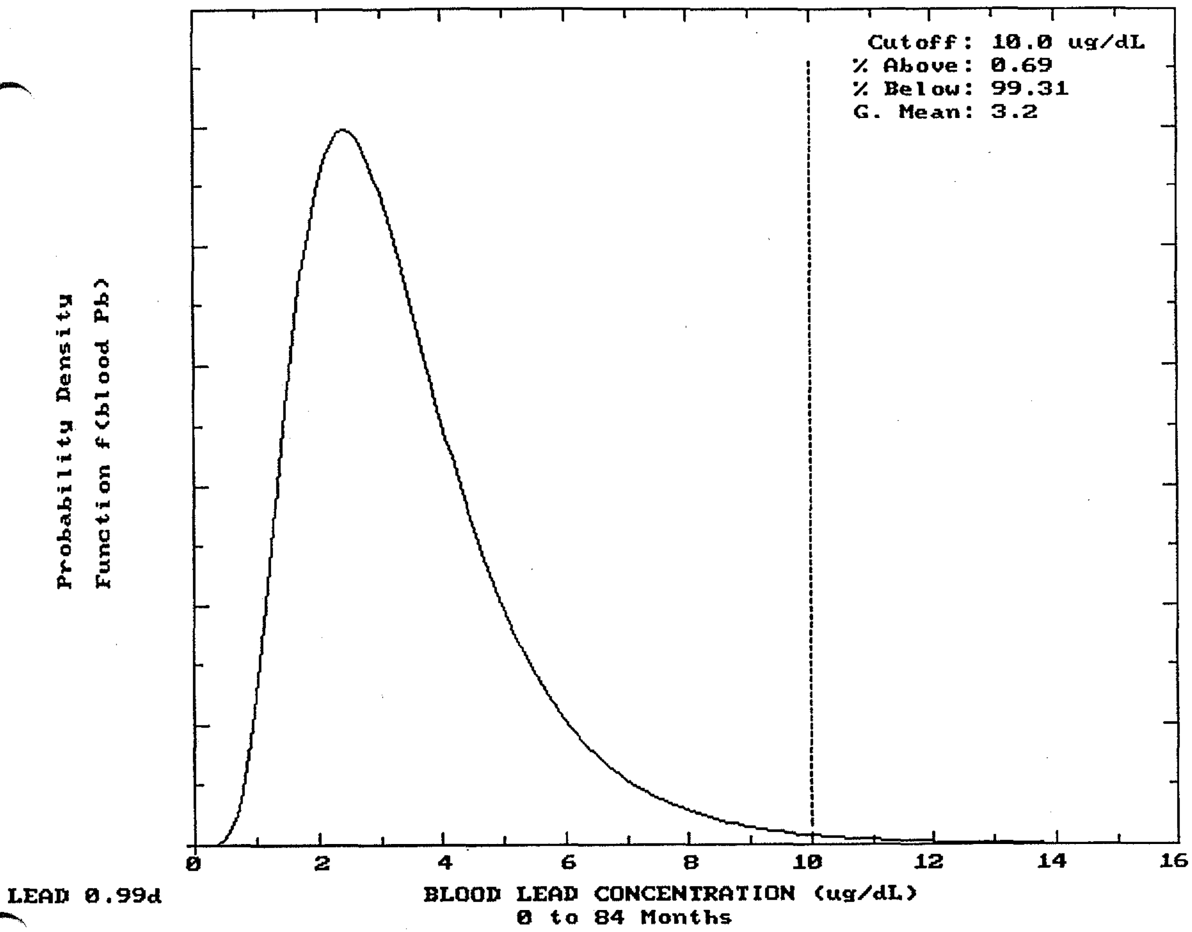


Figure 16-3
The Probability Distribution of Blood Lead Levels for Site 28, Hadnot Point Burn Dump - Current Scenario

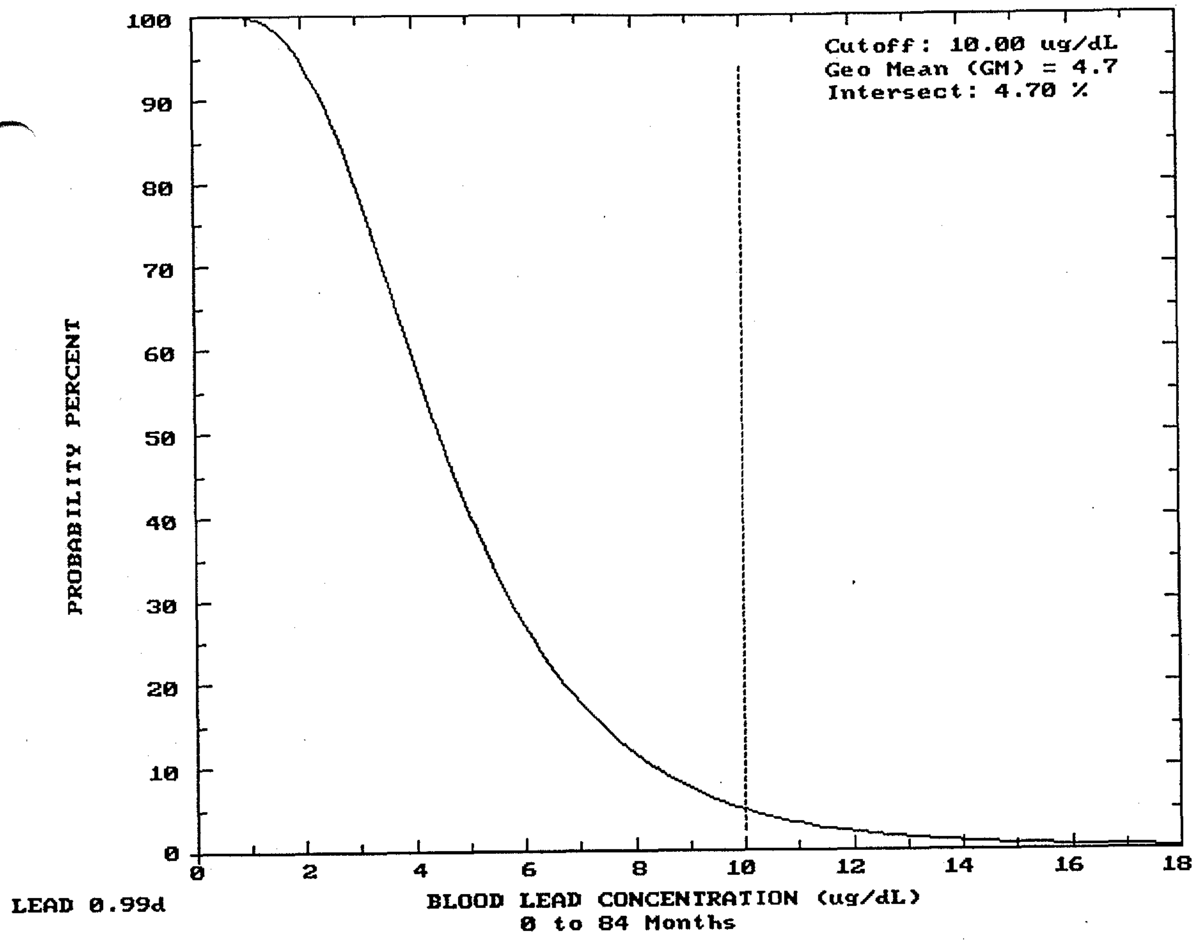


Figure 16-4
The Cumulative Probability Percent of Blood Lead Levels for Site 28, Hadnot Point Burn Dump - Future Scenario

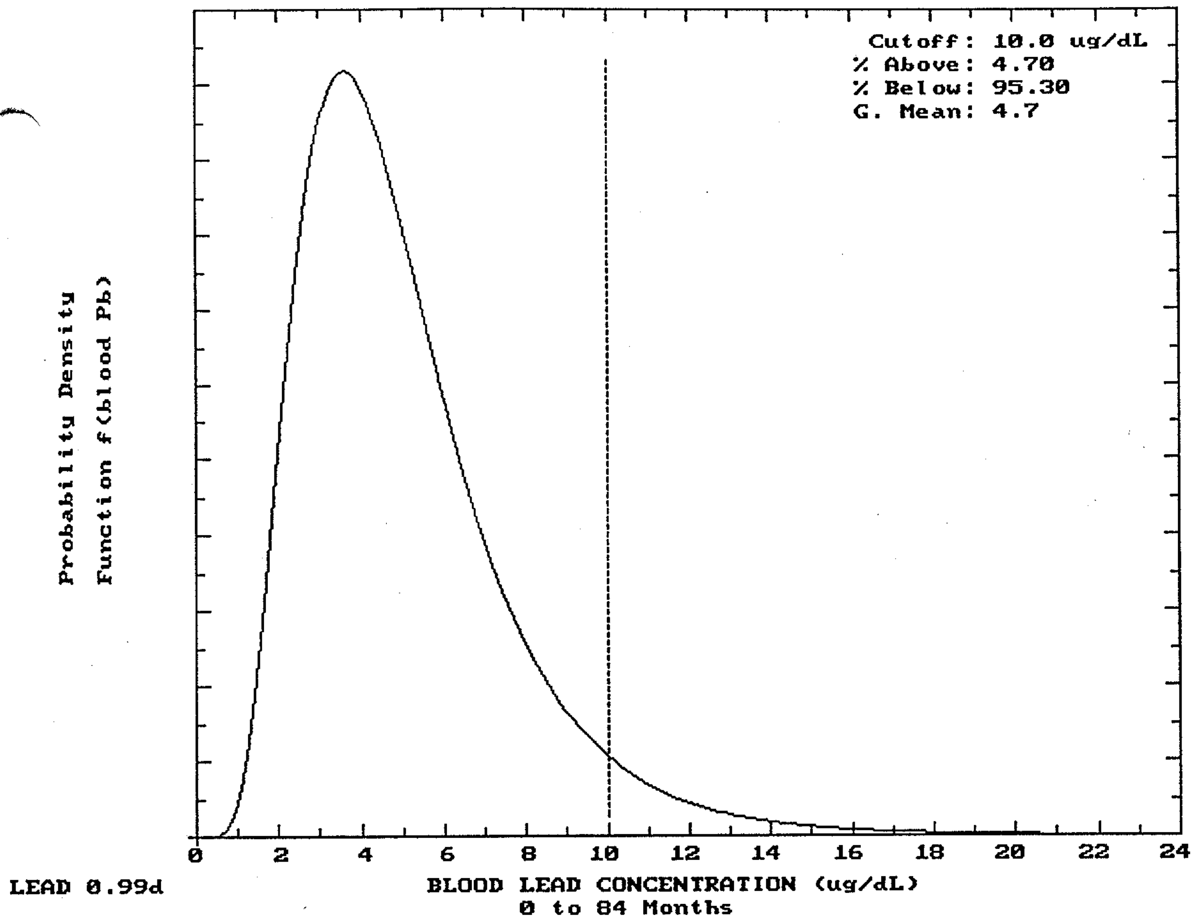


Figure 16-5
The Probability Distribution of Blood Lead Levels for Site 28, Hadnot Point Burn Dump - Future Scenario

17.0 ECOLOGICAL RISK ASSESSMENT

17.1 Introduction

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). In addition, various Federal and state laws and regulations concerning environmental protection are considered criteria/standards or to be considered (TBC) criteria.

This section presents the ecological risk assessment (ERA) conducted at Site 28 in Operable Unit (OU) No. 7 that addresses the potential impacts to ecological receptors from site-related contaminants.

17.1.1 Objectives of the Ecological Risk Assessment

The objective of this ERA was to evaluate if past disposal practices at Site 28 may be adversely impacting the ecological integrity of the terrestrial and aquatic communities on or adjacent to the site. This assessment also evaluated the potential effects of contaminants at Site 28 on sensitive environments including wetlands, protected species, and fish nursery areas. The conclusions of the ERA will be 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. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

17.1.2 Scope of the Ecological Risk Assessment

This ERA evaluated and analyzed the results from the RI and historical data collected during other studies. The RI included sampling and chemical analysis of the surface water, sediment, biota, soil, and groundwater at Site 28.

In addition, surface water, sediment, and biota samples were collected in May 1994 from three creeks in the White Oak River Basin (Hadnot Creek, Holland Mill Creek, and Webb Creek) that were used as off-site background reference stations. The fish from this sampling event were not chemically analyzed. However, fish collected in Hadnot Creek and the White Oak River by Baker in September through October 1993 were chemically analyzed and were used as reference station data for this ERA.

Information used to evaluate sensitive environments was obtained from historical data and previous studies conducted at Marine Corps Base (MCB) Camp Lejeune, North Carolina. In addition, a qualitative habitat evaluation was conducted at Site 28 to identify potential terrestrial receptors. The media of concern for this ERA were the surface water, sediment, biota (i.e., fish and benthic macroinvertebrates), and surface soil. This ERA focused on adverse impacts to aquatic and terrestrial receptors.

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992e). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- U.S. EPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989a)

- 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, 1990a)

- Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Water (USEPA, 1993c)

17.1.3 Organization of The Ecological Risk Assessment

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, 1992e). The problem formulation section (Section 17.2) includes a preliminary characterization of exposure and effects of the stressors on the ecological receptors. During the analysis (Section 17.3) the data are evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization (Section 17.4) the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. Section 17.5 evaluates the potential impact on the ecological integrity at the site from the contaminants detected in the media. Section 17.6 presents an uncertainty analysis, while Section 17.7 summarizes the conclusions of the ERA.

17.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects, as well as scientific data needs, policy and regulatory issues, and site-specific factors to define the feasibility, scope, and objectives for the ERA (USEPA, 1992e).

The results of the various site investigations indicated the presence of contaminants in the surface water, sediment, biota, soil, and groundwater. CERCLA directs USEPA to protect the environment with from releases of contaminants. Because ecological receptors may be exposed to the contaminants detected at Site 28, an ERA was performed.

Three types of information are needed to evaluate potential links between the contaminants of potential concern (COPCs) and the ecological endpoints. First, chemical analyses of the appropriate media are necessary to establish the presence, concentrations, and variabilities of the COPCs. Second, ecological surveys are necessary to establish if adverse ecological effects have occurred. Finally, toxicological information is necessary to evaluate the potential effects of the COPCs on the ecological receptors. The combination of all three types of data allows the assessment of the relative contribution of other potential causes of the observed effects (as measured by the ecological endpoints) that may be unrelated to the toxic effects of the contaminants of concern (e.g., habitat alterations and natural variability). Therefore, confidence in cleanup and monitoring decisions is greatly enhanced when based on a combination of chemical, ecological, and toxicological data.

Chemical analyses were performed on samples collected from the surface water, sediment, biota, soil, and groundwater to evaluate the presence, concentrations, and variabilities of the COPCs. Ecological surveys also were conducted as part of Baker's field activities during the RI and were used to develop the biohabitat map (refer to Section 13.5). Based on these observations and available habitat information, potential ecological receptors were identified. Finally, toxicological information for the COPCs detected in the media was obtained from available references and literature and was used to evaluate the potential adverse ecological effects on the ecological receptors.

The components of the problem formulation include stressor characteristics, ecosystems potentially at risk, ecological effects, endpoint selection, and a conceptual model. The following sections discuss each of these components and how they were evaluated in this ERA.

17.2.1 Stressor Characteristics

One of the initial steps in the problem formulation stage of an ERA is identifying the stressor characteristics. The term "stressor" is defined as any physical, chemical, or biological entity that can induce an adverse effect (USEPA, 1992e). For this ERA, the stressors that were evaluated include the contaminants detected in the surface water, sediment, biota, and surface soils. Contaminants in the subsurface soils and groundwater were not evaluated in this ERA, although the stressors introduced by groundwater discharge to surface water and soil erosion are considered.

The nature and extent of these contaminants are discussed in Section 14 of this report. Table 17-1 lists the contaminants that were detected in each media at Site 28. The location of samples was based on historical information available for the site and a site visit to evaluate potential ecosystems and ecological receptors. Figures 12-1, 12-2, 12-5, and 12-6 illustrate these sample locations. Tables 16-1 through 16-6 presents a comparison of the inorganics detected in the surface soil, surface water, and sediment to twice the average base background concentrations or to the range of positive detects at the off-site reference stations.

17.2.1.1 Contaminants of Potential Concern (COPCs)

The COPCs for the ERA were selected following the same basic procedures and criteria used for selecting the COPCs for the Baseline Human Health Risk Assessment. However, some of the COPCs included in the ERA were different than those included in the Human Health Risk Assessment. These differences can be the result of toxicity differences (some of the constituents detected may have a greater or lesser adverse impact to ecological receptors). In addition, the criteria and standards that are used for ecological receptors are different than those used for human receptors. Table 17-2 presents a summary of the COPC selection.

Quantifying risk for all positively identified contaminants may distract from the dominant risk driving contaminants at the site. Ecological risks (and human health) are additive, including chemicals that are not significant, as determined by the COPC selection process, will generate an overestimate of risk. The chemical acting alone may not pose an adverse risk, but, in conjunction with the remaining chemicals, the chemical contributes to the total site risk. Consequently, to include all detected parameters without taking into account other factors, such as detection frequency, background contribution, and site history would generate an overly conservative risk. Therefore, the data set was reduced to a list of COPCs. The criteria used in selecting the COPCs from the constituents detected during the field sampling and analytical phase of the investigation were: historical information; prevalence; mobility; persistence; toxicity; comparison to investigation-associated field and laboratory blank information; and comparison to background or naturally occurring levels. Appendix M contains the base background samples while Appendix N contains the off-site reference station background samples. In Appendix N, the statistics for the surface water and sediment samples are grouped by water body and by upstream, midstream or downstream.

COPCs - Surface Water

Surface water samples were collected at Site 28 from the New River, Cogdels Creek, and Orde Pond.

New River

The following VOC and SVOC detected in the surface water samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and were detected in QA/QC blanks associated with this media: acetone and bis(2-ethylhexyl)phthalate. Phenanthrene was not retained as a COPC because it was detected infrequently.

The following inorganics detected in the surface water samples were not addressed in the ERA because they are common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Nickel and thallium were detected infrequently, and nickel was detected at concentrations below surface water criteria. Therefore, these chemicals were not retained as COPCs. Barium was not retained as a COPC because it was detected at concentrations within off-site background concentrations.

The following chemicals detected in the surface water samples in the New River were included in the ERA because they could not be excluded based on the background results, blank results, or natural occurrences: 4,4'-DDE, 4,4'-DDD, aluminum, arsenic, cadmium, copper, iron, lead, manganese, vanadium, and zinc.

Cogdels Creek

There were no SVOCs, pesticides, or PCBs detected in the surface water samples.

Acetone, methylene chloride, and 2-hexanone were the only VOCs detected in the surface water in Cogdels Creek. They were detected infrequently and are considered common laboratory and/or decontamination contaminants. Therefore, they were not retained as COPCs in this ERA.

The following inorganics detected in the surface water samples were not addressed in the ERA because they were common naturally occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Arsenic and nickel were not retained as COPCs because they were detected at concentrations below surface water criteria. Barium was detected at concentrations within off-site background concentrations. Therefore, it was not retained as a COPC.

The following inorganics detected in the surface water samples in Cogdels Creek were included in the ERA because they could not be excluded based on the background results, blank results, or natural occurrences: aluminum, copper, iron, lead, manganese, vanadium, and zinc.

Orde Pond

There were no SVOCs, pesticides, or PCBs detected in the surface water samples.

Methylene chloride, detected in the surface water samples, was not addressed in the ERA because it was a common laboratory and/or decontamination contaminant and was detected in QA/QC blanks.

The following inorganics detected in the surface water samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Iron was not included as a COPC because it was detected at concentrations within the off-site background concentrations.

The following inorganics detected in the surface water samples at Orde Pond were included in the ERA because they could not be excluded based on the background results, blank results, or natural occurrences: aluminum, nickel, and thallium.

COPCs - Sediments

Sediment samples were collected at Site 28 from the New River, Cogdels Creek, and Orde Pond.

New River

The following VOCs and SVOCs detected in the sediment samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in the QA/QC blanks associated with this media: acetone, methylene chloride, 2-butanone, and bis(2-ethylhexyl)phthalate. Acetone, methylene chloride, and 2-butanone were also detected infrequently. Acenaphthalene and dibenz(a,h)anthracene were not retained as COPCs because they were detected at concentrations below sediment screening values.

The following inorganics detected in the sediment samples were not addressed in the ERA because they were common naturally occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Aluminum, chromium, cobalt, manganese, mercury, nickel, and vanadium were excluded as COPCs because they were detected at concentrations within off-site background concentrations.

The following chemicals detected in the sediment samples were addressed in the ERA because they could not be excluded based on the criteria stated above: antimony, arsenic, barium, copper, iron, lead, silver, zinc, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, gamma-chlordane, phenanthrene, anthracene, carbazole, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzofuran, fluorene, and benzo(g,h,i)perylene.

Cogdels Creek

The following VOCs detected in the sediment samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in the associated QA/QC samples: acetone and 2-butanone. Phenanthrene, anthracene, butyl benzylphthalate, 3,3'-dichlorobenzidine, benzo(b)fluoranthene, benzo(k)fluoranthene, and 4,4-DDT were not retained as COPCs because they were detected infrequently or were detected at concentrations below sediment screening values.

The following inorganics detected in the sediment samples were not addressed in the ERA because they were common naturally occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Cobalt and nickel were not retained as COPCs because they were detected at concentrations within off-site background concentrations.

The following chemicals detected in the sediment samples were addressed in the ERA because they could not be excluded based on the criteria stated above: aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, thallium, vanadium, zinc, 4,4'-DDE, 4,4'-DDD, alpha-chlordane, gamma-chlordane, carbon disulfide, bis(2-ethylhexyl)phthalate, fluoranthene, pyrene, benzo(a)anthracene, chrysene, and benzo(a)pyrene.

Orde Pond

The following VOCs and SVOC detected in the sediment samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in associated QA/QC samples: acetone, 2-butanone, toluene, and bis(2-ethylhexyl)phthalate.

The following inorganics detected in the sediment samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, and potassium. Barium and zinc were not retained as COPCs because they were detected at concentrations below sediment screening values and within off-site background concentrations.

The following chemicals detected in the sediment samples were addressed in the ERA because they could not be excluded based on the criteria stated above: aluminum, arsenic, beryllium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and 4,4'-DDD.

<u>*COPCs - Biota Samples*</u>

Biota samples for tissue analysis, which included fish, were collected at Site 28 from the New River and Orde Pond.

New River - fillets

The following VOCs and SVOCs detected in the fish fillet samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in the associated QA/QC samples: acetone, methylene chloride, and butylbenzylphthalate. Bis(2-ethylhexyl)phthalate was not retained as a COPC because it was detected within off-site background concentrations. Dieldrin and endrin aldehyde were not retained as COPCs because they were detected infrequently.

The following inorganics detected in the fish fillet samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Arsenic and mercury were not retained as COPCs because they were detected at concentrations within off-site background concentrations. Vanadium was not retained as a COPC because it was detected infrequently.

The following chemicals detected in the fish fillet samples were addressed in the ERA because they could not be excluded based on the criteria stated above: antimony, barium, cobalt, copper, selenium, 4,4'-DDE, 4,4'-DDD, and alpha-chlordane.

New River - whole body

The following VOCs and SVOCs detected in the fish whole body samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in the associated QA/QC samples: methylene chloride, 2-butanone, 2-hexanone, and bis(2-ethylhexyl)phthalate. Benzene was not retained as a COPC because it was only detected once in the fish tissue and was not detected in any other media at Site 28. Beta-BHC and endrin aldehyde were not retained as COPCs because they were detected infrequently.

The following inorganics detected in the fish whole body samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Beryllium was not retained as a COPC because it was detected infrequently.

The following chemicals detected in the fish whole body samples were addressed in the ERA because they could not be excluded based on the criteria stated above: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, selenium, silver, vanadium, zinc, 4,4'-DDE, 4,4'-DDD, and alpha-chlordane.

Orde Pond - fillets

There were no pesticides or PCBs detected in the fish fillet samples collected at Orde Pond.

The following VOC and SVOCs detected in the fish fillet samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in associated QA/QC samples: acetone, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate. 2-Methylphenol, 2,4,6-trichlorophenol, and 3-nitroaniline were not retained as COPCs because they were only detected once in the fish tissue and were not detected in either the surface water or sediment samples.

The following inorganics detected in the fish fillet samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Arsenic, chromium, copper, and mercury were not retained as COPCs because they were detected at concentrations within the off-site background concentrations. Cobalt was not retained as a COPC because it was detected infrequently.

The following chemicals detected in the fish fillet samples were addressed in the ERA because they could not be excluded based on the criteria stated above: barium, manganese, selenium, and zinc.

Orde Pond - whole body

The following VOCs and SVOCs detected in the fish whole body samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants and/or were detected in the QA/QC samples: acetone, methylene chloride, and bis(2-ethylhexyl)phthalate.

Toluene and total xylenes were not retained as COPCs because they were only detected once in the fish tissue.

The following inorganics detected in the fish whole body samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Antimony and vanadium were not retained as COPCs because they were only detected once in the fish tissue.

The following chemicals detected in the fish whole body samples were addressed in the ERA because they could not be excluded based on the criteria stated above: arsenic, barium, chromium, cobalt, copper, iron, manganese, mercury, selenium, zinc, 4,4'-DDE, and alpha-chlordane.

COPCs - Surface Soils

Surface soil samples were collected Site 28. The following SVOCs detected in the surface soil samples were not addressed in the ERA because they were common laboratory and/or decontamination contaminants or were detected in the QA/QC samples or were detected at concentrations below soil screening levels: di-n-butyl phthalate, butylbenzylphthalate, and di-n-octyl phthalate. Bis(2-chloroethyl)ether, naphthalene, acenapthene, dibenzofuran, fluorene, pentachlorophenol, dibenz(a,h)anthracene, chloromethane, methylene chloride, acetone, 1,1,1-trichloroethane, dieldrin, endrin, endosulfan sulfate, endrin aldehyde, Aroclor-1254, and Aroclor-1260 were not retained as COPCs because they were detected infrequently or they were detected at concentrations below soil screening levels.

The following inorganics detected in the surface soil samples were not addressed in the ERA because they were common, naturally-occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium. Selenium was not retained as a COPC because it was detected infrequently.

The following chemicals detected in the surface soil samples were addressed in the ERA because they could not be excluded based on the criteria stated above: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, thallium, vanadium, zinc, heptachlor epoxide, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, gamma-chlordane, phenanthrene, anthracene, carbazole, chrysene, bis(2-ethylhexyl)phthalate, fluoranthene, pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, and benzo(a)pyrene.

17.2.1.2 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) (freshwater), water solubility, organic carbon partition coefficient, octanol water partition coefficient, and vapor pressure. Table 17-3 summarizes these values for the COPCs identified in the sediments, surface water, surface soil, and biota samples for each site. Information from these tables was used in 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.

Water solubility is important in the ecological environment because it measures the tendency for a chemical to remain dissolved in the water column, partition to soil or sediment, or bioconcentrate in aquatic organisms. Chemicals with high water solubilities tend to be more bioavailable to aquatic organisms. However, they will not significantly bioconcentrate in the organisms. On the other hand, chemicals with a low water solubility will remain bound to the sediment and soils but may bioconcentrate in organisms to a significant degree.

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 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 log Kow is presented in Table 17-3.

The vapor pressure measures the tendency for a chemical to partition into air. This parameter is important for the ecological environment because it can be used to determine the concentrations of the constituents in air.

17.2.2 Ecosystems Potentially at Risk

Based on the site-specific and regional ecology, ecological receptors are potentially at risk from contaminants at the site (refer to Sections 1.2.6 and 13.5 for regional and site specific ecology, respectively). Contaminants were detected in the surface water, sediment, soil, groundwater, and biota samples at the site. 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 soils include deer, rabbits, foxes, raccoons, birds, and other fauna as well as terrestrial flora. This ERA will not evaluate contamination in the groundwater.

17.2.3 Ecological Effects

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic reference values from the following sources: North Carolina Water Quality Standards, USEPA Water Region IV Quality Screening Values, USEPA Ambient Water Quality Criteria, Sediment Screening Values, and terrestrial reference values. The following paragraphs discuss each of the above data sources.

The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) has promulgated Water Quality Standards (WQS) that are used to evaluate the quality of waters in North

Carolina. These WQS meet the requirements of both Federal and state law. These standards are regulatory values and are enforceable.

The USEPA Region IV Waste Management Division (Region IV) has adopted Water Quality Screening Values (WQSV) for chemicals detected at hazardous waste sites (USEPA, 1993). These values are intended as preliminary screening tools to review chemical data from hazardous waste sites. Exceedances of the screening level values indicate that there may be a need for further investigation of the site.

Section 304(a)(1) of the Clean Water Act of 1977 (P.L. 95-217) requires the Administrator of the USEPA to publish criteria for water quality that accurately reflect the latest scientific knowledge on the type and extent of all identifiable effects on health and welfare that may be expected from the presence of pollutants in any body of water, including groundwater. In accordance with the Clean Water Act, the USEPA Office of Water Regulations and Standards, Criteria and Standards Division has published Ambient Water Quality Criteria (AWQC) documents for several chemicals. These documents can be used to evaluate potential risks to aquatic organisms. In addition, potential risks to aquatic plants from contaminants can be evaluated using these documents.

Currently, promulgated sediment quality criteria do not exist. Until these criteria are developed, USEPA Region IV is using Sediment Screening Values (SSV) compiled by NOAA for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (USEPA, 1992f); where applicable, these SSVs were updated based on the literature. 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 of the chemicals identified during the sediment investigations at Site 28. If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-M and ER-L, adverse effects on the biota are considered possible. Finally, if contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (USEPA, 1992f).

A literature search was conducted to identify levels of contaminants in the soil that could cause adverse effects to terrestrial flora and invertebrates. However, these data cannot be used to evaluate potential risks to other terrestrial fauna (e.g., birds, deer, rabbits), since the exposure doses for these species are different than exposure doses for invertebrates and plants, which are in constant direct contact with the contaminants in the soil. In addition, the sensitivity of the organisms to the COPCs is not similar.

Terrestrial reference values (TRVs) for evaluating estimated chronic daily intakes (CDIs) of COPCs for the deer, quail, rabbit, fox, and raccoon were calculated from available toxicity data. 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), toxicological profiles for specific chemicals, and information from other reference books. These values are used to assess the potential effects of contaminants on terrestrial fauna.

17.2.4 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics, ecosystems potentially at risk, and ecological effects) was used to select the ecological endpoints for this ERA. The following section of this report contains a description of the ecological endpoints selected for this ERA and the reason they were selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if 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).

17.2.4.1 Assessment Endpoints

Assessment endpoints are the ultimate focus of risk characterization and link the measurement endpoints to the risk management process (USEPA, 1992e). There are five criteria that an assessment endpoint should satisfy (Suter, 1993):

- Societal relevance
- Biological relevance
- Unambiguous operational definition
- Accessibility to prediction and measurement
- Susceptibility to the hazardous agent

Societal relevance is important because risk to ecological receptors of little intrinsic interest to the public (e.g., nematodes, zooplankton) are unlikely to influence decisions unless they can be shown to indicate risks to biota of direct human interest (e.g., fish, wildlife) (Suter, 1993). The biological significance of a property is determined by its importance to a higher level of the biological hierarchy (Suter, 1993). The endpoint should be well defined and operational with a subject (e.g., benthic macroinvertebrates) and a characteristic of the subject (e.g., decrease in numbers of benthic macroinvertebrate) (USEPA, 1989d). The endpoint should be measurable (e.g., numbers of individuals) or predictable from measurements (e.g., toxicity tests). Finally, the endpoint must be susceptible to the contaminant being assessed. The assessment endpoints in this ERA were decreased integrity of aquatic and terrestrial floral and faunal communities.

Aquatic organisms (e.g., fish, benthic macroinvertebrates) are socially relevant because humans enjoy the sport of fishing and aquatic organisms also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other aquatic and terrestrial organisms. The endpoint is defined with a subject (aquatic organisms), and a characteristic of the subject (decreased integrity to aquatic organisms). The risk may be predicted by contaminant concentrations in media exceeding published aquatic reference values. Finally, aquatic organisms are susceptible to the COPCs at Site 28. This is explained in Section 17.2.5, Site Conceptual Model.

Terrestrial organisms (e.g., rabbits, deer, fox, raccoon, quail) are socially relevant because humans enjoy the sport of hunting and terrestrial organisms also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other terrestrial organisms and some also consume smaller mammals and plants which potentially have been contaminated. The endpoint is defined with a subject (rabbits, deer, fox, raccoon, and quail communities), and a characteristic of the subject (decreased integrity to rabbits, deer, fox, raccoon, and quail communities). The TRVs can be used to predict risks to terrestrial organisms. Finally, terrestrial organisms are susceptible to the COPCs at Site 28. This is explained in Section 17.2.5, Site Conceptual Model.

17.2.4.2 Measurement Endpoints

A measurement endpoint, or "ecological effects indicator" as it is sometimes called, 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.

Endpoints are divided into four primary ecological groups: individual, population, community, and ecosystem endpoints. Individual endpoints (e.g., death, growth, tissue concentrations) are evaluated through toxicity tests, models, and other methods used to assess the effects on individual organisms. Population endpoints (e.g., occurrence, abundance, reproductive performance) are evaluated to determine presence and absence of species through field studies. Community endpoints (e.g., number of species, species diversity) are used to describe the complexity of the community. Finally, ecosystem endpoints (e.g., biomass, productivity, nutrient dynamics) are used to determine the effects between groups of organisms, and between organisms and the environment. Individual, population, and community endpoints were evaluated in this assessment.

The primary goal in deciding upon which ecological endpoints to evaluate was to determine the current effects that the contamination is having on the environment. The following sections discuss the measurement endpoints that were chosen for the ERA.

Aquatic Endpoints

As discussed earlier in this report, aquatic species, including fish and benthic macroinvertebrates, are exposed to the COPCs at Site 28. Therefore, fish and benthic macroinvertebrates are potential ecological receptors at risk and were collected as part to the field activities.

Potential effects from contaminants detected at Site 28 to these species were evaluated by comparing the exposure levels of COPCs in the surface water and sediments to aquatic reference values (ARVs). In addition, the potential for decreased integrity to the aquatic community was evaluated by comparing the number and type of fish collected in the New River, Cogdels Creek, and Orde Pond to the number and type of fish collected at the appropriate off-site background stations. The COPCs detected in the tissue of the fish collected from the New River, Cogdels Creek, and Orde Pond were compared to chemical concentrations in fish collected at off-site locations, fish data collected in other studies, and literature toxicity values to determine if the levels of COPCs in the site fish were elevated or present at toxic levels.

The potential for decreased integrity to the benthic macroinvertebrate community was evaluated by comparing the type of species, the species diversity, macroinvertebrate biotic index (MBI), and community similarity of the benthic macroinvertebrates collected in the New River, Cogdels Creek, and Orde Pond to the appropriate off-site background stations. The following paragraphs discuss how the species diversity, MBI, and community similarity are calculated and how they are interpreted.

Species Diversity

The macroinvertebrate benthic 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 and Brillouin diversity were both calculated for the benthic species.

The Shannon-Wiener function (H') is one of the more commonly used formulas for calculating species diversity. Species diversity was calculated in logarithmic base 10 for the benthic macroinvertebrate species collected during the ecological investigation using the following equation (Brower and Zar, 1977):

$$H' = \sum (p_i * \log(p_i)).$$

H' = 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 nonrandomly 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

Typically, in waterways that are unpolluted and contain suitable habitat for aquatic life, diversity ranges from three to four, while in polluted rivers or rivers with unsuitable habitat diversity generally is less than one (USEPA, 1989c). 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. As will be discussed later in this ERA, the unsuitable habitat in some of the estuaries will cause the diversity of the benthic macroinvertebrate population to be less than one (Tenore, 1972).

Macroinvertebrate Biotic Index

Most of the benthic macroinvertebrates collected during the ecological investigation have been assigned a pollution tolerance rating. The tolerances were obtained from the NC DEHNR DEM, Environmental Sciences Branch (Lenat, 1993) and the USEPA Environmental Monitoring Systems Laboratory (USEPA, 1990a). NC DEHNR maintains a complete list of benthic macroinvertebrate species collected, or known to occur, in North Carolina on a database called BINDEX. BINDEX contains the scientific nomenclature, order, biotic index, and feeding group for each species. Biotic indices have not been established for many estuarine species. The BI ranges from zero to ten; a zero is assigned to taxa found only in unaltered streams of high water quality, and a ten is assigned to taxa known to occur in streams with intermediate degrees of pollution or disturbance. In addition, the U.S. EPA lists many common benthic macroinvertebrate species along with their tolerance to organic wastes, heavy metals, and acids (USEPA, 1990a).

The MBI was developed to provide a rapid stream quality assessment. North Carolina had a data set of over 2,000 stream macroinvertebrate samples, which were divided into five water-quality ratings. This data set was used to derive preliminary tolerance values for over 500 benthic macroinvertebrate taxa. The MBI is intended for the examination of the general level of pollutants regardless of the source. The index is an average of BI weighted by organism abundance, and is calculated as follows:

$$MBI = \sum (n_i * BI)/N.$$

MBI	=	Macroinvertebrate Biotic Index
n_i	=	Number of individuals occurring in the i^{th} taxa
BI	=	Biota Index assigned to the i^{th} taxa
N	=	Total number of individuals in the sample

The sampled benthic macroinvertebrate populations were assigned a general stream/water quality condition based on the MBI value. The five classes (Piedmont/Coastal Zone) and their corresponding MBI values are given below (Lenat, 1993):

Excellent Water Quality	Good Water Quality	Good-Fair Water Quality	Fair Water Quality	Poor Water Quality
< 5.24	5.25-5.95	5.96-6.67	6.68-7.70	> 7.71

The MBI for the benthic macroinvertebrate stations was calculated using the values listed in BINDEX. When a BI for a specific species was not listed, either the family BI (if available) was used or the species was not included in the MBI calculations.

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, 1977):

$$Sj = \frac{a}{a+b+c}$$

a = Number of species in the first collection
b = Number of species in the second collection
c = Number of species in both collections

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, 1977):

$$Ss = \frac{2a}{2a+b+c}$$

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, including salinity fluctuations, sediment type, size of water body, and time of collection determine the type of benthic population that will inhabit an area. As will be further discussed later in this ERA, the creeks which were selected for the reference stations were not exact replicates of the site stations with respect to all the above factors (and many others that are discussed). Therefore, 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 and the relative densities and species diversities of the reference stations as compared to the site stations.

Terrestrial Endpoints

As discussed earlier in this report, terrestrial faunal species including deer, birds, and small mammals potentially are exposed to the COPCs at Site 28. Potential effects from contaminants detected at Site 28 to these species were evaluated by comparing the CDIs to TRVs. In addition, comparisons of COPC concentrations in the soil to published plant and earthworm toxicity information were used to evaluate potential effects to some of these terrestrial species.

17.2.5 The Conceptional Model

This section of the report contains a list of hypotheses regarding how the stressors might affect ecological components of the natural environment:

- Aquatic receptors may be adversely affected by exposure to contaminated water, sediment, and contaminated biota they ingest.

- Terrestrial receptors may be adversely affected by exposure to contaminants in the surface water and surface soil.

- Terrestrial receptors may be adversely affected by exposure to contaminated biota they ingest.

17.3 Analysis Phase

The next phase after problem formulation is the analysis phase, which consists of the technical evaluation of the potential effects and exposure to the stressor on the ecological receptor. This phase includes the ecological exposure characterization and the ecological effects characterization.

17.3.1 Characterization of Exposure

Characterization of exposure evaluates the interaction of the stressor with the ecological component. The following sections characterize the exposure in accordance with the stressors, ecosystem, exposure analysis, and exposure profile.

17.3.1.1 Stressor Characterization: Distribution or Pattern of Change

The remedial investigations at Site 28 involved collecting samples from five media; surface water, sediment, soil, groundwater, and biota. The analytical results and source identification are presented in Section 14.5 of this report. The extent of contamination is discussed in Section 14.4 of this report.

17.3.1.2 Ecosystem Characterization

The regional ecology of the coastal plain and the habitats present at Site 28 are presented in Section 1.2.6 of this report; information on sensitive environments and endangered species also is included. Site-specific ecology is presented in Section 13.5 of this report. This section presents the site specific descriptions.

Site Description

Site 28 is located on the Mainside portion of MCB Camp Lejeune, adjacent to the Mainside Sewage Treatment Plant. Vehicle access to the site is via Julian C. Smith Boulevard near its intersection with O Street. The site is bordered to the north and east by wooded areas and to the southwest by the New River. Cogdels Creek forms a natural divide between the eastern and western potions of the site. Section 11.0 provides a detailed description of Site 28 and the surrounding areas.

Reference Stations

Off-site reference stations were located in three creeks in the White Oak River watershed: Hadnot Creek, Holland Mill Creek, and Webb Creek. Surface water and sediment samples were collected from these creeks for chemical analysis, while fish and benthic macroinvertebrates were collected from these creeks for population statistics. In September 1993, fish samples were collected from

Hadnot Creek for chemical analysis of their fillets (Baker, 1993b). The results of this sampling will be included in the ERA.

The White Oak River watershed is smaller than the New River watershed. It begins in the Hoffman Forest, flows approximately 48 miles, and empties into the Atlantic Ocean. Approximately 77 percent of the watershed is within the Hoffman Forest and the Croatan National Forest. This watershed has very little development; Swansboro is the largest town in the watershed. Therefore, the reference stations should be representative of an aquatic system with relatively few impacts from point and non-point sources of industrial pollution.

Initially Baker was to collect samples at three stations from each creek; one upstream freshwater station, one midstream freshwater/saltwater stations and one downstream saltwater station. However, a good undisturbed upstream freshwater station was not identified in Webb Creek. Therefore, two upstream locations were sampled in Hadnot Creek.

The fish and benthic macroinvertebrates at stations 28-FS/BN04 and 28-FS/BN05 were compared to the fish and benthic macroinvertebrates collected at background stations HC03 and HM03. The two stations at Site 28 were located in the New River, while the two background stations were located in the White Oak River. The New River and White Oak River at these locations were similar in that they were very wide and open. The sediments were fairly similar; they were silty/sandy and most samples contained some shell fragments.

The fish and benthic macroinvertebrates at the three stations in Cogdels Creek (28-FS/BN01, 28-FS/BN02, and 28-FS/BN03) were compared to the fish and benthic macroinvertebrates collected at background stations HM02, HC02, and WC02. These background stations were similar in size and sediment type. The salinity at HC02 and WC02 best matched the salinity in Cogdels Creek; however, there was a large fluctuation in the salinity at these stations.

The fish and benthic macroinvertebrates collected in Orde Pond (OP-FS/BN01) were compared to the fish and benthic macroinvertebrates collected at background station HC01. This background station was the most similar off-site background station to Orde Pond.

Biological Sampling

Biological samples collected at Site 28 consisted of fish and benthic macroinvertebrates. The collection of crabs was proposed at Site 28; however, only one crab was collected during the sampling events and was not sent to the laboratory for tissue analysis. The biological samples were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain fish tissue samples for chemical analysis. Before the sampling event at each station, the following information describing the site was recorded in the field log book (See Appendix T for sampling station information):

- 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

Water quality measurements were collected during the benthic macroinvertebrate sampling, at a minimum, and during collection of some of the fish samples. On-site water quality measurements at the sampling stations consisted of temperature, pH, specific conductance, salinity, and dissolved oxygen. These measurements were conducted prior to sample collection. The station locations and sampling procedures for the collection of the fish, shellfish, and benthic macroinvertebrates are discussed in Section 12.6 of this report.

Biological Sampling Results

The following sections present the results of sampling the abiotic habitat (e.g., substrate type, depth, water velocity) and biotic communities (e.g., fish, plants) from the ecological investigation. The results of the fish tissue samples are presented in Section 12.6.1 of this report.

Abiotic Habitat

Information describing the abiotic habitat at Site 28 and the reference stations was recorded in the field log books at each station and was later transferred to data sheets. This information is provided below. A field investigation photograph album was complied that includes representative photographs of the stations (Baker, 1994a).

Fish and benthic macroinvertebrates were sampled at two stations in the New River, three stations in Cogdels Creek, and one station in Orde Pond (see Figure 12-6). Fish and benthic macroinvertebrates also were sampled at two stations in Webb Creek, four stations in Hadnot Creek, and three stations in Holland Mill Creek (see Appendix N).

New River

Station 28-FS/BN04 was open and surrounded by mixed forests. The water was turbid and brown. At Station 28-FS/BN04, between sixteen to twenty-four ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments did not have a discernible odor. They were ninety percent fine sand with ten percent shell fragments. Debris, consisting of rocks and bricks, was present on the shore near this sampling station.

Station 28-FS/BN05 was open and surrounded by mixed forests. The water was turbid and brown. At Station 28-FS/BN05, approximately eight ounces of sediments were collected in each benthic macroinvertebrate replicate. The sediments, which did not have a discernible odor, were a silty-clay with some sand inclusions and shell fragments.

Cogdels Creek

Station 28-FS/BN01 was partly shaded and surrounded by forest. The stream was approximately 1 foot deep by 30 feet wide. The water was slightly turbid with a tannish color. Between twenty-four to forty ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slightly anaerobic odor to the sediments. The sediments were approximately ninety percent fine silt with sticks and woody debris.

Station 28-FS/BN02 was partly shaded and surrounded by forests. The stream at this station was approximately 1 to 2 feet deep and 40 feet wide. The water was slightly turbid with a tannish color. Between twenty-four to forty-two ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor to the sediments, which were fine silty-sand with approximately twenty-five to thirty-five percent woody debris (sticks, leaves, and needles).

Station 28-FS/BN03 was partly shaded and surrounded by mixed hardwoods. The stream at this station was approximately 3 to 4 feet deep and 30 to 40 feet wide. The water was turbid to opaque. Approximately eight ounces of sediments were collected for each benthic macroinvertebrate replicate sample. There was a slight anaerobic odor to the sediments. The sediment was primarily silty with some woody debris and shell fragments.

Orde Pond

Station 28-OP-FS/BN was open in an industrial area surrounded by forest. The middle of the pond was approximately 8 feet deep. The water was clear. Approximately eight ounces of sediment were collected for each benthic macroinvertebrate replicate sample. There was no odor to the sediments, which were very silty with some clay and grass.

Webb Creek

Station WC02 was open and surrounded by forests. The water was slightly turbid and brown. The stream at this station was 40 feet wide and 4 to 5 feet deep. At this station, between sixteen to eighty ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments had an anaerobic odor. The sediments in the first replicate were mostly silt with traces of sand and approximately 55 percent woody debris. The sediments in the second and third replicates contained more woody debris.

Station WC03 was open and surrounded by forests. The water was slightly turbid and brown. The stream at this station was 250 feet wide and approximately 25 feet deep. At Station WC03, between sixteen and fifty-six ounces of sediments were collected for each benthic macroinvertebrate replicate. The sediment had a slight anaerobic odor. The sediment was silt/muck with organic material. Some clay was observed in the third replicate.

Hadnot Creek

Station HC01 was shaded and in an urban area surrounded by forest. The stream depth was approximately 5 feet and the width was approximately 5 feet. The water was clear and brown. Between twenty-four to eighty ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor to the sediments, which were silty with some woody debris.

Station HC02 was partly shaded and surrounded by forests. The stream at this station was 6.5 feet deep and 40 feet wide. The water was slightly turbid and brown. Between sixteen to forty ounces of sediments were collected for the benthic macroinvertebrate replicate. There was an anaerobic odor to the sediments. The sediment were fine silty-sand with woody debris which included pine needles.

Station HC03 was in an urban area surrounded by forests. The width and the depth of Hadnot Creek was not measured at this station due to its large size . The water was turbid with a brown color. Approximately eight ounces of sediments were collected for each benthic macroinvertebrate replicate. There was a slight anaerobic odor to the sediments. The sediments were silty-sand with some woody debris.

Station HC04 was shaded and surrounded by forests. The water at this station was approximately 1 to 3 feet deep and 5 to 7 feet wide. The water was clear. Approximately eight ounces of sediments were collected for each benthic macroinvertebrate replicate. There was a slight anaerobic odor to the sediments. The sediments were sandy with little woody material.

Holland Mill Creek

Station HM01 was shaded in an urban area surrounded by forest. The stream depth was approximately 0.5 to 1.5 feet and the width was approximately 10 feet. The water was clear. Between sixteen to forty ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor to the sediments. The sediments were sandy with a light brown color.

Station HM02 was partly open and surrounded by forests. The stream at this station was approximately 3 to 4 feet deep and 50 feet wide. The water was turbid and brown. Between thirty-two to forty ounces of sediments were collected for the benthic macroinvertebrate replicate. There was a slight anaerobic odor in the sediments. The sediments were mostly silty with traces of sand. Approximately fifty percent of the sample was woody debris.

Station HM03 was open and in an urban area surrounded by forest. The width and depth of Holland Mill Creek was not measured at this station due to its large size. The water was opaque and brown. Between eight and sixteen ounces of sediments were collected for each benthic macroinvertebrate replicate. There was an anaerobic odor to the sediments. The sediment was very fine silt with shell fragments. Approximately ten percent of the sample was woody debris.

Biotic Habitat

Fish Population Statistics

The following sections discuss the fish population statistics for the New River, Cogdels Creek, Orde Pond, Webb Creek, Hadnot Creek, and Holland Mill Creek. Appendix L presents a summary of the fish population statistics for the New River, Cogdels Creek, and Orde Pond. Appendix N presents a summary of the fish population statistics for Webb Creek, Hadnot Creek, and Holland Mill Creek. Included in this appendix are the aquatic species identified, the total number collected at each sampling station, and the average, minimum, and maximum length and weight for each species identified. Table 17-4 is a summary of the fish species collected at Site 28, Table 17-5 is a list of the fish sent to the laboratory for tissue analysis, and Table 17-6 describes the characterization of the fish collected at Site 28.

New River

Species were collected from two stations, 28-FS04 and 28-FS05, at the New River. A total of 6 fish species consisting of 238 individuals were collected in the New River.

Of the six fish species collected at the two New River sample stations, the predominant fish species collected were the stripped mullet and Atlantic menhaden. One hundred ninety-eight Atlantic menhaden were collected at station 28-FS04. The length of these fish ranged from 14.0 to 20.5 cm and the weight ranged from 20 to 80 grams. At station 28-FS05, four Atlantic menhaden were collected. The fish length varied between 16.5 and 20.5 cm. The average weight of the fish was 56.3 grams. Fourteen stripped mullet were collected at station 28-FS04. The length of the fish ranged from 11.1 to 44 cm. The weight varied between 15 and 900 grams. At station 28-FS05 six stripped mullet were collected. The length of these fish varied between 23.5 and 39.5 cm. The average weight of the fish was 438 grams. Two summer flounder were collected at station 28-FS04 and seven were collected at station 28-FS05. The fish length varied between 6 to 37.5 cm and the fish weight varied between 6 to 580 grams. One black drum was collected at station 28-FS04; the fish length was 25.5 cm; the fish was not weighted. One spotted sea trout was collected at station 28-FS05. The fish length was 46.5 cm and the fish weight was 960 grams. Five silverside anchovies were collected at station 28-FS04. The fish length varied between 9.5 to 10.8 cm. The fish weight varied between 7.5 to 10 grams.

Cogdels Creek

Species were only collected from one station, 28-FS01, at Cogdels Creek. A total of four individuals representing two fish species and one crab species were collected in Cogdels Creek.

Two pumpkinseed were collected at station 28-FS01. The length of these fish ranged from 8 to 15 cm. The weight ranged from 10 to 35 grams. One stripped mullet was collected at station 28-FS01; the fish length was 12 cm; and the fish weight was 20 grams. Of the aquatic species other than fish collected at the Cogdels Creek sampling station, only one blue crab was identified. The length of the crab was 10 cm. The crab weight was 55 grams.

These fish were collected in the hoop nets. The gill nets were not successful at any of the stations in Cogdels Creek because they kept clogging up with woody debris. Electrofishing was not attempted in the creek because the salinity was too high and the water was very turbid during the sampling investigation.

Orde Pond

A total of six fish species were collected at the one sampling station located on Orde Pond. Of the six species collected at Orde Pond, 230 individuals were collected.

Of the 6 fish species collected at the Orde Pond sample station, the predominant fish species collected were the blue gill and redear sunfish. One hundred seventy-two blue gill were collected at Orde Pond. The length of the fish ranged from 2.5 to 18.4 cm. The fish weight varied from 3 to 55 grams. Thirty-six redear sunfish were collected at station 28-OP1. The length varied between 4 and 18.5 cm. The fish weight ranged from 4 to 105 grams. Thirteen largemouth bass were collected at Orde Pond. The length varied between 9 and 30 cm. The average fish weight was 91 grams. Two American eel were also collected at Orde Pond. The eel length ranged from 51 to 52 cm and the weight ranged from 245 to 265 grams. Six warmouth were collected. The fish length varied between 12.5 and 19.5 cm. The fish weight varied between 40 and 150 grams. One pumpkinseed was collected at Orde Pond. The fish length was 12.5 cm and the fish weight was 40 grams.

Webb Creek

A total of 13 fish species and 1 other aquatic species were collected at the two sampling stations located at Webb Creek. Of the 13 species collected at Webb Creek, 89 individuals were collected. Of the one other aquatic species, 3 individuals were collected.

Ten fish species collected at station WC02 in Webb Creek; the predominant fish species collected were the pinfish and long-nosed gar. Twenty-five pinfish were collected at station WC02. Length information was collected for one fish, which was 10.5 cm long. Nine long-nosed gar were collected at station WC02. The length varied between 66.5 and 75 cm. The fish weight ranged from 1,100 and 1,420 grams. Four spot and four stripped mullet were collected at station WC02 in Webb Creek. The length varied between 35.5 and 41.5 cm for the stripped mullet and 13 to 14.5 cm for the spot. The average fish weight was 700 grams for the stripped mullet and 8.3 grams for the spot. Three mudcat were collected at station WC02; the length and weight were not recorded for this fish. One redbreast-sunfish and one white catfish were also collected at station WC02 in Webb Creek. The redbreast sunfish was 16 cm long and the white catfish was 37 cm long. The weight of the redbreast sunfish was 60 grams and the weight of the white catfish was 750 grams. Four blue gill were collected at station WC02. The fish length varied between 16.75 and 23.5 cm. The fish weight varied between 85 to 300 grams. Two largemouth bass were also collected at station WC02; the average fish length was 34 cm, and the fish weight ranged from 525 to 600 grams. Three yellow bullhead catfish were also collected at station WC02. The fish length ranged from 32.5 to 38.5 cm. The fish weight ranged from 620 to 900 grams.

Four fish species and one other aquatic species were collected at station WC03 in Webb Creek. One summer flounder was collected at station WC03; the length of the fish was 21 cm, and the weight was 60 grams. Five long-nose gar were collected at station WC03. The fish length ranged from 71.5 to 97 cm. The fish weight ranged from 1,000 to 2,850 grams. Twenty-four pinfish and three mummichog were also collected at station WC03. The length and width were not recorded for these fish. Also, three grass shrimp were collected at station WC03. The length and width were not recorded for these shrimp.

Hadnot Creek

Species were collected from four stations, HC01, HC02, HC03, and HC04, at Hadnot Creek. A total of 19 fish species consisting of 58 individuals and one other aquatic species consisting of 3 individuals were collected in Hadnot Creek.

Of the six fish species collected at station HC01 in Hadnot Creek, the predominant fish species collected were the mudcat and American flier. Three mudcat and three American flier were collected at station HC01. The length and weight of the mudcat were not recorded. The length of the American flier ranged from 9.5 to 16.5 cm, and the weight ranged from 15 to 65 grams. Two redbreast sunfish and two yellow bullhead catfish were collected at station HC01. The length of the redbreast sunfish varied between 20 and 23.5 cm; the average length of the catfish was 26.5 cm. The weight of the redbreast sunfish ranged between 175 and 265 grams, and the weight of catfish ranged from 270 to 275 grams. One chain pickerel and one redear fish also were collected at station HC01. The length of the chain pickerel was 37 cm and the weight was 290 grams. The length and weight of the redear fish were not recorded.

Two species of fish were collected at station HC02. Three pumpkinseed and one warmouth were collected. The length of the pumpkinseed ranged from 13 to 17.5 cm. The weight ranged from 50 to 125 grams. The length of the warmouth was 22 cm and the weight was 250 grams.

Eight species of fish were collected at station HC03. The most abundant fish species collected at HC03 was the spot. Twelve spot were collected. The length of the spot ranged from 3.5 to 14 cm, and the weight ranged from 2.5 to 40 grams. Five pinfish and five Atlantic croaker were collected at station HC03. The length of the pinfish ranged from 10.5 to 13 cm. The length of the Atlantic croaker ranged from 7.5 to 11.5 cm. The weight of the pinfish varied from 22 to 37 grams and the weight of the Atlantic croaker varied from 2.5 to 20 grams. Three stripped mullet and the three blue fish were also collected at station HC03. The stripped mullet length ranged from 12.5 to 15.25 cm and the weight varied between 20 and 45 grams. The blue fish length ranged from 7 to 11 cm and the weight varied between 7 and 17 grams. Two Atlantic menhaden were collected from station HC03. The fish length and weight were measured for one fish. The length was 5 cm and the weight was approximately 2.5 grams. One white perch and one hogchoker were collected from HC03. The length of the white perch was 18.5 cm and the weight was 105 grams. The length of the hogchoker was 5.5 cm and the weight was 5 grams.

Two species of fish and one other aquatic species were collected at station HC04. Eight pirate perch were collected. The fish length varied between 4.5 and 5 cm, and the average fish weight was approximately 2.5 grams. Two redfin pickerel were also collected at station HC04. The average fish length was 17 cm and the average fish weight was 30 grams. Also, three crayfish were collected at station HC04. The length varied between 4 and 6 cm, and the average weight was 3.3 grams.

Holland Mill Creek

Species were collected from three stations, HM01, HM02, and HM03, at Holland Mill Creek. A total of 18 fish species consisting of 299 individuals and 3 other aquatic species consisting of 17 individuals were collected in Holland Mill Creek.

Six species of fish and two other aquatic species were collected at station HM01. Sixteen pumpkinseed were collected at station HM01. The fish length varied between 4.5 and 11 cm. The fish weight varied between 4.5 and 8.3 grams. Six swamp darter were collected at station HM01. The average length of the fish was 6 cm and the average weight was 3 grams. Two blue gill and two chain pickerel were also collected. The average length of the blue gill was 10.5 cm, the average weight was 10 grams. The length of the chain pickerel varied between 13 and 13.5 cm, and the average weight was 5 grams. One mud sunfish and one freshwater goby also were collected at station HM01. The length and weight of these fish were not recorded. Also, three crayfish and one unknown fish species were collected at station HM01.

Twelve species of fish and one other aquatic species were collected from station HM02. Eleven stripped mullet were collected from HM02. The fish length varied between 31 and 39.5 cm. The fish weight varied between 320 and 640 grams. Seven pinfish were also collected. The average length of the pinfish was 17.5 cm and the average weight was 80 grams. Three long-nose gar were collected at station HM02. The length ranged from 72.5 to 83 cm. The fish weight ranged from 1,250 to 2,000 grams. Two gizzard shad, two spotted sunfish, and two pumpkinseed were collected at station HM02. The pumpkinseed length ranged from 11.5 to 15 cm, the spotted sunfish length ranged from 15.5 to 17 cm, and the gizzard shad length ranged from 33 to 34 cm. The weight of the pumpkinseed varied between 30 and 50 grams, the weight of the spotted sunfish varied between 65 and 110 grams, and the weight of the gizzard shad varied between 460 and 480 grams. One summer flounder, black drum, largemouth bass, and blue gill were collected at station HM02. The length and weight of the summer flounder were 29.5 cm and 25 grams. The length of the black drum was 28 cm and the weight was 250 grams. The length of the largemouth bass was 34 cm, and the fish weight was 540 grams. The length of the blue gill was 17 cm, and the weight was 105 grams. Six mummichog and one freshwater goby were collected at station HM02; the length and weight of these fish was not recorded. Also, 13 grass shrimp were collected at station HM02, the length and weight were not recorded.

Six fish species were collected at station HM03. One hundred ninety-nine Atlantic menhaden were collected from station HM03. The average length of the fish was 6.5 cm and the average weight of the fish was 2.3 grams. Seventeen summer flounder were collected at station HM03. The fish length varied between 20.5 and 43 cm. The fish weight varied between 90 and 850 grams. Eight spot were collected at station HM03. The fish length varied between 5 and 12 cm. The fish weight varied between 2.5 and 25 grams. Three stripped mullet were also collected at station HM03. The fish length ranged from 6.5 to 14.5 cm; and the weight ranged from 2.5 to 40 grams. Two hogchoker were collected at the station HM03, the average length was 6 cm; and the average weight was 10 grams. Also, four pinfish were collected at station HM03. The average length of the fish was 5 cm, and the average weight was 2.5 grams.

Benthic Macroinvertebrate Population Statistics

Table 17-7 is a systematic listing of all benthic organisms collected from the sampling stations along the New River, Cogdels Creek, and Orde Pond, and Table 17-8 lists the biotic index and USEPA tolerance values for each species. Appendix U presents a systematic listing of the benthic organisms collected at each of the sampling stations. Individual organisms were identified to the genus or species level. Table 17-9 contains the summary statistics for the benthic macroinvertebrates collected from the New River, Cogdels Creek, and Orde Pond. Appendix U contains the raw data. The parameters include the number of benthic species collected at each station; the number of benthic organisms identified at each station; the species density, which is the number of organisms per square meter study area; the species diversity; and the macroinvertebrate biotic index. Overall species richness is indicated by the number of benthic species collected at each station. The macroinvertebrate biotic index (MBI), ranging from 0 to 10, summarizes overall population tolerance to a single value, which is used specifically for detecting organic pollution. These MBIs are presented in Table 17-9. The results of the benthic macroinvertebrate sample collection from the New River, Cogdels Creek, Orde Pond, and the reference stations at Webb Creek, Hadnot Creek, and Holland Mill Creek are presented in the following sections.

New River

In the New River, 14 benthic macroinvertebrate species consisting of 314 individuals were collected at the two sampling stations. The benthic macroinvertebrates were from the following phyla: Annelida, Arthropoda, and Mollusca.

Approximately 23 percent of the individuals were the capitellidae Capitella capitata and nineteen percent were the spionidae Streblospio benedicti. The majority of the benthic macroinvertebrate species found in the New River were from the Annelida phylum.

Thirteen benthic macroinvertebrate species were collected at station 28-BN04, while eight species were collected at station 28-BN05. Two hundred and fifty-one individuals were collected at station 28-BN04, while 63 individuals were collected at station 28-BN05. Species density was higher at station 28-BN04 (1,600 individuals/m^2) than at station 28-BN05 (402 individuals/m^2). The Shannon-Wiener species diversity was 0.930 at station 28-BN04 and 0.619 at station 28-BN05. The Brillouin's species diversity was 0.890 at station 28-BN04 and 0.550 at 28-BN05. The MBIs for both stations in New River could not be calculated because no biota indices were available for the species collected at these two stations.

Cogdels Creek

A total of 17 species consisting of 209 individuals were collected from the three sampling stations at Cogdels Creek. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 41 percent of the individuals was the capitellidae Capitella capitata and 14 percent of the detected organisms were the chironomidae Chironomus decorus gr.. The next abundant group of benthic macroinvertebrate species was the nereidae Nereis succinea, found at a frequency of approximately 12 percent.

Species abundance was greatest at station 28-BN01. The number of species detected at this station was 11, followed by 8 and 6 species at stations 28-BN02 and 28-BN03, respectively. The largest number of individuals was collected at station 28-BN02 (85), followed by 82 and 42 individuals at stations 28-BN01 and 28-BN03, respectively. Species density was greatest at stations 28-BN02 (542 individuals/m^2), followed by 523 and 268 individuals/m^2 at stations 28-BN01 and 28-BN03, respectively.

The Shannon-Weiner species diversity was 0.847 at station 28-BN01, 0.547 at station 28-BN02, and 0.493 at station 28-BN03. The Brillouin's species diversity was greatest (0.765) at station 28-BN01, 0.495 at station 28-BN01, and 0.422 at station 28-BN03. Finally. the MBIs were 9.4 at station 2-BN01, 8.3 at station 28-BN02, and 9.7 at station 28-BN03.

Orde Pond

Benthic macroinvertebrates were collected from one station in Orde Pond. A total of 13 species consisting of 123 individuals were identified. The identified phyla consisted of Annelida, Arthropoda, and Mollusca. Approximately 54 percent of the individuals were the chironomidae Chironomus ochreatus. Twenty-two percent of the detected organisms were the Chironomidae larsia sp. The next most abundant groups of benthic macroinvertebrate species were the tubificidae Limnodrilus hoffmeisteri and the chironomidae Dicrotendipes modestus, both at a frequency of 7 percent.

Species density was 784 individuals/m^2 at this station. The Shannon-Weiner species diversity was 0.651, and the Brillouin's diversity was 0.593. The MBI at Orde Pond was 9.2.

Webb Creek

In Webb Creek, 11 species consisting of 153 individuals were collected at the two sampling stations. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 69 percent of the individuals were the chironomidae Chrironomus decorus and 14 percent were the ampharetidae Hypaniola grayi. Most of the benthic macroinvertebrate species found in Webb Creek were from the Arthropoda phylum.

Seven species of benthic macroinvertebrate were collected at stations WC02 and WC03. At station WC02, 79 individual were collected, while 74 individuals were collected at station WC03. Species density was 504 individuals/m^2 at station WC02, and 472 individuals/m^2 at station WC03. The Shannon-Wiener species diversity was 0.570 at station WC02 and 0.323 at station WC03. The Brillouin's species diversity was 0.518 at station WC02 and 0.279 at station WC03.

Hadnot Creek

A total of 36 species consisting of 774 individuals were collected from the four sampling stations at Hadnot Creek. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 26 percent of the individuals were the tubificidae Isochaetides freyi and 11 percent of the individuals were the corophiidae Corophium lacuatre. The next abundant group of benthic macroinvertebrate species was the ampharetidae Hypaniola grayi, found at a frequency of approximately 9 percent.

Species abundance was greatest at station HC01 (20) followed by 4, 8, and 13 at stations HC02, HC03, and HC04, respectively. The largest number of individuals was collected at station HC01 (286), followed by 244, 165, and 79 individuals at stations HC03, HC04 and HC02, respectively. Species density was 1,823 organisms/m^2 at station HC01, 504 organisms/m^2 at station HC02, 1,555 organisms/m^2 at station HC03, and 1,052 organisms/m^2 at station HC04.

The Shannon-Weiner species diversity was greatest at station HC04 (0.807), followed by 0.802 at station HC01, 0.196 at station HC02, and 0.683 at station HC03. The Brillouin's species diversity was greatest at station HC04 (0.757), followed by 0.755 at station HC01, 0.072 at station HC02, and 0.675 at station HC03.

Holland Mill Creek

A total of 22 species consisting of 846 individuals were collected from the three sampling stations at Holland Mill Creek. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 45 percent of the individuals (383 out of 846) were the chironomidae Chironomus decorus gr., and 28 percent were the chironomidae Tribelos lucundum.

Species abundance was greatest at station HM01 (13), followed by 4 and 7 at stations HM02 and HM03. The highest number of individuals was collected at station HC02 (404), followed by 345 and 97 individuals at stations HC01 and HC03, respectively. Species density was greatest at stations HC02 (2,575 organisms/m^2), followed by 2,199 at station HC01 and 618 at station HC03. The Shannon-Weiner species diversity was greatest at station HC03 (0.538), followed by 0.525 at station HC01 and 0.128 at station HC02. The Brillouin's species diversity was greatest at station HC01 (0.500); the diversity was 0.122 at station HC02 and 0.497 at station HC03.

17.3.1.3 Exposure Analysis/Profile

The next step in the characterization of exposure is to combine the spatial and temporal distributions of both the ecological component and the stressor to evaluate exposure. This section of the ERA addresses and quantifies each exposure pathway via surface water, sediment, air, soil, and groundwater.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis was conducted including the identification and characterization of the exposure pathways. The following four elements were 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

Potential Exposure Scenarios

This section discusses the potential exposure scenarios at Site 28 including surface water, sediment, soil, groundwater and air. The location of samples was based on historical information available for the site and a site visit to evaluate potential ecosystems and ecological receptors.

Surface Water Exposure Pathway

Potential release sources to be considered in evaluating the surface water pathway 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 are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water on site or off site and downgradient relative to tidal influence.

COPCs were detected in the surface water demonstrating a release from a source to the surface transport medium. Potential receptors that may be exposed to contaminants in surface water in/or around surface water include fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic organisms (i.e., fish, benthic macroinvertebrates) are exposed to contaminants in the surface water by ingesting water while feeding and by direct contact. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the surface water. Overall, aquatic organisms have a high exposure to contaminants in the surface water. Potential decreased integrity of aquatic receptors from contaminants in the surface water was evaluated in this ERA by direct comparisons of contaminant concentrations in the surface water to published water quality standards and criteria and by evaluating the results of the ecological surveys.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water through ingestion and dermal contact. The magnitude of the exposure depends on the feeding habits of the receptors and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, insects, plants) that have bioconcentrated contaminants from the surface water. Total exposure of the terrestrial receptors to the COPCs in the surface waters was determined by estimating the CDI. Potential decreased integrity of terrestrial receptors from contaminants in the surface water was evaluated in this ERA by comparing CDI to TRVs representing acceptable daily doses in mg/kg/day.

Sediment Exposure Pathway

The potential release sources to be considered in evaluating the sediment pathway 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 sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the sediment.

COPCs were detected in the sediment demonstrating a release from a source to the sediment transport medium. Potential receptors that may be exposed to contaminants in sediment include benthic macroinvertebrates, bottom feeding fish, aquatic vegetation, and other aquatic life.

Aquatic organisms (i.e., fish, benthic macroinvertebrates) are exposed to contaminants in the sediment by ingesting sediment while feeding and by direct contact. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the sediment. Overall, aquatic organisms have a high exposure to contaminants in the sediment. Potential decreased integrity of aquatic receptors from contaminants in the sediment was evaluated in this ERA by direct comparisons of contaminant concentrations in the sediment to SSVs and by evaluating the results of the ecological surveys.

Terrestrial faunal receptors potentially are exposed to contaminants in the sediment through ingestion and dermal contact. The magnitude of the exposure depends on the feeding habits of the receptors and the amount of time they reside in the contaminated sediment. In addition, terrestrial species may ingest organisms (e.g., fish, insects, small mammals, plants) that have bioconcentrated contaminates from the sediment. Potential decreased integrity of terrestrial receptors from contaminants in the sediment was qualitatively evaluated in this ERA.

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 soils 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 in the areas of detected COPCs included 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 the feeding habits of the receptors and the amount of time they come in contact with the contaminated soil. In addition, terrestrial species may ingest organisms (e.g., insects, small mammals, plants) that have bioconcentrated contaminates from the soil. Potential decreased integrity of terrestrial receptors from contaminants in the surface soil was evaluated in this ERA by comparison of CDIs to TRVs and by and direct comparisons of soil concentrations to literature toxicity value for plants and invertebrates.

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. Since organisms are not directly exposed groundwater at Site 28, the groundwater to surface water exposure is taken into account in the surface water section of the ERA.

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.

No data have been collected to document exposure to receptors via the air pathway. However, based on the low concentrations of VOCs detected in the soil, sediment, and surface water and the negligible vapor pressure of pesticides and metals, the air concentration of the COPCs is not expected to cause a decrease in integrity of the terrestrial receptors. Therefore, this pathway was not evaluated as part of the ERA.

17.3.2 Ecological Effects Characterization

The potential ecological effects on aquatic receptors were determined by direct comparisons of contaminant concentrations in surface water and sediment to aquatic reference values and by evaluating the results of the fish and benthic macroinvertebrate survey. Potential ecological effects on terrestrial receptors were evaluated by comparison to literature values and by comparing the CDIs to TRVs. The following sections further discuss the aquatic reference value comparisons and the CDI to TRV comparisons to evaluate the potential ecological effects to aquatic and terrestrial receptors from the COPCs.

Contaminant concentrations detected in the surface water at Site 28 were compared to the NC DEHNR WQS, USEPA WQSV, USEPA AWQC, and other toxicity values obtained from USEPA AWQC documents to determine if there were any exceedances of the published values. In addition, each COPC positive detect was compared to the WQS, the acute and chronic WQSVs, and the acute and chronic AWQC using the quotient ratio method. This yields a value termed the Quotient Index (QI). A QI greater than unity indicates a potential for adverse effects to aquatic life. The ratio of each positive detection and the aquatic reference values was calculated for each COPC. The quotient ratio method and results of the QI calculations are discussed in Risk Characterization (Section 17.4). Finally, inorganic and pesticide/PCBs COPCs detected in the surface water were compared to Camp Lejeune base-wide concentrations of these contaminants.

Positively-detected contaminant concentrations detected in the sediment at Site 28 were compared to SSVs to determine if there were any exceedances in the established values. In addition, each COPC was compared to the Region IV lower 10 percentile (ER-L) and median percentile (ER-M) using the quotient ratio method. Because the screening values are set to be protective of the aquatic environment, any exceedances of these values indicate a potentially toxic environment for the aquatic organisms inhabiting the water body. A QI also was calculated for the sediment. Finally, inorganic and pesticide/PCB COPCs detected in the sediment were compared to Camp Lejeune base-wide concentrations of these contaminants.

17.3.2.1 Surface Water Quality

Tables 17-10 through 17-12 contain the freshwater and saltwater North Carolina WQS, the Region IV USEPA WQSV, and the USEPA AWQC for the COPCs detected at the New River (saltwater), Cogdels Creek (saltwater), and Orde Pond (freshwater) at Site 28.

The water quality values for the following metals are water hardness dependent: cadmium, chromium, copper, lead, nickel, and zinc. In general, the higher the water hardness (in mg/L of $CaCO_3$) the higher the water quality value. A hardness concentration of 50 mg/L $CaCO_3$ was used to calculate these values.

The following COPCs detected in the surface water samples do not have WQS, WQSV, or AWQC values: 4,4'-DDD, aluminum, iron, manganese, and vanadium in saltwater and manganese in freshwater. The potential impact to aquatic species from these chemicals in the surface water was evaluated using the results of acute and chronic tests obtained from the AQUIRE database (AQUIRE, 1993). The maximum detected concentrations of these chemicals in the surface water were below the adverse effects levels obtained from the database. Therefore, no decrease in the integrity of the aquatic community from these chemicals is expected, and these COPCs will not be further evaluated in this ERA.

The following sections discuss the surface water quality results at Site 28. These sections contain comparisons of the contaminants detected in the surface water the sites to their aquatic reference values (ARVs).

New River

Five surface water samples collected in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Copper exceeded the NCWQS, the acute and chronic WQSV, and the acute AWQC in three samples. Copper was detected at concentrations in the New River that were slightly above the concentrations detected in the base-wide samples. Lead exceeded the chronic WQSV and the chronic AWQC in one sample. Lead was detected at concentrations that were above the average and median concentrations detected in the base-wide samples. Zinc exceeded the NCWQS, the acute and chronic WQSV, and the acute and chronic AWQC in one sample. Zinc was detected at concentrations that were above the maximum detect in the base-wide surface water samples. No other TAL inorganics exceeded any of the surface water ARVs in the New River.

4,4'-DDE was detected at a concentration below the ARV. 4,4'-DDE was not detected in the base-wide surface water samples. 4,4'-DDD was detected in two samples at concentrations of 0.054 to 0.13 μg/L. 4,4'-DDD was detected once in the surface water in the New River at a concentration below the base-wide concentrations.

Cogdels Creek

Seven surface water samples collected in Cogdels Creek were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. None of the organics, pesticides, or PCBs had QIs greater than unity when compared to the surface water ARVs.

Copper exceeded the NCWQS, acute and chronic WQSV and the acute and chronic AWQC in one sample. The surface water COPCs were also compared to base-wide concentrations. Aluminum, copper, iron, lead, and vanadium were detected at concentrations in Cogdels Creek that were below the average base-wide concentrations and slightly above the base-wide median concentration. Manganese was detected at concentrations above the average and median base-wide surface water concentrations. Zinc was detected at concentrations below the average and median base-wide concentrations.

Orde Pond

Two surface water samples collected in Orde Pond were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Aluminum exceeded the chronic WQSV and chronic AWQC in two samples. No other TAL inorganics exceeded any of the surface water ARVs in Orde Pond. Aluminum was detected at concentrations below the average and median base-wide surface concentrations. Nickel and thallium were detected once in Orde Pond, at concentrations below the average and median base-wide concentrations.

No TCL organics, TCL pesticides, or TCL PCBs detected in Orde Pond had QIs greater than unity when compared to the surface water ARVs.

17.3.2.2 Sediment Quality

Tables 17-13 through 17-15 contain the sediment SSVs for the COPCs detected in the New River, Cogdels Creek, and Orde Pond at Site 28. Sediment samples were collected from zero to six inches, and six to twelve inches at most of the sediment stations. Some sediment stations only were sampled at a depth of zero to six inches due to sampler refusal.

The following COPCs detected in the sediments do not have SSVs: aluminum, barium, beryllium, cobalt, iron, manganese, vanadium, thallium, carbon disulfide, bis(2-ethylhexyl)phthalate, dibenzofuran, carbazole, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene. There is limited, if any, data assessing the effects on aquatic organisms exposed to these chemicals in sediment samples. Therefore, the effects of these chemicals on aquatic organisms were not determined.

The following sections discuss the sediment quality results at the sites. These sections contain a comparison of the contaminants detected in the sediments to their ARVs.

New River

Ten sediment samples collected from five stations in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Antimony and copper exceeded the ER-L in two samples and the ER-M in one sample. Antimony and copper also were detected at concentrations above the sediment base-wide average and median concentrations. Lead and silver exceeded the ER-L and ER-M in two samples. Lead and silver also were detected at concentrations above the sediment base-wide concentrations. No other TAL inorganics exceeded any of the sediment ARVs in the New River.

Among the pesticides, 4,4'-DDE and 4,4'-DDD exceeded the ER-L in two and three samples, respectively. 4,4'-DDT exceeded the ER-L and the ER-M in three samples. 4,4'-DDD and 4,4'-DDE were detected at concentrations below the sediment base-wide average and median concentrations. 4,4'-DDT was detected at concentrations above the average and median base-wide concentrations. Alpha-chlordane exceeded the ER-L in two samples and the ER-M in one sample, and gamma-chlordane exceeded the ER-L in two samples. Alpha- and gamma-chlordane were detected at concentrations above the sediment base-wide average and median concentrations. No other pesticides detected in the New River sediments exceeded the ER-L or ER-M values in any of these samples.

Among the SVOCs, anthracene, pyrene, and benzo(a)anthracene exceeded the ER-L in four samples. Phenanthrene exceeded the ER-L in two samples. Fluoranthene, chrysene, and benzo(a)pyrene exceeded the ER-L in three samples. Fluorene exceeded the ER-L in one sample. No other SVOCs exceeded any of the sediment ARVs in the New River.

Cogdels Creek

Fourteen sediment samples collected from seven stations were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides, TCL PCBs, and TAL inorganics. Lead exceeded the ER-L in seven samples and the ER-M in two samples. Lead was detected at concentrations above the sediment base-wide average and median concentrations. Mercury exceeded the ER-L in four samples. Mercury was also detected at concentrations above the base-wide average and median concentrations. Silver exceeded the ER-L in one sample and was detected at a concentration greater than the base-wide average concentration. Zinc exceeded the ER-L in two samples and the ER-M in one sample. Zinc was detected at concentrations above the sediment base-wide average and median concentrations. No other inorganics detected in the sediments exceeded the ER-L or ER-M values.

Among the pesticides, 4,4'-DDE exceeded the ER-L in nine samples and the ER-M in five samples. 4,4'-DDD exceeded the ER-L in seven samples and the ER-M in four samples. Alpha-chlordane exceeded the ER-L in two samples, and gamma-chlordane exceeded the ER-L and ER-M in two samples. Also, benzo(a)pyrene exceeded the ER-L in five samples. 4,4'-DDE, 4,4'-DDD, alpha-chlordane, and gamma-chlordane were detected at concentrations above the sediment base-wide average and median concentrations. No other organics, pesticides, or PCBs exceeded the ER-L or ER-M values in any of the sediment samples.

Orde Pond

Three sediment samples collected from three stations in Orde Pond were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics.

No TCL organics, TCL PCBs, or TAL inorganics detected in the Orde Pond sediments exceeded the ER-L or ER-M values. 4,4-DDD exceeded the ER-L in one sample.

The sediment COPCs were compared to sediment base-wide concentrations. Aluminum, arsenic, barium, and vanadium were detected at concentrations below the sediment base-wide average and slightly above the base-wide median concentration. Beryllium was detected once in the Orde Pond sediment at a concentration above the base-wide average and below the base-wide median concentration. Chromium was detected at concentrations above the base-wide average and median concentrations. Cobalt was detected once in the Orde Pond sediment at a concentration above the base-wide average and median concentrations. Copper, lead, manganese, nickel, and zinc were detected at concentrations above the base-wide average and median concentrations. 4,4'-DDD was the only pesticide COPC in the sediment, it was detected once at a concentration below both the base-wide average and median concentrations.

17.3.2.3 Surface Soil Quality

The amount of literature data evaluating adverse ecological effects on terrestrial species exposed to contaminants in surface soil is limited. However, toxicological effects on plants and/or invertebrates inhabiting contaminated soil were obtained from various studies in the literature for the following chemicals: arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and zinc. These data were used to evaluate decreased integrity of terrestrial flora and invertebrates from COPCs in the soil.

No toxicological information on the effects on plants and/or invertebrates inhabiting contaminated soil were obtained from various studies in the literature for the following chemicals: aluminum, antimony, cobalt, iron, thallium or TCL organics. Therefore, these contaminants were not evaluated in the ERA.

The following sections contain a comparison of the contaminants detected in the surface soils to the concentrations of the contaminants in soil that caused adverse effects to plants, terrestrial invertebrates, and terrestrial vertebrates. These data were obtained from various sources in the literature.

Arsenic concentrations ranged from 0.56 to 16 mg/kg in the surface soils at Site 28, which are below the 25 mg/kg that depressed crop yields (USDI, 1988). Barium concentrations ranged from 1.7 to 95 mg/kg, which are below the 2,000 mg/kg that induced plant toxicity (Adriano, 1986). Cadmium concentrations ranged from 0.66 to 13 mg/kg, which are greater than the 0.5 mg/kg that has been shown to cause low toxicity in the earthworm species Lumbricus rubellus (Hopkin, 1989). Chromium concentrations of 1.4J to 26 mg/kg were found in the surface soils, which are greater than the 10 mg/kg in surface soils that caused mortality in the earthworm species Pheretima pesthuma, (Hopkin, 1989). Copper concentrations ranged from 1.5 to 4,260J mg/kg, some of which are above the 50 mg/kg level that interfered with the reproduction activity of the earthworm species Allolobuphora caliginosa (Hopkin, 1989).

Lead concentrations ranged from 3.9 to 551 mg/kg, which are less than the 670 mg/kg considered to be hazardous to earthworms (Beyer, 1993). Manganese concentrations ranged from 2.4J to 39,100J mg/kg, some of which are greater than the mean U.S. soil concentration of 58 mg/kg (Adriano, 1986). Mercury concentrations ranged from 0.05 to 1 mg/kg, which are less than the 3 mg/kg which has been shown to interfere with reproduction in mallard ducks and produce brain lesions in their ducklings (Beyer, 1993). Nickel concentrations ranged from 1.1J to 36.3 mg/kg, some of which are greater than 17 mg/kg which has caused low toxicity to the earthworm species Lumbricus rubellus (Hopkin, 1989). Silver concentrations ranged from 1.5J to 6J, which are below the 11 mg/kg which was lethal to bush beans in solution (Adriano, 1986). Vanadium concentrations ranged from 1.3 to 19 mg/kg, which are less than the U.S. soil concentrations of 560 mg/kg (Adriano, 1986). Zinc concentrations ranged from 6.7J to 23,100J mg/kg, which are greater than the 450 to 1,400 mg/kg that caused plant toxicity (Adriano, 1986).

17.3.2.4 Biological Sample Quality

Fish Community Similarity

New River

The fish populations from the New River were compared to fish populations from the off-site reference stations (HC03 and HM03). A total of six fish species were collected in the New River. Eight fish species were collected at station HC03 and six fish species were collected at station HM03. Atlantic menhaden and stripped mullet were collected in both HC03 and the New River. Atlantic menhaden, stripped mullet, and summer flounder were collected in HM03 and the New River.

Cogdels Creek

The fish populations from Cogdels Creek were compared to fish populations from the off-site reference stations (WC02, HC02, and HM02). Fish were collected from one station in Cogdels Creek. Two pumpkinseed, one stripped mullet and one blue crab were collected from Cogdels Creek. Stripped mullet were collected at stations WC02 and HM02, and pumpkinseed were collected at stations HC02 and HM02. Blue crabs were not collected at the reference stations.

Orde Pond

The fish population at Orde Pond was compared to the off-site reference station (HC01) in Hadnot Creek. A total of six fish species were collected at Orde Pond while six fish species were collected at station HC01. The redear sunfish was the only fish collected in Orde Pond and station HC01 during the 1994 sampling. However, bluegill and large mouth bass also were collected at HC01 during this 1993 study..

Fish Tissue

The following sections discuss the chemical concentrations detected in the fish tissues for the samples collected from the New River and Orde Pond. Fish tissue samples were divided into two groups, whole body tissue analysis and fillet tissue analysis. Background information from Webb Creek and Holland Mill Creek was not included in this discussion, as fish were not collected for tissue analysis at these creeks. Fish were collected from Hadnot Creek and fillet tissue was analyzed; therefore, these results will be included in this discussion.

New River

The following sections discuss the chemical concentrations of the COPCs detected in the fish tissues for the samples collected from the New River.

Organic Compounds in Fish Tissue

Several pesticides were detected in the fish tissue collected from the New River. 4,4'-DDE, 4,4'-DDD, and alpha-chlordane were retained as COPCs in the fillet and whole body tissue samples.

4,4'-DDE, 4,4'-DDD and alpha-chlordane biodegrade at a very slow rate and have a high potential for bioaccumulation in aquatic organisms. The maximum levels for these pesticides, 0.16 and 0.058 mg/kg for 4,4'-DDE and 4,4'-DDD, respectively, were detected in the stripped mullet fillet tissue. The maximum level (0.0044NJ mg/kg) of alpha-chlordane was detected in the whole body tissue of the stripped mullet.

The average concentration level established in the National Study of Chemical Residues in Fish (NSCRF) for industrial/urban sites for any p,p'-DDE compound in fish tissue ranged between 0.00723 and 14.028 mg/kg with a mean concentration of 0.60234 mg/kg (NSCRF, 1992). In 1989, other ecological studies were conducted in Indonesia. These studies identified levels of p,p'-DDE in saltwater fish tissue to be between 0.040 and 6.8 mg/kg. Levels in the tissue of fish from the North Sea ranged between nondetect and 0.041 mg/kg. Another study conducted in Rhode Island detected levels of p,p'-DDD to be between 0.018 and 0.046 mg/kg. North Sea studies showed levels between nondetect and 0.028 mg/kg. Studies conducted in the Pacific Ocean revealed levels of 4,4'-DDT ranging from nondetect to 0.0736 mg/kg. Levels in the central Mediterranean Sea fell between 0.0039 and 0.0855 mg/kg. The non-carcinogenic fish flesh criteria for total DDT has been determined to be 0.11 mg/kg (Newell, 1987).

In a study conducted in the Albemarle-Pamilico Region in North Carolina, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT residues were detected in over 84 percent of the fish sampled (whole body analysis) (Benkert, 1992). 4,4'-DDE was found in white catfish at mean concentrations ranging from 0.04 to 0.22 mg/kg, in gizzard shad at mean concentrations ranging from 0.03 to 0.20 mg/kg, and longnose gar at mean concentrations of 0.06 to 0.85 mg/kg. 4,4'-DDE was detected in white catfish at mean concentrations ranging from 0.02 to 0.07 mg/kg, in gizzard shad at mean concentrations ranging from 0.02 to 0.10 mg/kg, and in longnose gar from 0.02 to 0.16 mg/kg. The concentrations of 4,4-'DDE and 4,4'-DDD detected in the New River samples fell within the range of concentrations detected in the fish collected during the Albemarle-Pamilico Region study.

Chlordane has been shown to adversely affect sensitive species of fish and other aquatic invertebrates at water concentration between 0.2 and 3.0 µg/L (USDI, 1990). Typical concentrations of chlordane found in various fish species range from 0.01 - 0.52 mg/kg (USDI, 1990). The criteria for protection of marine life has been determined to be 0.09 µg/L, and the one in one hundred cancer risk level from chlordane in the diet is 0.37 mg/kg for piscivorous wildlife (Newell, 1987).

4,4'-DDD was not detected in the background fillet tissue samples. 4,4'-DDE was detected in two samples with concentrations ranging from 0.0097 to 0.012 mg/kg. Alpha-chlordane was detected in one sample at a concentration of 0.00017 mg/kg in the background fillet tissue samples.

Inorganics in Fish Tissue

Several metals were retained as COPCs in the New River tissue samples. These metals included: antimony, barium, cobalt, copper, and selenium in the fish tissue fillets. Aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, mercury, selenium, silver, vanadium, and zinc were retained as COPCs in the whole body fish tissue. Information was available for arsenic, cadmium, chromium, copper, manganese, mercury, silver, and zinc in the literature. Information for the other detected inorganics in fish tissue was not found in the literature.

Arsenic was detected at concentrations ranging from 0.17 to 0.95 mg/kg in the fish fillet tissue samples and 0.23 to 0.77 mg/kg in the whole body tissue samples from the New River. Eisler found marine finfish tissues to contain 2 to 5 mg As/kg fresh weight; however, adverse effects of arsenic on aquatic organisms have been reported at concentrations of 1.3 to 5 mg/kg in fish tissues (USDI, 1988). In saltwater biota tissue residues, certain marine teleosts many remain unaffected at muscle total arsenic residues of 40 mg/kg (USDI, 1988). Cadmium was detected at concentrations of 0.02 to 0.03 mg/kg in the whole body tissue samples, but cadmium was not detected in the fillet tissue samples. Cadmium has been detected in whole fish samples in Atlantic coastal streams at concentrations ranging from non-detect to 0.81 mg/kg (May, 1981). Cadmium was detected in the fish collected during the Albemarle-Pamilico Region study (whole body analysis) (Benkert, 1992). Cadmium was detected in longnose gar at mean concentrations ranging from 0.03 to 0.31 mg/kg, in white catfish at mean concentrations ranging from 0.04 to 0.14 mg/kg, and in gizzard shad at mean concentrations ranging from 0.06 to 0.55 mg/kg.

Chromium was detected at concentrations ranging from 3.2 to 5.4 mg/kg in the fish whole body tissue samples, but chromium was not detected in the fish fillet tissue samples. Eisler found that individual tissues of most species of finfishes contained between 0.1 and 0.6 mg Cr/kg fresh weight (USDI, 1986). Chromium was detected in the fish collected during the Albemarle-Pamilico Region study (whole body analysis) (Benkert, 1992). Chromium was detected in longnose gar at mean concentrations ranging from 2.97 to 9.73 mg/kg, in white catfish at mean concentrations ranging from 0.45 to 2.00 mg/kg, and in gizzard shad at mean concentrations ranging from 0.48 to 2.80 mg/kg.

Mercury was detected at concentrations ranging from 0.0024 to 0.061 mg/kg in the fish fillet tissue samples, and 0.0024 to 0.014 mg/kg in the fish whole body tissue samples. The average mercury fish flesh tissue concentrations for major finfish species samples in the National Study of Chemical Residues in Fish was 0.00009 to 0.0287 mg/kg for whole body and 0.00014 to 0.00051 mg/kg for fillets (USEPA, 1993e). Copper and mercury were also detected in fish collected during the Albemarle-Pamilico Region study (Benkert, 1992). Copper was detected in longnose gar at mean concentrations ranging from 1.67 to 5.33 mg/kg, in white catfish at mean concentrations ranging from 1.70 to 3.72 mg/kg, and in gizzard shad at mean concentrations ranging from 1.43 to 67.0 mg/kg. Mercury was detected in longnose gar at mean concentrations ranging from 0.29 to 1.26 mg/kg, in white catfish at mean concentrations ranging from 0.18 to 0.45 mg/kg, and in gizzard shad at mean concentrations ranging from 0.04 to 0.19 mg/kg.

The concentration of silver detected in the fish tissue sampled from the New River ranged from 0.15J to 0.41J mg/kg in the whole body tissue; silver was not detected in the fillet samples. A National Marine Fishery (NMF) survey conducted in March, 1978, reported the average silver concentration to be 0.1 mg/kg in the muscle of fish and 0.2 mg/kg in the whole body (Hall, 1978). The maximum level of silver detected in the site fish tissue samples is above these reported values.

Zinc concentrations in the whole body tissue samples ranged from 10.8 to 18.3 mg/kg. Zinc was not detected in the fillet tissue. Other saltwater ecological studies detected the following zinc levels in fish tissue: 5.9 to 16.6 mg/kg in the Arabian Gulf (Ginn, 1989); 4.1 to 58.8 mg/kg in the Mediterranean Sea in Israel; 0.02 to 5.6 mg/kg in the United Kingdom (Ginn, 1988); and 88 to 145 mg/kg in the Gulf of Mexico (Ginn, 1987). The National Marine Fishery trace element survey revealed that the average concentration of zinc in fish muscle ranged from 2 to 200 mg/kg (Hall, 1978). Zinc was detected in the fish collected during the Albemarle-Pamilico Region study (whole body analysis) (Benkert, 1992). Zinc was detected in longnose gar at mean concentrations ranging from 50.9 to 67.7 mg/kg, in white catfish at mean concentrations ranging from 48.8 to 67.0 mg/kg, and in gizzard shad at mean concentrations ranging from 44.9 to 57.0 mg/kg. The concentrations of zinc detected in the fish in the New River fell within or slightly above the reported ranges.

As stated earlier, background fish tissue analysis was performed for fillets only. Antimony, barium, cadmium, cobalt, iron, selenium, silver, and vanadium were not detected in the background fish tissue samples. Copper was detected at concentration ranging from 0.18J to 0.61J mg/kg in the New River fillet tissue samples and 0.18 to 0.46 mg/kg in the background fish samples. Arsenic was detected in the New River whole body samples at concentrations ranging from 0.23J to 0.77J mg/kg and 0.34 to 3.9 mg/kg in the background fillet tissue samples. Chromium was detected at concentrations ranging from 0.21 to 0.68 mg/kg in the background fish tissue samples. Chromium was detected in the whole body samples at concentrations ranging from 3.2 to 5.4 mg/kg. Manganese was detected in the background fish samples at concentrations ranging from 0.08 to 0.38 mg/kg. Manganese was detected at concentrations ranging from 1.2 to 4.7 mg/kg in the New River whole body samples. Mercury was detected at concentrations ranging from 0.05 to 0.24 mg/kg in the background fish samples. Mercury was detected in the New River whole body samples at concentrations ranging from 0.0024 to 0.014 mg/kg. Zinc was detected at concentrations ranging from 3.9 to 6.5 mg/kg in the background fish samples. Zinc was detected in the New River whole body samples at concentrations ranging from 10.8 to 18.3 mg/kg.

Orde Pond

The following sections discuss the chemical concentrations detected in the fish tissue samples collected from Orde Pond.

Organic Compounds in Fish Tissue

4,4'-DDE and alpha-chlordane were retained as COPCs in the whole body tissue samples collected from Orde Pond. The concentration range for 4,4'-DDE was 0.0044 to 0.038 mg/kg and alpha-chlordane was detected once at a concentration of 0.013 mg/kg. The maximum concentrations of these pesticides were detected in the American eel. The safe fish flesh criterion to protect sensitive species has been determined to be 0.2 mg/kg in whole fish (Newell, 1987). For chlordane, 0.5 mg/kg has been found to be the non-carcinogenic fish flesh criteria (Newell, 1987).

Inorganics in Fish Tissue

The following inorganics were retained as COPCs in the fillet tissue samples collected from Orde Pond: barium, manganese, selenium, and zinc. The following metals were detected and retained as COPCs in the whole body tissue samples: arsenic, barium, chromium, cobalt, copper, iron, manganese, mercury, selenium, and vanadium. Information was available for arsenic, chromium, copper, mercury, selenium, and zinc in the literature. Studies on the other detected inorganics in fish tissue were not located.

Arsenic was detected at concentrations of 0.08 to 0.1 mg/kg in the fish fillet samples and 0.10 in the fish whole body tissue samples. Eisler found background arsenic concentrations in living organisms to be < 1 mg/kg in freshwater biota (USDI, 1988). In freshwater biota tissue residues, diminished growth and survival has been reported in immature bluegills when total arsenic residues in muscle were >1.3 mg/kg or >5 mg/kg in adults (USDI, 1998). Chromium was detected at concentrations ranging from 0.29 to 0.63 mg/kg in the fish fillet tissue samples, and 10.7 mg/kg in the fish whole body samples. Eisler has found individual tissues of most species of finfishes to contain chromium between 0.1 and 0.6 mg kg fresh weight (USDI, 1986).

Copper was detected at concentrations of 0.15 to 0.31 mg/kg in the fish fillet tissue samples and 0.23 to 1.2 mg/kg in the fish whole body tissue samples. The National Contaminant Biomonitoring Program detected the following concentrations of copper in freshwater fish: (1978-1979) 0.29 to 38.75 mg/kg; (1980-1981) 0.25 to 24.1 mg/kg (Lowe, 1985). Mercury was detected at concentrations ranging from 0.1 to 0.23 mg/kg in the fish fillet tissue samples and 0.14 to 0.18 mg/kg in the fish whole body tissue samples. The National Contaminant Biomonitoring Program found concentrations of mercury in freshwater fish in 1978-1979 to range between 0.01 and 1.10 mg/kg, and in 1980-1981 to range between 0.01 and 0.77 mg/kg (Lowe, 1985). Eisler has proposed criteria for the protection of fish, whole body brook trout, to be <5 mg/kg (USDI, 1987).

Selenium was detected at concentrations ranging from 0.26 to 0.32 mg/kg in fish fillet tissue samples, and 0.31 to 0.45 mg/kg in fish whole body tissue samples. Eisler found that in freshwater fishes, selenium concentrations ranged from 0.05 to 2.9 mg/kg with an average concentrations of 0.6 mg/kg (USDI, 1985). The National Contaminant Biomonitoring Program has detected selenium in freshwater fish at the following concentrations: (1978-1979) 0.09 to 3.65 mg/kg; (1980-1981) 0.09 to 2.47 mg/kg (Lowe, 1985). Zinc was detected at concentrations ranging from 14.7 to 22.9 mg/kg in the fish fillet samples and 12.8 to 26.3 mg/kg in the fish whole body samples. The National Contaminant Biomonitoring Program has found zinc concentrations in freshwater fish to range between 7.69 and 168.1 mg/kg (1978-1979), and 8.82 to 109.2 mg/kg (1980-1981) (Lowe, 1985).

As stated previously, barium, iron, selenium, and zinc were not detected in the background fillet fish tissue samples. Manganese was detected at concentrations ranging from 0.08J to 0.38 mg/kg in the background samples, and zinc was detected at concentration ranging from 3.9 to 6.5 mg/kg in the background samples. Arsenic was detected in the background samples at concentrations ranging from 0.34L to 3.9L mg/kg. Chromium was detected at concentrations ranging from 0.21L to 0.68L mg/kg in the background. Copper was detected at concentrations ranging from 0.18J to 0.46J in the background samples. Mercury was detected at concentrations ranging from 0.05 to 0.24 mg/kg in the background samples.

Benthic Macroinvertebrate Community Similarity

The following sections present the results of species similarity among the benthic macroinvertebrates collected at the New River, Cogdels Creek, and Orde Pond. Background locations from Webb Creek, Hadnot Creek, and Holland Mill Creek are included in the discussion.

New River, Hadnot Creek and Holland Mill Creek

Table 17-16 presents the results of the Jaccard coefficient (Sj) of community similarity and the SΦrenson index (Ss) of community similarity between benthic macroinvertebrate collection stations along the New River and one station each from Hadnot Creek and Holland Mill Creek. Hadnot Creek and Holland Mill Creek were the background stations for the New River.

The Sj value between the two New River sampling stations was 0.50; the Ss value was 0.78. The Sj values comparing the New River and Hadnot Creek stations ranged from 0.31 to 0.40 and the Ss values ranged from 0 to 0.10. The Sj values comparing the New River and Holland Mill Creek stations ranged from 0.18 to 0.25 and the Ss values ranged from 0.30 to 0.50.

Cogdels Creek, Webb Creek, Hadnot Creek, and Holland Mill Creek

Table 17-17 presents the results of the Sj and Ss indices between the benthic macroinvertebrate stations in Cogdels Creek, Webb Creek, Hadnot Creek, and Holland Mill Creek. One station each from Webb Creek, Hadnot Creek, and Holland Mill Creek served as the background stations for Cogdels Creek.

The Sj values between the Cogdels Creek collection stations ranged from 0.27 to 0.31. The Ss values between these stations ranged from 0.42 to 0.47. The Sj values between Cogdels Creek and the Webb Creek station ranged from 0.18 to 0.25. The Ss values between these stations ranged from 0.31 to 0.40. The Sj values between Cogdels Creek and the Hadnot Creek station were all 0.07. The Ss value between these stations was 0.13. The Sj values between Cogdels Creek and the Holland Mill Creek station ranged from 0.15 to 0.33. The Ss values between these stations ranged from 0.27 to 0.50.

Orde Pond and Hadnot Creek

Table 17-18 presents the results of the Sj and the Ss indices between the benthic macroinvertebrate collection station at Orde Pond and one station at Hadnot Creek.

The Sj value between the Orde Pond and Hadnot Creek station was 0.06. The Ss values between these stations was 0.12.

17.3.2.5 Terrestrial Chronic Daily Intake

A chronic daily intake model was used to estimate the exposure to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 28 by both direct and indirect exposure to COPCs via surface water, soil, and foodchain transfer.

Contaminants of potential concern at Site 28 are identified in Section 17.2.1.1 for each media. 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, and the bobwhite quail. The exposure points for these receptors are the surface soils, surface water, and biota transfers. 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 small mammal ingestion.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface water was determined by estimating the Chronic Daily Intake (CDI) dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. For this analysis, TRVs were developed from NOAELs or LOAELs obtained from the Integrated Risk Information System (IRIS, 1993) or other toxicological data in the literature (see Table 17-19).

CDI Calculations

Total exposure of the terrestrial receptors at Site 28 to the COPCs in the soil and surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. CDIs were estimated for the white-tailed deer, cottontail rabbit, bobwhite quail, raccoon, and red fox at Site 28. The estimated CDI dose of the receptors (bobwhite quail, cottontail rabbit, and white-tailed deer) to soil, surface water, and vegetation was determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv \ or \ Br)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Constituent concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/d
Cs	=	Constituent concentration in soil, mg/kg
Bv	=	Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Br	=	Soil to plant transfer coefficient in soil (fruits, 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 estimated CDI dose of the raccoon was determined using the following equation.

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Br)(Iv)+(Cs)(Is)+(Cf)(If)][H]}{BW}$$

where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Constituent concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/d
Cs	=	Constituent 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
If	=	Rate of fish ingestion, kg/d
Cf	=	Constituent concentration in the fish, mg/kg (whole body concentrations)
H	=	Contaminated area/Home area range area ratio, unitless
BW	=	Body weight, kg

The estimated CDI dose of the red fox was determined using the following equation:

$$CDI = \frac{(Cw)(Iw) + [(Cs)(Br)(Iv) + (Cs)(Is) + (Cm)(Im)][H]}{BW}$$

where:

CDI	=	Total Exposure, mg/kg/d
Cw	=	Constituent concentration in the surface water, mg/L
Iw	=	Rate of drinking water ingestion, L/d
Br	=	Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv	=	Rate of vegetation ingestion, kg/d
Cs	=	Constituent concentration in soil, mg/kg
Is	=	Incidental soil ingestion, kg/d
Im	=	Rate of small mammal ingestion, kg/d
Cm	=	Constituent concentrations in small mammals, mg/kg where: Cm = (Cs)(Bv) + (Cs)(Is)
H	=	Contaminated area/Home area range area ratio, unitless
BW	=	Body weight, kg

Bioconcentration of the COPCs to plants was calculated using the soil to plant transfer coefficient (Bv or Br) for organics (Travis, 1988) and metals (Baes, 1984). If a chemical was not detected in the surface water or fish tissue, it was assumed to be nondetect. The concentrations of the COPCs in the soil (Cs) used in the model were the upper 95 percent confidence limit or the maximum concentration detected of each COPC at each site. The upper 95 percent confidence limit or the maximum concentration detected for each constituent also was used as the concentration of each COPC in the surface water. The exposure parameters used in the CDI calculations are presented in Table 17-20 and are summarized for each receptor below.

For the white-tailed deer, the feeding rate is 1.6 kg/d (Dee, 1991). The deer's diet was assumed to be 100 percent vegetation (leaves, stems, straw). The incidental soil ingestion rate is 0.019 kg/d (Scarano, 1993). The rate of drinking water ingestion is 1.1 L/d (Dee, 1991). The rate of vegetation ingestion is 1.6 kg/d. The body weight is 45.4 kg (Dee, 1991), and the home range is 454 acres (Dee, 1991).

For the eastern cottontail rabbit, the feeding rate is 0.1 kg/d (Newell, 1987). The rabbit's diet was assumed to be 100 percent vegetation (leaves, stems, straw). The incidental soil ingestion rate is 0.002 kg/d (Newell, 1987). The rate of drinking water ingestion is 0.119 L/d (USEPA, 1993d). The rate of vegetation ingestion is 0.1 kg/d. The body weight is 1.229 kg (USEPA, 1993d), and the home range is 9.29 acres (USEPA, 1993d).

For the bobwhite quail, the feeding rate is 0.014 kg/d (USEPA, 1993d). The quail's diet was assumed to be 100 percent vegetation (leaves, stems, straw). The incidental soil ingestion rate is 0.001 kg/d (Newell, 1987). The rate of drinking water ingestion is 0.019 L/d (USEPA, 1993d). The rate of vegetation ingestion is 0.014 kg/d. The body weight is 0.177 kg (USEPA, 1993d), and the home range is 8.89 acres (USEPA, 1993d).

For the red fox, the feeding rate is 0.446 kg/d (USEPA, 1993d). The fox's diet was assumed to be 20 percent vegetation (seed, berries) and 80 percent small mammals. The incidental soil ingestion rate is 0.012 kg/d (USEPA, 1993d). The rate of drinking water ingestion is 0.399 L/d (USEPA, 1993d). The rate of vegetation ingestion is 0.089 kg/d, the rate of small mammal ingestion is 0.356 kg/d. The body weight is 4.69 kg (USEPA, 1993d), and the home range is 1,771 acres (USEPA, 1993d).

For the raccoon, the feeding rate is 0.319 kg/d (USEPA, 1993d). The raccoon's diet was assumed to be 40 percent vegetation (nuts, seeds, berries) and 60 percent fish. The incidental soil ingestion rate is 0.030 kg/d (USEPA, 1993d). The rate of drinking water ingestion is 0.331 L/d (USEPA, 1993d). The rate of vegetation ingestion is 0.128 Kg/d and the rate of fish ingestion is 0.192 kg/d. The body weight is 3.99 kg (USEPA, 1993d), and the home range is 385 acres (USEPA, 1993d).

17.4 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section evaluates the potential adverse effects on the ecological integrity at Site 28 from contaminants identified at the site.

A Quotient Index (QI) approach was used to characterize the risk to aquatic receptors from exposure to surface water and sediments. 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 17.3.2, Ecological Effects Characterization. The QI is calculated as follows:

$$QI = \frac{EL}{ARV}$$

Where: QI = Quotient Index
EL = Exposure Level, mg/L or mg/kg
ARV = Aquatic Reference Value, mg/L or mg/kg

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 in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

17.4.1 Surface Water

Tables 17-10 through 17-12 contain a comparison of the COPCs identified in the surface water at Site 28 to the aquatic reference values to determine if they exceeded the published values. A QI ratio of the detected value at each sampling station and WQS, WQSVs, and AWQC was calculated for each COPC. A QI ratio greater than unity indicates a potential for decreased integrity of aquatic life. Table 17-21 presents only the ratios that are greater than unity for the COPCs at the site. These ratios are presented graphically on Figure 17-1.

17.4.1.1 New River

Five surface water samples collected in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Copper had a QI ratio greater than unity when compared to the NCWQS, the acute and chronic WQSV, and the acute AWQC in three samples. Lead had QI ratios greater than unity when compared to the chronic WQSV and the chronic AWQC in one sample. Zinc had QI ratios greater than unity when compared to the NCWQS, the acute and chronic WQSV, and the acute and chronic AWQC in one sample. No other TAL inorganics had QIs greater than unity when compared to any of the surface water aquatic reference values.

There are no ARVs for the pesticides retained as COPCs in the New River. Therefore, there were no QI ratios calculated for them.

17.4.1.2 Cogdels Creek

Seven surface samples collected in Cogdels Creek were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. None of the organics, pesticides, or PCBs had QIs greater than unity when compared to the surface water ARVs. Copper had a QI ratio greater than unity when compared to the NCWQS, the acute and chronic WQSV, and the acute and chronic AWQC in one sample.

17.4.1.3 Orde Pond

Two surface water samples collected in Orde Pond were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Aluminum had QI ratios greater than unity when compared to the chronic WQSV and chronic AWQC in two samples. No other TAL inorganics exceeded any of the surface water ARVs/TBCs in Orde Pond and, therefore, had QIs greater than unity. No organics, TCL pesticides, or TCL PCBs detected in Orde Pond had QIs greater than unity when compared to the surface water ARVs/TBCs.

17.4.2 Sediment

Tables 17-13 through 17-15 contain comparisons of the COPCs identified in the sediment to the ARVs to determine if exceedances of published values occurred. The QI ratio of the detected values at each sampling station and the ER-L and ER-M was calculated for each COPC at Site 28. A ratio greater than unity indicates a possibility for adverse effects to aquatic life. Table 17-22 presents only the ratios that are greater than unity for the COPCs. COPCs were also compared to base-wide inorganic and pesticide/PCB concentrations.

The following sections discuss the sediment quality results at the sites. These sections contain a comparison of the contaminants detected in the sediments to their ARVs.

17.4.2.1 New River

Ten sediment samples collected from five stations in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Antimony and copper had QI ratios greater than unity when compared to the ER-L in two samples and the ER-M in one sample. Lead and silver had QI ratios greater than unity when compared to the ER-L and ER-M in two samples. No other TAL inorganics exceeded any of the sediment ARVs in the New River.

Among the pesticides, 4,4'-DDE and 4,4'-DDD had QI ratios greater than unity when compared to the ER-L in two and three samples, respectively. 4,4'-DDT had QI ratios greater than unity when compared to the ER-L and the ER-M in three samples. Alpha-chlordane had QI ratios greater than unity when compared to the ER-L in two samples and the ER-M in one sample, and gamma-chlordane had QI ratios greater than unity when compared to the ER-L in two samples. No other pesticides detected in the New River sediments exceeded the ER-L or ER-M values in any of these samples.

Among the SVOCs, anthracene, pyrene, and benzo(a)anthracene had QI ratios greater than unity when compared to the ER-L in four samples. Phenanthrene had QI ratios greater than unity when compared to the ER-L in two samples. Fluoranthene, chrysene, and benzo(a)pyrene had QI ratios greater than unity when compared to the ER-L in three samples. Fluorene had a QI ratio greater than unity when compared to the ER-L in one sample. No other SVOCs exceeded any of the sediment ARVs in the New River.

17.4.2.2 Cogdels Creek

Fourteen sediment samples collected from seven stations were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides, TCL PCBs, and TAL inorganics. Lead had QI ratios greater than unity when compared to the ER-L in seven samples and the ER-M in two samples. Mercury had QI ratios greater than unity when compared to the ER-L in four samples. Silver had a QI ratio greater than unity when compared to the ER-L in one sample. Zinc had QIs greater than unity when compared to the ER-L in two samples and the ER-M in one sample. No other inorganics detected in the sediments exceeded the ER-L or ER-M values.

Among the pesticides, 4,4'-DDE had QI ratios greater than unity when compared to the ER-L in nine samples and the ER-M in five samples. 4,4'-DDD had QI ratios greater than unity when compared to the ER-L in seven samples and the ER-M in four samples. Alpha-chlordane had QI ratios greater than unity when compared to the ER-L in two samples, and gamma-chlordane had QI ratios greater than unity when compared to the ER-L and ER-M in two samples. Also, benzo(a)pyrene had QI ratios greater than unity when compared to the ER-L in five samples. No other organics, pesticides, or PCBs exceeded the ER-L or ER-M values in any of the sediment samples.

17.4.2.3 Orde Pond

Three sediment samples collected from three stations in Orde Pond were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics.

No TCL organics, TCL PCBs, or TAL inorganics detected in the Orde Pond sediments exceeded the ER-L or ER-M values. 4,4-DDD had a QI ratio greater than unity when compared to the ER-L in one sample. No other COPC had ratios greater than unity when compared to the ER-L or ER-M.

17.4.3 Surface Soil

Concentrations of arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and zinc in the surface soils were compared to concentrations of these contaminants in soil that caused adverse effects to plants, terrestrial invertebrates, and terrestrial vertebrates. On comparison, cadmium, chromium, copper, manganese, nickel, and zinc concentrations in the surface soil at Site 28 were greater than the concentrations in the literature.

17.4.4 Fish

17.4.4.1 Fish Community

The fish community in the New River was compared to the fish communities at the off-site reference stations (HC03 and HM03). A total of six fish species were collected in the New River and HM03, whereas eight fish species were collected at station HC03. The number of species collected at each station is similar, and three of the six species collected in the New River (Atlantic menhaden, stripped mullet, and summer flounder) also were collected at the background stations. The lengths and weights of these fish also were similar. A species diversity was not calculated due to the differences in the fish collection techniques, but the community appeared to be relatively diverse. No tumors or lesions were observed on the fish, but several fish contained ispods, round worms, or anchorworms.

Fish were collected from one station in Cogdels Creek. Two pumpkinseed, one stripped mullet, and one blue crab were collected in hoop nets. The gill nets were not successful at any of the stations in Cogdels Creek, probably because the nets kept clogging up with woody debris. An attempt was not made to electrofish the creek because the salinity was too high and the water was very turbid during the sampling investigation.

The fish population at Orde Pond was compared to the fish population at background station HC01. A total of six species were collected at Orde Pond and station HC01. Of those six species only the redear sunfish was similar to both Orde Pond and HC01. However, during the 1993 background sampling, bluegill and largemouth bass also were collected at HC01. No tumors, lesions, or other abnormalities observed on the fish collected at Orde Pond.

17.4.4.2 Fish Tissue

Three pesticides and fifteen inorganics were retained as COPCs in the fish tissue samples collected from the New River. Two pesticides and ten inorganics were retained as COPCs in the fish tissue samples collected from Orde Pond.

Generally, the pesticides retained as COPCs in the New River were detected at concentrations similar to those found in the literature studies. However, there were a few instances where the concentrations detected in the New River were slightly above the concentrations detected in the background studies, and the maximum concentrations of 4,4'-DDE detected in the New River were slightly greater than the non-carcinogenic fish flesh criteria for DDT.

The majority of the inorganic COPC concentrations detected in the New River were within concentrations detected in the literature studies. Chromium, manganese, mercury, silver, and zinc were detected at concentrations greater than those found in the literature studies.

The concentrations of the pesticide COPCs detected in Orde Pond were below the safe fish flesh criterion found in the literature studies. The majority of the inorganic COPCs detected in Orde Pond also were at concentrations below the concentrations detected in the background studies. However, chromium was detected at concentrations greater than the background studies and zinc was detected at concentrations greater than those found in the Hadnot Creek background samples.

17.4.5 Benthic Macroinvertebrate

The benthic macroinvertebrate communities at stations 28-BN01, 28-BN02, and 28-BN03 were compared to benthic macroinvertebrate communities at background stations WC02, HC02, and HM02. Overall, the number of species and species density at the three site stations were similar to those at the three reference stations. However, the species diversity was substantially higher at the site stations than the background stations. Finally, the MBI values at the site stations (8.3 to 9.4) were similar to the MBI values at the background stations (7.6 to 9.6). An MBI was not calculated for the benthic macroinvertebrate community at 28-BN03 because only two of the species collected at this station had a biotic index value.

Overall, the benthic communities at 28-BN01, 28-BN02, and 28-BN03 appear to be normal when compared to the benthic communities at the background stations. Most of the population statistics at these stations were similar or better than the background stations, and the communities were fairly similar. Therefore, there does not appear to be a decrease in the integrity of the benthic community at stations 28-BN01, 28-BN02, and 28-BN03 in Cogdels Creek.

The benthic macroinvertebrate communities at stations 28-BN04 and 28-BN05 were compared to benthic macroinvertebrate communities at background stations HC03 and HM03. The number of species, species density, and species diversity were higher at 28-BN04 than the two reference stations, while the number of species and species density at 28-BN05 were similar to the two reference stations and less than one reference station. The species diversity at 28-BN05 was similar to one reference station, higher than one station, and less than one station. MBI values were not calculated for the benthic macroinvertebrate communities at 28-BN04 and 28-BN05 because only one species had a biotic index value.

Overall, the benthic communities at 28-BN04 and 28-BN05 appear to be normal when compared to the benthic community at the background stations. Most of the population statistics at these stations were similar to the background stations, and the communities were fairly similar. Therefore, there does not appear to be a decrease in the integrity of the benthic community at stations 28-BN04 and 28-BN05 in the New River.

The benthic macroinvertebrate community at OP-BN01 was compared to the benthic macroinvertebrate community at background station HC01. The number of species, species density, and species diversity were higher at HC01 than OP-BN01. In addition, the MBI value at HC01 was indicative of poor water quality, while the MBI value at OP-BN01 was indicative of serious water quality.

The benthic community at OP-BN01 appears to be slightly degraded compared to the benthic community at HC01. However, although HC01 was chosen as the background station for OP-BN01, the pond and station locations were significantly different. Orde Pond was open and much larger than the ponded area in Hadnot Creek. In addition, the benthic sample at OP-BN01 was collected in the middle of the pond while the benthic samples at HC01 were collected from the edge of the pond. Finally, and possibly most important, the benthic samples at OP-BN01 contained less than eight ounces of sediment and consisted of little woody debris, while the benthic samples at HC01 contained between 24 to 80 ounces of sediments and consisted mostly of woody debris. Therefore, the differences in the benthic community at OP-BN01 and HC01 are most likely due to natural conditions. There does not appear to be a decrease in the integrity of the benthic community at OP-BN01.

17.4.6 Terrestrial Chronic Daily Intake Model

The following sections discuss the QIs calculated for the terrestrial receptors.

17.4.6.1 QI Calculations

The QI approach was also used to characterize the risk to terrestrial receptors. In this case, the risks are characterized by comparing the CDIs for each COPC to the TRVs and are calculated as follows:

$$QI = \frac{CDI}{TRV}$$

Where: QI	=	Quotient Index
CDI	=	Total Exposure, mg/kg/day
TRV	=	Terrestrial Reference Value, mg/kg/day

Table 17-23 contains the QIs for the COPC for the terrestrial receptors. 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 in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

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 conditions at the site, 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).

The following sections discuss the results of the terrestrial CDI compared to the TRVs, the COPCs in the soils compared to published soil toxicity data, and an evaluation of the potential impacts to threatened and endangered species, wetlands, and other sensitive environments. TRVs could not be located for carbazole, aluminum, cobalt, and iron. Therefore, these COPCs could not be included in this comparison.

The CDI model was used to assess decreased integrity in terrestrial species from exposure to contaminants in surface water and surface soils. At Site 28, the QIs of the CDI to the TRVs were less than unity for all COPCs except manganese, silver, and zinc. The QI for manganese was calculated to be 1.31 for the raccoon, 51.4 for the rabbit, and 58.8 for the quail. The QI for silver was 2.76 for the rabbit and 2.97 for the quail. Therefore, the total QIs for the raccoon, rabbit and quail were greater than one. The total QIs were greater than unity, but were less than ten for all the contaminants except manganese, indicating low potential for adverse effects on the animals. The QI for manganese for the rabbit and quail are greater than 10 but less than 100 indicating a significant potential that greater exposure to these chemicals could result in adverse effects to terrestrial receptors.

17.4.7 Other Sensitive Environments

The New River and Cogdels Creek are designated as nutrient-sensitive tidal saltwaters by the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR, 1993), with designated usage for market shellfishing, primary recreation, aquatic life propagation and survival, fishing, and wildlife. Orde Pond is designated a freshwater pond. The potential impacts to the fish in these waters have already have been discussed in this report. No areas within the boundaries of Site 28 are designated as unique or special waters of exceptional state or national recreational or ecological significance that require special protection to maintain existing uses.

There are no known spawning and nursery areas for resident fish species within the New River, Cogdels Creek, or Orde Pond. Therefore, there is no potential for decreased integrity of fish spawning or nursing in the New River, Cogdels Creek, or Orde Pond.

Several threatened and/or endangered species are known to inhabit Camp Lejeune, as discussed in Section 1.9. The American alligator is known to inhabit Site 28. Protected species at Camp Lejeune require specific habitats that correspond to the habitats identified at Site 28. Therefore, potential adverse impacts to these protected species from contaminants at Site 28 may be possible. However, the most significant exceedences of aquatic reference values and terrestrial reference values do not concur with the most significant critical habitat areas.

The potential impact to terrestrial organisms that are present at Site 28 is discussed in earlier sections of this report. The terrestrial organisms that may be breeding in contaminated areas at Site 28 may be more susceptible to chemical stresses due to the higher sensitivity of the reproductive life stages of organisms to these types of stresses. However, the characterization of risks from exposure to site soils did not indicate a significant risk to these receptors.

17.5 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses impacts to the ecological integrity at Site 28 from the COPCs detected in the media and determines which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health RA, supports the selection of remedial action(s) for the Operable Unit that are protective of public health and the environment.

17.5.1 Aquatic Endpoints

The assessment endpoint used to assess the aquatic environment is decreased integrity of the aquatic community. In the New River surface water levels of copper exceeded aquatic reference values in the upstream stations adjacent to the site. These levels were indicative of a low potential for risk (QI < 10). Lead and zinc only exceeded unity slightly at a single station. Copper also slightly exceeded ARVs at one station on Cogdels Creek. Aluminum exceeded unity in Orde Pond. However, the exceedance was only slightly above unity.

In the sediments, lead exceeded the ER-M sediment aquatic reference value twice in Cogdels Creek at a low level (QI < 2). Lead (QI = 353) exceeded its ER-M sediment aquatic reference values significantly (high potential risk) and antimony (QI = 10) exceeded its sediment aquatic reference values moderately at the same station in the New River. This station may be associated with runoff from the active firing range. Pesticides exceeded the sediment aquatic reference values throughout Cogdels Creek. The highest QI for the ER-M sediment aquatic reference value was over 10 for several pesticide samples in the lower reach of the creek near the confluence with the New River. These QI values represent a moderate potential for risk to aquatic receptors. The levels detected in the sediments may be a result of routine application of pesticides in the general vicinity of Site 28, especially near the sewage treatment plant and recreational area. However, they do represent a moderate potential for impacting the integrity of the aquatic community.

The results of the analysis of benthic macroinvertebrates and fish populations indicate that Cogdels Creek and this reach of the New River support an aquatic community that is representative of a tidally-influenced freshwater and estuarine ecosystem with both freshwater and marine species.

The benthic community demonstrated the typical tidal/freshwater species trend of primarily chironomids and oligochaetes in the upper reaches of Cogdels Creek and polychaetes and amphipods in the lower reaches of Cogdels Creek and the New River. Species representative of both tolerant and intolerant taxa were present and the overall community composition did not indicate a benthic community adversely affected by surface water and sediment quality.

17.5.2 Terrestrial Endpoints

During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. The assessment endpoint used to assess the terrestrial environment is decreased integrity of terrestrial floral and faunal communities. Based on the soil toxicity data for cadmium, chromium, copper, manganese, nickel, and zinc concentrations of these contaminants at Site 28 may decrease the integrity of terrestrial invertebrates or plants at the site. In addition, some of these site concentrations greatly exceeded the literature values, and it is expected that these contaminants would present a potential significant ecological risk to these terrestrial receptors.

Other terrestrial receptors may be exposed to the contaminants in the surface soils by ingestion. Based on the comparison of the CDIs to TRVs for the deer, rabbit, fox, raccoon, and quail used in this ERA, there does appear to be an ecological risk to terrestrial vertebrate receptors. This risk is expected to have the potential to be significant because the total QIs for some of the species were between 10 and 100. Therefore, these is a significant potential that greater exposure to these contaminants could impact the integrity of the terrestrial community.

17.6 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 the uncertainty in the ERA.

The chemical sampling program at Site 28 consisted of surface water, sediments, soil, biota and groundwater. The concentrations of chemicals in the surface water will vary with the tides; the concentrations are expected to be lower at higher tides (more dilution) and higher at low tides (less dilution).

The proximity of estuaries to landmasses renders them highly susceptible to pollution from human activities; this pollution threatens fish communities in many regions. Anthropogenic stresses on fish populations can be intense. Whereas much attention has been focused on the acute exposure of these populations to pollutants, sublethal and chronic exposures also debilitate resident and seasonal species. The mobility and migratory habits of fishes, however, make observations on anthropogenic effects more difficult to assess, and most of the evidence on pollution-induced changes in fish populations has been derived from laboratory experiments. Effects of man-made stresses on fishes in estuaries are often obscured by naturally occurring and poorly understood, long-term variations.

The ecological investigation consisted of one sampling effort. The results of this sampling will only provide a "snapshot in time" of the ecological environment. Because the biotic community can have a high amount of natural variability, the "snapshot in time" may not be an accurate representation of actual site conditions. There also is error and uncertainty in the sampling methods used to collect the fish and benthic macroinvertebrates. Because few, if any, fish were collected at the stations, the population statistics were not reliable. In addition, in several of the tissue samples, only one fish was analyzed because only one was collected of that species. Therefore, the concentrations of contaminants may not be a good representation of the average tissue concentration.

The collection of benthic macroinvertebrates has less uncertainty than the collection of fish. However, the effectiveness of the ponar depends upon the sediment type. The ponar is less effective in hard, rocky sediments, or sediments with a lot of organic debris that may prevent the ponar from completely closing, than in soft, mucky sediments. Because the sediment types varied among the stations, the effectiveness of the ponar also would have varied.

There is uncertainty in trying to attribute differences in species density, diversity, and similarities between stations to specific hazards, because these differences may be the result of natural causes. As discussed previously, fish are mobile. Therefore, the tissue contaminant concentrations cannot be correlated with the contaminants detected at Site 28 because the fish may have been exposed to the contaminants at a different location. Also, as observed in this investigation, natural conditions (salt wedge, low dissolved oxygen) can result in low numbers of individuals.

There also is uncertainty in the use of toxicological data in ecological risk assessments. The surface water and sediment values established by North Carolina and Region IV are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemicals 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.

Estuaries are physically unstable areas characterized by large spatial and temporal variations in temperature, salinity, oxygen concentration, turbidity, and other factors. Temporally, such variations take place in the short term and long term. Yet, despite these variations, the basic structure of estuarine fish communities is reasonably stable, and the fishes often have more or less predictable patterns of abundance and distribution. However, estuarine fish populations change dramatically in response to environmental perturbations; these population changes can be permanent even though the predominantly estuarine species have broad temperature tolerances and strong osmoregulatory abilities. The species composition of estuarine communities change constantly, attesting to the variable environmental conditions and the limitations of the tolerances of the fish populations to alterations in the habitat.

There is uncertainty in the ecological endpoint comparison. The values used in the ecological endpoint comparison (either the WQS of the SSV) are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemical mixtures is not well understood. All the toxicity information used in the ecological risk assessment for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals. In addition, there were several contaminants that did not have WQS or SSVs. Therefore, potential effects to ecological receptors from these chemicals cannot be determined.

The SSVs were developed using data obtained from freshwater, estuarine, and marine environments. Therefore, their applicability for use to evaluate potential effects to aquatic organisms from contaminants in estuarine habitats must be evaluated on a chemical specific basis because of differences in both the toxicity of individual contaminants to freshwater and saltwater organisms and the bioavailability of contaminants in the two aquatic systems. In addition, the toxicity of several of the metals (cadmium, chromium, copper, lead, nickel, and zinc) to aquatic organisms increases or decreases based on water hardness. Because water hardness was not available, a default value of 50 mg/L of $CaCO_3$ was used.

Several contaminants in the surface water and sediment exceeded applicable ARV values. Some of the surface water and sediment samples were collected from areas that were not considered ecologically significant. Therefore, although the ARVs may have been exceeded in these samples, the potential for them to impact aquatic life may not be significant.

Finally, there is also uncertainty in the chronic daily intake models used to evaluate decreased integrity to terrestrial receptors. 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. Terrestrial species will also be exposed to contaminants by ingesting fauna that have accumulated contaminants. This additional exposure route was not evaluated in this ERA because the high uncertainty associated with this exposure route.

17.7 Conclusions

Overall, metals and pesticides appear to be the most significant site-related COPCs that have potential to affect the integrity of the aquatic receptors a Site 28. For the terrestrial receptors at Site 28, metals appear to be the most significant site-related COPC that have the potential to affect the ecosystem. Although the American alligator has been observed at Site 28, potential adverse impacts to this threatened or endangered species are low because of the low levels of most contaminants in its critical habitat.

17.7.1 Aquatic Ecosystem

In the New River surface water, copper exceeded aquatic reference values but at levels that were indicative of a low potential for risk. Lead and zinc only exceeded unity slightly at a single station. Copper exceeded the surface water reference values in Cogdels Creek, and aluminum exceeded the surface water reference values in Orde Pond. However, these exceedences were only slightly above the reference values.

In the sediment, lead exceeded the sediment aquatic reference values only once in Cogdels Creek at a low level but exceeded its sediment aquatic reference values significantly in the New River at one station. Antimony exceeded its sediment aquatic reference values moderately at the same station in the New River. This station may be associated with runoff from the active firing range. Pesticides exceeded the sediment aquatic reference values throughout Cogdels Creek with the highest exceedences in the lower reach of the creek near the confluence with the New River. These exceedences represent a moderate potential for risk to aquatic receptors. The levels detected in the sediment may be a result of routine application in the general vicinity of Site 28, especially near the sewage treatment plant and recreational area.

Results of the analysis of benthic macroinvertebrates and fish populations indicate that Cogdels Creek and this reach of the New River support an aquatic community that is representative of a tidally-influenced freshwater and estuarine ecosystem with both freshwater and marine species. The absence of pathologies observed in the fish sampled from Cogdels Creek and the New River indicates that the surface water and sediment quality does not adversely impact the fish community. The benthic community demonstrated the typical tidal/freshwater species trend of primarily chironomids and oligochaetes in the upper reaches of Cogdels Creek and polychaetes and amphipods in the lower reaches of Cogdels Creek and in the New River. Species representative of both tolerant and intolerant taxa were present, and the overall community composition did not indicate a benthic community adversely impacted by surface water and sediment quality.

17.7.2 Terrestrial Ecosystem

During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. Based on the soil toxicity data for several metals (cadmium, chromium, copper, manganese, nickel, and zinc), these contaminants at Site 28 may decrease the integrity of terrestrial invertebrates or plants at the site. Based on the evaluation of the deer, rabbit, fox, raccoon, and quail receptors used in this ERA, there does appear to be an ecological risk to terrestrial vertebrate receptors. This risk is expected to be significant if greater exposure to these contaminants results.

SECTION 17.0 TABLES

TABLE 17-1

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Site 28							
	Surface Water			Sediment			Surface Soil	Ecological Samples
	New River	Cogdels Creek	Orde Pond	New River	Cogdels Creek	Orde Pond		
Volatiles								
Acetone	X	X		X	X	X	X	X
Benzene								X
2-Butanone				X	X	X		X
Carbon Disulfide				X	X			
Chloromethane							X	
2-Hexanone		X						X
Methylene Chloride		X	X	X			X	X
Toluene						X		X
1,1,1-Trichloroethane							X	
Semivolatiles								
Acenaphthene				X			X	
Anthracene				X	X		X	
Di-n-butyl phthalate							X	
Bis(2-chloroethyl)ether							X	
Bis(2-ethylhexyl)phthalate	X			X	X	X	X	X
Benzo(a)anthracene				X	X		X	
Dibenz(a,h)anthracene				X			X	
Benzo(a)pyrene				X	X		X	
Benzo(b)fluoranthene				X	X		X	
Benzo(k)fluoranthene				X	X		X	
Benzo(g,h,i)perylene							X	
Butylbenzylphthalate				X	X		X	X
Indeno(1,2,3-cd)pyrene				X			X	
Carbazole				X			X	
Chrysene				X	X		X	
Dibenzofuran				X			X	
Di-n-octyl phthalate							X	X

TABLE 17-1 (Continued)

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Site 28							
	Surface Water			Sediment			Surface Soil	Ecological Samples
	New River	Cogdels Creek	Orde Pond	New River	Cogdels Creek	Orde Pond		
3,3'-Dichlorobenzidine					X			
Fluoranthene				X	X		X	
Fluorene				X			X	
2-Methylphenol								X
Naphthalene							X	
Pentachlorophenol							X	
Phenanthrene	X			X	X		X	
Pyrene				X	X		X	
Pesticides								
4,4'-DDE	X			X	X		X	X
4,4'-DDD	X			X	X	X	X	X
4,4'-DDT				X	X		X	
alpha-Chlordane				X	X		X	X
gamma-Chlordane				X	X		X	
Dieldrin							X	X
Endrin							X	
Endrin aldehyde							X	X
Endosulfan sulfate							X	
beta-BHC								X
Heptachlor epoxide							X	
PCBs								
PCB-1254							X	
PCB-1260							X	
Inorganics								
Aluminum	X	X	X	X	X	X	X	X
Antimony				X			X	X
Arsenic	X	X		X	X	X	X	X
Barium	X	X		X	X	X	X	X

TABLE 17-1 (Continued)

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES SITE 28, HADNOT POINT BURN DUMP REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site 28							
	Surface Water			Sediment				
Analyte	New River	Cogdels Creek	Orde Pond	New River	Cogdels Creek	Orde Pond	Surface Soil	Ecological Samples
Beryllium					X	X		X
Cadmium	X				X		X	X
Calcium	X	X	X	X	X	X	X	X
Chromium				X	X	X	X	X
Cobalt				X	X	X	X	X
Copper	X	X		X	X	X	X	X
Iron	X	X	X	X	X	X	X	X
Lead	X	X		X	X	X	X	
Magnesium	X	X	X	X	X	X	X	X
Manganese	X	X		X	X	X	X	X
Mercury				X	X		X	X
Nickel	X	X	X	X	X	X	X	
Potassium	X	X	X	X	X	X	X	X
Selenium							X	X
Silver				X	X		X	X
Sodium	X	X	X	X	X		X	X
Thallium	X		X		X		X	
Vanadium	X	X		X	X	X	X	X
Zinc	X	X		X	X	X	X	X

TABLE 17-2

SUMMARY OF COPCs SURFACE WATER, SEDIMENT, FISH TISSUE AND SURFACE SOIL SITE 28, HADNOT POINT BURN DUMP AREA REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water New River	Excluded - Low Frequency of Detection or Below Surface Water Criteria	Excluded - Within Off-Site Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
aluminum arsenic cadmium copper iron lead manganese vanadium zinc 4,4'-DDD 4,4'-DDE	nickel thallium phenanthrene	barium	calcium magnesium potassium sodium	bis(2-ethylhexyl)phthalate acetone

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER, SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water Cogdels Creek	Excluded - Low Frequency of Detection; Laboratory Contaminant; or Below Surface Water Criteria	Excluded - Within Off-Site Background	Excluded - Essential Nutrients
aluminum copper lead iron manganese vanadium zinc	arsenic nickel methylene chloride acetone 2-hexanone	barium	calcium magnesium potassium sodium

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Water Orde Pond	Excluded -Common Laboratory Contaminant	Excluded - Within Off-Site Background	Excluded - Essential Nutrients
aluminum nickel thallium	methylene chloride	iron	calcium magnesium potassium sodium

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment New River	Excluded - Low Frequency of Detection or Below Sediment Screening Values	Excluded - Within Off-Site Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
antimony arsenic barium copper iron lead silver zinc 4,4'-DDD 4,4'-DDE 4,4'-DDT alpha-chlordane gamma-chlordane phenanthrene anthracene carbazole fluoranthene pyrene benzo(a)anthracene chrysene benzo(b)fluoranthene benzo(k)fluoranthene benzo(a)pyrene indeno(1,2,3-cd)pyrene dibenzofuran fluorene benzo(g,h,i)perylene	acenaphthene dibenz(a,h)anthracene acetone methylene chloride 2-butanone	aluminum cobalt chromium manganese mercury nickel vanadium	calcium magnesium potassium sodium	bis(2-ethylhexyl)phthalate methylene chloride acetone 2-butanone

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER, SEDIMENT, FISH TISSUE AND SURFACE SOIL SITE 28, HADNOT POINT BURN DUMP AREA REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment Cogdels Creek	Excluded - Below Sediment Screening Values	Excluded - Within Off-Site Background	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants/Blank Contamination
aluminum	4,4'-DDT	cobalt	calcium	acetone
arsenic	phenanthrene	nickel	magnesium	2-butanone
barium	anthracene		potassium	
beryllium	butyl benzyl phthalate		sodium	
cadmium	3,3-dichlorobenzidine			
chromium	benzo(b)fluoranthene			
copper	benzo(k)fluoranthene			
iron				
lead				
manganese				
mercury				
silver				
thallium				
vanadium				
zinc				
4,4'-DDD				
4,4'-DDE				
alpha-chlordane				
gamma-chlordane				
carbon disulfide				
bis(2-ethylhexyl)phthalate				
fluoranthene				
pyrene				
benzo(a)anthracene				
chrysene				
benzo(a)pyrene				

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Sediment Orde Pond	Excluded - Within Off-Site Background Levels or Below Sediment Screening Values	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
aluminum arsenic beryllium chromium cobalt copper iron lead manganese nickel vanadium 4,4'-DDD	barium zinc	calcium magnesium potassium	acetone 2-butanone toluene bis(2-ethylhexyl)phthalate

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Fillet Tissue New River	Excluded - Low Frequency of Detection	Excluded - Within Off-Site Background Levels	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
antimony barium cobalt copper selenium 4,4'-DDD 4,4'-DDE alpha-chlordane	vanadium dieldrin endrin aldehyde	arsenic mercury bis(2-ethylhexyl)phthalate	calcium magnesium sodium potassium	methylene chloride acetone butyl benzyl phthalate

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Whole Body Tissue New River	Excluded - Low Frequency of Detection	Excluded - Within Off-Site Background Levels	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
aluminum	beryllium	NA	calcium	methylene chloride
antimony	benzene		magnesium	2-butanone
arsenic	beta-BHC		potassium	bis(2-ethylhexyl)phthalate
barium	endrin aldehyde		sodium	2-hexanone
cadmium				
chromium				
cobalt				
copper				
iron				
manganese				
mercury				
selenium				
silver				
vanadium				
zinc				
4,4'-DDD				
4,4'-DDE				
alpha-chlordane				

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER, SEDIMENT, FISH TISSUE AND SURFACE SOIL SITE 28, HADNOT POINT BURN DUMP AREA REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Fillet Tissue Orde Pond	Excluded - Low Frequency of Detection	Excluded - Within Off-Site Background Levels	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
barium manganese selenium zinc	cobalt 2-methylphenol 2,4,6-trichlorophenol 3-nitroaniline	arsenic chromium copper mercury	calcium magnesium potassium sodium	acetone bis(2-ethylhexyl)phthalate di-n-octyl phthalate

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Fish Whole Body Tissue Orde Pond	Excluded - Low Frequency of Detection	Excluded - Within Off-Site Background Levels	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants
arsenic barium chromium cobalt copper iron manganese mercury selenium zinc 4,4'-DDE alpha-chlordane	antimony vanadium toluene total xylenes	NA	calcium magnesium potassium sodium	acetone methylene chloride bis(2-ethylhexyl)phthalate

TABLE 17-2 (Continued)

SUMMARY OF COPCs SURFACE WATER,
SEDIMENT, FISH TISSUE AND SURFACE SOIL
SITE 28, HADNOT POINT BURN DUMP AREA
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs Surface Soil	Excluded - Low Frequency of Detection and Below Soil Screening Values	Excluded - Essential Nutrients	Excluded - Common Laboratory Contaminants or Below Soil Screening Values
aluminum	selenium	calcium	di-n-butyl phthalate
antimony	dieldrin	magnesium	butyl benzyl phthalate
arsenic	endrin	potassium	di-n-octylphthalate
barium	endosulfan sulfate	sodium	
cadmium	endrin aldehyde		
chromium	Aroclor-1254		
cobalt	Aroclor-1260		
copper	bis(2-chloroethyl)ether		
iron	naphthalene		
lead	acenaphthene		
manganese	dibenzofuran		
mercury	fluorene		
nickel	pentachlorophenol		
silver	dibenz(a,h)anthracene		
thallium	chloromethane		
vanadium	methylene chloride		
zinc	acetone		
heptachlor epoxide	1,1,1-trichloroethane		
4,4'-DDD			
4,4'-DDE			
4,4'-DDT			
alpha-chlordane			
gamma-chlordane			
phenanthrene			
anthracene			
carbazole			
chrysene			
benzo(a)pyrene			
bis(2-ethylhexyl)phthalate			
fluoranthene			
pyrene			
benzo(a)anthracene			
benzo(b)fluoranthene			
benzo(k)fluoranthene			
indeno(1,2,3-cd)pyrene			
benzo(g,h,i)perylene			

TABLE 17-3

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	BCF (L/kg)	Water Solubility (mg/L)	Organic Carbon Partition Coefficient (mL/g)	Vapor Pressure (mm Hg)	Log Octanol/ Water Coefficient
Inorganics					
Aluminum	ND[1,3]	ND[1,3]	ND[1]	ND[1,3]	ND[1,3,4]
Antimony	1[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Arsenic	44[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Barium	ND[1,3]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Beryllium	19[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Cadmium	64[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Chromium	16[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Cobalt	ND[3]	ND[1,3]	ND[1]	1,300[3]	ND[1,3,4]
Copper	36[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Iron	ND[3]	ND[1,3]	ND[1]	ND[1,3]	ND[1,3,4]
Lead	49[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Manganese	350,000[3]	ND[1,3]	ND[1]	ND[1,3]	ND[1,3,4]
Mercury	3,760 - 5,500[8]	ND[1,3]	ND[1]	0.002[3]	ND[1,3,4]
Nickel	47[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Selenium	6[8]	ND[1,2]	ND[1]	ND[1,2,3]	ND[1,3,4]
Silver	0.5[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
Thallium	119[8]	ND[1,3]	ND[1]	880[3]	ND[1,3,4]
Vanadium	ND[3]	ND[1,3]	ND[1]	ND[3]	ND[1,3,4]
Zinc	1[8]	ND[1,3]	ND[1]	ND[1,2,3]	ND[1,3,4]
VOCs					
Carbon Disulfide	ND[3]	2,940[1]	54[1]	360[1]	0[3]
SVOCs					
Anthracene	30[8]	0.043[3]	14,000[1]	ND[1,2,3]	4.5[3]
Benzo(a)anthracene	30[8]	ND[1,2,3]	1,380,000[1]	ND[1,2,3]	5.7[3]
Benzo(a)pyrene	30[8]	ND[1,2,3]	5,500,000[1]	ND[1,2,3]	6.0[3]
Benzo(b)fluoranthene	30[8]	ND[1,2]	550,000[1]	ND[2,3]	6.6[3]
Benzo(k)fluoranthene	30[8]	ND[1,2,3]	550,000[1]	ND[1,2,3]	6.1[1]

TABLE 17-3 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	BCF (L/kg)	Water Solubility (mg/L)	Organic Carbon Partition Coefficient (mL/g)	Vapor Pressure (mm Hg)	Log Octanol/ Water Coefficient
Benzo(g,h,i)perylene	30[8]	ND[1,2]	1,600,000[1]	ND[1,2]	6.5[1]
Bis(2-ethylhexyl)phthalate	130[8]	5.1[3]	100,000[9]	ND[2,3]	5.1[3]
Carbazole	ND[3,4,6]	ND[3,4,6]	ND[3,4,6]	ND[3,4,6]	ND[3,4,6]
Chrysene	30[8]	ND[1,2,3]	200,000[1]	ND[1,2,3]	5.7[3]
Dibenzofuran	ND	10[9]	7,943[9]	ND	4.12[9]
Fluoranthene	1,150[8]	0.206[1]	38,000[1]	ND[1,2]	4.9[1]
Fluorene	30[8]	1.69[6]	7,300[1]	7.10×10^{-4}[1]	4.2[1]
Indeno(1,2,3-cd)pyrene	30[8]	5.0×10^{-4}[4]	ND[4]	1.0×10^{-10}[4]	6.51[4]
Phenanthrene	30[8]	1.2[3]	14,000[1]	ND[1,2,3]	4.5[1]
Pyrene	30[8]	ND[1,2,3]	38,000[1]	ND[1,2,3]	4.88[1]
Pesticides/PCBs					
Chlordane, total	14,100[8]	0.056[3]	140,000[1]	ND[1,2,3]	5.5[7]
4,4'-DDE	53,600[8]	0.12[3]	4,400,000[1]	ND[1,2,3]	5.7[3]
4,4'-DDD	53,600[8]	0.09[3]	770,000[1]	ND[1,2,3]	.60[3]
4,4'-DDT	53,600[8]	0.025[3]	243,000[1]	ND[1,2,3]	6.4[3]
Heptachlor Epoxide	11,200[8]	0.2	ND	1.95×10^{-5}	5.40

(1) USEPA, 1986.
(2) Negligible (less than 0.1).
(3) SCDM, 1991.
(4) USEPA, 1985.
(5) Howard, 1989.
(6) Howard, 1991.
(7) Howard, 1991.
(8) USEPA, 1993.
(9) Montgomery, 1990.

ND = No data
BCF = Bioconcentration Factor
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds

TABLE 17-4

TOTAL NUMBER OF AQUATIC SPECIES IDENTIFIED PER AREA
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Orde Pond	Cogdels Creek			Total Detected	New River		Total Detected
	OP1	FS01	FS02	FS03		FS04	FS05	
FISH SPECIES								
Stripped Mullet		1			1	14	6	20
Atlantic Menhaden						198	4	202
Summer Flounder						2	7	9
Black Drum						1		1
Spotted Sea Trout							1	1
Largemouth Bass	13							
American Eel	2							
Redear Sunfish	36							
Warmouth	6							
Blue Gill	172							
Pumpkinseed	1	2			2			
Silverside Anchovy						5		5
NUMBER OF SPECIES	**6**	**2**	**0**	**0**	**2**	**5**	**4**	**6**
NO. OF INDIVIDUALS	**230**	**3**	**0**	**0**	**3**	**220**	**18**	**238**
OTHER AQUATIC SPECIES								
Blue crab		1			1			
NUMBER OF SPECIES	**0**	**1**	**0**	**0**	**1**	**0**	**0**	
NO. OF INDIVIDUALS	**0**	**1**	**0**	**0**	**1**	**0**	**0**	

TABLE 17-5

SUMMARY OF ECOLOGICAL SAMPLES SENT TO CEIMIC FOR TISSUE ANALYSIS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station Location	Sample Identification	Number of Organisms	Species	Whole Body or Fillet
Site 28 - New River				
Station 4				
FS04	28-FS04-SM-WB01	2	SM	WB
FS04	28-FS04-SM-WB2	2	SM	WB
FS04	28-FS04-SM-F01	5	SM	F
FS04	28-FS04-SM-F02	5	SM	F
FS04	28-FS04-SMRF-F01	1	SMRF	F
FS04	28-FS04-AM-WB01	29	AM	WB
FS04	28-FS04-AM-WB02	29	AM	WB
FS04	28-FS04-AM-WB03	29	AM	WB
FS04	28-FS04-BD-F01	1	BD	F
Station 5				
FS05	28-FS05-SM-F01	5	SM	F
FS05	28-FS05-SMRF-F01	3	SMRF	F
FS05	28-FS05-SMRF-F02	3	SMRF	F
FS05	28-FS05-SS01-F01	1	SS	F
FS05	28-FS05-SMRF-WB01	1	SMRF	WB
Site 28 - Orde Pond				
Station 1				
OP1A	OP1A-BGA	11	BG	F
OP1A	OP1A-BGB	11	BG	F
OP1A	OP1A-RDA	17	RD	F
OP1A	OP-1A-RDB	17	RD	F
OPFS	28-OPFS-AE-WB01	2	AE	WB
OPFS	28-OPFS-RS-WB01	6	RS	WB
OPFS	28-OPFS-WM-F01	3	WM	F
OPFS	28-OPFS-LB-F01	3	LB	F
OPFS	28-OPFS-LB-WB01	30	LB	WB

Species code: AM = Atlantic Menhaden, SMRF = Summer Flounder, SM = Striped Mullet, WM = Warmouth, LB = Largemouth Bass, RS = Redear Sunfish, BD = Black Drum, SS = Spotted Sea Trout, BG = Blue Gill, RD = Redear Sunfish, AE = American Eel

TABLE 17-6

FISH DISTRIBUTION AND CHARACTERIZATION
SITE 28 - NEW RIVER, COGDELS CREEK AND ORDE POND
REMEDIAL INVESTIGATION, CTO-0231
MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Atlantic Menhaden	Brevoortia tyrannus	20	46	Brackish or marine, enters freshwater	Rivers, streams	NA	Intermediate	Clupeidae	1,2,3,4
Stripped Mullet	Mugil cephalus	NA	23-35	Brackish or marine, enters freshwater	Rivers	NA	NA	Mugilidae	1,2
Pumpkinseed	Lepomis gibbosus	20	8-20	Freshwater	Streams, Creeks	April through October	Moderately Tolerant	Centrarchidae	1,2,3,4
Summer Flounder	Paralichthys dentatus	NA	37	Brackish or marine, enters freshwater	Rivers	NA	NA	Bothidae	1
Black Drum	Pogonias cromis	NA	to 99 cm	NA	Over sand or sandy mud in bays and estuaries	NA	NA	Sciaenidae	2
Spotted Sea Trout	Cynoscion nebulosus	NA	to 71 cm	NA	Estuaries, tidal mud flats, grass beds, and salt marshes	NA	NA	Sciaenidae	2
Largemouth Bass	Micropterus salmoides	48	12 - 70	Freshwater and brackish $<1\%$ salinity	Rivers, streams, creeks	May through June	Intermediate	Centrarchidae	1,2,3

TABLE 17-6 (Continued)

FISH DISTRIBUTION AND CHARACTERIZATION AT SITE 28 - NEW RIVER, COGDELS CREEK AND ORDE POND REMEDIAL INVESTIGATION, CTO-0231 MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Redear Sunfish	Lepomis microlophus	18	14 - 25	Freshwater	Streams, Creeks	May through August	Intermediate	Centrarchidae	1,2,3
Warmouth	Lepomis gulosus	16	8 - 26	Freshwater	Rivers, Streams	May through August	Intermediate	Centrarchidae	1,2,3
Blue Gill	Lepomis macrochirus	25	18 - 20	Freshwater	Rivers, Streams, Creeks	May through October	Intermediate	Centrarchidae	1,2,3
Silverside Anchovy	NA	8 cm	to 8 cm	NA	Rivers and streams	April to July	NA	Engraulidae	1,2
Blue Crab	Callinectes sapidus	NA	NA	Brackish or marine	Ocean and bay beaches	NA	Intermediate	Portunidae	6
American Eel	Anguilla rostata	NA	to 147.5	Brackish or freshwater	NA	December	Intermediate	Anguillidae	1,2,3,4,5

1 Menhinick, 1992.
2 Boschung, 1983.
3 USEPA, 1989d.
4 Raasch, 1991.
5 Kennish, 1986.
6 Zeiller, 1974.

TABLE 17-7

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
NEMERTEA	Phylum
Anopla	Class
Heteronemertea	Order
Lineidae	Family
Micrura leidyl	Genus Species
ANNELIDA	Phylum
Oligochaeta	Class
Tubificida	Order
Tubificidae	Family
Limnodrilus hoffmeisteri	Genus Species
Polychaeta	Class
Ariciida	Order
Orbiniidae	Family
Scoloplos fragilis	Genus Species
Capitellida	Order
Capitellidae	Family
Capitella capitata	Genus Species
Phyllodocida	Order
Nereidae	Family
Nereis succinea	Genus Species
Spionida	Order
Spionidae	Family
Polydora sp.	Genus Species
Streblospio benedicti	Genus Species
Terebellida	Order
Amphipoda	Family
Hypaniola grayi	Genus Species
ARTHROPODA	Phylum
Crustacea	Class
Amphipoda	Order
Gammaridae	Family

TABLE 17-7 (Continued)

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
Gammarus tigrinus	Genus Specis
Talitridae	Family
Orchestia grillus	Genus Species
Decapoda	Order
Portunidae	Family
Callinectes sp.	Genus Species
Tanaidacea	Order
Paratanaidae	Family
Leptochelia savignyi	Genus Species
Insecta	Class
Coleoptera	Order
Dytiscidae	Family
Hydroporus sp.	Genus Species
Diptera	Order
Ceratopogonidae	Family
Bezzia/Palpomyia sp.	Genus Species
Palpomyia/sphaeromias sp.	Genus Species
Chironomidai	Family
Chironomus decorus gr.	Genus Species
Chironomus ochreatus	Genus Species
Cladopelma sp.	Genus Species
Cladotanytarsus mancus gr.	Genus Species
Cricotopus bicinctus gr.	Genus Species
Dicrotendipes modestus	Genus Species
Larsia sp.	Genus Species
Macropelopia sp.	Genus Species
Nanocladius bicolor gr.	Genus Species
Procladius sp.	Genus Species
Pseudochironomus sp.	Genus Species
Thienemannimyia gr.	Genus Species
Tipulidae	Family

TABLE 17-7 (Continued)

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
Antocha sp.	Genus Species
Ephemeroptera	Order
Caenidae	Family
Caenis punctata	Genus Species
Odonata	Order
Coenagrionidae	Family
Enallagma signatum/vesperum	Genus Species
MOLLUSCA	Phylum
Bivalvia	Class
Veneroida	Order
Mactridae	Family
Mulinia lateralis	Genus Species
Semelidae	Family
Abra aequalis	Genus Species
Tellinidae	Family
Tellina sp.	Genus Species
Veneridae	Family
Gemma gemma	Genus Species

TABLE 17-8

BIOTIC INDEX AND USEPA TOLERANCE TO ORGANIC WASTE AND SENSITIVITY TO METALS FOR BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA(1) Metals	Organics	NCDEHNR(2) Biotic Index
NEMERTEA			
Anopla			
Heternomertea			
Lineidae			
Micrura leidyl	NA	NA	NA
ANNELIDA			
Oligochaeta			
Tubificida			
Tubificidae			
Limnodrilus hoffmeisteri	NA	5	9.8
Polychaeta			
Ariciida			
Orbiniidae			
Scoloplos fragilis	NA	NA	NA
Capitellida			
Capitellidae			
Capitella capitata	NA	NA	NA
Phyllodocida			
Nereidae			
Nereis succinea	NA	NA	NA
Spionida			
Spionidae			
Polydora sp.	NA	NA	NA
Streblospio benedicti	NA	NA	NA
Terebellida			
Ampharetidae			
Hypaniola grayi	NA	NA	NA
ARTHROPODA			
Crustacea			

TABLE 17-8 (Continued)

BIOTIC INDEX AND USEPA TOLERANCE TO ORGANIC WASTE AND SENSITIVITY TO METALS FOR BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[1] Metals	Organics	NCDEHNR[2] Biotic Index
Amphipoda			
Gammaridae			
Gammarus tigrinus	NA	2	NA
Talitridae			
Orchestia grillus	NA	NA	NA
Decapoda			
Portunidae			
Callinectes sp.	NA	NA	NA
Tanaidacea			
Paratanaidae			
Leptochelia savignyi	NA	NA	NA
Insecta			
Coleoptera			
Dytiscidae			
Hydroporus sp.	NA	NA	8.9
Diptera			
Ceratopogonidae			
Bezzia/Palpomyia sp.	NA	3.5	6.9
Palpomyia/sphaeromias sp.	NA	3	6.9
Chironomidae			
Chironomus decorus gr.	NA	NA	9.6
Chironomus ochreatus	NA	NA	9.6
Cladopelma sp.	NA	NA	3.4
Cladotanytarsus mancus gr.	NA	NA	4.0
Cricotopus bicinctus gr.	T	2	8.5
Dicrotendipes modestus	S	3	8.7
Larsia sp.	NA	2	9.3
Macropelopia sp.	NA	1	NA
Nanocladius bicolor gr.	NA	NA	7.1
Procladius sp.	S	3	9.1

TABLE 17-8 (Continued)

BIOTIC INDEX AND USEPA TOLERANCE TO ORGANIC WASTE AND SENSITIVITY TO METALS FOR BENTHIC MACROINVERTEBRATE SPECIES
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[1] Metals	Organics	NCDEHNR[2] Biotic Index
Pseudochironomus sp.	NA	2	5.5
Thienemannimyia gr.	D	0	NA
Tipulidae			
Antocha sp.	NA	NA	4.2
Ephemeroptera			
Caenidae			
Caenis punctata	NA	NA	7.6
Odonata			
Coenagrionidae			
Enallagma signatum/vesperum	NA	2	8.9
MOLLUSCA			
Bivalvia			
Veneroida			
Mactridae			
Mulinia lateralis	NA	NA	NA
Semelidae			
Abra aequalis	NA	NA	NA
Tellinidae			
Macoma tenta	NA	NA	NA
Veneridae			
Gemma gemma	NA	NA	NA

(1) Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters
(2) Lenat, 1993
NA = Not Available
S = Sensitive to heavy metals
D = Intolerant to organic wastes
T = Tolerant to heavy metals

TABLE 17-9

SUMMARY STATISTICS OF BENTHIC MACROINVERTEBRATE SPECIES AT NEW RIVER, COGDELS CREEK AND ORDE POND SITE 28, HADNOT POINT BURN DUMP REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Organisms	Species Density (#/m^2)	Species Diversity (Shannon-Weiner)	Species Diversity (Brillouin's)	Macroinvertebrate Biotic Index
28-OP-BN01	13	123	784	0.651	0.593	9.2
28-BN01	11	82	523	0.847	0.765	9.4
28-BN02	8	85	542	0.547	0.495	8.3
28-BN03	6	42	268	0.493	0.422	9.7
28-BN04	13	251	1600	0.930	0.890	NA
28-BN05	8	63	402	0.619	0.550	NA

28-OP-BN01 = Orde Pond Station
28-BN01 - 28-BN03 = Cogdels Creek Stations
28-BN04 - 28-BN05 = New River Stations
BN = Benthic Macroinvertebrate Sample
NA = Not Applicable
Species Density (#m^2) is based on a sample area of 0.0523 m^2.

TABLE 17-10

FREQUENCY AND RANGE OF DETECTION COMPARED TO SALTWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
SITE 28, HADNOT POINT BURN DUMP, NEW RIVER
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARVs					Contaminant Frequency/Range		Comparison to ARVs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above USEPA WQSVS		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (μg/L)												
Aluminum	NE	NE	NE	NE	NE	5/5	817 - 1,660	NA	NA	NA	NA	NA
Arsenic	50	69	36	69	36	3/5	4.2 - 4.3J	0/3	0/3	0/3	0/3	0/3
Cadmium	5	43	9.3	43	9.3	2/5	3.8 - 4.2	0/2	0/2	0/2	0/2	0/2
Copper	3	2.9	2.9	2.9	2.9	3/5	6.6 - 18.1	3/3	3/3	3/3	3/3	3/3
Iron	NE	NE	NE	NE	NE	5/5	1,190 - 2,010J	NA	NA	NA	NA	NA
Lead	25	220	8.5	220	8.5	3/5	1.7 - 23.4	0/3	0/3	1/3	0/3	1/3
Manganese	NE	NE	NE	NE	NE	5/5	20.7J - 49.8	NA	NA	NA	NA	NA
Vanadium	NE	NE	NE	NE	NE	3/5	3.6 - 6.1	NA	NA	NA	NA	NA
Zinc	86	95	86	95	86	3/5	10.4 - 363	1/3	1/3	1/3	1/3	1/3
Organics (μg/L)												
4,4'-DDE	NE	NE	NE	14[1]	NE	1/5	0.04J	NA	NA	NA	0/1	NA
4,4'-DDD	NE	NE	NE	NE	NE	1/5	0.05J	NA	NA	NA	NA	NA

NE = Not Established
NA = Not Applicable
[1] Criteria are Lowest Observed Effects Levels

TABLE 17-11

FREQUENCY AND RANGE OF DETECTION COMPARED TO SALTWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
SITE 28, HADNOT POINT BURN DUMP, COGDELS CREEK
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARVs					Contaminant Frequency/Range		Comparison to ARVs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above USEPA WQSVS		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (µg/L)												
Aluminum	NE	NE	NE	NE	NE	7/7	347 - 936	NA	NA	NA	NA	NA
Copper	3	2.9	2.9	2.9	2.9	1/7	6.2	1/1	1/1	1/1	1/1	1/1
Iron	NE	NE	NE	NE	NE	7/7	838J - 1,390J	NA	NA	NA	NA	NA
Lead	25	220	8.5	220	8.5	7/7	1.9 - 4.2	0/7	0/7	0/7	0/7	0/7
Manganese	NE	NE	NE	NE	NE	7/7	20.2 - 56.1	NA	NA	NA	NA	NA
Zinc	86	95	86	95	86	6/7	8 - 13	0/6	0/6	0/6	0/6	0/6
Vanadium	NE	NE	NE	NE	NE	1/7	3.6	NA	NA	NA	NA	NA

NE = Not Established
NA = Not Applicable

TABLE 17-12

FREQUENCY AND RANGE OF DETECTION COMPARED TO FRESHWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
SITE 28, HADNOT POINT BURN DUMP, ORDE POND
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARVs					Contaminant Frequency/Range		Comparison to ARVs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above USEPA WQSVS		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (μg/L)												
Aluminum	NE	750	87	750	87	2/2	97.5 - 170	NA	0/2	2/2	0/2	2/2
Nickel	88	789(1)	87.7(1)	789(1)	87.7(1)	1/2	12.8	0/1	0/1	0/1	0/1	0/1
Thallium	NE	NE	NE	1,400(2)	40(2)	1/2	4.7	NA	NA	NA	0/1	0/1

NE = Not Established
NA = Not Applicable
(1) Criteria are hardness dependent; values are based on a hardness of 50 mg/L as $CaCO_3$
(2) Criteria are Lowest Observed Effects Level

TABLE 17-13

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
SITE 28, HADNOT POINT BURN , NEW RIVER
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Comparison to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg)						
Antimony	2	25	2/4	8.7J - 263J	2/2	1/2
Arsenic	33	85	9/10	0.59J - 12.5	0/9	0/9
Barium	NE	NE	10/10	2.2 - 28.9	NA	NA
Copper	70	390	10/10	1.5 - 1,340	2/10	1/10
Iron	NE	NE	10/10	1,560 - 30,600	NA	NA
Lead	35	110	10/10	3.5J - 38,800	2/10	2/10
Silver	1	2.2	2/10	3.1J - 3.4J	2/2	2/2
Zinc	120	270	10/10	3.7 - 117J	0/10	0/10
Pesticides/PCBs (µg/kg)						
4,4'-DDD	2	20	3/10	8.6 - 15	3/3	0/3
4,4'-DDT	1	7	3/10	33 - 300	3/3	3/3
4,4'-DDE	2	15	2/10	8.4 - 8.5	2/2	0/2
alpha-Chlordane	0.5[(1)]	6[(1)]	2/10	4.8 - 6.6J	2/2	1/2
gamma-Chlordane	0.5[(1)]	6[(1)]	2/10	3.1J - 4.6J	2/2	0/2

TABLE 17-13 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
SITE 28, HADNOT POINT BURN DUMP, NEW RIVER
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Comparison to SSVs	
Analyte	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Semivolatiles (µg/kg)						
Phenanthrene	225	1,380	4/10	47J - 1,200	2/4	0/4
Anthracene	85	960	4/10	97J - 320J	4/4	0/4
Carbazole	NE	NE	3/10	57J - 160J	NA	NA
Fluoranthene	600	3,600	6/10	80J - 1,600	3/6	0/6
Pyrene	350	2,200	6/10	75J - 1,700	4/6	0/6
Benzo(a)anthracene	230	1,600	5/10	150J - 1,500	4/5	0/5
Chrysene	400	2,800	5/10	160J - 2,100	3/5	0/5
Benzo(b)fluoranthene	NE	NE	6/10	55J - 1,100	NA	NA
Benzo(k)fluoranthene	NE	NE	5/10	120J - 840	NA	NA
Benzo(a)pyrene	400	2,500	5/10	130J - 710	3/5	0/5
Indeno(1,2,3-cd)pyrene	NE	NE	5/10	68J - 320J	NA	NA
Benzo(g,h,i)perylene	NE	NE	5/10	65J - 320J	NA	NA
Dibenzofuran	NE	NE	1/10	60J	NA	NA
Fluorene	35	640	1/10	120J	1/1	0/1

SSV = Sediment Screening Values
NE = Not Established
NA = Not Applicable
(1) Values for Total Chlordane

TABLE 17-14

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
SITE 28, HADNOT POINT BURN DUMP, COGDELS CREEK
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg)						
Aluminum	NE	NE	14/14	403J - 29,900	NA	NA
Arsenic	33	85	10/14	0.67 - 11.9	0/10	0/10
Barium	NE	NE	14/14	2.1 - 59.4	NA	NA
Beryllium	NE	NE	1/14	0.57	NA	NA
Cadmium	5	9	2/14	1.5 - 2.2	0/2	0/2
Chromium	80	145	13/14	2.5 - 47.2	0/13	0/13
Copper	70	390	13/14	2.2 - 63.7	0/13	0/13
Iron	NE	NE	14/14	1,480 - 36,000J	NA	NA
Lead	35	110	14/14	6.8 - 202	7/14	2/14
Manganese	NE	NE	13/14	2.4J - 226	NA	NA
Mercury	0.15	1.3	6/14	0.12 - 0.41	4/6	0/6
Silver	1	2.2	1/14	2.0J	1/1	0/1
Thallium	NE	NE	1/14	4.1	NA	NA
Vanadium	NE	NE	14/14	1.9 - 56	NA	NA
Zinc	120	270	14/14	9.3J - 303	2/14	1/14

TABLE 17-14 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
SITE 28, HADNOT POINT BURN DUMP, COGDELS CREEK
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Organics (µg/kg)						
Fluoranthene	600	3,600	3/14	77J - 340J	0/3	0/3
Pyrene	350	2,200	5/14	63J - 250J	0/5	0/5
Carbon Disulfide	NE	NE	2/14	9J - 13J	NA	NA
Bis(2-ethylhexyl)phthalate	NE	NE	12/14	100J - 1,700J	NA	NA
Benzo(a)anthracene	230	1,600	2/14	56J - 140J	0/2	0/2
Chrysene	400	2,800	2/14	58J - 160J	0/2	0/2
Benzo(a)pyrene	400	2,500	9/14	47J - 1,700J	5/9	0/9
Pesticides/PCBs (µg/kg)						
4,4'-DDE	2	15	9/14	6.4J - 200J	9/9	5/9
4,4'-DDD	2	20	7/14	4.3J - 450J	7/7	3/7
alpha-Chlordane	0.5(1)	6(1)	2/14	2.6NJ - 5.9NJ	2/2	0/2
gamma-Chlordane	0.5(1)	6(1)	2/14	6.1J - 8.4J	2/2	2/2

SSV = Sediment Screening Values
NE = Not Established
NA = Not Applicable
(1) Values are for Total Chlordane

TABLE 17-15

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
SITE 28, HADNOT POINT BURN DUMP, ORDE POND
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg)						
Aluminum	NE	NE	3/3	2,060J - 4,880J	NA	NA
Arsenic	33	85	2/3	2.3 - 6.4	0/2	0/2
Beryllium	NE	NE	1/3	0.32	NA	NA
Chromium	80	145	3/3	3.6 - 11.8	0/3	0/3
Cobalt	NE	NE	1/3	1.7	NA	NA
Copper	70	390	2/3	1.7 - 1.7	0/2	0/2
Iron	NE	NE	3/3	1,240J - 4,550J	NA	NA
Lead	35	110	3/3	3.8 - 8.3	0/3	0/3
Manganese	NE	NE	3/3	1.8J - 9.8	NA	NA
Nickel	30	50	2/3	2.1 - 2.2	0/2	0/2
Vanadium	NE	NE	3/3	4 - 11.5	NA	NA
Pesticides/PCBs (µg/kg)						
4,4-DDD	2	20	1/2	8.3J	1/1	0/1

SSV = Sediment Screening Values
NE = Not Established
NA = Not Applicable

TABLE 17-16

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND
SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS
THE NEW RIVER, HADNOT CREEK AND HOLLAND MILL CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sj

Ss

Station	BN04	BN05	HC03	HM03
BN04	NA	0.50	0.31	0.18
BN05	0.78	NA	0.40	0.25
HC03	0.10	0.00	NA	0.25
HM03	0.30	0.50	0.40	NA

BN04 - BN05 = New River Stations
HC = Hadnot Creek Station
HM = Holland Mill Creek Station

TABLE 17-17

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTERBRATE STATIONS AT COGDELS CREEK, WEBB CREEK, HADNOT CREEK AND HOLLAND MILL CREEK SITE 28, HADNOT POINT BURN DUMP REMEDIAL INVESTIGATION, CTO-0231 MCB, CAMP LEJEUNE, NORTH CAROLINA

Sj

	Station	BN01	BN02	BN03	WC02	HC02	HM02
	BN01	NA	0.27	0.31	0.20	0.07	0.15
	BN02	0.42	NA	0.40	0.25	0.07	0.33
	BN03	0.47	0.57	NA	0.18	0.07	0.25
	WC02	0.33	0.40	0.31	NA	0.10	0.38
Ss	HC02	0.13	0.13	0.13	0.18	NA	0.14
	HM02	0.27	0.50	0.40	0.55	0.25	NA

BN01 - BN03 = Cogdels Creek Stations
WC = Webb Creek Station
HC = Hadnot Creek Station
HM = Holland Mill Creek Station

TABLE 17-18

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY
AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN
BENTHIC MACROINVERTERBRATE STATIONS AT
ORDE POND AND HADNOT CREEK
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sj

	Station	OP-BN01	HC01
	OP-BN01	NA	0.06
Ss	HC01	0.12	NA

OP-BN01 = Orde Pond Station
HC = Hadnot Creek Station

TABLE 17-19

TERRESTRIAL REFERENCE VALUES AND SOIL TO PLANT TRANSFER COEFFICIENTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Soil to Plant Transfer Coefficient (Bv)	Soil-to-Plant Concentration (Br)*	Terrestrial Reference Value (TRV) mg/kg/day
Aluminum	0.004 [6]	0.00065 [6]	NA
Antimony	0.2 [6]	0.03 [6]	0.35 [8]
Arsenic	0.040 [6]	0.006 [6]	16 [10]
Barium	0.150 [6]	0.015 [6]	30 [9]
Cadmium	0.550 [6]	0.150 [6]	4.7 [12]
Chromium	0.008 [6]	0.005 [6]	2.7 [13]
Cobalt	0.02 [6]	0.007 [6]	NA
Copper	0.400 [6]	0.250 [6]	300 [9]
Iron	0.004 [6]	0.001 [6]	NA
Lead	0.045 [6]	0.009 [6]	27.4 [9]
Manganese	0.250 [6]	0.050 [6]	0.14 [14]
Mercury	0.900 [6]	0.200 [6]	7.4 [15]
Nickel	0.060 [6]	0.060 [6]	5 [9]
Selenium	0.025 [6]	0.025 [6]	0.853 [8]
Silver	0.4 [6]	0.100 [6]	0.014 [9]
Thallium	0.004 [6]	0.0004 [6]	0.23 [8]
Vanadium	0.006 [6]	0.003 [6]	5 [8]
Zinc	1.500 [6]	0.900 [6]	38 [16]
Fluoranthene	0.057 [1,2]	0.057	125
Pyrene	0.033 [1,2]	0.033	75
Benzo(a)anthracene	0.02 [1,2]	0.02	150
Benzo(b)fluoranthene	0.006 [1,2]	0.006	150
Benzo(k)fluoranthene	0.012 [1,2]	0.012	150
Indeno(1,2,3-cd)pyrene	0.007 [1,2]	0.007	150
Benzo(g,h,i)perylene	0.007 [1,2]	0.007	150
Phenanthrene	0.097 [1,2]	0.097	150 [7]+
Anthracene	0.097 [1,2]	0.097	150 [7]+
Carbazole	NA	NA	NA
Chrysene	0.020 [1,2]	0.020	150 [7]+
Benzo(a)pryene	0.013 [1,2]	0.013	150 [7]+
Bis(2-ethylhexyl)phthalate	0.044 [1,2]	0.044	19

TABLE 17-19 (Continued)

TERRESTRIAL REFERENCE VALUES AND SOIL TO PLANT TRANSFER COEFFICIENTS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Soil to Plant Transfer Coefficient (Bv)	Soil-to-Plant Concentration (Br)*	Terrestrial Reference Value (TRV) mg/kg/day
4,4'-DDE	0.019 (1,4)	0.019	0.05 (9)
4,4'-DDD	0.013 (1,4)	0.013	0.05 (9)
4,4'-DDT	0.008 (1,4)	0.008	0.05 (9)
Chlordane, alpha	0.026 (1,4)	0.026	0.055 (9)
Chlordane, gamma	0.026 (1,4)	0.026	0.055 (9)
Heptachlor Epoxide	0.029 (1,3)	0.029	0.15 (9)++

NA - Information not available

(1) Travis, 1988
(2) Montgomery, 1990
(3) SCDM, 1991
(4) USEPA, 1986
(5) Howard, 1991
(6) Baes, 1984
(7) ATSDR, 1990
(8) HEAST, 1994
(9) IRIS, 1993
(10) USDH, 1992
(11) IRIS, 1991
(12) USDH, 1992a
(13) USDH, 1991
(14) IRIS, 1990
(15) ATSDR, 1988
(16) ATSDR, 1989

* - Br is assumed to be the same as Bv for organics
+ Value is for total PAHs
++ Value is for Heptachlor

TABLE 17-20

TERRESTRIAL CHRONIC DAILY INTAKE MODEL EXPOSURE PARAMETERS
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%
Feeding Rate	kg/d	1.6(2)	0.1(3)	0.014(4)	0.446(4)	0.319(4)
Incident Soil Ingestion	kg/d	0.019(1)	0.002(3)	0.001(3)	0.012(4)	0.030(4)
Rate of Drinking Water Ingestion	L/d	1.1(2)	0.119(4)	0.019(4)	0.399(4)	0.331(4)
Rate of Vegetation Ingestion	kg/d	1.6	0.1	0.014	0.089	0.128
Body Weight	kg	45.4(2)	1.229(4)	0.177(4)	4.69(4)	3.99(4)
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.356	NA
Rate of Fish Ingestion	kg/d	NA	NA	NA	NA	0.192
Home Range Size	acres	454(2)	9.29(4)	8.89(4)	1,771(4)	385(4)

NA - Not Applicable
(1) Scarano, 1993
(2) Dee, 1991
(3) Newell, 1987
(4) USEPA, 1993d

TABLE 17-21

SURFACE WATER QUOTIENT INDEX[1]
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration (μg/L)[4]	North Carolina (NCWQS)[2] Quotient Ratio	Region IV Screening Values (USEPA WQSV)[3] Quotient Ratio		USEPA Ambient Water Quality Criteria (USEPA AWQC) Quotient Ratio	
				Acute	Chronic	Acute	Chronic
New River							
Copper	28-NR-SW01	18.1	6.0	6.2	6.2	6.2	6.2
	28-NR-SW02	7.2	2.4	2.5	2.5	2.5	2.5
	28-NR-SW03	6.6	2.2	2.3	2.3	2.3	2.3
Lead	28-NR-SW01	23.4	0.94	0.11	2.8	0.11	2.8
Zinc	28-NR-SW03	363	4.2	3.8	4.2	3.8	4.2
Cogdels Creek							
Copper	28-CC-SW06	6.2	2.1	2.1	2.1	2.1	2.1
Orde Pond							
Aluminum	28-OP-SW01	170	NA	0.23	1.95	0.23	1.95
	28-OP-SW02	97.5	NA	0.13	1.12	0.13	1.12

(1) Ratios of sample concentrations to established criteria and/or screening values
(2) NCWQS = North Carolina Water Quality Standards
(3) USEPA WQSV = U.S. Environmental Protection Agency Water Quality Screening Values
(4) μg/L = micrograms per liter
NA = Not Available

TABLE 17-22

SEDIMENT SCREENING VALUES QUOTIENT INDEX[1]
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration	SSV[2] Quotient Ratio	
			ER-L[4]	ER-M[5]
New River				
Antimony (mg/kg)[6]	28-NR-SD01-06	263	131.5	10.5
	28-NR-SD04-06	8.7	4.4	0.35
Copper	28-NR-SD01-06	1340	19.1	3.4
	28-NR-SD01-612	78.3	1.1	0.20
Lead	28-NR-SD01-06	38800	1108.6	352.7
	28-NR-SD01-612	170	4.9	1.5
Silver	28-NR-SD03-06	3.4	3.4	1.5
	28-NR-SD05-06	3.1	3.1	1.4
4,4'-DDD (µg/kg)[3]	28-NR-SD01-06	15	7.5	0.75
	28-NR-SD03-06	14	7.0	0.70
	28-NR-SD04-612	8.6	4.3	0.43
4,4'-DDT	28-NR-SD01-06	50	50	7.1
	28-NR-SD03-06	33	33	4.7
	28-NR-SD03-612	300	300	42.9
4,4'-DDE	28-NR-SD01-06	8.5	4.3	0.55
	28-NR-SD03-06	8.4	4.2	0.56
alpha-Chlordane	28-NR-SD03-06	4.8	9.6	0.80
	28-NR-SD04-612	6.6	13.2	1.1
gamma-Chlordane	28-NR-SD03-06	3.1	6.2	0.52
	28-NR-SD04-612	4.6	9.2	0.77
Phenanthrene	28-NR-SD01-06	1200	5.3	0.87
	28-NR-SD03-06	450	2.0	0.33
Anthracene	28-NR-SD01-06	320	3.8	0.33
	28-NR-SD03-06	97	1.1	0.10
	28-NR-SD04-612	120	1.4	0.13
	28-NR-SD05-06	170	2.0	0.18
Fluoranthene	28-NR-SD01-06	1600	2.7	0.44
	28-NR-SD03-06	910	1.5	0.25
	28-NR-SD05-06	780	1.3	0.22

TABLE 17-22 (Continued)

SEDIMENT SCREENING VALUES QUOTIENT INDEX[1]
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration	SSV[2] Quotient Ratio	
			ER-L[4]	ER-M[5]
Fluorene	28-NR-SD01-06	120	3.4	0.19
Pyrene	28-NR-SD01-06	1700	4.9	0.77
	28-NR-SD03-06	670	1.9	0.30
	28-NR-SD04-612	420	1.2	0.19
	28-NR-SD05-06	620	1.8	0.28
Benzo(a)anthracene	28-NR-SD01-06	890	3.9	0.56
	28-NR-SD03-06	440	1.9	0.28
	28-NR-SD04-612	1100	4.8	0.69
	28-NR-SD05-06	1500	6.5	0.94
Chrysene	28-NR-SD01-06	790	1.9	0.28
	28-NR-SD04-612	1500	3.8	0.54
	28-NR-SD05-06	2100	5.3	0.75
Benzo(a)pyrene	28-NR-SD01-06	710	1.8	0.28
	28-NR-SD04-612	480	1.2	0.19
	28-NR-SD05-06	660	1.7	0.26
Cogdels Creek Lead	28-CC-SD01-06	130	3.7	1.2
	28-CC-SD03-06	69.7	1.1	0.63
	28-CC-SD04-612	202	5.8	1.8
	28-CC-SD05-06	91.9	2.6	0.84
	28-CC-SD06-612	43.4	1.2	0.39
	28-CC-SD07-06	80.3	2.3	0.73
	28-CC-SD07-612	55.4	1.6	0.50
Mercury	28-CC-SD01-06	0.41	2.7	0.32
	28-CC-SD03-06	0.29	1.9	0.22
	28-CC-SD04-612	0.25	1.7	0.19
	28-CC-SD05-06	0.29	1.9	0.22
Silver	28-CC-SD04-612	2.0	2.0	0.91
Zinc	28-CC-SD01-06	222	1.9	0.82
	28-CC-SD04-612	303	2.5	1.1

TABLE 17-22 (Continued)

SEDIMENT SCREENING VALUES QUOTIENT INDEX[1]
SITE 28, HADNOT POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration	SSV[2] Quotient Ratio ER-L[4]	SSV[2] Quotient Ratio ER-M[5]
Benzo(a)pyrene	28-CC-SD04-06	440	1.1	0.18
	28-CC-SD04-612	500	1.3	0.20
	28-CC-SD05-612	1700	4.3	0.68
	28-CC-SD06-612	510	1.3	0.20
	28-CC-SD07-612	700	1.8	0.28
4,4'-DDE	28-CC-SD01-06	160	80	10.7
	28-CC-SD01-612	200	100	13.3
	28-CC-SD02-612	9.5	4.6	0.63
	28-CC-SD03-06	6.4	3.2	0.43
	28-CC-SD05-06	28	14	1.9
	28-CC-SD06-06	23	11.2	1.5
	28-CC-SD06-612	20	10	1.3
	28-CC-SD07-06	12	6	0.80
	28-CC-SD07-612	9	4.5	0.60
4,4'-DDD	28-CC-SD01-06	370	185	18.5
	28-CC-SD01-612	450	225	22.5
	28-CC-SD03-06	13	6.5	0.65
	28-CC-SD03-612	4.3	2.2	0.22
	28-CC-SD06-612	36	18	1.8
	28-CC-SD07-06	37	18.5	1.9
	28-CC-SD07-612	16	8	0.80
alpha-Chlordane	28-CC-SD04-612	2.6	5.2	0.43
	28-CC-SD06-06	5.9	11.8	0.98
gamma-Chlordane	28-CC-SD06-06	6.1	12.2	1.0
	28-CC-SD07-06	8.4	16.8	1.4
Orde Pond				
4,4'DDD	28-OP-SD01-06	8.3	4.2	0.42

(1) Ratios of sample concentrations to established criteria and/or screening values
(2) SSVs = Sediment Screening Values
(3) µg/kg = micrograms per kilogram
(4) ER-L = Effects Range-Low
(5) ER-M = Effects Range-Median
(6) mg/kg = milligrams per kilogram

TABLE 17-23

QUOTIENT INDEX RATIOS, TERRESTRIAL MODEL - SITE 28
REMEDIAL INVESTIGATION, CTO-0231
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Bobwhite Quail	Red Fox	Cottontail Rabbit	Raccoon	Whitetail Deer
Phenanthrene	2.54E-05	5.86E-07	1.84E-05	1.47E-06	4.45E-07
Anthracene	1.81E-05	2.28E-07	1.30E-05	8.67E-07	2.65E-07
Carbazole	NA	NA	NA	NA	NA
Chrysene	1.34E-05	1.32E-07	6.01E-06	9.07E-07	1.04E-07
Benzo(a)pryene	1.19E-05	1.12E-07	4.80E-06	8.44E-07	7.85E-08
4,4'-DDE	4.96E-02	5.10E-04	2.21E-02	5.69E-03	3.86E-04
4,4'-DDD	8.56E-03	1.09E-04	3.47E-03	1.29E-03	6.43E-05
4,4'-DDT	1.86E-02	1.67E-04	6.70E-03	1.38E-03	1.02E-04
Chlordane, alpha	5.30E-03	5.42E-05	2.57E-03	7.77E-04	4.60E-05
Chlordane, gamma	1.80E-03	1.84E-05	8.73E-04	1.17E-04	1.56E-05
Heptachlor Epoxide	3.64E-04	3.80E-06	1.84E-04	2.32E-05	3.34E-06
Aluminum	NA	NA	NA	NA	NA
Antimony	3.44E-01	4.07E-03	2.90E-01	9.62E-03	6.12E-03
Arsenic	9.71E-04	2.18E-05	5.46E-04	1.56E-04	1.35E-05
Barium	2.01E-02	2.67E-04	1.61E-02	7.02E-04	3.94E-05
Cadmium	1.61E-02	2.33E-04	1.53E-02	2.68E-04	3.38E-04
Chromium	2.40E-02	2.12E-04	8.60E-03	7.43E-03	7.89E-06
Cobalt	NA	NA	NA	NA	NA
Copper	1.59E-02	2.20E-04	1.48E-02	4.11E-04	7.75E-07
Iron	NA	NA	NA	NA	NA
Lead	5.68E-02	6.06E-04	3.28E-02	2.19E-03	3.79E-06
Manganese	5.88E+01	7.35E-01	5.14E+01	1.31E+00	1.26E-06
Mercury	2.91E-03	3.78E-05	2.88E-03	7.86E-05	6.25E-05
Nickel	1.17E-02	2.78E-04	7.41E-03	7.67E-04	1.83E-04
Selenium	*	*	*	1.74E-03	*
Silver	2.97E+00	3.77E-02	2.76E+00	5.16-02	5.93E-02
Thallium	1.49E-02	1.36E-03	5.79E-03	2.22E-03	4.18E-04
Vanadium	9.72E-03	1.33E-04	3.35E-03	7.81E-04	6.24E-05
Zinc	3.44E+00	4.94E-02	3.47E+00	6.21E-02	7.58E-02
Bis(2-ethylbutyl)phthalate	1.47E-03	9.17E-04	1.21E-03	1.33E-03	2.63E-04
Fluoranthene	2.64E-05	3.06E-07	1.64E-05	1.46E-06	3.20E-07

TABLE 17-23 (Continued)

QUOTIENT INDEX RATIOS - SITE 28
REMEDIAL INVESTIGATION, CTO-0231
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Bobwhite Quail	Red Fox	Cottontail Rabbit	Raccoon	Whitetail Deer
Pyrene	3.33E-05	3.54E-07	1.75E-05	2.07E-06	3.22E-07
Benzo(a)anthracene	1.34E-05	1.32E-07	6.03E-06	9.03E-07	1.04E-07
Benzo(b)fluoranthene	1.20E-05	1.06E-07	4.16E-06	9.04E-07	6.16E-08
Benzo(k)fluoranthene	1.11E-05	1.03E-07	4.39E-06	7.95E-07	7.09E-08
Indeno(1,2,3)pyrene	1.05E-05	9.35E-08	3.72E-06	7.82E-07	5.61E-08
Benzo(g,h,i)perylene	1.04E-05	9.31E-08	3.71E-06	7.79E-07	5.59E-08
TOTAL	6.59E+01	8.32E-01	5.81E+01	1.46E+00	1.43E-01

NA - Terrestrial reference value not available; therefore a quotient index ratio could not be calculated.
* - COC for fish only, therefore QI calculated for raccoon only.

- 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 (Menzie et. al., 1993).

SECTION 17.0 FIGURES

LEGEND

28GW01	PILOT TEST BORING FOR SHALLOW MONITORING WELL (BAKER, 1994)
28GW01DW	PILOT TEST BORING FOR DEEP MONITORING WELL (BAKER, 1994)
SB1	SOIL BORING LOCATION
BB-SB37	BASE BACKGROUND SOIL BORING LOCATION
SB40	EXPLORATORY TEST BORING
	VEGATATION
— x —	FENCE
— — —	CREEK/DRAINAGE
	MARSH

SOURCE LANTDIV, FEBRUARY 1992

DATE	NOVEMBER 1994
SCALE	1"= 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
CADD#	231165RI

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc

SURFACE AND SUBSURFACE
SOIL SAMPLING LOCATIONS
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1"= 120'
DATE NOVEMBER 1994

FIGURE No
12-1

01500Q24X

NOTES
-ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)
-SAMPLE LOCATIONS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS

LEGEND

- 28-CC-SW/SD01 SURFACE WATER AND SEDIMENT SAMPLE
- VEGATATION
- FENCE
- CREEK/DRAINAGE
- MARSH

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
CADD#	231159RI

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc

POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SEDIMENT
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120'
DATE JANUARY 1995

FIGURE No
14-7

01500Q25X

NOTES
-ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)
-SAMPLE LOCATIONS SHOWN WITHOUT CONCENTRATIONS INDICATE NONDETECTABLE LEVELS

LEGEND

28-CC-SW/SD01	SURFACE WATER AND SEDIMENT SAMPLE
	VEGATATION
—x—	FENCE
— —	CREEK/DRAINAGE
	MARSH

SOURCE LANTDIV, FEBRUARY 1992

DATE	JANUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
CADD#	231159RI

NORTH

REMEDIAL INVESTIGATION CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc

POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SEDIMENT
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120'
DATE JANUARY 1995

FIGURE No
14-7

01500Q25X

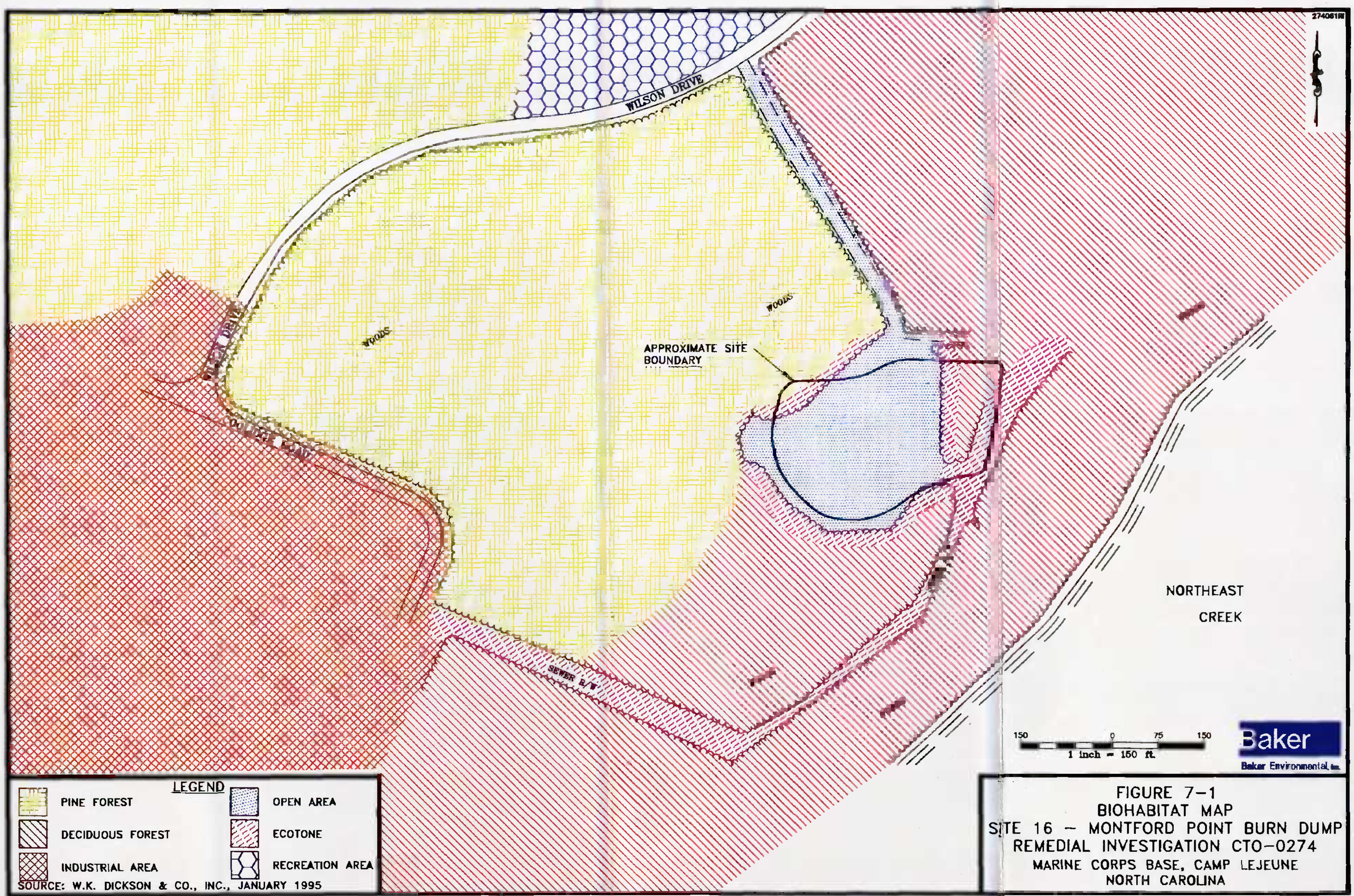


FIGURE 7-1
BIOHABITAT MAP
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q264

18.0 CONCLUSIONS AND SUMMARY

The following conclusions were derived from the RI conducted at Site 28:

- The soils underlying Site 28 are generally consistent throughout the shallow and deep subsurface. The soils consist of mostly silty sands with thinly interbedded layers of clay and silty clay which are discontinuous. A large quantity of fill material and debris (e.g., glass, metal, brick, and wire), varying in thickness from three to 22 feet, underlies the western portion of the site. The location and thickness of the fill and debris appear to coincide with existing information and results of previous investigations. The top of the River Bend Formation, which includes the upper portion of the Castle Hayne aquifer, at approximately 40 feet bgs.

- The hydrogeologic characteristics of the study area were investigated by installing a network of shallow and deep monitoring wells and staff gauges. Groundwater within the surficial aquifer discharges into Cogdels Creek. The water table gradient is relatively low (0.004). Flow velocity within the surficial aquifer was estimated at 4.1×10^{-2} feet/day. Groundwater flow within the deep aquifer was determined to be to the west-southwest with a relatively low gradient of 0.0013. Sightly different groundwater elevations (i.e., head differentials) were noted between the surficial and deep aquifer monitoring wells. In general, there is a downward movement (head) of groundwater at the site.

- There are no water supply wells within a one-mile radius of Site 28.

- Among organic compounds, semivolatile organics within soil samples at Site 28 appear to be the most directly linked to past disposal practices. Several SVOCs were identified in both surface and subsurface soil samples, primarily from the western disposal area. A majority of SVOCs detected in soil samples were PAH compounds, most probably resulting from combustion of waste material or refuse.

- Inorganic elements were detected in both surface and subsurface soil samples from the western portion of the study area at concentrations greater than one order of magnitude above base-specific background levels. In general, elevated metal concentrations were limited to soils obtained from the western portion of the study area. The metals copper, lead, manganese, and zinc were observed at maximum concentrations greater than two orders of magnitude above base-specific background levels. The same three metals had several positive detections in excess of the one order of magnitude level.

- The pesticides dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane appear to be the most widely scattered contaminants within soils at Site 28. Each of the five pesticides were detected in at least 15 of the 72 soil samples. The pesticide 4,4'-DDE was the most prevalent, with 44 positive detections ranging from 3.1 J to 1,600 μg/Kg. The highest pesticide concentration was that of 4,4'-DDT at 7,300 μg/Kg. In general, higher concentrations of those pesticides more frequently detected, were limited to the western portion of the study area, and in particular among borings 28-GW01, 28-GW01DW, and 28-W-SB12.

- Three organic PCB contaminants, Aroclor 1242, 1254, and 1260, were detected in soil samples obtained from borings at Site 28. The maximum PCB concentration was 140 J µg/Kg from the pilot test boring 28-GW07.

- Volatile compounds were found in one surface soil sample and two subsurface samples at very low concentrations. The VOCs benzene, tetrachloroethene, and 1,1,1-trichloroethane were each detected once within the 72 soil samples collected at Site 28. Based upon their wide dispersion, infrequent detection, and low concentration, the occurrence of volatile compounds in soils at Site 28 does not appear to be the result of past disposal practices.

- Inorganic elements were the most prevalent and widely distributed contaminants in groundwater at Site 28 and were found distributed throughout the site. Concentrations of TAL total metals, in samples obtained during both sampling rounds, were generally higher in shallow groundwater samples than in samples collected from the deeper aquifer. Lead was detected, and confirmed by the second sampling round, within only 1 of the 12 shallow and deep groundwater samples at a concentration which exceeded the NCWQS and federal action level from 28-GW08. Lead was also detected during the first sampling round in a sample retained from temporary well 28-TGWPA at a concentration which exceeded the NCWQS and federal action level. Iron and manganese were the most prevalent inorganic elements detected during both sampling rounds. Concentrations of iron and manganese were confirmed by the second sampling round to have exceeded either federal or state standards within 7 groundwater samples.

- Semivolatile compounds were detected in five of ten shallow groundwater samples obtained during the first sampling round from the western portion of the study area. The maximum SVOC concentration, 99 µg/L, was detected within the sample from temporary monitoring well 28-TGWPA, located in the central western portion of the study area. Semivolatile analyses of groundwater samples were not performed as part of the second sampling round.

- The organic pesticide compounds 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and gamma-chlordane were each detected at least once within samples obtained from six shallow monitoring wells located on the western portion of Site 28, during the first sampling round. Pesticides 4,4'-DDE and 4,4'-DDD were detected within five and six shallow groundwater samples, respectively. The highest pesticide concentration detected was 9 µg/L, within the sample obtained from monitoring well 28-GW07. A second round of groundwater samples was obtained from those monitoring wells that presented evidence of pesticide contamination during the first sampling round. However, groundwater samples obtained during the second sampling round did not exhibit pesticides.

- Positive detections of VOCs in groundwater were limited to the central western portion of the study area. The volatile compounds chloroform, ethylbenzene, and xylene were detected in a single shallow groundwater sample obtained from temporary well 28-TGWPA.

- In the current case, potential noncarcinogenic and carcinogenic risks to the military personnel, recreational adult, and fisherman were within acceptable risk levels. For the current recreational child receptor, there was a potential noncarcinogenic risk from New River sediment. The noncarcinogenic risk from the ingestion pathway was 1.2, which is slightly greater than the acceptable risk level of one. The COPC driving this noncarcinogenic risk was antimony.

- In the future case, the total potential noncarcinogenic risk to the child receptor (i.e., total noncancer risk is 23) exceeds the acceptable risk level of one. This risk is attributed to exposure to groundwater, subsurface soil, and sediment from the New River. For the adult receptor, there were noncarcinogenic and carcinogenic risks from exposure to groundwater. The risks to the construction worker were within acceptable risk levels.

- The results indicate that metals in groundwater, subsurface soil and sediment are driving the potential noncarcinogenic and carcinogenic risks at the site. These metals are antimony, arsenic, copper and zinc in the subsurface soil; manganese in groundwater, and antimony in the sediment of the New River. It is important to note that upon the segregation of the soil noncarcinogenic risks based on the effects on different target organs, the soil noncarcinogenic risk may be an overestimate.

- In terms of lead health impacts, use of the lead UBK model indicates that exposure to surface soil, subsurface soil and groundwater at this site generates blood lead levels in children that are within acceptable levels.

- It is important to note that the future exposure scenario is based on potential residential development of Site 28. At present the site is a recreational/picnic area, and is used for training military personnel. It is highly unlikely that the site will become a residential area in the foreseeable future. Consequently, exposure to subsurface soil and groundwater under a residential scenario is highly conservative and unlikely, given the present site conditions. It follows that the potential risks associated with this exposure scenario are conservative and may be overestimated values.

- Metals and pesticides appear to be the most significant site related COPCs that have potential to affect the integrity of the aquatic receptors at Site 28. For the terrestrial receptors at Site 28, metals appear to be the most significant site-related COPC that have the potential to affect the integrity of the ecosystem.

- In New River surface water, copper exceeded aquatic reference values but at levels that were indicative of a low potential risk. Lead and zinc only exceeded unity slightly at a single station. Copper exceeded the surface water reference values in Cogdels Creek, and aluminum exceeded unity in Orde Pond. However, the exceedance was only slightly above unity.

- In the sediments, lead exceeded aquatic reference values only once in Cogdels Creek at a low level but exceeded aquatic reference values significantly in the New River at one station. Antimony exceeded its sediment aquatic reference values moderately at the same station in the New River. This station may be associated with runoff from the active firing range. Pesticides exceeded the sediment aquatic reference values throughout Cogdels Creek with the highest exceedances in the lower reach of the creek near the confluence with the New River. These exceedances represent a moderate potential for risk to aquatic receptors. The levels of pesticides detected in the sediments may be a result of routine application in the vicinity of Site 28, especially near the sewage treatment plant and recreation area.

- Results of the analysis of benthic macroinvertebrates and fish populations indicate that Cogdels Creek and this reach of the New River support an aquatic community that is representative of a tidally-influenced freshwater and estuarine ecosystem with both freshwater and marine species. The absence of pathologies observed in the fish sampled from Cogdels Creek and the New River indicates that the surface water and sediment quality does not adversely impact the fish community relative. The benthic community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches of Cogdels Creek and polychaetes and amphipods in the lower reaches of Cogdels Creek and in the New River. Species representative of both tolerant and intolerant taxa were present and the overall community composition did not indicate a benthic community adversely impacted by surface water and sediment quality.

- During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. Based on the soil toxicity data for several metals (cadmium, chromium, copper, manganese, nickel, and zinc), these contaminants at Site 28 may decrease the integrity of terrestrial invertebrates or plants at the site. Based on the evaluation of the deer, rabbit, fox, raccoon, and quail receptors used in this ERA, there does appear to be an ecological risk to terrestrial vertebrate receptors. This risk is expected to be significant if greater exposure to those contaminants results.